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National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
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F/SER31:LC
SEP 24 2018 SER-2016-17799

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Federal Energy Regulatory Commission
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San Juan, Puerto Rico 00918

Dear Messieurs Swearingen and Castillo:

The National Marine Fisheries Service (NMFS) issued a Draft Biological Opinion ("Opinion") on June 20, 2018, pursuant to Section 7 of the Endangered Species Act (ESA) by the Federal Energy Regulatory Commission (FERC) for the following action.

Permit Number	Applicant	SER Number	Project Type
CP13-193-000, FERC/EIS-0253	Aguirre Offshore GasPort LLC, Subsidiary of Excelerate Energy LP	SER-2016-17799	Construction of an offshore gasport and pipeline from the existing Aguirre power plant facility to the new offshore gasport platform

NMFS received comments from FERC, USACE, and the applicant (Excelerate Energy, LP) regarding the draft Opinion. NMFS responded to all comments in an email to FERC and USACE dated August 31, 2018.

Enclosed is the final Opinion for this action. The final Opinion incorporates comments received by USACE to modify RPM #6 and Term & Condition #6. If you have any questions regarding this final Opinion, please contact Mark A. Lamb, Coral Branch Chief, by phone at (727)-209-5975, or by email at mark.lamb@noaa.gov.

Sincerely,

Roy E. Crabtree, Ph.D.
Regional Administrator

Enclosure

cc: USACE – Román
F/SER4 – Rivera, Wilber
EPA – Knutson, Soto
FERC – Fernandez Johnson, Laffoon

File: 1514-22.N

Endangered Species Act – Section 7 Consultation
Biological Opinion
for the

Construction and operation of the Aguirre Offshore GasPort and installation of a natural gas pipeline from the new offshore gasport to the existing Aguirre power plant facility, Jobos Bay, Salinas, Puerto Rico

NMFS Consultation Number: SER-2016-17799

Federal Action Agency: Federal Energy Regulatory Commission (Lead) and U.S. Army Corps of Engineers

Summary of NMFS Determinations:

ESA-Listed Species	ESA Listing Status of the Species (E= endangered, T= threatened)	NMFS' Effects Determination for ESA-Listed Species as a Result of the Action	NMFS' Effects Determination for Critical Habitat as a Result of the Action
South Atlantic Distinct Population Segment [DPS]) of green sea turtle (*Chelonia mydas)*	T	LAA, no jeopardy	
North Atlantic DPS of green sea turtle (*Chelonia mydas*	T	LAA, no jeopardy	
Leatherback sea turtle (*Dermochelys coriacea*)	E	LAA, no jeopardy	
Hawksbill sea turtle (*Eretmochelys imbricata*)	E	LAA, no jeopardy	
Northwest Atlantic Ocean DPS of loggerhead sea turtle (*Caretta caretta,*)	T	LAA, no jeopardy	
Elkhorn coral (*Acropora palmata*)	T	LAA, no jeopardy	LAA, no DAM
Staghorn coral (*Acropora cervicornis*)	T	LAA, no jeopardy	LAA, no DAM
Lobed star coral (*Orbicella annularis*)	T	LAA, no jeopardy	
Boulder star coral (*Orbicella franksi*)	T	LAA, no jeopardy	
Mountainous star coral (*Orbicella faveolata*)	T	LAA, no jeopardy	

Rough cactus coral (*Mycetophyllia ferox*)	T	LAA, no jeopardy	
Pillar coral (*Dendrogyra cylindrus*)	T	LAA, no jeopardy	
Blue whale (*Balaenoptera musculus*)	E	NLAA	
Fin whale (*Balaenoptera physalus*)	E	NLAA	
Sei whale (*Balaenoptera borealis*)	E	NLAA	
Sperm whale (*Physeter microcephalus*)	E	NLAA	
Nassau grouper (*Epinephelus striatus*)	T	NLAA	
Scalloped hammerhead shark, Central and Southwest Atlantic DPS, *Sphyrna lewini*	T	NLAA	
Giant manta ray, *Manta birostris*	T	NLAA	
NLAA = Not Likely to Adversely Affect; LAA = Likely to Adversely Affect; DAM = Destruction or Adverse Modification			

Consultation Conducted By: National Marine Fisheries Service
Southeast Region

Issued By:

Roy E. Crabtree, Ph.D.
Regional Administrator

Date: Sept 24, 2018

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Acronyms and Abbreviations

BA – Biological Assessment
BIRNM – Buck Island Reef National Monument
CCL – Curved Carapace Length
CPUE – Catch Per Unit Effort
DTRU – Dry Tortugas Recovery Unit
DWH – Deepwater Horizon
EFH – Essential Fish Habitat
EIS – Environmental Impact Statement
EPA – U.S. Environmental Protection Agency
ESA – Endangered Species Act
FERC – Federal Energy Regulatory Commission
FSRU – Floating Storage and Regasification Unit
FWRI – Florida Fish and Wildlife Research Institute
GADNR – Georgia Department of Natural Resources
GCRU – Greater Caribbean Recovery Unit
HDD – Horizontal Directional Drilling
HEA/REA – Habitat Equivalency Analysis/Resource Equivalency Analysis
JBNERR – Jobos Bay National Estuarine Research Reserve
LNG – Liquified Natural Gas
NCWRC – North Carolina Wildlife Resources Commision
NGMRU – Northern Gulf of Mexico Recovery Unit
NMFS – National Marine Fisheries Service
NOAA – National Oceanic and Atmospheric Administration
NOS – National Ocean Service
NRU – Northern Recovery Unit
NTU – Nephelometric Turbidity Unit
NWA – Northwest Atlantic
PHMSA – Pipeline and Hazardous Materials Safety Administration
PBS – Pilot Boarding Station
PRDNER – Puerto Rico Department of Natural and Environmental Resources
PRWQS – Puerto Rico Water Quality Standards
RPA – Reasonable and Prudent Alternative
RPM – Reasonable and Prudent Measure
SCDNR – South Carolina Department of Natural Resources
T&C – Terms and Conditions
TEWG – Turtle Expert Working Group
TSS – Total Suspended Solids
USACE – U.S. Army Corps of Engineers
USCG – U.S. Coast Guard
USFWS – U.S. Fish and Wildlife Service
USVI – U.S. Virgin Islands
WIDECAST – Wider Caribbean Sea Turtle Conservation Network

Units of Measurement

ac – acre
fps – feet/second
ft – feet
gph – gallons per hour
in – inch
kg – kilogram
km – kilometer
km^2 – square kilometer
lb - pound
m – meter
m^2 – square meters
m^3 – cubic meters
mgd – million gallons per day
mg/cm^2 – milligram per square centimeter
mg/L – milligrams per liter
mi – mile
mi^2 – square miles
mm – millimeters
mph – miles per hour
ppb – parts per billion
ppt – parts per thousand
µg/L – micrograms per liter
µm - micrometer

1 INTRODUCTION

Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 et seq.), requires each federal agency to "insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species." Section 7(a)(2) requires federal agencies to consult with the appropriate Secretary in carrying out these responsibilities. National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) share responsibilities for administering the Endangered Species Act (ESA).

Consultation is required when a federal action agency determines that a proposed action "may affect" listed species or designated critical habitat. Consultation is concluded after NMFS determines that the action is not likely to adversely affect listed species or critical habitat or issues a Biological Opinion ("Opinion") that identifies whether a proposed action is likely to jeopardize the continued existence of a listed species, or destroy or adversely modify critical habitat. Reasonable and prudent alternatives (RPAs) to the action as proposed are developed if the Opinion finds that the action is likely to jeopardize the continued existence of a listed species or destroy or adversely modify critical habitat. The Opinion states the amount or extent of incidental take of the listed species that may occur, develops measures (i.e., reasonable and prudent measures - RPMs) to reduce the effect of take, and recommends conservation measures to further the recovery of the species.

This document represents NMFS's Opinion based on our review of impacts associated with the proposed construction and operation of the Aguirre Offshore GasPort located in Salinas, Puerto Rico, by the Aguirre Offshore GasPort LLC, a subsidiary of Excelerate Energy LP (applicant) in partnership with the Puerto Rico Electric Power Authority (PREPA) with a license from the Federal Energy Regulatory Commission (FERC) and a federal permit from the U.S. Army Corps of Engineers (USACE). This Opinion analyzes the project's effects on threatened and endangered species and designated critical habitat, in accordance with Section 7 of the ESA. We based our Opinion on project information provided by FERC, as the lead agency, Excelerate Energy and its consultants, and other sources of information, including the published literature cited herein.

2 CONSULTATION HISTORY

The consultation history for this project is as follows:

- NMFS participated in interagency meetings and conference calls with FERC, USACE, USFWS, the U.S. Environmental Protection Agency (EPA), and the project applicant and consultants beginning in August 2012.
- On August 23, 2013, NMFS received a draft Biological Assessment (BA) from project consultants via email.
- NMFS sent a letter dated October 31, 2013, to FERC regarding the draft BA, as well as resource reports and other documents prepared for the project.

- FERC sent a letter dated August 14, 2014, that was received by NMFS on August 21, 2014, requesting an ESA Section 7 consultation for the project. The letter was accompanied by a copy of the draft Environmental Impact Statement (EIS) prepared for the project that contained the BA as an appendix.
- NMFS and USFWS met with FERC on September 10, 2014, to discuss potential changes to the project due to requirements of the Pipeline and Hazardous Materials Safety Administration (PHMSA) and the implications for the ESA consultations and preparation of the EIS.
- NMFS sent a letter dated September 25, 2014, to FERC with comments on the draft EIS, as well as the essential fish habitat (EFH) and ESA consultation documents included in the EIS as appendices.
- A conference call was held on November 24, 2014, between the NMFS's divisions that commented on the draft EIS, FERC, and the project applicant and consultants to discuss our comments and requests for additional information for the EFH and ESA consultations.
- NMFS sent a letter dated February 23, 2015, to FERC summarizing the additional information we had already requested in order to initiate the ESA Section 7 consultation for the project.
- NMFS sent a letter dated March 30, 2015, to FERC regarding the issuance of the final EIS despite not having completed EFH or ESA consultations for the project.
- On July 24, 2015, FERC sent an email regarding the status of the ESA Section 7 consultation for the project because the agency decided to revise the BA due to the changes to the project resulting from the PHMSA requirements and the applicant's proposal to use horizontal directional drilling (HDD) to install the pipeline in the area containing coral reef. FERC notified NMFS that they did not yet have a time line for sending a new consultation request.
- A conference call was held with FERC on September 15, 2015, to discuss NMFS's information needs in order to update the BA and initiate consultation.
- FERC sent a letter dated February 26, 2016 that was received by NMFS via email on February 29, 2016, requesting formal consultation for the project. The letter was accompanied by a new BA for the project reflecting the changes to the pipeline installation method, including the use of HDD, jetting in areas containing seagrass and soft bottom, and placement of concrete mats on inflection points in the pipeline.
- NMFS sent a letter dated March 14, 2016, to FERC requesting clarification of some of the points in their consultation initiation request, including some of their effects determinations.
- FERC responded to our letter via email on March 16, 2016.
- NMFS sent a letter to FERC dated May 17, 2016, requesting additional information after completing our review of the BA.
- The applicant sent a response to our request that was received on June 22, 2016, in hard copy and electronic format.
- A conference call was held with FERC and the applicant on July 8, 2016, to discuss our information request, the applicant's response, and information that was still needed regarding project impacts to ESA-listed species in order for us to initiate consultation.
- The applicant sent a response containing the additional information discussed during the July 8 conference call via email on July 15, 2016. NMFS reviewed the information and

notified the applicant via email dated August 1, 2016, that the information was adequate for us to initiate the ESA Section 7 consultation for the project. NMFS noted that the initiation date is July 15, 2016.

- During the writing of the Opinion, NMFS requested additional information via email dated November 28, 2016, and also discussed the request with Excelerate, FERC, and PREPA during a conference call the same day. NMFS sent an additional email on November 28, 2016, regarding monitoring plans and HDD operations that were discussed during the conference call.
- NMFS received responses to our November 28 information request via emails dated December 6, 13, 16, and 20, 2016.
- After calculating the potential acoustic impacts of pile driving associated with the construction of the offshore gasport, NMFS sent an email to the applicant and FERC on January 11, 2017, regarding additional measures to minimize potential acoustic impacts to sea turtles. The applicant sent a response the same day via email confirming acceptance of these measures.
- NMFS held a conference call with the applicant and FERC on March 29, 2017, to discuss the potential for alternate routes for the pipeline and NMFS's concerns related to potential impacts associated with HDD.
- NMFS convened a technical project meeting in SERO on May 23, 2017, with FERC, the applicant and the applicant's consultants, as well as industry representatives with some experience performing HDD operations invited by the applicant. It was agreed that the applicant would provide NMFS with additional information about how HDD technology would be applied to the proposed project, similar HDD examples, HDD performance standards, updated estimated of mud loss and sedimentation modeling, and the use of project scheduling work windows.
- NMFS received additional information as a follow up to the May 2017 meeting from the applicant on June 23, 2017. NMFS sent an email to applicant noting requested information that was still pending on July 5, 2017, and an email on July 10, 2017, providing information regarding sea turtles in the action area.
- NMFS received information regarding an LNG project from FERC August 3, 2017, in response to our request for examples of similar projects. The applicant submitted additional information regarding HDD requirements for the Aguirre project and the use of HDD technology in other projects the same day.
- NMFS received the new drilling mud dispersion modeling results from the applicant August 24, 2017.

3 DESCRIPTION OF THE PROPOSED ACTION AND ACTION AREA

3.1 Proposed Action

Aguirre Offshore GasPort LLC, a wholly owned subsidiary of Excelerate Energy LP, proposes the development of an offshore gasport and pipeline for the purpose of receiving, storing, and regasifying liquefied natural gas (LNG). The project is being developed in cooperation with the Puerto Rico Electric Power Authority (PREPA). The pipeline will allow the transfer of LNG to PREPA's existing Aguirre Power Complex in Salinas, Puerto Rico (Figure 1). The plant will be converted to a dual fuel generation facility that can use diesel and natural gas to generate electricity. The construction and operation of the project will further PREPA's ability to comply with EPA air quality regulations related to emissions generated by the Aguirre power plant.

FERC issued an order granting authorization of the siting, construction, and operation of the project under Section 3 of the Natural Gas Act on July 24, 2015, subject to certain conditions such as the need to complete ESA Section 7 consultations with NMFS and USFWS and obtain required federal and Commonwealth permits, including from the USACE.

The project will also require a National Pollutant Discharge Elimination System (NPDES) permit from the EPA for the operation of the offshore gasport, specifically the intake and discharge of seawater. EPA has not initiated an ESA Section 7 consultation for the NPDES permit with NMFS. However, we have considered the potential effects of seawater intake and discharge on ESA-listed species and their habitat in this Opinion in addition to the construction and operation portions of the project under FERC and USACE jurisdiction.

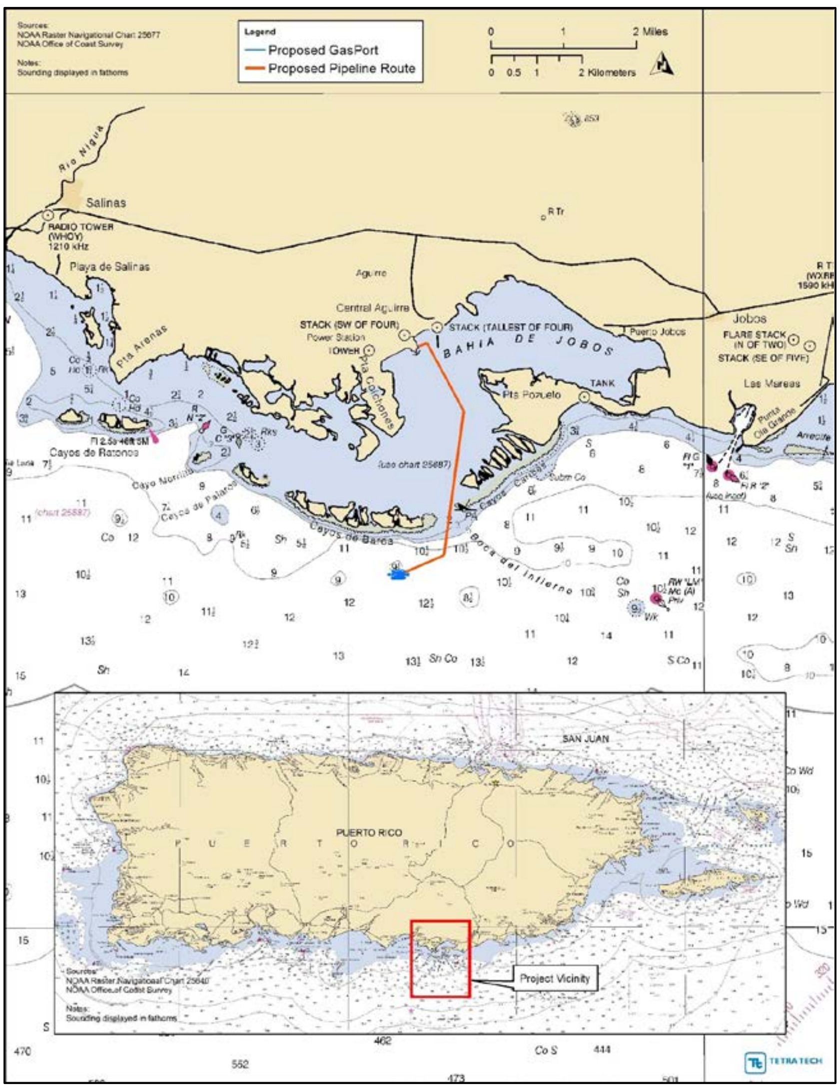

Figure 1. Location of Aguirre Offshore GasPort and Pipeline (from FERC 2016)

Terrestrial Facilities

The changes to the existing power plant facilities associated with the proposed project include the construction of piping, a metering station, pressure reduction equipment, and process gas heat exchangers. A pig receiver will be located at the onshore termination of the pipeline and a gas metering skid will also be constructed here to measure the amount of natural gas being delivered by the floating storage and regasification unit (FSRU). The onshore pipeline would have a diameter of 18 inches (in) and would extend approximately 985 feet (ft) from the onshore pipeline terminus to the gas delivery point to the northeast of the power plant facility. The pipeline will come ashore at the south end of an existing bulkhead. The metering station construction will affect 0.7 acre (ac) and the other equipment and 2-ft-wide pipeline corridor will affect an additional 0.4 ac of previously disturbed land within the existing power plant lands. An additional 1.5 ac of previously disturbed land within the Aguirre facilities will be used as a construction office, temporary staging and support area where the pipeline will reach landfall. A silt fence will be installed around the entire terrestrial work area to minimize the potential for sediment runoff to the bay during construction. Turbidity curtains will be installed near the shore approach where the pipeline will come ashore during construction activities associated with pipeline tie-in. A turbidity monitoring buoy will also be installed in the area to verify that turbidity plumes are not generated in the bay from terrestrial construction. Construction of the terrestrial facilities is expected to take 14 days to complete.

During construction of the pipeline and offshore platform, the Aguirre power plant would continue to operate with diesel fuel and fuel barge deliveries, which currently total approximately 208 per year (approximately 4 per week). In addition to fuel barge deliveries to the existing fuel pier, this pier and the existing operations pier at the Aguirre plant will be used by work vessels involved in project construction. Once the plant has been converted to a dual fuel facility and is operating with natural gas, fuel barge deliveries are expected to decrease by 90% to approximately 21 vessels per year.

Subsea Pipeline

Approximately 3.8 miles (mi; 20,064 ft) of subsea pipeline will connect the offshore platform to the existing plant. The pipeline will pass from the proposed offshore gasport through the Boca del Infierno pass between offshore cays and across Jobos Bay. The pipeline will be an 18-in-diameter steel pipe that will be coated with a 3-in concrete casing by the manufacturer. This will give the pipeline an outside diameter of approximately 21 in. The pipeline will be installed in 5 segments defined by points-of-inflection or pipe bends. The only sections of the pipeline that will not have a concrete coating will be at the pipe bend locations and in the portion of the pipe to be installed under the reef at Boca del Infierno using horizontal directional drilling (HDD). At pipe bend locations, 3 concrete mats measuring 8- or 12-ft-wide by 20-ft-long each (for a total length of 60 ft) will be used to cover the pipeline. The mats will not be anchored to the seafloor. The mats are a flexible matrix of solid concrete cells that are closely linked and joined individually by polypropylene rope. Mats have a thickness of 9 in. A 1,300-ft-long segment of pipeline at the onshore approach will also be covered with 65 concrete mats. These mats will have their edges buried using the hand-jetting equipment that will be used to bury portions of the pipeline in order to anchor the mats into the seafloor.

Non-HDD Pipeline Installation: Pipeline installation will require a 40-ft-wide workspace along the portions of the pipeline that will be buried and additional temporary workspace area at the pipe bends (500-ft radius on one side of the pipeline for each pipe bend) and shore approach.

The pipe lay barge (measuring approximately 400-ft-long by 120-ft-wide) will be positioned in Jobos Bay to begin pipeline installation. The barge will be positioned using a tug and then anchored in place with spuds. Pipeline welding and stringing will be done on the barge. As the pipeline is fabricated, it will be lowered over a ramp off the barge and into the water and held with a winch wire on the crane barge, which will also be located in the bay, to keep it off the bottom. Control lines and floatation buoys will also be placed on the pipeline to keep it on the water surface. Once the entire pipeline segment between bends has been fabricated, the pipeline will be lowered to the seafloor using the crane barge and tug assist by releasing the buoys and allowing the pipeline to flood. The crane barge will then move to the next location while the pipe lay barge will be turned to feed the next section of pipe. To complete the pipeline sections that will not be installed using HDD, the crane barge will be stationed at each pipe bend, the end of the pipeline will be lifted, and an over the side tie-in will be completed prior to lowering the connected pipe back to the seafloor. Pipeline installation, as well as installation of the concrete mats, will take place during daylight hours only. At one of the pipe inflection points in Jobos Bay and one near the shoreline, a 24-in steel pile will be installed using a vibratory hammer. The piles will be used to pull the pipeline from the lay barge. Installation of each pile is expected to take 4 hours. Once the pipeline is installed, the piles will be removed in the same manner in which they were installed.

In places where the pipeline is located in waters with depths of 12 ft or less (approximately 3,572 ft of pipe), it will be buried to a minimum of 3 ft (from top of pipe) below the seafloor. In areas where water depths are greater than 12 ft (approximately 11,373 ft of pipe) the pipeline will be buried such that the top of the pipe is even with the seafloor. Pipeline burial will be completed using a diver-operated jet/suction tool connected to a pump mounted on a crane barge. Prior to commencing pipeline burial, the diver will take a depth reading of the natural seafloor elevation at each joint marker to determine the depth of burial required. The crane barge will then be positioned over the section of pipe to be buried and anchored by spudding. The jet/suction pump hose would be moved by the crane at a speed as close to that of the diver as possible. The diver will hand jet first along the side of the pipeline nearest the crane barge up to 120 ft along the length of the pipeline. The diver will then cross over the pipeline and jet back toward the starting point in order to remove sediment from under both sides of the pipe. The initial diver pass with the jet will liquefy the sediment below the pipeline without causing a large sediment plume and establish the alignment for lowering the pipeline. When the diver returns to the starting point along a particular segment of pipe, the diver will begin suction pumping along the same length of pipeline that was previously jetted. The process will be repeated until the pipeline has reached the required burial depth. It is anticipated that 2 passes with the jet will be required to liquefy the sediment below the pipeline and lower it to the required burial depth.

A diffuser will be placed over the pipeline approximately 90 ft behind the diver and adjusted as necessary based on the diver’s speed. The pump would jet or suction sediment from under the pipeline and redeposit it through the discharge hose and diffuser over the pipeline areas that have been lowered to the required depth behind the diver. The diffuser head will be 9 – 12 ft wide to deposit spoils over the width of the disturbed area. The diffuser head will be suspended over the pipeline within a frame and the frame will be surrounded by a turbidity curtain to minimize sediment movement outside the pipeline work area. It is anticipated that 5 passes with the suction pump will be required to ensure the pipeline has reached the required 3 ft of cover in areas with water depths of 12 ft or less. Fewer passes will be required where the top of the pipeline will be level with the seafloor. The crane barge will be repositioned every 240 ft to continue burial operations. The pipeline burial operation will be 24 hours per day until burial is complete. Any excess sediment generated from pipeline installation and burial operations will be placed on a barge using the suction pipeline that will be used during burial operations. This sediment will be used as part of the proposed seagrass restoration activities that are part of the mitigation plan prepared by the applicant. The sediment would be placed in burlap sacks and lowered to the seafloor in areas where vessel groundings have resulted in deep scars.

<u>HDD Pipeline Installation:</u> Approximately 5,200 ft (1,585 meters [m]) of pipeline will be installed by HDD. At the HDD entry point (Figure 2), the installation of 4 24-in steel piles across the bow and 2 each on the starboard and port sides will be installed to anchor the barges needed for HDD operations (Table 1). Piles will be removed once HDD operations are complete. A maximum of 4 anchors will also be deployed off the back of the barge to provide additional support to minimize movement during HDD operations. Divers will assist in the placement of these anchors to minimize potential disturbance to benthic habitats.

Table 1. Pile Installation Required for Project

Location	Pile type	Number of Piles	Temporary or Permanent	Installation Method	Confined Space or Open Water
Pipe Inflections #4 and 5	24-in steel	2	Temporary	Vibratory hammer	Open Water (Jobos Bay, see Figure 1)
HDD Entry Point	24-in steel	8	Temporary	Vibratory hammer	Open Water (Jobos Bay near Boca del Infierno)
Offshore Platform	80-in steel	50	Permanent	Impact hammer	Open Water

For the portion of the pipeline to be installed by HDD, a derrick barge, support tugs, HDD unit, and 2 shallow-draft pipe haul barges (to store the joints of pipe) will be used. A second drill rig spread may also be used at the exit point during reaming and swabbing. Excelerate has left this as an option for contractors bidding on the project (Appendix A). HDD operations will take place 24 hours per day until complete. The entry and exit points require dredging, which will likely be done using a clamshell dredge from a barge at the entry point and using hand jetting at the exit point due to water depths. At the entry and exit points, a gradually sloping pit measuring approximately 10 ft deep at the deepest point and 80 ft long with a front width of 46 ft and a back width of 66 ft will be created. Dredged material will be side cast. At the entry point, dredged material will be used to refill the excavated hole once HDD operations are complete. The pit at the exit point may be larger to contain more of the drilling fluid and may remain in place permanently to retain unrecovered drilling fluid. The applicant estimated that 0.04 in of sediment may remain in the exit pit once HDD operations and cleanup are complete associated with the release of up to 195,497 gallons of drilling fluid during HDD operations (per revised calculations from Baird 2017). This is in addition to any temporary sediment impacts from the excavation of trenches at the entry and exit points. There will also be some loss of drilling mud at the entry point due to successive drilling runs. Cuttings from the hole will also be expelled as waste at the entry and exit points. The applicant noted that turbidity booms will be placed around the entry pit to minimize sediment transport outside the construction area but sediment plumes are expected to result from both excavation at entry and exit points and drilling fluid dispersion in the water column.

A pilot hole will be drilled along the drill path of the proposed HDD crossing under the reef. One or more hole-opening passes of the drill are used to open the hole for installation of the pipe increasing the size by 6 – 12-in intervals. The applicant estimates that up to 4 passes may be needed to create the borehole for the pipeline. Based on the need for 4 passes, the total volume of drilling mud to be used was estimated as 3 million gallons (Laney Directional Drilling Company [Laney]; Laney 2015). Once the hole is large enough (estimated at 30 – 36 in based on Laney (2015), the prefabricated pipe will be pulled back into the enlarged hole, likely from the exit side, possibly after reaming operations from both ends of the HDD segment are completed. Laney (2014) estimated that up to 2 million gallons of drilling fluid could be expelled from the entry and exit points during pilot hole boring and reaming of the pipeline route. The estimate of the total volume of drilling fluid that may be needed to complete HDD operations was revised based on the results of the 2015 geotechnical work by Laney (2015). Instead of the originally estimated 3 million gallons, which is approximately 10 times the volume of the HDD bore, the applicant estimates that approximately 1,950,000 gallons, or 7 times the volume of the borehole, are needed (MottMacdonald 2017). The estimate of drilling fluid release was also revised based on changes to required installation methodology and the incorporation of technologies to ensure better recirculation of drilling fluids for reuse and/or disposal and better recovery of drilling fluids at the exit point. The revised estimate from Baird (2017) is 195,497 gallons of drilling fluids that could be released at the exit point from pilot hole drilling, reaming, swabbing, and pipeline pulling for final installation.

A jack-up barge will be stationed at the exit point to attach to the drill pipe string as soon as it moves out the exit hole as the pilot hole is created. Jack-up barges have legs that are deployed to hold the vessel in place, similar to spuds but of larger size. The legs on jack-up barges are typically each more than 1 m in diameter. A second drill rig spread may be used at the exit side during reaming and swabbing to stabilize the pipe and to assist with recovery of drilling fluid. This is left to the discretion of the contractor so we cannot provide details of this aspect of HDD operations (see Appendix A, 5.1.5). However, no adverse effects to ESA resources would result given the construction condition requiring that barge anchoring shall not occur in areas containing coral unless absolutely necessary, and that if corals are present in such circumstances, any ESA-listed corals will be transplanted.

HDD operations will require approximately 80,000 – 100,000 gallons of freshwater per day. Freshwater will be generated by 2 reverse osmosis generators on the freshwater generating barge moored alongside the HDD barge located at the HDD entry point. Three seawater intake hoses with 100 micrometer (μm) screens will be used to reduce intake of marine organisms. The intake hoses will extend approximately 4 – 5 ft below the surface rather than being placed on the marine bottom to ensure excess rock or debris is not pulled into the equipment. The rate of intake will be 38 gallons per minute and seawater intake will occur 22 hours per day for a total intake of 50,160 gallons per day over the anticipated 60 days required to complete drilling activities for HDD operations. Freshwater will be pumped directly to the drilling mud mixing hopper through a flexible hose. The freshwater generation process will result in a brine effluent with a salinity of 64 – 70 parts per thousand (ppt). The discharge is expected to be approximately 0.2 million gallons per day (mgd) over the 50 – 60 days anticipated for HDD operations. Given the presence of seagrass beds in the area of the discharge, FERC (2016) anticipates impacts to seagrass growth and/or density during brine discharge.

At the HDD exit point, 2 concrete mats will be installed over the pipeline once in place for a total impact area measuring 8-ft-wide by 40-ft-long.

The applicant provided clarification regarding the potential recovery of drilling fluid via emails dated December 16 and 20, 2016, and revised calculations dated August 2, 2017. A casing will be required at the entry point (Appendix A, 3.2 and 5.2). The casing may need to be up to 300 ft long (Laney 2015) because of the type of substrate near the entry point to keep the hole open and reduce the potential for inadvertent fluid releases. As the pilot hole and subsequent reaming and swabbing of the hole are completed, drilling fluids composed of a mix of drilling mud and cuttings are returned via the drill hole and collected in the casing to be pumped to a hopper barge. Any fluids not collected in the casing will be retrieved from the excavated pit at the exit point. Fluids that cannot be collected from the exit point would fall into the excavated pit. Baird (2017) and MottMacdonald (2017) estimate that 7,551 gallons of drilling fluid will be released during drilling of the pilot hole; 14,633 gallons during reaming of the hole to a diameter of 36 in; 55,595 gallons during swab pass to clean the borehole; and 117,718 gallons to pull pipe through the borehole. The applicant will require that contractors use methods to recirculate drilling fluid for reuse and/or disposal and collect as much drilling fluid to the maximum extent possible from entry and exit points during and upon completion of HDD operations (Appendix A, 3.2 and 5.1). All used drilling fluid that can be collected will be disposed of at a terrestrial site.

Based on information provided by the applicant in August 2017, it is expected that no drilling mud will be released at the entry point due to the use of a casing and internal mud pump. Drilling mud will collect in the casing and will be brought to the surface through hoses and pumped to a barge. Even with recirculation, approximately 195,497 gallons of drilling fluid will be released at the exit point. The amount of drilling fluid that could be released during pilot hole drilling, reaming, swabbing, and pipeline installation depends on factors such as the pumping rate during each step in HDD operations and optimization of operations to maximize fluid returns toward the entry side of the borehole. Excelerate estimates that 98% of the total drilling fluids released at the exit point will be recovered for disposal. This means that 3,910 gallons of drilling fluids will not be recovered at the exit point.

<u>Sediment Monitoring:</u> The applicant proposes the deployment of buoys that will be equipped with sensors to remotely monitor turbidity during pipeline installation operations in Jobos Bay and potentially offshore. The buoys in Jobos Bay will be anchored using a 70 – 140 pound (lb) pyramid-shaped cast-steel mooring anchor or a concrete anchor block. The buoys installed in

deep water offshore will be moored to single-leg semi-taut moorings anchored with gravity anchors composed of concrete, rock, or steel weighing 800 – 2,000 lbs. Both shallow and deep moorings will have appropriate scope for the water depth to maintain mooring lines off the bottom. Marker buoys will be attached to the anchors of buoys in shallow waters of Jobos Bay. If necessary, midwater floatation will be installed on the deeper mooring to further assist in keeping anchor tackle off the bottom. The monitoring buoys will be moved periodically during construction operations to obtain turbidity measurements at locations affected by on-going construction activity. The buoys and anchors will be deployed and moved with a monitoring vessel by lifting the anchors using a capstan or winch and then lowered back to the bottom with the winch in shallow waters or dropped to the bottom in deep waters. All buoys and anchors will be removed upon completion of construction activities. No buoys will be installed in areas containing hard bottom.

The suspended sediment concentrations in the water column and subsequent sediment transport and deposition resulting from installation and burial of the pipeline and excavation of the HDD entry and exit points were modeled (Applied Science Associates 2015; FERC 2015). The overall impacts of sediment from the burial of the pipeline in Jobos Bay and in the offshore segment and the dredging at the HDD entry and exit holes are shown in Figures 3 and 4. New sediment dispersion modeling was completed in 2017 for discharges of drilling mud from the offshore exit point based on revisions to HDD drilling requirements meant to lessen discharges. The results of the revised modeling indicate that dispersal of drilling fluids from the exit point will be less than originally calculated with a potential for deposition of 0.04 in of drilling fluid in the exit pit and suspended sediments in a plume moving westward from the exit point up to 120 ft (Figure 5). Overall, up to 448 ac could be affected by the suspension of sediments (turbidity) in concentrations ranging from 5 – 10 milligrams per liter (mg/L) to 1,000 – 2,000 mg/L (Applied Science Associates 2015) during pipeline installation activities that do not include HDD drilling but do include excavations at the entry and exit point to allow drilling and to collect drilling mud (Figures 3 and 4). Modeling of the deposition of sediments from pipeline installation activities (other than HDD drilling determined that 0.004 to 1.97 in (0.1 – 50 millimeters [mm]) of sediment could be deposited on benthic habitats around the pipeline. Up to 210.1 ac could be affected by this sediment deposition of which 163.8 ac are not in the construction right-of way. Table 2 provides details of the predicted distribution of sediment plumes and sediment deposition associated with pipeline installation and burial and HDD entry and exit point excavations.

Table 2. Calculated turbidity plume concentrations and sediment deposition associated with pipeline installation and burial and HDD entry and exit point excavations (from FERC 2015)

Maximum Turbidity Concentrations			
Plume Concentration (mg/L)	Total Area (acres [cuerdas])	Area Outside Construction Right-of-Way (acres [cuerdas])	Maximum Distance from Pipeline (feet [m])
5 to 10	204.1 (210.0)	197.9 (203.7)	3,775.5 (1,150.5)
10 to 20	77.9 (80.1)	72.6 (74.7)	1,623.9 (495.0)
20 to 50	71.2 (73.2)	64.5 (66.4)	1,389.5 (423.5)
50 - 100	22.0 (22.6)	18.2 (18.7)	866.9 (264.2)
100 to 200	14.9 (15.3)	12.7 (13.1)	188.7 (57.5)
200 to 500	23.8 (24.5)	19.0 (19.6)	71.4 (21.8)
500 to 1000	28.8 (29.7)	15.8 (16.3)	40.7 (12.4)
1000 to 2000	5.3 (5.4)	0.8 (0.8)	24.5 (7.5)
> 2000	0	0	0

Source: Applied Science Associates, Inc., 2014

Maximum Sediment Deposition			
Accumulation (in [mm])	Total Area (acres [cuerdas])	Area Outside Construction Right-of-Way (acres [cuerdas])	Maximum Distance from Pipeline (feet [m])
0.004 to 0.04 (0.1 to 1)	131.6 (135.4)	107.1 (110.2)	1,115.3 (339.9)
0.04 to 0.08 (1 to 2)	32.8 (33.8)	27.7 (28.5)	257.8 (78.6)
0.08 to 0.16 (2 to 4)	24.3 (25.0)	17.3 (17.8)	170.9 (52.1)
0.16 to 0.24 (4 to 6)	11.9 (12.3)	4.9 (5.1)	113.0 (34.4)
0.24 to 0.32 (6 to 8)	2.6 (2.7)	2.3 (2.4)	83.0 (25.3)
0.32 to 0.39 (8 to 10)	2.1 (2.2)	1.9 (2.0)	60.8 (18.5)
0.39 to 1.97 (10 to 50)	4.8 (5.0)	2.6 (2.7)	50.4 (15.4)
> 1.97 (>50)	0	0	0

Source: Applied Science Associates, Inc., 2014

Summary, Pipeline Construction: Overall, the construction of the pipeline will affect 25.3 ac of seafloor, including 20.2 ac due to offshore lay barge construction areas, and 2.6 ac of this will be permanently impacted by the pipeline footprint (FERC 2016) without including the acreage to be affected by sediment transport outside the calculated footprint of temporary and permanent construction impacts. Impacts include 13.1 ac of impacts to seagrass during pipeline installation (including the use of HDD) of which 0.01 ac will be permanently impacted; and 1.2 ac of macroalgae during pipeline installation of which 0.01 ac will be permanently impacted. There will be no impacts to coral reefs or colonized hard bottom during construction or operation of the portion of the pipeline in Jobos Bay, offshore, and in the HDD section according to estimates by FERC (Figure 6). The coral reef where HDD will be used to install the pipeline was estimated to contain 40,115 coral colonies, including ESA-listed corals, within the originally proposed 20-ft direct-lay pipeline corridor through the reef (FERC 2015), which was to be sited in the area with less coral colonization. Additionally, based on new modeling predictions from 2017 (Baird & Associates 2017) the applicant estimated that there may be 0.04 in of accumulation of drilling fluids in the exit pit and suspended sediment concentrations of approximately 1-3 mg/L transported up to 120 ft westward from the exit point. In-water construction and installation of the pipeline would take approximately 95 days to complete with pipeline installation taking approximately 45 days and pipeline burial another 50 days. HDD operation will take up to 60 days to complete with a target of 40 days. Pipeline burial will be done at the same time HDD operations are underway so the total time estimated for pipeline installation is approximately 3 months.

Pipeline Testing and Operation: Once the pipeline is constructed, it must be tested to ensure the integrity of the piping. Testing involves filling the pipeline with water, pressurizing it, and then checking for pressure losses due to leakage. In order to conduct the testing, seawater will be pumped into the pipeline through high volume pumps located on the offshore lay barge. The intake rate would be between 14,900 – 22,500 gallons per hour (gph). The water intake would be approximately 6 ft below the water surface and would be fitted with a 100 µm screen to reduce the intake of organisms. Overall, approximately 240,000 gallons of water would be required to fill the pipeline and complete 1 full test but more could be required if isolated connections or flanges need depressurizing and retightening, which would then require some water replenishment. All test water from the pipeline would be filtered through a 100 µm screen before discharging at the shoreline approach of the pipeline in Jobos Bay. The discharge would be directed through a pipe secured approximately 6 ft below the water surface to minimize surface disturbance. A diffuser head would be attached to the discharge pipe to reduce discharge velocity and minimize sediment resuspension at the point of discharge.

Thermodynamic calculations of heat transfer were provided by the applicant indicating that the cold temperatures along the pipeline would affect ambient water temperatures within 1 in of the pipeline despite the concrete coating. With the proposed burial of the pipeline and placement of concrete mats at pipe bends, as well as the use of HDD in one segment, this effect is expected to be even less than originally predicted by the applicant (FERC 2015).

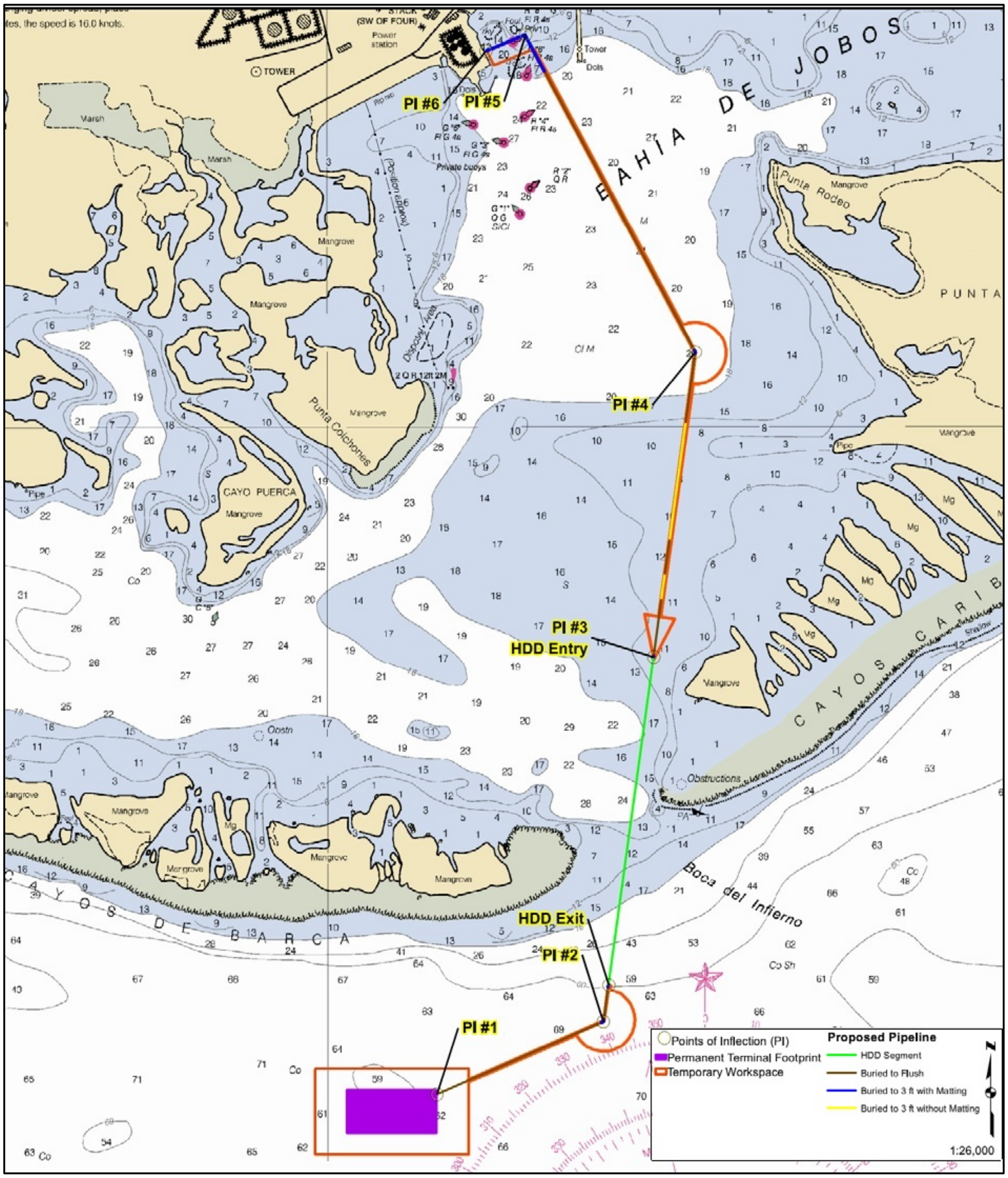

Figure 2. Location of pipeline segments installed using burial and HDD (from FERC 2016)

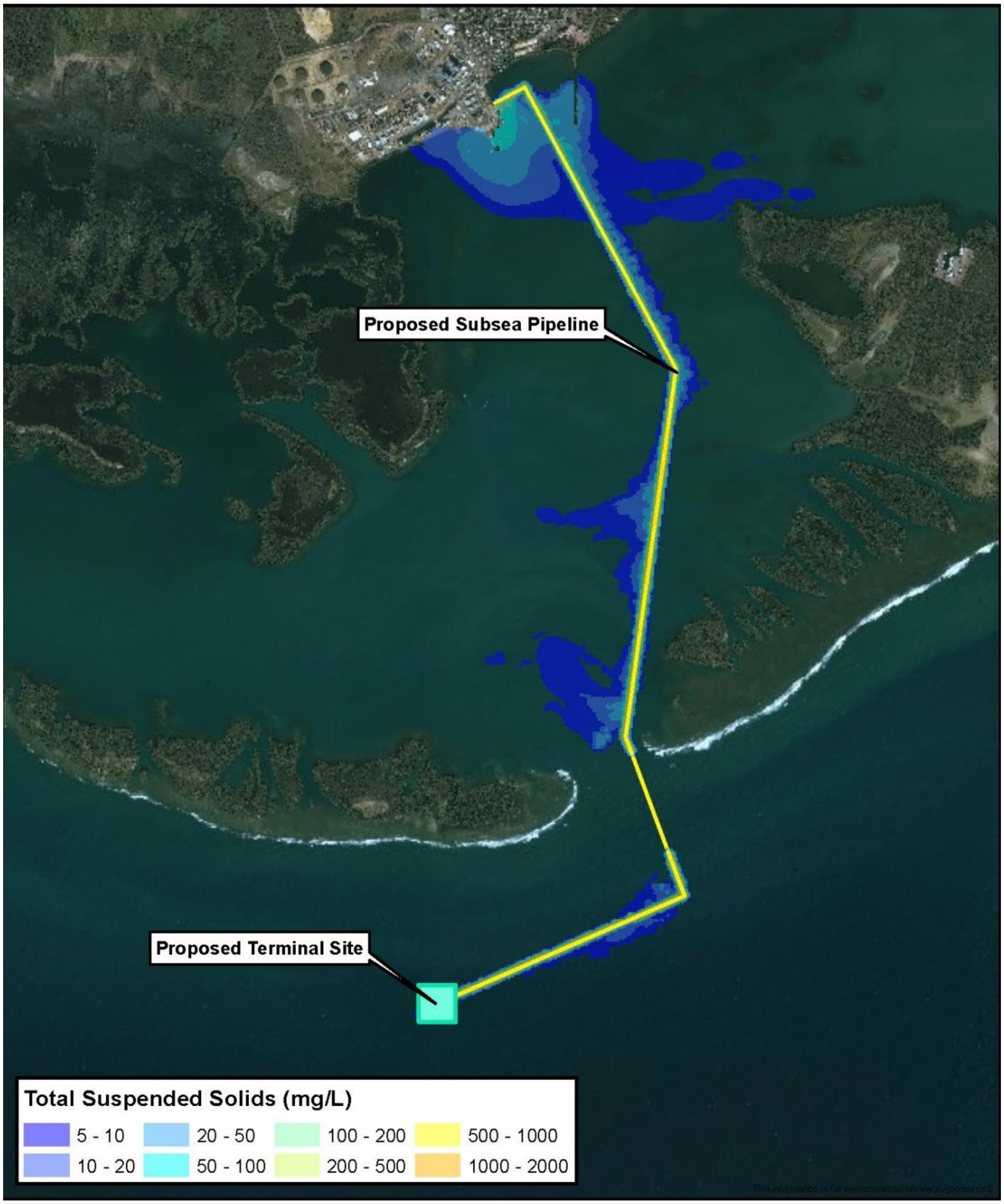

Figure 3. Predicted extent of suspended sediments in water column during pipeline installation and burial (FERC 2015)

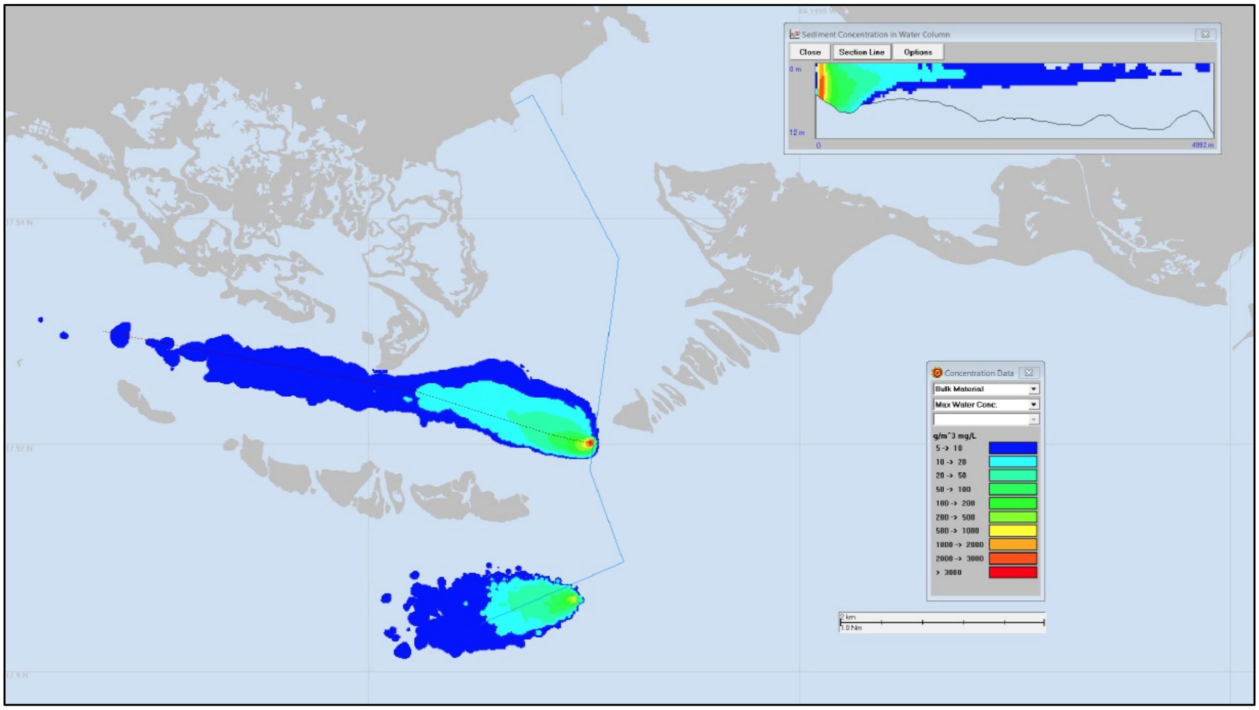

Figure 4. Predicted extent of suspended sediments in water column due to HDD exit and entry point dredging (Applied Science Associates 2015)

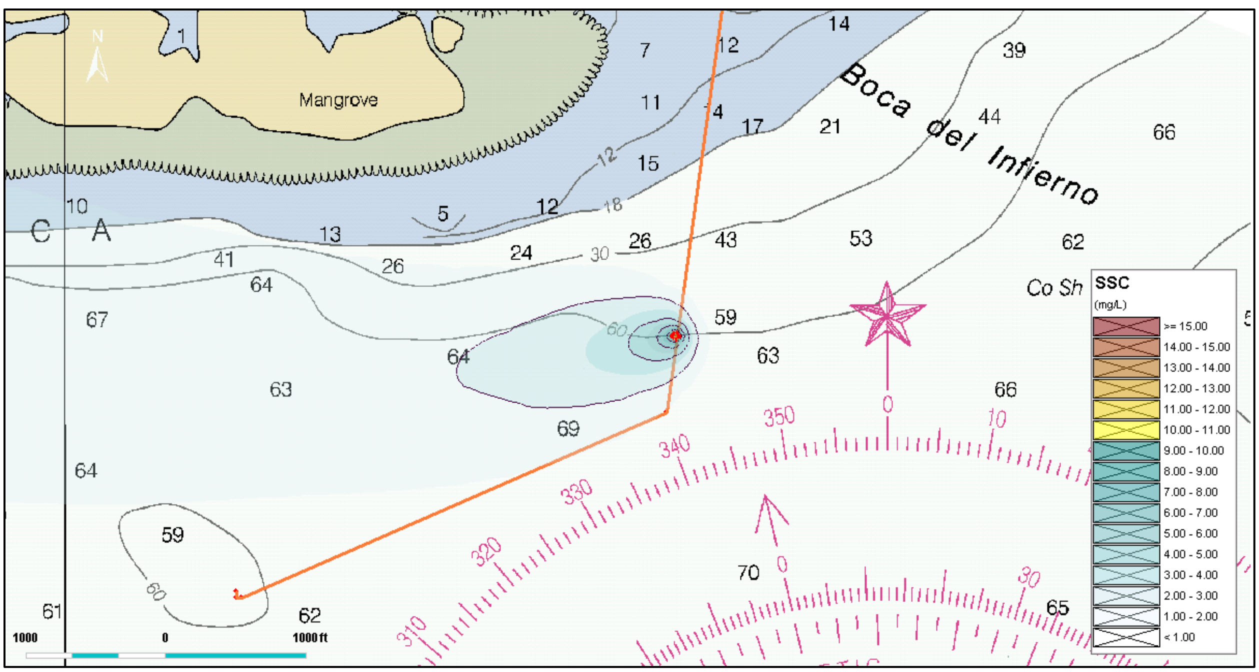

Figure 5. Predicted maximum suspended sediment concentrations for mean bulk density of drilling mud using a model prediction with a 3 hour rolling average, which yields the highest possible predictions (Baird 2017)

Offshore Gasport

The offshore gasport will be a berthing platform located approximately 3 miles (mi) off the coast of Salinas and Guayama, Puerto Rico, and 1 mile from Jobos Bay. The platform will provide berths for the FSRU that will be semi-permanently moored to the facility and for receipt of LNG carriers. The FSRU would be moored to the northern (landward) side of the platform and the LNG carriers would temporarily dock on the southern (seaward) side of the platform. The offshore berthing platform will be approximately 1,515 ft (464 m) in length and approximately 330 ft (101 m) wide (ranging from up to 640 ft [195 m] wide with both the FSRU and LNG carrier at berth). Eight structural jackets with 4 piles will be installed to support 4 mooring dolphins and 4 berthing dolphins. Three structural jackets with 6 piles will be installed to support 2 additional berthing dolphins and the utilities platform that will be the service vessel berth and contain areas to support the operation of the platform. Each structural jacket would be placed on mud mats on the seafloor prior to installation. The deck sections, module support frames and module packages would be installed once the structural jackets and piles are installed.

Pile-Driving: Piles will be 80-in diameter steel and will be installed using an impact hammer. There will be a total of 50 of these piles installed. These piles will fix the tubular steel structural jackets to the seafloor. The applicant estimates that 6,500 to 7,500 blows will be required to install each pile, resulting in 3.5 to 4.5 hours to install each pile (Table 1).

Sediment Monitoring: Turbidity levels for construction of the offshore terminal facilities were not modeled as they were for the installation of the pipeline but the FEIS (FERC 2015) stated that the Puerto Rico Water Quality Standards (PRWQS) for turbidity would be exceeded during construction of the facilities. The PRWQS for turbidity are 10 nephelometric turbidity units (NTU). Turbidity levels are expected to exceed PRWQS during installation of the piles and structural jackets only as the rest of the construction would take place at or above the water surface. Turbidity data from the Jobos Bay National Estuarine Research Reserve (JBNERR) cited in the project EIS indicate that the average turbidity level at a JBNERR monitoring station near the offshore cays was 3 NTU and was 4 NTU in 2014 at a monitoring station near the existing Aguirre outfall in the bay. The applicant noted turbidities in the mixing zone at the proposed offshore platform location measured from 0.3 – 1.45 NTU.

Summary, Offshore Platform Construction: Overall, the construction of the offshore gasport will affect 73.8 ac of seafloor and 21.5 ac of this will be permanently impacted by operation of the facility without including the acreage to be impacted by sediment transport. This includes 11.8 ac of impacts to seagrass during construction of which 2.7 ac will be permanently impacted, 58.1 ac of impacts to macroalgae of which 18.7 ac will be permanently impacted, and 3.9 ac of impacts to coral reefs during construction of which 0.2 ac will be permanently impacted according to estimates from FERC (Figure 6; (FERC 2015)). Approximately 4.1 ac of patch reefs colonized by corals, including ESA-listed corals, were identified in the area of the offshore gasport, but the survey area was limited to a box where temporary and permanent impacts are expected to occur and these reefs likely extend westward. Construction of the offshore terminal is expected to be completed in 9 months.

Offshore Platform Operation: During operation, generators on the platform will generate electric power to run the offshore facility. Nitrogen will be used and stored at the platform in a generator for purging the facility in preparation for maintenance or startup after a lengthy shutdown. All electrical equipment for the platform will be housed in a climate-controlled switch room.

Figure 6. Benthic habitat types in the offshore gasport and pipeline footprint (from (FERC 2016)

Vessels

Construction Vessels, Temporary Piles, Anchoring: The construction of the offshore gasport and pipeline will require the use of a crane barge and a shallow water lay barge which will be secured using spuds. The HDD drill rig barge at the entry point of HDD operations in Jobos Bay will be secured using a total of 8 24-in steel piles, 4 across the bow and 2 each on the starboard and port sides (Table 1). These piles will be installed using a vibratory hammer requiring approximately 4 hours to install each pile. These piles would remain until HDD operations are completed and then be removed in the same manner they were installed. A jack-up barge will be used to support HDD exit hole work and will be secured using the vessel legs. Vessel support tugs will be used to spot the lay barge and floating equipment and to float pipeline segments into place.

Crew/supply boats will be used to shuttle personnel and supplies from the landside pier to the lay barge and dive support vessels. The dive support vessel will be secured with anchors or will remain in place using dynamic positioning rather than anchoring. Pipe transport barges will be shuttled by tugs to transport pipe segments from the pipe yard and lay barge. Tugs used during pipeline installation and HDD operations to position work barges will transit through the existing barge channel in order to move between the offshore construction areas and Jobos Bay. No barges will be equipped with thrusters so all barge movement will require tugs. When tugs are not directly involved in maneuvering operations, they will moor directly to construction barges or a shore side location, such as the existing Aguirre power plant docks. When tugs are moored to barges, their propulsion system will not be in use.

Seawater Intake: One LNG carrier will visit the offshore platform approximately once per week so up to 52 LNG carrier vessels could visit the platform each year once the project is operational. The LNG carriers that will visit the platform will have a length up to 1,045 ft (319 m) and an average maximum design draft of 38 ft when fully laden. The LNG carriers will take on seawater to serve as ballast as the LNG is transferred off the vessels. Seawater for cooling the engines will also be required because the engines are powered up while at dock, meaning seawater would be needed for the approximately 88 hour period the vessels will be at the platform. It is estimated that up to 74.2 million gallons of water will be required for ballast while offloading an LNG carrier (with an intake rate up to 1.0 million gallons per hour [mgh]). Total cooling water intake could require up to 227.8 million gallons (with an intake rate up to 2.6 mgh) during LNG delivery. Therefore, up to 302 million gallons of water could be required during each LNG carrier delivery.

The FSRU will have an overall length of approximately 955 ft (291 m) and a design draft of 38 ft (11 m). The FSRU will have approximately double the discharging regasification rate required by the Aguirre plant. LNG regasification will be done using a closed-loop vaporization system, which does not require the intake and discharge of seawater. Water used to support FSRU operations would be drawn through 4 sea chests on the sides of the vessel. East sea chest would draw water through a series of grids. For the sea chests located starboard and port high, the sea chests will be approximately 22.8 ft below the ocean surface. For the sea chests located starboard and port low, the sea chests will be approximately 37.4 ft below the ocean surface. Each sea chest grid would have metal gratings with 0.87-in diameter slots between grating bars. Under normal water use, the through-screen velocity would be approximately 0.45 ft/second (fps), which is just below the upper velocity threshold of 0.5 fps recommended by the EPA to minimize impingement of aquatic organisms.

Seawater use is required during routine operations of the FSRU. Routine water use would total approximately 56 mgd to support machinery cooling through operation of the main condenser and auxiliary seawater cooling systems (with an intake rate of 47 mgd for the main condenser cooling system and 6 mgd for the auxiliary seawater cooling system), 0.6 mgd to generate the vessel’s water safety curtain during transfer from LNG carriers and regasification, 1.9 mgd for ballast water, and 0.3 mgd for the freshwater generator. Non-routine uses for seawater include maintenance of the water deluge and fire main systems that would run off dedicated pumps with a flow capacity of 232,000 – 238,000 gph, which are not included in the estimate of daily consumption as this intake will occur on an as-needed basis only. Based on anticipated intake of seawater by the FSRU and the LNG carriers, the applicant estimated that 82 million coral larvae (of which it is not possible to distinguish the percentage of ESA-listed coral species) will be entrained annually over a 3-month period from August – October based on the ESA-listed coral species that broadcast spawn in one of these months and coral larvae sampling conducted for the project. Sampling conducted in August 2013 found coral larvae densities of 8.5 larvae per 26,400 gallons during the day and 531 larvae per 26,400 gallons during the night. Sampling conducted in August, September and October 2015 showed a peak of 6,532 larvae per 26,400 gallons at night in September with peak densities lasting 7 – 11 days following the full moon. The applicant did not estimate potential entrainment or impingement of other organisms.

<u>Treated Water Outfalls:</u> All of the water used for the purposes described above would be discharged back into the ocean through various outfalls along the FSRU deck and hull with the exception of 0.03 mgd of water from the freshwater generator, which would be consumed. Intake water from the cooling system will discharge through a 55-in diameter pipe on the side of the vessel, 17.4 – 24.3 ft below the ocean surface (outfall 001). Water discharged from the FSRU would be approximately 21.6°F (12°C) above ambient water temperatures with a maximum discharge temperature of 106.9°F (41.6°C). The applicant estimates that a 135-ft-radius mixing zone from the outlet port will be needed for waters discharged from the FSRU to cool to the temperature of surrounding seawater. The thermal plume is expected to remain within the mixing zone and not reach the marine bottom based on modeling results in the FEIS (FERC 2015). Water discharge from the LNG carrier while at the offshore platform would also be dominated by condenser water from the cooling system. The water would be approximately 5.4°F (2.8°C) higher than surrounding seawater and the plume would be confined to within approximately 17 ft of the vessel. However, for the LNG carrier, due to the elevated flow rate, it is predicted that the thermal plume would impact the seafloor, which would also affect sediment resuspension and transport during all LNG carrier water discharge operations.

The auxiliary cooling system will also have an outfall (outfall 002). Water discharged from this outfall is expected to be 11°F (6.5°C) above ambient water temperature, leading to a maximum discharge temperature of 96.3°F (35.7°C). The mixing zone for this discharge was modeled as having a 95-ft radius based on the information in the mixing zone application for the project (Tetra Tech 2014c). The thermal plume from outfall 002 is expected to remain within the mixing zone and not reach the seafloor.

Outfall 003 will be for the water curtain that will be maintained over the deck and hull of the FSRU during LNG transfer or regasification to protect the hull from potential cracking or stress in the case of an LNG leak. The 0.6 mgd of water used for the protective curtain will simply run off both sides of the vessel.

Outfall 004 would discharge 0.27 mgd as brine from the freshwater generator. The salinity of the brine effluent is expected to be 64 – 70 ppt. The applicant noted that the brine plume is expected to mix with surrounding seawater but no estimates of the size of the mixing zone were provided.

Outfall 005 would be for the discharge of ballast water, which could reach up to 1.0 mgd during LNG loading and regasification. Ballast water for the FSRU will be withdrawn and discharged at the offshore platform so the introduction of invasive species as part of ballast water release is not anticipated, although the FSRU will leave the gasport during maintenance operations approximately every 5 years and will initially come from a different location as the vessel is already owned by the applicant. The LNG carrier is not expected to release ballast water, only take water in as LNG is unloaded so the introduction of invasive species is not anticipated as a result of the temporary operation of these vessels at the offshore gasport.

Outfall 006 would be for stormwater that collects and runs off the decks and other surfaces of the FSRU and could contain contaminants such as grease and lubricants. The stormwater management program for the vessel includes the deployment of equipment drip mats and oil absorbent material around collection drains but some level of runoff of materials from the decks during storms into the Caribbean Sea is anticipated.

The FSRU's raw water intake systems will have a copper-aluminum anode marine growth prevention system. This system will result in the regular release of approximately 2 parts per billion (ppb) of copper ions from the primary cooling water discharge outfall (outfall 001); and an unspecified concentration from the auxiliary cooling water outfall (outfall 002), the water curtain outfalls (outfall 003 A and B, port and starboard, respectively), and ballast water outfall (outfall 005). A release of copper ions from the LNG carrier vessel, similar to that from the FSRU primary cooling water discharge outfall, is anticipated (FERC 2015). A water quality characterization sampling at the proposed offshore gasport site found copper concentrations in the water column ranging from <2.0 – 7 micrograms per liter (µg/L) (Tetra Tech 2014c).

<u>Other Offshore Platform Operation Requirements:</u> The FSRU will require dry-dock maintenance approximately every 5 years during which time PREPA may require that a similar FSRU be used to meet contractual send-out rates to the Aguirre power plant.

During project operation, a port service vessel would transport personnel to and from the offshore gasport and assist with routine operations and delivery of supplies. Vessels would range in length from 110 – 125 ft and be able to transport approximately 30 tons of cargo and 30 – 40 people. Smaller vessels ranging from 25 – 30 ft in length may also be used to transport personnel. During routine operations, these vessels will transit to and from the gasport daily.

Operation of the FSRU will lead to the generation of wastes from the galley, bunks, and sanitary system. It is anticipated that 0.03 mgd of wastewater will be generated from the restroom, hoteling, and galley services. Wastewater will be treated daily on the FSRU and then pumped from the on-board septic system to a service vessel and taken onshore for disposal. Similarly, bilge water from the FSRU sump pumps and water from bottom blowdown of the ship's boilers will be pumped off the FSRU for onshore disposal. As part of this process, residual oil and grease would be concentrated and containerized.

Project Timeline

The total project construction timeline is expected to be 12 months with construction operations overlapping such that the push-pull and burial operations for pipeline installation (including 15 – 20 days for each pipeline segment) and HDD operations for pipeline installation would take up to 5 months with burial operations continuing when HDD operations are underway and the offshore platform and all in-water and above-water components expected to take 9 months to complete. Construction of terrestrial facilities is expected to take 14 days to complete. The proposed ownership agreement between Excelerate and PREPA will be for 15 years at this time, but the facility will be leased to the financing entity for 35 years or longer based on the application for the project filed with FERC.

Construction Conditions
The applicant has developed the following avoidance and minimization measures to protect ESA resources (i.e., ESA-listed species and their habitats):

1. Confined bubble curtains will be used during all pile-driving activities at the offshore gasport. The bubble curtains will consist of a perforated pipe or hose placed around the pile-driving activity. An air compressor on the derrick barge would then pump air into the hose or pipe to force bubbles out of the perforations creating a curtain around the pile-driving activity.

2. A 0.3 mile (mi [500 m]) zone would be established around pile-driving activities to minimize the potential for noise impacts to marine species. If animals are observed within this zone, pile-driving activities would cease until the animals leave the area.

3. No pile driving activities will occur at the offshore gasport site during some of the peak nesting months for hawksbill (September to November) and leatherback (April to May) sea turtles.

4. Ramp-up or soft start procedures will be used prior to all pile-driving activities to alert sea turtles and marine mammals and allow animals time to leave the area.

5. Acoustic monitoring will be conducted during pile driving activities to be sure the calculated acoustic impact zone for sea turtles is not larger than estimated and that the bubble curtain is effective. The plan for this monitoring will be developed and approved of by NMFS prior to commencement of any in-water construction.

6. To minimize the potential for vessel strikes affecting marine mammals and sea turtles, all vessels associated with project construction would operate at no wake/idle speed (5 miles per hour [mph] or 4.3 knots) at all times within Jobos Bay and nearshore areas and vessels will follow deep water routes whenever possible.

7. All construction vessels will have an observer on board during all phases of construction to look for marine mammals and sea turtles. Observers will be equipped with night vision scopes during night-time operations where practical. Prior to construction, the applicant will develop a detailed training and response protocol plan for the construction and operation phases of the project. The plan will incorporate NMFS's *Vessel Strike Avoidance and Reporting for Mariners* (revised February 7, 2008, Appendix B) and NMFS's *Sea Turtle and Smalltooth Sawfish Construction Conditions* (dated March 23, 2006, Appendix C).

8. During pile driving activities at the offshore gasport site, sea turtle monitoring will be expanded to include the entire estimated acoustic impact zone and monitoring will take place continuously including at night and for 2 weeks after pile driving activities are completed to look for dead and injured animals. Injured animals will be rehabilitated following guidelines such as those of the Wider Caribbean Sea Turtle Conservation Network (WIDECAST).

9. All construction personnel (including vessel operators, deck hands, construction staff, divers, and others) would receive protected species training that would include the identification of common marine mammals and sea turtles in Jobos Bay, a review of the effects of construction activities on these species, laws protecting the species, and potential fines associated with harassment of these species. Verified attendance by vessel operators would be provided to regulatory agencies.

10. HDD Specifications to minimize the potential for accidental releases of drilling fluid and ensure maximum recovery of fluid have been developed by the applicant (Appendix A) and will be included in contract documents once a contractor is selected to perform the work.

11. A Turbidity Monitoring Plan has been developed and will be implemented during installation and burial operations for pipeline segments that will not be installed using HDD.

12. The turbidity monitoring buoys to be deployed and moved during construction in Jobos Bay and offshore will not be placed in areas containing hard bottom. All buoys and anchors will be retrieved upon completion of construction activities.

13. A silt fence will be installed around all terrestrial work areas to minimize the potential for runoff of sediment during upland construction activities at the existing Aguirre power plant facilities. Turbidity curtains will be installed in the area of the pipeline shoreline approach during construction activities to minimize sediment resuspension and transport in the bay associated with this in-water construction.

14. A Benthic Resources Mitigation Plan has been developed to offset some impacts from project construction to seagrass and corals. The plan includes the transplant of seagrass from some pipeline segments in Jobos Bay and corals from the offshore gasport footprint. Corals larger than 1.57 in (4 centimeters [cm]) would be transplanted from the proposed offshore gasport location to a site nearby with similar environmental and physical characteristics (Excelerate Energy 2016a). Prior to construction, the applicant proposes to survey the pipeline corridor and offshore gasport site to document seagrass and coral community conditions. Transplant activities would be completed prior to any construction activities commencing. Post-construction surveys would also be conducted to determine whether additional incidental or unanticipated impacts to seagrass and corals occurred during construction. Transplant locations will be surveyed for 5 years following completion of project construction to determine whether transplant of seagrass and corals was successful.

15. A site-specific spill prevention and control plan will be developed and implemented to minimize the potential for inadvertent releases of hydrocarbons and to establish protocols for the containment, remediation, and reporting of accidental releases.

16. A document reviewing potential mitigation measures to reduce the impacts of project lighting on sensitive species has been prepared. The applicant will implement the mitigation measures where feasible and practicable according to the BA.

17. A Stormwater Pollution Prevention Plan will be developed for the project to avoid or minimize water quality impacts associated with construction and operation.

18. Once the gasport is operational, pilots will board the LNG carriers from the proposed Pilot Boarding Station (PBS) located 2 mi southwest of the gasport. The LNG carriers will transit at speeds between 8 – 10 knots from the shelf edge to the PBS. Once the pilot is aboard the LNG carrier, the vessel will transit at less than 4 knots from the PBS to the gasport.

19. No dynamic positioning vessels will be allowed in Jobos Bay to minimize potential impacts to benthic habitat from the use of thrusters in repositioning vessels. No floating equipment in the bay will use thrusters.

20. All floating equipment will be set up for zero discharge, equipment will be in good operational condition for the duration of the project, charts and limits will be posted on each piece of lifting equipment to ensure safe operation, biodegradable lubricants will be used when possible, and all equipment will be operated by certified operators.

21. All anchor, spud and temporary pile locations will be surveyed prior to construction by divers to ensure the absence of ESA-listed species and coral habitat. In the event that ESA-listed corals are present, the location of the anchor point will be adjusted. In the event the location cannot be changed, corals will be relocated, but it is anticipated that anchor locations without corals and coral habitat will be available.

22. All anchor lines will have midline buoys to prevent contact of anchor lines with the sea bottom. During anchor moving operations, the anchor handling tug will pick the anchors up from the bottom and tension will be maintained on anchor lines to ensure they do not drag on the bottom as the anchor is relocated.

23. All anchors and temporary mooring piles will be removed from the project site after construction work is complete with the possible exception of the 2 Stevpris anchors that will secure the barge pulling the HDD pipe. These anchors are designed to bury deeper as tension is increased on the anchor line so their retrieval may not be possible.

FERC has listed the following avoidance and minimization measures as part of the license (FERC Docket No. CP-13-193-000, Order Granting Authorization Under Section 3 of the Natural Gas Act, Issued July 24, 2015) requirements for the Aguirre project:

1. An HDD construction plan shall be filed for review and approval by FERC prior to any construction activities. The plan should identify how the applicant will ensure that impacts on benthic habitat and corals will be minimized based on the substrate that will be crossed, including but not limited to mitigation measures such as the use of casings to minimize the likelihood of an inadvertent release, turbidity curtains to minimize sediment transport, and barges to collect drilling mud (Appendix to Order, Environmental Conditions, #13a).

2. An HDD contingency plan shall be filed for review and approval detailing how the applicant will handle any inadvertent release of drilling mud into the waterbody or areas adjacent to the waterbody, including procedures to contain any inadvertent releases; seal the abandoned drill hole; and clean up any inadvertent releases (Appendix, Environmental Conditions, #13b).

3. Prior to construction, the applicant shall file a site-specific spill prevention and control plan for the construction and operation phases of the onshore and offshore portions of the project. As part of the plan, the applicant shall include response measures that will be implemented if wildlife, including federally listed species or migratory birds are impacted by an inadvertent hydrocarbon spill (Appendix, Environmental Conditions, #19).

4. The use of a pipeline lateral guidance system (or similar technology) shall be verified by the applicant. The system will effectively maintain the pipeline segments afloat and avoid contact with the seafloor outside the construction work area until the pipeline is ready for burial (Appendix, Environmental Conditions, #20).

5. The applicant shall consult with NMFS, USFWS, the Puerto Rico Department of Natural and Environmental Resources (PRDNER), and other appropriate agencies to finalize the Benthic Resources Mitigation Plan to address the currently proposed construction and operation impacts and include the actual pipeline design/route to be constructed. The plan shall address the seagrass that would be permanently impacted by shading due to the offshore berthing platform; a 5-year post-construction monitoring of the areas where the pipeline and/or concrete mats are above grade to determine if the mats are preventing the migration of conch, urchins, sea cucumbers, and other less mobile benthic organisms and identify measures, other than additional monitoring, that would be implemented if the mitigation sites are not trending toward successful restoration. In addition, the plan shall comply with the USACE's Compensatory Mitigation Rule under the Clean Water Act Section 404 Regulatory Program (Appendix, Environmental Conditions, #21).

6. The applicant shall consult with NMFS regarding the type of screen (e.g., wedge-wire) that will be used for hydrostatic test water withdrawals during construction of the project (Appendix, Environmental Conditions, #22).

7. The protocol that will be used to determine the effectiveness of the turbidity curtains during construction (including the use of HDD) shall be filed with FERC. The protocol shall outline the monitoring that will be conducted, thresholds that will be established to

define effectiveness, and measures to be implemented if turbidity curtains prove ineffective (Appendix, Environmental Conditions, #23).

8. The applicant shall file with FERC a description of the measures that will be used, in addition to lowering the mat edges, to secure all the concrete mats to the seafloor (Appendix, Environmental Conditions, #24).

9. Prior to construction, the applicant shall coordinate with USFWS, NMFS, and PRDNER to develop a detailed marine mammal observer training and response protocol plan for the construction and operation phases of the project. The plan shall provide appropriate measures to avoid and minimize potential vessel strikes of manatees and sea turtles and incorporate the USFWS's manatee conservation measures for in-water work, where applicable. In addition, the applicant shall restrict the transit of crew boats during construction and operation to daytime trips to allow for the observation of marine mammals and decrease the potential for vessel strikes. The plan shall also require that travel speeds for project-related construction vessels be reduced to no-wake (5 mph or 4.3 knots) levels, especially in waters shallower than 10 ft. In additional to the marine mammal observer plan, the applicant shall use aerial surveys to identify and assess impacts on the behavior of marine mammals and sea turtles proximate to the construction work areas (Appendix, Environmental Conditions, #25).

10. Prior to construction, the applicant shall verify that confined bubble curtains will be used when conducting vibratory and impact hammer pile driving activities in order to reduce impacts on marine wildlife species during construction of the project. The applicant shall develop a detailed noise mitigation protocol for the safety exclusion zone (0.3 mi or 500 m) that identifies when the noise mitigation protocol would be implemented during construction (including the use of HDD for the Boca del Infierno pass) and explains how each marine mammal observer would identify the limits of the exclusion zone (Appendix, Environmental Conditions, #26).

11. The applicant shall develop a lighting plan that identifies specific measures that would be implemented to minimize or avoid impacts associated with the project's operational nighttime lighting on avian species, fish species, marine mammals, various life stages of sea turtles, and individuals on the shoreline. The plan shall also analyze if the project could artificially induce biological aggregations, and provide empirical evidence of how these potential aggregations could affect local fisheries and ecotourism (Appendix, Environmental Conditions, #28).

12. The applicant shall consult with NMFS, USFWS, PRDNER, and other appropriate agencies to develop mitigation measures for entrainment impacts of ichthyoplankton and coral larvae associated with project operations and required water use. These measures shall include a 3-year study to analyze water intake impacts associated with project operation. In addition, the applicant shall conduct an analysis of potential impingement impacts on Nassau grouper that are larger than larval size that may congregate near the seawater intakes at the offshore berthing platform. The results of the grouper impingement analysis, ichthyoplankton and coral larvae baseline survey results and

monitoring plan, and mitigation measures for entrainment impacts shall be available prior to commencement of project operations (Appendix, Environmental Conditions, #29). If future monitoring indicates Nassau grouper impingement or entrainment, reinitiation of consultation will be required.

3.2 Action Area

The action area is defined by regulation as "all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action" (50 CFR 402.02). The new pipeline and offshore platform are located in and outside of Jobos Bay (Figure 1), Salinas, Puerto Rico.

For purposes of this consultation, NMFS will consider the action area for the proposed Aguirre Offshore GasPort and associated subsea pipeline (Table 3) to be the area of Jobos Bay and the Boca del Infierno reef break through which the pipeline will pass and the offshore area where the platform for docking of the FSRU and LNG carrier vessels will be constructed (see Figure 1). The entire Jobos Bay and the offshore cays fringing the outside of the bay are included in this action area because sediments and other pollutants from the construction and operation of this new facility and subsea pipeline may be transported to other portions of the bay and reef system during project construction and operation. The action area also encompasses the transit routes for LNG carrier vessels and the FSRU if it needs to leave the offshore gasport due to storm conditions to and from the platform.

The action area includes JBNERR, managed by the PRDNER, which includes terrestrial and marine resources such as mangrove forests, salt flats, seagrass beds, macroalgal beds, beaches, coral reefs, and colonized hard bottom in and around Jobos Bay, including some of the offshore cays fringing the bay. Cayos Caribe are made up of 15 cays all of which are in JBNERR. Cayos de Barca are made up of 12 cays, 4 of which are in JBNERR with the rest being privately owned. Jobos Bay is the second-largest estuary in Puerto Rico. The action area also includes the Aguirre State Forest, which also includes mangrove forests and salt flats, as well as dry forest. Offshore areas associated with the fringing reefs, some of which are emergent reefs that have formed cays with mangroves and other vegetation, as well as beaches and lagoons, contain coral reefs, colonized hard bottom, seagrass beds, and macroalgal flats. Deeper areas contain seagrass (in shallower areas to about 65 ft depth), macroalgae, coral reefs, and colonized hard bottom out to the shelf edge.

Table 3. Project Location

Address	**Latitude/Longitude (North American Datum 1983)**	**Water body**
PREPA Aguirre Power Complex, Road 3 kilometer 152.3, Aguire Ward, Salinas, Puerto Rico	Entry Point to Aguirre Plant (Pipe Bend #6): 17.9494688ºN, -66.2261465ºW Pipe Bend #5 (adjacent to plant): 17.9501526ºN, -66.2244078ºW Pipe Bend #4: 17.9365262ºN, -66.2167655ºW	Caribbean Sea

	Pipe Bend #3 (HDD entry point): 17.9234309ºN, -66.2186573ºW HDD Exit Point: 17.9092444ºN, -66.2207028ºW Pipe Bend #2: 17.9077418ºN, -66.2209202ºW Pipe Bend #1 (Offshore Platform): 17.9046271ºN, -66.2284288ºW	

4 STATUS OF LISTED SPECIES AND CRITICAL HABITAT

Listed species occurring within the action area that may be affected by the proposed action are listed in Table 3 with their respective scientific name and status. Designated critical habitat in the action area that may be affected by the proposed action is listed in Table 4.

Table 4. Effects Determinations for Species the Action Agency or NMFS Believes May Be Affected by the Proposed Action

Species	ESA Listing Status	Action Agency Effect Determination	NMFS Effect Determination
Sea Turtles			
South Atlantic Ocean distinct population segment[1] [DPS] of green, *Chelonia mydas*	T	LAA	LAA
North Atlantic Ocean DPS of green, *Chelonia mydas*	T	LAA	LAA
Leatherback, *Dermochelys coriacea*	E	NLAA	LAA
Northwest Atlantic Ocean [NWA] DPS of loggerhead, *Caretta caretta*	T	NLAA	LAA
Hawksbill, *Eretmochelys imbricata*	E	LAA	LAA
Fish			
Nassau grouper, *Epinephelus striatus*	T	NLAA	NLAA
Scalloped hammerhead shark, Central and Southwest Atlantic DPS, *Sphyrna lewini*	T	NLAA	NLAA
Giant manta ray, *Manta birostris*	T	ND	NLAA
Invertebrates			
Elkhorn coral (*Acropora palmata)*	T	LAA	LAA
Staghorn coral (*Acropora cervicornis)*	T	LAA	LAA
Boulder star coral (*Orbicella franksi)*	T	LAA	LAA

[1] Green sea turtles nesting in Puerto Rico are now within the North Atlantic DPS and green sea turtles nesting in the Virgin Islands are now within the South Atlantic DPS based on the final listing rule designating 11 DPSs published on April 6, 2016. However, because of the mobility of sea turtles, we consider both DPSs in this Opinion as it is not possible to separate animals observed in the action area into one or the other of the DPSs given the small geographic separation between Puerto Rico and the Virgin Islands.

Species	ESA Listing Status	Action Agency Effect Determination	NMFS Effect Determination
Mountainous star coral (*Orbicella faveolata)*	T	LAA	LAA
Lobed star coral (*Orbicella annularis)*	T	LAA	LAA
Rough cactus coral (*Mycetophyllia ferox)*	T	LAA	LAA
Pillar coral (*Dendrogyra cylindrus)*	T	LAA	LAA
Marine Mammals			
Blue whale (*Balaenoptera musculus*)	E	NLAA	NLAA
Fin whale (*Balaenoptera physalus*)	E	NLAA	NLAA
Sei whale (*Balaenoptera borealis*)	E	NLAA	NLAA
Sperm whale (*Physeter microcephalus*)	E	NLAA	NLAA
E = endangered; T = threatened; NLAA = may affect, not likely to adversely affect; NE = no effect; NP = not present			

NMFS published a final rule on September 8, 2016 (81 FR 62260) identifying 14 DPS's of humpback whales. The West Indies DPS, which includes Puerto Rico, was found not to merit listing under the ESA. Therefore, no effects determination is needed for humpback whales.

Table 5. Critical Habitat in the Action Area

Species	Critical Habitat Unit	Action Agency Effect Determination	NMFS Effect Determination
Elkhorn and staghorn coral	Puerto Rico Unit	LAA	LAA
LAA = likely to adversely affect			

4.1 Species Not Likely to be Adversely Affected

<u>*Nassau Grouper*</u>
A low percentage (0.02%) of larvae from the family that includes groupers was observed in the ichthyoplankton survey conducted in the fall of 2013 (Tetra Tech 2014b) but no larvae from this family were observed in 2014 surveys. Similarly, no Nassau grouper were observed during benthic surveys completed for the project, although these surveys did not include methods specific to fish sampling. A 2007 survey of fishers (Ojeda-Serrano et al. 2007) indicates that the overall project area contains a large concentration of historic spawning aggregation sites (SPAGs), including some where the offshore gasport is proposed. Recent studies of snapper and grouper SPAGs in the U.S. Virgin Islands indicate that multiple species from the same family often spawn around the same time and use the same SPAGs. The benthic habitats in Jobos Bay and offshore of the bay include macroalgae, seagrass and coral habitats, all of which may be used by different life stages of Nassau grouper, although no Nassau grouper of any life stage were observed during surveys conducted for the proposed project and fish surveys conducted by

NOAA scientists for research projects (Whitall et al. 2011) in Jobos Bay. Therefore, the action area around the footprint of the offshore platform and pipeline could provide nursery, refuge and foraging habitat for different life stages of this species and it is likely that this species historically occupied near and offshore habitats in the action area but may not currently be present due to the dramatic declines in its population associated with overexploitation.

Pile-Driving: Effects to Nassau grouper as a result of noise created by construction activities can physically injure the animals or change animal behavior in the affected areas. Physical injurious effects can occur in 2 ways. First, effects can result from a single noise event's exceeding the threshold for direct physical injury to animals, and these constitute an immediate adverse effect on these animals. Second, effects can result from prolonged exposure to noise levels that exceed the daily cumulative exposure threshold for the animals, and these can constitute adverse effects if animals are exposed to the noise levels for sufficient periods. Behavioral effects can be adverse if they interfere with animals migrating, feeding, resting, or reproducing, for example.

There are currently no established thresholds for injurious or behavioral effects to fish from the use of a vibratory hammer to drive piles. However, we believe it is extremely unlikely that the installation of temporary piles by vibratory hammer will result in injurious or behavioral noise effects to this species. Nassau grouper are rare in the action area based on the surveys conducted in the action area for this project and NOAA research projects, as well as based on overall population size estimates in the status review conducted as part of the recent ESA listing (NMFS 2012). In addition, there will be a limited number of piles installed (10 in total, 2 to assist in pipe laying and 8 for mooring HDD barge). Nassau grouper that are present are likely to move away from disturbance, particularly disturbance that will result in sediment plumes as these would interfere with visual cues used by the fish to look for prey and flee from predators. Pile driving for these temporary piles to support pipeline installation will take a total of 6 days that may not be concurrent depending on the installation of piles at the 2 pipe bend locations in the bay versus at the HDD exit and entry points. There is only mud bottom in the 2 locations where temporary piles will be installed using a vibratory hammer to assist pipe-laying activities in Jobos Bay, which means there is no habitat for Nassau grouper in these locations. The other locations where temporary piles will be installed to moor the HDD barge in Jobos Bay do support seagrass beds that could be used as forage habitat by younger life stages of Nassau grouper. Because there are extensive areas of seagrass beds, coral reefs, colonized hard bottom, and other benthic habitats used by various life stages of Nassau grouper in the action area and again given the apparent rarity of the species in the action area, as well as the limited number of piles to be installed that will take up to 6 days, we believe the effects from vibratory pile driving to this species will be insignificant.

Our noise calculations for the installation of 80-in steel pipe piles with an impact hammer assumed a peak threshold level of 220 decibels (dB), a single strike level (SEL) of 195 dB, and a cumulative SEL of 187 and 183 dB for fish less than and greater than 2 grams, respectively, to calculate injurious effects and a level of 150 dB to calculate behavioral effects to various life stages of Nassau grouper based on the most recent information on hydroacoustics of pile driving and fish (CALTRANS 2015). The installation of 80-in steel pipe piles will exceed the SEL threshold for injury to fish within 164 ft (50 m) of the pile-driving activities. We assumed that up to 2 piles will be driven per day based on the applicant's estimate that each pile will take 3.5 –

4.5 hours to install, piles will be installed one at a time, and up to 7,500 strikes will be required per pile. The peak pressure threshold for injurious noise effects would be exceeded up to 281 ft (86 m) from the source for fish. The cumulative sound exposure level of multiple pile strikes over the course of a day would cause injury to Nassau grouper up to 32,808 ft (10,000 m) from the pile, regardless of the size of the fish. Because the applicant will use confined bubble curtains for pile-driving activities associated with the installation of the 80-in steel piles at the offshore platform, we expect these injurious noise effects to be reduced. If the contractor is experienced in deploying and maintaining bubble curtains around piles of the size that will be used to construct the offshore platform, then we expect bubble curtains could reduce sound impacts by 10 dB on average for steel piles. If the contractor is not experienced with the use of bubble curtains or deploying them for the size of the pile proposed here to ensure they are sealed and function as intended, we expect bubble curtains could reduce sound impacts by 5 dB on average for the 80-in diameter steel piles. We base these sound reductions on CALTRANS (2015) and observations made by NMFS' biologists during pile driving activities with and without sound reduction measures. This means that peak pressure injury would be exceeded within 131 ft (40 m) and the injurious cumulative sound exposure radius would be reduced to 15,228 ft (4,641.6 m) away from the pile for all sizes of fish assuming a reduction of 5 dB due to the use of bubble curtains. If we assume a reduction of 10 dB, then peak pressure injury would be exceeded 61 ft (18.5 m) from the pile and cumulative sound exposure would be reduced to 7,068 ft (2,154 m) from the pile. Also, as noted previously, we do not have information to suggest that various life stages of Nassau grouper are common in the action area, given the depleted status of their populations and the lack of observations of this species during recent scientific work conducted in the action area. The area where the offshore platform is proposed is located in deeper waters seaward of the fringing reefs that form Jobos Bay. If Nassau grouper were present within the SEL or peak pressure thresholds, it would be adults and, because these fish are largely solitary except during spawning aggregations and tend to establish a home range, they would have been observed during surveys conducted in the action area. We assume that Nassau grouper do not currently occupy the area where pile-driving and other in-water construction activities will take place. Nassau grouper are unlikely to enter the offshore area where pile-driving and other in-water construction activities will be occurring simultaneously due to turbidity from pile-driving, vessel movement, and pipeline installation that would interfere with the ability of the animals to find prey and flee predators. If an individual does enter the in-water construction area, there are no impediments to affect its movement back out of the area and into portions of the action area where refuge and foraging habitat are present and where construction activities will not be on-going. Because we anticipate Nassau grouper will not be present in the area of in-water activity associated with pile driving due to the lack of evidence indicating that this species is common in the action area, we believe that an animal suffering physical injury from noise exposure is extremely unlikely to occur and is therefore discountable. An animal's movement away from the injurious sound radius is a behavioral response, with the effects discussed below.

The installation of steel pipe piles using an impact hammer could also result in behavioral effects at radii of 152,283 ft (46,416 m) for Nassau grouper. With the use of confined bubble curtains, assuming a 5 dB reduction in noise impacts, this effect is reduced to radii of 70,683.5 ft (21,544 m). A 10 dB reduction in noise impacts due to the use of confined bubble curtains would reduce behavioral effects to radii of 32,808 ft (10,000 m). Due to the mobility of Nassau grouper, we expect them to move away from in-water construction noise in the open water environment where the offshore platform will be located because they are likely to be startled by in-water activity and impacts such as sediment resuspension associated with pile driving. There are other areas of colonized hard bottom, coral reefs, seagrass beds, and macroalgae in the action area and because of the lack of evidence indicating Nassau grouper are common in the action area. If an individual chooses to remain within the behavioral response zone, it could be exposed to behavioral noise impacts during pile installation. Since installation will only occur during the day, Nassau grouper would be able to resume normal activities during quiet periods between pile installation and at night. In addition, because only 50 piles will be installed, any noise effects associated with pile-driving activities will be short-term, lasting approximately 25 days if 2 piles per day are installed. Therefore, we anticipate any behavioral effects to Nassau grouper will be discountable.

Seawater Intake: The Aguirre power plant has an existing seawater intake with traveling screens of 0.25-in smooth mesh panels operated at an approach velocity of 0.79 fps in front of the screens and 0.67 fps outboard of the bar racks that are fixed at the intake behind the screens. These rates are greater than the 0.5 fps recommended by EPA to minimize impingement of aquatic organisms. Based on required impingement (organisms are large enough to be retained by intake screens because velocity of intake does not enable them to get free and screen is too small for them to pass through) and entrainment (species are small enough to pass through intake screen and move through system) surveys conducted by PREPA, the traveling screen debris return system is not designed or operated in a manner that minimizes injury and mortality of impinged fish and larvae and eggs are impinged on the screens. There is a fish return system that operates as part of the cooling water intake system and it was demonstrated that the entrainment of fish and shellfish is very low at the facility, meaning that animals are returned to the sea with low mortality. However, those animals that are caught in the area of the traveling screens during washing cycles and larvae and eggs do suffer mortality. Therefore, there may already be an effect to various life stages of Nassau grouper associated with the operation of the existing Aguirre power plant and its seawater intake.

Additional impacts to various life stages could occur due to the operation of a seawater intake during HDD operations, which are expected to take a maximum of 3 months to complete. The rate of seawater intake for HDD operations is expected to be less than the 0.5 fps rate recommended by EPA but the screens that will be used on the intake pipelines are 100 µm. This size screen is likely to lead to entrainment of fry and larvae and potentially impingement of juveniles. Additional impacts to various life stages will also occur due to the operation of the seawater intakes on the FSRU. The rate of seawater intake by the FSRU will be 0.45 fps, which is less than the rate recommended by EPA to reduce the potential for impingement of aquatic organisms. The size and design of the sea chests that will serve as the seawater intakes for the FSRU will not reduce the potential for entrainment of smaller life stages, including eggs and larvae of Nassau grouper. However, ichthyplankton sampling conducted for the project found that groupers represented an extremely low percentage of the fish larvae collected in the action area (0.02%) and no Nassau grouper larvae were observed. Surveys conducted for the existing power plant also did not find Nassau grouper larvae. Nassau grouper were not observed during any of the benthic surveys conducted for the project and investigations conducted by NOAA in JBNERR similarly found groupers to be infrequent with no sightings of Nassau grouper during any of the fish surveys (Whitall et al. 2011). Thus, data for the action area indicate that Nassau grouper are infrequent in the area of Jobos Bay and the offshore cays and that they are no longer present in historic SPAGS in the action area. Although various life stages of this species could be affected by entrainment and impingement in the seawater intakes proposed as part of project construction and operation, compounded by impingement and entrainment from the continued operation of the existing power plant seawater intake, we believe these risks are low given the current lack of Nassau grouper adults and larvae in the action area. FERC is requiring that the applicant conduct a 3-year study of the seawater intakes once the FSRU is operational to determine whether there are entrainment and impingement concerns related to impacts to ESA-listed corals and Nassau grouper. Therefore, we believe the risk of entrainment and impingement of various life stages of Nassau grouper associated with seawater intakes during the use of HDD and the operation of the FSRU once the project is constructed will be discountable.

The intake of plankton in seawater could also affect early life stages of Nassau grouper that feed on dinoflagellates, fish larvae and mysids. Nassau grouper at all life stages are unspecialized predators, meaning they prey on a wide range of organisms rather than targeting specific groups or species (NMFS 2012). The seawater intakes needed to operate the FSRU and LNG carriers will be at the offshore platform and Nassau grouper of various life stages will still have access to prey items throughout the action area that are not taken into the seawater intakes. The seawater intake for HDD operations will be temporary, lasting a maximum of 60 days. Nassau grouper have not been observed at the site where the offshore platform is proposed or in the Boca del Infierno area where HDD will be used to install the pipeline based on surveys conducted by the applicant and information from surveys conducted by EPA and NOAA. Therefore, we believe the impacts to various life stages of Nassau grouper associated with seawater intake of potential prey items during the use of HDD and the operation of the FSRU and LNG carriers once the project is constructed will be insignificant.

<u>Temporary and Permanent Habitat Impacts:</u> Nassau grouper could also be impacted by the temporary and permanent loss of habitat associated with the proposed installation and operation of the pipeline and offshore platform due to anchoring and spudding of vessels, installation of structures, pipeline burial, vessel operations, and water quality changes. Water quality changes include sediment resuspension and transport associated with pipeline installation and burial activities, excavation of the exit and entry points for HDD operations and drilling fluid releases, propeller wash including during operation of platform, discharge of superheated brine during HDD operations and FSRU operation once the project is operational, and discharge of copper associated with FSRU system maintenance. Impacts of in-water construction will last at least 9 months but some impacts, such as sediment deposition, may extend over a longer period depending on the extent of habitat burial associated with sediment transport outside the in-water project footprint. Modeling by the applicant indicated that sediment deposition outside the in-water impact footprint will be significant in terms of spatial extent but have a minimal impact on benthic habitat in Jobos Bay due to the low sediment concentrations that will be deposited in the majority of the areas outside the construction footprint (see Table 2). The habitat impacts associated with heated brine discharges during HDD operations will extend over 3 months and will affect a localized area in Jobos Bay. At the offshore platform, the FSRU will discharge superheated brine on a daily basis in large volumes. However, these discharges will also affect a localized area around the offshore platform based on modeling by the applicant indicating that

the brine discharge is expected to mix into surrounding waters within 25 ft of a discharge point. In terms of the discharge of copper associated with maintenance of the FSRU's cooling water system, the discharge will be concentrated in the area of the platform and the copper ions are expected to bond quickly to sediment and organic material in the water column, which would reduce the bioavailability of copper ions. Therefore, despite the impacts to habitat that may be used by Nassau grouper associated with project construction and operation, we believe the effects of temporary and permanent habitat loss to this species will be insignificant. We base this conclusion on the acreage of temporary impact areas in comparison to the extent of existing seagrass, macroalgae and coral habitats in the action area, the required development and implementation of a turbidity monitoring plan to ensure in-water turbidity controls are effective and minimize the potential for the extent of sediment deposition calculated by the applicant, and because of the lack of data indicating that Nassau grouper are common in the action area.

Accidental Spills: Nassau grouper could also be affected should accidental spills occur during construction and operation of the offshore platform. Various life stages of the fish could be directly affected by spills of petroleum from vessels operating during construction and operation of the project, as well as spills of chemicals and other materials used or generated at the offshore platform once it is operational such as cleaning agents and wastewater. Similarly, habitat for Nassau grouper could be affected by accidental spills. The extent of the impact would depend on the volume of material spilled, the type of material (because some things like diesel for fueling the generator at the platform float while other compounds may sink), and oceanographic conditions at the time of the spill (because strong winds and waves may mix compounds into the water column more quickly, complicating any cleanup operations and strong currents will move floatable materials a longer distance from the source of the spill.) The applicant has noted that a site-specific spill prevention and control plan will be developed and implemented to minimize the potential for inadvertent releases of hydrocarbons and to establish protocols for the containment, remediation, and reporting of accidental releases. The U.S. Coast Guard (USCG) requires spill response plans for large commercial vessels and will require one for the offshore platform as one of the agencies responsible for inspecting this type of facilities. The USCG requirements will address all potential contaminant releases, not just hydrocarbons that will require a cleanup response be implemented in order to minimize pollution to the marine environment. Therefore, we believe the impacts to Nassau grouper associated with accidental spills of hydrocarbons and other compounds during construction and operation of the project will be discountable.

Lighting: Nassau grouper could be attracted to the offshore platform by the accumulation of smaller fish that serve as prey items. Fish could be attracted not only to the structure but to the lights that will operate at all times during nighttime construction and operation of the offshore platform. Nassau grouper in the project area could adjust their feeding habits to target the aggregations of fish at the offshore platform. Constant lighting could also affect spawning Nassau grouper as the species uses the full moon typically in December, January, and/or February to synchronize spawning events. However, as noted previously, the historic SPAGS in the action area no longer contain Nassau grouper based on information from Ojeda-Serrano et al. (2007) and Nassau grouper were not observed during benthic surveys conducted for the project or surveys conducted by NOAA in JBNERR (Whitall et al. 2011). Additionally, FERC has required that the applicant develop a lighting plan that identifies specific measures that would be implemented to minimize or avoid impacts associated with the project's operational nighttime lighting on avian species, fish species, marine mammals, various life stages of sea turtles, and individuals on the shoreline. FERC also required that the plan analyze if the project could artificially induce biological aggregations, leading to potential impacts to fishery species such as Nassau grouper. Therefore, we believe the effects of behavioral alteration of Nassau grouper related to targeting prey items that aggregate at the offshore platform and the artificial lighting at the platform affecting the ability of fish to synchronize spawning events will be discountable.

Scalloped Hammerhead Shark, Central and Southwest Atlantic Distinct Population Segment, Giant Manta Ray

Data from the Marine Recreational Information Program (MRIP) from Puerto Rico from 2001 – 2016 show 797 scalloped hammerhead sharks were landed by recreational charter boats using vertical line gear within Puerto Rico's territorial waters, which extend to 9 nm from shore. The greatest number of scalloped hammerhead sharks, 516, were captured in 2003. The other landings were from 2004 (44), 2006 (30), 2012 (98), and 2016 (109). Landed sharks ranged in length from 600 – 800 millimeters (mm), meaning they were likely neonates or juveniles as maturity is reached when males are approximately 1,219 mm and females are 1,981 mm. At least some of the sharks may have been misidentified and were actually bonnetheads and others were included in a general hammerhead shark category and could be species other than scalloped hammerhead, but these are the best data available from recreational fisheries landings (M. Wunderlich, NMFS SERO, pers. comm. to L. Carrubba, NMFS OPR, October 13, 2017). MRIP data are not collected from the U.S. Virgin Islands (USVI). However, shark research conducted in St. Thomas and St. John, USVI, in 2004 and 2005 resulted in the capture of a total of nine scalloped hammerhead sharks in Mehan's Bay, St. Thomas over both years (DeAngelis (2006)). The scalloped hammerhead sharks captured by DeAngelis (2006) were all neonates, indicating that the bay provides nursery habitat for the species. Commercial fisheries data for the U.S. Caribbean do not distinguish between hammerhead shark species but NMFS estimates up to two animals are captured using line gear in deep offshore waters outside territorial seas per year (M. Wunderlich, NMFS SERO, pers. comm. to L. Carrubba, NMFS OPR, October 13, 2017). These animals are more likely to be adult sharks due to the water depth and distance from shore as adults tend to be more common in offshore waters while neonates and juveniles are more common in nearshore waters.

Giant manta ray are typically found offshore in the open ocean though these animals are sometimes found around nearshore reefs and estuarine waters, which are present in the action area, though no data are available documenting the presence of giant mantas in the area of Jobos Bay and its offshore cays. Giant manta ray have been observed infrequently near the entrance to San Juan Bay particularly near channel marker buoys by NMFS biologists and infrequent observations of this species have also been reported in deeper waters off bays and over deep reefs around USVI (A. Dempsey, BioImpact, personal communications to L. Carrubba, NMFS, January 26, 2018, and February 26, 2018; R. Nemeth, University of the Virgin islands, personal communication to L. Carrubba, NMFS, January 26, 2018). Because the action area has similar habitat as the sites around the USVI where these animals have occasionally been sighted, it is possible that they transit through the action area periodically. However, numerous in-water plankton sampling events and benthic surveys were conducted as part of the preparation of the

BA and other environmental documents associated with the proposed project and no giant manta rays were reported.

Pile-Driving: Scalloped hammerhead sharks and giant manta rays are not expected to suffer injurious effects due to impact hammer pile driving activities at the offshore platform site or vibratory pile driving activities associated with the installation of temporary piles to serve as moorings for work barges during pipeline installation. Based on what is currently known regarding the hearing of sharks and rays and their lack of a swim bladder, sound pressures from pile driving are not expected to result in injurious effects to these animals. In addition, there are no reports of scalloped hammerhead sharks and giant manta rays in the action area and, if any life stages of the species were present, the animals would be expected to leave areas with concentrated human activity. Therefore, we believe there will be no effect to scalloped hammerhead sharks and giant manta rays as a result of pile driving.

Seawater Intake: Based on the recreational fisheries data available, if scalloped hammerhead sharks are present in the action area, they would be neonates or juveniles and too large to be affected by entrainment or impingement. Similarly, given the size of giant manta rays, they would be too large to be affected by the seawater intakes associated with the proposed action.

Scalloped hammerhead sharks could be affected if entrainment or impingement results in a reduction in prey items for the juvenile and neonate life stages that may be present in the action area. Giant manta ray could also be affected if entrainment or impingement results in a reduction in prey consumed by the species. The seawater intake for HDD operations will be temporary, lasting a maximum of 60 days. The intakes for the FSRU will be active at all times while the vessel is at the offshore platform. LNGs will also operate seawater intakes while moored at the platform. Scalloped hammerhead sharks and giant manta rays were not reported in benthic surveys conducted by the applicant or surveys by EPA and NOAA conducted in the action area. If younger life stages of scalloped hammerhead sharks are in the area of Jobos Bay and adults and larger juveniles are present in the area of the proposed offshore platform, these animals would still have access to the extensive coral reef, colonized hard bottom, and other habitats in the action area where they would be able to find prey. Giant manta rays are unlikely to be inside the bay as they prefer areas of deeper waters but animals could be present along the offshore reefs where the offshore platform will be constructed. As is the case for scalloped hammerhead sharks, giant manta rays would still have access to the water column in the action area where they would be able to find prey. Therefore, we believe the impacts to various life stages of scalloped hammerhead shark and giant manta rays associated with seawater intake of potential prey items during the use of HDD and the operation of the FSRU and LNG carriers once the project is constructed will be insignificant.

Temporary and Permanent Habitat Impacts: Various life stages of scalloped hammerhead sharks could be impacted by the temporary and permanent loss of habitat associated with the proposed installation and operation of the pipeline and offshore platform. Impacts of in-water construction will last at least 9 months. The habitat impacts associated with heated brine discharges during HDD operations will extend over 3 months and will affect a localized area in Jobos Bay. At the offshore platform, the FSRU will discharge superheated brine on a daily basis in large volumes that will affect a localized area and there will be other habitat impacts at the offshore platform site associated with the operation of vessels and other discharges. However, there are extensive areas within the action area that will still provide functional habitat for different life stages of this species during project construction and operation. Therefore, despite the impacts to habitat that may be used by various life stages of scalloped hammerhead sharks associated with project construction and operation, we believe the effects of temporary and permanent habitat loss to this species will be insignificant.

Giant manta rays may be found over coral reefs and colonized hard bottom and in open water. The temporary and permanent impacts to benthic habitats such as seagrass beds, coral reefs, and colonized hard bottom associated with the installation and operation of the pipeline and offshore platform are not expected to impact giant manta rays. Giant manta rays feed in the water column and do not appear to directly use benthic habitats. Therefore, we believe there will be no effect to giant manta rays associated with temporary and permanent habitat impacts during project construction and operation.

Accidental Spills: Giant manta rays and various life stages of scalloped hammerhead sharks could also be affected should accidental spills occur during construction and operation of the offshore platform. Sharks and rays could be directly affected by spills of petroleum from vessels operating during construction and operation of the project, as well as spills of chemicals and other materials used or generated at the offshore platform once it is operational. Habitat and prey for the scalloped hammerhead sharks and prey for giant manta rays could be affected by accidental spills. The extent of the impact would depend on the volume of material spilled, the type of material spilled, the toxicity of the spilled material, and oceanographic conditions at the time of the spill. The applicant has noted that a site-specific spill prevention and control plan will be developed and implemented to minimize the potential for inadvertent releases of hydrocarbons and to establish protocols for the containment, remediation, and reporting of accidental releases. The USCG requires spill response plans for large commercial vessels and will require one for the offshore platform that will address all potential contaminant releases that ill require a cleanup response be implemented in order to minimize pollution to the marine environment. Therefore, we believe the impacts to scalloped hammerhead sharks and giant manta rays associated with accidental spills of hydrocarbons and other compounds during construction and operation of the project will be discountable.

Lighting: Scalloped hammerhead sharks could be attracted to the offshore platform by the accumulation of smaller fish that serve as prey items and could change their feeding patterns to target fish concentrated at the platform. Fish could be attracted not only to the structure but to the lights that will operate at all times during nighttime construction and operation of the offshore platform. Giant manta rays could also be attracted to the offshore platform by the accumulation of plankton due to lighting of the platform especially because they appear to be primarily nocturnal feeders. However, there are no reports of scalloped hammerhead sharks from surveys conducted as part of the project or by EPA and NOAA and, based on commercial and recreational fishing data, the species is not common around Puerto Rico. JBNERR has a monitoring program and also has not reported the presence of the species in the area. The JBNERR managers noted that the reserve management plant was revised in 2017 and, as part of the revision process, reserve staff searched through scientific surveys completed within the reserve and no giant manta sightings were reported (A. Pabón, DNER, personal communication to L. Carrubba, NMFS, March 15, 2018). FERC is requiring that the applicant develop a lighting plan identifying specific measures that would be implemented to minimize or avoid impacts associated with the project's operational nighttime lighting on avian species, fish species, marine mammals, various life stages of sea turtles, and individuals on the shoreline. Therefore, we believe the effects of behavioral alteration of scalloped hammerhead sharks and giant manta rays related to targeting prey items that aggregate at the offshore platform will be discountable.

Whales
We do not have recent survey data for ESA-listed whale species in the action area. Blue, fin, sei, and sperm whales are oceanic and predominantly found seaward of the continental shelf (i.e., deeper than 260 – 460 ft) in the Gulf of Mexico and South Atlantic and in deep waters off the insular shelf in the Caribbean. A baby sperm whale was stranded on Vieques Island, Puerto Rico last year.

Vessel Collisions: ESA-listed whale species could be struck by work vessels transiting to and from the offshore platform and pipeline installation locations, in particular if work takes place during winter migration. Construction vessels will consist mainly of barges moved into place by tugs and will operate at slow speeds. All construction vessels will have a marine observer on board to look for marine mammals and sea turtles. This will provide protection to ESA-listed whales during the transit of work vessels by requiring vessels maintain set distances from whales for their transit. The applicant has incorporated NMFS's *Vessel Strike Avoidance Measures and Reporting for Mariners* (Appendix A) into a monitoring plan developed for sea turtle and marine mammals. The monitoring plan will include a sea turtle and marine mammal survey program to determine the numbers and species of animals present in the action area during construction and operation of the project (note on 11-28-16 conference call). FERC has required that the applicant finalize the plan in coordination with NMFS prior to construction. Because ESA-listed whales are not likely to be present in the action area year-round, and given the survey program and FERC license requirements, we believe the risk of injury to ESA-listed whales from collision with work vessels during transit and construction of the offshore portions of the project will be discountable.

ESA-listed whale species could also be struck by LNG carriers and the FSRU (when it leaves the platform during periods of inclement weather or every 5 years for maintenance) during operation of the offshore gasport. Up to 52 LNG carrier vessels measuring approximately 1,045 ft in length could visit the offshore platform in a given year once it is operational. A port service vessel ranging in length from 110 – 125 ft will be used to transport cargo and personnel and smaller vessels ranging from 25 – 30 ft in length may also be used to transport personnel. During routine operations, these vessels will transit to and from the gasport daily. PREPA currently receives 3 – 4 fuel barge deliveries weekly, or up to 208 vessels in a given year. These vessels access the existing Aguirre power plant through the navigation channel into Jobos Bay. The size of the fuel barges is restricted due to the size of the navigation channel. According to the applicant, 35 – 45 commercial fishing vessels, which are mainly small wooden vessels less than 25 ft in length, also transit regularly in the action area. Thus, the project will represent an increase in the number of very large vessels accessing the action area. Compliance with NMFS's *Vessel Strike Avoidance Measures and Reporting for Mariners* (Appendix A) will be part of the required implementation of a monitoring plan for sea turtles and marine mammals that

FERC has included in the license requirements for the project. As noted above, the plan will be finalized in coordination with NMFS and will include a survey program to determine the presence of ESA-listed whales and ensure vessel operations are carried out in a way that will have minimal impact on these animals. During operation of the offshore gasport, the applicant will also require that LNG carriers transit at speeds between 8 – 10 knots from the shelf edge to the PBS and then at less than 4 knots once the pilot is aboard, which will further reduce the potential for vessel interactions with whales associated with project operation. Given the lack of impediments to whale movements in deep waters where the offshore platform will be located and the fact that ESA-listed whale species are unlikely to be landward of the shelf edge, we expect that the risk of collisions will be extremely low despite the number of trips the LNG carrier vessels are expected to make annually. Therefore, we believe the risk of collisions with ESA-listed whale species from vessel transit associated with the operation of the offshore gasport will be discountable. As part of the monitoring plan, we will receive regular reports with the results of the sea turtle and marine mammal surveys from the applicant in order to verify both the presence of ESA-listed whales and that vessel interactions are not impacting them.

4.2 Status of Species and Critical Habitat Likely to be Adversely Affected

Leatherback, NWA DPS of loggerhead, hawksbill, and SA and NA DPSs of green sea turtles; elkhorn, staghorn, pillar, rough cactus, lobed star, mountainous star, and boulder star corals; and elkhorn and staghorn coral critical habitat will all be adversely affected by the proposed project. Specifically, individuals of the various sea turtle species are known to be present in the action area, including where pile-driving will occur in order to construct the offshore platform. Colonies of ESA-listed corals and elkhorn and staghorn coral critical habitat are present along portions of the subsea pipeline route (in the reef areas where HDD is proposed and in the footprint of the offshore platform).

The summaries that follow describe the status of the ESA-listed species and critical habitat that occur within the action area and are considered in this Opinion. More detailed information on the status and trends of these listed resources and the biology and ecology of these listed species can be found in the listing regulations published in the Federal Register, status reviews, and on these NMFS websites:

- http://sero.nmfs.noaa.gov/protected_resources/index.html
- http://www.nmfs.noaa.gov/pr/species/esa/index.htm.

4.2.1 General Threats Faced by All Sea Turtle Species

Sea turtles face numerous natural and man-made threats that shape their status and affect their ability to recover. Many of the threats are either the same or similar in nature for all listed sea turtle species, those identified in this section are discussed in a general sense for all sea turtles. Threat information specific to a particular species are then discussed in the corresponding status sections where appropriate.

Fisheries

Incidental bycatch in commercial fisheries is identified as a major contributor to past declines, and threat to future recovery, for all of the sea turtle species (NMFS and USFWS

1991;1992;1993;2008; NMFS et al. 2011). Domestic fisheries often capture, injure, and kill sea turtles at various life stages. Sea turtles in the pelagic environment are exposed to U.S. Atlantic pelagic longline fisheries. Sea turtles in the benthic environment in waters off the coastal United States are exposed to a suite of other fisheries in federal and state waters. These fishing methods include trawls, gillnets, purse seines, hook-and-line gear (including bottom longlines and vertical lines [e.g., bandit gear, handlines, and rod-reel]), pound nets, and trap fisheries. Refer to the Environmental Baseline section of this opinion for more specific information regarding federal and state managed fisheries affecting sea turtles within the action area). The Southeast U.S. shrimp fisheries have historically been the largest fishery threat to benthic sea turtles in the southeastern United States, and continue to interact with and kill large numbers of sea turtles each year.

In addition to domestic fisheries, sea turtles are subject to direct as well as incidental capture in numerous foreign fisheries, further impeding the ability of sea turtles to survive and recover on a global scale. For example, pelagic stage sea turtles, especially loggerheads and leatherbacks, circumnavigating the Atlantic are susceptible to international longline fisheries including the Azorean, Spanish, and various other fleets (Aguilar et al. 1994; Bolten et al. 1994). Bottom longlines and gillnet fishing is known to occur in many foreign waters, including (but not limited to) the northwest Atlantic, western Mediterranean, South America, West Africa, Central America, and the Caribbean. Shrimp trawl fisheries are also occurring off the shores of numerous foreign countries and pose a significant threat to sea turtles similar to the impacts seen in U.S. waters. Many unreported takes or incomplete records by foreign fleets make it difficult to characterize the total impact that international fishing pressure is having on listed sea turtles. Nevertheless, international fisheries represent a continuing threat to sea turtle survival and recovery throughout their respective ranges.

Non-Fishery In-Water Activities

There are also many non-fishery impacts affecting the status of sea turtle species, both in the ocean and on land. In nearshore waters of the United States, the construction and maintenance of federal navigation channels has been identified as a source of sea turtle mortality. Hopper dredges, which are frequently used in ocean bar channels and sometimes in harbor channels and offshore borrow areas, move relatively rapidly and can entrain and kill sea turtles (NMFS 1997). Sea turtles entering coastal or inshore areas have also been affected by entrainment in the cooling-water systems of electrical generating plants. Other nearshore threats include harassment and/or injury resulting from private and commercial vessel operations, military detonations and training exercises, in-water construction activities, and scientific research activities.

Coastal Development and Erosion Control

Coastal development can deter or interfere with nesting, affect nesting success, and degrade nesting habitats for sea turtles. Structural impacts to nesting habitat include the construction of buildings and pilings, beach armoring and renourishment, and sand extraction (Lutcavage et al. 1997; Bouchard et al. 1998). These factors may decrease the amount of nesting area available to females and change the natural behaviors of both adults and hatchlings, directly or indirectly, through loss of beach habitat or changing thermal profiles and increasing erosion, respectively (Ackerman 1997; Witherington et al. 2003;2007). In addition, coastal development is usually accompanied by artificial lighting which can alter the behavior of nesting adults (Witherington 1992) and is often fatal to emerging hatchlings that are drawn away from the water (Witherington and Bjorndal 1991). In-water erosion control structures such as breakwaters, groins, and jetties can impact nesting females and hatchling as they approach and leave the surf zone or head out to sea by creating physical blockage, concentrating predators, creating longshore currents, and disrupting of wave patterns.

Environmental Contamination

Multiple municipal, industrial, and household sources, as well as atmospheric transport, introduce various pollutants such as pesticides, hydrocarbons, organochlorides (e.g., dichlorodiphenyltrichloroethane [DDT], polychlorinated biphenyls [PCB], and perfluorinated chemicals [PFC]), and others that may cause adverse health effects to sea turtles (Iwata et al. 1993; Grant and Ross 2002; Garrett 2004; Hartwell 2004). Acute exposure to hydrocarbons from petroleum products released into the environment via oil spills and other discharges may directly injure individuals through skin contact with oils (Geraci 1990), inhalation at the water's surface, and ingesting compounds while feeding (Matkin 1997). Hydrocarbons also have the potential to impact prey populations, and therefore may affect listed species indirectly by reducing food availability in the action area.

The April 20, 2010, explosion of the DEEPWATER HORIZON (DWH) oil rig affected sea turtles in the Gulf of Mexico. An assessment has been completed on the injury to Gulf of Mexico marine life, including sea turtles, resulting from the spill (DWH Trustees 2015). Following the spill, juvenile Kemp's ridley, green, and loggerhead sea turtles were found in *Sargassum* algae mats in the convergence zones, where currents meet and oil collected. Sea turtles found in these areas were often coated in oil and/or had ingested oil. The spill resulted in the direct mortality of many sea turtles and may have had sublethal effects or caused environmental damage that will impact other sea turtles into the future. Information on the spill impacts to individual sea turtle species is presented in the Status of the Species sections for each species.

Marine debris is a continuing problem for sea turtles. Marine debris is a problem due primarily to sea turtles ingesting debris and blocking the digestive tract, causing death or serious injury (Lutcavage et al. 1997; Laist et al. 1999). Schuyler et al. (2015) estimated that, globally, 52% of individual sea turtles have ingested marine debris. Gulko and Eckert (2003) estimated that between one-third and one-half of all sea turtles ingest plastic at some point in their lives; this figure is supported by data from Lazar and Gračan (2011), who found 35% of loggerheads had plastic in their gut. A Brazilian study found that 60% of stranded green sea turtles had ingested marine debris (Bugoni et al. 2001). Loggerhead sea turtles had a lesser frequency of marine debris ingestion. Plastic is possibly ingested out of curiosity or due to confusion with prey items. Marine debris consumption has been shown to depress growth rates in post-hatchling loggerhead sea turtles, increasing the time required to reach sexual maturity and increasing predation risk (McCauley and Bjorndal 1999). Sea turtles can also become entangled and die in marine debris, such as discarded nets and monofilament line (NRC 1990b; Lutcavage et al. 1997; Laist et al. 1999).

Climate Change

Our climate is changing. The globally averaged combined land and ocean surface temperature data, as calculated by a linear trend, show a warming of approximately 0.85^{o} Celsius over the period 1880 to 2012 (IPCC 2014). Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850 (IPCC 2014). Burning fossil fuels has increased atmospheric carbon dioxide concentrations by 35% with respect to pre-industrial levels, with consequent climatic disruptions that include a higher rate of global warming than occurred at the last global-scale state shift. Ocean warming dominates the increase in energy stored in the climate system, accounting for more than 90% of the energy accumulated between 1971 and 2010 (IPCC 2014). It is virtually certain that the upper ocean (0 to 700 m) warmed from 1971 to 2010 and it likely warmed between the 1870s and 1971 (IPCC 2014). On a global scale, ocean warming is highest near the surface and the upper 75 m warmed by 0.11^{o} Celsius per decade over the period 1971 to 2010 (IPCC 2014). There is high confidence, based on substantial evidence, that observed changes in marine systems are associated with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels, and circulation. Higher carbon dioxide concentrations have also caused the ocean to rapidly become more acidic, evidenced as a decrease in pH of 0.05 over the past two decades (Doney 2010).

We expect the extinction risk of ESA-listed species to rise with global warming. The direct effects of climate change will result in increases in atmospheric temperatures, changes in sea surface temperatures, patterns of precipitation, and sea level. Primary effects of climate change on individual species include habitat loss or alteration, distribution changes, altered and/or reduced distribution and abundance of prey, changes in the abundance of competitors and/or predators, shifts in the timing of seasonal activities of species, and geographic isolation or extirpation of populations that are unable to adapt. Secondary effects include increased stress, disease susceptibility, and predation.

For sea turtles, temperature regime increases generally lead to female-biased nests (Hill et al. 2015). Acevedo-Whitehouse and Duffus (2009) proposed that the rapidity of environmental changes, such as those resulting from global warming, can harm immunocompetence and reproductive parameters in wildlife to the detriment of population viability and persistence. An example of this is the altered sex ratios observed in sea turtle populations worldwide (Mazaris et al. 2008; Reina et al. 2009; Robinson et al. 2009; Fuentes et al. 2010). This does not appear to have yet affected population viabilities through reduced reproductive success, although nesting and emergence dates of days to weeks in some locations have changed over the past several decades (Poloczanska et al. 2009). Altered ranges can also result in the spread of novel diseases to new areas via shifts in host ranges (Simmonds and Eliott 2009; Schumann et al. 2013).

Changes in global climatic patterns will likely have profound effects on the coastlines of every continent by increasing sea levels and the intensity, if not the frequency, of hurricanes and tropical storms (Wilkinson and Souter 2008). A half-degree Celsius increase in temperatures during hurricane season from 1965-2005 correlated with a 40% increase in cyclone activity in the Atlantic. Sea levels have risen an average of 1.7 mm/year over the 20th century due to glacial melting and thermal expansion of water, with minor contributions from melt water (Blunden and Arndt 2013). Based on computer models, these phenomena would inundate sea turtle nesting beaches, change patterns of coastal erosion and sand accretion that are necessary to maintain those beaches, and would increase the number of turtle nests destroyed by tropical storms and hurricanes (Wilkinson and Souter 2008). Inundation itself reduces hatching success by creating hypoxic conditions within inundated eggs (Pike et al. 2006). In addition, flatter beaches preferred by smaller sea turtle species would be inundated sooner than would steeper beaches preferred by larger species (Hawkes et al. 2014). The loss of nesting beaches by itself would have catastrophic effects on sea turtles populations globally if they are unable to colonize new beaches that form or if the beaches do not provide the habitat attributes (sand depth, temperature regimes, refuge) necessary for egg survival. In some areas, increases in sea level alone may be sufficient to inundate sea turtles nests and reduce hatching success (Caut et al. 2010). Storms may also cause direct harm to sea turtles, causing "mass" strandings and mortality (Poloczanska et al. 2009). Increasing temperatures in sea turtle nests alters sex ratios, reduces incubation times (producing smaller hatchlings), and reduces nesting success due to exceeded thermal tolerances (Fuentes et al. 2009; Fuentes et al. 2010; Fuentes et al. 2011). Small individuals likely experience increased predation (Fuentes et al. 2011).

Other Threats

Predation by various land predators is a threat to developing nests and emerging hatchlings. The major natural predators of sea turtle nests are mammals, including raccoons, dogs, pigs, skunks, and badgers. Emergent hatchlings are preyed upon by these mammals as well as ghost crabs, laughing gulls, and the exotic South American fire ant (*Solenopsis invicta*). In addition to natural predation, direct harvest of eggs and adults from beaches in foreign countries continues to be a problem for various sea turtle species throughout their ranges (NMFS and USFWS 2008).

Diseases, toxic blooms from algae and other microorganisms, and cold stunning events are additional sources of mortality that can range from local and limited to wide-scale and impacting hundreds or thousands of animals.

4.2.1.1 North and South Atlantic DPSs of Green Sea Turtle (*Chelonia mydas*)

The green sea turtle was originally listed as threatened under the ESA on July 28, 1978, except for the Florida and Pacific coast of Mexico breeding populations, which were listed as endangered. On April 6, 2016, the original listing was replaced with the listing of 11 distinct population segments (DPSs; 81 FR 20057 2016; Figure 7). The Mediterranean, Central West Pacific, and Central South Pacific DPSs were listed as endangered. The North Atlantic, South Atlantic, Southwest Indian, North Indian, East Indian-West Pacific, Southwest Pacific, Central North Pacific, and East Pacific were listed as threatened. For the purposes of this consultation, only the South Atlantic DPS (SA DPS) and North Atlantic DPS (NA DPS) will be considered, as they are the only two DPSs with individuals occurring in the Atlantic and Gulf of Mexico waters of the United States.

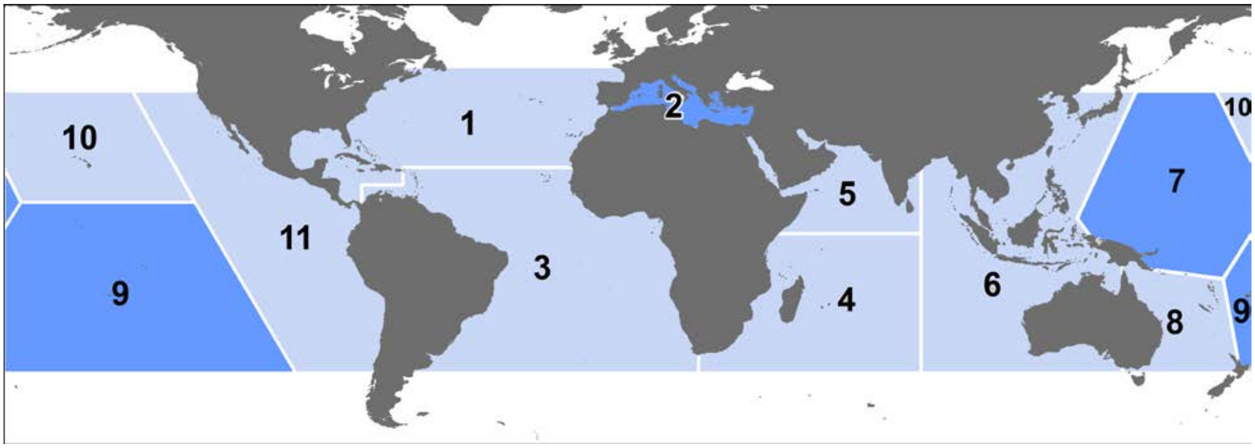

Figure 7. Threatened (light) and endangered (dark) green turtle DPSs: 1. North Atlantic, 2. Mediterranean, 3. South Atlantic, 4. Southwest Indian, 5. North Indian, 6. East Indian-West Pacific, 7. Central West Pacific, 8. Southwest Pacific, 9. Central South Pacific, 10. Central North Pacific, and 11. East Pacific.

Species Description and Distribution

The green sea turtle is the largest of the hardshell marine turtles, growing to a weight of 350 lb (159 kilograms [kg]) with a straight carapace length of greater than 3.3 ft (1 m). Green sea turtles have a smooth carapace with 4 pairs of lateral (or costal) scutes and a single pair of elongated prefrontal scales between the eyes. They typically have a black dorsal surface and a white ventral surface, although the carapace of green sea turtles in the Atlantic Ocean has been known to change in color from solid black to a variety of shades of grey, green, or brown and black in starburst or irregular patterns (Lagueux 2001).

With the exception of post-hatchlings, green sea turtles live in nearshore tropical and subtropical waters where they generally feed on marine algae and seagrasses. They have specific foraging grounds and may make large migrations between these forage sites and natal beaches for nesting (Hays et al. 2001). Green sea turtles nest on sandy beaches of mainland shores, barrier islands, coral islands, and volcanic islands in more than 80 countries worldwide (Hirth 1997). The 2 largest nesting populations are found at Tortuguero, on the Caribbean coast of Costa Rica (part of the NA DPS), and Raine Island, on the Pacific coast of Australia along the Great Barrier Reef.

Differences in mitochondrial DNA properties of green sea turtles from different nesting regions indicate there are genetic subpopulations (Bowen et al. 1992; FitzSimmons et al. 2006). Despite the genetic differences, sea turtles from separate nesting origins are commonly found mixed together on foraging grounds throughout the species' range. Within U.S. waters individuals from both the NA and SA DPSs can be found on foraging grounds. While there are currently no in-depth studies available to determine the percent of NA and SA DPS individuals in any given location, two small-scale studies provide an insight into the degree of mixing on the foraging grounds. An analysis of cold-stunned green turtles in St. Joseph Bay, Florida (northern Gulf of Mexico) found approximately 4% of individuals came from nesting stocks in the SA DPS (specifically Suriname, Aves Island, Brazil, Ascension Island, and Guinea Bissau) (Foley et al. 2007). On the Atlantic coast of Florida, a study on the foraging grounds off Hutchinson Island found that approximately 5% of the turtles sampled came from the Aves Island/Suriname nesting assemblage, which is part of the SA DPS (Bass and Witzell 2000). All of the individuals in both studies were benthic juveniles. Available information on green turtle migratory behavior indicates that long distance dispersal is only seen for juvenile turtles. This suggests that larger adult-sized turtles return to forage within the region of their natal rookeries, thereby limiting the potential for gene flow across larger scales (Monzón-Argüello et al. 2010). While all of the mainland U.S. nesting individuals are part of the NA DPS, the U.S. Caribbean nesting assemblages are split between the NA and SA DPS. Nesters in Puerto Rico are part of the NA DPS, while those in the U.S. Virgin Islands are part of the SA DPS. We do not currently have information on what percent of individuals on the U.S. Caribbean foraging grounds come from which DPS.

North Atlantic DPS Distribution
The NA DPS boundary is illustrated in Figure 7. Four regions support nesting concentrations of particular interest in the NA DPS: Costa Rica (Tortuguero), Mexico (Campeche, Yucatan, and Quintana Roo), U.S. (Florida), and Cuba. By far the most important nesting concentration for green turtles in this DPS is Tortuguero, Costa Rica. Nesting also occurs in the Bahamas, Belize, Cayman Islands, Dominican Republic, Haiti, Honduras, Jamaica, Nicaragua, Panama, Puerto Rico, Turks and Caicos Islands, and North Carolina, South Carolina, Georgia, and Texas, U.S.A. In the eastern North Atlantic, nesting has been reported in Mauritania (Fretey 2001).

The complete nesting range of NA DPS green sea turtles within the southeastern United States includes sandy beaches between Texas and North Carolina, as well as Puerto Rico (Dow et al. 2007; NMFS and USFWS 1991). The vast majority of green sea turtle nesting within the southeastern United States occurs in Florida (Johnson and Ehrhart 1994; Meylan et al. 1995). Principal U.S. nesting areas for green sea turtles are in eastern Florida, predominantly Brevard south through Broward counties.

In U.S. Atlantic and Gulf of Mexico waters, green sea turtles are distributed throughout inshore and nearshore waters from Texas to Massachusetts. Principal benthic foraging areas in the southeastern United States include Aransas Bay, Matagorda Bay, Laguna Madre, and the Gulf inlets of Texas (Doughty 1984; Hildebrand 1982; Shaver 1994), the Gulf of Mexico off Florida from Yankeetown to Tarpon Springs (Caldwell and Carr 1957), Florida Bay and the Florida Keys (Schroeder and Foley 1995), the Indian River Lagoon system in Florida (Ehrhart 1983), and the Atlantic Ocean off Florida from Brevard through Broward Counties (Guseman and Ehrhart 1992; Wershoven and Wershoven 1992). The summer developmental habitat for green sea turtles also encompasses estuarine and coastal waters from North Carolina to as far north as Long Island Sound (Musick and Limpus 1997). Additional important foraging areas in the western Atlantic include the Culebra archipelago and other Puerto Rico coastal waters, the south coast of Cuba, the Mosquito Coast of Nicaragua, the Caribbean coast of Panama, scattered areas along Colombia and Brazil (Hirth 1971), and the northwestern coast of the Yucatán Peninsula.

South Atlantic DPS Distribution
The SA DPS boundary is shown in Figure 7, and includes the U.S. Virgin Islands in the Caribbean. The SA DPS nesting sites can be roughly divided into four regions: western Africa, Ascension Island, Brazil, and the South Atlantic Caribbean (including Colombia, the Guianas, and Aves Island in addition to the numerous small, island nesting sites).

The in-water range of the SA DPS is widespread. In the eastern South Atlantic, significant sea turtle habitats have been identified, including green turtle feeding grounds in Corisco Bay, Equatorial Guinea/Gabon (Formia 1999); Congo; Mussulo Bay, Angola (Carr and Carr 1991); as well as Principe Island. Juvenile and adult green turtles utilize foraging areas throughout the Caribbean areas of the South Atlantic, often resulting in interactions with fisheries occurring in those same waters (Dow et al. 2007). Juvenile green turtles from multiple rookeries also frequently utilize the nearshore waters off Brazil as foraging grounds as evidenced from the frequent captures by fisheries (Lima et al. 2010; López-Barrera et al. 2012; Marcovaldi et al. 2009). Genetic analysis of green turtles on the foraging grounds off Ubatuba and Almofala, Brazil show mixed stocks coming primarily from Ascension, Suriname and Trindade as a secondary source, but also Aves, and even sometimes Costa Rica (North Atlantic DPS)((Naro-Maciel et al. 2007; Naro-Maciel et al. 2012). While no nesting occurs as far south as Uruguay and Argentina, both have important foraging grounds for South Atlantic green turtles (Gonzalez Carman et al. 2011; Lezama 2009; López-Mendilaharsu et al. 2006; Prosdocimi et al. 2012; Rivas-Zinno 2012).

Life History Information

Green sea turtles reproduce sexually, and mating occurs in the waters off nesting beaches and along migratory routes. Mature females return to their natal beaches (i.e., the same beaches where they were born) to lay eggs (Balazs 1982; Frazer and Ehrhart 1985) every 2-4 years while males are known to reproduce every year (Balazs 1983). In the southeastern United States, females generally nest between June and September, and peak nesting occurs in June and July (Witherington and Ehrhart 1989b). During the nesting season, females nest at approximately 2-week intervals, laying an average of 3-4 clutches (Johnson and Ehrhart 1996). Clutch size often varies among subpopulations, but mean clutch size is approximately 110-115 eggs. In Florida, green sea turtle nests contain an average of 136 eggs (Witherington and Ehrhart 1989b). Eggs incubate for approximately 2 months before hatching. Hatchling green sea turtles are approximately 2 inches (5 cm) in length and weigh approximately 0.9 ounces (25 grams). Survivorship at any particular nesting site is greatly influenced by the level of man-made stressors, with the more pristine and less disturbed nesting sites (e.g., along the Great Barrier Reef in Australia) showing higher survivorship values than nesting sites known to be highly disturbed (e.g., Nicaragua) (Campell and Lagueux 2005; Chaloupka and Limpus 2005).

After emerging from the nest, hatchlings swim to offshore areas and go through a post-hatchling pelagic stage where they are believed to live for several years. During this life stage, green sea turtles feed close to the surface on a variety of marine algae and other life associated with drift lines and debris. This early oceanic phase remains one of the most poorly understood aspects of green sea turtle life history (NMFS and USFWS 2007). Green sea turtles exhibit particularly slow growth rates of about 0.4-2 inches (1-5 cm) per year (Green 1993), which may be attributed to their largely herbivorous, low-net energy diet (Bjorndal 1982). At approximately 8-10 inches (20-25 cm) carapace length, juveniles leave the pelagic environment and enter nearshore developmental habitats such as protected lagoons and open coastal areas rich in sea grass and marine algae. Growth studies using skeletochronology indicate that green sea turtles in the western Atlantic shift from the oceanic phase to nearshore developmental habitats after approximately 5-6 years (Bresette et al. 2006; Zug and Glor 1998). Within the developmental habitats, juveniles begin the switch to a more herbivorous diet, and by adulthood feed almost exclusively on seagrasses and algae (Rebel 1974), although some populations are known to also feed heavily on invertebrates (Carballo et al. 2002). Green sea turtles mature slowly, requiring 20-50 years to reach sexual maturity (Chaloupka and Musick 1997; Hirth 1997).

While in coastal habitats, green sea turtles exhibit site fidelity to specific foraging and nesting grounds, and it is clear they are capable of "homing in" on these sites if displaced ((McMichael et al. 2003). Reproductive migrations of Florida green sea turtles have been identified through flipper tagging and/or satellite telemetry. Based on these studies, the majority of adult female Florida green sea turtles are believed to reside in nearshore foraging areas throughout the Florida Keys and in the waters southwest of Cape Sable, and some post-nesting turtles also reside in Bahamian waters as well (NMFS and USFWS 2007).

Status and Population Dynamics

Accurate population estimates for marine turtles do not exist because of the difficulty in sampling turtles over their geographic ranges and within their marine environments. Nonetheless, researchers have used nesting data to study trends in reproducing sea turtles over time. A summary of nesting trends and nester abundance is provided in the most recent status review for the species (Seminoff et al. 2015), with information for each of the DPSs.

North Atlantic DPS

The NA DPS is the largest of the 11 green turtle DPSs, with an estimated nester abundance of over 167,000 adult females from 73 nesting sites. Overall this DPS is also the most data rich. Eight of the sites have high levels of abundance (i.e., <1000 nesters), located in Costa Rica, Cuba, Mexico, and Florida. All major nesting populations demonstrate long-term increases in abundance (Seminoff et al. 2015).

Tortuguero, Costa Rica is by far the predominant nesting site, accounting for an estimated 79% of nesting for the DPS (Seminoff et al. 2015). Nesting at Tortuguero appears to have been increasing since the 1970's, when monitoring began. For instance, from 1971-1975 there were approximately 41,250 average annual emergences documented and this number increased to an average of 72,200 emergences from 1992-1996 (Bjorndal et al. 1999). Troëng and Rankin (2005) collected nest counts from 1999-2003 and also reported increasing trends in the population consistent with the earlier studies, with nest count data suggesting 17,402-37,290 nesting females per year (NMFS and USFWS 2007). Modeling by Chaloupka et al. (2008) using data sets of 25 years or more resulted in an estimate of the Tortuguero, Costa Rica population's growing at 4.9% annually.

In the continental United States, green sea turtle nesting occurs along the Atlantic coast, primarily along the central and southeast coast of Florida where an estimated 200-1,100 females nest each year (Meylan et al. 1994; Weishampel et al. 2003). Occasional nesting has also been documented along the Gulf Coast of Florida (Meylan et al. 1995). Green sea turtle nesting is documented annually on beaches of North Carolina, South Carolina, and Georgia, though nesting is found in low quantities (nesting databases maintained on www.seaturtle.org).

In Florida, index beaches were established to standardize data collection methods and effort on key nesting beaches. Since establishment of the index beaches in 1989, the pattern of green sea turtle nesting has generally shown biennial peaks in abundance with a positive trend during the 10 years of regular monitoring (Figure 8). According to data collected from Florida's index nesting beach survey from 1989-2015, green sea turtle nest counts across Florida have increased approximately ten-fold from a low of 267 in the early 1990s to a high of 27,975 in 2015. Two consecutive years of nesting declines in 2008 and 2009 caused some concern, but this was followed by increases in 2010 and 2011, and a return to the trend of biennial peaks in abundance thereafter (Figure 8). Modeling by Chaloupka et al. (2008) using data sets of 25 years or more has resulted in an estimate of the Florida nesting stock at the Archie Carr National Wildlife Refuge growing at an annual rate of 13.9%.

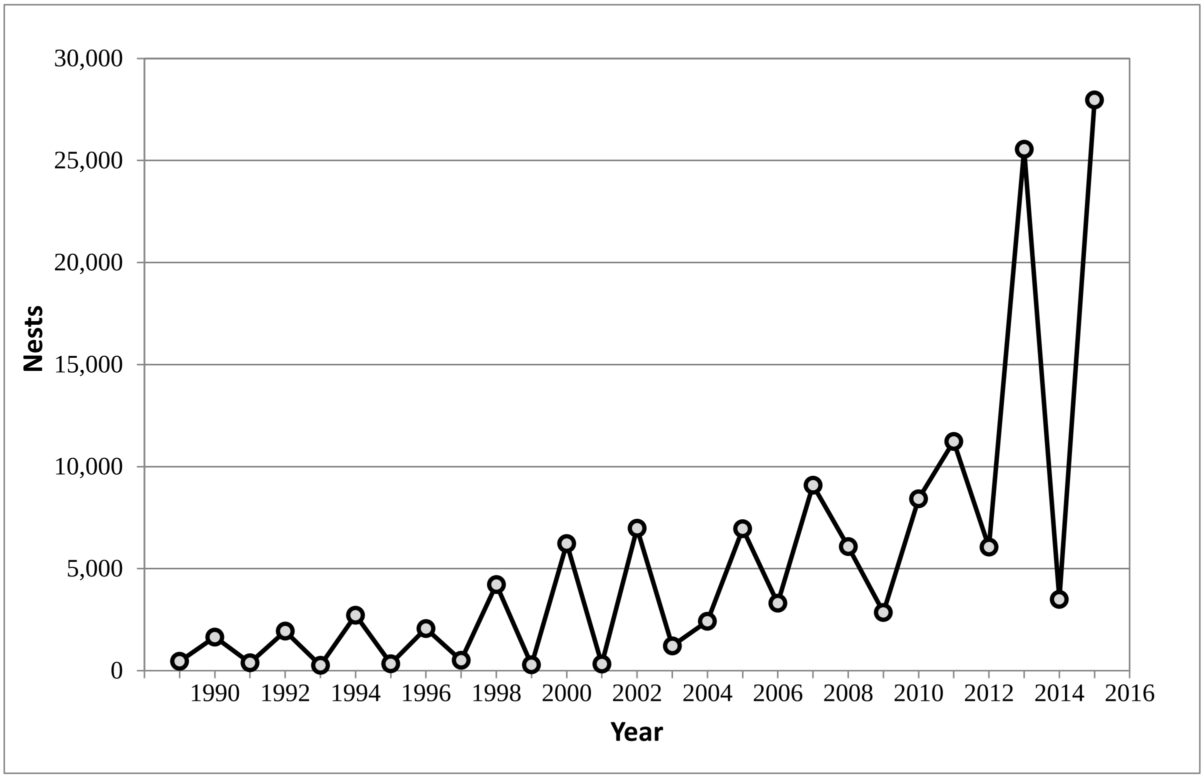

Figure 8. Green sea turtle nesting at Florida index beaches since 1989

Similar to the nesting trend found in Florida, in-water studies in Florida have also recorded increases in green turtle captures at the Indian River Lagoon site, with a 661 percent increase over 24 years (Ehrhart et al. 2007), and the St Lucie Power Plant site, with a significant increase in the annual rate of capture of immature green turtles (SCL<90 cm) from 1977 to 2002 or 26 years (3,557 green turtles total; M. Bressette, Inwater Research Group, unpubl. data; (Witherington et al. 2006).

South Atlantic DPS

The SA DPS is large, estimated at over 63,000 nesters, but data availability is poor. More than half of the 51 identified nesting sites (37) did not have sufficient data to estimate number of nesters or trends (Seminoff et al. 2015). This includes some sites, such as beaches in French Guiana, which are suspected to have large numbers of nesters. Therefore, while the estimated number of nesters may be substantially underestimated, we also do not know the population trends at those data-poor beaches. However, while the lack of data was a concern due to increased uncertainty, the overall trend of the SA DPS was not considered to be a major concern as some of the largest nesting beaches such as Ascension Island, Aves Island (Venezuela), and Galibi (Suriname) appear to be increasing. Others such as Trindade (Brazil), Atol das Rocas (Brazil), and Poilão and the rest of Guinea-Bissau seem to be stable or do not have sufficient data to make a determination. Bioko (Equatorial Guinea) appears to be in decline but has less nesting than the other primary sites (Seminoff et al. 2015).

In the U.S., nesting of SA DPS green turtles occurs on the beaches of the U.S. Virgin Islands, primarily on Buck Island. There is insufficient data to determine a trend for Buck Island nesting, and it is a smaller rookery, with approximately 63 total nesters utilizing the beach (Seminoff et al. 2015).

Threats

The principal cause of past declines and extirpations of green sea turtle assemblages has been the overexploitation of the species for food and other products. Although intentional take of green sea turtles and their eggs is not extensive within the southeastern United States, green sea turtles that nest and forage in the region may spend large portions of their life history outside the region and outside U.S. jurisdiction, where exploitation is still a threat. Green sea turtles also face many of the same threats as other sea turtle species, including destruction of nesting habitat from storm events, oceanic events such as cold-stunning, pollution (e.g., plastics, petroleum products, petrochemicals), ecosystem alterations (e.g., nesting beach development, beach nourishment and shoreline stabilization, vegetation changes), poaching, global climate change, fisheries interactions, natural predation, and disease. A discussion on general sea turtle threats can be found in Section 4.2.1.

In addition to general threats, green sea turtles are susceptible to natural mortality from fibropapillomatosis (FP) disease. FP results in the growth of tumors on soft external tissues (flippers, neck, tail, etc.), the carapace, the eyes, the mouth, and internal organs (gastrointestinal tract, heart, lungs, etc.) of turtles (Aguirre et al. 2002; Herbst 1994; Jacobson et al. 1989). These tumors range in size from 0.04 inches (0.1 cm) to greater than 11.81 inches (30 cm) in diameter and may affect swimming, vision, feeding, and organ function (Aguirre et al. 2002; Herbst 1994; Jacobson et al. 1989). Presently, scientists are unsure of the exact mechanism causing this disease, though it is believed to be related to both an infectious agent, such as a virus (Herbst et al. 1995), and environmental conditions (e.g., habitat degradation, pollution, low wave energy, and shallow water (Foley et al. 2005). FP is cosmopolitan, but it has been found to affect large numbers of animals in specific areas, including Hawaii and Florida (Herbst 1994; Jacobson 1990; Jacobson et al. 1991).

Cold-stunning is another natural threat to green sea turtles. Although it is not considered a major source of mortality in most cases, as temperatures fall below 46.4°-50°F (8°-10°C) turtles may lose their ability to swim and dive, often floating to the surface. The rate of cooling that precipitates cold-stunning appears to be the primary threat, rather than the water temperature itself (Milton and Lutz 2003). Sea turtles that overwinter in inshore waters are most susceptible to cold-stunning because temperature changes are most rapid in shallow water (Witherington and Ehrhart 1989a). During January 2010, an unusually large cold-stunning event in the southeastern United States resulted in around 4,600 sea turtles, mostly greens, found cold-stunned, and hundreds found dead or dying. A large cold-stunning event occurred in the western Gulf of Mexico in February 2011, resulting in approximately 1,650 green sea turtles found cold-stunned in Texas. Of these, approximately 620 were found dead or died after stranding, while approximately 1,030 turtles were rehabilitated and released. During this same time frame, approximately 340 green sea turtles were found cold-stunned in Mexico, though approximately 300 of those were subsequently rehabilitated and released.

Whereas oil spill impacts are discussed generally for all species in Section 4.2.1, specific impacts of the DWH spill on green sea turtles are considered here. Impacts to green sea turtles occurred to offshore small juveniles only. A total of 154,000 small juvenile greens (36.6% of the total small juvenile sea turtle exposures to oil from the spill) were estimated to have been exposed to oil. A large number of small juveniles were removed from the population, as 57,300 small juveniles greens are estimated to have died as a result of the exposure. A total of 4 nests (580 eggs) were also translocated during response efforts, with 455 hatchlings released (the fate of which is unknown) (DWH Trustees 2015). Additional unquantified effects may have included inhalation of volatile compounds, disruption of foraging or migratory movements due to surface or subsurface oil, ingestion of prey species contaminated with oil and/or dispersants, and loss of foraging resources which could lead to compromised growth and/or reproductive potential. There is no information currently available to determine the extent of those impacts, if they occurred.

While green turtles regularly use the northern Gulf of Mexico, they have a widespread distribution throughout the entire Gulf of Mexico, Caribbean, and Atlantic, and the proportion of the population using the northern Gulf of Mexico at any given time is relatively low. Although it is known that adverse impacts occurred and numbers of animals in the Gulf of Mexico were reduced as a result of the Deepwater Horizon oil spill of 2010 (DWH), the relative proportion of the population that is expected to have been exposed to and directly impacted by the DWH event, as well as the impacts being primarily to smaller juveniles (lower reproductive value than adults and large juveniles), reduces the impact to the overall population. It is unclear what impact these losses may have caused on a population level, but it is not expected to have had a large impact on the population trajectory moving forward. However, recovery of green turtle numbers equivalent to what was lost in the northern Gulf of Mexico as a result of the spill will likely take decades of sustained efforts to reduce the existing threats and enhance survivorship of multiple life stages (DWH Trustees 2015).

4.2.1.2 Leatherback Sea Turtle (*Dermochelys coriacea*)

The leatherback sea turtle was listed as endangered throughout its entire range on June 2, 1970, (35 FR 8491) under the Endangered Species Conservation Act of 1969.

Species Description and Distribution

The leatherback is the largest sea turtle in the world, with a curved carapace length (CCL) that often exceeds 5 ft (150 cm) and front flippers that can span almost 9 ft (270 cm) (NMFS and USFWS 1998). Mature males and females can reach lengths of over 6 ft (2 m) and weigh close to 2,000 lb (900 kg). The leatherback does not have a bony shell. Instead, its shell is approximately 1.5 in (4 cm) thick and consists of a leathery, oil-saturated connective tissue overlaying loosely interlocking dermal bones. The ridged shell and large flippers help the leatherback during its long-distance trips in search of food.

Unlike other sea turtles, leatherbacks have several unique traits that enable them to live in cold water. For example, leatherbacks have a countercurrent circulatory system (Greer et al. 1973),[2] a thick layer of insulating fat (Davenport et al. 1990; Goff and Lien 1988), gigantothermy (Paladino et al. 1990),[3] and they can increase their body temperature through increased metabolic activity (Bostrom and Jones 2007; Southwood et al. 2005). These adaptations allow leatherbacks to be comfortable in a wide range of temperatures, which helps them to travel further than any other sea turtle species (NMFS and USFWS 1995). For example, a leatherback may swim more than 6,000 mi (10,000 kilometers [km]) in a single year (Benson et al. 2007a; Benson et al. 2011; Eckert 2006; Eckert et al. 2006). They search for food between latitudes 71°N and 47°S in all oceans, and travel extensively to and from their tropical nesting beaches. In the Atlantic Ocean, leatherbacks have been recorded as far north as Newfoundland, Canada, and Norway, and as far south as Uruguay, Argentina, and South Africa (NMFS 2001).

While leatherbacks will look for food in coastal waters, they appear to prefer the open ocean at all life stages (Heppell et al. 2003). Leatherbacks have pointed tooth-like cusps and sharp-edged jaws that are adapted for a diet of soft-bodied prey such as jellyfish and salps. A leatherback's mouth and throat also have backward-pointing spines that help retain jelly-like prey. Leatherbacks' favorite prey are jellies (e.g., medusae, siphonophores, and salps), which commonly occur in temperate and northern or sub-arctic latitudes and likely has a strong influence on leatherback distribution in these areas (Plotkin 2003). Leatherbacks are known to be deep divers, with recorded depths in excess of a half-mile (Eckert et al. 1989), but they may also come into shallow waters to locate prey items.

Genetic analyses using microsatellite markers along with mitochondrial DNA and tagging data indicate there are 7 groups or breeding populations in the Atlantic Ocean: Florida, Northern Caribbean, Western Caribbean, Southern Caribbean/Guianas, West Africa, South Africa, and Brazil (Turtle Expert Working Group [TEWG] 2007). General differences in migration patterns and foraging grounds may occur between the 7 nesting assemblages, although data to support this is limited in most cases.

Life History Information
The leatherback life cycle is broken into several stages: (1) egg/hatchling, (2) post-hatchling, (3) juvenile, (4) subadult, and (5) adult. Leatherbacks are a long-lived species that delay age of maturity, have low and variable survival in the egg and juvenile stages, and have relatively high and constant annual survival in the subadult and adult life stages (Chaloupka 2002; Crouse 1999; Heppell et al. 1999; Heppell et al. 2003; Spotila et al. 1996; Spotila et al. 2000). While a robust

[2] Countercurrent circulation is a highly efficient means of minimizing heat loss through the skin's surface because heat is recycled. For example, a countercurrent circulation system often has an artery containing warm blood from the heart surrounded by a bundle of veins containing cool blood from the body's surface. As the warm blood flows away from the heart, it passes much of its heat to the colder blood returning to the heart via the veins. This conserves heat by recirculating it back to the body's core.

[3] "Gigantothermy" refers to a condition when an animal has relatively high volume compared to its surface area, and as a result, it loses less heat.

estimate of the leatherback sea turtle's life span does not exist, the current best estimate for the maximum age is 43 (Avens et al. 2009). It is still unclear when leatherbacks first become sexually mature. Using skeletochronological data, Avens et al. (2009) estimated that leatherbacks in the western North Atlantic may not reach maturity until 29 years of age, which is longer than earlier estimates of 2-3 years by Pritchard and Trebbau (1984), of 3-6 years by Rhodin (1985), of 13-14 years for females by Zug and Parham (1996), and 12-14 years for leatherbacks nesting in the U.S. Virgin Islands by Dutton et al. (2005). A more recent study that examined leatherback growth rates estimated an age at maturity of 16.1 years (Jones et al. 2011).

The average size of reproductively active females in the Atlantic is generally 5-5.5 ft (150-162 cm) CCL (Benson et al. 2007a; Hirth et al. 1993; Starbird and Suarez 1994). Still, females as small as 3.5-4 ft (105-125 cm) CCL have been observed nesting at various sites (Stewart et al. 2007).

Female leatherbacks typically nest on sandy, tropical beaches at intervals of 2-4 years (Garcia M. and Sarti 2000; McDonald and Dutton 1996; Spotila et al. 2000). Unlike other sea turtle species, female leatherbacks do not always nest at the same beach year after year; some females may even nest at different beaches during the same year (Dutton et al. 2005; Eckert 1989; Keinath and Musick 1993; Steyermark et al. 1996). Individual female leatherbacks have been observed with fertility spans as long as 25 years (Hughes 1996). Females usually lay up to 10 nests during the 3-6 month nesting season (March through July in the United States), typically 8-12 days apart, with 100 eggs or more per nest (Eckert et al. 2012; Eckert 1989; Maharaj 2004; Matos 1986; Stewart and Johnson 2006; Tucker 1988). Yet, up to approximately 30% of the eggs may be infertile (Eckert 1989; Eckert et al. 1984; Maharaj 2004; Matos 1986; Stewart and Johnson 2006; Tucker 1988). The number of leatherback hatchlings that make it out of the nest on to the beach (i.e., emergent success) is approximately 50% worldwide (Eckert et al. 2012), which is lower than the greater than 80% reported for other sea turtle species (Miller 1997). In the United States, the emergent success is higher at 54-72% (Eckert and Eckert 1990; Tucker 1988; Stewart and Johnson 2006). Thus the number of hatchlings in a given year may be less than the total number of eggs produced in a season. Eggs hatch after 60-65 days, and the hatchlings have white striping along the ridges of their backs and on the edges of the flippers. Leatherback hatchlings weigh approximately 1.5-2 oz (40-50 g), and have lengths of approximately 2-3 in (51-76 mm), with fore flippers as long as their bodies. Hatchlings grow rapidly, with reported growth rates for leatherbacks from 2.5-27.6 in (6-70 cm) in length, estimated at 12.6 in (32 cm) per year (Jones et al. 2011).

In the Atlantic, the sex ratio appears to be skewed toward females. The TEWG reports that nearshore and onshore strandings data from the U.S. Atlantic and Gulf of Mexico coasts indicate that 60% of strandings were females (TEWG 2007). Those data also show that the proportion of females among adults (57%) and juveniles (61%) was also skewed toward females in these areas (TEWG 2007). (James et al.) (2007) collected size and sex data from large subadult and adult leatherbacks off Nova Scotia and also concluded a bias toward females at a rate of 1.86:1.

The survival and mortality rates for leatherbacks are difficult to estimate and vary by location. For example, the annual mortality rate for leatherbacks that nested at Playa Grande, Costa Rica, was estimated to be 34.6% in 1993-1994, and 34.0% in 1994-1995 (Spotila et al. 2000). In contrast, leatherbacks nesting in French Guiana and St. Croix had estimated annual survival rates of 91% (Rivalan et al. 2005) and 89% (Dutton et al. 2005), respectively. For the St. Croix population, the average annual juvenile survival rate was estimated to be approximately 63% and the total survival rate from hatchling to first year of reproduction for a female was estimated to be between 0.4% and 2%, assuming age at first reproduction is between 9-13 years (Eguchi et al. 2006). Spotila et al. (1996) estimated first-year survival rates for leatherbacks at 6.25%.

Migratory routes of leatherbacks are not entirely known; however, recent information from satellite tags have documented long travels between nesting beaches and foraging areas in the Atlantic and Pacific Ocean basins (Benson et al. 2007a; Benson et al. 2011; Eckert 2006; Eckert et al. 2006; Ferraroli et al. 2004; Hays et al. 2004; James et al. 2005). Leatherbacks nesting in Central America and Mexico travel thousands of miles through tropical and temperate waters of the South Pacific (Eckert and Sarti 1997; Shillinger et al. 2008). Data from satellite tagged leatherbacks suggest that they may be traveling in search of seasonal aggregations of jellyfish (Benson et al. 2007b; Bowlby et al. 1994; Graham 2009; Shenker 1984; Starbird et al. 1993; Suchman and Brodeur 2005).

Status and Population Dynamics

The status of the Atlantic leatherback population has been less clear than the Pacific population, which has shown dramatic declines at many nesting sites (Santidrián Tomillo et al. 2007; Sarti Martínez et al. 2007; Spotila et al. 2000). This uncertainty has been a result of inconsistent beach and aerial surveys, cycles of erosion, and reformation of nesting beaches in the Guianas (representing the largest nesting area). Leatherbacks also show a lesser degree of nest-site fidelity than occurs with the hardshell sea turtle species. Coordinated efforts of data collection and analyses by the leatherback TEWG have helped to clarify the understanding of the Atlantic population status (TEWG 2007).

The Southern Caribbean/Guianas stock is the largest known Atlantic leatherback nesting aggregation (TEWG 2007). This area includes the Guianas (Guyana, Suriname, and French Guiana), Trinidad, Dominica, and Venezuela, with most of the nesting occurring in the Guianas and Trinidad. The Southern Caribbean/Guianas stock of leatherbacks was designated after genetics studies indicated that animals from the Guianas (and possibly Trinidad) should be viewed as a single population. Using nesting females as a proxy for population, the TEWG (2007) determined that the Southern Caribbean/Guianas stock had demonstrated a long-term, positive population growth rate. The TEWG observed positive growth within major nesting areas for the stock, including Trinidad, Guyana, and the combined beaches of Suriname and French Guiana (TEWG 2007). More specifically, Tiwari et al. (2013) report an estimated three-generation abundance change of +3%, +20,800%, +1,778%, and +6% in Trinidad, Guyana, Suriname, and French Guiana, respectively.

Researchers believe the cyclical pattern of beach erosion and then reformation has affected leatherback nesting patterns in the Guianas. For example, between 1979 and 1986, the number of leatherback nests in French Guiana had increased by about 15% annually (NMFS 2001). This increase was then followed by a nesting decline of about 15% annually. This decline corresponded with the erosion of beaches in French Guiana and increased nesting in Suriname. This pattern suggests that the declines observed since 1987 might actually be a part of a nesting cycle that coincides with cyclic beach erosion in Guiana (Schulz 1975). Researchers think that the cycle of erosion and reformation of beaches may have changed where leatherbacks nest throughout this region. The idea of shifting nesting beach locations was supported by increased nesting in Suriname, while the number of nests was declining at beaches in Guiana (Hilterman et al. 2003). Though this information suggested the long-term trend for the overall Suriname and French Guiana population was increasing.

The Western Caribbean stock includes nesting beaches from Honduras to Colombia. Across the Western Caribbean, nesting is most prevalent in Costa Rica, Panama, and the Gulf of Uraba in Colombia (Duque et al. 2000). The Caribbean coastline of Costa Rica and extending through Chiriquí Beach, Panama, represents the fourth largest known leatherback rookery in the world (Troëng et al. 2004). Examination of data from index nesting beaches in Tortuguero, Gandoca, and Pacuaré in Costa Rica indicate that the nesting population likely was not growing over the 1995-2005 time series (TEWG 2007). Other modeling of the nesting data for Tortuguero indicates a possible 67.8% decline between 1995 and 2006 (Troëng et al. 2007). Tiwari et al. (2013) report an estimated three-generation abundance change of -72%, -24%, and +6% for Tortuguero, Gandoca, and Pacuare, respectively.

Nesting data for the Northern Caribbean stock is available from Puerto Rico, St. Croix (U.S. Virgin Islands), and the British Virgin Islands (Tortola). In Puerto Rico, the primary nesting beaches are at Fajardo and on the island of Culebra. Nesting between 1978 and 2005 has ranged between 469-882 nests, and the population has been growing since 1978, with an overall annual growth rate of 1.1% (TEWG 2007). Tiwari et al. (2013) report an estimated three-generation abundance change of -4% and +5,583% at Culebra and Fajardo, respectively. At the primary nesting beach on St. Croix, the Sandy Point National Wildlife Refuge, nesting has varied from a few hundred nests to a high of 1,008 in 2001, and the average annual growth rate has been approximately 1.1% from 1986-2004 (TEWG 2007). From 2006-2010, Tiwari et al. (2013) report an annual growth rate of +7.5% in St. Croix and a three-generation abundance change of +1,058%. Nesting in Tortola is limited, but has been increasing from 0-6 nests per year in the late 1980s to 35-65 per year in the 2000s, with an annual growth rate of approximately 1.2% between 1994 and 2004 (TEWG 2007).

The Florida nesting stock nests primarily along the east coast of Florida. This stock is of growing importance, with total nests between 800-900 per year in the 2000s following nesting totals fewer than 100 nests per year in the 1980s (Florida Fish and Wildlife Conservation Commission, unpublished data). Using data from the index nesting beach surveys, the TEWG (2007) estimated a significant annual nesting growth rate of 1.17% between 1989 and 2005. FWC Index Nesting Beach Survey Data generally indicates biennial peaks in nesting abundance beginning in 2007 (Figure 9 and Table 6). A similar pattern was also observed statewide (Table 6). This up-and-down pattern is thought to be a result of the cyclical nature of leatherback nesting, similar to the biennial cycle of green turtle nesting. Overall, the trend shows growth on Florida's east coast beaches. Tiwari et al. (2013) report an annual growth rate of 9.7% and a three-generation abundance change of +1,863%.

Table 6. Number of Leatherback Sea Turtle Nests in Florida

Nests Recorded	2011	2012	2013	2014	2015
Index Nesting Beaches	625	515	322	641	489
Statewide	1,653	1,712	896	1,604	NA

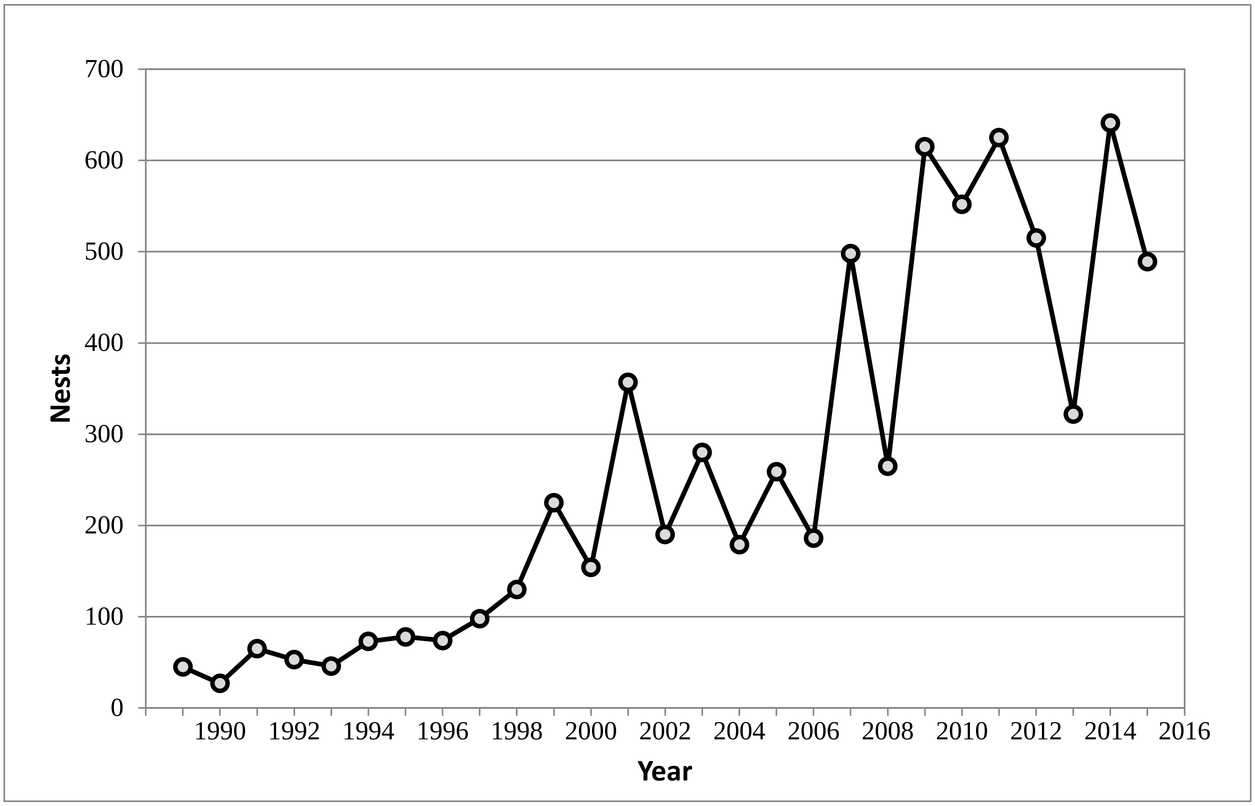

Figure 9. Leatherback sea turtle nesting at Florida index beaches since 1989

The West African nesting stock of leatherbacks is large and important, but it is a mostly unstudied aggregation. Nesting occurs in various countries along Africa's Atlantic coast, but much of the nesting is undocumented and the data are inconsistent. Gabon has a very large amount of leatherback nesting, with at least 30,000 nests laid along its coast in a single season (Fretey et al. 2007). Fretey et al. (2007) provide detailed information about other known nesting beaches and survey efforts along the Atlantic African coast. Because of the lack of consistent effort and minimal available data, trend analyses were not possible for this stock (TEWG 2007).

Two other small but growing stocks nest on the beaches of Brazil and South Africa. Based on the data available, TEWG (2007) determined that between 1988 and 2003, there was a positive annual average growth rate between 1.07% and 1.08% for the Brazilian stock. TEWG (2007) estimated an annual average growth rate between 1.04% and 1.06% for the South African stock.

Because the available nesting information is inconsistent, it is difficult to estimate the total population size for Atlantic leatherbacks. Spotila et al. (1996) characterized the entire Western Atlantic population as stable at best and estimated a population of 18,800 nesting females. Spotila et al. (1996) further estimated that the adult female leatherback population for the entire

Atlantic basin, including all nesting beaches in the Americas, the Caribbean, and West Africa, was about 27,600 (considering both nesting and interesting females), with an estimated range of 20,082-35,133. This is consistent with the estimate of 34,000-95,000 total adults (20,000-56,000 adult females; 10,000-21,000 nesting females) determined by the TEWG (2007). The TEWG (2007) also determined that at of the time of their publication, leatherback sea turtle populations in the Atlantic were all stable or increasing with the exception of the Western Caribbean and West Africa populations. The latest review by NMFS USFWS (2013) suggests the leatherback nesting population is stable in most nesting regions of the Atlantic Ocean.

Threats
Leatherbacks face many of the same threats as other sea turtle species, including destruction of nesting habitat from storm events, oceanic events such as cold-stunning, pollution (plastics, petroleum products, petrochemicals, etc.), ecosystem alterations (nesting beach development, beach nourishment and shoreline stabilization, vegetation changes, etc.), poaching, global climate change, fisheries interactions, natural predation, and disease. A discussion on general sea turtle threats can be found in Section 4.2.1; the remainder of this section will expand on a few of the aforementioned threats and how they may specifically impact leatherback sea turtles.

Of all sea turtle species, leatherbacks seem to be the most vulnerable to entanglement in fishing gear, especially gillnet and pot/trap lines. This vulnerability may be because of their body type (large size, long pectoral flippers, and lack of a hard shell), their attraction to gelatinous organisms and algae that collect on buoys and buoy lines at or near the surface, their method of locomotion, and/or their attraction to the lightsticks used to attract target species in longline fisheries. From 1990-2000, 92 entangled leatherbacks were reported from New York through Maine and many other stranded individuals exhibited evidence of prior entanglement (Dwyer et al. 2003). Zug and Parham (1996) point out that a combination of the loss of long-lived adults in fishery-related mortalities and a lack of recruitment from intense egg harvesting in some areas has caused a sharp decline in leatherback sea turtle populations. This represents a significant threat to survival and recovery of the species worldwide.

Leatherback sea turtles may also be more susceptible to marine debris ingestion than other sea turtle species due to their predominantly pelagic existence and the tendency of floating debris to concentrate in convergence zones that adults and juveniles use for feeding and migratory purposes (Lutcavage et al. 1997; Shoop and Kenney 1992). The stomach contents of leatherback sea turtles revealed that a substantial percentage (33.8% or 138 of 408 cases examined) contained some form of plastic debris (Mrosovsky et al. 2009). Blocking of the gut by plastic to an extent that could have caused death was evident in 8.7% of all leatherbacks that ingested plastic (Mrosovsky et al. 2009). Mrosovsky et al. (2009) also note that in a number of cases, the ingestion of plastic may not cause death outright, but could cause the animal to absorb fewer nutrients from food, eat less in general, etc.– factors which could cause other adverse effects. The presence of plastic in the digestive tract suggests that leatherbacks might not be able to distinguish between prey items and forms of debris such a plastic bags (Mrosovsky et al. 2009). Balazs (1985) speculated that the plastic object might resemble a food item by its shape, color, size, or even movement as it drifts about, and therefore induce a feeding response in leatherbacks.

As discussed in Section 4.2.1, global climate change can be expected to have various impacts on all sea turtles, including leatherbacks. Global climate change is likely to also influence the distribution and abundance of jellyfish, the primary prey item of leatherbacks (NMFS and USFWS 2007). Several studies have shown leatherback distribution is influenced by jellyfish abundance (Houghton et al. 2006; Witt et al. 2007; Witt et al. 2006); however, more studies need to be done to monitor how changes to prey items affect distribution and foraging success of leatherbacks so population-level effects can be determined.

While oil spill impacts are discussed generally for all species in Section 4.2.1, specific impacts of the DWH oil spill on leatherback sea turtles are considered here. Available information indicates leatherback sea turtles (along with hawksbill turtles) were likely directly affected by the oil spill. Leatherbacks were documented in the spill area, but the number of affected leatherbacks was not estimated due to a lack of information compared to other species. But given that the northern Gulf of Mexico is important habitat for leatherback migration and foraging (TEWG 2007), and documentation of leatherbacks in the DWH oil spill zone during the spill period, it was concluded that leatherbacks were exposed to DWH oil, and some portion of those exposed leatherbacks likely died. Potential DWH-related impacts to leatherback sea turtles include direct oiling or contact with dispersants from surface and subsurface oil and dispersants, inhalation of volatile compounds, disruption of foraging or migratory movements due to surface or subsurface oil, ingestion of prey species contaminated with oil and/or dispersants, and loss of foraging resources which could lead to compromised growth and/or reproductive potential. There is no information currently available to determine the extent of those impacts, if they occurred. Although adverse impacts likely occurred to leatherbacks, the relative proportion of the population that is expected to have been exposed to and directly impacted by the DWH event may be relatively low. Thus, a population-level impact may not have occurred due to the widespread distribution and nesting location outside of the Gulf of Mexico for this species.

4.2.1.3 Northwest Atlantic DPS of Loggerhead Sea Turtle (*Caretta caretta*)

The loggerhead sea turtle was listed as a threatened species throughout its global range on July 28, 1978. NMFS and USFWS published a Final Rule which designated 9 DPSs for loggerhead sea turtles (76 FR 58868, September 22, 2011, and effective October 24, 2011). This rule listed the following DPSs: (1) Northwest Atlantic Ocean (NWA; threatened), (2) Northeast Atlantic Ocean (endangered), (3) South Atlantic Ocean (threatened), (4) Mediterranean Sea (endangered), (5) North Pacific Ocean (endangered), (6) South Pacific Ocean (endangered), (7) North Indian Ocean (endangered), (8) Southeast Indo-Pacific Ocean (endangered), and (9) Southwest Indian Ocean (threatened). The NWA DPS is the only one that occurs within the action area, and therefore it is the only one considered in this Opinion.

Species Description and Distribution

Loggerheads are large sea turtles. Adults in the southeast United States average about 3 ft (92 cm) long, measured as a straight carapace length (SCL), and weigh approximately 255 lb (116 kg) (Ehrhart and Yoder 1978). Adult and subadult loggerhead sea turtles typically have a light yellow plastron and a reddish brown carapace covered by non-overlapping scutes that meet along seam lines. They typically have 11 or 12 pairs of marginal scutes, 5 pairs of costals, 5 vertebrals, and a nuchal (precentral) scute that is in contact with the first pair of costal scutes (Dodd Jr. 1988).

The loggerhead sea turtle inhabits continental shelf and estuarine environments throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans (Dodd Jr. 1988). Habitat uses within these areas vary by life stage. Juveniles are omnivorous and forage on crabs, mollusks, jellyfish, and vegetation at or near the surface (Dodd Jr. 1988). Subadult and adult loggerheads are primarily found in coastal waters and eat benthic invertebrates such as mollusks and decapod crustaceans in hard bottom habitats.

The majority of loggerhead nesting occurs at the western rims of the Atlantic and Indian Oceans concentrated in the north and south temperate zones and subtropics (NRC 1990a). For the NWA DPS, most nesting occurs along the coast of the United States, from southern Virginia to Alabama. Additional nesting beaches for this DPS are found along the northern and western Gulf of Mexico, eastern Yucatán Peninsula, at Cay Sal Bank in the eastern Bahamas (Addison and Morford 1996; Addison 1997), off the southwestern coast of Cuba (Moncada Gavilan 2001), and along the coasts of Central America, Colombia, Venezuela, and the eastern Caribbean Islands.

Non-nesting, adult female loggerheads are reported throughout the U.S. Atlantic, Gulf of Mexico, and Caribbean Sea. Little is known about the distribution of adult males who are seasonally abundant near nesting beaches. Aerial surveys suggest that loggerheads as a whole are distributed in U.S. waters as follows: 54% off the southeast U.S. coast, 29% off the northeast U.S. coast, 12% in the eastern Gulf of Mexico, and 5% in the western Gulf of Mexico (TEWG 1998).

Within the NWA DPS, most loggerhead sea turtles nest from North Carolina to Florida and along the Gulf Coast of Florida. Previous Section 7 analyses have recognized at least 5 western Atlantic subpopulations, divided geographically as follows: (1) a Northern nesting subpopulation, occurring from North Carolina to northeast Florida at about 29ºN; (2) a South Florida nesting subpopulation, occurring from 29°N on the east coast of the state to Sarasota on the west coast; (3) a Florida Panhandle nesting subpopulation, occurring at Eglin Air Force Base and the beaches near Panama City, Florida; (4) a Yucatán nesting subpopulation, occurring on the eastern Yucatán Peninsula, Mexico (TEWG 2000; Márquez M. 1990); and (5) a Dry Tortugas nesting subpopulation, occurring in the islands of the Dry Tortugas, near Key West, Florida (NMFS 2001).

The recovery plan for the Northwest Atlantic population of loggerhead sea turtles concluded that there is no genetic distinction between loggerheads nesting on adjacent beaches along the Florida Peninsula. It also concluded that specific boundaries for subpopulations could not be designated based on genetic differences alone. Thus, the recovery plan uses a combination of geographic distribution of nesting densities, geographic separation, and geopolitical boundaries, in addition to genetic differences, to identify recovery units. The recovery units are as follows: (1) the Northern Recovery Unit (NRU; Florida/Georgia border north through southern Virginia), (2) the Peninsular Florida Recovery Unit (Florida/Georgia border through Pinellas County, Florida), (3) the Dry Tortugas Recovery Unit (DTRU; islands located west of Key West, Florida), (4) the Northern Gulf of Mexico Recovery Unit (NGMRU; Franklin County, Florida, through Texas), and (5) the Greater Caribbean Recovery Unit (GCRU; Mexico through French Guiana, the

Bahamas, Lesser Antilles, and Greater Antilles) (NMFS and USFWS 2008). The recovery plan concluded that all recovery units are essential to the recovery of the species. Although the recovery plan was written prior to the listing of the NWA DPS, the recovery units for what was then termed the Northwest Atlantic population apply to the NWA DPS.

Life History Information

The Northwest Atlantic Loggerhead Recovery Team defined the following 8 life stages for the loggerhead life cycle, which include the ecosystems those stages generally use: (1) egg (terrestrial zone), (2) hatchling stage (terrestrial zone), (3) hatchling swim frenzy and transitional stage (neritic zone[4]), (4) juvenile stage (oceanic zone), (5) juvenile stage (neritic zone), (6) adult stage (oceanic zone), (7) adult stage (neritic zone), and (8) nesting female (terrestrial zone) (NMFS and USFWS 2008). Loggerheads are long-lived animals. They reach sexual maturity between 20-38 years of age, although age of maturity varies widely among populations (Frazer and Ehrhart 1985; NMFS 2001). The annual mating season occurs from late March to early June, and female turtles lay eggs throughout the summer months. Females deposit an average of 4.1 nests within a nesting season (Murphy and Hopkins 1984), but an individual female only nests every 3.7 years on average (Tucker 2010). Each nest contains an average of 100-126 eggs (Dodd Jr. 1988) which incubate for 42-75 days before hatching (NMFS and USFWS 2008). Loggerhead hatchlings are 1.5-2 inches long and weigh about 0.7 oz (20 g).

As post-hatchlings, loggerheads hatched on U.S. beaches enter the "oceanic juvenile" life stage, migrating offshore and becoming associated with *Sargassum* habitats, driftlines, and other convergence zones (Carr 1986; Witherington 2002; Conant et al. 2009). Oceanic juveniles grow at rates of 1-2 inches (2.9-5.4 cm) per year (Snover 2002; Bjorndal et al. 2003) over a period as long as 7-12 years (Bolten et al. 1998) before moving to more coastal habitats. Studies have suggested that not all loggerhead sea turtles follow the model of circumnavigating the North Atlantic Gyre as pelagic juveniles, followed by permanent settlement into benthic environments (Laurent et al. 1998; Bolten and Witherington 2003). These studies suggest some turtles may either remain in the oceanic habitat in the North Atlantic longer than hypothesized, or they move back and forth between oceanic and coastal habitats interchangeably (Witzell 2002). Stranding records indicate that when immature loggerheads reach 15-24 in (40-60 cm) SCL, they begin to reside in coastal inshore waters of the continental shelf throughout the U.S. Atlantic and Gulf of Mexico (Witzell 2002).

After departing the oceanic zone, neritic juvenile loggerheads in the Northwest Atlantic inhabit continental shelf waters from Cape Cod Bay, Massachusetts, south through Florida, The Bahamas, Cuba, and the Gulf of Mexico. Estuarine waters of the United States, including areas such as Long Island Sound, Chesapeake Bay, Pamlico and Core Sounds, Mosquito and Indian River Lagoons, Biscayne Bay, Florida Bay, as well as numerous embayments fringing the Gulf of Mexico, comprise important inshore habitat. Along the Atlantic and Gulf of Mexico shoreline, essentially all shelf waters are inhabited by loggerheads (Conant et al. 2009).

Like juveniles, non-nesting adult loggerheads also use the neritic zone. However, these adult loggerheads do not use the relatively enclosed shallow-water estuarine habitats with limited

[4] Neritic refers to the nearshore marine environment from the surface to the sea floor where water depths do not exceed 200 meters.

ocean access as frequently as juveniles. Areas such as Pamlico Sound, North Carolina, and the Indian River Lagoon, Florida, are regularly used by juveniles but not by adult loggerheads. Adult loggerheads do tend to use estuarine areas with more open ocean access, such as the Chesapeake Bay in the U.S. mid-Atlantic. Shallow-water habitats with large expanses of open ocean access, such as Florida Bay, provide year-round resident foraging areas for significant numbers of male and female adult loggerheads (Conant et al. 2009).

Offshore, adults primarily inhabit continental shelf waters, from New York south through Florida, The Bahamas, Cuba, and the Gulf of Mexico. Seasonal use of mid-Atlantic shelf waters, especially offshore New Jersey, Delaware, and Virginia during summer months, and offshore shelf waters, such as Onslow Bay (off the North Carolina coast), during winter months has also been documented (Hawkes et al. 2007); Georgia Department of Natural Resources [GADNR}, unpublished data; South Carolina Department of Natural Resources [SCDNR], unpublished data). Satellite telemetry has identified the shelf waters along the west Florida coast, The Bahamas, Cuba, and the Yucatán Peninsula as important resident areas for adult female loggerheads that nest in Florida (Foley et al. 2008; Girard et al. 2009; Hart et al. 2012). The southern edge of the Grand Bahama Bank is important habitat for loggerheads nesting on the Cay Sal Bank in The Bahamas, but nesting females are also resident in the bights of Eleuthera, Long Island, and Ragged Islands. They also reside in Florida Bay in the United States, and along the north coast of Cuba (A. Bolten and K. Bjorndal, University of Florida, unpublished data). Moncada et al. (2010) report the recapture of 5 adult female loggerheads in Cuban waters originally flipper-tagged in Quintana Roo, Mexico, which indicates that Cuban shelf waters likely also provide foraging habitat for adult females that nest in Mexico.

Status and Population Dynamics
A number of stock assessments and similar reviews (TEWG 1998;2000;2009; NMFS 2001; NMFS-SEFSC 2009; Heppell et al. 2003; NMFS and USFWS 2008; Conant et al. 2009) have examined the stock status of loggerheads in the Atlantic Ocean, but none have been able to develop a reliable estimate of absolute population size.

Numbers of nests and nesting females can vary widely from year to year. Nesting beach surveys, though, can provide a reliable assessment of trends in the adult female population, due to the strong nest site fidelity of female loggerhead sea turtles, as long as such studies are sufficiently long and survey effort and methods are standardized (e.g., (NMFS and USFWS 2008). NMFS and USFWS (2008) concluded that the lack of change in 2 important demographic parameters of loggerheads, remigration interval and clutch frequency, indicate that time series on numbers of nests can provide reliable information on trends in the female population.

<u>Peninsular Florida Recovery Unit</u>
The Peninsular Florida Recovery Unit is the largest loggerhead nesting assemblage in the Northwest Atlantic. A near-complete nest census (all beaches including index nesting beaches) undertaken from 1989 to 2007 showed an average of 64,513 loggerhead nests per year, representing approximately 15,735 nesting females per year (NMFS and USFWS 2008). The statewide estimated total for 2015 was 89,295 nests (Florida Fish and Wildlife Research Institute [FWRI] nesting database).

In addition to the total nest count estimates, the FWRI uses an index nesting beach survey method. The index survey uses standardized data-collection criteria to measure seasonal nesting and allow accurate comparisons between beaches and between years. This provides a better tool for understanding the nesting trends (Figure 10). FWRI performed a detailed analysis of the long-term loggerhead index nesting data (1989-2016; http://myfwc.com/research/wildlife/sea-turtles/nesting/loggerhead-trend/). Over that time period, 3 distinct trends were identified. From 1989-1998, there was a 24% increase that was followed by a sharp decline over the subsequent 9 years. A large increase in loggerhead nesting has occurred since, as indicated by the 71% increase in nesting over the 10-year period from 2007 and 2016. Nesting in 2016 also represents a new record for loggerheads on the core index beaches. FWRI examined the trend from the 1998 nesting high through 2016 and found that the decade-long post-1998 decline was replaced with a slight but nonsignificant increasing trend. Looking at the data from 1989 through 2016, FWRI concluded that there was an overall positive change in the nest counts although it was not statistically significant due to the wide variability between 2012-2016 resulting in widening confidence intervals (http://myfwc.com/research/wildlife/sea-turtles/nesting/loggerhead-trend/).

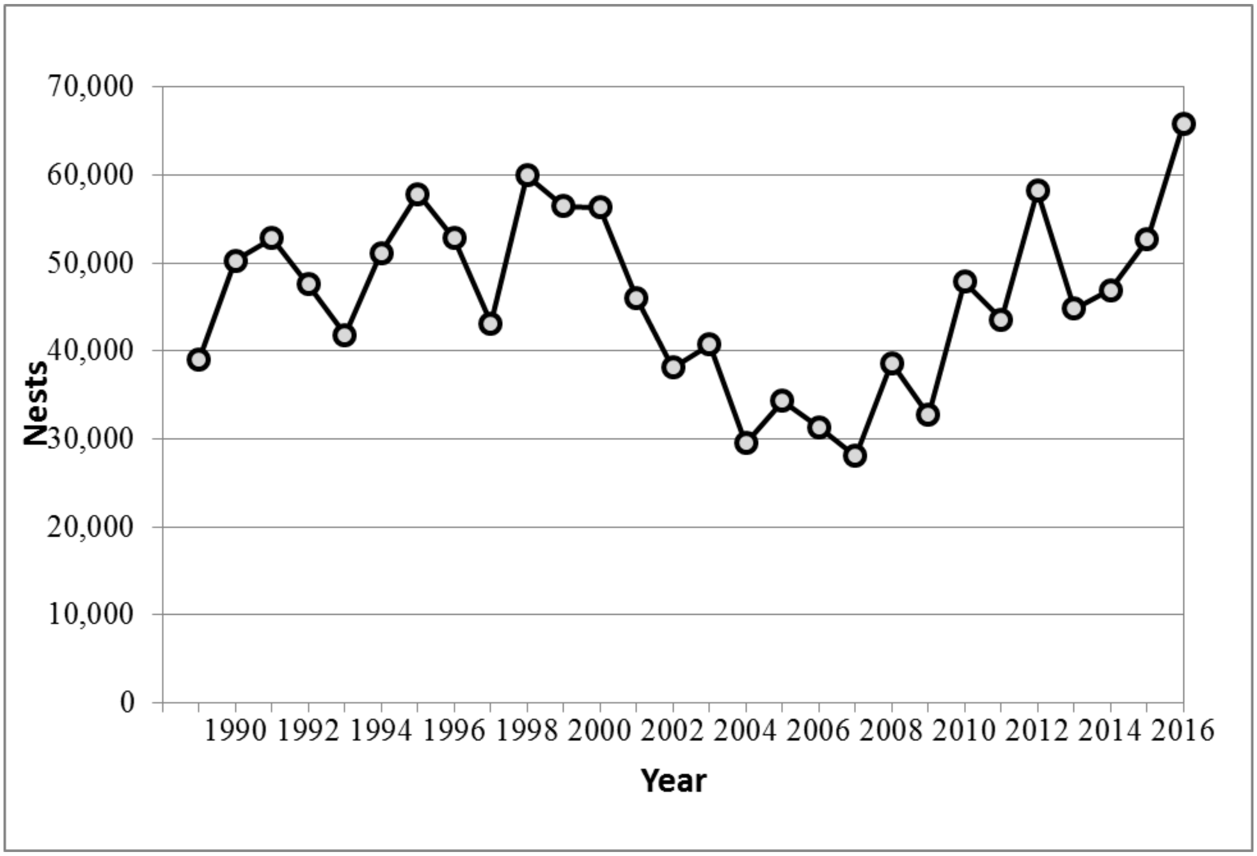

Figure 10. Loggerhead sea turtle nesting at Florida index beaches since 1989

Northern Recovery Unit (NRU)

Annual nest totals from beaches within the NRU averaged 5,215 nests from 1989-2008, a period of near-complete surveys of NRU nesting beaches (GADNR unpublished data, North Carolina Wildlife Resources Commission [NCWRC] unpublished data, SCDNR unpublished data), and represent approximately 1,272 nesting females per year, assuming 4.1 nests per female (Murphy and Hopkins 1984). The loggerhead nesting trend from daily beach surveys showed a significant decline of 1.3% annually from 1989-2008. Nest totals from aerial surveys conducted by SCDNR showed a 1.9% annual decline in nesting in South Carolina from 1980-2008. Overall, there are strong statistical data to suggest the NRU had experienced a long-term decline over that period of time.

Data since that analysis (Table 7) are showing improved nesting numbers and a departure from the declining trend. Georgia nesting has rebounded to show the first statistically significant increasing trend since comprehensive nesting surveys began in 1989 (Mark Dodd, GADNR press release, http://www.georgiawildlife.com/node/3139). South Carolina and North Carolina nesting have also begun to shift away from the past declining trend. Loggerhead nesting in Georgia, South Carolina, and North Carolina all broke records in 2015 and then topped those records again in 2016.

Table 7. Total Number of NRU Loggerhead Nests (GADNR, SCDNR, and NCWRC nesting datasets compiled at Seaturtle.org)

Nests Recorded	2008	2009	2010	2011	2012	2013	2014	2015	2016
Georgia	1,649	998	1,760	1,992	2,241	2,289	1,196	2,319	3,265
South Carolina	4,500	2,182	3,141	4,015	4,615	5,193	2,083	5,104	6,443
North Carolina	841	302	856	950	1,074	1,260	542	1,254	1,612
Total	**6,990**	**3,472**	**5,757**	**6,957**	**7,930**	**8,742**	**3,821**	**8,677**	**11,320**

South Carolina also conducts an index beach nesting survey similar to the one described for Florida. Although the survey only includes a subset of nesting, the standardized effort and locations allow for a better representation of the nesting trend over time. Increases in nesting were seen for the period from 2009-2012, and 2012 shows the highest index nesting total since the start of the program (Figure 11).

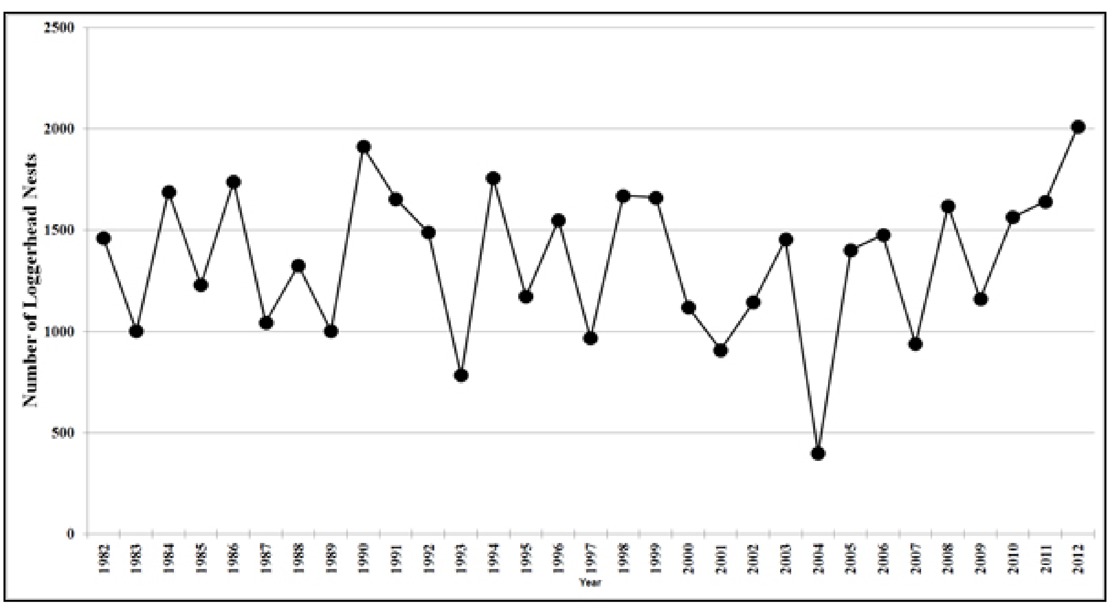

Figure 11. South Carolina index nesting beach counts for loggerhead sea turtles (from the SCDNR website: http://www.dnr.sc.gov/seaturtle/nest.htm)

Other Northwest Atlantic DPS Recovery Units

The remaining 3 recovery units—DTRU, NGMRU, and GCRU—are much smaller nesting assemblages, but they are still considered essential to the continued existence of the species. Nesting surveys for the DTRU are conducted as part of Florida's statewide survey program. Survey effort was relatively stable during the 9-year period from 1995-2004, although the 2002 year was missed. Nest counts ranged from 168-270, with a mean of 246, but there was no detectable trend during this period (NMFS and USFWS 2008). Nest counts for the NGMRU are focused on index beaches rather than all beaches where nesting occurs. Analysis of the 12-year dataset (1997-2008) of index nesting beaches in the area shows a statistically significant declining trend of 4.7% annually. Nesting on the Florida Panhandle index beaches, which represents the majority of NGMRU nesting, had shown a large increase in 2008, but then declined again in 2009 and 2010 before rising back to a level similar to the 2003-2007 average in 2011. Nesting survey effort has been inconsistent among the GCRU nesting beaches, and no trend can be determined for this subpopulation (NMFS and USFWS 2008). Zurita et al. (2003) found a statistically significant increase in the number of nests on 7 of the beaches on Quintana Roo, Mexico, from 1987-2001, where survey effort was consistent during the period. Nonetheless, nesting has declined since 2001, and the previously reported increasing trend appears to not have been sustained (NMFS and USFWS 2008).

In-water Trends

Nesting data are the best current indicator of sea turtle population trends, but in-water data also provide some insight. In-water research suggests the abundance of neritic juvenile loggerheads is steady or increasing. Although Ehrhart et al. (2007) found no significant regression-line trend in a long-term dataset, researchers have observed notable increases in catch per unit effort (CPUE) (Ehrhart et al. 2007; Epperly et al. 2007; Arendt et al. 2009). Researchers believe that this increase in CPUE is likely linked to an increase in juvenile abundance, although it is unclear whether this increase in abundance represents a true population increase among juveniles or merely a shift in spatial occurrence. Bjorndal et al. (2005), cited in NMFS and USFWS (2008), caution about extrapolating localized in-water trends to the broader population and relating localized trends in neritic sites to population trends at nesting beaches. The apparent overall increase in the abundance of neritic loggerheads in the southeastern United States may be due to increased abundance of the largest oceanic/neritic juveniles (historically referred to as small benthic juveniles), which could indicate a relatively large number of individuals around the same age may mature in the near future (TEWG 2009). In-water studies throughout the eastern United States, however, indicate a substantial decrease in the abundance of the smallest oceanic/neritic juvenile loggerheads, a pattern corroborated by stranding data (TEWG 2009).

Population Estimate

The NMFS Southeast Fisheries Science Center developed a preliminary stage/age demographic model to help determine the estimated impacts of mortality reductions on loggerhead sea turtle population dynamics (NMFS-SEFSC 2009). The model uses the range of published information for the various parameters including mortality by stage, stage duration (years in a stage), and fecundity parameters such as eggs per nest, nests per nesting female, hatchling emergence success, sex ratio, and remigration interval. Resulting trajectories of model runs for each individual recovery unit, and the western North Atlantic population as a whole, were found to be very similar. The model run estimates from the adult female population size for the western North Atlantic (from the 2004-2008 time frame), suggest the adult female population size is approximately 20,000-40,000 individuals, with a low likelihood of females' numbering up to 70,000 (NMFS-SEFSC 2009). A less robust estimate for total benthic females in the western North Atlantic was also obtained, yielding approximately 30,000-300,000 individuals, up to less than 1 million (NMFS-SEFSC 2009). A preliminary regional abundance survey of loggerheads within the northwestern Atlantic continental shelf for positively identified loggerhead in all strata estimated about 588,000 loggerheads (interquartile range of 382,000-817,000). When correcting for unidentified turtles in proportion to the ratio of identified turtles, the estimate increased to about 801,000 loggerheads (interquartile range of 521,000-1,111,000) (NMFS-NEFSC 2011).

Threats (Specific to Loggerhead Sea Turtles)
The threats faced by loggerhead sea turtles are well summarized in the general discussion of threats in Section 4.2.1. Yet the impact of fishery interactions is a point of further emphasis for this species. The joint NMFS and USFWS Loggerhead Biological Review Team determined that the greatest threats to the NWA DPS of loggerheads result from cumulative fishery bycatch in neritic and oceanic habitats (Conant et al. 2009).

Regarding the impacts of pollution, loggerheads may be particularly affected by organochlorine contaminants; they have the highest organochlorine concentrations (Storelli et al. 2008) and metal loads (D'ilio et al. 2011) in sampled tissues among the sea turtle species. It is thought that dietary preferences were likely to be the main differentiating factor among sea turtle species. Storelli et al. (2008) analyzed tissues from stranded loggerhead sea turtles and found that mercury accumulates in sea turtle livers while cadmium accumulates in their kidneys, as has been reported for other marine organisms like dolphins, seals, and porpoises (Law et al. 1991).

While oil spill impacts are discussed generally for all species in Section 4.2.1, specific impacts of the DWH oil spill event on loggerhead sea turtles are considered here. Impacts to loggerhead sea turtles occurred to offshore small juveniles as well as large juveniles and adults. A total of 30,800 small juvenile loggerheads (7.3% of the total small juvenile sea turtle exposures to oil from the spill) were estimated to have been exposed to oil. Of those exposed, 10,700 small juveniles are estimated to have died as a result of the exposure. In contrast to small juveniles, loggerheads represented a large proportion of the adults and large juveniles exposed to and killed by the oil. There were 30,000 exposures (almost 52% of all exposures for those age/size classes) and 3,600 estimated mortalities. A total of 265 nests (27,618 eggs) were also translocated during response efforts, with 14,216 hatchlings released, the fate of which is unknown (DWH Trustees 2015). Additional unquantified effects may have included inhalation of volatile compounds, disruption of foraging or migratory movements due to surface or subsurface oil, ingestion of prey species contaminated with oil and/or dispersants, and loss of foraging resources which could lead to compromised growth and/or reproductive potential. There is no information currently available to determine the extent of those impacts, if they occurred.

The majority of nesting for the NWA loggerhead DPS occurs on the Atlantic coast, and thus loggerheads were impacted to a relatively lesser degree. However, it is likely that impacts to the NGMRU of the NWA loggerhead DPS would be proportionally much greater than the impacts occurring to other recovery units. Impacts to nesting and oiling effects on a large proportion of the NGMRU recovery unit, especially mating and nesting adults likely had an impact on the NGMRU. Based on the response injury evaluations for Florida Panhandle and Alabama nesting beaches (which fall under the NFMRU), the Trustees estimated that approximately 20,000 loggerhead hatchlings were lost due to DWH oil spill response activities on nesting beaches. Although the long-term effects remain unknown, the DWH oil spill event impacts to the Northern Gulf of Mexico Recovery Unit may result in some nesting declines in the future due to a large reduction of oceanic age classes during the DWH oil spill event. Although adverse impacts occurred to loggerheads, the proportion of the population that is expected to have been exposed to and directly impacted by the DWH oil spill event is relatively low. Thus we do not believe a population-level impact occurred due to the widespread distribution and nesting location outside of the Gulf of Mexico for this species.

Specific information regarding potential climate change impacts on loggerheads is also available. Modeling suggests an increase of 2°C in air temperature would result in a sex ratio of over 80% female offspring for loggerheads nesting near Southport, North Carolina. The same increase in air temperatures at nesting beaches in Cape Canaveral, Florida, would result in close to 100% female offspring. Such highly skewed sex ratios could undermine the reproductive capacity of the species. More ominously, an air temperature increase of 3°C is likely to exceed the thermal threshold of most nests, leading to egg mortality (Hawkes et al. 2007). Warmer sea surface temperatures have also been correlated with an earlier onset of loggerhead nesting in the spring (Weishampel et al. 2004; Hawkes et al. 2007), short inter-nesting intervals (Hays et al. 2002), and shorter nesting seasons (Pike et al. 2006).

4.2.1.4 Hawksbill Sea Turtle (*Eretmochelys imbricata*)

The hawksbill sea turtle was listed as endangered throughout its entire range on June 2, 1970 (35 FR 8491), under the Endangered Species Conservation Act of 1969, a precursor to the ESA. Critical habitat was designated on June 2, 1998, in coastal waters surrounding Mona and Monito Islands in Puerto Rico (63 FR 46693).

Species Description and Distribution

Hawksbill sea turtles are small- to medium-sized (99-150 lb on average [45-68 kg]) although females nesting in the Caribbean are known to weigh up to 176 lb (80 kg) (Pritchard et al. 1983). The carapace is usually serrated and has a tortoise-shell" coloring, ranging from dark to golden brown, with streaks of orange, red, and/or black. The plastron of a hawksbill turtle is typically yellow. The head is elongated and tapers to a point, with a beak-like mouth that gives the species its name. The shape of the mouth allows the hawksbill turtle to reach into holes and crevices of coral reefs to find sponges, their primary adult food source, and other invertebrates. The shells of hatchlings are 1.7 in (42 mm) long, are mostly brown, and are somewhat heart-shaped (Hillis and Mackay 1989; van Dam and Sarti 1989; Eckert 1995).

Hawksbill sea turtles have a circumtropical distribution and usually occur between latitudes 30°N and 30°S in the Atlantic, Pacific, and Indian Oceans. In the western Atlantic, hawksbills are widely distributed throughout the Caribbean Sea, off the coasts of Florida and Texas in the continental United States, in the Greater and Lesser Antilles, and along the mainland of Central America south to Brazil (Lund 1985; Plotkin and Amos 1988; Amos 1989; Groombridge and

Luxmoore 1989; Plotkin and Amos 1990; NMFS and USFWS 1998; Meylan and Donnelly 1999). They are highly migratory and use a wide range of habitats during their lifetimes (Musick and Limpus 1997; Plotkin 2003). Adult hawksbill sea turtles are capable of migrating long distances between nesting beaches and foraging areas. For instance, a female hawksbill sea turtle tagged at Buck Island Reef National Monument (BIRNM) in St. Croix was later identified 1,160 mi (1,866 km) away in the Miskito Cays in Nicaragua (Spotila 2004).

Hawksbill sea turtles nest on sandy beaches throughout the tropics and subtropics. Nesting occurs in at least 70 countries, although much of it now only occurs at low densities compared to that of other sea turtle species (NMFS and USFWS 2007b). Meylan and Donnelly (1999) believe that the widely dispersed nesting areas and low nest densities is likely a result of overexploitation of previously large colonies that have since been depleted over time. The most significant nesting within the United States occurs in Puerto Rico and the U.S. Virgin Islands, specifically on Mona Island and BIRNM, respectively. Although nesting within the continental United States is typically rare, it can occur along the southeast coast of Florida and the Florida Keys. The largest hawksbill nesting population in the western Atlantic occurs in the Yucatán Peninsula of Mexico, where several thousand nests are recorded annually in the states of Campeche, Yucatán, and Quintana Roo (Spotila 2004; Garduño-Andrade et al. 1999). In the U.S. Pacific, hawksbills nest on main island beaches in Hawaii, primarily along the east coast of the island. Hawksbill nesting has also been documented in American Samoa and Guam. More information on nesting in other ocean basins may be found in the 5-year status review for the species (NMFS and USFWS 2007a).

Mitochondrial DNA studies show that reproductive populations are effectively isolated over ecological time scales (Bass et al. 1996). Substantial efforts have been made to determine the nesting population origins of hawksbill sea turtles assembled in foraging grounds, and genetic research has shown that hawksbills of multiple nesting origins commonly mix in foraging areas (Bowen and Witzell 1996). Since hawksbill sea turtles nest primarily on the beaches where they were born, if a nesting population is decimated, it might not be replenished by sea turtles from other nesting rookeries (Bass et al. 1996).

Life History Information

Hawksbill sea turtles exhibit slow growth rates although they are known to vary within and among populations from a low of 0.4-1.2 in (1-3 cm) per year, measured in the Indo-Pacific (Chaloupka and Limpus 1997; Whiting 2000; Mortimer et al. 2002; Mortimer et al. 2003), to a high of 2 in (5 cm) or more per year, measured at some sites in the Caribbean (León and Diez 1999; Diez and Van Dam 2002). Differences in growth rates are likely due to differences in diet and/or density of sea turtles at foraging sites and overall time spent foraging (Bjorndal and Bolten 2002; Chaloupka et al. 2004). Consistent with slow growth, age to maturity for the species is also long, taking between 20 and 40 years, depending on the region (Chaloupka and Musick 1997; Limpus and Miller 2000). Hawksbills in the western Atlantic are known to mature faster (i.e., 20 or more years) than sea turtles found in the Indo-Pacific (i.e., 30-40 years) (Boulan 1983; Boulon Jr. 1994; Limpus and Miller 2000; Diez and Van Dam 2002). Males are typically mature when their length reaches 27 in (69 cm), while females are typically mature at 30 in (75 cm) (Limpus 1992; Eckert et al. 1992).

Female hawksbills return to the beaches where they were born (natal beaches) every 2-3 years to nest (Witzell 1983; Van Dam et al. 1991) and generally lay 3-5 nests per season (Richardson et al. 1999). Compared with other sea turtles, the number of eggs per nest (clutch) for hawksbills can be quite high. The largest clutches recorded for any sea turtle belong to hawksbills (approximately 250 eggs per nest) ((Hirth and Latif 1980), though nests in the U.S. Caribbean and Florida more typically contain approximately 140 eggs (USFWS hawksbill fact sheet, http://www.fws.gov/northflorida/SeaTurtles/Turtle%20Factsheets/hawksbill-sea-turtle.htm). Eggs incubate for approximately 60 days before hatching (USFWS hawksbill fact sheet). Hatchling hawksbill sea turtles typically measure 1-2 in (2.5-5 cm) in length and weigh approximately 0.5 oz (15 g).

Hawksbills may undertake developmental migrations (migrations as immatures) and reproductive migrations that involve travel over many tens to thousands of miles (Meylan 1999a). Post-hatchlings (oceanic stage juveniles) are believed to live in the open ocean, taking shelter in floating algal mats and drift lines of flotsam and jetsam in the Atlantic and Pacific oceans (Musick and Limpus 1997) before returning to more coastal foraging grounds. In the Caribbean, hawksbills are known to almost exclusively feed on sponges (Meylan 1988; Van Dam and Diez 1997), although at times they have been seen foraging on other food items, notably corallimorphs (coral anemones or false corals, an order of marine cnidarians closely related to stony corals) and zooanthids (small soft corals) (Van Dam and Diez 1997; Mayor 1998; León and Diez 2000).

Reproductive females undertake periodic (usually non-annual) migrations to their natal beaches to nest and exhibit a high degree of fidelity to their nest sites. Movements of reproductive males are less certain, but are presumed to involve migrations to nesting beaches or to courtship stations along the migratory corridor. Hawksbills show a high fidelity to their foraging areas as well (Van Dam and Diez 1998). Foraging sites are typically areas associated with coral reefs, although hawksbills are also found around rocky outcrops and high energy shoals which are optimum sites for sponge growth. They can also inhabit seagrass pastures in mangrove-fringed bays and estuaries, particularly along the eastern shore of continents where coral reefs are absent (Bjorndal 1997; Van Dam and Diez 1998).

Status and Population Dynamics

There are currently no reliable estimates of population abundance and trends for non-nesting hawksbills at the time of this consultation; therefore, nesting beach data is currently the primary information source for evaluating trends in global abundance. Most hawksbill populations around the globe are either declining, depleted, and/or remnants of larger aggregations (NMFS and USFWS 2007a). The largest nesting population of hawksbills occurs in Australia where approximately 2,000 hawksbills nest off the northwest coast and about 6,000-8,000 nest off the Great Barrier Reef each year (Spotila 2004). Additionally, about 2,000 hawksbills nest each year in Indonesia and 1,000 nest in the Republic of Seychelles (Spotila 2004). In the United States, hawksbills typically laid about 500-1,000 nests on Mona Island, Puerto Rico in the past (Diez and Van Dam 2007), but the numbers appear to be increasing, as the Puerto Rico Department of Natural and Environmental Resources counted nearly 1,600 nests in 2010 (PRDNER nesting data). Another 56-150 nests are typically laid on Buck Island off St. Croix (Meylan 1999b; Mortimer and Donnelly 2008a). Nesting also occurs to a lesser extent on beaches on Culebra

Island and Vieques Island in Puerto Rico, the mainland of Puerto Rico, and additional beaches on St. Croix, St. John, and St. Thomas, U.S. Virgin Islands.

Mortimer and Donnelly (2008a) reviewed nesting data for 83 nesting concentrations organized among 10 different ocean regions (i.e., Insular Caribbean, Western Caribbean Mainland, Southwestern Atlantic Ocean, Eastern Atlantic Ocean, Southwestern Indian Ocean, Northwestern Indian Ocean, Central Indian Ocean, Eastern Indian Ocean, Western Pacific Ocean, Central Pacific Ocean, and Eastern Pacific Ocean). They determined historic trends (i.e., 20-100 years ago) for 58 of the 83 sites, and also determined recent abundance trends (i.e., within the past 20 years) for 42 of the 83 sites. Among the 58 sites where historic trends could be determined, all showed a declining trend during the long-term period. Among the 42 sites where recent (past 20 years) trend data were available, 10 appeared to be increasing, 3 appeared to be stable, and 29 appeared to be decreasing. With respect to regional trends, nesting populations in the Atlantic (especially in the Insular Caribbean and Western Caribbean Mainland) are generally doing better than those in the Indo-Pacific regions. For instance, 9 of the 10 sites that showed recent increases are located in the Caribbean. Buck Island and St. Croix's East End beaches support 2 remnant populations of between 17-30 nesting females per season (Hillis and Mackay 1989; Mackay 2006). While the proportion of hawksbills nesting on Buck Island represents a small proportion of the total hawksbill nesting occurring in the greater Caribbean region, Mortimer and Donnelly (2008a) report an increasing trend in nesting at that site based on data collected from 2001-2006. The conservation measures implemented when BIRNM was expanded in 2001 most likely explains this increase.

Nesting concentrations in the Pacific Ocean appear to be performing the worst of all regions despite the fact that the region currently supports more nesting hawksbills than either the Atlantic or Indian Oceans (Mortimer and Donnelly 2008a). While still critically low in numbers, sightings of hawksbills in the eastern Pacific appear to have been increasing since 2007, though some of that increase may be attributable to better observations (Gaos et al. 2010). More information about site-specific trends can be found in the most recent 5-year status review for the species (NMFS and USFWS 2007a).

Threats

Hawksbills are currently subjected to the same suite of threats on both nesting beaches and in the marine environment that affect other sea turtles (e.g., interaction with federal and state fisheries, coastal construction, oil spills, climate change affecting sex ratios) as discussed in Section 4.2.1. There are also specific threats that are of special emphasis, or are unique, for hawksbill sea turtles discussed in further detail below.

While oil spill impacts are discussed generally for all species in Section 4.2.1, specific impacts of the DWH spill on hawksbill turtles have been estimated. Hawksbills made up 2.2% (8,850) of small juvenile sea turtle (of those that could be identified to species) exposures to oil in offshore areas, with an estimate of 615 to 3,090 individuals dying as a result of the direct exposure (DWH Trustees 2015). No quantification of large benthic juveniles or adults was made. Additional unquantified effects may have included inhalation of volatile compounds, disruption of foraging or migratory movements due to surface or subsurface oil, ingestion of prey species contaminated with oil and/or dispersants, and loss of foraging resources which could lead to compromised growth and/or reproductive potential. There is no information currently available to determine the extent of those impacts, if they occurred. Although adverse impacts occurred to hawksbills, the relative proportion of the population that is expected to have been exposed to and directly impacted by the DWH event is relatively low, and thus a population-level impact is not believed to have occurred due to the widespread distribution and nesting location outside of the Gulf of Mexico for this species.

The historical decline of the species is primarily attributed to centuries of exploitation for the beautifully patterned shell, which made it a highly attractive species to target (Parsons 1972). The fact that reproductive females exhibit a high fidelity for nest sites and the tendency of hawksbills to nest at regular intervals within a season made them an easy target for capture on nesting beaches. The shells from hundreds of thousands of sea turtles in the western Caribbean region were imported into the United Kingdom and France during the nineteenth and early twentieth centuries (Parsons 1972). Additionally, hundreds of thousands of sea turtles contributed to the region's trade with Japan prior to 1993 when a zero quota was imposed (Milliken and Tokunaga 1987), as cited in Brautigam and Eckert (2006).

The continuing demand for the hawksbills' shells as well as other products derived from the species (e.g., leather, oil, perfume, and cosmetics) represents an ongoing threat to its recovery. The British Virgin Islands, Cayman Islands, Cuba, Haiti, and the Turks and Caicos Islands (United Kingdom) all permit some form of legal take of hawksbill sea turtles. In the northern Caribbean, hawksbills continue to be harvested for their shells, which are often carved into hair clips, combs, jewelry, and other trinkets (Márquez M. 1990; Stapleton and Stapleton 2006). Additionally, hawksbills are harvested for their eggs and meat, while whole, stuffed sea turtles are sold as curios in the tourist trade. Hawksbill sea turtle products are openly available in the Dominican Republic and Jamaica, despite a prohibition on harvesting hawksbills and their eggs (Fleming 2001). Up to 500 hawksbills per year from 2 harvest sites within Cuba were legally captured each year until 2008 when the Cuban government placed a voluntary moratorium on the sea-turtle fishery (Carillo et al. 1999; Mortimer and Donnelly 2008a). While current nesting trends are unknown, the number of nesting females is suspected to be declining in some areas (Carillo et al. 1999; Moncada et al. 1999). International trade in the shell of this species is prohibited between countries that have signed the Convention on International Trade in Endangered Species of Wild Flora and Fauna, but illegal trade still occurs and remains an ongoing threat to hawksbill survival and recovery throughout its range.

Due to their preference to feed on sponges associated with coral reefs, hawksbill sea turtles are particularly sensitive to losses of coral reef communities. Coral reefs are vulnerable to destruction and degradation caused by human activities (e.g., nutrient pollution, sedimentation, contaminant spills, vessel groundings and anchoring, recreational uses) and are also highly sensitive to the effects of climate change (e.g., higher incidences of disease and coral bleaching) (Wilkinson 2004; Crabbe 2008). Because continued loss of coral reef communities (especially in the greater Caribbean region) is expected to impact hawksbill foraging, it represents a major threat to the recovery of the species.

4.2.2 General Threats Faced by All Coral Species

Corals face numerous natural and man-made threats that shape their status and affect their ability to recover. Because many of the threats are either the same or similar in nature for all listed coral species, those identified in this section are discussed in a general sense for all corals. All threats are expected to increase in severity in the future. More detailed information on the threats to listed corals is found in the Final Listing Rule (79 FR 53851; September 10, 2014). Threat information specific to a particular species is then discussed in the corresponding status sections where appropriate.

Several of the most important threats contributing to the extinction risk of corals are related to global climate change. The main concerns regarding impacts of global climate change on coral reefs generally, and on listed corals in particular, are the magnitude and the rapid pace of change in greenhouse gas (GHG) concentrations (e.g., carbon dioxide [CO_2] and methane) and atmospheric warming since the Industrial Revolution in the mid-19th century. These changes are increasing the warming of the global climate system and altering the carbonate chemistry of the ocean (ocean acidification). Ocean acidification affects a number of biological processes in corals, including secretion of their skeletons.

Ocean Warming

Ocean warming is one of the most important threats posing extinction risks to the listed coral species, but individual susceptibility varies among species. The primary observable coral response to ocean warming is bleaching of adult coral colonies, wherein corals expel their symbiotic algae in response to stress. For many corals, an episodic increase of only 1°C–2°C above the normal local seasonal maximum ocean temperature can induce bleaching. Corals can withstand mild to moderate bleaching; however, severe, repeated, and/or prolonged bleaching can lead to colony death. Coral bleaching patterns are complex, with several species exhibiting seasonal cycles in symbiotic algae density. Thermal stress has led to bleaching and mass mortality in many coral species during the past 25 years.

In addition to coral bleaching, other effects of ocean warming can harm virtually every life-history stage in reef-building corals. Impaired fertilization, developmental abnormalities, mortality, impaired settlement success, and impaired calcification of early life phases have all been documented. Average seawater temperatures in reef-building coral habitat in the wider Caribbean have increased during the past few decades and are predicted to continue to rise between now and 2100. Further, the frequency of warm-season temperature extremes (warming events) in reef-building coral habitat has increased during the past 2 decades and is predicted to continue to increase between now and 2100.

Ocean Acidification

Ocean acidification is a result of global climate change caused by increased CO_2 in the atmosphere that results in greater releases of CO_2 that is then absorbed by seawater. Reef-building corals produce skeletons made of the aragonite form of calcium carbonate. Ocean acidification reduces aragonite concentrations in seawater, making it more difficult for corals to build their skeletons. Ocean acidification has the potential to cause substantial reduction in coral calcification and reef cementation. Further, ocean acidification impacts adult growth rates and fecundity, fertilization, pelagic planula settlement, polyp development, and juvenile growth.

Ocean acidification can lead to increased colony breakage, fragmentation, and mortality. Based on observations in areas with naturally low pH, the effects of increasing ocean acidification may also include reductions in coral size, cover, diversity, and structural complexity.

As CO_2 concentrations increase in the atmosphere, more CO_2 is absorbed by the oceans, causing lower pH and reduced availability of calcium carbonate. Because of the increase in CO_2 and other GHGs in the atmosphere since the Industrial Revolution, ocean acidification has already occurred throughout the world's oceans, including in the Caribbean, and is predicted to increase considerably between now and 2100. Along with ocean warming and disease, we consider ocean acidification to be one of the most important threats posing extinction risks to coral species between now and the year 2100, although individual susceptibility varies among the listed corals.

Diseases

Disease adversely affects various coral life history events by, among other processes, causing adult mortality, reducing sexual and asexual reproductive success, and impairing colony growth. A diseased state results from a complex interplay of factors including the cause or agent (e.g., pathogen, environmental toxicant), the host, and the environment. All coral disease impacts are presumed to be attributable to infectious diseases or to poorly-described genetic defects. Coral disease often produces acute tissue loss. Other forms of "disease" in the broader sense, such as temperature-caused bleaching, are discussed in other threat sections (e.g., ocean warming as a result of climate change).

Coral diseases are a common and significant threat affecting most or all coral species and regions to some degree, although the scientific understanding of individual disease causes in corals remains very poor. The incidence of coral disease appears to be expanding geographically, though the prevalence of disease is highly variable between sites and species. Increased prevalence and severity of diseases is correlated with increased water temperatures, which may correspond to increased virulence of pathogens, decreased resistance of hosts, or both. Moreover, the expanding coral disease threat may result from opportunistic pathogens that become damaging only in situations where the host integrity is compromised by physiological stress or immune suppression. Overall, there is mounting evidence that warming temperatures and coral bleaching responses are linked (albeit with mixed correlations) with increased coral disease prevalence and mortality.

Trophic Effects of Reef Fishing

Fishing, particularly overfishing, can have large-scale, long-term ecosystem-level effects that can change ecosystem structure from coral-dominated reefs to algal-dominated reefs ("phase shifts"). Even fishing pressure that does not rise to the level of overfishing potentially can alter trophic interactions that are important in structuring coral reef ecosystems. These trophic interactions include reducing population abundance of herbivorous fish species that control algal growth, limiting the size structure of fish populations, reducing species richness of herbivorous fish, and releasing corallivores from predator control.

In the Caribbean, parrotfishes can graze at rates of more than 150,000 bites per square meter per day (Carpenter 1986), and thereby remove up to 90-100% of the daily primary production (e.g., algae; Hatcher 1997). With substantial populations of herbivorous fishes, as long as the cover of living coral is high and resistant to mortality from environmental changes, it is very unlikely that the algae will take over and dominate the substrate. However, if herbivorous fish populations, particularly large-bodied parrotfish, are heavily fished and a major mortality of coral colonies occurs, then algae can grow rapidly and prevent the recovery of the coral population. The ecosystem can then collapse into an alternative stable state, a persistent phase shift in which algae replace corals as the dominant reef species. Although algae can have negative effects on adult coral colonies (e.g., overgrowth, bleaching from toxic compounds), the ecosystem-level effects of algae are primarily from inhibited coral recruitment. Filamentous algae can prevent the colonization of the substrate by planula larvae by creating sediment traps that obstruct access to a hard substrate for attachment. Additionally, macroalgae can block successful colonization of the bottom by corals because the macroalgae takes up the available space and causes shading, abrasion, chemical poisoning, and infection with bacterial disease. Trophic effects of fishing are a medium importance threat to the extinction risk for listed corals.

Sedimentation

Human activities in coastal and inland watersheds introduce sediment into the ocean by a variety of mechanisms including river discharge, surface runoff, groundwater seeps, and atmospheric deposition. Humans also introduce sewage into coastal waters through direct discharge, treatment plants, and septic leakage. Elevated sediment levels are generated by poor land use practices and coastal and nearshore construction.

The most common direct effect of sedimentation is sediment's landing on coral surfaces as it settles out from the water column. Corals with certain morphologies (e.g., mounding) can passively reject settling sediments. In addition, corals can actively remove sediment but at a significant energy cost. Corals with large calices (skeletal component that holds the polyp) tend to be better at actively rejecting sediment. Some coral species can tolerate complete burial for several days. Corals that cannot remove sediment will be smothered and die. Sediment can also cause sublethal effects such as reductions in tissue thickness, polyp swelling, zooxanthellae loss, and excess mucus production. In addition, suspended sediment can reduce the amount of light in the water column, making less energy available for coral photosynthesis and growth. Sedimentation also impedes fertilization of spawned gametes and reduces larval settlement and survival of recruits and juveniles.

Nutrient Enrichment

Elevated nutrient concentrations in seawater affect corals through 2 main mechanisms: direct impacts on coral physiology, and indirect effects through stimulation of other community components (e.g., macroalgal turfs and seaweeds, and filter feeders) that compete with corals for space on the reef. Increased nutrients can decrease calcification; however, nutrients may also enhance linear extension while reducing skeletal density. Either condition results in corals that are more prone to breakage or erosion, but individual species do have varying tolerances to increased nutrients. Anthropogenic nutrients mainly come from point-source discharges (such as rivers or sewage outfalls) and surface runoff from modified watersheds. Natural processes, such as *in situ* nitrogen fixation and delivery of nutrient-rich deep water by internal waves and upwelling, also bring nutrients to coral reefs.

4.2.2.1 Elkhorn Coral (*Acropora palmata*)

Elkhorn coral was listed as threatened under the ESA in May 2006 (71 FR 26852). In December 2012, NMFS proposed changing its status from threatened to endangered (77 FR 73219). On September 10, 2014, NMFS determined that elkhorn coral should remain listed as threatened (79 FR 53851).

Species Description and Distribution
Elkhorn coral colonies have frond-like branches, which appear flattened to near round, and typically radiate out from a central trunk and angle upward. Branches are up to approximately 20 in (50 cm) wide and range in thickness from about 1.5-2 in (4 to 5 cm). Individual colonies can grow to at least 6.5 ft (2 m) in height and 13 ft (4 m) in diameter (*Acropora* Biological Review Team 2005). Colonies of elkhorn coral can grow in nearly single-species, dense stands and form an interlocking framework known as thickets.

Elkhorn coral is distributed throughout the western Atlantic, Caribbean, and Gulf of Mexico. The northern extent of the range in the Atlantic is Broward County, Florida, where it is relatively rare (only a few known colonies), but fossil elkhorn coral reef framework extends into Palm Beach County, Florida. There are 2 known colonies of elkhorn coral, which were discovered in 2003 and 2005, at the Flower Garden Banks, which is located 100 mi (161 km) off the coast of Texas in the Gulf of Mexico (Zimmer et al. 2006). The species has been affected by extirpation from many localized areas throughout its range (Jackson et al. 2014).

Goreau (1959) described 10 habitat zones on a Jamaican fringing reef from inshore to the deep slope, finding elkhorn coral in 8 of the 10 zones. Elkhorn coral commonly grows in turbulent water on the fore-reef, reef crest, and shallow spur-and-groove zone (Cairns 1982b; Miller et al. 2008; Rogers et al. 1982; Shinn 1963) in water ranging from approximately 3-15 ft (1-5 m) depth. Elkhorn coral often grows in thickets in fringing and barrier reefs (Jaap 1984; Tomascik and Sander 1987; Wheaton and Jaap 1988) and formed extensive barrier-reef structures in Belize (Cairns 1982b), the greater and lesser Corn Islands, Nicaragua (Lighty et al. 1982), and Roatan, Honduras, and built extensive fringing reef structures throughout much of the Caribbean (Adey 1978). Early studies termed the reef crest and adjacent seaward areas from the surface down to approximately 20 ft (5-6 m) depth the “palmata zone” because of the domination by the species (Goreau 1959; Shinn 1963). Although elkhorn coral’s predominant habitat is reef crests and shallow fore-reefs less than 40 ft (12 m) in depth, it also occasionally occurs in back-reef environments and in depths up to 98 ft (30 m).

Life History Information
Relative to other corals, elkhorn coral has a high growth rate that have allowed acroporid reef growth to keep pace with past changes in sea level (Fairbanks 1989). Growth rates, measured as skeletal extension of the end of branches, range from approximately 2-4 in (4-11 cm) per year (Acropora Biological Review Team 2005). However, growth rates in Curaçao have been reported to be slower today than they were several decades ago (Brainard et al. 2011a). Annual linear extension has been found to be dependent on the size of the colony, and new recruits and juveniles typically grow at slower rates. Additionally, stressed colonies and fragments may also exhibit slower growth.

Elkhorn coral is a hermaphroditic broadcast spawning species that reproduces sexually after the full moon of July, August, and/or September, depending on location and timing of the full moon (Acropora Biological Review Team 2005). Split spawning (spawning over a 2 month period) has been reported from the Florida Keys (Fogarty et al. 2012). The estimated size at sexual maturity is approximately 250 in^2 (1,600 cm^2), and growing edges and encrusting base areas are not fertile (Soong and Lang 1992). Larger colonies have higher fecundity per unit area, as do the upper branch surfaces (Soong and Lang 1992). Although self-fertilization is possible, elkhorn coral is largely self-incompatible (Baums et al. 2005a; Fogarty et al. 2012); .

Sexual recruitment rates are low, and this species is generally not observed in coral settlement studies in the field. Rates of post-settlement mortality after 9 months are high based on settlement experiments (Szmant and Miller 2005). Laboratory studies have found that certain species of crustose-coralline algae facilitate larval settlement and post-settlement survival (Ritson-Williams et al. 2010). Laboratory experiments have shown that some individuals (i.e., genotypes) are sexually incompatible (Baums 2013) and that the proportion of eggs fertilized increases with higher sperm concentration (Fogarty et al. 2012). Experiments using gametes collected in Florida and Belize showed that Florida corals had lower fertilization rates than those from Belize, possibly due to genotype incompatibilities (Fogarty et al. 2012).

Reproduction occurs primarily through asexual fragmentation that produces multiple colonies that are genetically identical (Bak and Criens 1982; Highsmith 1982; Lirman 2000; Miller et al. 2007; Wallace 1985). Storms can be a method of producing fragments to establish new colonies (Fong and Lirman 1995). Fragmentation is an important mode of reproduction in many reef-building corals, especially for branching species such as elkhorn coral (Highsmith 1982; Lirman 2000; Wallace 1985). However, in the Florida Keys where populations have declined, there have been reports of failure of asexual recruitment due to high fragment mortality after storms (Porter et al. 2012; Williams and Miller 2010; Williams et al. 2008).

The combination of relatively rapid skeletal growth rates and frequent asexual reproduction by fragmentation can enable effective competition within, and domination of, elkhorn coral in reef-high-energy environments such as reef crests. Rapid skeletal growth rates and frequent asexual reproduction by fragmentation facilitate potential recovery from disturbances when environmental conditions permit (Highsmith 1982; Lirman 2000). However, low sexual reproduction can lead to reduced genetic diversity and limits the capacity to repopulate sites distant from the parent.

Status and Population Dynamics

Information on elkhorn coral status and populations dynamics is spotty throughout its range. Comprehensive and systematic census and monitoring has not been conducted. Thus, the status and populations dynamics must be inferred from the few locations were data exist.

There appears to be 2 distinct populations of elkhorn coral. Genetic samples from 11 locations throughout the Caribbean indicate that elkhorn coral populations in the eastern Caribbean (St. Vincent and the Grenadines, U.S. Virgin Islands, Curaçao, and Bonaire) have had little or no genetic exchange with populations in the western Atlantic and western Caribbean (Bahamas, Florida, Mexico, Panama, Navassa, and Puerto Rico) (Baums et al. 2005b). While Puerto Rico is more closely connected with the western Caribbean, it is an area of mixing with contributions from both regions (Baums et al. 2005b). Models suggest that the Mona Passage between the Dominican Republic and Puerto Rico acts as a filter for larval dispersal and gene flow between the eastern Caribbean and western Caribbean (Baums et al. 2006b).

The western Caribbean is characterized by genetically depauperate populations with lower densities (0.13 ± 0.08 colonies per m^2), while denser (0.30 ± 0.21 colonies per m2), genotypically rich stands characterize the eastern Caribbean (Baums et al. 2006a). Baums et al. (2006a) concluded that the western Caribbean had higher rates of asexual recruitment and that the eastern Caribbean had higher rates of sexual recruitment. They postulated these geographic differences in the contribution of reproductive modes to population structure may be related to habitat characteristics, possibly the amount of shelf area available.

Genotypic diversity is highly variable. At 2 sites in the Florida Keys, only one genotype per site was detected out of 20 colonies sampled at each site (Baums et al. 2005a). In contrast, all 15 colonies sampled in Navassa had unique genotypes (Baums et al. 2006a). Some sites have relatively high genotypic diversity such as in Los Roques, Venezuela (118 unique genotypes out of 120 samples; (Zubillaga et al. 2008) and in Bonaire and Curaçao (18 genotypes of 22 samples and 19 genotypes of 20 samples, respectively; (Baums et al. 2006a). In the Bahamas, about one third of the sampled colonies were unique genotypes, and in Panama between 24 and 65 % of the sampled colonies had unique genotypes, depending on the site (Baums et al. 2006a).

A genetic study found significant population structure in Puerto Rico locations (Mona Island, Desecheo Island, La Parguera) both between reefs and between locations; population structure in La Parguera suggests restriction of gene flow between some reefs in close proximity (Garcia Reyes and Schizas 2010). A more-recent study provided additional detail on the genetic structure of elkhorn coral in Puerto Rico, as compared to Curaçao, the Bahamas, and Guadeloupe that found unique genotypes in 75 % of the samples with high genetic diversity (Mège et al. 2014). The recent results support 2 separate populations of elkhorn coral in the eastern Caribbean and western Caribbean; however, there is less evidence for separation at Mona Passage, as found by Baums et al. (2006a).

Elkhorn coral was historically one of the dominant species on Caribbean reefs, forming large, monotypic thickets and giving rise to the nominal distinct zone in classical descriptions of Caribbean reef morphology (Goreau 1959). Mass mortality, apparently from white-band disease (Aronson and Precht 2001), spread throughout the Caribbean in the mid-1970s to mid-1980s and precipitated widespread and radical changes in reef community structure (Brainard et al. 2011a). This mass mortality occurred throughout the range of the species within all Caribbean countries and archipelagos, even on reefs and banks far from localized human influence (Aronson and Precht 2001; Wilkinson 2008b). In addition, continuing coral mortality from periodic acute events such as hurricanes, disease outbreaks, and mass bleaching events added to the decline of elkhorn coral (Brainard et al. 2011a). In locations where historic quantitative data are available (Florida, Jamaica, U.S. Virgin Islands), there was a reduction of greater than 97% between the 1970s and early 2000s in elkhorn coral populations (Acropora Biological Review Team 2005).

Since the 2006 listing of elkhorn coral, continued population declines have occurred in some locations with certain populations of elkhorn coral decreasing up to an additional 50% or more (Colella et al. 2012; Lundgren and Hillis-Starr 2008; Muller et al. 2008; Rogers and Muller 2012; Williams et al. 2008). In addition, Williams et al. (2008) reported asexual recruitment failure between 2004 and 2007 in the upper Florida Keys after a major hurricane season in 2005; less than 5% of the fragments produced recruited into the population. In contrast, several studies describe elkhorn coral populations that are showing some signs of recovery or are stable including in the Turks and Caicos Islands (Schelten et al. 2006), U.S. Virgin Islands (Grober-Dunsmore et al. 2006; Mayor et al. 2006; Rogers and Muller 2012), Venezuela (Zubillaga et al. 2008), and Belize (Macintyre et al. 2007).

Extrapolated population estimates of elkhorn coral from stratified random samples across habitat types in the Florida Keys were 0.6 ± 0.5 million (standard error [SE]) colonies in 2005, 1.0 ± 0.3 million (SE) colonies in 2007, and 0.5 ± 0.3 million (SE) colonies in 2012 . Because these population estimates are based on random sampling, differences between years may be a function of sampling effort rather than an indication of population trends. Relative to the abundance of other corals in the Florida Keys region, elkhorn coral was among the least abundant, ranking among corals that are naturally rare in abundance; historically elkhorn coral was a dominant species on Florida reef. Further, no colonies of elkhorn coral were observed in surveys of the Dry Tortugas in 2006 and 2008. The size class distribution of the Florida Keys population included both small and large individuals (> approximately 103 in [260 cm]), but after 2005 the majority of the colonies were smaller in size. These smallest corals (0-8 in [0-20 cm]) had approximately 0-2% percent partial mortality during all three survey years. Partial mortality across all other size classes was approximately 20-70% in 2005, 5-50% in 2007, and 15-90% in 2012 (Miller et al. 2013a).

Colonies monitored in the upper Florida Keys showed a greater than 50% loss of tissue as well as a decline in the number of colonies, and a decline in the dominance by large colonies between 2004 and 2010 (Vardi et al. 2012); (Williams and Miller 2012). Elasticity analysis from a population model based on data from the Florida Keys has shown that the largest individuals have the greatest contribution to the rate of change in population size (Vardi et al. 2012). Between 2010 and 2013, elkhorn coral in the middle and lower Florida Keys had mixed trends. Population densities remained relatively stable at 2 sites and decreased at 2 sites by 21% and 28% (Lunz 2013).

Relatively abundant elkhorn coral communities have been documented from various locations, including Cuba (Alcolado et al. 2010a; González-Díaz et al. 2010); , Colombia (Sanchez and Pizarro 2005), Venezuela (Martínez and Rodríguez Quintal 2012), Navassa (Bruckner 2012b), Jamaica (Jackson et al. 2014), and the U.S. Virgin Islands (Muller et al. 2014). Density estimates from sites in Cuba range from 0.14 colonies per m^2 (Alcolado et al. 2010a) to 0.18 colonies per m^2 (González-Díaz et al. 2010). Maximum elkhorn coral density at ten sites in St. John, U.S. Virgin Islands was 0.18 colonies per m^2 (Muller et al. 2014).

Mayor et al. (2006) reported the abundance of elkhorn coral in Buck Island Reef National Monument, St. Croix, U.S. Virgin Islands. They surveyed 617 sites from May to June 2004 and extrapolated density observed per habitat type to total available habitat. Within an area of 795 ha, they estimated 97,232–134,371 (95% confidence limits) elkhorn coral colonies with any dimension of connected live tissue greater than one meter. Mean densities (colonies ≥ 1 m) were 0.019 colonies per m^2 in branching coral-dominated habitats and 0.013 colonies per m2 in other hard bottom habitats.

Puerto Rico contains the greatest known extent of elkhorn coral in the U.S. Caribbean, however, the species is still rarely encountered. Between 2006 and 2007, a survey of 431 random points in habitat suitable for elkhorn coral in 6 marine protected areas in Puerto Rico revealed a variable density of 0-52 elkhorn coral colonies per 100 m^2 (0.52 colonies per m^2), with average density of 3.3 colonies per 100 m^2 (0.03 colonies per m^2). Overall 30.7% of all points sampled had live elkhorn coral colonies and total loss of elkhorn coral was evidenced in 13.6% of the random survey areas where only dead standing colonies were present (Schärer et al. 2009).

In stratified random surveys along the south, southeast, southwest, and west coasts of Puerto Rico designed to locate *Acropora* colonies, elkhorn coral was observed at 5 out of 301 stations with sightings outside of the survey area at an additional 2 stations (García Sais et al. 2013). Elkhorn coral colonies were absent from survey sites along the southeast coast. Maximum density was 18 colonies per 15 m^2 (1.2 colonies per m^2), and maximum colony size was approximately 7.5 ft (2.3 m) in diameter (García Sais et al. 2013).

Zubillaga et al. (2005) report densities of 3.2 colonies of elkhorn coral per 10 m^2 (0.32 colonies per m^2) in Los Roques National Park, Venezuela. At 10 sites surveyed in the national park in 2003 to 2004, density ranged from 0 to 3.4 colonies per 10 m^2 (0 to 0.34 colonies per m^2) with 4 of the sites showing only standing dead colonies (Zubillaga et al. 2008). In the 6 sites with live colonies, small (0.1 to 50 cm^2), and medium-sized (50 to 4,550 cm^2) colonies predominated over larger-sized (4,550 to16,500 cm^2) colonies.

At Los Colorados reef in northwestern Cuba, a 2006 study at 12 reef crest sampling stations reported average elkhorn coral densities of 0.18 colonies per m^2, and that elkhorn coral made up 8.7 % of the total live coral colonies at the study sites. The study also reported that the nearby Baracoa and Rincon de Guanabo reefs had similar elkhorn coral densities (González-Díaz et al. 2010). The size of elkhorn coral colonies indicates some recruitment in Cuba, but not the proportions of sexual versus asexual recruits. In a 2005 study of 280 elkhorn coral colonies at four sites on the north coast of Cuba, 30.4% were less than 10 cm in diameter (González-Díaz et al. 2008). In a 2006 study of approximately 1,100 elkhorn coral colonies at 3 sites on the north coast of Cuba, diameter and height size-classes were measured (<2, 3-5, 6-7, 8-10, 11-80, and >80 cm). For the 3 sites combined, there were approximately 25 to100 colonies in each of the four smaller size classes (Perera-Pérez et al. 2012).

Supplemental information we found on elkhorn coral's population trends includes the following. At 8 of 11 sites in St. John, U.S. Virgin Islands, colonies of elkhorn coral increased in abundance, between 2001 and 2003, particularly in the smallest size class, with the number of colonies in the largest size class decreasing (Grober-Dunsmore et al. 2007). Colonies of elkhorn coral monitored monthly between 2003 and 2009 in Haulover Bay on St. John, U.S. Virgin Islands suffered bleaching and mortality from disease but showed an increase in abundance and size at the end of the monitoring period (Rogers and Muller 2012). The overall density of elkhorn coral colonies around St. John did not significantly differ between 2004 and 2010 with 6 out of the 10 sites showing an increase in colony density. Size frequency distribution did not significantly change at 7 of the 10 sites, with 2 sites showing an increased abundance of large-sized (> 51 cm) colonies (Muller et al. 2014).

In Colombia, elkhorn coral was present at 4 of the 32 plots (3 of the 6 reefs) monitored annually from 1998 to 2004. Coverage of elkhorn coral ranged from 0.8-2.4%. Over the eight-year period, the species was stable at 2 reefs and declined at the other reef, likely in response to a hurricane in 1999 (Rodriguez-Ramirez et al. 2010). Macintyre and Toscano (2007) report the return of "numerous large colonies" of elkhorn coral on the shallow fore-reef at the southern limit of Carrie Bow Cay, Belize though no quantitative data were presented.

Elkhorn coral monitored in Curaçao between 2009 and 2011 decreased in abundance and increased in colony size, with stable tissue abundance following hurricane damage (Bright et al. 2013). The authors explained that the apparently conflicting trends of increasing colony size but similar tissue abundance likely resulted from the loss of small-sized colonies that skewed the distribution to larger size classes, rather than colony growth.

Simulation models using data from matrix models of elkhorn coral colonies from specific sites in Curaçao (2006-2011), the Florida Keys (2004-2011), Jamaica (2007-2010), Navassa (2006 and 2009), Puerto Rico (2007 and 2010), and the British Virgin Islands (2006 and 2007) indicate that most of these studied populations will continue to decline in size and extent by 2100 if environmental conditions remain unchanged (i.e., disturbance events such as hurrricanes do not increase; (Vardi 2011). In contrast, the studied populations in Jamaica were projected to increase in abundance, and studied populations in Navassa were projected to remain stable. Studied populations in the British Virgin Islands were predicted to decrease slightly from their initial very low levels. Studied populations in Florida, Curaçao, and Puerto Rico were predicted to decline to zero by 2100. Because the study period did not include physical damage (storms), the population simulations in Jamaica, Navassa, and the British Virgin Islands may have contributed to the differing projected trends at sites in these locations.

A report on the status and trends of Caribbean corals over the last century indicates that cover of elkhorn coral has remained relatively stable at approximately 1% throughout the region since the large mortality events of the 1970s and 1980s. The report also indicates that the number of reefs with elkhorn coral present steadily declined from the 1980s to 2000-2004, then remained stable between 2000-2004 and 2005-2011. Elkhorn coral was present at about 20% of reefs surveyed in both the 5-year period of 2000-2004 and the 7-year period of 2005-2011. Elkhorn coral was dominant on approximately 5 to 10% of hundreds of reef sites surveyed throughout the Caribbean during the 4 periods of 1990-1994, 1995-1999, 2000-2004, and 2005-2011 (Jackson et al. 2014).

Based on population estimates from both the Florida Keys and St. Croix, U.S. Virgin Islands, there are at least hundreds of thousands of elkhorn coral colonies. Absolute abundance is higher than estimates from these 2 locations given the presence of this species in many other locations throughout its range. The effective population size is smaller than indicated by abundance estimates due to the tendency for asexual reproduction. Across the Caribbean, percent cover appears to have remained relatively stable, albeit it at extremely low levels, since the population crash in the 1980s. Frequency of occurrence has decreased since the 1980s, indicating potential decreases in the extent of occurrence and effects on the species' range. However, the proportions of Caribbean sites where elkhorn coral is present and dominant have recently stabilized since the mid-2000s. There are locations such as the U.S. Virgin Islands where populations of elkhorn coral appear stable or possibly increasing in abundance and some such as the Florida Keys where population number appears to be decreasing. In some cases when size class distribution is not reported, there is uncertainty of whether increases in abundance indicate growing populations or fragmentation of larger size classes into more small-sized colonies. From locations where size class distribution is reported, there is evidence of recruitment, but not the proportions of sexual versus asexual recruits. The best evidence of recovery would come from multi-year studies showing an increase in the overall amount of living tissue of this species, growth of existing colonies, and an increase in the number of small corals arising from sexual recruitment (Rogers and Muller 2012). Simulation models predict by 2100 that elkhorn coral will become absent at specific sites in several locations (Florida, Curaçao, and Puerto Rico), decrease at specific sites in the British Virgin Islands, remain stable at specific sites in Navassa, and increase at specific sites in Jamaica. These simulations are based on the assumption that conditions experienced during the monitoring period, ranging from 1 to 7 years depending on location, would remain unchanged in the future. We conclude there has been a significant decline of elkhorn coral throughout its range, with recent population stability at low percent coverage. We also conclude that absolute abundance is at least hundreds of thousands of colonies, but likely to decrease in the future with increasing threats.

Threats

A summary of threats to all corals is provided in Section 4.2.2 General Threats Faced by All Coral Species. Detailed information on the threats to elkhorn coral can be found in the Final Listing rule (79 FR 53851; September 10, 2014); however, a brief summary is provided here. Elkhorn coral is highly susceptible to ocean warming, disease, ocean acidification, sedimentation, and nutrients, and susceptible to trophic effects of fishing, depensatory population effects from rapid, drastic declines and low sexual recruitment, and anthropogenic and natural abrasion and breakage.

Elkhorn coral is highly susceptible to disease as evidenced by the mass-mortality event in the 1970s and 1980s. White pox seems to be more common today than white band disease. The effects of disease are spatially and temporally (both seasonally and inter-annually) variable. Results from longer-term monitoring studies in the U.S. Virgin Islands and the Florida Keys indicate that disease can be a major cause of both partial and total colony mortality.

Elkhorn coral is highly susceptible to ocean warming. High water temperatures affect elkhorn coral through bleaching, lowered resistance to disease, and effects on reproduction. Temperature-induced bleaching and mortality following bleaching are temporally and spatially variable. Bleaching associated with the high temperatures in 2005 had a large impact on elkhorn coral with 40 to 50 % of bleached colonies suffering either partial or complete mortality in several locations. Algal symbionts did not shift in elkhorn coral after the 1998 bleaching event indicating the ability to adapt to rising temperatures may not occur through this mechanism. However, elkhorn coral showed evidence of resistance to bleaching from warmer temperatures in some portions of its range under some circumstances (Little Cayman). Through the effects on reproduction, high temperatures can potentially decrease larval supply and settlement success, decrease average larval dispersal distances, and cause earlier larval settlement, affecting gene flow among populations.

Elkhorn coral is susceptible to acidification through reduced growth, calcification, and skeletal density. The effects of increased carbon dioxide combined with increased nutrients appear to be much worse than either stressor alone and caused 100% mortality in some combination in one laboratory study.

There are few studies of the effects of nutrients on elkhorn coral. Field experiments indicate that the mean net rate of uptake of nitrate by elkhorn coral exceeds that of ammonium by a factor of two and that elkhorn coral does not uptake nitrite (Bythell 1990). In Vega Baja, Puerto Rico, elkhorn coral mortality increased to 52% concurrent with pollution and sedimentation associated with raw sewage and beach nourishment, respectively, between December 2008 and June 2009 (Hernandez-Delgado et al. 2011). Mortality presented as patchy necrosis-like and white pox-like conditions that impacted local reefs following anthropogenic disturbances and was higher inside the shallow platform (52-69%) and closer to the source of pollution (81-97%) compared to the outer reef (34 to 37 percent; (Hernandez-Delgado et al. 2011). Elkhorn coral is sensitive to nutrients as evidenced by increased mortality after exposure to raw sewage. We conclude that elkhorn coral is highly susceptible to nutrient enrichment. Elkhorn coral is also sensitive to sedimentation due to its poor capability of removing sediment and its high reliance on clear water for nutrition. Sedimentation can also cause tissue mortality.

Predators can have an impact on elkhorn coral both through tissue removal and the potential to spread disease. Predation pressure is spatially variable and almost non-existent in some locations. However, the effects of predation can become more severe if colonies decrease in abundance and density, as predators focus on the remaining living colonies.

Summary of Status

The species has undergone substantial population decline and decreases in the extent of occurrence throughout its range due mostly to disease. Although localized mortality events have continued to occur, percent benthic cover and proportion of reefs where elkhorn coral is dominant have remained stable over its range since the mid-1980s. There is evidence of synergistic effects of threats for this species including disease outbreaks following bleaching events. Elkhorn coral is highly susceptible to a number of threats, and cumulative effects of multiple threats are likely to exacerbate vulnerability to extinction. Despite the large number of islands and environments that are included in the species' range, geographic distribution in the highly disturbed Caribbean exacerbates vulnerability to extinction because elkhorn coral is limited to an area with high localized human impacts and predicted increasing threats. Elkhorn coral occurs in turbulent water on the back reef, fore reef, reef crest, and spur and groove zone in water ranging from 1 to 30 m in depth. This moderates vulnerability to extinction because the species occurs in numerous types of reef environments that will, on local and regional scales, experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute population abundance has been estimated as at least hundreds of thousands of colonies in both Florida and a portion of the U.S. Virgin Islands and is higher than the estimate from these

2 locations due to the occurrence of the species in many other areas throughout its range. Elkhorn coral has low sexual recruitment rates, which exacerbates vulnerability to extinction due to decreased ability to recover from mortality events when all colonies at a site are extirpated. In contrast, its fast growth rates and propensity for formation of clones through asexual fragmentation enables it to expand between rare events of sexual recruitment and increases its potential for local recovery from mortality events, thus moderating vulnerability to extinction. Its abundance and life history characteristics, combined with spatial variability in ocean warming and acidification across the species' range, moderate vulnerability to extinction because the threats are non-uniform. Subsequently, there will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time. We also conclude that the population abundance is likely to decrease in the future with increasing threats.

4.2.2.2 Staghorn Coral (*Acropora cervicornis*)

Staghorn coral was listed as threatened under the ESA in May 2006 (71 FR 26852). In December 2012, NMFS proposed changing its status from threatened to endangered (77 FR 73219). On September 10, 2014, NMFS determined that staghorn coral should remain listed as threatened (79 FR 53851).

Species Description and Distribution

Staghorn coral is characterized by antler-like colonies with straight or slightly curved, cylindrical branches. The diameter of branches ranges from 0.1-2 in (0.25-5 cm; Lirman et al. 2010), and linear branch growth rates have been reported to range between 1.2-4.5 in (3-11.5 cm) per year (*Acropora* Biological Review Team 2005). The species can exist as isolated branches, individual colonies up to about 5 ft (1.5 m) diameter, and thickets comprised of multiple colonies that are difficult to distinguish from one another (*Acropora* Biological Review Team 2005).

Staghorn coral is distributed throughout the Caribbean Sea, in the southwestern Gulf of Mexico, and in the western Atlantic Ocean. The fossil record indicates that during the Holocene epoch, staghorn coral was present as far north as Palm Beach County in southeast Florida (Lighty et al. 1978), which is also the northern extent of its current distribution (Goldberg 1973).

Staghorn coral commonly occurs in water ranging from 5 to 20 m in depth, though it occurs in depths of 16-30 m at the northern extent of its range, and has been rarely found to 60 m in depth. Staghorn coral naturally occurs on spur and groove, bank reef, patch reef, and transitional reef habitats, as well as on limestone ridges, terraces, and hard bottom habitats (Goldberg 1973; Gilmore and Hall 1976; Cairns 1982b; Davis 1982; Jaap 1984; Wheaton and Jaap 1988; Miller et al. 2008). Historically it grew in thickets in water ranging from approximately 16-65 ft (5-20 m) in depth; though it has rarely been found to approximately 195 ft (60 m; Schuhmacher and Zibrowius 1985; Davis 1982; Jaap 1984; Wheaton and Jaap 1988; Jaap et al. 1989). At the northern extent of its range, it grows in deeper water (~53-99 ft [16-30 m]; Goldberg 1973). Historically, staghorn coral was one of the primary constructors of mid-depth (approximately 33-50 ft [10-15 m]) reef terraces in the western Caribbean, including Jamaica, the Cayman Islands, Belize, and some reefs along the eastern Yucatan peninsula (Adey 1978). In the Florida Keys, staghorn coral occurs in various habitats but is most prevalent on patch reefs as opposed to their former abundance in deeper fore-reef habitats (Miller et al. 2008). There is no evidence of range constriction, though loss of staghorn coral at the reef level has occurred (*Acropora* Biological Review Team 2005).

Precht and Aronson (2004) suggest that coincident with climate warming, staghorn coral only recently re-occupied its historic range after contracting to south of Miami, Florida, during the late Holocene. They based this idea on the presence of large thickets off Ft. Lauderdale, Florida, which were discovered in 1998 and had not been reported in the 1970s or 1980s (Precht 2004). However, because the presence of sparse staghorn coral colonies in Palm Beach County, north of Ft. Lauderdale, was reported in the early 1970s (though no thicket formation was reported; Goldberg 1973), there is uncertainty associated with whether these thickets were present prior to their discovery or if they recently appeared coincident with warming. The proportion of reefs with staghorn coral present decreased dramatically after the Caribbean-wide mass mortality in the 1970s and 1980s, indicating the spatial structure of the species has been affected by extirpation from many localized areas throughout its range (Jackson et al. 2014).

Life History Information

Relative to other corals, staghorn coral has a high growth rate that have allowed acroporid reef growth to keep pace with past changes in sea level (Fairbanks 1989). Growth rates, measured as skeletal extension of the end of branches, range from approximately 2-4 in (4-11 cm) per year (*Acropora* Biological Review Team 2005). Annual linear extension has been found to be dependent on the size of the colony. New recruits and juveniles typically grow at slower rates. Stressed colonies and fragments may also exhibit slower growth.

Staghorn coral is a hermaphroditic broadcast spawning species[5]. The spawning season occurs several nights after the full moon in July, August, or September depending on location and timing of the full moon, and may be split over the course of more than one lunar cycle (Vargas-Angel et al. 2006; Szmant 1986). The estimated size at sexual maturity is approximately 6 in (17 cm) branch length, and large colonies produce proportionally more gametes than small colonies (Soong and Lang 1992). Basal and branch tip tissue is not fertile (Soong and Lang 1992). Sexual recruitment rates are low, and this species is generally not observed in coral settlement studies. Laboratory studies have found that certain species of crustose-coralline algae produce exudates which facilitate larval settlement and post-settlement survival (Ritson-Williams et al. 2010).

Reproduction occurs primarily through asexual fragmentation that produces multiple colonies that are genetically identical (Tunnicliffe 1981). The combination of branching morphology, asexual fragmentation, and fast growth rates relative to other corals, can lead to persistence of large areas dominated by staghorn coral. The combination of rapid skeletal growth rates and frequent asexual reproduction by fragmentation can enable effective competition and can facilitate potential recovery from disturbances when environmental conditions permit. However, low sexual reproduction can lead to reduced genetic diversity and limits the capacity to repopulate spatially dispersed sites.

[5] Simultaneously containing both sperm and eggs, which are released into the water column for fertilization.

Status and Population Dynamics
Information on staghorn coral status and populations dynamics is infrequently documented throughout its range. Comprehensive and systematic census and monitoring has not been conducted. Thus, the status and populations dynamics must be inferred from the few locations were data exist.

Vollmer and Palumbi (2007) examined 22 populations of staghorn coral from 9 regions in the Caribbean (Panama, Belize, Mexico, Florida, Bahamas, Turks and Caicos, Jamaica, Puerto Rico, and Curaçao) and concluded that populations greater than approximately 310 mi (500 km) apart are genetically different from each other with low gene flow across the greater Caribbean. Fine-scale genetic differences have been detected at reefs separated by as little as 1.25 mi (2 km), suggesting that gene flow in staghorn coral may not occur at much smaller spatial scales (Vollmer and Palumbi 2007; Garcia Reyes and Schizas 2010). This fine-scale population structure was greater when considering genes of elkhorn coral were found in staghorn coral due to back-crossing of the hybrid *A. prolifera* with staghorn coral (Garcia Reyes and Schizas 2010; Vollmer and Palumbi 2007). Populations in Florida and Honduras are genetically distinct from each other and other populations in the U.S. Virgin Islands, Puerto Rico, Bahamas, and Navassa (Baums et al. 2010), indicating little to no larval connectivity overall. However, some potential connectivity between the U.S. Virgin Islands and Puerto Rico was detected and also between Navassa and the Bahamas (Baums et al. 2010).

Staghorn coral historically was one of the dominant species on most Caribbean reefs, forming large, single-species thickets and giving rise to the nominal distinct zone in classical descriptions of Caribbean reef morphology (Goreau 1959). Massive, Caribbean-wide mortality, apparently primarily from white band disease (Aronson and Precht 2001), spread throughout the Caribbean in the mid-1970s to mid-1980s and precipitated widespread and radical changes in reef community structure (Brainard et al. 2011a). In addition, continuing coral mortality from periodic acute events such as hurricanes, disease outbreaks, and mass bleaching events has added to the decline of staghorn coral (Brainard et al. 2011a). In locations where quantitative data are available (Florida, Jamaica, U.S. Virgin Islands, Belize), there was a reduction of approximately 92 to greater than 97% between the 1970s and early 2000s (*Acropora* Biological Review Team 2005).

Since the 2006 listing of staghorn coral as threatened, continued population declines have occurred in some locations with certain populations of both listed *Acropora* species decreasing up to an additional 50% or more (Lundgren and Hillis-Starr 2008; Muller et al. 2008; Williams et al. 2008; Colella et al. 2012; Rogers and Muller 2012). There are some small pockets of remnant robust populations such as in southeast Florida (Vargas-Angel et al. 2003), Honduras (Riegl et al. 2009; Keck et al. 2005), and Dominican Republic (Lirman et al. 2010). Additionally, Lidz and Zawada (2013) observed 400 colonies of staghorn coral along 44 mi (70.2 km) of transects near Pulaski Shoal in the Dry Tortugas where the species had not been seen since the cold water die-off of the 1970s. Cover of staghorn coral increased on a Jamaican reef from 0.6% in 1995 to 10.5% in 2004 (Idjadi et al. 2006).

Riegl et al. (2009) monitored staghorn coral in photo plots on the fringing reef near Roatan, Honduras from 1996 to 2005. Staghorn coral cover declined from 0.42% in 1996 to 0.14% in

1999 after the Caribbean bleaching event in 1998 and mortality from run-off associated with a Category 5 hurricane. Staghorn coral cover further declined to 0.09% in 2005. Staghorn coral colony frequency decreased 71% between 1997 and 1999. In sharp contrast, offshore bank reefs near Roatan had dense thickets of staghorn coral with 31% cover in photo-quadrats in 2005 and appeared to survive the 1998 bleaching event and hurricane, most likely due to bathymetric separation from land and greater flushing. Modeling showed that under undisturbed conditions, retention of the dense staghorn coral stands on the banks off Roatan is likely with a possible increased shift towards dominance by other coral species. However, the authors note that because their data and the literature seem to point to extrinsic factors as driving the decline of staghorn coral, it is unclear what the future may hold for this dense population (Riegl et al. 2009).

Miller et al. (2013a) extrapolated population abundance of staghorn coral in the Florida Keys and Dry Tortugas from stratified random samples across habitat types. Population estimates of staghorn coral in the Florida Keys were 10.2 ± 4.6 (standard error [SE]) million colonies in 2005, 6.9 ± 2.4 (SE) million colonies in 2007, and 10.0 ± 3.1 (SE) million colonies in 2012. Population estimates in the Dry Tortugas were 0.4 ± 0.4 (SE) million colonies in 2006 and 3.5 ± 2.9 (SE) million colonies in 2008, though the authors note their sampling scheme in the Dry Tortugas was not optimized for staghorn coral. Because these population estimates were based on random sampling, differences in abundance estimates between years is more likely to be a function of sample design rather than population trends. In both the Florida Keys and Dry Tortugas, most of the population was dominated by small colonies less than 12 in (30 cm) diameter. Further, partial mortality was reported as highest in 2005 with up to 80% mortality observed and lowest in 2007 with a maximum of 30%. In 2012, partial mortality ranged from 20-50% across most size classes.

Staghorn coral was observed in 21 out of 301 stations between 2011 and 2013 in stratified random surveys designed to detect *Acropora* colonies along the south, southeast, southwest, and west coasts of Puerto Rico (García Sais et al. 2013). Staghorn coral was also observed at 16 sites outside of the surveyed area. The largest colony was 24 in (60 cm) and density ranged from 1-10 colonies per 162 ft^2 (15 m2; García Sais et al. 2013).

While cover of staghorn coral increased from 0.6% in 1995 to 10.5% in 2004 (Idjadi et al. 2006) and 44% in 2005 on a Jamaican reef, it collapsed after the 2005 bleaching event and subsequent disease to less than 0.5% in 2006 (Quinn and Kojis 2008). A cold water die-off across the lower to upper Florida Keys in January 2010 resulted in the complete mortality of all staghorn coral colonies at 45 of the 74 reefs surveyed (61%) (Schopmeyer et al. 2012). Walker et al. (2012) report increasing size of 2 thickets (expansion of up to 7.5 times the original size of 1 of the thickets) monitored off southeast Florida, but also noted that cover within monitored plots concurrently decreased by about 50% highlighting the dynamic nature of staghorn coral distribution via fragmentation and re-attachment.

A report on the status and trends of Caribbean corals over the last century indicates that cover of staghorn coral has remained relatively stable (though much reduced) throughout the region since the large mortality events of the 1970s and 1980s. The frequency of reefs at which staghorn coral was described as the dominant coral has remained stable. The number of reefs with staghorn coral present declined during the 1980s (from approximately 50 to 30% of reefs), remained relatively stable at 30% through the 1990s, and decreased to approximately 20% of the reefs in 2000-2004 and approximately 10% in 2005-2011 (Jackson et al. 2014).

Based on population estimates, there are at least tens of millions of colonies present in the Florida Keys and Dry Tortugas combined. Absolute abundance is higher than the estimate from these 2 locations given the presence of this species in many other locations throughout its range. The effective population size is smaller than indicated by abundance estimates due to the tendency for asexual reproduction. There is no evidence of range constriction or extirpation at the island level. However the species is absent at the reef level. Populations appear to consist mostly of isolated colonies or small groups of colonies compared to the vast thickets once prominent throughout its range. Thickets are a prominent feature at only a few known locations. Across the Caribbean, percent cover appears to have remained relatively stable since the population crash in the 1980s. Frequency of occurrence has decreased since the 1980s. There are examples of increasing trends in some locations (Dry Tortugas and southeast Florida), but not over larger spatial scales or longer time frames. Population model projections from Honduras at one of the only known remaining thickets indicate the retention of this dense stand under undisturbed conditions. If refuge populations are able to persist, it is unclear whether they would be able to repopulate nearby reefs as observed sexual recruitment is low. Thus, we conclude that the species has undergone substantial population decline and decreases in the extent of occurrence throughout its range. Percent benthic cover and proportion of reefs where staghorn coral is dominant have remained stable since the mid-1980s and since the listing of the species as threatened in 2006. We also conclude that population abundance is at least tens of millions of colonies, but likely to decrease in the future with increasing threats.

Threats

A summary of threats to all corals is provided in Section 4.2.2 General Threats Faced by All Coral Species. Detailed information on the threats to staghorn coral can be found in the Final Listing rule (79 FR 53851; September 10, 2014); however, a brief summary is provided here. Staghorn coral is highly susceptible to ocean warming, disease, ocean acidification, sedimentation, and nutrients, as well as susceptible to trophic effects of fishing, depensatory population effects from rapid, drastic declines and low sexual recruitment, and anthropogenic and natural abrasion and breakage.

Staghorn coral is highly susceptible to disease as evidenced by the mass-mortality event in the 1970s and 1980s. Although disease is both spatially and temporally variable, about 5-6% of staghorn coral colonies appear to be affected by disease at any one time, though incidence of disease has been reported to range from 0-32% and up to 72% during an outbreak. There is indication that some colonies may be resistant to white band disease. Staghorn coral is also susceptible to several other diseases including one that causes rapid tissue loss from multiple lesions (e.g., Rapid Wasting Disease, White Patch Disease). Because few studies track diseased colonies over time, determining the present-day colony and population level effects of disease is difficult. One study that monitored individual colonies during an outbreak found that disease can be a major cause of both partial and total colony mortality (Williams and Miller 2005).

Staghorn coral is highly susceptible to bleaching in comparison to other coral species, and mortality after bleaching events is variable. Algal symbionts did not shift in staghorn coral after the 1998 bleaching event, indicating the ability of this species to acclimatize to rising temperatures may not occur through this mechanism. Data from Puerto Rico and Jamaica following the 2005 Caribbean bleaching event indicate that temperature anomalies can have a large impact on total and partial mortality and reproductive output.

Staghorn coral is highly susceptible to acidification through reduced growth, calcification, and skeletal density. The effects of increased carbon dioxide combined with increased nutrients appear to be synergistically worse and caused 100% mortality in some combination in one laboratory study.

Staghorn coral has high susceptibility to sedimentation through its sensitivity to turbidity (reduced light results in lower photosynthesis by symbiotic algae, so there is less food for the coral), and increased run-off from land clearing has resulted in mortality of this species through smothering. In addition, laboratory studies indicate the combination of sedimentation and nutrient enrichment appears to be synergistically worse.

Staghorn coral is also highly susceptible to elevated nutrients, which can cause decreased growth in staghorn coral. The combined effects of nutrients with other stressors such as elevated carbon dioxide and sedimentation appear to be worse than the effects of nutrients alone, and can cause colony mortality in some combinations.

Predators can have a negative impact on staghorn coral through both tissue removal and the spread of disease. Predation pressure appears spatially variable. Removal of tissue from growing branch tips of staghorn coral may negatively affect colony growth, but the impact is unknown as most studies do not report on the same colonies through time, inhibiting evaluation of the longer-term impact of these predators on individual colonies and populations. We anticipate that staghorn coral is highly susceptible to predation.

Summary of Status

The species has undergone substantial population decline and decreases in the extent of occurrence throughout its range due mostly to disease. Although localized mortality events have continued to occur, percent benthic cover and proportion of reefs where staghorn coral is dominant have remained stable over its range since the mid-1980s. There is evidence of synergistic effects of threats for this species where the effects of increased nutrients are combined with acidification and sedimentation. Staghorn coral is highly susceptible to a number of threats, and cumulative effects of multiple threats are likely to exacerbate vulnerability to extinction. Despite the large number of islands and environments that are included in the species' range, geographic distribution in the highly disturbed Caribbean exacerbates vulnerability to extinction because staghorn coral is limited to areas with high, localized human impacts and predicted increasing threats. Staghorn coral commonly occurs in water ranging from 5 to 20 m in depth, though it occurs in depths of 16-30 m at the northern extent of its range, and has been rarely found to 60 m in depth. It occurs in spur and groove, bank reef, patch reef, and transitional reef habitats, as well as on limestone ridges, terraces, and hard bottom habitats. This habitat heterogeneity moderates vulnerability to extinction because the species occurs in numerous types of reef and hard bottom environments that are predicted, on local and regional scales, to experience highly variable thermal regimes and ocean chemistry at any given point in time. Its absolute population abundance has been estimated as at least tens of millions of colonies in the Florida Keys and Dry Tortugas combined and is higher than the estimate from these 2 locations due to the occurrence of the species in many other areas throughout its range. Staghorn coral has low sexual recruitment rates, which exacerbates vulnerability to extinction due to decreased ability to recover from mortality events when all colonies at a site are extirpated. In contrast, its fast growth rates and propensity for formation of clones through asexual fragmentation enables it to expand between rare events of sexual recruitment and increases its potential for local recovery from mortality events, thus moderating vulnerability to extinction. Its abundance and life history characteristics, combined with spatial variability in ocean warming and acidification across the species' range, moderate the species' vulnerability to extinction because the threats are non-uniform. Subsequently, there will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time. However, we also anticipate that the population abundance is likely to decrease in the future with increasing threats.

4.2.2.3 Pillar Coral (*Dendrogyra cylindrus*)

On September 10, 2014, NMFS listed pillar coral as threatened (79 FR 53851).

Species Description and Distribution

Pillar coral forms cylindrical columns on top of encrusting bases. Colonies are generally grey-brown in color and may reach approximately 10 ft (3 m) in height. Polyps' tentacles remain extended during the day, giving columns a furry appearance.

Pillar coral is present in the western Atlantic Ocean and throughout the greater Caribbean Sea, though is absent from the southwest Gulf of Mexico (Tunnell 1988). Brainard et al. (2011b) identified a single known colony in Bermuda that is in poor condition. There is fossil evidence of the presence of the species off Panama less than 1,000 years ago, but it has been reported as absent today (Florida Fish and Wildlife Conservation Commission 2013). Pillar coral inhabits most reef environments in water depths ranging from approximately 3-75 ft (1-25 m), but it is most common in water between approximately 15-45 ft (5-15 m) deep (Cairns 1982a; Acosta and Acevedo 2006; Goreau and Wells 1967).

Life History Information

Average growth rates of 0.7-0.8 in (1.8-2.0 cm) per year in linear extension have been reported in the Florida Keys (Hudson and Goodwin 1997) compared to 0.3 in (0.8 cm) per year as reported in Colombia and Curaçao. Partial mortality rates are size-specific with larger colonies having greater rates. Frequency of partial mortality can be high (e.g., 65% of 185 colonies surveyed in Colombia), while the amount of partial mortality per colony is generally low (average of 3% of tissue area affected per colony).

Pillar coral is a gonochoric broadcast spawning[6] species with relatively low annual egg production for its size. The combination of gonochoric spawning with persistently low

[6] Parents only contain one gamete (egg or sperm), which are released into the water column for fertilization by another parent's gamete.

population densities is expected to yield low rates of successful fertilization and low larval supply. Sexual recruitment of this species is low, and there have been no reports of juvenile colonies in the Caribbean. Spawning has been observed to occur several nights after the full moon of August in the Florida Keys (Waddell and Clarke 2008b; Neely et al. 2013) and in La Parguera, Puerto Rico (Szmant 1986). Pillar coral can also reproduce asexually by fragmentation following storms or other physical disturbance, but it is uncertain how much storm generated fragmentation contributes to asexually produced offspring.

Status and Population Dynamics

Information on pillar coral status and populations dynamics is spotty throughout its range. Comprehensive and systematic census and monitoring has not been conducted outside of Florida. Thus, the status and populations dynamics must be inferred from the few locations where data exist.

Pillar coral is uncommon but conspicuous with scattered, isolated colonies. It is rarely found in aggregations. In coral surveys, it generally has a rare encounter rate, low percent cover, and low density.

Information on pillar coral is most extensive for Florida. Pillar coral ranked as the least abundant to third least abundant coral species in stratified random surveys of the Florida Keys between 2005 and 2009 and was not encountered in surveys in 2012 (Miller et al. 2013b). Pillar coral was seen only on the ridge complex and mid-channel reefs at densities of approximately 1 and 0.1 colonies per 10 m^2 (approximately 100 ft^2), respectively, between 2005 and 2010 in surveys from West Palm Beach to the Dry Tortugas (Burman et al. 2012). In surveys conducted between 1999 and 2016 from Palm Beach to the Dry Tortugas, pillar coral was present at 2% of sites surveyed and ranged in density from 0 to 0.4 colonies per m^2 with an average density of 0.004 colonies per 10 m^2 (approximately 100 ft^2)(NOAA, unpublished data). In 2014, there were 714 known colonies of pillar coral along the Florida reef tract from southeast Florida to the Dry Tortugas. By 2017, many of these colonies had suffered tissue loss, and over half (57%) suffered complete mortality due to disease, most likely associated with multiple years of warmer than normal temperatures (K. Neely and C. Lewis, unpublished data). The majority of these colonies were lost from the northern portion of the reef tract (Figure 12).

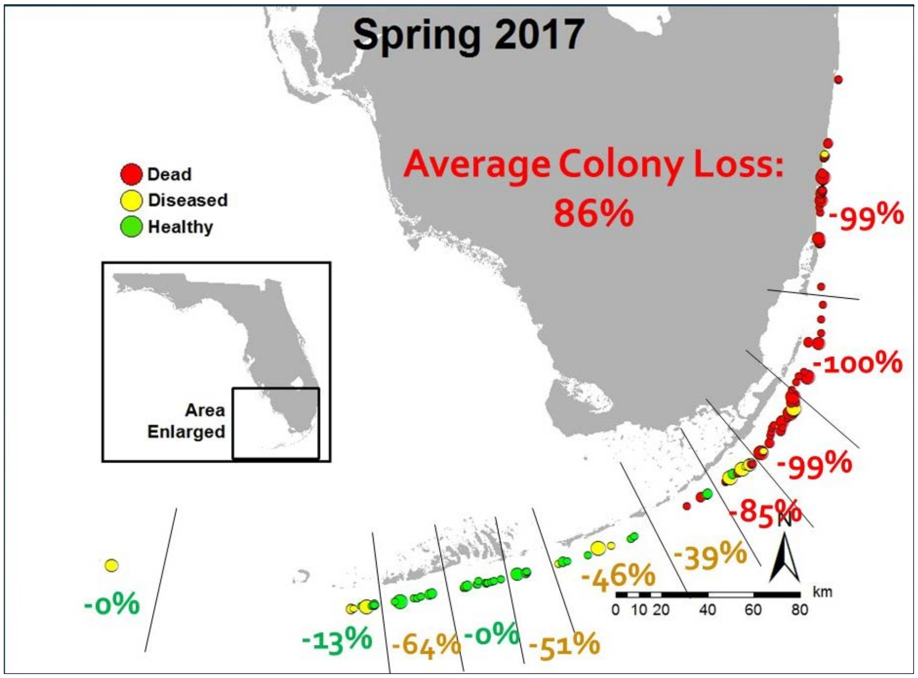

Figure 12. Condition of known pillar coral colonies in Florida between 2014 and 2017 (Figure curtesy of K. Neely and C. Lewis).

Density of pillar corals in other areas of the Caribbean is also low and on average less than 0.1 colonies per 10 m^2. The average number of pillar coral colonies in remote reefs off southwest Cuba was 0.013 ± 0.045 colonies per 10 m (approximately 32 ft) transect, and the species ranked sixth rarest out of 38 coral species (Alcolado et al. 2010b). In a study of pillar coral demographics at Providencia Island, Colombia, a total of 283 pillar coral colonies were detected in a survey of 1.66 km^2 (0.6 square miles) for an overall density of approximately 0.000017 colonies per 10 m^2 (approximately 100 ft^2)(Acosta and Acevedo 2006). In Puerto Rico, density of pillar coral ranged from 0 to 0.3 colonies per m^2 with an average density of 0.03 colonies per 10 m^2 (approximately 100 ft^2); it occurred at 4% of the sites surveyed between 2008 and 2016 (NOAA unpublished data). In the US Virgin Islands, density of pillar coral ranged between 0 and 0.3 colonies per m^2 with an average density of 0.01 colonies per 10 m^2 (approximately 100 ft^2); it occurred in 3% of the sites surveyed between 2002 and 2015 (NOAA unpublished data).

Benthic cover is generally less than 1% in monitoring studies. Pillar coral's average cover was 0.002% on patch reefs and 0.303% in shallow offshore reefs in annual surveys of 37 sites in the Florida Keys between 1996 and 2003 (Somerfield et al. 2008). In surveys conducted in Florida between 1996 and 2016, cover of pillar coral ranged from 0 to 0.5% with an average of 0.0002% (NOAA, unpublished data). At permanent monitoring stations in the U.S. Virgin Islands, pillar coral was observed in low abundance at 10 of 33 sites and ranged in cover from less than 0.05-0.22% where present (Smith 2013). In surveys conducted in the U.S. Virgin Islands between 1992 and 2015, percent cover of pillar coral ranged from 0 to 6% with an average cover of 0.03% (NOAA, unpublished data). In Puerto Rico, cover of pillar coral ranged between 0 and 4% with an average of 0.02% in surveys conducted between 2001 and 2016 (NOAA, unpublished data). In Dominica, pillar coral comprised less than 0.9% cover and was present at 13.3% of 31 surveyed sites (Steiner 2003b). Pillar coral was observed on 1 of 7 fringing reefs surveyed off Barbados, and cover was 2.7 ± 1.4% (Tomascik and Sander 1987).

Other than the declining population in Florida, there are two reports of population trends from the Caribbean. In monitored photo-stations in Roatan, Honduras, cover of pillar coral increased slightly from 1.35% in 1996 to 1.67% in 1999 and then declined to 0.44% in 2003 and to 0.43% in 2005 (Riegl et al. 2009). In the U.S. Virgin Islands, 7% of 26 monitored colonies experienced total colony mortality between 2005 and 2007, though the very low cover of pillar coral (0.04%) remained relatively stable during this time period (Smith et al. 2013a).

Pillar coral is currently uncommon to rare throughout Florida and the Caribbean. Low abundance and infrequent encounter rate in monitoring programs result in small samples sizes. The low coral cover of this species renders monitoring data difficult to extrapolate to realize trends. The few studies that report pillar coral population trends indicate a general decline at some specific sites, though it is likely that the population remains stable at other sites. Low density and gonochoric broadcast spawning reproductive mode, coupled with no observed sexual recruitment, indicate that natural recovery potential from mortality is low.

Threats

A summary of threats to all corals is provided in Section 4.2.2 General Threats Faced by All Coral Species. Detailed information on the specific threats to pillar coral can be found in the Final Listing Rule (79 FR 53851; September 10, 2014); however, a brief summary is provided here. Pillar coral is susceptible to ocean warming, disease, ocean acidification, sedimentation, and nutrients, and the trophic effects of fishing.

Pillar coral appears to have some susceptibility to ocean warming, though there are conflicting characterizations of the susceptibility of pillar coral to bleaching. Some locations experienced high bleaching of up to 100% of pillar coral colonies during the 2005 Caribbean bleaching event (Oxenford et al. 2008) while others had a smaller proportion of colonies bleach (e.g., 36%; Bruckner and Hill 2009). Reports of low mortality after less severe bleaching indicate potential resilience, though mortality information is absent from locations that reported high bleaching frequency. Although bleaching of most coral species is spatially and temporally variable, understanding the susceptibility of pillar coral is further confounded by the species' rarity and, hence, low sample size in any given survey.

Pillar coral is sensitive to cold temperatures. In laboratory studies of cold shock, pillar coral had the most severe bleaching of the 3 species tested at 12°C (Muscatine et al. 1991). During the 2010 cold water event in the Florida Keys, pillar coral experienced 100% mortality on surveyed inshore reefs, while other species experienced lower mortality (Kemp et al. 2011).

Pillar coral is susceptible to black band disease and white plague, though impacts from white plague are likely more extensive because of rapid progression rates (Brainard et al. 2011b). Disease appears to be present in about 3-4% of pillar coral populations in locations surveyed (Acosta and Acevedo 2006; Ward et al. 2006). Because few studies have tracked disease progression in pillar coral, the effects of disease are uncertain at both the colony and population level. However, in Florida where all known colonies of pillar coral were regularly monitored, extensive partial and whole colony mortality due to disease occurred in a large portion of the reef tract, reducing the overall number of pillar coral colonies in Florida by 57% and virtually eliminating pillar coral from the northern-most portion of its range (Figure 12).

Pillar coral appears to be moderately capable of removing sediment from its tissue (Brainard et al. 2011b). However, pillar coral may be more sensitive to turbidity due to its high reliance on nutrition from photosynthesis (Brainard et al. 2011b) and as evidenced by the geologic record (Hunter and Jones 1996). Pillar coral survival may also be susceptible to nutrient enrichment as evidenced by its absence from eutrophic sites in Barbados (Brainard et al. 2011b), but there is uncertainty about whether its absence is a result of eutrophic conditions or a result of its naturally uncommon or rare occurrence. We anticipate that pillar coral likely has some susceptibility to sedimentation and nutrient enrichment. The available information does not support a more precise description of its susceptibility to this threat.

Summary of Status

Pillar coral survival is susceptible to a number of threats, and there is evidence of population declines in some locations. Despite the large number of islands and environments that are included in the species' range, geographic distribution in the highly disturbed Caribbean exacerbates vulnerability to extinction because pillar coral is limited to an area with high, localized human impacts and predicted increasing threats. *Dendrogyra cylindrus* inhabits most reef environments in water depths ranging from 3-82 ft (1-25 m), but is naturally rare. It is a gonochoric broadcast spawner with observed low sexual recruitment. Its low abundance, combined with its geographic location, exacerbates vulnerability to extinction. This is because increasingly severe conditions within the species' range are likely to affect a high proportion of its population at any given point in time. Also, low sexual recruitment, combined with its gonochoric, broadcast spawning reproduction mode and low density, is likely to inhibit recovery potential from mortality events, further exacerbating its vulnerability to extinction. We anticipate that pillar coral is likely to decrease in abundance in the future with increasing threats.

4.2.2.4 Rough Cactus Coral (*Mycetophyllia ferox*)

On September 10, 2014, NMFS listed rough cactus coral as threatened (79 FR 53851).

Species Description and Distribution

Rough cactus coral forms a thin, encrusting plate that is weakly attached to substrate. Rough cactus coral is taxonomically distinct (i.e., separate species), though difficult to distinguish in the field from other *Mycetophyllia* species. Maximum colony size is 20 in (50 cm) in diameter.

Rough cactus coral occurs in the western Atlantic Ocean and throughout the wider Caribbean Sea. It has not been reported in the Flower Garden Banks (Gulf of Mexico) or in Bermuda. It inhabits reef environments in water depths of 16-295 ft (5-90 m), including shallow and mesophotic habitats (e.g., > 100 ft [30 m]).

Life History Information

Rough cactus coral is a hermaphroditic brooding[7] species. Colony size at first reproduction is greater than 15 in^2 (100 cm^2). Recruitment of rough cactus coral appears to be very low, even in

[7] Simultaneously containing both sperm and eggs, which are fertilized within the parent colony and grows for a period of time before release.

studies from the 1970s. Rough cactus coral has a lower fecundity compared to other species in its genus (Morales Tirado 2006). Over a 10-year period, no colonies of rough cactus coral were observed to recruit to an anchor-damaged site in the U.S. Virgin Islands, although adults were observed on the adjacent reef (Rogers and Garrison 2001). No other life history information appears to exist for rough cactus coral.

Status and Population Dynamics
Information on rough cactus coral status and populations dynamics is infrequently documented spotty throughout its range. Comprehensive and systematic census and monitoring has not been conducted. Thus, the status and populations dynamics must be inferred from the few locations where data exist.

Density of rough cactus coral in southeast Florida and the Florida Keys was approximately 0.8 colonies per approximately 100 ft^2 (10 m^2) between 2005 and 2007. In a survey of 97 stations in the Florida Keys, rough cactus coral declined in occurrence from 20 stations in 1996 to 4 stations in 2009. At 21 stations in the Dry Tortugas, rough cactus coral declined in occurrence from 8 stations in 2004 to 3 stations in 2009 (Brainard et al. 2011a). This appears to indicate that the species was much more abundant in the upper Florida Keys in the 1970s.

In stratified random surveys in the Florida Keys conducted by Miller et al. (2013a), rough cactus coral ranked 39th out of 47 species in 2005, and the least abundant in 2009 and 2012. Extrapolated population estimates were 1.0 ± 0.7 (standard error [SE]) million in 2005, 9,500 ± 9,500 (SE) colonies in 2009, and 7,000 ± 7,000 (SE) in 2012. These abundance estimates are based on random surveys, and differences between years are more likely a result of sample design rather than population trends. Miller et al. (2013a) also observed that the approximately 4-8 in (10-20 cm) diameter size class was the most abundant and equaled the combined abundance of the other size classes. The largest size class observed was 12-15 in (30-40 cm). Average partial mortality per size class ranged from nearly 1-50% and was greatest in the 8-12 in (20-30 cm) size class (Miller et al. 2013a).

In the Dry Tortugas, Florida, rough cactus coral ranked 35th most abundant out of 43 species in 2006 and 30th out of 40 in 2008. Population estimates were 0.5 ± 0.4 (SE) million in 2006 and 0.5 ± 0.2 million (SE) in 2008. The number of colonies in 2006 was similar between the 0-4 in (0-10 cm) and 4-8 in (10-20 cm) size classes, and the largest colonies were in the 8-12 in (20-30 cm) size class. Greatest partial mortality was around 10%. Two years later, in 2008, the highest proportion of colonies was in the 8-12 in (20-30 cm) size class, and the largest colonies were in the 16-20 in (40-50 cm) size class. The greatest partial mortality was about 60% in the 12-16 in (30-40 cm) size class; however, the number of colonies at that size were few (Miller et al. 2013a).

Benthic cover of rough cactus coral in the Red Hind Marine Conservation District off St. Thomas, U.S. Virgin Islands, which includes mesophotic coral reefs, was 0.003 ± 0.004% in 2007, accounting for 0.02% of coral cover, and ranking second to last out of 21 coral species (Nemeth et al. 2008; Smith et al. 2010). In the U.S. Virgin Islands between 2001 and 2012, rough cactus coral appeared in 12 of 33 survey sites and accounted for 0.01% of the colonized bottom and 0.07% of the coral cover, ranking as 13th most common (Smith 2013).

In a survey of Utila, Honduras between 1999 and 2000, rough cactus coral was observed at 8% of 784 surveyed sites and was the 36th most commonly observed out of 46 coral species; other *Mycetophyllia* species were seen more commonly (Afzal et al. 2001). In surveys of remote southwest reefs of Cuba, rough cactus coral was observed at 1 of 38 reef-front sites, where average abundance was 0.004 ± 0.027 (standard deviation [SD]) colonies per approximately 32-ft (10 m) transect; this was comparatively lower than the other 3 *Mycetophyllia* species observed (Alcolado et al. 2010a). Between 1998 and 2004, rough cactus coral was observed at 3 of 6 sites monitored in Colombia, where their cover ranged from 0.3-0.4% (Rodriguez-Ramirez et al. 2010). In Barbados, rough cactus coral was observed on 1 of 7 reefs surveyed, and the average cover was 0.04% (Tomascik and Sander 1987).

In 1981, rough cactus coral was observed on 1 of 4 reefs surveyed in the upper Florida Keys at 0.1% cover (Burns 1985). In surveys of the Florida Keys between 1996 and 2003, rough cactus coral cover was 0.022%, 0.005%, and less than 0.001% on patch reefs, deep offshore reefs, and shallow offshore reefs, respectively (Somerfield et al. 2008). At permanent monitoring stations in the Florida Keys, the number of stations where rough cactus coral was present declined between 1996 and 2003 (Waddell 2005). Of 42 spp. surveyed on the Florida reef tract between 2005 and 2010, rough cactus coral was the least abundant at densities of 0.02 and 0.01 colonies per approximately 100 ft^2 (10 m^2) on mid-channel reefs and fore-reefs, respectively (Burman et al. 2012).

Rough cactus coral has been reported to occur on 3-50% of reefs surveyed and is one of the least common coral species observed. On reefs where rough cactus coral is found, it generally occurs at abundances of less than 1 colony per approximately 100 ft^2 (10 m^2) and percent cover of less than 0.1. Based on population estimates, there are at least hundreds of thousands of rough cactus coral colonies present in the Florida Keys and Dry Tortugas combined. Absolute abundance is higher than the estimate from these 2 locations given the presence of this species in many other locations throughout its range. Low encounter rate and percent cover coupled with the tendency to include *Mycetophyllia* spp. at the genus level make it difficult to discern population trends of rough cactus coral from monitoring data. However, reported losses of rough cactus coral from monitoring stations in the Florida Keys and Dry Tortugas (63-80% loss) indicate population decline in these locations. Based on declines in Florida, we conclude rough cactus coral has likely declined throughout its range, and will continue to decline based on increasing threats.

Threats
A summary of threats to all corals is provided in Section 4.2.2 General Threats Faced by All Coral Species. Detailed information on the threats to rough cactus coral can be found in the Final Listing Rule (79 FR 53851; September 10, 2014); however, a brief summary is provided here. Rough cactus coral survival is highly susceptible to disease, and susceptible to ocean warming, acidification, trophic effects of fishing, nutrients, and sedimentation.

Rough cactus coral survival has some susceptibility to ocean warming. However, the available information does not support a more precise description of susceptibility to this threat. The bleaching reports available specifically for rough cactus coral and at the genus level indicate similar trends of relatively low bleaching observed in 1995, 1998, and 2010 (less than 25%).

Further in the more severe 2005 bleaching event, higher beaching levels (50-65%) or no bleaching, were observed in different locations in its range. Reproductive failure and a disease outbreak were reported for the genus after the 2005 bleaching event. Although bleaching of most coral species is spatially and temporally variable, understanding the susceptibility of rough cactus coral is somewhat confounded by the species' low sample size in any given survey due to its low encounter rate.

Rough cactus coral survival is highly susceptible to disease. Reports in the Florida Keys indicate rough cactus coral is very susceptible to white plague, and reports of high losses and correlation with higher temperatures date back to the mid-1970s (Dustan 1977). Although heavy impacts of disease on rough cactus coral have not been reported in other locations, an outbreak of white plague was credited with causing heavy mortality at the genus level in Puerto Rico after the 2005 bleaching event (Wilkinson 2008a).

Rough cactus coral may be susceptible to nutrient enrichment as evidenced by its absence from eutrophic sites in one location. However, there is uncertainty about whether the absence is a result of eutrophic conditions or a result of uncommon or rare occurrence. Therefore, we conclude that rough cactus coral likely has some susceptibility to nutrient enrichment. However, the available information does not support a more precise description of susceptibility.

Summary of Status

Rough cactus coral has declined due to disease in at least a portion of its range and has low recruitment, which limits its capacity for recovery from mortality events and exacerbates vulnerability to extinction. Despite the large number of islands and environments that are included in the species' range, geographic distribution in the highly disturbed Caribbean exacerbates vulnerability to extinction because rough cactus coral is localized to areas with high, localized human impacts and predicted increasing threats. Its depth range of 5 to 90 m moderates vulnerability to extinction because deeper areas of its range will usually have lower temperatures than surface waters. Acidification is predicted to accelerate most in deeper and cooler waters than those in which the species occurs. Its habitat includes shallow and mesophotic reefs which moderates vulnerability to extinction because the species occurs in numerous types of reef environments that are predicted, on local and regional scales, to experience highly variable thermal regimes and ocean chemistry at any given point in time. Rough cactus coral is usually uncommon to rare throughout its range. Its absolute abundance has been estimated as at least hundreds of thousands of colonies in the Florida Keys and Dry Tortugas combined and is higher than the estimate from these 2 locations due to the occurrence of the species in many other areas throughout its range. Its abundance, combined with spatial variability in ocean warming and acidification across the species' range, moderate vulnerability to extinction because the threats are non-uniform. Subsequently, there will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time. However, we anticipate that the population abundance is likely to decrease in the future with increasing threats.

4.2.2.5 Lobed, Mountainous, and Boulder Star Coral (*Orbicella annularis*, *Orbicella faveolata*, *Orbicella franksi*)

On September 10, 2014, NMFS listed lobed star coral as threatened (79 FR 53851). Lobed star coral (*Orbicella annularis*), mountainous star coral (*Orbicella faveolata*), and boulder star coral

(*Orbicella franksi*) are the 3 species in the *Orbicella annularis* star coral complex. These 3 species were formerly in the genus *Montastraea*; however, recent work has reclassified the 3 species in the *annularis* complex to the genus *Orbicella* (Budd et al. 2012). The star coral species complex was historically one of the primary reef framework builders throughout the wider Caribbean. The complex was considered a single species – *Montastraea annularis* – with varying growth forms ranging from columns, to massive boulders, to plates. In the early 1990s, Weil and Knowlton (1994) suggested the partitioning of these growth forms into separate species, resurrecting the previously described taxa, *Montastraea* (now *Orbicella*) *faveolata* and *Montastraea* (now *Orbicella*) *franksi.* The 3 species were differentiated on the basis of morphology, depth range, ecology, and behavior (Weil and Knowton 1994). Subsequent reproductive and genetic studies have supported the partitioning of the *annularis* complex into 3 species.

Some studies report on the star coral species complex rather than individual species since visual distinction can be difficult where colony morphology cannot be discerned (e.g. small colonies or photographic methods). Information from these studies is reported for the species complex. Where species-specific information is available, it is reported. However, information about *Orbicella annularis* published prior to 1994 will be attributed to the species complex since it is dated prior to the split of *Orbicella annularis* into 3 separate species.

Species Description and Distribution
Lobed Star Coral: Lobed star coral colonies grow in columns that exhibit rapid and regular upward growth. In contrast to the other 2 star coral species, margins on the sides of columns are typically dead. Live colony surfaces usually lack ridges or bumps.

Lobed star coral is common throughout the western Atlantic Ocean and greater Caribbean Sea including the Flower Garden Banks, but may be absent from Bermuda. Lobed star coral is reported from most reef environments in depths of approximately 1.5-66 ft (0.5-20 m). The star coral species complex is a common, often dominant component of Caribbean mesophotic (e.g., >100 ft [30 m]) reefs, suggesting the potential for deep refuge across a broader depth range, but lobed star coral is generally described with a shallower distribution.

Asexual fission and partial mortality can lead to multiple clones of the same colony. The percentage of unique individuals is variable by location and is reported to range between 18% and 86% (thus, 14-82% are clones). Colonies in areas with higher disturbance from hurricanes tend to have more clonality. Genetic data indicate that there is some population structure in the eastern, central, and western Caribbean with population connectivity within but not across areas. Although lobed star coral is still abundant, it may exhibit high clonality in some locations, meaning that there may be low genetic diversity.

Mountainous Star Coral: Mountainous star coral grows in heads or sheets, the surface of which may be smooth or have keels or bumps. The skeleton is much less dense than in the other 2 star coral species. Colony diameters can reach up to 33 ft (10 m) with heights of 13-16 ft (4-5 m).

Mountainous star coral occurs in the western Atlantic and throughout the Caribbean, including Bahamas, Flower Garden Banks, and the entire Caribbean coastline. There is conflicting information on whether or not it occurs in Bermuda. Mountainous star coral has been reported in most reef habitats and is often the most abundant coral at 33-66 ft (10-20 m) in fore-reef environments. The depth range of mountainous star coral has been reported as approximately 1.5-132 ft (0.5-40 m), though the species complex has been reported to depths of 295 ft (90 m), indicating mountainous star coral's depth distribution is likely deeper than 132 ft (40 m). Star coral species are a common, often dominant component of Caribbean mesophotic reefs (e.g., > 100 ft [30 m]), suggesting the potential for deep refugia for mountainous star coral.

Boulder Star Coral: Boulder star coral is distinguished by large, unevenly arrayed polyps that give the colony its characteristic irregular surface. Colony form is variable, and the skeleton is dense with poorly developed annual bands. Colony diameter can reach up to 16 ft (5 m) with a height of up to 6.5 ft (2 m).

Boulder star coral is distributed in the western Atlantic Ocean and throughout the Caribbean Sea including in the Bahamas, Bermuda, and the Flower Garden Banks. Boulder star coral tends to have a deeper distribution than the other 2 species in the *Orbicella* species complex. It occupies most reef environments and has been reported from water depths ranging from approximately 16-165 ft (5-50 m), with the species complex reported to 250 ft (90 m). *Orbicella* species are a common, often dominant, component of Caribbean mesophotic reefs (e.g., >100 ft [30 m]), suggesting the potential for deep refugia for boulder star coral.

Life History Information

The star coral species complex has growth rates ranging from 0.02-0.5 in (0.06-1.2 cm) per year and averaging approximately 0.3 in (1 cm) linear growth per year. The reported growth rate of lobed star coral is 0.4 to 1.2 cm per year (Cruz-Piñón et al. 2003; Tomascik 1990). They grow more slowly in deeper water and in less clear water.

All 3 species of the star coral complex are hermaphroditic broadcast spawners[8], with spawning concentrated on 6-8 nights following the full moon in late August, September, or early October depending on location and timing of the full moon. All 3 species are largely self-incompatible (Knowlton et al. 1997; Szmant et al. 1997). Further, mountainous star coral is largely reproductively incompatible with boulder star coral and lobed star coral, and it spawns about 1-2 hours earlier. Fertilization success measured in the field was generally below 15% for all 3 species, as it is closely linked to the number of colonies concurrently spawning. Lobed star coral is reported to have slightly smaller egg size and potentially smaller size/age at first reproduction that the other 2 species of the *Orbicella* genus. In Puerto Rico, minimum size at reproduction for the star coral species complex was 12 in^2 (83 cm^2).

Successful recruitment by the star coral complex species has seemingly always been rare. Only a single recruit of *Orbicella* was observed over 18 years of intensive observation of 130 ft^2 (12 m^2) of reef in Discovery Bay, Jamaica. Many other studies throughout the Caribbean also report negligible to absent recruitment of the species complex.

Lobed Star Coral: In addition to low recruitment rates, lobed star corals have late reproductive maturity. Colonies can grow very large and live for centuries. Large colonies have lower total

[8] Simultaneously containing both sperm and eggs, which are released into the water column for fertilization.

mortality than small colonies, and partial mortality of large colonies can result in the production of clones. The historical absence of small colonies and few observed recruits, even though large numbers of gametes are produced on an annual basis, suggests that recruitment events are rare and were less important for the survival of the lobed star coral species complex in the past (Bruckner 2012a). Large colonies in the species complex maintain the population until conditions favorable for recruitment occur; however, poor conditions can influence the frequency of recruitment events. While the life history strategy of the star coral species complex has allowed the taxa to remain abundant, the buffering capacity of this life history strategy has likely been reduced by recent population declines and partial mortality, particularly in large colonies.

Mountainous Star Coral: Life history characteristics of mountainous star coral is considered intermediate between lobed star coral and boulder star coral especially regarding growth rates, tissue regeneration, and egg size,. Spatial distribution may affect fecundity on the reef, with deeper colonies of mountainous star coral being less fecund due to greater polyp spacing. Reported growth rates of mountainous star coral range between 0.12 and 0.64 in (0.3 and 1.6 cm) per year (Cruz-Piñón et al. 2003; Tomascik 1990; Villinski 2003; Waddell 2005). Graham and van Woesik (2013) report that 44% of small colonies of mountainous star coral in Puerto Morelos, Mexico that resulted from partial colony mortality produced eggs at sizes smaller than those typically characterized as being mature. The number of eggs produced per unit area of smaller fragments was significantly less than in larger size classes. Szmant and Miller (2005) reported low post-settlement survivorship for mountainous star coral transplanted to the field with only 3-15% remaining alive after 30 days. Post-settlement survivorship was much lower than the 29% observed for elkhorn coral after 7 months (Szmant and Miller 2005).

Mountainous star coral has slow growth rates, late reproductive maturity, and low recruitment rates. Colonies can grow very large and live for centuries. Large colonies have lower total mortality than small colonies, and partial mortality of large colonies can result in the production of clones. The historical absence of small colonies and few observed recruits, even though large numbers of gametes are produced on an annual basis, suggests that recruitment events are rare and were less important for the survival of the star coral species complex in the past (Bruckner 2012a). Large colonies in the species complex maintain the population until conditions favorable for recruitment occur; however, poor conditions can influence the frequency of recruitment events. While the life history strategy of the star coral species complex has allowed the taxa to remain abundant, we conclude that the buffering capacity of this life history strategy has been reduced by recent population declines and partial mortality, particularly in large colonies.

Boulder Star Coral: Of 351 boulder star coral colonies observed to spawn at a site off Bocas del Toro, Panama, 324 were unique genotypes. Over 90% of boulder star coral colonies on this reef were the product of sexual reproduction, and 19 genetic individuals had asexually propagated colonies made up of 2 to 4 spatially adjacent clones of each. Individuals within a genotype spawned more synchronously than individuals of different genotypes. Additionally, within 16 ft (5 m), colonies nearby spawned more synchronously than farther spaced colonies, regardless of genotype. At distances greater than 16 ft (5 m), spawning was random between colonies (Levitan et al. 2011).

In addition to low recruitment rates, lobed star corals have late reproductive maturity. Colonies can grow very large and live for centuries. Large colonies have lower total mortality than small colonies, and partial mortality of large colonies can result in the production of clones. The historical absence of small colonies and few observed recruits, even though large numbers of gametes are produced on an annual basis, suggests that recruitment events are rare and were less important for the survival of the lobed star coral species complex in the past (Bruckner 2012a). Large colonies in the species complex maintain the population until conditions favorable for recruitment occur; however, poor conditions can influence the frequency of recruitment events. While the life history strategy of the star coral species complex has allowed the taxa to remain abundant, the buffering capacity of this life history strategy has likely been reduced by recent population declines and partial mortality, particularly in large colonies.

Status and Population Dynamics

Lobed Star Coral: Information on lobed star coral status and populations dynamics is infrequently documented throughout its range. Comprehensive and systematic census and monitoring has not been conducted. Thus, the status and populations dynamics must be inferred from the few locations were data exist.

Lobed star coral has been described as common overall. Demographic data collected in Puerto Rico over 9 years before and after the 2005 bleaching event showed that population growth rates were stable in the pre-bleaching period (2001–2005) but declined 1 year after the bleaching event. Population growth rates declined even further 2 years after the bleaching event, but they returned and then stabilized at the lower rate the following year.

In the Florida Keys, abundance of lobed star coral ranked 30 out of 47 coral species in 2005, 13 out of 43 in 2009, and 12 out of 40 in 2012. Extrapolated population estimates from stratified random samples were 5.6 million ± 2.7 million (standard error [SE]) in 2005, 11.5 million ± 4.5 million (SE) in 2009, and 24.3 million ± 12.4 million (SE) in 2012. Size class distribution was somewhat variable between survey years, with a larger proportion of colonies in the smaller size classes in 2005 compared to 2009 and 2012 and a greater proportion of colonies in the greater than 36-in (90 cm) size class in 2012 compared to 2005 and 2009. Partial colony mortality was lowest at less than 4 in (10 cm; as low as approximately 5%) and up to approximately 70% in the larger size classes. In the Dry Tortugas, Florida, abundance of lobed star coral ranked 41 out of 43 in 2006 and 31 out of 40 in 2008. The extrapolated population estimate was 0.5 million ± 0.3 million (SE) colonies in 2008. Differences in population estimates between years may be attributed to sampling effort rather than population trends (Miller et al. 2013a).

Colony density varies by habitat and location, and ranges from less than 0.1 to greater than 1 colony per approximately 100 ft^2 (10 m^2). In surveys of 1,176 sites in southeast Florida, the Dry Tortugas, and the Florida Keys between 2005 and 2010, density of lobed star coral ranged between 0.09 and 0.84 colonies per approximately 100 ft^2 (10 m^2) and was highest on mid-channel reefs followed by inshore reefs, offshore patch reefs, and fore-reefs (Burman et al. 2012). Along the east coast of Florida, density was highest in areas south of Miami (0.34 colonies per approximately 100 ft^2 [10 m^2]) compared to Palm Beach and Broward Counties (0.04 colonies per ~100 ft2 [10 m2]; Burman et al. 2012). In surveys between 2005 and 2007 along the Florida reef tract from Martin County to the lower Florida Keys, density of lobed star coral was approximately 1.3 colonies per approximately 100 ft^2 ([10 m^2] (Wagner et al. 2010). Off southwest Cuba on remote reefs, lobed star coral density was 0.31 ± 0.46 (SD) per approximately 30 ft (10 m) transect on 38 reef-crest sites and 1.58 ± 1.29 colonies per approximately 30 ft (10 m) transect on 30 reef-front sites. Colonies with partial mortality were far more frequent than those with no partial mortality which only occurred in the size class less than 40 in (100 cm) (Alcolado et al. 2010a).

Population trends are available from a number of studies. In a study of sites inside and outside a marine protected area in Belize, lobed star coral cover declined significantly over a 10-year period (1998/99 to 2008/09) (Huntington et al. 2011). In a study of 10 sites inside and outside of a marine reserve in the Exuma Cays, Bahamas, cover of lobed star coral increased between 2004 and 2007 inside the protected area and decreased outside the protected area (Mumby and Harborne 2010). Between 1996 and 2006, lobed star coral declined in cover by 37% in permanent monitoring stations in the Florida Keys (Waddell and Clarke 2008a). Cover of lobed star coral declined 71% in permanent monitoring stations between 1996 and 1998 on a reef in the upper Florida Keys (Porter et al. 2001).

Star corals are the 3rd most abundant coral by percent cover in permanent monitoring stations in the U.S. Virgin Islands. A decline of 60% was observed between 2001 and 2012 primarily due to bleaching in 2005. However, most of the mortality was partial mortality and colony density in monitoring stations did not change (Smith 2013).

Bruckner and Hill (2009) did not note any extirpation of mountainous star coral at 9 sites off Mona and Desecheo Islands, Puerto Rico, monitored between 1995 and 2008. However, mountainous star coral and lobed star coral sustained the largest losses with the number of colonies of lobed star coral decreasing by 19% and 20% at Mona and Desecheo Islands, respectively. In 1998, 8% of all corals at 6 sites surveyed off Mona Island were lobed star coral colonies, dipping to approximately 6% in 2008. At Desecheo Island, 14% of all coral colonies were lobed star coral in 2000 while 13% were in 2008 (Bruckner and Hill 2009).

In a survey of 185 sites in 5 countries (Bahamas, Bonaire, Cayman Islands, Puerto Rico, and St. Kitts and Nevis) in 2010 and 2011, size of lobed star coral and boulder star coral colonies was significantly smaller than mountainous star coral. Total mean partial mortality of lobed star coral colonies at all sites was 40%. Overall, the total area occupied by live lobed star coral declined by a mean of 51%, and mean colony size declined from 299 in^2 to 146 in^2 (1927 cm^2 to 939 cm^2). There was a 211% increase in small tissue remnants less than 78 in^2 (500 cm^2), while the proportion of completely live large (1.6-32 ft^2 [1,500- 30,000 cm^2]) colonies declined. Star coral colonies in Puerto Rico were much larger with large amounts of dead sections. In contrast, colonies in Bonaire were also large with greater amounts of live tissue. The presence of dead sections was attributed primarily to outbreaks of white plague and yellow band disease, which emerged as corals began recovering from mass bleaching events. This was followed by increased predation and removal of live tissue by damselfish algal lawns (Bruckner 2012a).

Cover of lobed star coral at Yawzi Point, St. John, U.S. Virgin Islands declined from 41% in 1988 to approximately 12% by 2003 as a rapid decline began with the aftermath of Hurricane Hugo in 1989. This decline continued between 1994 and 1999 during a time of 2 hurricanes

(1995) and a year of unusually high sea temperature (1998) but percent cover remained statistically unchanged between 1999 and 2003. Colony abundances declined from 47 to 20 colonies per approximately 10 ft^2 (1 m^2) between 1988 and 2003, due mostly to the death and fission of medium-to-large colonies (≥ 24 in^2 [151 cm^2]). Meanwhile, the population size class structure shifted between 1988 and 2003 to a higher proportion of smaller colonies in 2003 (60% less than 7 in^2 [50 cm^2] in 1988 versus 70% in 2003) and lower proportion of large colonies (6% greater than 39 in^2 [250 cm^2] in 1988 versus 3% in 2003). The changes in population size structure indicated a population decline coincident with the period of apparent stable coral cover. Population modeling forecasted the 1988 size structure would not be reestablished by recruitment and a strong likelihood of extirpation of lobed star coral at this site within 50 years (Edmunds and Elahi 2007).

Lobed star coral colonies were monitored between 2001 and 2009 at Culebra Island, Puerto Rico. The population was in demographic equilibrium (high rates of survival and stasis) before the 2005 bleaching event, but it suffered a significant decline in growth rate (mortality and shrinkage) for 2 consecutive years after the bleaching event. Partial tissue mortality due to bleaching caused dramatic colony fragmentation that resulted in a population made up almost entirely of small colonies by 2007 (97% were less than 7 in^2 [50 cm^2]). Three years after the bleaching event, the population stabilized at about half of the previous level, with fewer medium-to-large size colonies and more smaller colonies (Hernandez-Delgado et al. 2011).

Lobed star coral was historically considered to be one of the most abundant species in the Caribbean (Weil and Knowton 1994). Percent cover has declined to between 37% and 90% over the past several decades at reefs at Jamaica, Belize, Florida Keys, The Bahamas, Bonaire, Cayman Islands, Curaçao, Puerto Rico, U.S. Virgin Islands, and St. Kitts and Nevis. Based on population estimates, there are at least tens of millions of lobed star coral colonies present in the Florida Keys and Dry Tortugas combined. Absolute abundance is higher than the estimate from these 2 locations given the presence of this species in many other locations throughout its range. Star coral remains common in occurrence. Abundance has decreased in some areas to between 19% and 57%, and shifts to smaller size classes have occurred in locations such as Jamaica, Colombia, The Bahamas, Bonaire, Cayman Islands, Puerto Rico, U.S. Virgin Islands, and St. Kitts and Nevis. At some reefs, a large proportion of the population is comprised of non-fertile or less-reproductive size classes. Several population projections indicate population decline in the future is likely at specific sites, and local extirpation is possible within 25-50 years at conditions of high mortality, low recruitment, and slow growth rates. We conclude that while substantial population decline has occurred in lobed star coral, it is still common throughout the Caribbean and remains one of the dominant species numbering at least in the tens of millions of colonies. We conclude that the buffering capacity of lobed star coral's life history strategy that has allowed it to remain abundant has been reduced by the recent population declines and amounts of partial mortality, particularly in large colonies. We also conclude that the population abundance is likely to decrease in the future with increasing threats.

<u>Mountainous Star Corals</u>: Information on mountainous star coral status and populations dynamics is infrequently documented throughout its range. Comprehensive and systematic census and monitoring has not been conducted. Thus, the status and populations dynamics must be inferred from the few locations were data exist.

Information regarding population structure is limited. Observations of mountainous star coral from 182 sample sites in the upper and lower Florida Keys and Mexico showed 3 well-defined populations based on 5 genetic markers, but the populations were not stratified by geography, indicating they were shared among the 3 regions (Baums et al. 2010). Of 10 mountainous star coral colonies observed to spawn at a site off Bocas del Toro, Panama, there were only 3 genotypes (Levitan et al. 2011) potentially indicating 30% clonality.

Extrapolated population estimates from stratified random samples in the Florida Keys were 39.7 ± 8 million (standard error [SE]) colonies in 2005, 21.9 ± 7 million (SE) colonies in 2009, and 47.3 ± 14.5 million (SE) colonies in 2012. The greatest proportion of colonies tended to fall in the 4-8 in (10-20 cm) and 8-12 in (20-30 cm) size classes in all survey years, but there was a fairly large proportion of colonies in the greater than 36-in (90 cm)-size class. Partial mortality of the colonies was between 10% and 60% of the surface across all size classes. In the Dry Tortugas, Florida, mountainous star coral ranked seventh most abundant out of 43 coral species in 2006 and fifth most abundant out of 40 in 2008. Extrapolated population estimates were 36.1 ± 4.8 million (SE) colonies in 2006 and 30 ± 3.3 million (SE) colonies in 2008. The size classes with the largest proportion of colonies were 4-8 in (10-20 cm) and 8-12 in (20-30 cm), but there was a fairly large proportion of colonies in the greater-than-36-in (90 cm) size class. Partial mortality of the colonies ranged between approximately 2% and 50%. Because these population abundance estimates are based on random surveys, differences between years may be attributed to sampling effort rather than population trends (Miller et al. 2013a).

In a survey of 31 sites in Dominica between 1999 and 2002, mountainous star coral was present at 80% of the sites at 1-10% cover (Steiner 2003a). In a 1995 survey of 16 reefs in the Florida Keys, mountainous star coral ranked as the coral species with the second highest percent cover (Murdoch and Aronson 1999). On 84 patch reefs (10 ft [3 m] to 16.5 ft [5 m] depth) spanning 149 mi (240 kilometers) in the Florida Keys, mountainous star coral was the third most abundant coral species comprising 7% of the 17,568 colonies encountered. It was present at 95% of surveyed reefs between 2001 and 2003 (Lirman and Fong 2007). In surveys of 280 sites in the upper Florida Keys in 2011, mountainous star coral was present at 87% of sites visited (Miller et al. 2011). In 2003 on the East Flower Garden Bank, mountainous star coral comprised 10% of the 76.5% coral cover on reefs 105-132 ft (32-40 m), and partial mortality due to bleaching, disease, and predation were rare at monitoring stations (Precht et al. 2005).

Colony density ranges from approximately 0.1-1.8 colonies per 108 ft^2 (10 m^2) and varies by habitat and location. In surveys along the Florida reef tract from Martin County to the lower Florida Keys, density of mountainous star coral was approximately 1.6 colonies per 108 ft^2 (10 m2Wagner et al. 2010). On remote reefs off southwest Cuba, density of mountainous star coral was 0.12 ± 0.20 (SE) colonies per 33 ft (10 m) transect on 38 reef-crest sites and 1.26 ± 1.06 (SE) colonies per 33 ft (10 m) transect on 30 reef-front sites (Alcolado et al. 2010a). In surveys of 1,176 sites in southeast Florida, the Dry Tortugas, and the Florida Keys between 2005 and 2010, density of mountainous star coral ranged between 0.17 and 1.75 colonies per 108 ft^2 (10 m^2) and was highest on mid-channel reefs followed by offshore patch reefs and fore-reefs (Burman et al. 2012). Along the east coast of Florida, density was highest in areas south of

Miami at 0.94 colonies per 108 ft^2 (10 m^2) compared to 0.11 colonies per 108 ft^2 (10 m^2) in Palm Beach and Broward Counties (Burman et al. 2012).

Mountainous star coral is the sixth most abundant species by percent cover in permanent monitoring stations in the U.S. Virgin Islands. The star coral species complex had the highest abundance at these stations and included all colonies where species identification was uncertain. Population estimates in the 19 mi^2 (49 km^2) of the Red Hind Marine Conservation District are at least 16 million colonies of mountainous star corals (Smith 2013).

Population trend data exists for several locations. At 9 sites off Mona and Desecheo Islands, Puerto Rico, no species extirpations were noted at any site over 10 years of monitoring between 1998 and 2008 (Bruckner and Hill 2009). Both mountainous star coral and lobed star coral sustained large losses during the period. The number of colonies of mountainous star coral decreased by 36% and 48% at Mona and Desecheo Islands, respectively (Bruckner and Hill 2009). In 1998, 27% of all corals at 6 sites surveyed off Mona Island were mountainous star coral colonies, but this statistic decreased to approximately 11% in 2008 (Bruckner and Hill 2009). At Desecheo Island, 12% of all coral colonies were mountainous star coral in 2000, compared to 7% in 2008.

In a survey of 185 sites in 5 countries (Bahamas, Bonaire, Cayman Islands, Puerto Rico, and St. Kitts and Nevis) between 2010 and 2011, size of mountainous star coral colonies was significantly greater than boulder star coral and lobed star coral. The total mean partial mortality of mountainous star coral at all sites was 38%. The total live area occupied by mountainous star coral declined by a mean of 65%, and mean colony size declined from 43 ft^2 to 15 ft^2 (4005 cm^2 to 1413 cm^2). At the same time, there was a 168% increase in small tissue remnants less than 5 ft^2 (500 cm^2), while the proportion of completely live large (1.6 ft^2 to 32 ft^2 [1,500- 30,000 cm^2]) colonies decreased. Mountainous star coral colonies in Puerto Rico were much larger and sustained higher levels of mortality compared to the other 4 countries. Colonies in Bonaire were also large, but they experienced much lower levels of mortality. Mortality was attributed primarily to outbreaks of white plague and yellow band disease, which emerged as corals began recovering from mass bleaching events. This was followed by increased predation and removal of live tissue by damselfish to cultivate algal lawns (Bruckner 2012a).

Based on population estimates, there are at least tens of millions of colonies present in each of several locations including the Florida Keys, Dry Tortugas, and the U.S. Virgin Islands. Absolute abundance is higher than the estimate from these 3 locations given the presence of this species in many other locations throughout its range. Population decline has occurred over the past few decades with a 65% loss in mountainous star coral cover across 5 countries. Losses of mountainous star coral from Mona and Descheo Islands, Puerto Rico include a 36-48% reduction in abundance and a decrease of 42-59% in its relative abundance (i.e., proportion relative to all coral colonies). High partial mortality of colonies has led to smaller colony sizes and a decrease of larger colonies in some locations such as The Bahamas, Bonaire, Puerto Rico, Cayman Islands, and St. Kitts and Nevis. Partial colony mortality is lower in some areas such as the Flower Garden Banks. We conclude that mountainous star coral has declined but remains common and likely has at least tens of millions of colonies throughout its range. Additionally, as discussed in the genus section, we conclude that the buffering capacity of mountainous star coral's life history strategy which has allowed it to remain abundant has been reduced by the recent population declines and amounts of partial mortality, particularly in large colonies. We also conclude that the population abundance is likely to decrease in the future with increasing threats.

Boulder Star Corals: Information on boulder star coral status and populations dynamics is infrequently documented throughout its range. Comprehensive and systematic census and monitoring has not been conducted. Thus, the status and populations dynamics must be inferred from the few locations were data exist.

Boulder star coral is reported as common. In a 1995 survey of 16 reefs in the Florida Keys, boulder star coral had the highest percent cover of all species (Murdoch and Aronson 1999). In surveys throughout the Florida Keys, boulder star coral in 2005 ranked 26th most abundant out of 47 coral species, 32nd out of 43 in 2009, and 33rd out of 40 in 2012. Extrapolated population estimates from stratified random surveys were 8.0 ± 3.5 million (standard error [SE]) colonies in 2005, 0.3 ± 0.2 million (SE) colonies in 2009, and 0.4 ± 0.4 million (SE) colonies in 2012. The authors note that differences in extrapolated abundance between years were more likely a function of sampling design rather than an indication of population trends. In 2005, the greatest proportions of colonies were in the smaller size classes of approximately 4-8 in (10-20 cm) and approximately 8-12 in (20-30 cm). Partial colony mortality ranged from 0% to approximately 73% and was generally higher in larger colonies (Miller et al. 2013a).

In the Dry Tortugas, Florida, boulder star coral ranked 4th highest in abundance out of 43 coral species in 2006 and 8th out of 40 in 2008. Extrapolated population estimates were 79 ± 19 million (SE) colonies in 2006 and 18.2 ± 4.1 million (SE) colonies in 2008. The authors note the difference in estimates between years was more likely a function of sampling design rather than population decline. In the first year of the study (2006), the greatest proportion of colonies were in the size class approximately 8-12 in (20-30 cm) with twice as many colonies as the next most numerous size class and a fair number of colonies in the largest size class of greater than 3 ft (90 cm). Partial colony mortality ranged from approximately 10-55%. Two years later (2008), no size class was found to dominate, and proportion of colonies in the medium-to-large size classes (approximately 24-36 in) appeared to be less than in 2006. The number of colonies in the largest size class of greater than 3 ft (90 cm) remained consistent. Partial colony mortality ranged from approximately 15-75% (Miller et al. 2013a).

In 2003, on the east Flower Garden Bank, boulder star coral comprised 46% of the 76.5% coral cover on reefs approximately 105-131 ft (32-40 m) in depth. Partial coral mortality due to bleaching, disease and predation was rare in survey stations (Precht et al. 2005). In a survey of 31 sites in Dominica between 1999 and 2002, boulder star coral was present in 7% of the sites at less than 1% cover (Steiner 2003a).

Reported density is variable by location and habitat and is reported to range from 0.02 to 1.05 colonies per approximately (~) 100 ft^2 (10 m^2). In surveys of 1,176 sites in southeast Florida, the Dry Tortugas, and the Florida Keys between 2005 and 2010, density of boulder star coral ranged between 0.04 and 0.47 colonies per ~100 ft^2 (10 m^2) and was highest on the offshore patch reef and fore-reef habitats (Burman et al. 2012). In south Florida, density was highest in areas south of Miami at 0.44 colonies per ~100 ft^2 (10 m^2) compared to 0.02 colonies per ~100 ft^2 (10 m^2) in Palm Beach and Broward Counties (Burman et al. 2012). Along the Florida reef tract from Martin County to the lower Florida Keys, density of boulder star coral was ~0.9 colonies per ~100 ft^2 (10 m^2; (Wagner et al. 2010). On remote reefs off southwest Cuba, colony density was 0.083 ± 0.17 (SD) per ~100 ft^2 (10 m^2) transect on 38 reef-crest sites and 1.05 ± 1.02 colonies per ~100 ft^2 (10 m^2) transect on 30 reef-front sites (Alcolado et al. 2010a). The number of boulder star coral colonies in Cuba with partial colony mortality were far more frequent than those with no mortality across all size classes, except for 1 (i.e., less than ~20 in [50 cm]) that had similar frequency of colonies with and without partial mortality (Alcolado et al. 2010a).

In the U.S. Virgin Islands, boulder star coral is the second most abundant species by percent cover at permanent monitoring stations. However, because the species complex, which is the most abundant by cover, was included as a category prior to separating the 3 sibling species, it is likely that boulder star coral is the most abundant, when including mesophotic reefs. Population estimates of boulder star coral in the approximately 19-mi^2 (49 km^2) area of the Red Hind Marine Conservation District are at least 34 million colonies (Smith 2013).

Abundance in Curaçao and Puerto Rico appears to be stable over an 8-10 year period. In Curaçao, abundance was stable between 1997 and 2005, with partial mortality similar or less in 2005 compared to 1998 (Bruckner and Bruckner 2006). Abundance was also stable between 1998-2008 at 9 sites off Mona and Desecheo Islands, Puerto Rico. In 1998, 4% of all corals at 6 sites surveyed off Mona Island were boulder star coral colonies and approximately 5% in 2008; at Desecheo Island, about 2% of all coral colonies were boulder star coral in both 2000 and 2008 (Bruckner and Hill 2009).

On the other hand, colony size has decreased over the past several decades. Bruckner conducted a survey of 185 sites (2010 and 2011) in 5 countries (The Bahamas, Bonaire, Cayman Islands, Puerto Rico, and St. Kitts and Nevis) and reported the size of boulder star coral and lobed star coral colonies as significantly smaller than mountainous star coral. The total mean partial mortality of boulder star coral was 25%. Overall, the total live area occupied by boulder star coral declined by a mean of 38%, and mean colony size declined from 210 in^2 to 131 in^2 (1356 cm^2 to 845 cm^2). At the same time, there was a 137% increase in small tissue remnants, along with a decline in the proportion of large (1,500 to 30,000 cm^2), completely alive colonies. Mortality was attributed primarily to outbreaks of white plague and yellow band disease, which emerged as corals began recovering from mass bleaching events. This was followed by increased predation and removal of live tissue by damselfish to cultivate algal lawns (Bruckner 2012a).

Based on population estimates, there are at least tens of millions of colonies present in both the Dry Tortugas and U.S. Virgin Islands. Absolute abundance is higher than the estimate from these 2 locations given the presence of this species in many other locations throughout its range. The frequency and extent of partial mortality, especially in larger colonies of boulder star coral, appear to be high in some locations such as Florida and Cuba, though other locations like the Flower Garden Banks appear to have lower amounts of partial mortality. A decrease in boulder star coral percent cover by 38% and a shift to smaller colony size across 5 countries suggest that population decline has occurred in some areas; colony abundance appears to be stable in other areas. We anticipate that while population decline has occurred, boulder star coral is still common with the number of colonies at least in the tens of millions. Additionally, we conclude that the buffering capacity of boulder star coral's life history strategy that has allowed it to remain abundant has been reduced by the recent population declines and amounts of partial mortality, particularly in large colonies. We also anticipate that the population abundance is likely to decrease in the future with increasing threats.

Threats
A summary of threats to all corals is provided in Section 4.2.2 General Threats Faced by All Coral Species. Detailed information on the threats to star corals can be found in the Final Listing Rule (79 FR 53851; September 10, 2014); however, a brief summary is provided here.

<u>Lobed Star Coral</u>: Lobed star coral is highly susceptible to ocean warming, disease, ocean acidification, sedimentation, and nutrients, and susceptible to trophic effects of fishing.

Lobed star coral is highly susceptible to bleaching with 45-100% of colonies observed to bleach. Reported mortality from bleaching ranges from 2-71%. Recovery after bleaching is slow with paled colonies observed for up to a year. Reproductive failure can occur a year after bleaching, and reduced reproduction has been observed 2 years post-bleaching. There is indication that new algal symbiotic species establishment can occur prior to, during, and after bleaching events and results in bleaching resistance in individual colonies. Thus, lobed star coral is highly susceptible to ocean warming.

In a 2010 cold-water event that affected south Florida, mortality of lobed star coral was higher than any other coral species in surveys from Martin County to the lower Florida Keys. Average partial mortality was 56% during the cold-water event compared to 0.3% from 2005 to 2009. Surveys at a Florida Keys inshore patch reef, which experienced temperatures less than 18˚C for 11 days, revealed lobed star coral was one of the most susceptible coral species with all colonies experiencing total colony mortality.

Although there is no species-specific information on the susceptibility of lobed star coral to ocean acidification, genus information indicates the species complex has reduced growth and fertilization success under acidic conditions. Thus, we conclude lobed star coral likely has high susceptibility to ocean acidification.

Lobed star coral survival is highly susceptible to disease. Most studies report lobed star coral as among the species with the highest disease prevalence. Disease can cause extensive loss in coral cover, high levels of partial colony mortality, and changes in the relative proportions of smaller and larger colonies, particularly when outbreaks occur after bleaching events.

Lobed star coral survival has high susceptibility to sedimentation. Sedimentation can cause partial mortality and decreased coral cover of lobed star coral. In addition, genus information indicates sedimentation negatively affects primary production, growth rates, calcification, colony size, and abundance. Lobed star coral also has high susceptibility to nutrients. Elevated nutrients cause increased disease severity in lobed star coral. Genus-level information indicates elevated nutrients also cause reduced growth rates and lowered recruitment.

Mountainous Star Coral: Mountainous star coral is highly susceptible to ocean warming, disease, ocean acidification, sedimentation, and nutrients, and susceptible to trophic effects of fishing.

Mountainous star coral is highly susceptible to elevated temperatures. In lab experiments, elevated temperatures resulted in misshapen embryos and differential gene expression in larvae that could indicate negative effects on larval development and survival. Bleaching susceptibility is generally high; 37-100% of mountainous star coral colonies have reported to bleach during several bleaching events. Chronic local stressors can exacerbate the effects of warming temperatures, which can result in slower recovery from bleaching, reduced calcification, and slower growth rates for several years following bleaching. Additionally, disease outbreaks affecting mountainous star coral have been linked to elevated temperature as they have occurred after bleaching events. We conclude that mountainous star coral is highly susceptible to elevated temperature.

Surveys at an inshore patch reef in the Florida Keys that experienced temperatures less than 18˚C for 11 days revealed species-specific cold-water susceptibility and low survivorship. Mountainous star coral was one of the more susceptible species with 90% of colonies experiencing total colony mortality, including some colonies estimated to be more than 200 years old (Kemp et al. 2011). In surveys from Martin County to the lower Florida Keys, mountainous star coral was the second most susceptible coral species, experiencing an average of 37% partial mortality (Lirman et al. 2011).

Mountainous star coral is highly susceptible to ocean acidification. Laboratory studies indicate that ocean acidification affects that mountainous star coral both through reduced fertilization of gametes and reduced growth of colonies.

Mountainous star coral is often among the coral species with the highest disease prevalence and tissue loss. Outbreaks have been reported to affect 10-19% of mountainous star coral colonies, and yellow band disease and white plague have the greatest effect. Disease often affects larger colonies, and reported tissue loss due to disease ranges from 5-90%. Additionally, yellow band disease results in lower fecundity in diseased and recovered colonies of mountainous star coral. Therefore, we anticipate that mountainous star coral is highly susceptible to disease.

Sedimentation can cause partial mortality of mountainous star coral, and genus-level information indicates that sedimentation negatively affects primary production, growth rates, calcification, colony size, and abundance. Therefore, we anticipate that mountainous star coral is highly susceptible to sedimentation.

Although there is no species-specific information, the star coral species complex is susceptible to nutrient enrichment through reduced growth rates, lowered recruitment, and increased disease severity. Therefore, based on genus-level information, we anticipate that mountainous star coral is likely highly susceptible to nutrient enrichment.

Boulder Star Coral: Boulder star coral is highly susceptible to ocean warming, disease, ocean acidification, sedimentation, and nutrients, and susceptible to trophic effects of fishing.

Available information indicates that boulder star coral is highly susceptible to warming temperatures with a reported 88-90% bleaching frequency. Reported bleaching-related mortality from one study is high at 75%. There is indication that new algal symbiotic species establishment occurs after bleaching in boulder star coral.

In a 2010 cold-water event that affected south Florida, boulder star coral ranked as the 14th most susceptible coral species out of the 25 most abundant coral species. Average partial mortality was 8% in surveys from Martin County to the lower Florida Keys after the 2010 cold-water event compared to 0.4% average mortality during summer surveys between 2005 and 2009.

Although there is no species-specific information on the susceptibility of boulder star coral to ocean acidification, genus information indicates that the species complex has reduced growth and fertilization success under acidic conditions. Thus, we conclude boulder star coral survival likely has high susceptibility to ocean acidification.

Boulder star coral is often reported as among the species with the highest disease prevalence. Although there are few quantitative studies of the effects of disease on boulder star coral, there is evidence that partial mortality can average about 25-30% and that disease can cause shifts to smaller size classes. Thus, we conclude that boulder star coral survival is highly susceptible to disease.

Genus information indicates sedimentation negatively affects primary production, growth rates, calcification, colony size, and abundance. Genus level information also indicates boulder star coral is likely susceptible to nutrient enrichment through reduced growth rates and lower recruitment. Additionally, nutrient enrichment has been shown to increase the severity of yellow band disease in boulder star coral. Thus, we conclude that boulder star coral survival is highly susceptible to sedimentation and nutrient enrichment.

Summary of Status

Lobed Star Coral: Lobed star coral has undergone major declines mostly due to warming-induced bleaching and disease. Several population projections indicate population decline in the future is likely at specific sites and that local extirpation is possible within 25-50 years at conditions of high mortality, low recruitment, and slow growth rates. There is evidence of synergistic effects of threats for this species including disease outbreaks following bleaching events and increased disease severity with nutrient enrichment. Lobed star coral is highly susceptible to a number of threats, and cumulative effects of multiple threats have likely contributed to its decline and exacerbate vulnerability to extinction. Despite high declines, the species is still common and remains one of the most abundant species on Caribbean reefs. Its life history characteristics of large colony size and long life span have enabled it to remain relatively persistent despite slow growth and low recruitment rates, thus moderating vulnerability to extinction. However, the buffering capacity of these life history characteristics is expected to decrease as colonies shift to smaller size classes, as has been observed in locations in the species' range. Its absolute population abundance has been estimated as at least tens of millions of colonies in the Florida Keys and Dry Tortugas combined and is higher than the estimate from these 2 locations due to the occurrence of the species in many other areas throughout its range. Despite the large number of islands and environments that are included in the species' range, geographic distribution in the highly disturbed Caribbean exacerbates vulnerability to extinction because lobed star coral is limited to a areas with high localized human impacts and predicted increasing threats. Star coral occurs in most reef habitats 0.5-20 m in depth which moderates vulnerability to extinction because the species occurs in numerous types of reef environments that are predicted, on local and regional scales, to experience high temperature variation and ocean chemistry at any given point in time. Its abundance and life history characteristics, combined with spatial variability in ocean warming and acidification across the species' range, moderate vulnerability to extinction because the threats are non-uniform. Subsequently, there will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time. We also anticipate that the population abundance is likely to decrease in the future with increasing threats.

<u>Mountainous Star Coral</u>: Mountainous star coral has undergone major declines mostly due to warming-induced bleaching and disease. There is evidence of synergistic effects of threats for this species including disease outbreaks following bleaching events and reduced thermal tolerance due to chronic local stressors stemming from land-based sources of pollution. Mountainous star coral is highly susceptible to a number of threats, and cumulative effects of multiple threats have likely contributed to its decline and exacerbate its vulnerability to extinction. Despite high declines, the species is still common and remains one of the most abundant species on Caribbean reefs. Its life history characteristics of large colony size and long life span have enabled it to remain relatively persistent despite slow growth and low recruitment rates, thus moderating vulnerability to extinction. The buffering capacity of these life history characteristics, however, is expected to decrease as colonies shift to smaller size classes as has been observed in locations in its range. Its absolute population abundance has been estimated as at least tens of millions of colonies in each of several locations including the Florida Keys, Dry Tortugas, and the U.S. Virgin Islands and is higher than the estimate from these 3 locations due to the occurrence of the species in many other areas throughout its range. Despite the large number of islands and environments that are included in the species' range, geographic distribution in the highly disturbed Caribbean exacerbates vulnerability to extinction because mountainous star coral is limited to an area with high, localized human impacts and predicted increasing threats. Its depth range of 0.5 m to at least 40 m, possibly up to 90 m, moderates vulnerability to extinction because deeper areas of its range will usually have lower temperatures than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Mountainous star coral occurs in most reef habitats, including both shallow and mesophotic reefs, which moderates vulnerability to extinction because the species occurs in numerous types of reef environments that are predicted, on local and regional scales, to experience highly variable temperatures and ocean chemistry at any given point in time. Its abundance, life history characteristics, and depth distribution, combined with spatial variability in ocean warming and acidification across the species' range, moderate vulnerability to extinction because the threats are non-uniform. Subsequently, there will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time. We also anticipate that the population abundance is likely to decrease in the future with increasing threats.

Boulder Star Coral: Boulder star coral has undergone declines most likely from disease and warming-induced bleaching. There is evidence of synergistic effects of threats for this species including increased disease severity with nutrient enrichment. Boulder star coral is highly susceptible to a number of threats, and cumulative effects of multiple threats have likely contributed to its decline and exacerbate vulnerability to extinction. Despite declines, the species is still common and remains one of the most abundant species on Caribbean reefs. Its life history characteristics of large colony size and long life span have enabled it to remain relatively persistent despite slow growth and low recruitment rates, thus moderating vulnerability to extinction. However, the buffering capacity of these life history characteristics is expected to decrease as colonies shift to smaller size classes as has been observed in locations in its range. Its absolute population abundance has been estimated as at least tens of millions of colonies in both a portion of the U.S. Virgin Islands and the Dry Tortugas and is higher than the estimate from these 2 locations due to the occurrence of the species in many other areas throughout its range. Despite the large number of islands and environments that are included in the species' range, geographic distribution in the highly disturbed Caribbean exacerbates vulnerability to extinction because boulder star coral is limited to a areas with high localized human impacts and predicted increasing threats. Its depth range of approximately 16-165 ft (5-50 m), possibly up to 295 ft (90 m), moderates vulnerability to extinction because deeper areas of its range will usually have lower temperatures than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Boulder star coral occurs in most reef habitats, including both shallow and mesophotic reefs, which moderates vulnerability to extinction because the species occurs in numerous types of reef environments that are predicted, on local and regional scales, to experience highly variable temperatures and ocean chemistry at any given point in time. Its abundance, life history characteristics, and depth distribution, combined with spatial variability in ocean warming and acidification across the species' range, moderate vulnerability to extinction because the threats are non-uniform. Subsequently, there will likely be a large number of colonies that are either not exposed or do not negatively respond to a threat at any given point in time. However, we anticipate that the population abundance is likely to decrease in the future with increasing threats.

4.2.3 Elkhorn and Staghorn Coral Critical Habitat

On November 26, 2008, a Final Rule designating *Acropora* critical habitat was published in the Federal Register. Within the geographical area occupied by a listed species, critical habitat consists of specific areas on which are found those physical or biological features essential to the conservation of the species. The feature essential to the conservation of *Acropora* species (also known as the essential feature) is substrate of suitable quality and availability in water depths from the mean high water line to 30 m in order to support successful larval settlement, recruitment, and reattachment of fragments. "Substrate of suitable quality and availability" means consolidated hard bottom or dead coral skeletons free from fleshy macroalgae or turf algae and sediment cover. Areas containing this feature have been identified in 4 locations within the jurisdiction of the United States: the Florida area, which comprises approximately 1,329 mi^2 (3,442 km^2) of marine habitat; the Puerto Rico area, which comprises approximately 1,383 mi^2 (3,582 km^2) of marine habitat; the St. John/St. Thomas area, which comprises approximately 121 mi^2 (313 km^2) of marine habitat; and the St. Croix area, which comprises approximately 126 mi^2 (326 km^2) of marine habitat. The total area covered by the designation is thus approximately 2,959 mi^2 (7,664 km^2).

The essential feature can be found unevenly dispersed throughout the critical habitat units, interspersed with natural areas of loose sediment, fleshy or turf macroalgae covered hard substrate. Existing federally authorized or permitted man-made structures such as artificial reefs, boat ramps, docks, pilings, channels or marinas do not provide the essential feature. The proximity of this habitat to coastal areas subjects this feature to impacts from multiple activities including dredging and disposal activities, stormwater run-off, coastal and maritime construction, land development, wastewater and sewage outflow discharges, point and non-point source pollutant discharges, fishing, placement of large vessel anchorages, and installation of submerged pipelines or cables. The impacts from these activities, combined with those from natural factors (i.e., major storm events), significantly affect the quality and quantity of available substrate for these threatened species to successfully sexually and asexually reproduce.

A shift in benthic community structure from coral-dominated to algae-dominated that has been documented since the 1980s means that the settlement of larvae or attachment of fragments is often unsuccessful (Hughes and Connell) 1999). Sediment accumulation on suitable substrate also impedes sexual and asexual reproductive success by preempting available substrate and smothering coral recruits.

While algae, including crustose coralline algae and fleshy macroalgae, are natural components of healthy reef ecosystems, increases in the dominance of algae since the 1980s impedes coral recruitment. The overexploitation of grazers through fishing has also contributed fleshy macroalgae to persist in reef and hard bottom areas formerly dominated by corals. Impacts to water quality associated with coastal development, in particular nutrient inputs, are also thought to enhance the growth of fleshy macroalgae by providing them with nutrient sources. Fleshy macroalgae are able to colonize dead coral skeleton and other hard substrate and some are able to overgrow living corals and crustose coralline algae. Because crustose coralline algae is thought to provide chemical cues to coral larvae indicating an area is appropriate for settlement, overgrowth by macroalgae may affect coral recruitment (Steneck 1986). Several studies show that coral recruitment tends to be greater when algal biomass is low (Rogers et al. 1984; Hughes 1985; Connell et al. 1997; Edmunds et al. 2004; Birrell et al. 2005; Vermeij 2006). In addition to preempting space for coral larval settlement, many fleshy macroalgae produce secondary metabolites with generalized toxicity, which also may inhibit settlement of coral larvae (Kuffner and Paul 2004). The rate of sediment input from natural and anthropogenic sources can affect reef distribution, structure, growth, and recruitment. Sediments can accumulate on dead and living corals and exposed hard bottom, thus reducing the available substrate for larval settlement and fragment attachment.

In addition to the amount of sedimentation, the source of sediments can affect coral growth. In a study of 3 sites in Puerto Rico, Torres (2001) found that low-density coral skeleton growth was correlated with increased re-suspended sediment rates and greater percentage composition of terrigenous sediment. In sites with higher carbonate percentages and corresponding low percentages of terrigenous sediments, growth rates were higher. This suggests that re-suspension of sediments and sediment production within the reef environment does not necessarily have a negative impact on coral growth while sediments from terrestrial sources increase the probability that coral growth will decrease, possibly because terrigenous sediments do not contain minerals that corals need to grow (Torres 2001).

Long-term monitoring of sites in the USVI indicate that coral cover has declined dramatically; coral diseases have become more numerous and prevalent; macroalgal cover has increased; fish of some species are smaller, less numerous, or rare; long-spined black sea urchins are not abundant; and sedimentation rates in nearshore waters have increased from one to 2 orders of magnitude over the past 15 to 25 years (Rogers et al. 2008). Thus, changes that have affected elkhorn and staghorn coral and led to significant decreases in the numbers and cover of these species have also affected the suitability and availability of habitat.

Elkhorn and staghorn corals require hard, consolidated substrate, including attached, dead coral skeleton, devoid of turf or fleshy macroalgae for their larvae to settle. Atlantic and Gulf of Mexico Rapid Reef Assessment Program data from 1997-2004 indicate that although the historic range of both species remains intact, the number and size of colonies and percent cover by both species has declined dramatically in comparison to historic levels (Ginsburg and Lang 2003). Monitoring data from the USVI TCRMP indicate that the 2005 coral bleaching event caused the largest documented loss of coral in USVI since coral monitoring data have been available with a decline of at least 50% of coral cover in waters less than 25 m deep (Smith et al. 2011). Many of the shallow water coral monitoring stations showed at most a 12% recovery of coral cover by 2011, 6 years after the loss of coral cover due to the bleaching event (Smith et al. 2011). The lack of coral cover has led to increases in algal cover on area hard bottom, including the critical habitat essential feature.

5 ENVIRONMENTAL BASELINE

This section describes the effects of past and ongoing human and natural factors leading to the current status of the species, their habitat (including designated critical habitat), and the ecosystem, within the action area. The environmental baseline is a “snapshot” of a species’ health at a specified point in time. It does not include the effects of the action under review in this consultation.

By regulation, environmental baselines for Biological Opinions include the past and present impacts of all state, federal, or private actions and other human activities in the action area. We identify the anticipated impacts of all proposed federal projects in the specific action area of the consultation at issue that have already undergone formal or early Section 7 consultations, as well as the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

Focusing on the impacts of the activities in the action area specifically allows us to assess the prior experience and state (or condition) of the endangered and threatened individuals and areas of designated critical habitat that occur in an action area, and that will be exposed to effects from the actions under consultation. This is important because, in some phenotypic states or life history stages, listed individuals will commonly exhibit, or be more susceptible to, adverse responses to stressors than they would be in other states, stages, or areas within their distributions. The same is true for localized populations of endangered and threatened species: the consequences of changes in the fitness or performance of individuals on a population's status depends on the prior state of the population. Designated critical habitat is not different: under some ecological conditions, the physical and biotic features of critical habitat will exhibit responses that they would not exhibit in other conditions.

Land use in the action area includes the JBNERR composed of terrestrial areas on the main island of Puerto Rico in the Municipalities of Salinas and Guayama and on some of the offshore cays that fringe Jobos Bay and also including some mangrove wetlands and coastal lagoons. Portions of the Aguirre State Forest are also in the action area and are composed of upland and wetland forest sections in the Municipality of Guayama, including the area of Punta Pozuelo. Some portions of both managed areas have been affected by encroachment for the construction of residential and commercial facilities, as well as alterations in hydrology due to agricultural operations and associated irrigation changing the amount and frequency of freshwater flows into areas containing mangrove and brackish water wetlands and salt flats, as well as into waters of Jobos Bay. The existing Aguirre power plant is located in Jobos Bay. There are also various communities along the shores of Jobos Bay, Punta Pozuelo, and the wetland area of Mar Negro to the west of Aguirre. These communities consist mainly of residential and commercial facilities, including in-water facilities such as docks and piers. Recreational and fishing boat traffic is common in the area, although there are some vessel restrictions in portions of the Jobos Bay that are part of the JBNERR management plan implementation and enforced by the PRDNER. The area of Aguirre was formerly a large sugarcane processing facility and portions of the JBNERR facilities and the Aguirre power plant are located on lands that were formerly part of this industrial complex. For this reason, sediment testing in inner portions of Jobos Bay has found low levels of contaminants associated with industrial operations, as well as the operation of vessels. The Aguirre power plant received regular fuel deliveries by barge and also operates some support vessels for conducting maintenance, including of the existing intake and outfall structures that are in the water. The main process water discharge from the Aguirre power plant is in an area of the bay that used to contain a coral reef near shoreline mangroves and seagrass beds. The navigation channel into Jobos Bay to access the power plant (and previously the sugarcane processing plant) has been dredged in the past, though maintenance dredging is infrequent. Dredged areas, areas near the existing power plant, and the area around the plant’s discharge outfall in Jobos Bay are characterized as mud or sand bottom with little to no colonization, likely due to the effects of plant operation, including vessel traffic.

5.1 Status of North and South Atlantic DPS of Green, Leatherback, Northwest Atlantic DPS of Loggerhead, and Hawksbill Sea Turtles within the Action Area

In Sections 4.2.1.1 through 4.2.1.4, we described the range-wide status of green, leatherback, loggerhead, and hawksbill sea turtles. Within the action area, leatherback nesting is reported in the Punta Pozuelo area and hawksbill nesting is also reported in this area as well as on some of the offshore cays that contain beaches. Green and loggerhead sea turtles were observed during benthic surveys conducted for the project, including in the area where the offshore platform is proposed and along the pipeline route. PRDNER reports that hawksbill sea turtles are also observed in the action area and stranding reports indicate that green and hawksbill sea turtles are common while loggerhead sea turtles are not (PRDNER, unpublished data).

NWA DPS Loggerhead sea turtles are not common around Puerto Rico. The only nesting of these animals reported for Puerto Rico has been on the east coast of the main island and a beach on Culebra Island, also off the east coast of the main island (PRDNER, unpublished data). Similarly, over a period of more than 20 years, only 4 strandings of this species have been reported (PRDNER, unpublished data). The nearest loggerhead sea turtle stranding to the proposed Aguirre Offshore GasPort was off the coast of Humacao, which is over 33 miles east of the project. However, 2 loggerhead sea turtles were observed offshore of the Boca del Infierno pass during coral mapping work conducted for this project in November 2013. If we use the survey area of 75.5 ac, then this would mean there is 1 loggerhead sea turtle approximately every 38 ac. Given that past aerial surveys around the entire island of Puerto Rico estimated that this species represented only 0.5% of all sea turtle species observed (Rathbun et al. 1985) and no loggerhead sea turtles were observed during overflights of the southwest coast (Mignucci-Giannoni et al. 2004), this is likely an overestimate.

Green and hawksbill sea turtles have been sighted in Jobos Bay and around the offshore cays during aerial censuses carried out by PRDNER to look for manatees (C. Diaz, PRDNER, pers. comm. to L. Carrubba, NMFS, April 14, 2016). Four green sea turtles were observed by project consultants during coral surveys conducted in the Boca del Infierno and offshore platform areas. PRDNER also has unpublished stranding data for the period from 1992 to 2008 and there have been several reports of green and hawksbill sea turtles in the project area, all of which stranded due to incidental or targeted capture by fishers or for unknown reasons. None of the green or hawksbill sea turtles reported as stranded in the project area appeared to have been impacted by boats. Based on information from previous aerial surveys around Puerto Rico, green sea turtles comprised approximately 30% of the sightings and hawksbills approximately 8% (Rathbun et al. 1985). In the action area, there may be more hawksbills than greens or the same number of each species particularly because of reported hawksbill nesting in the action area and because unpublished stranding data from PRDNER indicates that this species may be just as common as green sea turtles in the action area, given that about the same number of animals of both species stranded over the same time period in waters of the action area. Based on aerial survey data from the USFWS manatee project that also recorded sightings of sea turtles during periodic overflights around all of Puerto Rico and Culebra and Vieques Islands in 1984 – 1985, 1992 – 1995, and 1996 – 2003, in years when sea turtles were observed during surveys, the majority could not be identified to species and, when they could, there were approximately as many green sea turtles observed as hawksbills. A total of 26 sea turtles were observed over all survey time periods and of these 4 were green, 3 were hawksbill and the rest could not be identified to species. During most survey years, 1 – 2 turtles were observed but during surveys in 1984, 12 turtles were observed with 2 being green, 1 hawksbill, and the rest unidentified.

Based on reports JBNERR staff receive from local residents, there is nesting by hawksbill sea turtles in the area of Punta Pozuelo (approximately 2 miles east of the Boca del Infierno where HDD will be used to install a portion of the pipeline on the peninsula that connects to the mainland adjacent to the cays called "Cayos del Caribe", see Figure 1) and on the offshore cays that fringe Jobos Bay (A. Dieppa, PRDNER, pers. comm. to L. Carrubba, NMFS, April 14, 2016). Green sea turtle nesting activity is low in Puerto Rico and the U.S. Virgin Islands when compared to other areas of the Caribbean and Atlantic. In addition, PRDNER nesting data is gathered mainly for leatherback sea turtles, though no nesting data are collected from beaches in the action area. Nesting data for other species and on beaches that are not part of PRDNER's set survey sites is largely lacking.

Based on information from PRDNER (A. Dieppa, PRDNER, pers. comm. to L. Carrubba, NMFS, April 14, 2016), nesting of leatherbacks occurs some years in the area of Punta Pozuelo. No leatherback sea turtles were observed during benthic or plankton surveys conducted for the project, but this may also be due to the fact that the majority of the surveys took place outside the peak leatherback nesting season and many of the surveys were conducted inside Jobos Bay and were not looking specifically for sea turtles or marine mammals. Peak leatherback nesting in Puerto Rico occurs from approximately May – July each year. Past aerial surveys of the entire island of Puerto Rico found leatherbacks to be uncommon on average but there was a peak in sightings during the wet/warm months of May – October (Rathbun et al. 1985), likely because of the more frequent nesting by this species during a portion of these months. Leatherbacks are an offshore species and come inshore only during nesting, but there are no nesting monitoring programs within JBNERR. Leatherback sea turtles were not observed during any of the USFWS aerial surveys in the action area nor were strandings of these animals reported in the action area, though strandings were reported in other areas of Puerto Rico.

ESA-listed sea turtles are highly mobile and therefore not as susceptible to localized stressors, though as juveniles green and hawksbill sea turtles have been found to establish home ranges in some areas of Puerto Rico, particularly Culebra for greens and Mona/Monito for hawksbills. On-going operations of the Aguirre plant could affect leatherback, loggerhead, green, and hawksbill sea turtles due to vessel operations because approximately 4 fuel barge deliveries occur each week. There are also various communities in the action area, many of which rely on tourism and fishing and a number of commercial and private boating facilities including single-family piers. However, despite the number of recreational vessels using the area and the frequency of fuel barge deliveries, there are no reports of vessel collisions with sea turtles. The unpublished stranding data from PRDNER indicates that all sea turtle strandings reported in the area have been of green and hawksbill sea turtles and, of the causes that could be determined, the majority were due to directed or incidental capture. In addition, JBNERR regulations include limitations on the operation of motorized vessels in some areas, which likely serves to protect sea turtles to some degree from vessel collisions. Sediment testing in inner portions of Jobos Bay has found low levels of contaminants associated with industrial operations, as well as the operation of vessels, likely due to the area's history as a sugarcane processing center, as well as due to the large agricultural areas and associated use of chemical fertilizers and pesticides. The main process water discharge from the Aguirre power plant is in an area of the bay that used to contain a coral reef near shoreline mangroves and seagrass beds. Discharge of superheated water from the power plant, along with dredging and vessel operations associated with the plant and past industrial activities at the site have led to a lack of colonized benthic habitat in the inner portions of the bay closest to the power plant facilities, meaning there is a lack of habitat for green and hawksbill sea turtles and likely few benthic resources such as crabs on which loggerhead sea turtles could forage in these areas. There is evidence of increases in nesting by hawksbill sea turtles, particularly on Mona Island where hawksbill nesting is closely monitored, and by leatherback sea turtles on regularly monitored nesting beaches such as those on the northeast coast of Puerto Rico. However, there are no in-water data for Puerto Rico or regular nesting surveys of beaches around the island that enable us to estimate populations of each sea turtle species. Therefore, we believe the status of ESA-listed sea turtle species described in Sections 4.2.1.1 through 4.2.1.4 is an accurate reflection of the species' status within the action area.

5.2 Status of Elkhorn, Staghorn, Pillar, Rough Cactus, Lobed Star, Boulder Star, and Mountainous Star Corals, and Elkhorn and Staghorn Coral Critical Habitat within the Action Area

In Sections 4.2.2.1 through 4.2.2.5, we described the range-wide status of elkhorn, staghorn, pillar, rough cactus, lobed star, mountainous star, and boulder star corals. Within the action area, all 7 of these species occur and all are reported on the coral reefs and colonized hard bottom in the area of Boca del Infierno where installation of a section of the pipeline using HDD is proposed along with the associated HDD exit point, excavation of a dredge pit, and accumulation of HDD drilling fluid.

Elkhorn, staghorn, pillar, rough cactus, lobed star, boulder star, and mountainous star corals were reported as occurring on the coral reefs and colonized hard bottom on the offshore cays fringing Jobos Bay (Figures 13 and 14) and where the offshore platform is proposed based on information from surveys conducted by the applicant. Information from coral surveys conducted by the EPA in the action area also noted the presence of ESA-listed coral colonies on reefs in the area of Boca del Infierno. The number of colonies of *Orbicella* spp. and pillar corals within the proposed offshore gasport footprint was not provided by the applicant. Elkhorn, staghorn, pillar, lobed star, mountainous star, and boulder star coral colonies were observed within the proposed pipeline corridor where HDD is now proposed in order to install the pipeline below the reef surface. The quantity of colonies of each species was not provided but an ESA-listed coral survey conducted in 2013 (Tetra Tech 2012) documented staghorn corals as the most common (making up approximately 28% of the 152 coral colonies sampled) followed by mountainous star coral (making up approximately 8.5% of the coral colonies sampled) and pillar coral (making up approximately 2% of the coral colonies sampled). One colony of rough cactus coral was observed during the initial benthic survey conducted for the pipeline and elkhorn and lobed star coral colonies were reported outside the selected survey area for the 2013 coral survey. In 2010 and 2011, 0.2552 square meters (m^2) and 3.7699 m^2 of elkhorn coral, respectively; 0.6518 m^2 of staghorn coral (2011); 0.037 m^2 and 0.0028 m^2 (2010 and 2011, respectively) of rough cactus coral; 5.8448 m^2 of lobed star coral (2010); 33.6238 m^2 and 5.2684 m^2 (2010 and 2011, respectively) of mountainous star coral; and 0.1414 m^2 of boulder star coral (2010) were reported as part of the observed overall coral coverage at the EPA coral survey stations located in the Boca del Infierno area. Other EPA sampling stations along the offshore cays in the action area reported additional coverage of mountainous star corals and pillar coral. The sampling stations are 8 – 10 m radial belt transects (Fisher 2007) so the characterization is of a very small area compared to the total reef area, at least in the case of sampling sites such as those in the action area that contain extensive coral reefs.

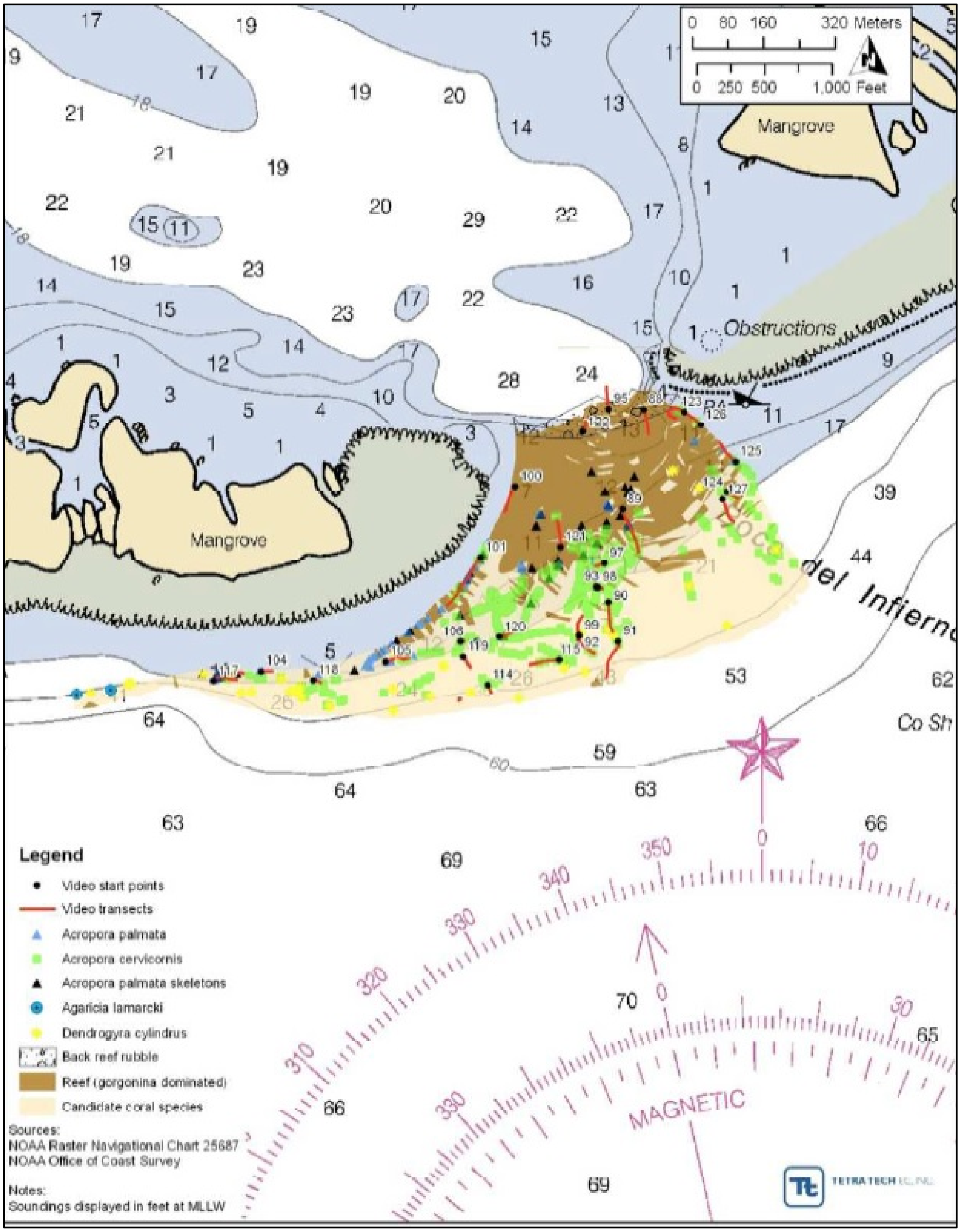

Figure 13. Map of observed locations of ESA-listed (and candidate species at time of survey) coral colonies on reefs in Boca del Infierno area collected using towed video (from Tetra Tech 2012)

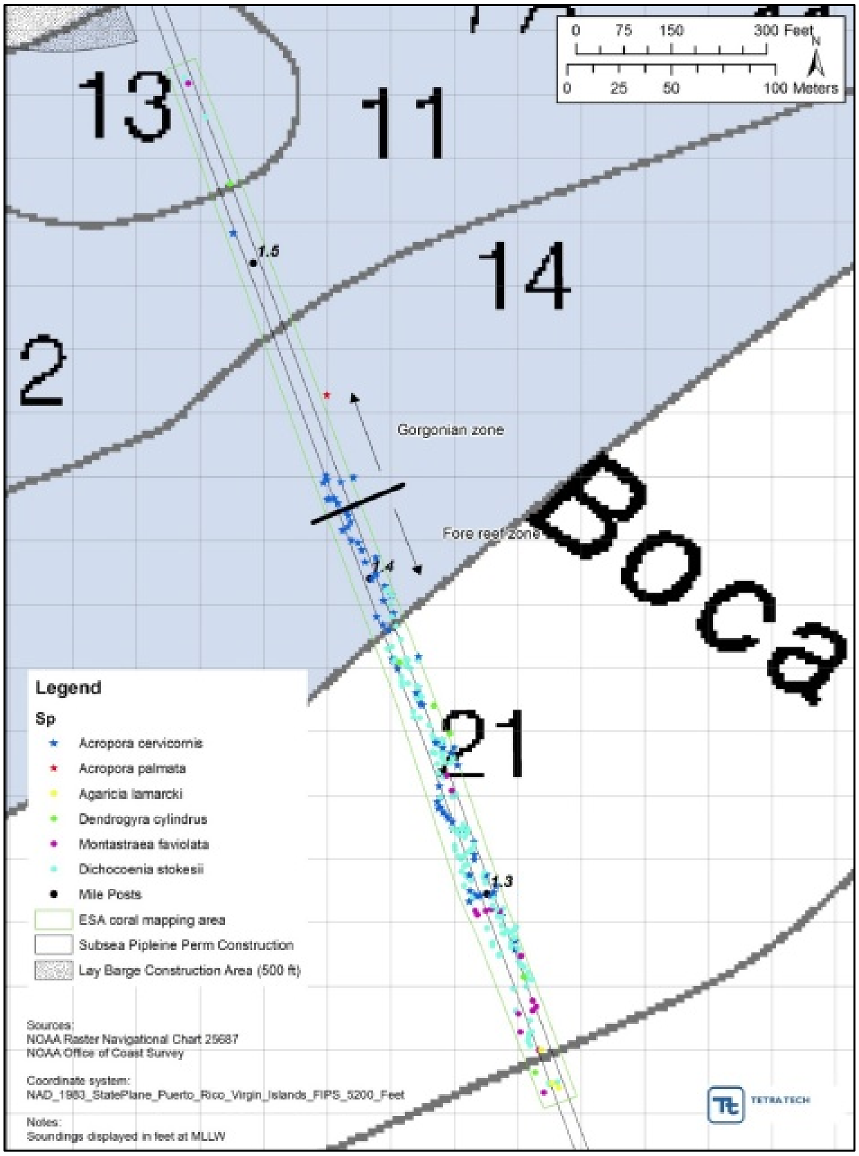

Figure 14. Map of observed locations of ESA-listed (and candidate species at time of survey) coral colonies along proposed pipeline route prior to change to HDD installation (from Tetra Tech 2014a)

Pillar, rough cactus, and all 3 species from the star coral complex were observed in the area where the offshore platform is proposed using towed-video surveys. The applicant estimated that 4,379 colonies of ESA-listed coral colonies will be impacted by the construction of the offshore gasport. The applicant noted that of these, 214 ESA-listed coral colonies are expected to be permanently impacted because these are within the footprint of the structure where pile driving will take place and where permanent shading from the platform will occur (Excelerate Energy 2016b) and these colonies will be relocated outside the impact footprint. NMFS used the estimates of approximate percentages of different ESA-listed coral species from the EPA survey data because the data are representative of all 7 ESA-listed coral species and extrapolated to the 5 species that were observed in the area of the proposed offshore platform in the towed video surveys. The approximate percentage estimates used were 10% pillar, 3% rough cactus, 12% lobed star, 68% mountainous star, and 7% boulder star, adjusted to reflect presence of 5 rather than 7 species. Based on the estimated total of 4,379 ESA-listed coral colonies, approximately

438 pillar, 131 rough cactus, 525 lobed star, 2,978 mountainous star, and 307 boulder star coral colonies would be impacted by the proposed offshore platform. Of these, as noted above, 214 colonies would be transplanted to a recipient site in the action area. We estimate that these 214 coral colonies represent 21 pillar, 6 rough cactus, 26 lobed star, 146 mountainous star, and 15 boulder coral colonies to be relocated.

NMFS used the estimates of approximate percentages of different ESA-listed coral species from the EPA survey data because the data are representative of all 7 ESA-listed coral species. The approximate percentage estimates used were 16% elkhorn, 3% staghorn, 10% pillar, 0.03% rough cactus, 3% lobed star, 68% mountainous star, and 0.07% boulder star corals. The pipeline impact corridor was surveyed when the applicant was proposing to direct-lay the pipeline through the Boca del Infierno coral reef. The applicant found that stony corals accounted for approximately 17.65% of the biotic percent cover on the reef and estimated that 40,115 total coral colonies were in the pipeline impact corridor, which measured approximately 0.87 ac (Tetra Tech 2012;2014a). Of these corals, the applicant estimated that 421 were ESA-listed species. If we assume the total reef area in Boca del Infierno in water depths ranging from 5 – 45 ft is 60 ac and use the estimate of 421 ESA-listed corals in a 0.87 ac area, then approximately 29,062 ESA-listed coral colonies may be present on the coral reef in the Boca del Infierno area. Using the percentage estimates from the EPA data to determine the approximate number of each ESA-listed coral species then yields estimates of 4,645 elkhorn (in depths up to 18 ft only based on TetraTech (2012), 871 staghorn, 2,903 pillar, 9 rough cactus, 871 lobed star, 19,743 mountainous star, and 20 boulder star coral colonies.

The applicant conducted plankton sampling on August 20 and 28, 2013, and again on August 6 – 12 and September 3 -17, 2015, to provide site-specific data on coral larvae densities in the area of the proposed offshore platform. Sampling was done using subsurface plankton tows to collect free-swimming larvae of cnidarians (i.e., anemones, coral, octocoral) ranging from 0.01 – 0.03 in (300 – 700 µm) in size using nets with a mesh size of 300 µm or smaller. It is important to note that, while it is possible to distinguish anemone larvae from coral and octocoral larvae under a microscope, it is difficult to distinguish between coral and octocoral using a microscope in part because most coral larvae are indistinguishable until they settle to the bottom and begin to grow (FERC 2016). Genetic analyses were not done to confirm which coral species were collected during sampling. Therefore, a gross density estimate of coral larvae expressed as the total number per 26,400 gallons (100 cubic meters [m^3]) was derived for each sampling effort and compared with representative larval densities from previous studies to estimate the potential impact of seawater intakes associated with operation of the offshore gasport on ESA-listed coral colonies in the action area.

No coral larvae were detected during the plankton surveys conducted in August 2013 but anecdoctal information indicated coral slicks were apparent along the southwestern Puerto Rico shoreline August 24, 2013, indicating that sampling on August 20 may simply have missed the mass spawning event. Sampling on August 28, 2013, detected 8.5 coral larvae per 100 m^3 during the day and 531 larvae per 100 m^3 at night (single tows along a single transect – one during the day and one at night). During the 3 sampling events in August - October 2015, 4 plankton tows were done using a 200 µm net along the same transect used in 2013 to collect larvae. The 2015 survey collected a water surface and a mid-water (i.e., the 23 – 36 ft depth range of the planned

FSRU cooling water intakes) sample during both daytime and nighttime sampling. Densities of coral larvae at the water surface were lower than at mid-depth but this difference was determined not to be statistically significant (FERC 2016). Peak densities of coral larvae lasted an average of 3 - 5 days within 7 – 11 days after the full moon. The highest coral larvae density was 6,532 larvae per 100 m^3 in a nighttime mid-depth tow in September and coral larvae densities were greater in September sampling overall. Lower larval densities were obtained in August and October (Table 8). Studies in Puerto Rico have reported elkhorn, staghorn, lobed star, boulder star, and mountainous star corals spawning in August and September after the full moon, and pillar coral also spawning after the August full moon (Williams 2006). Corals in the star coral complex are also reported spawning in October in Florida (Brainard et al. 2011a) and the collection of coral larvae in the October 2015 plankton samples indicates that there is also some spawning in Puerto Rico in October as well. These corals are all broadcast spawners, meaning the species release eggs and sperm in mass spawning events and the gametes are fertilized in the water column while rough cactus corals are brooders having internal fertilization and embroyogenesis before releasing larger larvae (compared to those of broadcast spawners) that settle quickly once they are released into the water column. Rough cactus corals typically fertilize gametes in December – January and release their larvae in late February – March so larvae of these species are not expected to have been part of the samples collected during 2013 and 2015 plankton surveys.

Table 8. Observed coral larval densities from daytime and nighttime plankton tows on water surface and mid-depth in area of proposed offshore platform, August – October 2015 (from FERC 2016)

Coral Larvae Densities Observed in the 2015 Sampling Effort

Date	Days After Full Moon	Density Observed (no./26,400 gallons [no./100 m^3]) [a]			
		Daytime Surface [b]	Daytime Mid-Depth [b]	Nighttime Surface [b]	Nighttime Mid-Depth [b]
6 August 2015	6	91.9	52.8	47.6	66.6
8 August 2015	8	83.3	446.1	108.8	**1,364.2**
10 August 2015	10	**641.3**	**961.8**	**356.8**	574.4
12 August 2015	12	11.3	12.1	14.7	33.2
3 September 15	5	632.1	346.2	151.2	241.0
5 September 15	7	343.8	802.5	294.5	682.9
7 September 15	9	**2,194.2**	**4,305.9**	**2,977.7**	**6,532.0**
9 September 15	11	829.0	758.0	655.3	652.5
11 September 15	13	29.5	95.6	36.3	35.2
13 September 15	15	23.2	9.4	19.7	14.2
15 September 15	17	1.5	8.6	1.9	0.0
17 September 15	19	8.6	9.1	15.8	30.2
5 October 2015	7	89.1	73.5	8.1	53.6
7 October 2015	9	37.1	99.7	**49.0**	**216.1**
9 October 2015	11	**154.4**	**290.0**	No data	No data
11 October 2015	13	1.5	32.3	9.9	28.7

[a] Peak densities for each month and sample type are highlighted in bold.
[b] "Surface" refers to 3.3 feet (1 m) deep; "Mid-depth" refers to 23 to 36 feet (7 to 11 m) deep (the depth of the proposed FSRU and LNG Carrier intakes).

ESA-listed corals are non-motile and susceptible to relatively localized adverse effects as a result. Localized adverse effects on ESA-listed coral colonies in the action area have resulted from many of the same stressors affecting this species throughout its range, namely anthropogenic breakage, disease, and intense weather events (i.e., hurricanes and extreme sea surface temperatures). These stressors have led to declines in abundance of ESA-listed coral colonies in the action area commensurate with the declines seen elsewhere in the species' range, though elkhorn, staghorn, and corals from the star coral complex remain abundant on Caribbean reefs. Pillar and rough cactus coral are also susceptible to a number of threats but are naturally rare. There is little evidence of population declines on the part of pillar coral in the action area. There is evidence of local population declines on the part of rough cactus coral, which could mean range-wide declines. Therefore, we believe the status of ESA-listed coral species described in Sections 4.2.2.1 through 4.2.2.5 is an accurate reflection of the species' status within the action area.

In Section 4.2.3, we described the status of elkhorn and staghorn coral critical habitat, including the Puerto Rico elkhorn and staghorn coral critical habitat unit. Within the Puerto Rico elkhorn and staghorn coral critical habitat marine unit, approximately 292 mi^2 (756 km^2) are likely to contain the essential feature of ESA-designated elkhorn and staghorn coral critical habitat, based on the amount of coral, rock reef, colonized hard bottom, and other coralline communities mapped by the National Ocean and Atmospheric Administration (NOAA's) National Ocean Service (NOS) Biogeography Program in 2000 (Kendall et al. 2001). Within the action area, the essential feature of elkhorn and staghorn coral critical habitat is present along the shorelines of offshore cays bordering Jobos Bay and their associated coral reefs, as well as on patch reefs and colonized hard bottom outside Jobos Bay and seaward of the cays, including in the area where the offshore terminal is proposed. Impacts to critical habitat described in Section 4.2.3 include land-based sources of pollutants, fishing activities, boating, and commercial activities. There have been vessel groundings in the action area, including a large grounding that affected mainly seagrass but some coral areas in the Cayo Caribe area where the applicant proposes some seagrass mitigation through habitat restoration. Approximately 3.9 ac of patch reefs that contain the essential feature of elkhorn and staghorn coral critical habitat will be in the footprint of the offshore terminal. Approximately 60 ac of coral reef and colonized hard bottom are in the immediate area of Boca del Infierno where HDD activities will take place. Given that the action area includes vessel transit routes, commercial operations, and areas with coastal development, we believe the status of critical habitat described in Section 4.2.3 accurately reflects the status of critical habitat within the action area.

5.3 Factors Affecting Leatherback, NWA DPS Loggerhead, North and South Atlantic DPS Green, and Hawksbill Sea Turtles, Elkhorn, Staghorn, Pillar, Rough Cactus, Lobed Star, Mountainous Star, and Boulder Star Corals and Elkhorn and Staghorn Coral Critical Habitat within the Action Area

The environmental baseline for this Opinion includes the effects of several activities that affect the survival and recovery of ESA-listed sea turtles and corals and the condition of elkhorn and staghorn coral critical habitat. We describe these activities' effects in the sections below.

5.3.1 Federal Actions

Sea Turtles

There are federally-managed fisheries that operate in federal waters from 9 nautical miles from shore (which is the limit of Commonwealth jurisdictional waters) out to the limits of the Exclusive Economic Zone (EEZ) where the LNG carriers will transit. Threatened and endangered sea turtles are adversely affected by fishing gears used throughout the continental shelf in the action area. Net and hook-and-line gear have been documented as interacting with sea turtles in Puerto Rico based on stranding data from Commonwealth waters (PRDNER unpublished data). Incidental catch in fishing gear accounted for 1% of reported sea turtle strandings in the action area for the period from 1991 – 2008 while directed capture, including shooting, accounted for 40% of strandings (PRDNER unpublished data). Abandoned or lost fishing gear can also affect the quality of refuge and foraging habitat for green, loggerhead, and hawksbill sea turtles as abandoned gear can lead to abrasion and breakage in hard bottom and coral reef habitats and have shading impacts on seagrass and macroalgae if the gear is large enough such as traps and nets.

For all fisheries for which there is a Fishery Management Plan (FMP) or for which any federal action is taken to manage that fishery, impacts are evaluated under Section 7 of the ESA. All of these opinions found that the actions described were likely to adversely affect, but not likely to jeopardize the continued existence, of sea turtle species. Formal Section 7 consultations have been conducted on the following fisheries occurring in the action area and found fisheries actions to be likely to adversely affect threatened and endangered sea turtles: Caribbean Reef Fish and Caribbean Spiny Lobster FMPs under the jurisdiction of the Caribbean Fishery Management Council (CFMC). Anticipated levels of take associated with these actions reflect the impact on sea turtles and other listed species of each activity anticipated from the date of the ITS forward in time in the waters of the EEZ off Puerto Rico and the U.S. Virgin Islands. Anticipated levels of take under the Caribbean Reef Fish FMP are 75 lethal takes of green sea turtles over 3 years, 51 lethal takes of hawksbill sea turtles with no more than 3 non-lethal takes over 3 years, and 48 lethal takes of leatherback sea turtles over 3 years. No take of loggerhead sea turtles under this FMP is anticipated due to the scarcity of this species in the U.S. Caribbean. Anticipated levels of take under the Spiny Lobster FMP are 12 lethal takes of green and hawksbill sea turtles over 3 years and 9 lethal takes of leatherback sea turtles over 3 years. Informal Section 7 consultations were also completed for the Caribbean Coral and Queen Conch FMPs. NMFS concluded that implementation of the Coral and Queen Conch FMPs is not likely to adversely affect ESA-listed sea turtles.

Anticipated levels of take are also part of Section 7 consultations for FMPs in the Gulf and South Atlantic where sea turtles found in the action area may also transit. Table 9 details the lethal and total anticipated levels of take under the Gulf of Mexico/South Atlantic Spiny Lobster and South Atlantic Snapper-Grouper FMPs and the FMPS for highly migratory species (HMS) including Coastal Migratory Pelagics, Dolphin-Wahoo, HMS-Pelagic Longline, and Shark Fisheries, as well as takes that may occur under the Southeastern U.S. Shrimp Fishery. The take numbers for the shrimp fishery were estimated based on TED enforcement as a surrogate for actual numbers of animals.

Table 9. Anticipated levels of take of leatherback, hawksbill, green, and loggerhead sea turtles under Gulf, South Atlantic, and HMS FMPs, and the Southeastern U.S. Shrimp Fishery.

FMP or Fishery	**Leatherback**		**Hawksbill**		**Green**		**Loggerhead**	
	Lethal Takes	Total Takes	Lethal Takes	Total Takes	Lethal Takes	Total Takes	Lethal Takes	Total Takes
Gulf of Mexico/South Atlantic Spiny Lobster		1 (note: may be lethal or non-lethal) over 3 years		1 (note: may be lethal or non-lethal) over 3 years		3 (note: may be lethal or non-lethal) over 3 years		3 (note: may be lethal or non-lethal) over 3 years
South Atlantic Snapper-Grouper	5	6 over 3 years	4	6 over 3 years	42 (NA DPS)	111 (NA DPS)	208 (NWA DPS)	629 (NWA DPS)

					3 (SA DPS)	over 3 years 6 (SA DPS) over 3 years		over 3 years
Gulf of Mexico Reef Fish	11	11 over 3 years	8	9 over 3 years	75	116 over 3 years	575	1.044 over 3 years
Coastal Migratory Pelagics	1	1 over 3 years	1	1 over 3 years	9 (NA DPS)	31 (NA DPS) over 3 years	7	27 over 3 years
Dolphin-Wahoo	1	12 over 1 year	1	3 over 1 year	1	3 over 1 year	2	12 over 1 year
Pelagic Longline	252	1,764 over 3 years	18	105 over 3 years	18	105 over 3 years	339	1,905 over 3 years
Shark Fisheries	9	18	9	18	33	57	78	126
Southeastern U.S. Shrimp Fishery	144 per year		78 per year		1,453 per year		7,778 per year	

Potential sources of adverse effects from federal vessel operations in the action area include operations of EPA and NOAA. EPA conducts coral surveys at different locations around Puerto Rico, often annually, using motorized vessels. NMFS has not completed a Section 7 consultation with EPA for their coral survey program at this time. Similarly, NOAA, including NOS and other line offices, conduct coral reef monitoring, benthic surveys, sediment sampling and other scientific surveys in the action area. NOS and the Southeast Fishery Science Center lead the NOAA National Coral Reef Monitoring Program efforts that take place every 2 years at randomly selected sampling sites around Puerto Rico. NOAA’s Coral Reef Conservation Program has been in conversations with NMFS’s Office of Protected Resources in Silver Spring regarding the possibility of completing a programmatic Section 7 consultation for the monitoring program and other efforts that receive some or all of their funding from the coral program but no consultation has been completed to date. Through the Section 7 process, where applicable, NMFS will establish conservation measures for federal agency vessel operations to avoid or minimize adverse effects to sea turtles. At the present time, however, they present the potential for some level of interaction.

NMFS and the USCG completed an informal Section 7 consultation for the Caribbean Marine Event Program for annually occurring marine events in USVI and Puerto Rico in 2009. As a result of this consultation, the USCG now includes guidelines to avoid and minimize potential impacts of marine events, especially events involving motorized vessels such as speedboat races, to listed sea turtles and their habitat as permit conditions the event participants must follow. A programmatic consultation is now in progress with the USCG for their Caribbean Marine Event Program that will include all activities that may be covered by the USCG under the program.

The proliferation of vessels is associated with the proliferation and expansion of docks, the expansion and creation of port facilities, and the expansion and creation of marinas and many of these activities take place in the action area, including port expansion in Ponce, private docks in Guayama and Salinas, and the expansion of marina facilities in Salinas. As part of the Section 7 process for dock, port, and marina construction activities under the jurisdiction of the USACE, NMFS also considers the impacts of vessel traffic from the operation of these facilities and any measures to avoid and minimize adverse impacts to sea turtles. Additionally, because the construction of many of these in-water facilities involves pile-driving, NMFS also considers the potential acoustic impacts of facility construction on sea turtles and any measures to avoid and minimize injurious and behavioral acoustic impacts to sea turtles.

Other federal agencies such as the EPA are also responsible for permitting activities in the coastal and marine zones in the action area. EPA authorizes discharges into nearshore and offshore waters, as well as seawater intakes for the operation of industrial facilities, including the existing Aguirre thermoelectric power plant. The intake structures are designed to include screens and other features that minimize the potential for entrapment of sea turtles and other animals and no impacts to sea turtles as a result of the operation of the existing Aguirre power plant intake, for example, have been documented. EPA has included requirements such as modification to the fish return system to reduce impingement mortality, modifications to the operational measures such as continuous operation of the traveling screens and washing pressure and frequency to reduce impingement mortality, and investigation of other feasible methods to reduce entrainment of larvae and eggs that are also protective of various life stages of sea turtles.

Four of the 5 outfalls for the Aguirre power plant that are permitted by EPA are located along the shoreline of the bay at the Aguirre facilities. The largest outfall is located in waters of Jobos Bay 5,800 ft from the power plant and discharges 652 mgd of cooling and process water. Water discharged through this outfall is permitted to reach 101.3ºF (38.5ºC). Sponges are not necessarily affected by high temperatures, unlike corals, and some sponges actually increase in abundance during high sea surface temperature events and these are typically bioeroding species that can then affect coral composition on reefs (Kelmo et al. 2013). Photosynthesis of seagrass is reduced at high temperatures, particularly those over 35ºC, which is the case for the Aguirre outfall. Therefore, the continued operation of the outfall may alter the composition or quality of foraging habitat for green and hawksbill sea turtles in particular.

ESA-Listed Corals and Elkhorn and Staghorn Coral Critical Habitat

Several types of fishing gear may also adversely affect coral colonies and critical habitat. Longline, other types of hook-and-line gear and traps have all been documented as interacting with coral habitat and coral colonies in general, though no data specific to ESA-listed corals and their habitat is available. Available information suggests hooks and lines can become entangled in reefs, resulting in breakage and abrasion of corals. Net fishing can also affect coral habitat and coral colonies if this gear drags across the marine bottom either due to efforts targeting reef and hard bottom areas or due to derelict gear. Studies by Sheridan et al. (2003) and Schärer et al. (2004) showed that most trap fishers do not target high-relief bottoms to set their traps due to potential damage to traps. Unfortunately, lost traps and illegal traps can affect corals and their habitat if they are moved onto reefs or colonized hard bottoms during storms or placed on coral habitat because the movement of the traps leads to breakage and abrasion of corals.

NMFS reinitiated Section 7 consultations for the Coral, Queen Conch, Reef Fish, and Spiny Lobster FMPs under the jurisdiction of the CFMC when elkhorn and staghorn corals were listed and critical habitat was designated for these corals. NMFS concluded that the implementation of the Coral FMP would have no effect on listed corals or coral designated critical habitat. On September 26, 2016, NMFS reinitiated consultation for the Spiny Lobster and Reef Fish FMPs when pillar, rough cactus, lobed star, mountainous star, and boulder star corals were listed. On January 19, 2016, NMFS determined that allowing the continued authorization of fishing managed by the Spiny Lobster and Reef Fish FMPs was not likely to adversely affect these corals.

Potential sources of adverse effects such as anchor and propeller damage and accidental groundings from federal vessel operations in the action area include operations of the EPA and NOAA, as well as the USCG. EPA conducts coral surveys at different locations around Puerto Rico, often annually. In the past, EPA used a large research vessel but the agency no longer owns the vessel so any survey operations are done using smaller motorized vessels, typically through rental agreements with local operators. NMFS has not completed a Section 7 consultation with EPA for their coral survey program at this time. Similarly, NOAA, including NOS and other line offices, conduct coral reef monitoring in the action area. NOS has conducted a number of benthic surveys and sediment sampling in Jobos Bay. NOS and the Southeast Fishery Science Center lead the NOAA National Coral Reef Monitoring Program efforts that take place every 2 years at randomly selected sampling sites around Puerto Rico. NOAA's Coral Reef Conservation Program has been in conversations with NMFS's Office of Protected Resources in Silver Spring regarding the possibility of completing a programmatic Section 7 consultation for the monitoring program and other efforts that receive some or all of their funding from the coral program but no consultation has been completed to date.

NMFS and the USCG District 7 completed a Section 7 consultation for the continued maintenance of federal ATONs that included all of Puerto Rico. Federal ATONs are present in Jobos Bay associated with the barge channel used by vessels that provide fuel and other services to PREPA, as well as used by fishers and others who navigate to and from Jobos Bay. ATON maintenance requires the use of USCG cutters and the consultation included requirements to minimize potential impacts of vessel operation and other actions associated with ATON maintenance on ESA-listed corals and their habitat. Through the Section 7 process, where applicable, NMFS will establish conservation measures for agency vessel operations to avoid or minimize adverse effects to ESA-listed corals and their habitat. At the present time, however, they present the potential for some level of interaction.

Federal agencies such as the USACE are responsible for permitting of coastal and marine development activities including the construction of docks, boardwalks along the shoreline, and dredging, all of which are activities that have been permitted within the last 5 years in the action area by the USACE. We have conducted consultations with the USACE for those projects that had the potential to affect ESA resources under our purview.

EPA is also responsible for permitting, including under the NPDES program. The Aguirre power plant holds an existing NPDES permit for the withdrawal of 652 mgd of seawater from

Jobos Bay and the discharge of this water into the bay. The seawater intake has dual flow traveling screens of 0.25 in smooth mesh panels that are operated at an approach velocity of 0.79 fps in front of the screens and 0.67 fps outboard of the bar racks that are fixed at the intake behind the screens. These rates are greater than the 0.5 fps recommended by EPA to minimize impingement of aquatic organisms. In the draft NPDES permit renewal from 2010, EPA acknowledged that the cooling water intake structure of the plant does not represent the best technology available for the following reasons: 1) the traveling screen debris return system is not designed or operated in a manner that minimizes injury and mortality of impinged fish; and 2) larvae and eggs are trapped on the screens and effectively impinged by the seagrass that accumulates on the screens. EPA included requirements such as modification to the fish return system to reduce impingement mortality, modifications to the operational measures such as continuous operation of the traveling screens and washing pressure and frequency to reduce impingement mortality, and investigation of other feasible methods to reduce entrainment of larvae and eggs. Thus, there may be some impacts to coral larvae associated with the intake of the existing power plant, although impacts are likely to be low due to the location of the intake in Jobos Bay at the existing power plant facilities where no coral colonies or coral habitat are present.

Four of the 5 permitted outfalls are located along the shoreline of the bay at the Aguirre facilities and discharge 0.25 mgd, 1.65 mgd, and 0.04 mgd (note that the other outlet is of stormwater only so there is no set discharge volume), respectively. The largest outfall is located in waters of Jobos Bay 5,800 ft from the power plant and discharges 652 mgd of cooling and process water. Water discharged through this outfall is permitted to reach 101.3ºF (38.5ºC). Corals can tolerate temperature ranges between 73 – 84ºF (22.8 – 28.9ºC), although they cannot tolerate the high end of this range for extended periods of time without demonstrating signs of thermal stress. Our files indicate that EPA sent us a copy of the draft permit for the renewal of the NDPES permit for the Aguirre power plant (permit number PR0001660) but we did not receive a request to initiate an ESA Section 7 consultation for the continued operation of the intake and outfalls of the plant.

5.3.2 State or Private Actions

Sea Turtles

Commonwealth-managed fisheries operating in the action area have potential impacts to sea turtles similar to those analyzed in the CFMC FMP consultations described in the previous section. Commonwealth waters extend to 9 nautical miles from the shore meaning they encompass shallow and deep water areas where all 4 sea turtle species may be present. As noted above, incidental catch in fishing gear accounted for 1% of reported sea turtle strandings in the action area for the period from 1991 – 2008 and sea turtle poaching is common, accounting for 40% of strandings (PRDNER unpublished data). However there were low numbers of stranded sea turtles overall in the area of Guayama and Salinas with a total of 4 greens and 6 hawksbills over the period from 1991 – 2008 (PRDNER unpublished data). Guayama and Salinas have active commercial fishing communities and there are also recreational fishers, particularly in Salinas. There are restrictions on fishing and operation of motorized vessels in some portions of Jobos Bay in accordance with the JBNERR management plan.

Commercial and recreational vessel traffic can have adverse effects on sea turtles via propeller and boat-strike injuries. None of the sea turtle strandings reported in the area of Guayama and Salinas were found to be due to vessels (PRDNER, unpublished data). Vessel operation and the associated proliferation of docks and other boating facilities have resulted in the loss or degradation of refuge and foraging habitat, particularly for greens and hawksbill sea turtles due to impacts to seagrass and coral habitats from propeller scarring, propeller wash, accidental groundings, and in-water construction. Coastal runoff, marina and dock construction, dredging, industrial operations, increased underwater noise, and boat traffic can degrade marine habitats used by sea turtles (Colburn et al. 1996). Fueling and pump-out facilities at marinas can sometimes discharge oil, gas, and sewage into sensitive coastal habitats. Although these contaminant concentrations do not likely affect pelagic waters, the species of turtles analyzed in this Opinion travel between near shore and offshore habitats and various life stages of green and hawksbill sea turtles in particular can be found in nearshore waters in the action area year-round. There are extensive seagrass beds and coral habitats in the action area where there has been no marine development and EPA coral surveys found the reef communities along the fringing reefs outside Jobos Bay to be in good condition meaning there are large areas of refuge and foraging habitat for green, hawksbill and loggerhead sea turtles in the action area. However, the species of turtles analyzed in this Opinion may be exposed to and accumulate terrestrial contaminants that are released into the marine environment during their life cycles.

ESA-Listed Coral and Elkhorn and Staghorn Coral Critical Habitat
In addition to federally-managed fisheries in the action area, there are Commonwealth-managed fisheries that operate in, or have effects in the action area with the same potential impacts to corals and their habitat as described in Section 5.3.1 due to the use of hook-and-lines, net, and trap fishing gear. There are several fishing communities in Guayama and Salinas where commercial fishers have shared facilities. There are also areas where recreational fishers concentrate. In Jobos Bay, there are restrictions on fishing and associated vessel transit that are enforced by PRDNER as part of the implementation of the JBNERR management plan in an effort to limit the effects of fishing gear and associated motorized vessel transit on shallow benthic habitats in the bay. The majority of commercial fishers target areas on the shelf edge where they fish for reef fish species.

Adverse effects from commercial vessel operations in the action area are also possible. PREPA receives fuel barge deliveries (3 – 4 weekly) at the dock along the shoreline of the existing power plant in Jobos Bay and other commercial vessels associated with dock repairs and other facility operations. We do not have documented reports of fuel barge or other vessel groundings associated with the operation of the Aguirre power plant. However, grounding reports to the USCG are often generated only when vessels run hard aground and have to be removed by other vessels. There could be incidents of propeller scarring that are not reported and cannot be tracked but there are no coral reefs or colonized hard bottom along the fuel barge routes into the bay, which is through an existing navigation channel in areas containing sand bottom that is colonized by seagrass and macroalgae in some areas. The other commercial vessel operations in the action area are associated with the artisanal fishing communities, although most of the commercial fishing activities take place offshore in deep waters due in part to restrictions on fishing and motorized vessels in Jobos Bay as part of the management of JBNERR. The applicant estimated there are 35 – 45 commercial fishing vessels, which are mainly small wooden vessels less than 25 ft in length, that transit in Jobos Bay on a weekly basis (Excelerate Energy 2013). Commercial fishers, because of the small size and shallow draft of their vessels, often transit through the passes between coral cays, including Boca del Infierno. Although we have no records of grounding of these vessels, it is likely that the hulls or propellers of the vessels come into contact with coral colonies that are close to the water surface due to the shallow water depth and number of coral colonies in these passes through the cays. Commercial diving operators also visit the area of Jobos Bay, particularly the cays and offshore reef line, resulting in 1 – 5 vessels per week (Excelerate Energy 2013). We do not have information regarding where these vessels anchor but, given that they target reefs for diving and snorkeling with their customers, there is a possibility that the anchoring of these vessels leads to some impacts to corals. There are also occasional commercial vessel operations associated with salvers when large recreational vessels run aground in the action area, as happened at Cayos Caribe where the applicant proposes seagrass restoration as part of the mitigation of project impacts to seagrass beds in Jobos Bay.

PRDNER operates vessels in Jobos Bay and around the cays in order to manage different areas within JBNERR, perform maintenance operations including on dock facilities at the cays and along the shoreline of Aguirre, and conduct water quality and other scientific research activities in JBNERR. JBNERR also has programs to sponsor research by graduate students and scientists, including marine investigations. PRDNER also has a Ranger office responsible for the enforcement of regulations specific to JBNERR, as well as Puerto Rico-wide regulations such as those related to fishing and boating. We do not expect PRDNER research and enforcement operations or research by those associated with JBNERR to have negative impacts to ESA-listed corals or their habitat. However, when research is proposed that requires the use of extractive techniques to sample corals, PRDNER requires a permit and requests comments from NMFS as to whether or not changes to the techniques or overall project should be made to be protective of ESA-listed corals or their habitat.

Recreational fishing is common in the action area, typically in motorized vessels less than 40 ft in length that transit in Jobos Bay and around offshore cays. The applicant estimated that 50 – 75 recreational fishing vessels transit in the area of Jobos Bay on a weekly basis (Excelerate Energy 2013). There are also recreational fishing tournaments, but these target deep water pelagic species so vessel transit associated with these is largely in offshore areas. We do have reports of groundings by recreational vessels in the action area, some of which were in areas of coral cays, although the most severe impacts of these groundings that has been documented to date were to seagrass beds rather than to coral reefs.

Through JBNERR, PRDNER promotes recreational activities such as walking tours. There are also local businesses that manage kayaking trips in the estuary. Private individuals visit the action area to snorkel, kayak, and hike. Kite boarding and wind surfing are also becoming popular in portions of Jobos Bay, particularly the areas around the offshore cays. A kite boarding tournament occurred in 2012 sponsored by a group based in Punta Pozuelo and is expected to reoccur, potentially becoming an annual event (ExcelerateEnergy 2013). Kite boarders often cut through Boca del Infierno so there is the potential for impacts to corals and their habitat associated with these activities.

Nutrient loading from land-based sources, such as coastal communities and agricultural operations, and other land-based sources of pollutants, such as from the Salinas landfill which is within the watershed of the action area and the operation of the Aguirre power plant, can affect marine water and sediment quality. Sediment and elutriate testing completed by NOAA NOS and the applicant in Jobos Bay found low levels of petroleum-based contaminants, heavy metals, and pesticides, especially in nearshore areas of the bay close to existing development likely associated with terrestrial runoff to the bay and marine operations, including those for the power plant.

5.3.3 Other Potential Sources of Impacts to the Environmental Baseline

Sea Turtles
Hurricanes and large coastal storms can significantly modify both nesting and in-water sea turtle habitat. Beach profiles change in response to wave action and storm-induced erosion on the coast, which can also lead to the loss of nests or the loss of nesting habitat for a single season or multiple seasons depending on the size of the beach and the extent to which the beach profile is altered. Intense storms that cover a broad area can eliminate or damage large expanses of reef or result in blowouts and loss of seagrass habitats. Major hurricanes have caused significant changes in the physical structure of many reefs around Puerto Rico. Tropical storms and hurricanes can also result in severe flooding, leading to significant sediment transport to nearshore waters and additional degradation of reef habitats. In addition to affecting the sessile benthic organisms themselves, these changes in the structure of the reef affect species like sea turtles, in particular greens and hawksbills that use reef habitats for refuge and foraging. In-water habitat for green and hawksbill sea turtles is temporarily or permanently lost or degraded depending on the magnitude of the storm. The recent impacts of Hurricanes Maria and Irma on the coastal area of Puerto Rico have not yet been assessed but preliminary reports indicate that beaches in many parts of the island and outlying islands such as Culebra and Vieques were significantly affected by erosion associated with storm surge (E. Díaz, PRDNER, pers. comm. to L. Carrubba, NMFS, October 12, 2017). There have also been reports of numerous vessel groundings, contamination of nearshore waters due to flooding of terrestrial areas including wastewater treatment plants, transport of debris to nearshore waters and debris accumulation where in-water structures were damaged, and storm damage to coral habitats (E. Díaz, PRDNER, pers. comm. to L. Carrubba, NMFS, October 12, 2017).

ESA-Listed Corals and Elkhorn and Staghorn Coral Critical Habitat
Hurricanes and large coastal storms can also harm corals and alter their habitat. Historically, large storms potentially resulted in asexual reproductive events if the fragments encountered suitable substrate, attached, and grew into new colonies. Over the past 2 decades, the amount of suitable substrate has been significantly reduced; therefore, many fragments created by storms die. Hurricanes are also sometimes beneficial, if they do not result in heavy storm surge and associated damage to corals, during years with high sea surface temperatures because hurricanes and other storms lower water temperatures. This provides relief to corals during periods of high thermal stress (Heron et al. 2008). Major hurricanes have caused significant losses in coral cover and changes in the physical structure of many reefs in the U.S. Caribbean. Flooding from hurricane events leads to transport of land-based sources of pollutants to reefs, along with an influx of freshwater to nearshore environments that affects water quality, in addition to the

physical damage caused by the storms themselves and by the discharge of debris from large rivers during storm flows. In the action area, the large areas of coastal wetlands and the offshore cays and associated fringing reefs and colonized hard bottom protect portions of the coastline, particularly in Jobos Bay, but the reefs and hard bottoms bear the brunt of storms that approach from the south. Hurricane Maria at the end of September 2017 caused large swells in Jobos Bay that carried coral from the fringing reefs outside the bay all the way to the shoreline and mangroves fringing the bay near the Aguirre power plant (A. Pabón, JBNERR, pers. comm. to L. Carrubba, NMFS, September 25, 2017). There are also reports of widespread damage to coral habitats around Puerto Rico and the fringing reefs outside Jobos Bay are likely to have suffered impacts based on the reports of storm surge effects in this area. The impacts from the hurricanes of 2017 are not yet fully assessed or understood.

5.3.4 Conservation and Recovery Actions Shaping the Environmental Baseline

Sea Turtles

NMFS has implemented a series of regulations aimed at reducing the potential for incidental capture and mortality of sea turtles from commercial fisheries in the action area. These include sea turtle release gear requirements for Caribbean fisheries, including long line and trap gears.

Under Section 6 of the ESA, NMFS may enter into cooperative research and conservation agreements with states to assist in recovery actions for listed species. We currently have an agreement with Puerto Rico and the Commonwealth has regulations to protect sea turtle species as well. Any projects conducted under Section 6 agreements must be reviewed for compliance with Section 7 of the ESA. Many of the projects are aimed at determining the population status of ESA-listed species within the jurisdiction and working toward the recovery of the species. The PRDNER conducts research on hawksbill sea turtles in the area of Mona and occasionally Desecheo Islands and on green sea turtles in Culebra. As part of a recent Section 6 proposal, PRDNER would like to expand this research to better determine population dynamics in various natural reserves around Puerto Rico. PRDNER also monitors beaches around Puerto Rico, although monitoring is mainly for leatherback sea turtle nesting. PRDNER is also working to strengthen its volunteer sea turtle nesting monitoring network in order to obtain more comprehensive information regarding nesting by all sea turtle species around the island.

NMFS has established stranding procedures to rescue and rehabilitate any live stranded sea turtles. The PRDNER responds to sea turtle strandings in Puerto Rico. NMFS has issued regulations (66 FR 67495, December 31, 2001) detailing handling and resuscitation techniques for sea turtles that are incidentally caught during scientific research or fishing activities. Persons participating in fishing activities or scientific research are required to handle and resuscitate (as necessary) sea turtles as prescribed in the Final Rule. These measures help to prevent mortality of hard-shelled turtles caught in fishing or scientific research gear.

A Final Rule (70 FR 42508, July 25, 2005) allows any agent or employee of NMFS, USFWS, USCG, or any other federal land or water management agency, or any agent or employee of a state agency responsible for fish and wildlife, when acting in the course of his or her official duties, to take endangered sea turtles encountered in the marine environment if such taking is necessary to aid a sick, injured, or entangled sea turtle, or dispose of a dead endangered sea turtle, or salvage a dead endangered sea turtle that may be useful for scientific or educational purposes. NMFS also affords the same protection to sea turtles listed as threatened under the ESA (50 CFR 223.206(b)).

On August 3, 2007, NMFS published a Final Rule (75 FR 43176) requiring selected fishing vessels to carry observers on board to collect data on sea turtle interactions with fishing operations, to evaluate existing measures to reduce sea turtle takes, and to determine whether additional measures to address prohibited sea turtle takes may be necessary. This Rule also extended the number of days, from 30 – 180, that NMFS observers are placed on vessels. This was done in response to a determination by the Assistant Administrator that the unauthorized take of sea turtles may be likely to jeopardize their continued existence under existing regulations.

Recovery teams comprised of sea turtle experts have been convened to work toward revising sea turtle recovery plans based on the latest and best available information. Five-year status reviews are completed for green, hawksbill, leatherback, and loggerhead sea turtles. These reviews are conducted to comply with the ESA mandate for periodic status evaluation of listed species to ensure that their threatened or endangered listing status remains accurate. Each review determined that no delisting or reclassification of a species status (i.e, threatened or endangered) was warranted at this time. However, further review of species data for the green and loggerhead sea turtles resulted in a determination that DPS should be established for these species, which was completed for loggerhead sea turtles in 2011 and for green sea turtles in 2016. On February 5, 2018, NMFS announced its 90-day finding on a petition to identify a Northwest Atlantic DPS of leatherback sea turtles and to list it as a threatened species. We found the petitioned action may be warranted, and initiated a status review that includes examining the species globally with regard to application of the DPS policy (82 FR 57565).

ESA-Listed Coral and Elkhorn and Staghorn Coral Critical Habitat

The CFMC has established regulations prohibiting the use of bottom-tending fishing gear in seasonally and permanently closed fishing areas containing coral reefs in federal waters of the (EEZ). The Coral Reef Conservation Act and the FMPs established by the CFMC under the Magnuson-Stevens Fishery Conservation and Management Act (the Reef Fish Fishery of Puerto Rico and the U.S. Virgin Islands and the Corals and Reef Associated Plants and Invertebrates of Puerto Rico and the U.S. Virgin Islands), require the protection of corals and prohibit the collection of hard corals.

The Commonwealth Government regulates activities that occur in terrestrial and marine habitats of Puerto Rico. Puerto Rico Regulation 6766 (Law 241 of 1999, the New Wildlife Law) establishes protections for listed species. Permits can be issued by the Secretary of DNER for the collection and transport of species listed by the Commonwealth as vulnerable, threatened, endangered, or critically endangered species for rehabilitation, scientific use, or survival and species’ benefit purposes. (Note that federally-listed species are also protected through this Commonwealth regulation, as is ESA-designated critical habitat). In addition, the regulation prohibits the modification of listed species’ habitat without a mitigation plan approved by the Secretary of DNER, although the regulation also restricts the type of habitat that can be modified at all. Regulation 6768 under the same law also regulates the collection of all organisms, not just listed species. The DNER Secretary can issue a collection permit for the purposes of scientific investigation, or educational activities or exhibits. Puerto Rico Law 147 of 1999 for the protection, conservation, and management of coral reefs in Puerto Rico, prohibits the removal, extraction, mutilation, or destruction of coral reefs and associated systems. The Secretary of DNER can issue permits for scientific investigations that require extraction of corals, or those that will otherwise affect corals. Additionally, Puerto Rico has a state regulatory program that regulates most land, including upland and wetland, and surface water alterations, including in partnership with NOAA under the Coastal Zone Management Act, and EPA under the Clean Water Act. EPA has maintained regulatory authority for some activities regulated under the Clean Water Act, such as the non-point source discharge elimination system permits.

Section 6 of the ESA allows NMFS to enter into cooperative agreements with states to assist in recovery actions of ESA-listed species, including scientific research related to documenting species condition and trends in presence and abundance. PRDNER renewed its Section 6 agreement with NMFS this fiscal year, although the status of any ESA Section 6 funding for the Commonwealth is not known at this time as the proposal competition closed in November 2016. Recovery actions may also include the collection of fragments from coral colonies, their grow-out in nursery areas, and the outplanting of fragments. The PRDNER has issued memoranda of understanding to several coral nursery operators with coral nurseries in various areas around Puerto Rico, though there are none currently in the area of JBNERR. The PRDNER is also the entity responsible for permitting the use of coral species, including ESA-listed corals, in coral nurseries. NMFS is currently conducting as ESA Section 7 consultation with the USACE for the issuance of a Regional General Permit, SAJ-112, that would authorize the installation and maintenance of coral nursery operations up to 1 ac in size that do not require the placement of fill, such as the installation of PVC “trees”. NOAA’s Restoration Center also maintains coral nurseries in various locations around Puerto Rico and uses farmed corals in efforts to repair damage from vessel groundings on reefs.

NMFS convened a recovery team comprised of fishers, scientists, managers, and agency personnel from Florida, Puerto Rico, and USVI, as well as federal representatives to create a recovery plan for elkhorn and staghorn corals and their habitat. NMFS has also created a recovery outline for the development of a recovery plan for the 5 additional coral species that were listed in September 2014 (http://sero.nmfs.noaa.gov/protected_resources/coral/documents/recovery_outline.pdf).

The NOAA CRCP, through its internal grants, external grants, and grants to the Territory, Commonwealth, and the CFMC, has provided funding for several activities with an education and outreach component for informing the public about the importance of the coral reef ecosystem of the USVI and Puerto Rico. The NMFS Southeast Regional Office has also developed outreach materials regarding the listing of elkhorn and staghorn corals, the listing of 5 other coral species on September 10, 2014, the ESA Section 4(d) rule for elkhorn and staghorn corals, and the designation of elkhorn and staghorn coral critical habitat. These materials have been circulated to constituents during education and outreach activities and public meetings, and as part of other Section 7 consultations, and are readily available on the web: http://sero.nmfs.noaa.gov/protected_resources/coral/index.html.

6 EFFECTS OF THE ACTION ON SPECIES AND CRITICAL HABITAT

Effects of the action include direct and indirect effects of the action under consultation. Indirect effects are those that result from the proposed action, occur later in time (i.e., after the proposed action is complete), but are still reasonably certain to occur.

As described below, NMFS believes that the proposed action will adversely affect leatherback, loggerhead, green, and hawksbill sea turtles; elkhorn, staghorn, pillar, rough cactus, lobed star, mountainous star, and boulder star corals; and elkhorn and staghorn coral critical habitat. As part of this Opinion and because the action will result in adverse effects, NMFS must evaluate whether the action is likely to jeopardize the continued existence of these species or result in destruction or adverse modification of the critical habitat. If so, NMFS must develop RPAs to avoid the likelihood of jeopardy to the species or destruction or adverse modification of the critical habitat. If NMFS determines the action is not likely to jeopardize the continued existence of ESA-listed corals, NMFS may authorize incidental take, subject to RPMs to minimize the effects of the take and terms and conditions to implement the RPMs.

6.1 Assumptions

The analysis of potential effects to ESA-listed sea turtles, corals, and elkhorn and staghorn coral critical habitat in the following sections are based on a series of assumptions given the information provided by the applicant and FERC.

The first assumption is based on the applicant's assertion that the HDD technology to be used for the project will enable the recovery of all drilling fluid at the HDD entry point and 98% of the drilling fluid at the exit point with no releases outside the excavated pit at the exit point. The applicant provided examples of HDD operations and information from MottMacdonald (2017). The applicant also provided the detailed specifications that will be provided to contractors bidding on the project that include the requirement that drilling fluid be recovered for reuse and disposal during HDD operations to the maximum extent possible and that any fluid remaining after pipeline installation is complete be recovered and disposed of at a terrestrial facility. MottMacdonald (2017) modeled drilling fluid recovery based on technology they have employed during HDD projects, including some of those presented as examples by the applicant. The specifications contractors will be required to comply with include similar technological requirements for drilling fluid recovery.

The second assumption is based on the applicant's assertions that: a) the geology of the site is appropriate for HDD; and b) that HDD can be performed successfully with no accidental releases of drilling fluid along the borehole. We have based our conclusions on the information provided by the applicant from MottMacdonald (2017) and the examples of HDD operations provided by FERC and Excelerate as the best information available for us to analyze the potential effects of the HDD portion of the project on ESA-listed sea turtles, corals and elkhorn and staghorn coral critical habitat. These examples include the Gulfstream Bartow Lateral Pipeline project in Tampa Bay, Tampa, Florida; the Florida Power and Light electric line relocation project in Biscayne Bay, Miami, Florida; and the Wastewater Treatment Plant Outfall Extension project in Gig Harbor, Washington. The Biscayne Bay project is the most similar to the Aguirre Offshore GasPort project. The geology of the pipeline routes was coral and limestone formations, the pipelines had to be installed at depths of -75 ft or greater to clear existing seawall pilings and allow for future port deepening, and the area contained sensitive marine resources such as coral and seagrass. The project included two HDD water-to-shore pipelines of 2,200 ft and 2,300 ft. The project was completed with no loss of drilling fluid due in part to the use of innovative HDD methods such as forward reaming, terminating reaming passes 50 to 60 ft before punch out to ensure drilling fluid returns to entry point, and the removal of plugs at exit points during final operation when pipelines are pulled back (Bueno 2005; Halderman 2006). The applicant will require the use of similar methods by the contractor selected for the project.

Our third assumption is based on the applicant's assertions that: a) the offshore platform will resist major hurricanes; and b) that the design and installation of the pipeline adequately accounts for impacts associated with swells from large storms. The recent impacts of Hurricane Maria included large swells in Jobos Bay that carried coral from the fringing reefs outside the bay all the way to the shoreline and mangroves fringing the bay near the power plant (A. Pabón, JBNERR, pers. comm. to L. Carrubba, NMFS, September 25, 2017). Following the 2017 hurricanes, NMFS asked the applicant whether the proposed pipeline and offshore platform design would withstand impacts if storms of similar magnitude occur once the project is constructed. The applicant replied in a November 16, 2017, email that the design of the pipeline at the shoreline is sufficient to resist scour and/or breaking waves at the shoreline. The applicant also stated that the pipeline design summary concluded that the pipeline installed flush with the seabed and with concrete coating at the pipe bends will be stable. However, the applicant noted that a bottom survey will be conducted prior to the completion of the detailed design of the pipeline. The survey will check that bottom depths and other conditions that could affect the pipeline remain similar to what was observed during preliminary pipeline design so that the final design can incorporate any changes required to ensure the pipeline is stable along its entire route. In terms of the offshore platform, the applicant noted the design basis for the structure includes a 100-year return period for storm wind and wave and a 500-year return period for extreme wind and wave gather from historical and hind cast data. The piles supporting the structure will be driven deep into the substrate so scour on the upper portions of the piles would not affect structural integrity and topside equipment was designated to withstand a 1 in 500 year wind load. However, the applicant noted that the most recent storm information from the 2017 hurricanes will be evaluated prior to beginning the detailed design of the structure to be sure the assumptions used to create the preliminary design are still valid and the structure will be built to withstand major hurricanes.

6.2 Effects of the Action on Leatherback, Loggerhead, Green, and Hawksbill Sea Turtles

The leatherback sea turtle is an offshore species that is rarely observed close to shore except during their nesting season. Due to the location of portions of the offshore pipeline and platform, as well as the transit routes for vessels during construction and operation of the facility, leatherbacks may be present in offshore portions of the action area if jellyfish that serve as forage for this species are present. Nesting of leatherbacks occurs some years in the area of Punta Pozuelo (A. Dieppa, PRDNER, pers. comm. to L. Carrubba, NMFS, April 14, 2016). Therefore, leatherbacks may be present in the area where the offshore platform and offshore sections of the subsea pipeline are proposed, as well as along transit routes for work vessels, LNG carriers, and the FSRU. No leatherback sea turtles were observed during benthic or plankton surveys conducted for the project, but surveys took place outside the peak leatherback nesting season, many were inside Jobos Bay, and there were no targeted surveys looking for sea turtles and marine mammals.

Two loggerhead sea turtles were reported by the project consultants as observed offshore of the Boca del Infierno pass during coral mapping work conducted for this project in November 2013. There is a possibility this was a misidentification and the animals were green sea turtles given the rarity of loggerheads versus the predominance of green sea turtles in the area and no loggerhead sightings based on aerial survey data from USFWS from 1984 – 1985, 1992 – 1995, and 1996 – 2003 (USFWS, unpublished data). However, we err on the side of caution and assume loggerheads may be present in the project area given infrequent strandings of loggerhead sea turtles in various areas around Puerto Rico (rarely one per year; PRDNER stranding data) and reports of infrequent nesting on the east coast of Puerto Rico and Culebra.

Green and hawksbill sea turtles are reported by PRDNER in Jobos Bay and around offshore cays (C. Diaz, PRDNER, pers. comm. to L. Carrubba, NMFS, April 14, 2016) and hawksbill sea turtles nest in the area of Punta Pozuelo and on some of the offshore cays (A. Dieppa, PRDNER, pers. comm. to L. Carrubba, NMFS, April 14, 2016). Green sea turtles were also observed by project consultants during coral surveys conducted in the Boca del Infierno and offshore platform areas. PRDNER also has unpublished stranding data for the period from 1992 to 2008 and there have been several reports of green and hawksbill sea turtles in the project area, all of which stranded due to incidental or targeted capture by fishers or for reasons that could not be determined.

6.2.1 Discountable and Insignificant Effects to Sea Turtles

In-Water Equipment: Effects to all sea turtle species include the potential risk of injury from being struck by in-water construction machinery in the offshore areas where pipeline installation, including HDD operations that involve the excavation of a pit to receive drilling fluid and the operation of HDD drilling equipment, and construction of the offshore platform, including pile-driving, will take place. The potential to be struck by in-water construction equipment operating in Jobos Bay is also a possibility for green and hawksbill sea turtles, which are known to use various habitats within the bay. The barges used during construction operations will be anchored in place using spuds in Jobos Bay and temporary piles in offshore areas and areas where HDD operations will take place in Jobos Bay and offshore. These vessels will be moved infrequently during construction activities. This includes the pile-driving barge, which will remain anchored in place or move very little during pile-driving operations associated with the construction of the offshore platform. We do not have reports of impacts to sea turtles from the fuel barges that make regular deliveries to the existing Aguirre plant facilities in Jobos Bay. Construction of the project will take place during both day and nighttime hours but FERC has included a requirement in the license that vessel transit is restricted to daylight-only-hours so observers can look for animals. Sea turtles will be able to hear and see in-water construction machinery. We expect any animals that approach the in-water work areas to swim away. The areas where pile-driving and other in-water construction will take place are open to the sea and access to open water will not be impeded during construction activities. The applicant has proposed the implementation of NMFS's *Sea Turtle and Smalltooth Sawfish Construction Conditions* (Appendix B) and we anticipate that compliance with these conditions will be a requirement of any USACE permit issued for the project. The implementation of the construction conditions will provide protection to sea turtles by requiring temporary work stoppages to protect sea turtles that approach the in-water work area. The applicant also proposes the use of sea turtle and marine mammal observers and the training of all construction personnel and vessel operators as observers. Therefore, we believe the risk of injury to all sea turtle species from in-water construction machinery will be discountable.

The operation of in-water equipment during 24-hour HDD operations could affect nesting female sea turtles. If nighttime operations occur during nesting season, we expect females to avoid nesting sites such as those reported on offshore cays near Boca del Infierno where 24-hour operations associated with HDD installation of the pipeline will occur. This could lead to a reduction in nesting in the year when pipeline installation is underway. Although females may transit to other nesting sites, the need to invest additional energy in selecting different nesting sites means that females may nest fewer times than usual. However, the applicant proposes to conduct HDD operations in the mid-December to February timeframe, which would avoid peak nesting periods for leatherback and hawksbills sea turtles. Therefore, we believe the potential impacts of HDD operations on sea turtle nesting will be discountable.

Vessel Collisions: All sea turtle species could also be struck by work vessels during project construction. Both greens and hawksbills are likely to be in Jobos Bay, as well as offshore. Leatherbacks and loggerheads may be offshore and project consultants observed loggerheads offshore of Boca del Infierno during environmental studies conducted for the project. All sea turtle species could also be struck by LNG carriers and the FSRU during project operation. During project construction, all vessels will operate at very slow speeds and construction barges will be anchored using temporary piles, anchor spread, or spuds so movement of these vessels will be infrequent. Dive boats and other support vessels will move throughout the in-water construction area more frequently. All vessels will have marine mammal and sea turtle observers on board to look for animals that may be present in in-water construction footprints and along the path of work vessels. The applicant proposes the implementation of NMFS's *Vessel Strike Avoidance Measures and Reporting for Mariners* (Appendix A) as part of their sea turtle and marine mammal monitoring plan and FERC required that the plan be finalized in coordination with NMFS prior to any project construction. FERC also included a requirement in the license issued for the project that the transit of all crew boats during project construction and operation be restricted to daylight-only-hours so that observers can look for sea turtles and marine mammals during transit and collisions can be avoided. In terms of during project operation, as noted above, we do not have reports of impacts to sea turtles from current PREPA vessel operations that involve the use of barges to deliver petroleum to the power plant through an existing navigation channel into Jobos Bay. The sea turtle and marine mammal monitoring plan will also include a survey program to determine whether sea turtles are present and ensure vessel operations are carried out in a way that will have minimal impact on these animals. During operation of the offshore gasport, the applicant will also require that LNG carriers transit at speeds between 8 – 10 knots from the shelf edge to the PBS and then at less than 4 knots once the pilot is aboard, which will further reduce the potential for project vessel interactions with sea turtles as vessels transit to and from the offshore platform. Therefore, we believe the risk of vessel strikes to green, hawksbill, leatherback, and loggerhead sea turtles associated with project construction and operation will be discountable.

Seawater Intake: We do not expect adult or juvenile hawksbill and green sea turtles to become entrapped in the seawater intake to be used for the HDD operation because of the location and temporary nature of the 3 intake hoses that will extend from the freshwater supply barge to a water depth of 4 – 5 ft near the HDD entry point in Jobos Bay. We do not expect there to be any impingement of hatchling hawksbill or leatherback sea turtles associated with the intake of seawater during HDD operations because of the temporary nature of the seawater intake for HDD operations, the fact that most reported nesting is on the seaward side of Punta Pozuelo and the offshore cays while the intake will be in Jobos Bay, the limited nesting by sea turtles in the action area, and the expected low velocity of intake. Because there is no reported green or loggerhead sea turtle nesting activity in the action area, we believe there will be no impingement of these animals associated with seawater intakes during HDD operations.

Similarly, due to the design of the sea chests on the FSRU and the seawater intake rate, we do not expect adult leatherback and loggerhead and juvenile and adult green and hawksbill sea turtles to become entrapped in the intake structures that will be used by the FSRU during operation of the offshore gasport. Juvenile and adult turtles are too large to be affected by the 0.45 fps intake rate to be used by the FSRU. The existing Aguirre power plant has a seawater intake rate of 0.79 fps in front of traveling screens, which are 0.25-in smooth mesh panels that move. No entrapment or impingement of sea turtles has been reported as part of the operation of this intake structure, which has a higher intake rate than that to be used as part of the construction and operation of the proposed project. We also do not expect the impingement of green or leatherback hatchlings in the seawater intakes of the FSRU once the offshore gasport is operational. Each sea chest would have metal gratings with 0.87-in diameter slots between grating bars and the through-screen velocity would be approximately 0.45 fps, which is below the threshold of 0.5 fps recommended by the EPA to minimize impingement of aquatic organisms. In addition, there is limited sea turtle nesting activity in the action area and these areas are largely to the east of the proposed offshore platform, meaning there are large expanses of ocean available for hatchlings to move to sea and avoid interaction with the proposed offshore platform. Because there is no reported green or loggerhead sea turtle nesting activity in the action area, we believe there will be no impingement of these animals associated with seawater intakes once the offshore gasport is operational and the FSRU is semi-permanently berthed at the platform. Therefore, we believe the risk of entrapment and impingement of various life stages of leatherback, green, loggerhead, and hawksbill sea turtles associated with seawater intakes during the use of HDD and the operation of the FSRU once the project is constructed will be discountable.

Temporary and Permanent Habitat Impacts: Hawksbill, green, and loggerhead sea turtles could also be impacted by the temporary and permanent loss of use of potential forage and refuge habitat associated with the proposed installation and operation of the pipeline. Project documents indicate that 13.1 ac of seagrass and 1.2 ac of macroalgae will be impacted by the pipeline construction and 11.8 ac of seagrass and 58.1 ac of macroalgae by the construction of the offshore platform. At the offshore platform, the applicant also estimates that 4.1 ac of coral reef will be impacted. Of these areas, the applicant estimates that 0.01 ac of seagrass at the pipeline and 2.7 ac at the offshore platform; 0.01 ac of macroalgae at the pipeline and 18.7 ac at the offshore platform; and 0.2 ac of coral reef at the offshore platform will be permanently impacted by the construction and operation of the project. Seagrass beds in Jobos Bay and at the offshore platform will be impacted by the proposed construction of the pipeline and the platform, including through anchoring and spudding of work vessels during construction and from propeller wash from the use of thrusters by the large LNG carriers that will visit the platform weekly once the project is operational. Areas containing coral reefs and colonized hard bottom within the portion of the pipeline route to be installed using HDD will be impacted by the excavation of the entry and exit points due to sediment transport and the accumulation of drilling fluid in front of the forereef where the HDD drill will exit and at the entry point due to the back-and-forth of the drill string during boring and reaming operations. Coral reef and colonized hard bottom areas will also be impacted should there be inadvertent releases of drilling fluid through cracks in the overlying substrate during drilling operations and from the transport of drilling fluid to the backreef area from the entry point. The applicant has calculated that suspended sediment from construction, particularly burial of the pipeline sections that will not be installed using HDD, and the dredging of HDD entry and exit points will impact over 400 ac of benthic habitat, including many areas containing seagrass and macroalgae in Jobos Bay, with over 200 ac of sediment deposition. Approximately 80% of this acreage is outside the calculated project right-of-way along the pipeline route. These impacts are expected to extend over the approximately 3 months of pipeline burial activities and potentially beyond depending upon the degree of sediment deposition. However, the majority of sediment deposition from pipeline burial and excavations in Jobos Bay will be at depths up to 0.04-in so sediments are not expected to smother seagrass and macroalgal habitats to a level that would prohibit their continued growth. The applicant has proposed a turbidity monitoring program to track turbidity generated during the installation of the pipeline in Jobos Bay and determine whether natural levels are exceeded using a series of buoys. The applicant did not propose any remedial measures should monitored turbidity levels be higher than natural levels due to pipeline installation. Despite this, hawksbill, green, and loggerhead sea turtles will still have access to extensive seagrass, coral reef, and colonized hard bottom habitats in the action area located outside the projected suspended and deposited sediment areas.

At the offshore platform, construction will also result in sediment resuspension and transport due to pile driving activities, though only 13 pile structures will be installed so sediment resuspension and transport will be limited. The HDD and operation of the FSRU once construction is complete will also affect habitat used by the 3 sea turtle species due to the discharge of heated brine. The impacts of this discharge associated with HDD operations will be temporary because drilling and pipeline installation using HDD is expected to take 3 months. The discharge should be concentrated in the area to be impacted by the excavation of the HDD entry point and operation of the drill rig in shallow waters of Jobos Bay. At the offshore platform, the FSRU will discharge superheated brine on a daily basis in large volumes. Modeling by the applicant indicates that one of the discharges could affect the marine bottom due to the magnitude of flow, potentially leading to scour, but that overall the brine discharge is expected to mix into surrounding waters within 25 ft of the discharge point. Modeling of potential scour around the piles supporting the offshore platform determined that there will be a scoured area of marine bottom within 10 ft around each pile. Despite the impacts to habitat that may be used by green, loggerhead, and hawksbill sea turtles associated with project construction and operation, we believe the effects of temporary and permanent habitat loss to these species will be insignificant. We base this conclusion on the acreage of temporary impact areas in comparison to the extent of existing seagrass, macroalgae and coral habitats in the action area and because of the ability of sea turtles to relocate to adjacent, unimpacted areas of similar habitat present along the south coast of Puerto Rico.

Impacts to green, hawksbill, and loggerhead sea turtles due to the release of copper and other existing pre-project contaminants from sediments in Jobos Bay and potentially at the offshore platform site during pipeline construction could occur as a result of the ingestion of prey items that take up these contaminants. NOAA NOS and the applicant have conducted sediment testing in Jobos Bay found low levels of petroleum-based contaminants, heavy metals, and pesticides, especially in nearshore areas of the bay such as near the power plant and Aguirre community.

Green, hawksbill, and loggerhead sea turtles travel between nearshore and offshore habitats and various life stages of green and hawksbill sea turtles in particular can be found in nearshore waters around Puerto Rico year-round. There are studies on organic contaminants and trace metal accumulation in green, loggerhead, and leatherback sea turtles (Aguirre et al. 1994; Caurant et al. 1999; Mckenzie et al. 1999; Corsolini et al. 2000). Mckenzie et al. (1999) found that omnivorous loggerhead turtles had the highest organochlorine pesticide contaminant concentrations in all the tissues sampled from different life stages and eggs, including those from green and leatherback sea turtles (Storelli et al. 2008). Whitall et al. (2011) found some of these pesticides in sediment samples from Jobos Bay including DDT, dieldrin, and chlordane, among others. Therefore, sediment resuspension associated with project construction in Jobos Bay could expose foraging green, hawksbill, and loggerhead sea turtles to organochlorine pesticides. It is thought that dietary preferences were likely to be the main differentiating factor among species. Lipid contamination decreased with increasing size in green turtles, most likely attributable to a change in diet with age as turtles shift from an omnivorous to an herbivorous diet. No information on detrimental threshold concentrations of various contaminants is available and little is known about the consequences of exposure to things like organochlorine compounds to sea turtles. As omnivores, loggerheads could ingest contaminated prey items. Hawksbills and green sea turtles could also ingest contaminants during feeding, particularly younger like stages that are also more omnivorous. However, elevated levels of copper are present in various areas within the bay, including where fuel barges and other vessels transit likely leading to sediment resuspension and transport and potential exposure of sea turtle prey items. Despite this there are no associated reports of large numbers of stranded animals or information from necropsies of sea turtles from rare stranding events indicating animals appeared to be suffering from health effects that could be associated with contaminant exposure. Exposure to contaminants due to resuspension of sediments during project construction will be short-term as the project is expected to be constructed in 9 months. Therefore, we believe the effects to green, loggerhead, and hawksbill sea turtles of the release of copper and other contaminants from sediment resuspension and transport during pipeline construction activities will be discountable.

During operation of the offshore platform, copper ions will be released into surrounding waters from the FSRU cooling system maintenance. Copper can accumulate in the tissues of marine sponges, which are preyed upon by hawksbill sea turtles. The accumulation of copper in sponges leads to shifts in the symbiotic microbial community hosted by the sponge and often an overall decline in health (Tian et al. 2014). The benthic surveys conducted at the offshore platform were limited and did not indicate the number and species of sponges on the patch reefs in the area so we are not able to determine whether species of sponges preferred by hawksbills are present in the area where the offshore platform will operate. Approximately 4.1 ac of patch reefs will be affected by the construction of the offshore gasport and these reefs likely extend to the west away from the proposed footprint of the platform based on the surveys of the area completed by the applicant. A study of juvenile hawksbills around Mona and Monito Island by Díez and vanDam (2002) found between 0.11 and 0.5 immature hawksbills per acre. If we assume there are resident immature hawksbills in the area of the proposed offshore platform, there could be up to 2 turtles using the area as their resident habitat. Copper ions tend to sorb to organic material so copper released into the water column from the FSRU should not remain biologically available for long periods of time; therefore sponges that are in the area of the discharges and serve as prey items for hawksbills may not absorb high concentrations of copper. There is no evidence to suggest that hawksbills preferentially forage in the area where the offshore gasport is proposed and there are other areas that provide forage habitat, including along the reefs associated with the offshore cays in the action area and in deeper areas where reefs and colonized hard bottom are present. Given the low number of potential immature hawksbills that could be resident in the area where the offshore gasport is proposed, the lack of evidence suggesting the area is preferentially used as foraging habitat by hawksbills, and the availability of large expanses of colonized hard bottom and coral reefs in the action area, we believe the potential effects to hawksbill sea turtles associated with copper contamination of prey items will be discountable.

Accidental Spills: ESA-listed sea turtles could also be affected should accidental spills occur during construction and operation of the offshore platform. Leatherback adults and hatchlings, juvenile and adult green, adult loggerhead, and hatchling, juvenile and adult hawksbill sea turtles could be directly affected by spills of petroleum from vessels operating during construction and operation of the project, as well as spills of chemicals and other materials used or generated at the offshore platform once it is operational such as cleaning agents and wastewater if the animals are in the area of the spill when it occurs. Similarly, habitat for green and hawksbill sea turtles could be affected by accidental spills. As discussed previously for Nassau grouper, the extent of the impact to the animals and habitat for green and hawksbill sea turtles would depend on the volume of material spilled, the type of material, and oceanographic conditions at the time of the spill. The applicant plans to develop and implement a site-specific spill prevention and control plan to minimize the potential for inadvertent releases of hydrocarbons and to establish protocols for the containment, remediation, and reporting of accidental releases. The facility will also be regulated by the USCG that requires spill response plans for large commercial vessels and will require one for the offshore platform. Given the mobility of sea turtles, the low numbers of nesting leatherback and hawksbill sea turtles in the action area, and the likelihood of sea turtles not to be in the area of active in-water construction or operation of the gasport due to their avoidance of noise generated by construction and operation, and the availability of habitat throughout the action area, we believe the impacts to leatherback, loggerhead, hawksbill, and green associated with accidental spills of hydrocarbons and other compounds during construction and operation of the project will be discountable.

Vibratory Pile-Driving: Leatherbacks are not expected to be in the areas inside Jobos Bay where temporary piles will be installed because they are an offshore species that only come inshore to nest and reported nesting habitat is outside the bay in the Punta Pozuelo area. Therefore, we believe there will be no effect to leatherback sea turtles from the installation of temporary piles as part of the construction of the project. Temporary piles will be installed to serve as anchor points for pulling the pipeline in Jobos Bay and to anchor the HDD barge near the entry point for HDD operations. There are currently no established thresholds for injurious or behavioral effects to sea turtles from the use of a vibratory hammer to drive piles. However, we believe it is extremely unlike that the installation of temporary piles by vibratory hammer will result in injurious or behavioral noise effects to these animals. Given the mobility of sea turtles, we expect them to move away from noise disturbances. Because there are benthic habitats that may be used by green, loggerhead, and hawksbill sea turtles outside the footprint of proposed pile-driving activities, we believe animals will use other refuge and foraging habitats in open waters of the bay rather than stay in the area of vibratory pile-driving and other construction activities. If an individual choses to remain within the behavioral response zone, it could be exposed to behavioral noise impacts during pile installation. Since installation will occur only during the day, loggerhead, green, and hawksbill sea turtles will be able to resume normal activities during quiet periods between pile installations and at night. In addition, the 500-m safety zone established for the project will enable observers to ensure sea turtles are not present near vibratory pile-driving activity and minimize the potential for behavioral impacts to animals associated with pile driving. Therefore, we anticipate any behavioral effects to sea turtles from vibratory pile-driving activities for the installation of temporary piles will be insignificant.

6.2.2 Adverse Effects to Sea Turtles

Pile-Driving with Impact Hammer: Effects to sea turtles as a result of noise created by construction activities can physically injure the animals or change animal behavior in the affected areas. Physical injurious effects can occur in 2 ways. First, effects can result from a single noise event’s exceeding the threshold for direct physical injury to animals, and these constitute an immediate adverse effect on these animals. Second, effects can result from prolonged exposure to noise levels that exceed the daily cumulative exposure threshold for the animals, and these can constitute adverse effects if animals are exposed to the noise levels for sufficient periods. Behavioral effects can be adverse if they interfere with animals migrating, feeding, resting, or reproducing, for example.

There are currently no established thresholds for injurious and behavioral impacts to sea turtles from the use of an impact hammer to drive piles. Given the size of the piles and to be conservative, we have used thresholds accepted by NMFS, the Navy, and the Air Force in recent consultations[9]. We use these thresholds rather than the default marine mammal thresholds that

[9] NMFS' Biological Opinion for the U.S. Navy's Atlantic Fleet Training and Testing Activities from November 2013 through November 2018 and the National Marine Fisheries Services' Promulgation of Regulations and Issuance of Letters of Authorization Pursuant to the Marine Mammal Protection Act for the U.S. Navy to "Take" Marine Mammals Incidental to Atlantic Fleet Training and Testing Activities from November 2013 through November 2018 (2013), FPR-2012-9025; NMFS' Biological Opinion for the U.S. Navy's Atlantic Fleet Training and Testing Activities in the Hawaii-Southern California Training and Testing Study from December 2013 through December 2018, the National Marine Fisheries Services' Promulgation of Regulations Pursuant to the Marine Mammal Protection Act for the U.S. Navy to "Take" Marine Mammals Incidental to Training and Testing Activities in the Hawaii-Southern California Training and Testing Study Area from December 2013 through December 2018, and the

have been used in the past because they are suitably protective of sea turtles. These thresholds are 226 dB and 232 dB for peak pressure for the onset of temporary and permanent effects, respectively, and cumulative SELs of 189 dB and 204 dB for temporary and permanent effects, respectively. We assumed that up to 2 piles will be driven per day based on the applicant's estimate that each pile will take 3.5 – 4.5 hours to install and that up to 7,500 strikes will be required per pile. Based on our noise calculations, the peak pressure threshold for injurious noise effects would be exceeded up to 33 ft (10 m) and 13 ft (4 m) from the source for temporary and permanent effects, respectively, to sea turtles. The cumulative sound exposure level of multiple pile strikes over the course of a day would cause injury to sea turtles up to 32,808 ft (10,000 m) and 5,012 ft (1,528 m) from the pile for temporary and permanent effects, respectively. Because the applicant will use confined bubble curtains for pile-driving activities associated with the installation of the 80-in steel piles at the offshore platform, we expect these injurious noise effects to be reduced. Depending on the experience of the contractor in using confined bubble curtains with 80-in steel piles, sound impacts could be reduced by 5 – 10 dB. We calculated sound reductions of 5 and 10 dB to determine the possible range of changes to the injury zones associated with the use of bubble curtains. This means that peak pressure injury would be exceeded within 7 ft (2 m) and 3 ft (1 m) of the pile for temporary and permanent effects, respectively, if a 5 dB reduction is achieved. The cumulative sound exposure would be reduced to 15,230 ft (4,642 m) and 2,326 ft (709 m) away from the pile for temporary and permanent effects, respectively, if a 5 dB reduction were achieved from the use of confined bubble curtains. If a 10 dB reduction is achieved, peak pressure injury would be exceeded within 0 ft and 3 ft (1 m) of the pile for temporary and permanent effects, respectively, and cumulative SELs would be reduced to 7,067 ft (2,154 m) and 1,079 ft (329 m) away from the pile for temporary and permanent effects, respectively. Prior to active pile driving, a marine observer must be present. This observer will survey the area for sea turtles prior to the commencement of any pile-driving activities, and delay pile driving if one is seen within 500-m of the pile-driving barge or during driving of piles. However, given the calculated distance over which injurious effects of pile-driving could occur, the proposed safety zone will not prevent cumulative sound exposure injuries over the 25 – 50 days of pile-driving activities at the offshore platform site. In addition, because of the length of time over which pile-driving noise will be sustained in order to install each pile, as well as the distance over which cumulative sound exposure injury could occur, we do not believe sea turtles could swim away from the affected area fast enough to escape all injurious effects of pile driving. To minimize potential noise impacts, in addition to the use of the confined bubble curtain system, the applicant has proposed to perform a ramp-up of pile-driving activities to enable animals to move away from work area. This soft start will give sea turtles more time to leave the area but, because the safety zone is much smaller than the predicted size of the acoustic impact area for pile-driving activities, sea turtles are still likely to be impacted by pile-driving.

Based on information from the applicant, up to 3 green sea turtles were sighted in a single day during benthic and coral surveys conducted for the project. No hawksbills were sighted but

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National Marine Fisheries Services' Issuance of Two Letters of Authorization Pursuant to Regulations under the Marine Mammal Protection Act to "Take" Marine Mammals Incidental to Training Exercises and Testing Activities in the Hawaii-Southern California Training and Testing Study Area from December 2013 through December 2018 (2013), FPR-2012-9026; and NMFS' Biological Opinion for the Ongoing Eglin Gulf Testing and Training Range Activities by the United States Air Force (2017), FPR-2016-9151 stranding data indicate they are present in the area with up to 2 hawksbill sea turtle strandings reported per day one year in the area of Juana Díaz (PRDNER unpublished data) but all other stranding data indicated that only 1 hawksbill in a year stranded and rarely were there strandings in multiple years. The applicant also reported sighting 2 loggerhead sea turtles in one day during a coral demographic survey.

In a search of unpublished aerial survey data for manatees from USFWS where sea turtle sightings were also reported, 5 green sea turtles, 1 hawksbill, and 9 unknown species of sea turtles were observed on survey days in 1984 – 1985; 6 unknown species and 1 hawksbill in 1995; 1 hawksbill in 1997; 2 unknown species of sea turtles in 2000; 1 unknown species in 2002; and 1 unknown species of sea turtle in 2003. It appears that hawksbills were more commonly sighted during fall surveys, possibly corresponding with peak nesting season. Due to the number of turtles that could not be identified to species, we err on the side of the species and assume loggerheads are also present, though rare, in the project area. We used the number of survey days (42 in total across all years), the total number of turtles spotted during all surveys (5 green, 4 hawksbill, 18 unknown), multiplied the number of unknowns by 0.5% to estimate the number of loggerheads as 1 animal (from Rathbun et al. 1985 who estimated loggerheads around Puerto Rico representing approximately 0.5% of all sea turtles), and divided the remaining 17 unknowns between green and hawksbill sea turtles. This provides an estimate of 1 loggerhead, 14 green, and 12 hawksbills over 42 days. If pile driving activities last for 50 days, then we expect that a total of 17 green sea turtles, 14 hawksbills, and 1 loggerhead could be impacted by the noise of pile driving, assuming that there are no resident turtles and that different individuals transit through the area each day. (Note that this is calculated by dividing the number of turtles of each species by the 42 days of surveying in order to determine the number of turtles that would be present in a 50 day period). Green and hawksbill sea turtles could be juveniles or adults based on information from studies of these species, including in Puerto Rico, showing size classes found during in-water surveys include juvenile and adult animals (Diez and vanDam 2002 and 2007). We also estimate that 1 leatherback sea turtle could be impacted by the noise of pile driving given that nesting by this species has been reported by residents in the Punta Pozuelo area and pile driving will take place during some of the months when leatherbacks may be nesting. Given the extent of the cumulative sound exposure even if confined bubble curtains are used, all of these animals could suffer temporary or permanent hearing loss. Temporary hearing loss would affect the fitness of the animals for as long as the effect lasts because animals' ability to hear things like motorized vessels will be impaired. Permanent hearing loss could result in the mortality of affected animals if their ability to avoid collisions with motorized vessels or in-water equipment decreases. Permanent hearing loss does not necessarily mean that animals will lose all ability to hear. Permanent hearing loss could also be a reduction in the range of sounds animals can hear, which could impair their ability to avoid predators and other threats such as vessels over the long term. We have no way of determining how many turtles will suffer permanent versus short-term hearing loss as a result of acoustic impacts from pile driving. However, due to the use of ramp up procedures, the ability of sea turtles to swim long distances away from the disturbance, and the availability of other similar habitats within the sea turtles' swimming range, we believe sea turtles will leave the area and any temporary or permanent hearing loss experienced by sea turtles will not cause indirect lethal effects (effects occurring later in time due to decreased fitness). The acoustic effects to sea turtles are discussed further in Section 8.

The installation of steel pipe piles using an impact hammer could also result in behavioral effects up to 13,061 ft (3,981 m) from the pile for sea turtles. This effect is reduced to radii of 6,062 ft (1,848 m) with a 5 dB reduction associated with the use of confined bubble curtains and 2,815 ft (858 m) with a 10 dB reduction. Due to the mobility of sea turtles, we expect them to move away from noise disturbances in the open-water environment where the offshore platform is proposed. There are other areas of colonized hard bottom, coral reef, and seagrass beds in the action area and the platform will be offshore in open ocean. Since installation will occur only during the day, these species will be able to resume normal activities during quiet periods between pile installations and at night. Foraging by green, loggerhead, and hawksbill sea turtles (and potentially leatherbacks if pile-driving takes place during nesting season and there are jellyfish that serve as prey items for this species in the action area) is expected to resume once the animal leaves the area. Resting and transiting through the action area would also continue as soon as animals have moved away from the disturbing level of noise. It is unlikely that a disruption in foraging, resting, or migrating over the 25 – 50 days during which pile-driving activities would take place would impact the health of any individual animal. We also do not expect there to be any permanent decrease in fitness or other negative consequence to individuals of each sea turtle species that occurs in the action area as a result of the behavioral effects of pile-driving noise.

There is the potential for noise to disrupt hawksbill and leatherback nesting. Leatherback nesting is reported in the area of Punta Pozuelo, which is approximately 16,000 ft from the proposed offshore platform. Hawksbill nesting is reported in the area of Punta Pozuelo and on offshore cays that have beaches, which are within approximately 11,000 ft from the proposed pile-driving activities. Thus, hawksbill and leatherback nesting beaches will be within the radii for injurious and behavioral effects. Female hawksbill and leatherback sea turtles could elect not to nest in the action area due to avoidance of sound from pile-driving activities during the day leading to females transiting out of the action area. Similarly, hatchlings trying to avoid noise could become disoriented or swim along the shoreline rather than out to open water trying to move away from noise associated with pile-driving.

No leatherback sea turtles were reported in stranding data for the action area and none were observed during benthic surveys, including those conducted in April and May when leatherbacks may be nesting, or reported in USFWS aerial survey data. The applicant proposes the construction of the offshore terminal during the months of December through July. The applicant has agreed not to perform pile driving during April and May and October and November to minimize impacts to leatherback and hawksbill sea turtles during peak nesting periods, which reduces the potential for impacts to leatherback sea turtles due to pile driving. Pile driving will still occur during spring and summer months when leatherbacks are present in nearshore waters of the project area so there is a possibility of noise impacts to leatherback sea turtles. Pile driving could also occur during late summer and winter months that are outside the peak nesting season for hawksbill sea turtles. There is the possibility for adult and hatchling leatherback sea turtles and adult and hawksbill hatchlings to be affected by noise generated by pile driving. Despite the apparently low numbers of nests of these species that can be found in the action area during a given nesting season, the size of the cumulative sound exposure zone means that if leatherback or hawksbill sea turtles do nest within this zone hatchlings that emerge when pile driving is still occurring could suffer mortality. Hatchlings could suffer mortality due to the injurious noise effects or become disoriented due to temporary or permanent hearing loss, making them more susceptible to predation. As pile driving will only occur during the day, females may lay nests within the cumulative sound exposure zone at night. The fact that work will not be conducted during certain months of peak nesting for both species is expected to lessen this effect.

We assume that there could be one adult leatherback sea turtle in the area as noted above. Because a single female leatherback nests up to 10 times over the 3-6 month nesting season, we assume that this animal could nest up to 4 times in February and March (up to twice per month) when pile driving will occur and leatherbacks begin to nest in Puerto Rico. Leatherbacks typically have up to 110 eggs in the nest of which approximately 30% are infertile (Eckert 1989; Maharaj 2004; Stewart and Johnson 2006). The number of leatherback hatchlings that make it out of the nest onto the beach (i.e., emergent success) is between 54% and 72% in the United States (Eckert and Eckert 1990; Stewart and Johnson 2006; Tucker 1988). Thus, if we assume there are 77 fertile eggs per nest and 4 nests are lain while pile driving is occurring, 308 leatherback eggs would produce between 166 and 222 leatherback hatchlings (with emergent success between 54 and 72%). Similarly, we assume there could be one nesting hawksbill sea turtle in the area during pile driving. A single hawksbill lays 3-5 nests per season, nesting in Puerto Rico is typically from August to November, and no pile driving will take place in October and November, so we estimate that up to 2 hawksbill nests could be affected (1 per month in August and September). Hawksbill clutch size is approximately 140 eggs and emergent success at nesting beaches in the Caribbean is approximately 80% (Ditmer and Stapleton 2012). Thus, there could be 280 eggs resulting in 224 hawksbill hatchlings (140 times 2 times 80% emergent success). Studies have shown that sea turtle hatchling mortality rates range from 30-60% as the animals leave the beach and swim toward open water and only 2.5 in 1,000 reach adulthood (Pilcher 1999; Frazer 1992). Thus, if we assume the higher emergent success for leatherback sea turtle hatchlings and using the 30-60% mortality rates to determine the number of hatchlings that actually survive to swim toward open water and the area where pile driving will be occurring, 89-155 leatherback sea turtle hatchlings could suffer injurious effects from pile driving. Of the estimated hawksbill sea turtle hatchlings, using the 30-60% mortality rate, 90-157 hawksbill sea turtle hatchlings could suffer injurious effects from pile driving as they swim toward open water.

The effects of pile driving on nesting sea turtles and hatchlings are further discussed in Section 8.

Lighting: During construction, construction operations, particularly those associated with pipeline installation, will take place 24 hours a day. Lighting will be required to ensure worker safety during nighttime operations. FERC has required that the applicant develop a lighting plan that identifies specific measures that would be implemented to minimize or avoid impacts associated with the project's operational nighttime lighting on avian species, fish species, marine mammals, various life stages of sea turtles, and individuals on the shoreline. Lighting of the construction operation would allow observers to spot any sea turtles that are resting on the surface of the water at night in order to ensure the animals are not harmed by in-water construction equipment (FERC included a requirement in the license prohibiting vessel transit at night to be protective of ESA-listed species) as noted previously. However, nighttime lighting could result in disorientation of hawksbill and leatherback sea turtle hatchlings in the water if the portions of the project requiring nighttime construction operations will occur during nesting season. Disorientation of both hawksbill and leatherback sea turtle hatchlings associated with offshore work could occur as these species are reported nesting in the area of Punta Pozuelo and hawksbills are also reported to nest on the beaches of some offshore cays, including near Boca del Infierno where HDD operations will take place and require lighting.

The offshore platform will require lighting at all times during its construction and operation to ensure vessels can see the platform, enable operations to take place continuously associated with offloading of LNG carriers, and to ensure worker safety. Disorientation of adult and hatchling sea turtles on the beach is common in developed areas due to lights from cars and other vehicles and lighting of pathways, roadways, and buildings. Disorientation associated with lighting of navigational aids can also occur. Even with lighting plans, the glow from developed areas on land and lighted in-water facilities can lead to disorientation of animals. FERC has required the development of a lighting plan as part of the project in part to minimize the potential for disorientation of sea turtles. However, the plan has no specific components related to preventing disorientation of turtles in the water or conducting lighting surveys to determine whether or not the lights on the platform are effectively shielded to minimize disorientation of females transiting to and from nesting beaches in the action area and hatchlings leaving nesting beaches. However, sea turtle nesting activity is limited in the action area so large numbers of nesting females and hatchlings are not expected to be present in the action area. Beaches outside the project area provide important nesting habitat for hawksbill and leatherback sea turtles and nesting is reported on these beaches annually rather than intermittently (which is the case in the action area). It is also possible that the lighting of the existing Aguirre power plant contributes to sea turtle disorientation and that, coupled with the permanent lights at the new offshore platform, will lead to a decline in sea turtle nesting activity in the action area. Again, sea turtle nesting activity in the action area is limited so large numbers of nesting females and hatchlings are not expected to be present. Hatchlings have been shown to be attracted to offshore lights on vessels and structures. Disorientation due to lighting during project construction will occur only during the 9 months of pipeline and offshore platform in-water construction. Lights will be designed and installed in a way that minimizes potential impacts to sea turtles based on FERC's required lighting plan but construction will occur during leatherback and hawksbill nesting season. For hawksbill and leatherback sea turtles that nest in the action area, the permanent lighting of the offshore platform during its operation on adult and hatchling sea turtles of these species could lead to disorientation. During construction, lighting would affect the same number of adult female and hatchling leatherback and hawksbill sea turtles as pile-driving (i.e., one adult female leatherback and 89 – 155 leatherback hatchlings and one adult female hawksbill and 90 – 157 hawksbill hatchlings) if nesting of these animals takes place during construction of the offshore platform. During operation of the offshore platform, lighting would also be expected to affect this number of adult female and hatchling leatherback and hawksbill sea turtles each year nesting occurs. These effects are discussed further in Section 8.

6.3 Effects of the Action on ESA-Listed Corals

As discussed in Section 5.2 the applicant estimated that 4,379 colonies of pillar, rough cactus, lobed star, mountainous star, and boulder star coral colonies will be impacted by the construction of the offshore gasport. Of these, 214 ESA-listed coral colonies are expected to be permanently impacted. It is important to note that the total number of colonies to be impacted and the number to be transplanted outside the footprint of direct effects is a very rough estimate because no quantitative data in terms of the number of each coral species have been collected at the proposed offshore platform location. An accurate number of ESA-listed coral colonies to be affected by the construction of the offshore platform will not be available until pre-construction surveys are conducted for the project immediately prior to construction. Similarly, the number of coral colonies of each species is not available. Therefore, NMFS used the estimates of approximate percentages of different ESA-listed coral species from the EPA survey data because the data are representative of all 7 ESA-listed coral species and extrapolated to the 5 species that were observed in the area of the proposed offshore platform in the towed video surveys. The approximate percentage estimates used were 10% pillar, 3% rough cactus, 12% lobed star, 68% mountainous star, and 7% boulder star. Based on the estimated total of 4,379 ESA-listed coral colonies, approximately 438 pillar, 131 rough cactus, 525 lobed star, 2,978 mountainous star, and 307 boulder star coral colonies would be impacted by the proposed offshore platform. Of these, as noted above, 214 colonies would be transplanted to a recipient site in the action area. We estimate that these 214 coral colonies represent 21 pillar, 6 rough cactus, 26 lobed star, 146 mountainous star, and 15 boulder star coral colonies to be relocated. Note that these may be overestimates for pillar and rough cactus coral colonies as these were found to be very rare in the EPA surveys. These potential variations in numbers indicate the difficulty in accurately estimating the number of ESA-listed corals in the area of the proposed offshore platform given the lack of detailed surveys of the area.

NMFS also used the estimates of approximate percentages of different ESA-listed coral species from the EPA survey data to estimate the percentages of each of the 7 ESA-listed coral species in the pipeline corridor. The approximate percentage estimates used were 16% elkhorn, 3% staghorn, 10% pillar, 0.03% rough cactus, 3% lobed star, 68% mountainous star, and 0.07% boulder star corals. The pipeline corridor was surveyed when the applicant was proposing to direct-lay the pipeline through the Boca del Infierno coral reef. The applicant found that stony corals accounted for approximately 17.65% of the biotic percent cover on the reef and estimated that 40,115 total coral colonies were in the pipeline impact corridor, which measured approximately 0.87 ac (Tetra Tech 2012; Tetra Tech 2014a). Of these corals, the applicant estimated that 421 were ESA-listed species. If we assume the total reef area in Boca del Infierno in water depths ranging from 5 – 45 ft is 60 ac and use the estimate of 421 ESA-listed corals in a 0.87 ac area, then approximately 29,062 ESA-listed coral colonies may be present on the coral reef in the Boca del Infierno area. Using the percentage estimates from the EPA data to determine the approximate number of each ESA-listed coral species then yields estimates of 4,645 elkhorn (in depths up to 18 ft only based on Tetra Tech (2012), 871 staghorn, 2,903 pillar, 9 rough cactus, 871 lobed star, 19,743 mountainous star, and 20 boulder star coral colonies. Note that Tetra Tech (2014a) found that staghorn coral colonies represented 28% of samples in a coral demography survey because the species was more prevalent in deeper waters so the estimate of 871 colonies in a 60-ac reef area is likely to be an underestimate and the number might be as high as 8,130 colonies. Similarly, Tetra Tech (2014a) found that pillar coral colonies represented only 2% of the sample in the coral demography survey conducted for the project in the Boca del Infierno area so the estimate of 2,903 colonies of this species is likely to be an overestimate and could be as low as 581 colonies. Tetra Tech (2014a) also found that mountainous star coral colonies represented only 8.5% of the sample in the coral demography survey so the estimate of 19,743 colonies of this species may be an overestimate and there could be only 2,468 colonies. We believe the higher number is more accurate given that this species was the dominant ESA-listed coral species in all stations surveyed by the EPA although a survey of transects along the fringing reef system of these cays found lobed star coral to be dominant with a mean cover of 12.4% and a maximum of 22.8% (Garcia-Sais et al. 2014). The Garcia-Sais et al. (2014) survey was conducted in depths of 9 – 12 m, which also affects which hard coral species were dominant.

The applicant calculated the risk of entrainment of coral larvae for the 23 – 36 ft depth, corresponding to the depth of the FSRU seawater intakes, based on coral larvae sampling and the maximum daily seawater intake. The applicant's estimate attempts to represent the temporal distribution of larval density, which was not homogeneously distributed over time. The applicant calculated the entrainment estimate as the sum of daily entrainment estimates over 3 months based on time-varying coral larvae density and timing of LNG carrier deliveries. The hypothetical LNG carrier timing used in the calculations was selected to coincide with the September peak in coral larvae density (see Table 8) as a worst case scenario (FERC 2016). For the daily entrainment estimates, days without empirical data used interpolations to estimate daily coral larvae density. For days in the intervals between observed density peaks, coral larvae density was conservatively estimated as 14.5 larvae per 100 m^3. Also, because spawning does not occur on a single day, the entrainment analysis performed by the applicant assumed that larvae may be in the water column as early as 3 days after the full moon and as late as 24 days after, which is consistent with the 2015 sampling effort and available literature (FERC 2016). The sum of all daily entrainment estimates for the 3 spawning events from the 2015 sampling totals approximately 82 million coral larvae annually entrained by the FSRU and calling LNG carriers. This estimate assumed 3 months of susceptibility for broadcast spawners. This could be considered a conservative estimate as it does not account for natural mortality of the larvae (FERC 2016). This estimate does not account for the temporary seawater intake associated with HDD operations over a 3 month period, which could increase the estimate of coral larvae to be affected if the intake associated with HDD construction will occur during spawning of broadcast spawners (i.e., elkhorn, staghorn, pillar, lobed star, mountainous star, and boulder star corals).

6.3.1 Discountable and Insignificant Effects to ESA-Listed Corals

Accidental Groundings: ESA-listed corals could be affected by the transit of work vessels to and from the offshore mooring site if a work vessel was to ground on a shallow reef or colonized hard bottom area containing these corals. Similarly, ESA-listed corals could be affected by accidental groundings of the LNG carriers as they transit to the offshore platform and by the FSRU when it transits to and from the offshore platform as part of maintenance activities expected to occur every 5 years or because of a large storm that requires the vessel leave the platform. The applicant estimates that up to 52 LNG carriers (approximately 1 per week) will visit the offshore platform once it is operational. While the majority of vessel transit during construction will be through the existing barge channel to deep water offshore of the cays, there will be construction barges operating in close proximity to the cays that could come loose from their moorings or have a tow rope come loose during towing by tugs. For the LNG carriers and FSRU, these vessels will also transit through deep waters where accidental groundings are not possible, but vessels could ground on the offshore cays in the action area if vessels have a mechanical problem or due to weather conditions, as has happened near the deep water entrance to Guayanilla Bay, an area on the southwest coast of Puerto Rico that supports a number of commercial and industrial operations that involve large vessel transit, including of LNG carriers. In the Guayanilla area, ESA-listed corals have been damaged by vessel groundings, including in water depths over 35 ft due to the draft of the vessels. However, according to information from the USCG related to the groundings in Guayanilla, many of the groundings occurred due to the lack of aids to navigation (ATONS) on shallow reefs and hard bottoms on either side of the navigation channel as well as the boarding of pilots too close to shore. The applicant is not proposing any ATONS to mark vessel transit routes during construction or operation due to the existence of the barge channel into Jobos Bay and the location of the proposed offshore platform in relation to shallow water areas. FERC is requiring that all construction vessels transit during daylight hours only to minimize the potential for interactions with ESA resources, including corals. The applicant will require that pilots board the LNG carriers at the PBS located 2 mi southwest of the proposed platform and that vessels proceed at very slow speeds, which will also reduce the potential for a loss of control, impacts due to lack of familiarity with the area, and rapid motion that would prevent being able to slow the vessel to avoid grounding. The offshore platform will be located in water depths up to 65 ft and approximately 3,900 ft from the closest offshore cays. Therefore, vessels that come loose from the platform, temporary moorings or anchors for construction vessels, or suffer mechanical difficulties that prevent them from reaching the platform or a construction anchor system would have approximately 2,000 ft to weigh anchor to stop the vessel's motion toward shallow areas and prevent, due to the vessel's length, that swing on the anchor would lead to collision with the offshore cays. Based on surveys conducted for the project, the area between the proposed offshore platform and the offshore cays is largely unconsolidated bottom with some seagrass and macroalgal colonization until reaching the forereef areas along the cays. Thus, if vessels need to weigh anchor, anchor damage to ESA-listed corals is not expected to occur. For the reasons discussed above, we believe the potential for vessel transits associated with the construction and operation of this project leading to accidental groundings impacting elkhorn, staghorn, pillar, rough cactus, lobed star, mountainous star, and boulder star coral colonies is discountable.

<u>Vessel Anchoring:</u> ESA-listed corals could be affected by anchoring and spudding of work vessels during construction operations. Anchors and spuds will be used to moor construction vessels and barges in Jobos Bay and offshore of Boca del Infierno and at the proposed offshore platform during pipeline installation and burial operations, including HDD and dredging for HDD, and construction of the offshore platform. The 2 Stevpris anchors that will be used to secure the barge while pulling the HDD pipe may be left on the bottom because these anchors are designed to bury deeper as tension is placed on the anchor line. This will depend on the bottom substrate where the anchors are placed. If possible, these anchors will be retrieved once construction is complete. A total of 10 anchors will be used to secure the offshore HDD support barge but it is expected that all of these anchors can be retrieved once construction is complete. Other barges in Jobos Bay and offshore will be secured with temporary piles or spuds. The applicant noted that the locations for anchoring, spudding, and installation of temporary mooring piles will be surveyed by divers prior to any in-water construction to ensure areas selected do not contain ESA-listed corals. The applicant also noted that, if an anchor location must be in an area with ESA-listed corals, the corals would be relocated prior to any installation of anchors, spuds, or temporary moorings. However, the applicant does not anticipate that this will occur due to the amount of marine bottom in the project area that does not have coral reef or hard bottom. All

anchor lines will have midline buoys to prevent contact of anchor lines with the sea bottom. This will also minimize the potential for anchor lines to interact with areas containing ESA-listed coral colonies, reducing the possibility of breakage or abrasion of coral colonies from swinging of the anchor lines because the floats will maintain the lines in the water column. Additionally, in-water construction of the pipeline and offshore platform is expected to be completed in 9 months with an additional 3 months to complete the above-water portions of the offshore platform (during which time work vessels can moor to the structure itself as needed). Therefore, we believe the potential impacts from anchoring of work vessels during project construction on ESA-listed coral colonies will be discountable.

Seawater Intake and Discharge During HDD Operations: Three seawater intake hoses with 100 micrometer (µm) screens to reduce the intake of aquatic organisms will be used. The intake hoses will extend approximately 4 – 5 ft below the surface rather than being placed on the marine bottom to ensure excess rock or debris is not pulled into the equipment. The rate of intake will be 38 gallons per minute (or 54,720 gallons per day) and seawater intake will occur 22 hours per day over the anticipated 60 days required to complete drilling activities for HDD operations. The impacts of entrainment calculated by the applicant did not account for seawater intake during the 60 days of HDD operations. Depending on the time of year HDD operations occur, this intake could also lead to entrainment of coral larvae and an impact to reproduction of ESA-listed corals. However, the intake pipes will be located in Jobos Bay in an area with no coral colonization and this impact will be temporary in nature. In addition, the applicant has revised the project construction timeline to avoid HDD operations during the time of year when ESA-listed corals that are broadcast spawners may be reproducing sexually, which would prevent the entrainment of coral larvae during HDD operations. Therefore, we believe this effect to ESA-listed corals associated with the potential entrainment of coral larvae in the seawater intake during HDD operations will be discountable.

The freshwater generation process required for HDD operations will result in a brine effluent with a salinity of 64 – 70 parts per thousand (ppt). The discharge is expected to be approximately 0.2 million gallons per day (mgd) over the 50 – 60 days anticipated for HDD operations. The discharge will occur in Jobos Bay, outside the footprint of coral reefs and colonized hard bottom containing ESA-listed corals. Based on information from the applicant, the predominant transport patterns in the area will be into the bay and away from the reef areas in Boca del Infierno. The brine discharge will be at the high end of the tolerance range for ESA-listed corals but will be present for a short period. Therefore, we believe the effects to ESA-listed corals of the discharge of brine from the generation of freshwater during HDD operations will be discountable.

Sediment Resuspension and Transport During Pipeline Installation: The project may result in impacts to elkhorn, staghorn, pillar, rough cactus, lobed star, mountainous star, and boulder star coral colonies in the area of Boca del Infierno. These ESA-listed coral colonies could be affected by the resuspension and transport of sediment during excavations associated with HDD operations, specifically the dredging of exit and entry points, as well as the burial of the pipeline in areas where HDD will not be used, installation of concrete mats where the pipeline will not be buried, and pile-driving activities to install temporary mooring piles for construction barges. The release of drilling mud from the use of HDD to install a portion of the pipeline and associated sediment effects is discussed below.

The sediment resuspension and transport and sediment deposition modeling associated with installation and burial of the pipeline indicates that the majority of sediment impacts will occur in Jobos Bay near the existing Aguirre power plant facilities and at various points along the pipeline route in the bay, including near the Boca del Infierno pass and at the offshore pipeline bend past the forereef. In contrast, sediment impacts associated with HDD entry and exit excavations will extend from Jobos Bay out along the navigation channel in the case of the entry point and toward offshore reefs at the offshore platform site in the case of the exit point (Figures 3 and 4). Modeling included a scenario related to burial of the pipeline and another to simulate sediment generated by dredging the HDD entry and exit points (Applied Science Associates 2015).

Based on modeling of suspended sediment generation during construction of the project and transport of this sediment, the applicant concluded that up to 448 ac could be affected by the transport of suspended sediments in concentrations ranging from 5 – 10 mg/L to 1,000 – 2,000 mg/L. Of this area, 365.9 ac are outside the projected construction right-of-way. The largest area, 204.1 ac of which 197.9 ac are outside the construction right-of-way will be impacted by suspended sediment concentrations of 5 – 10 mg/L (Figures 3 and 4). The highest suspended sediment concentrations (greater than 50 mg/L) were within 100 ft of the pipeline construction activities (FERC 2016). Resuspended sediment generated by HDD dredging operations at the entry and exit points were predicted to generate larger plumes, likely due to the larger area and depth of excavation than that required for pipeline burial. In addition, sediment plumes from HDD excavations were predicted to travel further away from the excavation footprint and high sediment concentrations (greater than 50 mg/L) were predicted further away than for pipeline burial (Figures 3 and 4) within the 448 ac calculated impact area. Reefs not subject to stresses from human activities in the U.S. Virgin Islands were found to have mean sediment deposition rates of less than 1 milligram per square centimeter (mg/cm^2) per day and suspended sediment concentrations less than 10 mg/L (Rogers 1990). Based on modeling, the HDD excavation areas generated the largest sediment plumes in the water column and the offshore plume (with concentrations of 5 – 10 mg/L) moved to areas containing ESA-listed corals where the offshore platform is proposed. Modeling showed sediment resuspension due to pipeline construction in the same area also moved over these offshore reef areas.

Sediment deposition associated with non-HDD pipeline installation and excavation at the HDD entry and exit points was also modeled. Based on the model results, 0.004 to 1.97 in (0.1 – 50 mm) of sediment could be deposited on benthic habitats around the pipeline. Up to 210.1 ac could be affected by this sediment deposition of which 163.8 ac are not in the construction right-of way. The largest area of sediment deposition, 131.6 ac of which 107.1 are outside the construction right-of-way could have 0.004 – 0.04 in (0.1 – 1 mm) of sediment deposited. Table 2 provides details of the predicted distribution of sediment plumes and sediment deposition associated with pipeline installation and burial in all sections except where HDD will be used, as well as associated with dredging at the HDD entry and exit points. As for sediment resuspension, the HDD excavations led to deposition of sediments in westward-moving plumes that included the offshore coral area where the offshore platform is proposed. Sediment deposition modeling predicted that sediment deposition would be concentrated along the pipeline corridor with bottom depositions of over 20,000 mg/cm^2. Excavations as part of HDD operations will lead to sediment deposition levels of approximately 25 mg/cm^2 in the offshore reef areas.

Overall, both suspended sediment and sediment deposition associated with project construction are not expected to adversely affect ESA-listed coral colonies in the area of the offshore cays, including Boca del Infierno, because sediments in the water column and deposited on the marine bottom will be concentrated in areas where pipeline burial and HDD excavation activities will take place. All of these activities except dredging of the HDD exit point will be located in Jobos Bay in areas without colonization by ESA-listed corals. In addition, dominant transport patterns modeled by the applicant indicate that sediment will be transported away from the coral reefs in Boca del Infierno. Therefore, we believe that the effects of sediment resuspension and transport and subsequent deposition on ESA-listed coral colonies in the Boca del Infierno area and along the offshore cays will be discountable.

Sediment sampling performed by the applicant indicates that copper, potentially in concentrations that could affect aquatic organisms, is likely to be released into the water column due to sediment resuspension and transport during pipeline construction (FERC 2016). While low levels of other contaminants were also observed in sediments along portions of the pipeline route, none were found at levels that are expected to affect aquatic organisms due to sediment resuspension and transport and subsequent exposure to these contaminants in sediment. However, these elevated levels of copper were found in sediments within Jobos Bay and dominant transport patterns, based on modeling by the applicant conducted for the project, indicate that these sediments are not likely to be transported to the offshore cays where ESA-listed corals are present. Therefore, we believe the effects to ESA-listed corals of the release of copper and other contaminants from sediment resuspension and transport during pipeline construction activities will be discountable.

HDD Activities: Note that sediment resuspension and transport and deposition associated with the excavation of the HDD entry and exit points were discussed above. This section focuses on the releases of HDD drilling mud and the potential impacts to ESA-listed coral colonies that could occur as a result.

In order to create the hole for the pipeline using HDD, a pilot hole is bored and, as part of this process, potential problems such as voids, fractures, and collapsible soils may be identified. Limestone, which is the primary substrate under Boca del Infierno, may be of medium to high strength but is often in-filled with sedimentary materials. Sedimentary materials such as gravel are often loose, leading to losses of drilling fluid and pressure in holes drilled through limestone substrate (Chevron Australia Pty Ltd 2011). Karst areas in general pose increased risks to the successful installation of pipelines using HDD due to difficulties arising from loss of drilling fluids, unstable soils and open voids along the drill path (Gulf Interstate Engineering 2014). In limestone areas, the loss of drilling fluid in voids and inadvertent drilling fluid returns are more likely as is ground subsidence and possible sinkholes due to exaction of zones with loose, unstable soils. There is also a high probability of the drill getting stuck, as well as the carrier pipe during pullback due to unstable zones in limestone substrate (Gulf Interstate Engineering

2014). In a submarine cable project in St. Croix in 2000, the release of HDD drilling mud that was left on the marine bottom for several weeks to months was found to remain on the bottom unless agitated by currents or ground swells and then to eventually form a kind of cement coating on everything it covered. This led to the death of sessile benthic organisms such as corals. The deposition rate of the HDD drilling mud is far greater than natural sedimentation rates. The environmental impacts of the release of drilling fluid are acute though they may be temporary in nature if mud can be cleaned up quickly to prevent it solidifying on marine habitats.

The success in drilling the pilot hole will indicate whether the crossing of the reef area using HDD will be successful as real-time drilling will enable the contractor to determine the actual geotechnical strata and assess whether variations in the proposed route are needed. The location of borings collected to date have been limited to areas outside the reef (Laney 2015) so real-time drilling of the pilot hole is needed to ensure the best route with the lowest potential for inadvertent release of drilling fluid and/or collapse of the borehole. The applicant will require real-time monitoring of pressure in the borehole and other measures to determine whether there are voids or other problems as the pilot hole is drilled in order to minimize the potential for inadvertent releases of drilling fluid (see Appendix A). The applicant also noted that, due to the depth at which the borehole will be drilled under the reef, which will be approximately 70 ft below the reef surface, inadvertent releases along the borehole are likely to remain in voids and other formations underground rather than making their way to the surface and affecting the reef.

The original HDD feasibility report for the project prepared by TETRA Technologies (2014) determined that, due to approximately 41 ft change in vertical distance between the HDD entry and exit points and the soils in the area, there will be a tendency for fluid loss, which will also leave initial sections of the borehole without fluid and may lead to hole collapse. The report found the likelihood of borehole fractures and the inadvertent loss of drilling fluid to be high and the likelihood that the borehole will become obstructed requiring a rerouting of the pipeline or that the pipeline will be stuck in the borehole due to material collapse to be moderate. Similarly, if the pipe becomes lodged in the hole during pullback and cannot be moved, the drilled hole and pipe have to be abandoned and the entire process has to be restarted from the beginning. This would lead to the need to uptake more seawater to produce additional drilling fluid and the subsequent release of more fluid and cuttings into the Boca del Infierno reef area, as well as meaning that any fluid that cannot be recaptured through the use of casings, pumps and hoses would remain on the marine bottom for a longer time until all HDD operations are complete. The TETRATechnologies (2014) report assumed the installation of a shorter pipeline segment using HDD (total borehole length 3,838 ft) than is currently proposed (5,200 ft). The required amount of drilling fluid and the associated possibility of an inadvertent release, material collapse, or other failure resulting in the loss of bentonite mud into the surrounding environment increases with pipeline length. Similarly, the first Laney (2014) report determined that the high gravel content of the soils along the approach to the Boca del Infierno reef area could cause borehole instability and make it difficult to maintain an open hole while jetting the pilot hole, reaming the hole, and/or installing the pipeline. High gravel content of soils along much of the proposed HDD pipeline segment was confirmed by additional soil borings as part of a 2015 geotechnical report (GeoCim 2015). The applicant determined, based on the Laney 2015 report and the detailed geotechnical samples that were collected in order to generate the report, and based on information from contractors who have performed HDD operations in similar situations (see

Bueno 2005; Halderman 2006) that soils in the area are more stable than originally thought and that the use of methods such as a casing at the entry point will reduce the risk of inadvertent releases to almost zero.

The hole is bored, reamed (larger diameter drills used) and swabbed (to remove fragments of rock and other material from hole creation and enlargement) until the desired size, in this case 36-in, is reached for pulling the pipeline through, typically from HDD exit side to entry side. During the drilling and swabbing process, fluids are used to maintain the borehole and fluids continue to be added as the hole is lengthened and widened in order to maintain the integrity of the hole and reduce the possibility of a collapse. Drilling fluids may be expelled at the entry and exit points because of the back-and-forth of the drill string during boring and reaming. In the case of the Aguirre project, the applicant will require the use of a recirculation system to recover drilling fluid during the creation of the pilot hole and subsequent reaming and swabbing passes (see Appendix A). The applicant anticipates that no drilling fluids will be lost to the environment at the entry point due to the use of this system. At the exit point, Baird (2017) and MottMacdonald (2017) estimate that 7,551 gallons of drilling fluid will be released during pilot hole drilling; 14,633 gallons during reaming; 55,595 gallons during swabbing; and 117,718 gallons during pulling of the pipe. The largest amount of drilling fluids will be released during the pipe pull because that is the step in the process where work will be done from the exit point seaward for this project. Cleanup of drilling fluid typically does not begin until the pipeline has been pulled through the borehole. In the case of this project, the applicant will require monitoring and the use of divers to assess suspected releases immediately in order to begin cleanup operations if necessary. Although bentonite mud is considered non-toxic, bentonite in suspension and on the bottom from releases can bury living organisms leading to mortality (Chevron Australia Pty Ltd 2011). Therefore, any inadvertent releases that reach the reef and cleanup operations themselves that occur in the reef areas of Boca del Infierno could result in physical damage to ESA-listed coral colonies due to operation of waste recovery equipment (Harvey Consulting 2016). While the applicant will require immediate cleanup of all releases (see Appendix A), no requirements regarding minimization of impacts to ESA-listed corals during cleanup of inadvertent releases were specified. However, as discussed above, the applicant anticipates that the required HDD techniques to be employed for this project will ensure that no inadvertent releases occur and based this on the use of these technologies in similar projects effectively, particularly that in Biscayne Bay, Florida (Bueno 2005; Halderman 2006; Section 6.1). Therefore, we believe the HDD operations as proposed by the applicant will be effective in preventing the inadvertent release of drilling fluid to the reef in the Boca del Infierno area and impacts to ESA-listed corals will be discountable.

Sea state contributes greatly to the possibility of shutdowns of HDD operations. If the operation shuts down, the risk of pipeline collapse or closure may increase, potentially requiring the creation of a new borehole. Sea state also affects the supports required to maintain the drill string and alignment and any contractor selected by the applicant will have to design the drill rig or rigs to be placed at the exit point to withstand the physical conditions at the site. Based on the examples of HDD projects described in Section 6.1, particularly the electric power project in Biscayne Bay (Bueno 2005; Halderman 2006), the applicant and FERC believe that by requiring HDD installation and mud recovery techniques specific to the project site, there will be no inadvertent releases of drilling fluid and 98% of all planned releases of drilling fluid associated with drilling of the pilot hole, reaming and swabbing of the borehole, and pipe pulling can be recovered. The remaining 2% of drilling fluid will remain in the exit pit and, based on sediment modeling by Baird (2017) may be transported 120 ft westward toward the offshore platform site in concentrations of approximately 10 mg/L. Baird (2017) predicts that the majority of the drilling fluid will settle in the exit pit and suspended sediment transport will occur only at times when drilling fluid is leaving the exit point and falling through the water toward the pit over the 40 – 60 days predicted for HDD operations. The sediment modeling indicates that no sediment transport associated with planned releases of drilling fluid in the direction of Boca del Infierno will occur.

The Laney (2014) and Laney (2015) reports determined that a significant volume of drilling fluid will be expelled to the seafloor even if no inadvertent release of fluid occurs during drilling, estimating up to 2 million gallons of the approximately 3 million gallons needed during HDD operations would be released from the borehole. Laney (2015) estimated that even with the use of a casing at the entry side, drilling fluid may be lost to the limestone reef formation and returns may not flow through the casing leading to large releases of drilling fluid on the exit side of the pipeline crossing. In December 2016, the applicant provided information via email indicating that approximately 50% of the drilling mud (1,500,000 gallons) could be recovered at the entry point using the casing and internal mud pump. The applicant also noted that approximately 25% of the overall amount of drilling mud used for the project will likely remain in the hole surrounding the installed pipe leaving 750,000 gallons of drilling fluid and an unquantified amount of cuttings to be collected at the exit hole. Approximately 60% of the remaining 750,000 gallons of drilling fluid could then be collected using pumps at the exit hole, or 450,000 gallons, leaving 300,000 gallons to be released to the collection pit at the exit point. In 2017, the applicant further revised the estimates of drilling fluid release and recovery based on consultations with contractors such as Mears that have performed similar operations. The new estimates anticipate the release of 195,497 gallons of drilling fluid at the exit point with the majority (60%) of this being during pipe pulling (Baird 2017). MottMacdonald (2017; https:www.mottmac.com/en-US/oil-and-gas/trenchless-technology) estimate that 98% of the drilling fluid can be recovered with recovery occurring during HDD operations. This means that 3,910 gallons of drilling fluid would be left in the exit pit. In addition, because the estimated volume of the exit pit is approximately 300,000 gallons based on its proposed dimensions, drilling fluid released during the creation of the pilot hole, remaining and swabbing passes, and pipe pulling is expected to be contained in the pit. The electric power line project in Biscayne Bay was completed by Mears (http://www.mears.net/) in an area with similar geology and sensitive resources, did not result in any advertent release of drilling fluid, and the technology employed allowed full recovery of drilling fluid (Bueno 2005; Halderman 2006).

The release of drilling mud from the HDD exit point will lead to additional sediment accumulation in the water column. The applicant estimated that the suspended sediment concentration associated with the release of 197,497 gallons of drilling fluid during the approximately 3 months of HDD operations will be up to 10 mg/L 120 ft westward of the exit point toward the offshore platform site but these sediments are expected to be mixed in the water column with no settlement on the marine bottom (Baird 2017). The greatest concentration of TSS from the release of drilling fluid will be within a radius of 10 ft around the exit point and no sediment will be transported to the Boca del Infierno area where colonies of ESA-listed corals are present (Baird 2017; Figure 5). Sediment modeling results indicated that the marine bottom in the exit pit will be covered by 0.04 in of sediment associated with the release of drilling fluid from the exit point during HDD operations but no sediment deposition will occur outside the exit pit (Baird 2017). The applicant does not anticipate any loss of drilling fluid from the entry point due to the required use of a casing and mud pump to recover fluids, which is a system that has been used successfully in other projects (see Section 6.1). The information provided by the applicant concludes that sediment transport associated with the expulsion of drilling fluid from the exit pit will be limited to 120 ft from the exit point and will occur only over the 40 – 60 days required to completed HDD operations, and an estimated 3,910 gallons of drilling fluid will remain in the exit pit, which is in an area with no corals or hard bottom. Therefore, we believe that impacts to ESA-listed corals associated with the planned release of drilling fluid will be discountable.

The amount of drill cuttings was not estimated by the applicant. Harvey Consulting (2016) estimated that up to 1,041 m^3 of material from boring and reaming of the drill hole will be generated. This rock material could be expelled at the entry and exit points, though it is expected that most of it would be expelled from the exit side of the crossing as discussed previously. It is not clear whether the pump system proposed by the applicant and discussed in the December 2016 emails and information provided in June and August 2017 would be capable of collecting rock material as well but it is likely that this material would remain on the seafloor, although we anticipate that this effect would be discountable for ESA-listed corals as the material will remain near the point of exit due to its weight.

Accidental Spills: ESA-listed corals could also be affected should accidental spills occur during construction and operation of the pipeline and offshore platform. Established coral colonies and coral larvae could be affected by spills of petroleum from vessels operating during construction and operation of the project, as well as spills of chemicals and other materials used or generated at the offshore platform once it is operational such as cleaning agents and wastewater. The extent of the impact would depend on the volume of material spilled, the type of material, and oceanographic conditions at the time of the spill in terms of where the incident occurs in relation to the location of ESA-listed coral colonies and current patterns that could transport materials. The applicant is required by FERC to develop and implement a site-specific spill control and prevention plan to minimize the potential for inadvertent releases of hydrocarbons and to establish protocols for the containment, remediation, and reporting of accidental releases. The USCG will also require spill response plans for large commercial vessels and the offshore platform and will also be responsible for inspecting the facility, as well as having the authority to inspect vessels associated with the construction and operation of the project. The USCG requirements will address all potential contaminant releases, not just hydrocarbons that will require a cleanup response be implemented in order to minimize pollution to the marine environment. Therefore, we believe the impacts to ESA-listed coral colonies associated with accidental spills of hydrocarbons and other compounds during construction and operation of the project will be discountable.

6.3.2 Adverse Effects to ESA-Listed Corals

Coral Transplant: A noted above, approximately 214 ESA-listed coral colonies are expected to be permanently impacted by construction of the offshore platform. The applicant proposes the relocation of coral colonies with a diameter of 4 cm or greater to an as yet to be determined recipient site in the action area. The site must contain the similar characteristics in terms of water depth and water quality as the offshore platform site. We estimate that the 214 ESA-listed coral colonies to be transplanted represent 21 pillar, 6 rough cactus, 26 lobed star, 146 mountainous star, and 15 boulder star coral colonies to be relocated. We expect there could be 10% mortality of transplanted corals based on recent coral transplant work such as that for the USACE San Geronimo restoration project in the Condado Lagoon, San Juan, Puerto Rico. This means that up to 2 pillar, 1 rough cactus, 3 lobed star, 15 mountainous star, and 1 boulder star coral colonies could suffer mortality from being transplanted (calculating 10% mortality for each species although there will be differences in survival between species). Transplanted corals could also suffer temporary declines in health due to the stress of being relocated. Temporary declines in the health of transplanted corals that survive transplantation may occur and would be evidenced by bleaching and/or partial tissue mortality, and a lack of sexual reproduction within the first spawning season following transplantation.

Seawater Intake at Offshore Platform: As described in Section 3.1, the LNG carriers will take on seawater to serve as ballast as the LNG is transferred off the vessels and for cooling the engines because they are powered up while at dock. It is estimated that up to 74.2 million gallons of water will be required for ballast while offloading an LNG carrier. Total cooling water intake could require up to 227.8 million gallons. Therefore, up to 302 million gallons of water could be required during each LNG carrier delivery.

Seawater use is required during routine operations of the FSRU. Routine water use would include 47 mgd for the main condenser cooling system and 6 mgd for the auxiliary seawater cooling system, 0.6 mgd to generate the vessel's water safety curtain during transfer from LNG carriers and regasification, 1.9 mgd for ballast water, and 0.3 mgd for the freshwater generator. Non-routine uses for seawater include maintenance of the water deluge and fire main systems that would run off dedicated pumps with a flow capacity of 232,000 – 238,000 gph, which are not included in the estimate of daily consumption as this intake will occur on an as-needed basis only.

Coral larval density is patchy and varies based on many biological, physical, and temporal factors and is not directly correlated to the relative density of adult corals. Therefore, the estimates at the beginning of Section 6.3 may not be precise but are the best estimate in terms of determining potential impacts of seawater intakes on ESA-listed corals NMFS has available. Larval density depends on physical and temporal factors, as reflected in the sampling results (Table 6). Larval densities were found to be higher in the mid-depth range, which is also where the seawater intakes will be located on the FSRU. Larvae begin to lose buoyancy and distribute through the water column before they ultimately settle on suitable substrate. While coral larvae can swim, the majority of their dispersal is due to ocean currents. The applicant found the predominant currents to be westerly, meaning coral larvae from broadcast spawners in the Boca del Infierno area would likely be carried toward the FSRU and its seawater intakes.

Based on anticipated intake of seawater by the FSRU and the LNG carriers and the results of coral larvae sampling (see Table 8), the applicant provided very conservative estimates of the number of ESA-listed corals that could be entrained. The applicant estimated that 82 million coral larvae (of which it is not possible to distinguish the percentage of ESA-listed coral species so the applicant assumed all are ESA-listed coral larvae) will be entrained over a 3-month period from August – October each year as discussed in Sections 3.1, 5.1, and above. The applicant estimated, based on estimates of the number of eggs per polyp for common Caribbean coral species, that 814 – 1,409 eggs are produced per square cm of a "generic" adult coral colony (where generic means that the assumption is that common Caribbean coral species all produce the same number of eggs per polyp; FERC 2016). Based on this estimate of the number of eggs produced by an adult coral colony and the estimated 82 million larvae the applicant estimates will be entrained during periods of coral mass spawning each year, the applicant calculated the future reproductive biomass of adult corals in the action area. The applicant calculated that the future reproductive biomass represented by 82 million larvae would be roughly equivalent to 5.8 – 10 m^2 of adult coral (assuming no mortality and instead full growth to maturity of all larvae) or 580 – 1,000 m^2 of adult coral (assuming 99% mortality; in other words, assuming that the 82 million larvae represent the 1% of total spawned larvae that survived (FERC 2016)). Given the reefs in the area, the applicant calculated that this would be representative of approximately 87 – 150 m^2 (0.02 – 0.04 ac) of "average" reef (under the no mortality assumption) or 8,700 – 15,000 m^2 (2.15 – 3.71 ac) of "average" reef (assuming 99% mortality, meaning 1% of larvae would grow to maturity; where "average" reef means reefs with average coral cover, species composition, health, and other factors based on Caribbean coral reefs). It is important to note that the calculated number of larvae produced versus the calculated number of future adult coral colonies is not 1:1 because adult coral colonies produce multiple gametes (as represented by the statement describing the number of eggs produced by each square cm of an adult coral colony.)

The difficulty with these estimates is that ESA-listed coral larvae could not be separated from larvae of other coral and octocoral species based on the sample characterization methods used by Tetra Tech, which did not include genetic analyses. However, it is conceivable that in certain years, under certain circumstances, ESA-listed coral larvae, particularly from species that were found to be present in high numbers in the EPA surveys like mountainous star corals, comprise all or the vast majority of larvae entrained. Therefore, we assumed that all of the estimated 82 million coral larvae that may be entrained annually by project operation will be ESA-listed coral larvae. This is a reasonable worst case estimate and resolves the uncertainty on behalf of the species. We then used the estimated 82 million ESA-listed coral larvae to calculate the approximate numbers of future ESA-listed coral colonies that will not be produced due to entrainment of larvae as a reasonable worst case estimate that errs in favor of the species. If we use the estimate of 421 ESA-listed corals in a 0.87 ac area from surveys in the Boca del Infierno area completed by the applicant and assume 99% mortality (as larvae are known to experience mortality of 90% or more from predation and other factors prior to settlement and metamorphosis), then the 2.15 – 3.71 ac of "average" reef generating the larvae to be impacted by entrainment calculated by the applicant as described in the previous paragraph could represent 1,040 – 1,795 future colonies of ESA-listed corals that will be lost (in other words, calculating the number of ESA-listed coral colonies in the 2.15 – 3.71 ac using the survey findings of 421 coral colonies per 0.87 ac). Again using the approximate percent distributions of each species based on EPA survey data (16% elkhorn, 3% staghorn, 10% pillar, 0.03% rough cactus, 3% lobed star, 68% mountainous star, and 0.07% boulder star corals), and using the most conservative estimate of 1,795 future colonies of ESA-listed corals, this would mean the annual loss of approximately 166 - 287 potential elkhorn, 31 - 54 potential staghorn, 104 - 179 potential pillar, 0 potential rough cactus, 31 - 54 potential lobed star, 707 – 1220 potential mountainous star, and 1 potential boulder star coral colonies would occur due to entrainment of larvae of these species. It is important to note that these calculations assume that ESA-listed corals will reproduce sexually every year, which is typically not the case. It is also important to note that these calculations assume that post-settlement larvae will have the same survivorship rates between species and all post-settlement larvae will grow to adulthood, which is very conservative. FERC requires that the applicant develop mitigation measures to reduce the impacts of the entrainment of coral larvae and conduct a 3-year study once the project is operational to determine the entrainment effects of FSRU operation on coral larvae to assess the degree to which entrainment of coral larvae occurs and the effectiveness of mitigation measures.

Sediment Resuspension and Transport at the Offshore Platform: At the offshore platform site, rough cactus, pillar, lobed star, mountainous star, and boulder star corals were observed during a towed-video survey conducted for the project. We believe there will be measurable impacts to ESA-listed corals in the area of the proposed offshore platform during project construction as these corals will receive sediment plumes and have sediment deposited on them based on the modeling done by the applicant (see Figure 4), particularly during excavation at the HDD exit point. It is important to note that the applicant did not perform sediment modeling for construction of the offshore platform itself but, given the size of the piles to be driven, it is likely that in-water construction activities at the platform site will also generate sediment that will affect the ESA-listed corals in the temporary and permanent construction footprints. Water quality sampling performed by the applicant in 2014 as part of the mixing zone application for the FSRU discharges found turbidity levels from 0.3 – 1.45 NTU and total suspended solid (TSS) concentrations of 4 mg/L or less at the proposed offshore platform site (Tech 2014c). A 4-year monitoring study of the reef complex in Caret Bay before, during, and after a terrestrial construction project showed a significant difference among transects and depths with sedimentation rates between 10 – 14 mg/cm^2 per day leading to a 38% increase in the number of coral colonies experiencing pigment loss compared to reef sites exposed to rates between 4 – 8 mg/cm^2 per day (Nemeth and Sladek Nowlis 2001). Bleaching of corals was strongly correlated to sedimentation rate, indicating that corals bleached in response to sediment stress. A recent study by Fourney and Figueiredo (2017) determined that turbidity levels should remain below 7 NTU in order to ensure coral recruit survival, particularly during times when sea surface temperatures are elevated, which is becoming more frequent. Therefore, the estimated 417 pillar, 125 rough cactus, 499 lobed star, 2,832 mountainous star, and 292 boulder star coral colonies that will remain at the offshore platform site during construction (because 214 colonies within the direct impact footprint of construction, specifically the footprint of the piles, will be transplanted prior to construction activities as discussed above) are likely to suffer bleaching and other physical responses to sediment stress and sexual recruits of these species are also likely to be affected by sediment stress.

Sampling conducted for the project at the proposed offshore gasport location found a maximum suspended sediment concentration of 4 mg/L (TetraTech 2014c) so anticipated sediment resuspension and transport associated with construction of the pipeline will result in higher concentrations than are naturally occurring in the project area based on modeling done by the applicant for the project. Sediment modeling predicted TSS concentrations of 5 - 10 mg/L (see Figure 4). Reefs not subject to stresses from human activities in the USVI had mean sediment rates of less than 1 mg per cm^2 per day and TSS concentrations less than 10 mg/L (Rogers 1990). Smith et al. (2013b) found that nearshore sites around USVI affected by human activities had TSS concentrations as high as 25 mg/L and that corals in these areas were more likely to show signs of stress such as tissue mortality, bleaching, and disease. The applicant also determined that the action of waves and currents on the pile structures that will support the offshore platform will lead to scour of an area measuring approximately10 ft around each pile. Thus, additional sediment resuspension and transport to the patch reefs will also occur when project construction is complete. The operation of tugs during project construction and large vessels during project operation is also likely to lead to propeller wash. During site inspections in the Port of Ponce, NMFS biologists observed the sediment plumes generated by the operation of thrusters by the tugs used to guide cargo vessels into the harbor, even in water depths of 55 ft. Based on this information, it is likely that the ESA-listed coral colonies on the 4.1 ac patch reefs in the area of the proposed offshore platform will be affected by chronic impacts due to sediment resuspension, transport, and deposition. These are the estimated 417 pillar, 125 rough cactus, 499 lobed star, 2,832 mountainous star, and 292 boulder star coral colonies that will remain at the offshore platform site during construction that will also be affected by the construction of the project due to sediment resuspension and transport and deposition. In addition to sediment impacts associated with project construction and operation, these corals are likely to be affected by shading due to the presence of the offshore platform and semi-permanent mooring of the FSRU, as well as the frequent presence of LNG carriers at the platform all of which will affect light penetration in the area. While rough cactus and corals of the star coral complex have relatively large depth ranges (typically to 120 and 130 ft, respectively), meaning they can survive in deeper waters where less light is present, pillar corals are not common in water depths beyond 65 ft. Therefore, we anticipate that pillar coral survival and recruitment to the patch reefs in the area of the offshore gasport will decline as the species is already at the limit of its depth tolerance and the loss of light is likely to lead to mortality. The rough cactus coral colonies and colonies of species in the star coral complex may also suffer partial or full mortality or declines in growth and/or reproduction because they will not be adapted to the new light regime that will result once the platform is constructed and operational. In terms of full or partial mortality, this could affect the estimated 417 pillar, 125 rough cactus, 499 lobed star, 2,832 mountainous star, and 292 boulder star coral colonies that will remain at the offshore platform site, meaning that all remaining ESA-listed corals estimated to be at the proposed offshore platform site will be affected. The effects of the loss of these coral colonies on the survival and recovery of these species is discussed further in Section 8.1.

Discharges: Approximately 56 mgd of treated seawater will be discharged to the ocean through various outfalls along the FSRU deck and hull. Intake water from the cooling system will discharge through a 55-in diameter pipe on the side of the vessel, 17.4 – 24.3 ft below the ocean surface (Outfall 001). Water discharged from the FSRU would be approximately 21.6^{o}F (12^{o}C) above ambient water temperatures with a maximum discharge temperature of 106.9^{o}F (41.6^{o}C). The applicant estimates that a 135-ft radius mixing zone from the outlet port will be needed for lowering discharge waters to the temperature of surrounding seawater. The FSRU auxiliary cooling system outfall (Outfall 002) will discharge water at 11^{o}F (6.5^{o}C) above ambient water temperature, leading to a maximum discharge temperature of 96.3^{o}F (35.7^{o}C). The mixing zone for this discharge was modeled as having a 95-ft radius (based on the revised mixing zone application, (Tetra Tech 2014c). Outfall 003 would discharge to port and starboard as runoff from the water curtain that will be maintained over the deck and hull of the FSRU during LNG transfer or regasification. Outfall 004 would discharge 0.27 mgd as brine from the freshwater generator. The salinity of the brine effluent is expected to be 64 – 70 ppt. No estimate of the expected mixing zone was provided. Outfall 005 would be for the discharge of ballast water, which could reach up to 1.0 mgd during LNG loading and regasification. Ballast water for the FSRU will be withdrawn and discharged at the offshore platform and no change in water temperature or introduction of non-native species is expected because of this. Outfall 006 would be for stormwater that collects and runs off the decks and other surfaces of the FSRU and could contain contaminants such as grease and lubricants. The stormwater management program for the vessel includes the deployment of equipment drip mats and oil absorbent material around collection drains but some level of runoff of materials from the decks during storms into the Caribbean Sea is anticipated.

Outfalls 1 and 2 (and likely 4 although the temperature of the brine discharge was not provided) from the FSRU will be above the temperature tolerance limit of ESA-listed corals, which is between 25 – 30^{o} C (77 – 86^{o} F). These corals can tolerate elevated temperatures greater than 30^{o} C for short periods of time but extended exposure to high temperatures leads to coral bleaching. Therefore, impacts to ESA-listed corals could be chronic. Similarly, the salinity of the brine discharge from Outfall 4 will be at the high end of the tolerance range for ESA-listed corals so any ESA-listed coral colonies affected by this discharge plume are expected to suffer chronic impacts because the discharge will be continuous over the operational lifetime of the FSRU's freshwater generating system. Corals exist naturally in salinities ranging from 32 – 40 ppt (Veron 1986) and fluctuations in salinity affect coral settlement, growth, and survival (Hoegh-Guldberg 1999). The applicant has indicated that, based on modeling of the discharge plumes from these outfalls, the plumes will not reach depths at which ESA-listed coral colonies are present in the area of the proposed offshore platform. However, if coupled with natural elevations in sea surface temperatures, the thermal discharges coupled with the brine discharge could lead to bleaching and other effects to ESA-listed corals in the area of the offshore platform. These corals will be affected by other aspects of project construction and operation as discussed in other portions of this section. The effects of brine discharge on ESA-listed corals are discussed further in Section 8.

Water discharge from the LNG carrier while at the offshore platform would be dominated by condenser water from the cooling system. The water would be approximately 5.4^{o}F (2.8^{o}C) higher than surrounding seawater and the plume would be confined to within approximately 17 ft of the vessel. However, for the LNG carrier, due to the elevated flow rate of the discharge, it is predicted that the thermal plume would impact the seafloor, which would also affect sediment resuspension and transport during all LNG carrier water discharge operations. The temperature difference may also affect ESA-listed corals, particularly during periods when sea surface temperatures are already elevated, as the discharge from the LNG carrier would be continuous for the 3 days the vessel is at the offshore platform and would be coupled with the continuous release of superheated discharges from the FSRU. Because there may be 1 LNG carrier per week visiting the offshore gasport facilities, the effects of sediment scour from the discharge plume on ESA-listed corals in the area of the offshore platform will be chronic, especially given that the LNG carriers will moor on the seaward side of the platform, which is the area where reefs containing ESA-listed corals are located. The effects of sediment resuspension and transport during project operation were discussed above and are discussed further in Section 8.

The FSRU's raw water intake systems will have a copper-aluminum anode marine growth prevention system. This system will result in the regular release of approximately 2 parts per billion (ppb, which is also roughly equivalent to µg/L) of copper ions from the primary cooling water discharge outfall (outfall 001); and an unspecified concentration from the auxiliary cooling water outfall (outfall 002), the water curtain outfalls (outfall 003 A and B, port and starboard, respectively), and ballast water outfall (outfall 005). A release of copper ions from the LNG carrier vessel, similar to that from the FSRU primary cooling water discharge outfall, is anticipated (FERC 2015). A water quality characterization sampling at the proposed offshore gasport site found copper concentrations in the water column ranging from <2.0 – 7 µg/L (Tetra Tech 2014c). In a study testing the effects of exposure to copper in staghorn, mountainous star, and cauliflower coral (an Indo-Pacific species), after exposure to copper concentrations from 2 – 20 µg/L for 5 weeks Bielmyer et al. (2010) found significantly different sensitivities between species. Staghorn corals showed effects with exposure to copper concentrations as low as 4 µg/L in terms of zooxanthellae photosynthesis and significant decreases in carbonic anhydrase (enzymes that play a major role in the carbon supply for calcium carbonate precipitation and in carbon-concentrating mechanisms for symbiont photosynthesis [(Bertucci et al. 2013)]) and skeletal growth. Mountainous star corals also demonstrated significant decreases in carbonic anhydrase. Mountainous star corals are one of the ESA-listed coral species present in the area of the offshore platform where regular discharges of copper will occur. Therefore, we anticipate that, given the natural presence of copper in the water column based on sampling completed by the applicant, the additional release of 2 µg/L of copper on a regular basis will lead to accumulation of copper in coral tissues, leading to declines in calcification and growth. Other corals in the star coral complex, along with pillar and rough cactus coral colonies known to be in the area of the proposed offshore gasport are also likely to be affected in a similar manner. These are the same coral colonies that will be affected by chronic sediment resuspension and transport, shading, and discharges of superheated brine from the FSRU. The effects of copper on ESA-listed corals are discussed further in Section 8.

<u>Lighting:</u> Constant lighting and wavelengths of light could affect ESA-listed corals that are broadcast spawners that use the full moon to synchronize spawning events. Spawning synchrony is affected by changes in the length of dark period after twilight on each night of the lunar cycle. Specifically, a Pacific acroporid species was found to require the length of the dark period after sunset be long enough for the spawn-initiating process to come to completion for individual gravid corals. Exposure to lunar illumination or certain wavelengths at twilight inhibit initiation and reduce the number of individuals reaching the critical threshold (Boch et al. 2011). Thus, the constant lighting at the offshore platform could lead to the suppression of egg and sperm production in gravid corals, affecting reproduction. FERC has required that the applicant develop a lighting plan that identifies specific measures that would be implemented to minimize or avoid impacts associated with the project's operational nighttime lighting on avian species, fish species, marine mammals, various life stages of sea turtles, and individuals on the shoreline.

This plan is not likely to reduce the effects of permanent lighting on ESA-listed coral species in the action area. Depending on the distance over which artificial lighting from the platform affects ESA-listed coral colonies in terms of the amount of light reaching them, impacts of lighting could be significant. Also, lighting plans developed to protect sea turtles, for instance, often use LEDs. A study by Davies et al. (2015) on the effects of LEDs on the composition of epifaunal marine invertebrate communities found that some sessile invertebrates, including cnidarian species (specifically hydroids) displayed significantly reduced settlement and colonization when exposed to white LED light. Light is known to play a role in coral larval settlement and studies have shown larvae of different species settling differently in response to variable light intensity and wavelengths. Results of experiments with coral larvae collected from symmetrical brain coral in the Caribbean found that larvae collected from deepwater populations of this species showed diminished settlement under light conditions typical of more shallow-water environments (Strader et al. 2015). Therefore, we believe the effects of constant lighting of the offshore platform will affect both mass spawning in terms of the ability of broadcast spawning coral species to synchronize spawning and in terms of the ability of larvae from ESA-listed corals to settle resulting in the loss of future ESA-listed coral colonies at a minimum in the immediate footprint of the platform. As discussed in the section on ESA-listed sea turtles (Section 6.2), the applicant has drafted a lighting plan to reduce potential lighting impacts to sea turtles. The plan includes shielding lights, which likely will result in lights pointing down into the water. This would definitely affect the ESA-listed corals the applicant will leave around the offshore platform. Therefore, we assume the ESA-listed coral species that are broadcast spawners will be affected, which includes the estimated 417 pillar, 499 lobed star, 2,832 mountainous star, and 292 boulder star coral colonies that will remain at the offshore platform site, that will also be affected by other aspects of the operation of the offshore platform. The effects of lighting on ESA-listed corals that are broadcast spawners are discussed further in Section 8.

6.4 Effects of the Action on Elkhorn and Staghorn Coral Critical Habitat

As discussed in Section 5.1, FERC estimates that approximately 3.9 ac of patch reefs that contain the essential feature of elkhorn and staghorn coral critical habitat will be in the footprint of the offshore terminal but there is a total of 4.1 ac of this patch reef habitat in the area based on information from the applicant. NMFS estimated that approximately 60 ac of coral reef and colonized hard bottom are in the immediate area of Boca del Infierno where HDD activities will take place.

Accidental Groundings: If a work vessel was to ground on a shallow reef or colonized hard bottom area containing the essential feature of elkhorn and staghorn coral critical habitat, the quality of the habitat could be affected. Similarly, elkhorn and staghorn coral critical habitat could be affected by accidental groundings of the LNG carriers as they transit to the offshore platform and by the FSRU when it transits to and from the offshore platform as part of maintenance activities expected to occur every 5 years or because of a large storm that requires the vessel leave the platform. The majority of vessel transit during construction will be through the existing barge channel to deep water offshore of the cays, but there will be construction barges operating in close proximity to the cays that could come loose from their moorings or have a tow rope come loose during towing by tugs. For the LNG carriers and FSRU, these vessels will also transit through deep waters where accidental groundings are not possible, but vessels could ground on the offshore cays in the action area due mechanical problems or weather conditions. FERC is requiring that all construction vessels transit during daylight hours only to minimize the potential for interactions with ESA resources. The applicant will require that pilots board the LNG carriers at the PBS located 2 mi southwest of the proposed platform and that vessels proceed at very slow speeds, which will also reduce the potential for accidental groundings. The offshore platform will be located in water depths up to 65 ft and approximately 3,900 ft from the closest offshore cays. Vessels that come loose from the platform, temporary moorings or anchors for construction vessels, or suffer mechanical difficulties that prevent them from reaching the platform or a construction anchor system would have approximately 2,000 ft to weigh anchor to stop the vessel's motion toward shallow areas and prevent, due to the vessel's length, that swing on the anchor would lead to collision with the offshore cays. Therefore, we believe the potential for vessel transit associated with the construction and operation of this project leading to accidental groundings impacting elkhorn and staghorn coral critical habitat is discountable.

Vessel Anchoring: Elkhorn and staghorn coral critical habitat could be affected by anchoring and spudding of work vessels during construction operations. Anchors and spuds will be used to moor construction vessels and barges in Jobos Bay and offshore of Boca del Infierno and at the proposed offshore platform during pipeline installation and burial operations, including HDD and dredging for HDD, and construction of the offshore platform. The applicant will survey the locations for anchoring, spudding, and installation of temporary mooring piles prior to any in-water construction to select sites where potential impacts to ESA-listed corals will be minimized. This means that some anchor sites, particularly those near the Boca del Infierno and patch reefs at the proposed offshore platform location could contain coral habitat although the applicant noted that due to the extent of uncolonized bottom in the project area, anchoring in coral habitat is not anticipated. All anchor lines will have midline buoys to prevent contact of anchor lines with the sea bottom. This will minimize the potential for anchor lines to interact with areas containing the essential feature of elkhorn and staghorn coral critical habitat, reducing the possibility of habitat damage from swinging of the anchor lines because the floats will maintain the lines in the water column. Therefore, we believe the potential impacts from anchoring of work vessels during project construction on elkhorn and staghorn coral critical habitat will be discountable.

Sediment Resuspension and Transport: The project may result in impacts to elkhorn and staghorn coral critical habitat in the area of Boca del Infierno, which is part of a fringing reef system, and at the proposed offshore platform location where patch reefs were observed in the southwest portion of the proposed footprint. Coral habitat could be affected by to the resuspension and transport of sediment during excavations associated with HDD operations, as well as pipeline burial in non-HDD sections, installation of concrete mats, and pile-driving activities. The release of drilling mud from the use of HDD to install a portion of the pipeline and associated sediment effects is discussed separately.

Sediment impacts associated with HDD entry and exit excavations will extend from Jobos Bay out along the navigation channel in and toward offshore reefs at the offshore platform site (Figures 3 and 4). Modeling of suspended sediment generation and transport during construction of the project indicates that up to 448 ac could be affected by the transport of suspended sediments in concentrations ranging from 5 – 10 mg/L to 1,000 – 2,000 mg/L. Of this area, 365.9 ac are outside the projected construction right-of-way. The 5 – 10 mg/L levels will occur over areas containing the essential feature of elkhorn and staghorn coral critical habitat where the offshore platform is proposed (see Figure 4). Resuspended sediment generated by HDD dredging operations were predicted to generate larger plumes than pipeline burial, likely due to the larger area and depth of excavation required at the HDD exit and entry points. In addition, sediment plumes from HDD excavations were predicted to travel farther away from the excavation footprint and high sediment concentrations (greater than 50 mg/L) were predicted further away than for pipeline burial (Figures 3 and 4). Sediment deposition was also modeled. Up to 210.1 ac could be affected by sediment deposition, of which 163.8 ac are not in the construction right-of way. Table 2 provides details of the predicted distribution of sediment plumes and sediment deposition associated with pipeline installation and burial and dredging at the HDD entry and exit points. Sediment resuspension, transport, and deposition due to pipeline burial and HDD excavations will not reach many coral reef and colonized hard bottom areas in Jobos Bay that contain the essential feature of elkhorn and staghorn coral critical habitat. Sediment resuspension, transport, and deposition due to pipeline burial and HDD excavations will affect the area where the offshore platform is proposed that contains patch reefs containing the essential feature of elkhorn and staghorn coral critical habitat.

Sediment resuspension and transport is also likely to affect offshore patch reef habitats during project operation. The applicant determined that the action of waves and currents on the pile structures that will support the offshore platform will lead to scour of an area measuring approximately10 ft around each pile and some of the piles will be located in the area containing patch reefs. Thus, additional sediment resuspension and transport to the patch reefs will occur when project construction is complete, as well as direct impacts of scour due to wave action against the structure. Because some of the piles will be installed in coral critical habitat, scour will result in the loss of the essential feature in an area of approximately 10 ft around each pile located in patch reefs and this effect will be in addition to the direct loss of habitat in the footprint of the pile. The operation of tugs during project construction and large vessels during project operation is also likely to lead to propeller wash and associated sediment resuspension and deposition in the patch reefs at the offshore platform site. During site inspections in the Port of Ponce, NMFS's biologists observed the sediment plumes generated by the operation of thrusters by the tugs used to guide cargo vessels into the harbor, even in water depths of 55 ft. Based on this information, it is likely that the essential feature of elkhorn and staghorn coral critical habitat on the 4.1 ac patch reefs in the area of the proposed offshore platform will be affected by chronic impacts due to sediment resuspension, transport, and deposition during project construction and operation to the extent the feature will be lost. These effects are discussed further in Section 8.

<u>HDD Activities:</u> This section focuses on the releases of HDD drilling mud and potential impacts to elkhorn and staghorn coral critical habitat that could occur as a result. The potential sediment impacts discussed in this section are related only to the release of drilling fluid because other sediment generating activities and their potential effects on elkhorn and staghorn coral critical habitat were discussed above.

Drilling fluid consisting mainly of bentonite mud is used throughout the HDD pipeline installation process during pilot hole drilling and subsequent enlargement of the hole. The applicant has stated that drilling fluids will only be expelled from the exit point because of the required use of HDD technologies to recover the majority of drilling fluid during operations. Drilling fluid may be lost to voids in the substrate or released through voids and fractures back to the surface. However, as discussed in Section 6.3 regarding the potential impacts to ESA-listed corals, the applicant anticipates that, due to the use of a casing at the entry point, real-time monitoring of drilling, and the depth of the borehole under the reef, there will be no inadvertent releases of drilling fluid to the reef in the Boca del Infierno area. If there are any inadvertent releases, the potentially affected areas would be assessed by divers who will be present during all HDD operations and cleanup would begin immediately. Therefore, we believe the HDD operations as proposed by the applicant will be effective in preventing the inadvertent release of drilling fluid to the reef in the Boca del Infierno area and no degradation of the essential feature of elkhorn and staghorn coral critical habitat will occur as a result, meaning the effects will be discountable.

The Laney (2014; 2015)) reports determined that a significant volume of drilling fluid will be expelled to the seafloor even if no inadvertent release of fluid occurs during drilling and that there are no effective methods of recovering drilling fluid from seafloor or dredged pits, particularly at the exit point but also at the entry. As discussed in Section 6.3, the applicant has modified the project to require that the contractor selected to complete the work employ a series of methods during HDD operations (see Appendix A) that have been used successfully in other projects where HDD has been used to install submarine pipelines. The use of these measures means that the amount of drilling fluid that will be generated is 35% less than that calculated by (Laney 2014;2015) or 1,950,000 gallons versus 3 million gallons. The revised HDD requirements also mean that no loss of drilling fluid is anticipated at the entry point and the volume of fluid lost at the exit point will be a maximum of 197,497 gallons, which is less than the over 300,000 gallon estimated volume of the exit pit, ensuring that the majority of the fluids can be contained for recovery and disposal.

The release of drilling mud from the HDD exit point will lead to additional sediment accumulation in the water column as mud is released. The applicant estimated that the suspended sediment concentration associated with the release of 197,497 gallons of drilling fluid during the 40 – 60 days of HDD operations will be 10 mg/L up to 120 ft westward of the exit point with no sediment transport toward the Boca del Infierno reef (Baird 2017; Figure 5). Sediment modeling results indicated that sediment accumulation from this release of drilling fluid at the exit point will result in the deposition of sediment to 0.04 in in the exit pit only (Baird 2017). Thus, the release of drilling fluids from the exit point is not expected to impact the Boca del Infierno reef. The westward transport of sediment from the release of drilling fluids will be toward the offshore platform site where patch reefs containing the essential feature of elkhorn and staghorn coral are present. However, these areas are further than 120 ft from the exit point and will not be affected by the temporary TSS concentrations in the water column during HDD operations. Therefore, we believe that no changes to the essential feature of elkhorn and staghorn coral critical habitat will occur as a result of the planned release of drilling fluid and impacts to coral critical habitat will be discountable.

In terms of drill cuttings, as for ESA-listed corals (Section 6.3), we anticipate that the effect of the expulsion of rock fragments from the exit point would be discountable for elkhorn and staghorn coral critical habitat as the material will remain near the point of exit due to its weight and there are no areas containing the essential feature of coral critical habitat at the exit point of the borehole.

Another potential impact to elkhorn and staghorn coral critical habitat associated with drilling is the effect of vibrations as the drill moves through the substrate. Depending on the depth to the surface, as well as the characteristics of the limestone reef substrate, in terms of the amount of voids and other open spaces or thin sections, the vibration of the drill during pilot hole drilling and subsequent reaming of the borehole could lead to fracturing and collapse of substrate in areas where the depth of substrate between the marine bottom and the drill hole is shallow. The applicant noted that the borehole will be completed approximately 70 ft below the surface of the reef in the Boca del Infierno area. In addition, where depth of substrate in relation to the location of the borehole is shallow, which is the entry point for HDD, a steel casing will be used to stabilize the borehole. Therefore, we believe this effect to elkhorn and staghorn coral critical habitat will be discountable.

<u>Discharges:</u> As discussed in the previous section, approximately 56 mgd of treated seawater will be discharged to the ocean through various outfalls along the FSRU deck and hull. Two of these discharges will have temperatures 21.6^{o}F (12^{o}C) - 11^{o}F (6.5^{o}C) above ambient water temperature and mixing zones with radii of 135-ft and 95-ft, respectively. One of the outfalls will discharge brine from the freshwater generator with salinities of 64 – 70 ppt and no estimate of the expected mixing zone for the brine discharge.

The discharges from the continued operation of the FSRU will lead to chronic impacts although the impacts are predicted to be of low intensity according to the applicant as modeling of the discharge plumes indicated that only one of them would have the magnitude and velocity to reach the marine bottom. The applicant did find that the currents in the area are largely wind driven so, during calm periods, there may be a possibility for high temperature water and brine effluents to remain in the area longer, potentially reaching the patch reefs on the marine bottom in the area where the FSRU will be semi-permanently moored to the offshore platform. While high temperature water and brine may not directly affect the essential feature of coral critical habitat, they will make coral larvae less likely to settle and grow on the substrate in the area of the offshore platform, thus diminishing the capacity of the habitat to support larval settlement and growth. Additionally, at least one of the discharges is expected to reach the seafloor. If this occurs in an area containing the essential feature of elkhorn and staghorn coral critical habitat, it would lead to scour of the habitat in the area where the discharge constantly comes in contact with the hard substrate. This would lead to a reduction in the capacity of the essential feature to promote growth and settlement of coral larvae. A portion of the elkhorn and staghorn coral critical habitat area that will be affected by other stressors caused by the construction and operation of the project, namely sediment and drilling fluid transport and settlement during construction and scour and other impacts of the operation of the offshore platform, will be the same area that could be affected by discharges from the FSRU. These effects are discussed further in Section 8.

Accidental Spills: We do not expect accidental spills of petroleum from vessels used during construction and operation or chemicals that may be used during operation of the platform to affect elkhorn and staghorn coral critical habitat. Petroleum products that will be used by vessels operating at the offshore platform and for operations such as running the generator at the platform are expected to be light products that will float on the water surface rather than reaching the bottom. If these products do reach the bottom, they will affect organisms colonizing the habitat but are not expected to alter the habitat itself. Similarly, cleaning agents and other chemicals that may be used during operation of the platform are also expected to potentially affect aquatic organisms but not to alter the characteristics of the habitat.

Other Habitat Impacts: There will be a thermal difference along the pipeline that will result in colder temperatures immediately adjacent to the pipeline. The applicant performed hydrodynamic calculations that indicated temperature changes will affect surrounding waters up to 2 in from the pipeline due to the cold temperature at which LNG will be transported through the line. This effect is less in areas where the pipeline will be concrete-coated, under concrete mats, and buried. Because the pipeline will only pass through coral critical habitat in the HDD portion of the route, we do not anticipate that thermal differences between the pipeline and substrate will impact the essential feature of elkhorn and staghorn coral critical habitat, assuming the thermodynamic calculations are correct and *in situ* conditions do not prove to be different than calculated. Therefore, we believe these effects will be insignificant.

There will be temporary and permanent losses of elkhorn and staghorn coral critical habitat at the proposed offshore platform location due to the direct impacts of construction of the offshore platform. These losses are within the same 4.1 ac of elkhorn and staghorn coral critical habitat estimated by the applicant to be in the area of the proposed offshore platform for which we anticipate there will be chronic impacts associated with construction and operation of the proposed offshore platform (see Sediment Resuspension and Transport discussion above) that will result in the loss of the entire 4.1 ac coral critical habitat essential feature at the proposed offshore platform site. During construction, this habitat will be temporarily affected by construction activities, including anchoring of construction barges and pile-driving and associated sediment resuspension and transport and the portion within the footprint of some of the piles to be installed to support the platform will be destroyed. These effects are discussed further in Section 8.

6.5 Summary of the Effects of the Action on Leatherback, Loggerhead, Hawksbill, and Green Sea Turtles, ESA-Listed Coral Species, and Elkhorn and Staghorn Coral Critical Habitat

The construction and operation of the Aguirre Offshore GasPort is expected to result in the take of the North and/or South Atlantic DPSs of green sea turtles, the NWA DPS of loggerhead, hawksbill and leatherback sea turtles due to noise generated by pile-driving activities. The construction and operation of the project is also expected to result in the take of colonies of elkhorn, staghorn, pillar, rough cactus, lobed star, mountainous star, and boulder star corals and the modification and loss of elkhorn and staghorn coral critical habitat.

We estimate that the noise generated by pile-driving activities associated with the construction of the offshore platform will cause non-lethal hearing loss (permanent or temporary) on the following numbers of sea turtle adults and lethal or non-lethal effects to the following numbers of hatchlings:

- 17 adult or juvenile North and/or South Atlantic DPS green sea turtles
- 14 adult or juvenile hawksbill sea turtles
- 1 adult NWA DPS loggerhead sea turtle
- 1 adult female leatherback
- Up to 155 leatherback and 157 hawksbill sea turtle hatchlings, if present, over the 50 day period needed to complete pile-driving activities

We also estimate that lighting impacts during construction and operation of the offshore platform will cause disorientation of the following numbers of sea turtle adults and hatchlings each year nesting by leatherback and hawksbill sea turtles occurs over the project lifetime:

- 1 adult NWA DPS loggerhead sea turtle*
- 1 adult female leatherback*
- Up to 155 leatherback and 157 hawksbill sea turtle hatchlings*

* We expect that the same adult and hatchling sea turtles will be affected by both pile-driving and lighting during the year when in-water construction occurs at the offshore platform site.

Based on estimates by the applicant of the entrainment impacts and associated loss of future colonies of ESA-listed corals, there could be a loss of:

- 166 – 287 new elkhorn coral colonies
- 31 – 54 new staghorn coral colonies
- 104 – 179 new pillar coral colonies
- 0 new rough cactus coral colonies
- 31 – 54 new lobed star coral colonies
- 707 – 1,220 new mountainous star coral colonies
- 1 new boulder star coral colony

on an annual basis over the operational lifetime of the project.

A percentage of the ESA-listed coral colonies at the offshore platform will be transplanted prior to commencement of construction activities because these corals are in the footprint of the piles that will be installed to support the structure. We estimate that 10% of the transplanted coral colonies will be lost due to transplant stress based on the results of previous projects as discussed in Section 6.3. The remaining ESA-listed coral colonies in the area of the offshore platform are expected to experience temporary impacts during pipeline construction, including excavation of the exit pit for HDD operations based on sediment modeling performed by the applicant. These corals will also experience chronic impacts resulting from sediment resuspension and transport associated with vessel operation and scour around the piles, as well as discharges of brine, super-heated water, and copper, resulting in the full or partial mortality of all of these colonies. The expected take of ESA-listed coral colonies at the offshore platform site is summarized in Table 10.

Table 10. Summary of Expected Take of ESA-Listed Coral Colonies

Species	Transplant from Offshore Platform Site	Transplant Mortality	Chronic Impacts at Offshore Platform Site, Full or Partial Mortality
Pillar	21	2	417
Rough Cactus	6	1	125
Lobed Star	26	3	499
Mountainous Star	146	15	2,832
Boulder Star	15	1	292

We also expect elkhorn and staghorn coral critical habitat at the offshore platform to be directly impacted due to platform construction, particularly the installation of piles in areas containing the essential feature of critical habitat. Coral critical habitat will also be affected by sediment resuspension and transport during pipeline installation, including excavation of the exit pit for HDD, scour from wave action against the piles at the offshore platform, and vessel operation during construction and once the platform is operational due to things like propeller wash that result in sediment resuspension. We estimate that the essential feature on 4.1 ac of elkhorn and staghorn coral critical habitat will be lost due to the construction and operation of the offshore platform and pipeline installation, particularly associated with the direct impact footprint of piles, sediment resuspension and transport eliminating the essential feature at the offshore platform, and scour from water discharges from FSRU.

7 CUMULATIVE EFFECTS

Cumulative effects include the effects of future state, tribal, local or private actions that are reasonably certain to occur in the action area considered in this Biological Opinion. Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of the ESA (50 CFR 402.14).

Most activities affecting ESA-listed sea turtles, corals and critical habitat are regulated federally; therefore, any future activities within the action area, which is in waters of the U.S., will likely require ESA Section 7 consultation. An exception is residential and agricultural development occurring in the action area, including the municipalities of Salinas and Guayama that can affect water quality, in particular through the transport of land-based sources of pollution in sediments and stormwater runoff, but often do not require federal authorization. Upland development, whether for housing or agriculture, often has no federal nexus if the project is located on uplands and is small in size. Depending on the number and location of these developments, sediment and nutrient loading to nearshore waters could become a chronic stressor, which would affect ESA-listed corals and elkhorn and staghorn coral critical habitat in Jobos Bay and along the offshore cays fringing the bay, as well as in the area of Punta Pozuelo, for example. Impacts to nearshore habitats would also affect loggerhead, green, and hawksbill sea turtles that use the area as refuge and/or foraging habitat. JBNERR's boundaries have been encroached upon in the past by residential and agricultural development and many of these actions have resulted in the degradation of the condition of wetlands within the reserve.

The fisheries in the action area are expected to continue into the foreseeable future. NMFS is not aware of any proposed or anticipated changes in these fisheries that would substantially change the impacts each fishery has on the sea turtles, ESA-listed corals and elkhorn and staghorn coral covered by this Opinion.

In addition to fisheries, NMFS is not aware of any proposed or anticipated changes in other human-related actions (e.g., recreational use, habitat degradation including from vessel use) or natural conditions (e.g., over-abundance of predators, changes in oceanic conditions) that would substantially change the impacts that each threat has on the sea turtles, ESA-listed corals and elkhorn and staghorn coral critical habitat covered by this Opinion. Therefore, NMFS expects that the levels of interactions with sea turtles, ESA-listed corals and critical habitat described for each of the fisheries and non-fisheries activities in Section 5.3 (Factors Affecting Species and Critical Habitat within the Action Area) will continue at similar levels into the foreseeable future.

8 INTEGRATION AND SYNTHESIS

8.1 Jeopardy Analysis

The analyses conducted in the previous sections of this Opinion serve to provide a basis to determine whether the proposed actions would be likely to jeopardize the continued existence of leatherback, loggerhead, green, and hawksbill sea turtles, and elkhorn, staghorn, pillar, rough cactus, lobed star, mountainous star, and boulder star corals, by identifying the nature and extent of adverse effects (take) expected to impact each species. In Section 6.0, we outlined how the proposed action can affect these species. Now we turn to an assessment of the species' responses to these impacts, in terms of overall population effects, and whether those effects of the proposed action, when considered in the context of the status of the species (Section 4.0), the environmental baseline (Section 5.0), and the cumulative effects (Section 7.0), will jeopardize the continued existence of the affected species.

To *jeopardize the continued existence of* is defined as "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). Thus, in making this determination, NMFS must look at whether the proposed action will directly or indirectly reduce the reproduction, numbers, or distribution of a listed species. Then if there is a reduction in one or more of these elements, we evaluate whether it would be expected to cause an appreciable reduction in the likelihood of both the survival and the recovery of the species in the wild.

In the following analyses, we find that some reduction in numbers and reproduction of leatherback, green, loggerhead, and hawksbill sea turtles is expected as a result of the construction of the proposed Aguirre Offshore GasPort project. We also find that some reduction in numbers and reproduction of elkhorn, staghorn, pillar, rough cactus, lobed star, mountainous star, and boulder star corals is expected as a result of the construction and operation of the proposed Aguirre Offshore GasPort project.

8.1.1 Sea Turtles

All life stages are important to the survival and recovery of a species; however, it is important to note that individuals of one life stage are not equivalent to those of other life stages. For example, the take of male juveniles may affect survivorship and recruitment rates into the reproductive population in any given year and yet not significantly reduce the reproductive potential of the population. Yet, the death of mature, breeding females can have an immediate effect on the reproductive rate of a species. Sublethal effects on adult females may also reduce reproduction by hindering forage success, as sufficient energy reserves are probably necessary for producing multiple clutches of eggs in a breeding year. Different age classes may be subject to relative rates of mortality, resilience, and overall effects of population dynamics. Ontogenetic shifts, or changes in location and habitat, have a major impact on where sea turtles occur and what human hazards they may encounter. Based on some sea turtle population modeling efforts, the reduction of mortality in early age classes is likely to positively affect population dynamics by increasing cohort size (Mazaris et al. 2005). A shift in diet for all sea turtles occurs when juvenile sea turtles shift to a neritic habitat and benthic feeding, at which time they would become more susceptible to impacts. Later stage juveniles and adult green and hawksbill sea turtles, adult loggerhead and leatherback, and hatchling hawksbill and leatherback sea turtles are likely to be subject to incidental take as a result of acoustic impacts of pile-driving during construction of the proposed offshore platform. Adult female leatherback and hawksbill sea turtles are also likely to be affected by disorientation and an associated reduction in nesting due to lighting during project construction and operation.

Leatherback Sea Turtles

As detailed in Section 6.2, we believe there is the potential for the non-lethal take of 1 adult female leatherback sea turtle associated with injurious (temporary or permanent hearing loss) and behavioral acoustic effects of pile-driving during the construction of the proposed offshore platform and the non-lethal take of 1 adult female leatherback associated with disorientation from lighting at the offshore platform during construction and operation. This take is likely to result in reduced reproductive output as the female is likely to abandon nesting attempts due to disorientation and a desire to flee the area. Leatherback hatchlings could also be disoriented, suffer mortality, or suffer temporary or permanent hearing loss due to the injurious effects of pile driving noise. We estimate that up to 155 leatherback hatchlings could be affected, assuming one nest is lain during pile driving activities associated with the project. Lighting during project construction and during operation of the offshore platform could also disrupt leatherback nesting, affecting both adult female and hatchling turtles. Due to the lack of a nest monitoring program or in-water sea turtle monitoring in JBNERR, we assume one adult female and up to 155 hatchlings could be affected during pile-driving activities associated with the construction of the offshore platform due to infrequent nesting in low numbers. These same individuals (adult female and hatchlings) will also be affected by lighting at the proposed offshore platform site during construction. Once the project is operational, we assume one adult female and up to 155 hatchlings could be affected by disorientation due to lighting at the offshore platform (see discussion in Section 6.2.2).

Given these sea turtles generally have large ranges in which they disperse, no reduction in the distribution of leatherback sea turtles is expected from the proposed action.

No lethal take of adult leatherback sea turtles is expected. Any reduced reproductive potential associated with non-lethal temporary or permanent hearing loss of 1 adult female leatherback from the pool of reproductive adults, either permanently or during the year the platform is constructed, would not appreciably reduce the likelihood of survival of the species. The leatherback TEWG estimates there are between 34,000 – 95,000 total adults (20,000 – 56,000 adult females; 10,000 – 21,000 nesting females) in the North Atlantic. Of the 5 leatherback populations or groups of populations in the North Atlantic, 3 show an increasing or stable trend (Florida, Northern Caribbean, and Southern Caribbean). This includes the largest nesting population located in the Southern Caribbean at Suriname and French Guiana. Of the remaining 2 populations, there is not enough information available on the West African population to conduct a trend analysis and, for the Western Caribbean, a slight decline in annual population growth rate was detected (TEWG 2007). The latest review by NMFS USFWS (2013) suggests the leatherback nesting population is stable in most nesting regions of the Atlantic Ocean. No reduction in numbers of adult females is anticipated from disorientation caused by lighting during construction and operation but this disorientation could lead to a reduction in nesting.

We believe the proposed action is not reasonably expected to cause, directly or indirectly, an appreciable reduction in the likelihood of survival of leatherback sea turtles in the wild. While no lethal take of adult leatherbacks is anticipated, up to 155 hatchlings could suffer mortality during the 50 days of pile-driving activities associated with the construction of the offshore platform. Leatherback sea turtle hatchlings could also be disoriented by lighting. These effects would result in a slight reduction in absolute population numbers and, regardless of whether take is lethal or non-lethal, there would be a slight reduction in reproduction (at a minimum during the year when pile-driving occurs and potentially other years due to lighting), it is not likely this reduction would appreciably reduce the likelihood of survival of leatherback sea turtles. Considering that nesting trends for the Florida and Northern Caribbean populations and the largest nesting population, which is the Southern Caribbean, are all either stable or increasing and that nesting by leatherbacks in the action area is only reported at Punta Pozuelo and takes place infrequently and in low numbers, we believe the proposed action is not likely to have any measurable effect on overall population trends.

The Atlantic recovery plan for the U.S. population of the leatherback sea turtle (NMFS and USFWS 1992) lists the following relevant recovery objective:

- The adult female population increases over the next 25 years, as evidenced by a statistically significant trend in the number of nests at Culebra, Puerto Rico; St. Croix, U.S. Virgin Islands; and along the east coast of Florida.

We believe the proposed action is not likely to impede the recovery objective above and will not result in an appreciable reduction in the likelihood of leatherback sea turtles' recovery in the wild. In Puerto Rico, the main nesting areas are at Fajardo on the main island of Puerto Rico and on the island of Culebra. Between 1978 – 2005 nesting increased in Puerto Rico from a minimum of 9 nests recorded in 1978 to 469 – 882 nests recorded each year from 2000 – 2005. The annual rate of increase in nesting was estimated to be 1.1 with a growth rate interval between 1.04 – 1.12, using nest numbers from 1978 – 2005 (NMFS and USFWS 2007b). In the USVI, researchers estimated a population growth of approximately 13% per year on Sandy Point

National Wildlife Refuge from 1994 – 2001. Between 1990 and 2005, the number of nests recorded has ranged from 143 (1990) to 1,008 (2001). The average annual growth rate was calculated as approximately 1.10 (with an estimated interval of 1.07 – 1.13; NMFS and USFWS 2007b). In Florida, a Statewide Nesting Beach Survey program has documented an increase in leatherback nesting numbers from 98 (1989) to 800 – 900 (early 2000's). Based on standardized nest counts made at Index Nesting Beach Survey sites surveyed with constant effort over time, there has been a substantial increase in leatherback nesting in Florida since 1989. The estimated annual growth rate was approximately 1.18 (with an estimated 95% interval of 1.1 – 1.21; (NMFS and USFWS 2007b). The numbers stayed over 500 until 2013 when they dipped to near 300; however, in 2014, they reached a record 641 nests. Thus, even with this newer information, the annual growth rate of the Florida nesting population is still within the 95% confidence intervals estimated in the 2007 status review.

The potential non-lethal take of 1 adult female leatherback sea turtle and the lethal or non-lethal take of up to 155 hatchlings from pile-driving associated with the proposed action and impacts to adult and hatchling sea turtles from lighting during project construction and operation is not likely to reduce population numbers over time given current population sizes and expected recruitment. Thus, the proposed action is not likely to impede the recovery objective above and will not result in an appreciable reduction in the likelihood of leatherback sea turtles' recovery in the wild. In conclusion, we believe that the effects associated with the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of leatherback sea turtles in the wild.

NWA DPS Loggerhead Sea Turtles

In Section 6.2, we determined that no lethal take of loggerhead sea turtles is expected. However, 1 loggerhead sea turtle may experience injurious (temporary or permanent hearing loss) and behavioral acoustic effects of the pile-driving activities that will take place as part of the construction of the proposed offshore platform. Due to the use of ramp up procedures, the ability of sea turtles to swim long distances away from the disturbance, and the availability of other similar habitats within the sea turtles' swimming range, we believe sea turtles will leave the area and any temporary or permanent hearing loss experienced by sea turtles will not cause indirect lethal effects (effects occurring later in time due to decreased fitness).

Given the large range over which these sea turtles disperse, no reduction in the distribution of loggerhead sea turtles is expected from the proposed action.

Though no lethal take of loggerheads is expected, any reduced reproductive potential associated with non-lethal temporary or permanent hearing loss of 1 adult loggerhead sea turtle from the pool of reproductive adults, either permanently or during the year the platform is constructed, would not appreciably reduce the likelihood of survival of the species. The NMFS SEFSC stage/age demographic model estimates the adult female population size for the western North Atlantic (from 2004 – 2008) as 20,000 – 40,000 individuals, with a low likelihood of up to 70,000 females (NMFS-SEFSC 2009). A less robust estimate for total benthic females in the western North Atlantic was also obtained, yielding approximately 30,000 – 300,000 individuals, up to less than 1 million (NMFS-SEFSC 2009). A preliminary regional abundance survey of loggerheads within the northwestern Atlantic continental shelf, corrected for unidentified turtles in proportion to the ratio of identified turtles, estimates about 801,000 loggerheads (NMFS-NEFSC 2011). Of the 5 loggerhead Northwest Atlantic DPS recovery units, the PFRU is the largest loggerhead nesting assemblage in the Northwest Atlantic. The PFRU index nesting beach survey by FWRI concluded that there was an overall positive change in nest counts from 1989 – 2016. An average of approximately 15,735 nesting females per year are estimated based on index nesting beach surveys (NMFS and USFWS 2008). The NRU nesting trend from daily beach surveys from 1989 – 2008 and aerial surveys conducted by SCDNR from 1980 – 2008 indicate there has been a long-term decline in nesting. However, more recent nesting data indicate that nesting in Georgia, South Carolina and North Carolina is now on an upward trend. The DTRU, NGMRU and GCRU are all much smaller nesting assemblages. The DTRU nesting survey data did not show a detectable trend. The NGMRU data show a significant decline trend of 4.7% annually from 1997 – 2008, though there have been some increases since that time. Nesting survey effort on GCRU beaches is inconsistent and no trend can be determined for this subpopulation (NMFS and USFWS 2008).

We believe the proposed action is not reasonable expected to cause, directly or indirectly, an appreciable reduction in the likelihood of survival of loggerhead sea turtles in the wild. One adult loggerhead could suffer some reduced fitness as a result of temporary or permanent hearing loss. However, it is not likely this reduction would appreciably reduce the likelihood of survival of loggerhead sea turtles. As discussed above, nesting trends for the Florida nesting population is increasing and this is the largest nesting population in the DPS and that the recent nesting data for NRU also show an increasing trend and loggerheads do not commonly nest in Puerto Rico and have never been reported nesting in the action area. Therefore, we believe the proposed action is not likely to have any measurable effect on overall population trends.

The Atlantic recovery plan for the Northwest Atlantic DPS of loggerhead sea turtle (NMFS and USFWS 2008) lists the following relevant recovery objective:

- Ensure that the number of nests in each recovery unit is increasing and that this increase corresponds to an increase in the number of nesting females.

We believe the proposed action is not likely to impede the recovery objective above and will not result in an appreciable reduction in the likelihood of loggerhead sea turtles' recovery in the wild. In Puerto Rico, limited nesting by loggerhead sea turtles has been reported on the east coast of the island and on the island of Culebra but other areas within the GCRU such as 7 of the beaches on Quintana Roo, Mexico showed increases in the numbers of nests from 1987 – 2001 (Zurita et al. 2003), although this trend appears not to have been sustained based on data since 2001 (NMFS and USFWS 2008). Nesting beaches in the GCRU are consisted essential for the survival of the species but are much smaller and less productive than those in other recovery units. As discussed above, the 2 largest recovery units, PFRU and NRU appear to be experiencing increases in nesting and the in-water population of loggerheads in the Northwest Atlantic DPS is estimated at approximately 801,000 individuals.

The potential non-lethal take of 1 adult loggerhead sea turtle from pile-driving associated with the proposed action is not likely to reduce population numbers over time given current population sizes and expected recruitment. Thus, the proposed action is not likely to impede the recovery objective above and will not result in an appreciable reduction in the likelihood of loggerhead sea turtles' recovery in the wild. In conclusion, we believe that the effects associated with the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of loggerhead sea turtles in the wild.

North and South Atlantic DPSs of Green Sea Turtles

In Section 6.2, we described the potential for the take of up to 17 green sea turtles associated with injurious (temporary or permanent hearing loss) and behavioral acoustic effects associated with pile-driving activities needed to construct the proposed offshore platform. The take associated with injurious and behavioral effects of pile-driving at the proposed offshore platform site is expected to be non-lethal and could affect juvenile and/or adult green sea turtles. Take is expected to affect individuals by causing them to flee the noise and due to disorientation caused by the noise, as well as by causing temporary or permanent hearing loss. Because green sea turtles could be from the North or South Atlantic DPS, we will conduct a jeopardy analysis for each DPS.

Even if take is non-lethal, the fleeing of the action area due to pile driving noise can cause individuals to expend more energy seeking suitable habitat. This can result in reduced growth rates, older age to maturity, and lower lifetime fecundity. Nesting females affected by pile-driving noise may also have a reduced reproductive output.

North Atlantic DPS

No reduction in the distribution of green sea turtles from the NA DPS is expected from this take as green turtles will continue to be present throughout waters surrounding Puerto Rico.

Whether the potential reduction in numbers due to lethal take or due to impacts to reproductive output would appreciably reduce the likelihood of survival of green sea turtles from the North Atlantic DPS depends on the probable effect the changes in numbers and reproduction would have relative to current population sizes and trends. The NA DPS is the largest of the 11 green turtle DPSs with an estimated abundance of over 167,000 adult females from 73 nesting sites. All major nesting populations demonstrate long-term increases in abundance (Seminoff et al. 2015). We believe the proposed action is not reasonably expected to cause, directly or indirectly, an appreciable reduction in the likelihood of survival of green sea turtles from the NA DPS in the wild. Although the potential mortality of 17 turtles from this DPS may occur as a result of the noise impacts from pile-driving activities at the proposed offshore platform site and would result in a reduction in absolute population numbers, the population of green sea turtles in the NA DPS would not be appreciably affected. Likewise, the reduction in reproduction that could occur during the year pile-driving occurs (non-lethal) or due to lethal take of the 17 individuals would not appreciably affect reproductive output in the North Atlantic. For a population to remain stable sea turtles must replace themselves through successful reproduction at least once over the course of their reproductive lives and at least 1 offspring must survive to reproduce itself. If the hatchling survival rate to maturity is greater than the mortality rate of the population, the loss of breeding individuals would be exceeded through recruitment of new breeding individuals from successful reproduction of non-taken sea turtles. Because the abundance trend information for green sea turtles is increasing, we believe the anticipated takes attributed to the proposed action will not have any measurable effect on that trend.

The Atlantic Recovery Plan for the population of Atlantic green sea turtles (NMFS and USFWS 1991) lists the following recovery objective over a period of 25 continuous years that is relevant to the impacts of the proposed action:

- A reduction in stage class mortality is reflected in higher counts of individuals on foraging grounds.

There are no reliable estimates of the number of immature green sea turtles that inhabit coastal areas of the southeastern United States and the U.S. Caribbean. Since 2000, sea turtle surveys in Culebra have resulted in the capture of 553 green sea turtles and all have been either juveniles or subadults based on size and testosterone levels suggesting Culebra is an important developmental habitat (Diez et al. 2007). The largest remaining green turtle population in the Atlantic that provides resident and transient juveniles to the Puerto Rican (NA DPS) and St. Croix (SA DPS) population (based on genetic data) is potentially threatened by the resurgence of the commercial artisanal green turtle fishery in Nicaragua (Campell and Lagueux 2005). Nicaragua is the site of the principal feeding grounds for adult sea turtles from the Tortuguero, Costa Rica rookery (Campell and Lagueux 2005). Campell and Lagueux (2005) found that survival rate estimates of females tagged at nesting beaches and juveniles and adults tagged at Nicaragua fishing sites may be too low to sustain the population. Similarly Tröeng and Rankin (2005) concluded that events and policy decisions in Costa Rica, Nicaragua, and Panama (the main nesting, feeding and mating grounds for green sea turtles in the NA DPS) greatly influence survivorship. Troëng and Rankin (2005) found that, while protections are in place in Costa Rica and to varying degrees in the 2 other countries, the capture levels in Nicaragua are believed to be higher than ever. However, it is important to note that in the years following that research nesting in Tortuguero has continued to increase and it is likely that numbers on foraging grounds have increased similarly.

In conclusion, the anticipated lethal or non-lethal take of 17 green sea turtles that could be from the NA DPS expected to result from pile-driving activities at the proposed offshore platform are not likely to reduce population numbers over time given current population sizes and expected recruitment. Thus, the proposed action is not likely to impede the recovery objective above and will not result in an appreciable reduction in the likelihood of the NA DPS of green sea turtles' recovery in the wild. In conclusion, we believe that the effects associated with the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of the NA DPS of green sea turtles in the wild.

South Atlantic DPS

No reduction in the distribution of green sea turtles from the SA DPS is expected from this take as it will not affect the presence of green sea turtles around Puerto Rico.

Whether the potential reduction in numbers due to lethal take or due to impacts to reproductive output would appreciably reduce the likelihood of survival of green sea turtles from the South Atlantic DPS depends on the probable effect the changes in numbers and reproduction would have relative to current population sizes and trends. The SA DPS is large, estimated at over 63,000 nesting females, but data availability is poor with 37 of the 51 identified nesting sites not having sufficient data to estimate number of nesters or trends (Seminoff et al. 2015). While the lack of data was a concern due to increased uncertainty, the overall trend of the SA DPS was not considered to be a major concern as some of the largest nesting beaches such as Ascension Island and Aves Island in Venezuela and Galibi in Suriname appear to be increasing with others (Trindade, Brazil; Atol das Rocas, Brazil; Poilão and the rest of Guinea-Bissau) appearing to be stable. In the U.S., nesting of green sea turtles occurs in the SA DPS on beaches of the U.S. Virgin Islands, primarily on Buck Island and Sandy Beach, St. Croix, although there are not enough data to establish a trend. We believe the proposed action is not reasonable expected to cause, directly or indirectly, an appreciable reduction in the likelihood of survival of green sea turtles from the SA DPS in the wild. Although the potential mortality of 17 turtles from this DPS may occur as a result of the noise impacts from pile-driving activities at the proposed offshore platform site and would result in a reduction in absolute population numbers, the population of green sea turtles in the SA DPS would not be appreciably affected. Likewise, the reduction in reproduction that could occur during the year pile-driving occurs (non-lethal) or due to lethal take of the 17 individuals would not appreciably affect reproduction output in the South Atlantic.

The Atlantic Recovery Plan for the population of Atlantic green sea turtles (NMFS and USFWS 1991) lists the following recovery objective over a period of 25 continuous years that is relevant to the impacts of the proposed action:

- A reduction in stage class mortality is reflected in higher counts of individuals on foraging grounds.

There are no reliable estimates of the number of immature green sea turtles that inhabit coastal areas of the southeastern United States and the U.S. Caribbean. Juvenile greens from multiple rookeries frequently utilize the nearshore waters off Brazil as foraging grounds and juvenile and adult green turtles utilize foraging areas throughout the Caribbean areas of the south Atlantic based on captures in fisheries (Lima et al. 2010; López-Barrera et al. 2012; Marcovaldi et al. 2009; Dow and Eckert 2007). Culebra Island, which is on the border between the North and South Atlantic DPSs, is an important developmental habitat based on capture data from 2000 – 2006 of juveniles and subadults (Diez et al. 2007).

The anticipated lethal or non-lethal take of 17 green sea turtles that could be from the SA DPS expected to result from pile-driving activities at the proposed offshore platform are not likely to reduce population numbers over time given current population sizes and expected recruitment. Thus, the proposed action is not likely to impede the recovery objective above and will not result in an appreciable reduction in the likelihood of green sea turtles' recovery in the wild. In conclusion, we believe that the effects associated with the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of the SA DPS of green sea turtles in the wild.

Hawksbill Sea Turtles

As described in Section 6.2, we believe there is the potential for the take of up to 14 hawksbill sea turtles associated with injurious (temporary or permanent hearing loss) and behavioral acoustic effects of pile-driving during the construction of the proposed offshore platform. These turtles could be adults or juveniles. Take is expected to be non-lethal. This could be expected to result in reduced reproductive output if adult females abandon nesting attempts due to disorientation and a desire to flee the area. We assumed there would be one nesting female experiencing potential injurious effects (temporary or permanent hearing loss) of pile driving and up to 157 hawksbill hatchlings based on survey data from USFWS and anecdotal information regarding the small number of nests that are infrequently laid by hawksbills in the area of Punta Pozuelo and on offshore cays. Lighting during project construction and during operation of the offshore platform could also disrupt hawksbill nesting, affecting both adult female and hatchling turtles. We estimate that one female hawksbill and up to 157 hatchling sea turtles could be affected by non-lethal take annually once the project is operational due to lighting at the offshore platform.

Even if take is non-lethal, the fleeing of the action area due to pile driving noise and abandonment of nesting attempts due to noise and/or lighting can cause individuals to expend more energy seeking suitable habitat. This can result in reduced growth rates, older age to maturity, and lower lifetime fecundity. Nesting females affected by pile-driving noise or disorientation from lighting may also have a reduced reproductive output.

No reduction in the distribution of hawksbill sea turtles is expected from this take as hawksbill turtles will continue to be present throughout most waters surrounding Puerto Rico.

Whether the potential reduction in numbers due to lethal take or due to impacts to reproductive output would appreciably reduce the likelihood of survival of hawksbill sea turtles depends on the probable effect the changes in numbers and reproduction would have relative to current population sizes and trends. There are currently no reliable estimates of population abundance and trends for non-nesting hawksbills at the time of this consultation; therefore, nesting beach data is currently the primary information source for evaluating trends in abundance. Mortimer and Donnelly (2008b) found that for nesting populations in the Atlantic (especially in the Insular Caribbean and Western Caribbean Mainland), 9 of the 10 sites with recent data (within the past 20 years) that show nesting increases were located in the Caribbean. With increasing nesting trends in the Caribbean, we believe the losses expected due to the proposed action will be replaced due to increased nest production. Therefore, we believe the reduction in numbers and reproduction will not appreciably reduce hawksbill turtle's survival in the wild.

The Recovery Plan for the population of the hawksbill sea turtle (NMFS and USFWS 1993) lists the following relevant recovery objectives over a period of 25 continuous years:

- The adult female population is increasing, as evidenced by a statistically significant trend in the annual number of nests at five index beaches, including Mona Island (Puerto Rico and Buck Island Reef National Monument (St. Croix).

- The numbers of adults, subadults, and juveniles are increasing, as evidenced by a statistically significant trend on at least five key foraging areas within Puerto Rico, U.S. Virgin Islands, and Florida.

Of the hawksbill sea turtle rookeries regularly monitored – Jumby Bay (Antigua/Barbuda), Barbados, Mona Island (Puerto Rico), and Buck Island Reef National Monument (USVI), all show increasing trends in the annual number of nests (NMFS and USFWS). In-water research projects at Mona Island, Buck Island, and the Marquesas, Florida, which involve the observation and capture of juvenile hawksbill turtles, are underway. Although there are over 15 years of data for the Mona Island project, abundance indices have not yet been incorporated into a rigorous analysis or a published trend assessment. The time series for the Marquesas project is not long enough to detect a trend (NMFS and USFWS 2007a).

The non-lethal take of 14 adult and/or juvenile hawksbill sea due to the effects of pile-driving noise and the lethal or non-lethal take of up to 157 hatchlings, the non-lethal take of 1 nesting female during the estimated 50 days required to complete the installation of piles as part of the construction of the proposed offshore platform, and the non-lethal take of up to 157 hatchlings and 1 nesting female annually during project operation due to disorientation caused by lighting at the offshore platform are not likely to reduce overall population numbers over time. We base this conclusion on the expected recruitment of hawksbills given the increasing trends in nesting. With increased nesting in the Caribbean, the proposed action is not expected to affect the numbers of adult females recruiting into the population nor the numbers of adults, juveniles, and hatchlings. Therefore, we believe the proposed action is not likely to impede the recovery objectives above and will not result in an appreciable reduction in the likelihood of hawksbill sea turtles' recovery in the wild. In conclusion, we believe the effects associated with the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of hawksbill sea turtles in the wild.

8.1.2 ESA-Listed Corals

Elkhorn and Staghorn Corals

As noted in Section 6.3, elkhorn and staghorn coral colonies are expected to be adversely affected by the proposed action, in particular due to the operation of seawater intakes and associated entrainment of coral larvae at the offshore platform. We estimate that between 166 – 247 new elkhorn coral colonies and 31 – 54 new staghorn coral colonies could be lost annually due to the continuous operation of seawater intakes over the operational lifetime of the project. At this time, the proposed ownership agreement will be for 15 years but the facility will be leased to the financing entity for 35 years or longer based on the application for the project filed with FERC. Thus, if we calculate the potential loss of future elkhorn and staghorn recruits over a 35-year operational project lifetime and use the high end of the estimated loss due to entrainment, up to 8,645 elkhorn and 1,890 staghorn coral colonies could be lost. As noted in Section 6.3.2, this estimate is extremely conservation because it assumes that elkhorn and staghorn coral will reproduce sexually over the project lifetime and that all coral larvae entrained in the seawater intakes will be from ESA-listed coral.

Abundance

Elkhorn and staghorn corals were first listed as threatened under the ESA in May 2006 (71 FR 26852: May 9, 2006). In December 2012, NMFS proposed changing their status from threatened to endangered but in September 2014, but determined that both should remain listed as threatened (79 FR 53852; September 10, 2014). The species have undergone substantial population declines and decreases in occurrence to low levels of coverage throughout their range. Elkhorn and staghorn coral are highly susceptible to a number of threats and cumulative and synergistic effects of multiple threats are likely to exacerbate vulnerability to extinction. The lack of adequate regulatory mechanisms contributes to elkhorn and staghorn corals' vulnerability, particularly in the highly disturbed Caribbean region where localized human impacts are high. The abundance of elkhorn and staghorn coral is a fraction of what it was before the mass mortality in the 1970s and 80s and recent population models forecast the extirpation of elkhorn coral from some locations over the foreseeable future, including a site in Vieques that was included in the Jackson et al. (2014) report. The presence of staghorn coral on reefs throughout its range has continued to decrease. Elkhorn corals occupy habitats from back reef environments to turbulent water on the fore reef, reef crest, and shallow spur-and-groove zone, which moderates the species' vulnerability to extinction although many of the reef environments it occupies will experience highly variable thermal regimes and ocean chemistry due to climate change. Staghorn corals occupy a broad range of depths and multiple, heterogeneous habitat types, including deeper waters, which moderates the species' vulnerability to extinction over the foreseeable future. Elkhorn coral abundance is at least hundreds of thousands of colonies but likely to decrease in the future with increasing threats. Staghorn coral abundance is at least tens of millions of colonies but likely to decrease in the future with increasing threats.

The project is expected to result in the loss of up to 8,645 future elkhorn and 1,890 future staghorn coral colonies over the projected 35-year operational lifetime of the project due to entrainment in the seawater intakes needed for FSRU and LNG operations. The loss of future elkhorn and staghorn coral colonies during project operation could result in a reduction in numbers in the populations of these species in the action area. The loss of up to 8,645 future elkhorn and 1,890 future staghorn coral colonies during project operation could also result in the loss of reproductive potential, as described below.

Reproductive Potential
The loss of up to 8,645 future elkhorn and 1,890 future staghorn coral colonies may occur as a result of the 35-year estimated operational lifetime of the project and the required seawater intakes and associated entrainment of coral larvae that will occur. There will also be some additional losses of future recruits of elkhorn and staghorn corals as a result of the potential loss of up to 4.1 ac of future settlement habitat due to the removal of 0.2 ac for the installation of piles to support the proposed offshore platform and chronic impacts to the remaining 3.9 ac in the footprint of the offshore platform site associated with sediment resuspension and transport during project construction and then from vessel operation and wave action against the piles during project operation as discussed in Section 6.4. Despite the potential loss of future reproductive potential, the area to be affected is part of a larger reef system outside Jobos Bay where numerous colonies of elkhorn and staghorn corals are present based on the coral survey data from EPA. At this time, no colonies of elkhorn and staghorn coral are present at the proposed offshore platform site, which is outside the preferred depth range of elkhorn corals. The Boca del Infierno and other areas on the fringing cays outside Jobos Bay have numerous colonies of elkhorn and staghorn corals based on benthic surveys conducted for this project and the unpublished EPA data. We anticipate that these areas will not only be the source of any larvae impacted by entrainment but will also be the habitat areas where new elkhorn and staghorn coral colonies are likely to grow as long as the assumptions presented in Section 6.1 that HDD operations will be protective of ESA-listed corals prove correct. Therefore, we do not expect the proposed action will alter the geographic range for the species and we do not expect

that the proposed action will result in a reduction of the overall distribution of elkhorn and staghorn corals.

Likelihood of Survival

Whether the expected reduction in future reproduction of elkhorn and staghorn corals would appreciably reduce their likelihood of survival depends on the probable effect the changes in reproduction would have relative to the current population levels and trends. Based on best available population estimates, there are at least hundreds of thousands of elkhorn coral colonies and at least tens of millions of staghorn coral colonies present in the Florida Keys and St. Croix, USVI. Absolute abundance is higher than estimates from these locations alone given the presence of these species in many other locations throughout their range, including around Puerto Rico and other areas of the USVI. In the status of the species section, we concluded there has been a significant decline of elkhorn coral throughout its range with recent population stability at low percent cover and that local extirpations are possible. We conclude that staghorn coral has declined throughout its range as well. We also conclude that abundance of both species is likely to decrease in the future with increasing threats.

Elkhorn coral has low sexual recruitment rates, meaning that genetic heterogeneity is low. However, its fast growth rates and propensity for formation of clones through asexual fragmentation enables it to expand between rare events of sexual recruitment and increases its potential for local recovery from mortality events, thus moderating vulnerability to extinction. Also, given elkhorn coral's estimated abundance (hundreds of thousands of colonies based on data from the Florida Keys and St. Croix), the loss of the reproductive potential represented by the loss of up to 8,645 future elkhorn coral colonies in the action area over 35 years will not measurably impact the species' abundance in Puerto Rico or throughout the species' range. This estimate of future elkhorn colonies is extremely conservative as explained previously but there are numerous elkhorn coral colonies in the action area, particularly on the fringing reefs outside Jobos Bay based on benthic studies from this project and EPA data. Therefore, we believe the loss of elkhorn coral colonies due to the operation of the Aguirre Offshore GasPort project will not appreciably reduce elkhorn coral's ability to survive in the wild.

Staghorn corals occur throughout the Caribbean basin and the corals in the action area account for a very small portion of the total numbers of or area occupied by staghorn coral. The species' absolute abundance is at least tens of millions of colonies, based on estimates from only 2 locations. Impacts to the species' areal coverage would also likely be undetectable on a Caribbean-wide scale. Therefore, we believe the loss of up to 1,890 future staghorn coral colonies in the action area over 35 years will not have any measurable effect on the overall population and is not likely to reduce the species likelihood of survival in the wild. As discussed for elkhorn coral, the estimate of potential future staghorn colonies is extremely conservative but there are numerous staghorn coral colonies in the action area.

Likelihood of Recovery

Now we evaluate whether the expected reduction in reproduction of elkhorn and staghorn corals will appreciably reduce the likelihood of the species' recovery in the wild. A recovery plan for elkhorn and staghorn corals was published March 5, 2015. The recovery plan notes that elkhorn and staghorn corals continue to decline and are at only a small percentage of their abundance throughout their ranges. The recovery plan outlines a recovery strategy for the species: "Elkhorn and staghorn coral populations should be large enough so that successfully reproducing individuals comprise numerous populations across the historical ranges of these species and are large enough to protect their genetic diversity and maintain their ecosystem functions. Threats to these species and their habitat must be sufficiently abated to ensure a high probability of survival into the future" (NMFS 2015).

The recovery plan established 3 recovery criteria associated with the objective of ensuring population viability and 7 recovery criteria associated with the objective of eliminating or sufficiently abating global, regional, and local threats that contribute to species' status. The best available information indicates that all recovery objectives must be met for elkhorn and staghorn corals to achieve recovery. The most relevant criteria to the impacts expected from the proposed action include:

Objective 1: Ensure Population Viability
Criterion 1: Abundance
Elkhorn coral: Thickets are present throughout approximately 10% of consolidated reef habitat in 1 – 5 m water depth within the forereef zone. Thickets are defined as either a) colonies $\geq$ 1 m diameter in size at a density of 0.25 colonies per m^2 or b) live elkhorn coral benthic cover of approximately 60%. Populations with these characteristics should be present throughout the range and maintained for 20 years.
Staghorn coral: Thickets are present throughout approximately 5% of consolidated reef habitat in 5 – 20 m water depth within the forereef zone. Thickets are defined as either a) colonies $\geq$ 0.5 m diameter in size at a density of 1 colony per m^2 or b) live staghorn coral benthic cover of approximately 25%. Populations with these characteristics should be present throughout the range and maintained for 20 years.

Criterion 3: Recruitment
Observe recruitment rates necessary to achieve Criteria 1 and 2 (Genotypic Diversity) over approximately 20 years; and
Observe effective sexual recruitment (i.e., establishment of new larval derived colonies and survival to sexual maturity) in each species' population across their geographic range.

Objective 2: Eliminate or Sufficiently Abate Global, Regional, and Local Threats
Criterion 6: Loss of Recruitment Habitat
Abundance (Criterion 1 above) addresses the threat of Loss of Recruitment Habitat because the criterion specifies the amount of habitat occupied by the 2 species. If Criterion 1 is met, then this threat is sufficiently abated; or
Throughout the ranges of these 2 species, at least 40% of the consolidated reef substrate in 1 – 20 m depth within the forereef remains free of sediment and macroalgal cover as measured on a broad reef to regional spatial scale.

As discussed above and in Section 6.3, up to 8,645 future elkhorn and 1,890 future staghorn coral colonies could be lost over the 35-year operational lifetime of the project due to entrainment of coral larvae in seawater intakes. Our analysis of the project's impacts on critical habitat (Section 8.2) concluded that the proposed action would affect the essential feature of 4.1 ac of designated critical habitat but that this would not delay recovery or make recovery more difficult for elkhorn and staghorn coral due to the small area of impact in relation to the amount of critical habitat in the action area. In terms of the recovery objectives, the project is not expected to reduce the abundance of elkhorn coral in the action area, particularly given that these species are not present in the area where the offshore platform is proposed. In terms of recovery objective 1, the area of habitat impacts is not part of the forereef zones and no elkhorn or staghorn coral thickets are currently present or expected to occur at the site of the proposed offshore platform, meaning we do not expect the abundance objective to be affected. Similarly, while the project is expected to result in the loss of future recruits due to entrainment in seawater intakes, the area where the intakes will be located is not the only source of new larvae and there are no elkhorn coral in the area of the intakes so recruitment potential in the action area will not be lost as a result of the project, meaning we do not expect the recruitment criterion to be affected. Though the project will result in the loss of 4.1 ac of habitat containing the essential feature of elkhorn and staghorn coral critical habitat, there are extensive reefs in the action area that contain the essential feature and are not expected to be impacted by the proposed project and will continue to serve as recruit habitat. We expect recruitment habitat to remain in the action area within the percentage established to meet recovery objective 2. Therefore, even with the loss of a small area of critical habitat from the action area due to the construction and operation of the project, we do not believe there will be an appreciable reduction in the likelihood of recovery in the wild for elkhorn and staghorn corals. We base this conclusion on the fact that the designated critical habitat is only a relatively small portion of elkhorn and staghorn corals' overall range and part of a larger reef system that is not expected to lose connectivity as a result of the impacts to the patch reefs in the area of the proposed offshore platform. In addition, elkhorn and staghorn corals have fast growth rates and a propensity for formation of clones through asexual fragmentation enabling them to expand between rate events of sexual recruitment. This also increases the potential for local recovery from mortality events, thus moderating vulnerability to extinction. Also, elkhorn and staghorn corals have sufficiently larger populations (hundreds of thousands to tens of millions, respectively, based on information from Florida and USVI only). Thus, we do not believe the loss of future recruits and colonies will prohibit reaching recovery criteria 1, 3, or 6. Therefore, we do not believe the proposed action will jeopardize the continued existence of elkhorn and staghorn corals in the wild.

Pillar Corals

We do not have precise population estimates for the species. The listing rule (79 FR 53852; September 10, 2014) notes that there are at least tens of thousands of colonies in the Florida Keys, although the species is naturally uncommon to rare and population estimates for the Caribbean are not available, though the species has been observed in limited numbers in sites in Honduras, Cuba, Providencia Island, Colombia, USVI, Dominica, Barbados, and Curaçao. As discussed in other sections of this document (see, for instance, Section 5.2), EPA coral sampling data from 2010 and 2011 in the action area documented the presence and coverage in m^2 of ESA-listed corals, including pillar coral, but the data are from observations made in 8 – 10 m belt transects. We used the EPA data and data from surveys conducted for the project to obtain estimates of the approximate number of pillar coral colonies that may be impacted by the proposed project at the offshore platform location during construction and operation. Pillar corals are naturally rare so our numbers may be overestimates, although survey data indicate there are numerous pillar coral colonies in the area.

As discussed in Section 6.3, 21 pillar coral colonies will be transplanted from the proposed pile footprint of the offshore platform and 2 of these colonies could suffer mortality due to transplant stress. Based on recent coral transplant work such as that for the USACE San Geronimo restoration project in Condado Lagoon, San Juan, Puerto Rico, a loss of approximately 10% of transplanted corals can be expected. An additional 417 pillar coral colonies that will remain in the area of the offshore platform are expected to suffer chronic impacts associated with the construction and operation of the facility. Over the operational lifetime of the project (estimated as 35 years), between 104 – 179 future pillar coral colonies would not be available due to entrainment of coral larvae in seawater intakes for a total of up to 6,265 colonies (179 times 35 years). As discussed for elkhorn and staghorn corals, the number of potential future colonies of pillar coral is an extremely conservative estimate that assumes pillar coral will reproduce sexually every year and all coral larvae entrained by the seawater intakes is from ESA-listed corals and our estimates of percentages of each species are correct.

Abundance
Pillar coral is distributed throughout most of the greater Caribbean in most reef environments between 1-25 m in depth but the low coral cover of this species makes it difficult to extrapolate monitoring data in order to determine trends in abundance. The proposed action will not affect the life history vulnerabilities of pillar corals. The listing rule concluded that this species is naturally uncommon to rare. The rule states that the major threats faced by these corals are high vulnerability to disease and moderate vulnerability to ocean warming, acidification, trophic effects of fishing, sedimentation, and nutrient enrichment. The proposed action will not increase the magnitude of the species' vulnerability to disease, ocean warming, acidification, trophic effects of fishing, and nutrient enrichment in the action area; however, the proposed action will cause increases in sedimentation in the action area. These effects will be chronic in the area of the proposed offshore platform where pillar coral colonies are located. The action area where the project is located, particularly the fringing reefs delimiting Jobos Bay, appears to be an area with a large concentration of pillar coral. Based on information in our project files from other sites in the U.S. Caribbean, pillar coral appears to be more common around Puerto Rico and USVI in general than in South Florida (NOAA, unpublished data).

In the following analysis, we find that the anticipated take of pillar coral colonies associated with transplanting and impacts from the operation of the offshore platform will result in a reduction in numbers of this species. The 21 corals to be transplanted are likely to suffer partial tissue mortality and bleaching as a result of the stress of transplantation. In addition, 2 of these colonies are expected to suffer mortality based on the anticipated loss of 10% of transplanted corals. The 417 pillar coral colonies that will remain on the patch reefs in the area of the offshore platform are expected to experience stress from sediment resuspension and transport during construction and operation of the facility, discharges of superheated water and brine from the FSRU, and discharge of copper ions. Given that the estimated operational lifetime is 35 years, we expect the colonies that remain at the offshore platform to suffer full or partial mortality as a result of chronic stress. The proposed action may cause mortality of 2 transplanted colonies and 417 pillar coral colonies at the offshore platform. Up to 6,265 future pillar coral colonies may be lost over the 35-year operational lifetime of the project based on extremely conservative estimates of impacts from entrainment of coral larvae at the offshore platform. The reduction in numbers of pillar corals in the action area is also expected to result in a loss of reproductive potential, as described below.

Reproductive Potential
The loss of 2 transplanted colonies and 417 pillar coral colonies at the offshore platform, and up to 6,265 future pillar coral colonies may occur as a result of the 35-year estimated operational lifetime of the project and the required seawater intakes and associated entrainment of coral larvae. Despite the potential loss of future reproductive potential, the action area represents a small portion of the species' range and, based on information from EPA surveys in particular, as well as benthic surveys performed for the proposed project, pillar corals may be more common in the action area than in other areas within the species' range.

Based on information from a limited coral demographic survey completed for the project, we estimate that approximately 66% of the pillar coral colonies that will be affected by the proposed action are sexually mature. This means that up to 14 of the colonies to be transplanted could be sexually mature and 2 of these colonies could be lost if they are the colonies that suffer mortality due to the stress of transplantation. Even if all 14 of these colonies survive, they would be temporarily lost from the reproductive pool due to transplant stress. Based on our observations of the time it takes for sexually mature corals to recover following other relocation projects, we expect that transplanted pillar corals that survive transplantation will begin to reproduce again sexually within 1-2 years following transplantation. Similarly, in the area of the offshore platform, 275 of the 417 colonies that will remain at the site are expected to be sexually mature (again assuming that approximately 66% of the colonies are sexually mature). There will also be a loss of recruits over the estimated 35-year operational lifetime of the project as discussed above and in Section 6.3 due to entrainment of coral larvae in seawater intakes and the associated loss of future recruitment. The potential sediment impacts to 3.9 ac of coral habitat at the offshore platform location during project construction and operation and the elimination of 0.2 ac of coral habitat within the pile footprints will also result in some additional losses of future sexual and asexual recruits due to impacts to this settlement habitat.

Despite the estimated loss of sexually reproductive individuals due to the proposed action, we do not believe that sexually mature pillar corals in the action area will be affected to a degree that will cause long-term damage to the species' ability to sexually reproduce. Pillar corals were found in the Boca del Infierno area, as well as on other fringing reefs outside Jobos Bay based on the benthic surveys conducted for the project and EPA data. Therefore, although we believe the project will lead to a loss of reproductive potential related to the loss of sexually mature pillar coral colonies and future colonies and the temporary loss of reproductive potential due to transplant stress for up to 14 additional colonies, we do not anticipate that this would represent a detectable reduction in the long-term reproduction of pillar coral in the action area.

Distribution
We do not expect the proposed action will alter the geographic range for the species or result in a reduction of the overall distribution of pillar coral.

Likelihood of Survival
Whether the expected reduction in reproduction of pillar corals will appreciably reduce their likelihood of survival depends on the probable effect the changes in reproduction would have relative to the current population levels and trends. There is no evidence to indicate the species is undergoing a significant decline and the population is estimated to be in the tens of thousands for the Florida Keys, which is the only area with adequate data to estimate population size. We are unable to determine absolute abundances of pillar corals due to the scarcity of data. Pillar coral population and abundance estimates are available largely only for Florida. Pillar coral was one of the least abundant species in the Florida Keys in surveys between 2005 – 2009 and was not found in 2012 surveys (Miller et al. 2013a). Similarly, in surveys conducted from Palm Beach to the Dry Tortugas, pillar corals were present at only 2% of surveyed sites in very low densities (NOAA, unpublished data). By 2017, over 57% of the known colonies along the Florida reef tract suffered complete mortality due to disease, mainly from the northern portion of the reef tract. The same trend has not been observed in the U.S. Caribbean, although there have been were declines at monitoring stations in USVI following the 2005 bleaching event (Smith et al. 2013a).

The combination of low population densities and broadcast spawning by separate sexes is expected to yield low rates of successful fertilization and low larval supply. Pillar coral can propagate by fragmentation, although growth rates are slower than those of staghorn coral, for example. Given pillar coral's likely population size, the loss of reproductive potential represented by the loss of 2 transplanted colonies, 417 pillar coral colonies at the offshore platform, and up to 6,265 future pillar coral colonies in the action area over 35 years will not measurably impact the species' abundance in Puerto Rico or throughout the species' range. The apparent frequency of occurrence of pillar corals on the coral reefs fringing Jobos Bay based on survey data from EPA and the applicant indicates that this species is more abundant in the action area than in other sites within its range.

Pillar corals occur through the Greater Caribbean and the corals in the action area account for a small portion of the total numbers of or area occupied by the species. The species' absolute abundance cannot be estimated, as discussed previously, but in the portions of the Florida Keys for which coral survey data are available, the population is estimated at tens of thousands. Impacts to the species' areal coverage would also likely be undetectable on a range-wide scale. Therefore, we believe the loss of 419 pillar coral colonies and up to 6,265 future colonies in the action area over 35 years will not have any measurable effect on the overall population and is not likely to appreciably reduce the species' likelihood of survival in the wild.

Likelihood of Recovery
Pillar corals were listed as threatened in September 2014 and we do not have an extensive consultation history for the species. A recovery plan is not available for pillar corals. NMFS has developed a recovery outline for this species (available at http://sero.nmfs.noaa.gov/protected_resources/coral/documents/recovery_outline.pdf). The outline is meant to serve as an interim guidance document to direct recovery efforts, including recovery planning, until a full recovery plan is developed and approved. A preliminary strategy for recovery of the species is presented, as are recommended high priority actions to stabilize and recover the species. The Summary Assessment in the recovery outline concludes that population

trends for pillar corals are unknown. Therefore, recovery will depend on successful sexual reproduction and reducing mortality of extant populations. The key challenges will be moderating the impacts of ocean warming associated with climate change and decreasing susceptibility to disease which may be furthered through reduction of local stressors. The recovery of this species will require an ecosystem approach including habitat protection measures, a reduction in threats caused by human activity, additional research, and time. The recovery vision for the species concludes that it should be present across the historical range, with populations large enough and genetically diverse enough to support successful reproduction and recovery from mortality events and dense enough to maintain ecosystem function. Recovery will require conservation of the coral reef ecosystem through threats abatement to ensure a high probability of survival into the future..

To determine if the proposed action will appreciably reduce the likelihood of recovery for pillar corals, we will evaluate the proposed action's impacts, if any, on the key elements of the recovery outline discussed above. As discussed previously, the proposed action will result in impacts to 438 existing colonies (21 to be transplanted of which 2 may die and 417 to remain at the offshore platform site) and the loss of up to 6,265 future colonies. We can, therefore, assess the effects of the proposed action on the likelihood of recovery of pillar coral in the context of our knowledge of the status of the species, its environmental baseline, the extinction risk analyses in the listing rule, and the information in the recovery outline. The final listing rule identifies this species' abundance, life history characteristics, depth distribution, and threat vulnerabilities as characteristics that increase extinction risk. Its low abundance, combined with its geographic location, exacerbates vulnerability to extinction. This species can be found in depth ranges from 1 – 25 m, but is most common in waters from 5 – 15 m deep. Pillar corals are present in the action area in the deeper waters where the offshore platform is proposed and in shallow waters at Boca del Infierno and other locations along the fringing reef outside Jobos Bay. The proposed action will not affect the species' life history characteristics. Similarly, the proposed action will not increase the magnitude of or the species' vulnerability to climate change threats such as ocean warming but the proposed action will cause and increase sedimentation in the action area. These effects will be chronic in the 4.1 ac area of the proposed offshore platform where pillar corals are present. Effects to these habitats are likely to result in the loss of substrate for larval attachment into the foreseeable future due to the operation of the platform. In addition, the reproductive potential of the species will be diminished either temporarily (due to transplant) or permanently (due to the mortality of 2 transplanted colonies and chronic impacts to the 417 colonies to remain at the platform) due to the operation of the offshore gasport. The proposed action will also cause the loss of future recruits due to the entrainment of coral larvae in seawater intakes over the 35 years the project will operate. The area affected is a small portion of the species' range. The species are still present in Puerto Rico and more common in the action area than in other surveyed sites based on survey data and the losses will not affect the overall density and distribution of the species or impede sexual reproduction. Therefore, we believe the increased sedimentation resulting from the proposed action will not increase the magnitude of this threat range-wide to levels that will appreciably reduce the likelihood of this species' recovery in the wild.

Habitat improvement is vital to recovery of ESA-listed species and may lead to increased survival. The loss of 4.1 ac of habitat in the area of the proposed offshore platform will not affect future recruitment, growth and survival of pillar corals in the action area because the patch reefs that will be lost are part of a series of similar habitat and the fringing reef system that defines Jobos Bay. The habitat that will be lost is part of a well-developed reef system that, based on data from EPA, has high coral cover and diversity in comparison to many other sites around Puerto Rico. The applicant is not proposing compensatory measures to offset the impact to coral recruits based on the loss of recruitment habitat at the offshore platform site at this time but this habitat represents only a small fraction of that available in the action area (an estimated 0.7% of the total habitat available for corals).

The area affected is a small portion of the species' range and as stated in the listing rule, the habitat heterogeneity of the species allows for variation in the responses of individuals to threats to play a role in moderating vulnerabilities to extinction. The proposed action will cause the mortality of up to 419 existing pillar coral colonies (2 of which will be due to transplant mortality) and 6,265 future colonies (over a 35 year period). Despite the number of colonies of this uncommon to rare species that will be affected by the proposed action and the projected numbers of future colonies that may be lost over the 35 years the project is expected to operate, the data from EPA indicate that there are likely at least 3,000 other colonies of the species present in the Boca del Infierno and offshore platform area so losses will not appreciably affect overall density and distribution of the species or lead to detectable effects to long-term reproduction of the species in the action area. Therefore, we believe that the increased sedimentation and other impacts to pillar corals resulting from the proposed action will not increase the magnitude of the threats that led to the listing of the species as threatened range wide to levels that will appreciably reduce this species' likelihood of recovering in the wild.

We conclude the proposed action is not likely to jeopardize the continued existence of pillar coral in the wild.

Rough Cactus Corals

As discussed in Section 6.3, 6 rough cactus coral colonies will be transplanted from the proposed pile footprint of the offshore platform and 1 of these colonies could suffer mortality due to transplant stress. An additional 125 rough cactus coral colonies that will remain in the area of the offshore platform are expected to suffer chronic impacts associated with the construction and operation of the facility. Over the operational lifetime of the project (estimated as 35 years) no future rough cactus coral colonies are expected to be affected by entrainment of coral larvae in seawater intakes.

Abundance

Rough cactus coral is reported in the Caribbean and western Atlantic with the exceptions of the Flower Garden Banks, Bermuda, Brazil, and the southeast U.S. north of South Florida. The proposed action will not affect the life history vulnerabilities of rough cactus corals. The listing rule concluded that this species is naturally uncommon to rare. Rough cactus coral is one of the least common coral species observed when it is present. The rule states that the major threats faced by these corals are high vulnerability to disease and nutrient enrichment; moderate vulnerability to ocean warming, acidification, trophic effects of fishing, and sedimentation. The proposed action will not increase the magnitude of the species' vulnerability to disease, ocean warming, acidification, tropic effects of fishing, and nutrient enrichment in the action area;

however, the proposed action will cause increases in sedimentation in the action area. These effects will be chronic in the area of the proposed offshore platform where rough cactus coral colonies are located. Rough cactus coral appears to be more common in the action area compared to other sites based on information in our project files from other sites around Puerto Rico and USVI, though still rare and with low coral cover compared to other species.

In the following analysis, we find that the anticipated take of rough cactus coral colonies associated with transplanting during project construction and impacts from the operation of the offshore platform will result in a reduction in numbers of this species. The 6 corals to be transplanted are likely to suffer partial tissue mortality and bleaching as a result of the stress of transplantation. In addition, 1 of these colonies is expected to suffer mortality based on the anticipated loss of 10% of transplanted corals. The 125 rough cactus coral colonies that will remain on the patch reefs in the area of the offshore platform are expected to experience stress from sediment resuspension and transport during construction and operation of the facility, discharges of superheated water and brine from the FSRU, and discharge of copper ions. Given that the estimated operational lifetime is 35 years, we expect these colonies to suffer full mortality as a result of chronic stress. The reduction in numbers of rough cactus corals in the action area is also expected to result in a loss of reproductive potential, as described below.

Reproductive Potential

We have no data on rough cactus corals from the limited coral demographic survey completed for the project. Therefore, we estimate that 100% of the rough cactus coral colonies that will be affected by the proposed action are sexually mature. This means that the 6 colonies to be transplanted could be sexually mature and 1 of these colonies could be lost if it suffers mortality due to the stress of transplantation. Even if all 6 of these colonies survive, they would be temporarily lost from the reproductive pool (for 1 -2 years based on our observations from previous projects) due to transplant stress.

In the area of the offshore platform, the 125 rough cactus coral colonies that will remain at the site and suffer mortality due to chronic impacts are expected to be sexually mature. The potential sediment impacts to coral habitat in the offshore platform location during project construction will result in some losses of future sexual and asexual recruits due to impacts to this settlement habitat. Despite the estimated loss of sexually reproductive individuals due to the proposed action, we do not believe that sexually mature rough cactus corals in the action area will be affected to a degree that will cause long-term damage to the species' ability to sexually reproduce. As for other ESA-listed coral species in the action area, rough cactus corals are present on other portions of the fringing reefs outside Jobos Bay. Data from EPA coral surveys indicate that there are other areas within the same reef system that have rough cactus coral colonies, though apparently not at the numbers estimated for the offshore site although this could be because the EPA surveys are limited to shallower water depths or because we overestimated the potential number of colonies present at the proposed offshore platform site. There are also additional patch reef areas in deeper waters where EPA does not survey that have the same habitat characteristics as the offshore platform site and likely contain colonies of rough cactus corals.

Distribution

The relocation of the 6 rough cactus coral colonies prior to in-water construction at the offshore platform site and the loss of rough cactus coral colonies from the same site due to chronic impacts will not result in changes to the overall distribution pattern of the species in Puerto Rico or the wider Caribbean. Therefore, we believe that the proposed action will not result in a reduction in the overall distribution of rough cactus corals.

Likelihood of Survival
Whether the expected reduction in reproduction of rough cactus corals will appreciably reduce its likelihood of survival depends on the probable effect the changes in reproduction would have relative to the current population levels and trends. Low encounter rate and low percent cover as well as a tendency to identify *Mycetophyllia* only to genus in surveys make it difficult to discern population trends from monitoring data. However, reported losses of rough cactus corals from monitoring stations in the Florida Keys and Dry Tortugas indicate populations have declined in these areas. Based on the declines in Florida, the listing rule concludes that rough cactus coral has likely declined throughout its range. The population of the species is estimated as at least hundreds of thousands of colonies based on estimates from 2 locations, meaning absolute abundance is higher because the species occurs in many other locations throughout its range.

Rough cactus coral is a hermaphroditic brooding species with very low recruitment, even in the 1970s when coral populations were larger. Recruitment of the species was not observed over a 10-year period at a reef in USVI even though adult colonies were present in the area (Rogers and Garrison 2001). However, the species has been classified as generalist, weedy, competitive, and stress-tolerant (Darling et al. 2012), meaning that it is expected to be more resistant to environmental stress. As discussed in other sections of this document (see, for instance, Section 5.2), EPA coral sampling data from 2010 and 2011 in the action area documented the presence and coverage in m^2 of ESA-listed corals, including rough cactus corals and we used the EPA data and data from surveys conducted for the project to obtain estimates of the approximate number of rough cactus coral colonies that may be impacted by the proposed project. The applicant also provided estimates of the approximate numbers of the different ESA-listed coral species observed at the proposed offshore platform site, including rough cactus corals. Given the presence of rough cactus corals on the coral reefs fringing Jobos Bay and in deeper water hard bottom habitat and patch reefs, we believe the proposed project will not result in an appreciable reduction in the likelihood of survival of rough cactus coral.

Rough cactus coral occurs throughout the Caribbean and western Atlantic with a few exceptions where it is not reported as noted above. The species' absolute abundance is in the hundreds of thousands based on estimates from only 2 locations. Impacts to the species' areal coverage associated with the loss of colonies due to the construction and operation of the proposed project would likely be undetectable on a Caribbea-wide scale. Therefore, we believe the loss of 126 rough cactus coral colonies (1 from transplant mortality and the rest due to chronic impacts) in the action area will not have any measurable effect on the overall population and is not likely to appreciably reduce the species likelihood of survival in the wild.

Likelihood of Recovery
Rough cactus corals were listed as threatened in September 2014 and we do not have an extensive consultation history for the species. A recovery plan is not available for rough cactus

corals but, as for pillar corals, NMFS has developed a recovery outline (available at http://sero.nmfs.noaa.gov/protected_resources/coral/documents/recovery_outline.pdf). The outline is meant to serve as an interim guidance document to direct recovery efforts, including recovery planning, until a full recovery plan is developed and approved. The Summary Assessment in the recovery outline concludes that population trends for rough cactus coral are unknown but the species does appear to have experienced a decline in Florida. Therefore, recovery will depend on successful sexual reproduction and reducing mortality of extant populations. The key challenges will be moderating the impacts of ocean warming associated with climate change and decreasing susceptibility to disease which may be furthered through reduction of local stressors. The recovery of this species will require an ecosystem approach including habitat protection measures, a reduction in threats caused by human activity, additional research, and time. The recovery vision for the species concludes that it should be present across the historical range, with populations large enough and genetically diverse enough to support successful reproduction and recovery from mortality events and dense enough to maintain ecosystem function. Recovery will require conservation of the coral reef ecosystem through threats abatement to ensure a high probability of survival into the future.

To determine if the proposed action will appreciably reduce the likelihood of recovery for rough cactus corals, we will evaluate the proposed action's impacts, if any, on the key elements of the recovery outline discussed above. We can, therefore, assess the effects of the proposed action on rough cactus coral in the context of our knowledge of the status of the species, its environmental baseline, and the extinction risk analyses in the listing rule. The final listing rule identifies this species' abundance, life history characteristics, and threat vulnerabilities as characteristics that increase extinction risk. Its low abundance, combined with its geographic location, exacerbates vulnerability to extinction. This species can be found in depth ranges from 5 – 90 m. Rough cactus corals are present in the action area in the deeper waters where the offshore platform is proposed and in lower numbers in shallow waters at Boca del Infierno and other locations along the fringing reef outside Jobos Bay. The proposed action will not affect the species' life history characteristics. Similarly, the proposed action will not increase the magnitude of or the species' vulnerability to climate change threats such as ocean warming but the proposed action will cause and increase sedimentation in the action area. These effects will be chronic in the 4.1 ac area of the proposed offshore platform where rough cactus corals are present. Effects to these habitats are likely to result in the loss of substrate for larval attachment into the foreseeable future due to the operation of the platform. In addition, the reproductive potential of the species will be diminished either temporarily (due to transplant) or permanently (due to the mortality of 1 transplanted colonies and chronic impacts to the 125 colonies to remain at the platform) due to the operation of the offshore gasport. The area affected is a small portion of the species' range. The species are still present in Puerto Rico and the losses will not affect the overall density and distribution of the species or impede sexual reproduction. Therefore, we believe the increased sedimentation resulting from the proposed action will not increase the magnitude of this threat range-wide to levels that will appreciably reduce the species' ability to recover in the wild.

Habitat improvement is vital to recovery of ESA-listed species and may lead to increased survival. The loss of 4.1 ac of habitat in the area of the proposed offshore platform is not likely to be enough to affect future recruitment, growth and survival of rough cactus corals in the action area. This habitat represents only 0.7% of the available coral habitat in the action area and is part of a deeper water patch reef system based on limited surveys conducted by the applicant.

The area affected is a small portion of the species' range and as stated in the listing rule, the habitat heterogeneity of the species allows for variation in the responses of individuals to threats to play a role in moderating vulnerabilities to extinction. The proposed action may cause the mortality of up to 126 existing rough cactus coral colonies (1 from transplant mortality and 125 from chronic impacts associated with the construction and operation of the offshore platform). The data from EPA indicate that there are other colonies of the species present in the action area so losses will not affect overall density and distribution of the species or lead to detectable effects to reproduction of the species in the action area. Therefore, we believe that the increased sedimentation and other impacts to rough cactus corals resulting from the proposed action will not increase the magnitude of the threats that led to the listing of the species as threatened range wide to levels that will appreciably reduce these species' ability to recover in the wild.

We conclude the proposed action is not likely to jeopardize the continued existence of rough cactus coral in the wild.

Lobed Star, Mountainous Star, and Boulder Star Corals

In Section 6.3 and the following analysis, we find that there will be take of lobed star, mountainous star, and boulder star coral associated with the construction and operation of the proposed Aguirre Offshore GasPort. Take includes:

- 26 lobed star, 146 mountainous star, and 15 boulder star coral colonies that will be transplanted out of the in-water pile construction footprint at the offshore platform site, of which 3 lobed star, 15 mountainous star and 1 boulder star colonies are expected to die
- 499 lobed star, 2,832 mountainous star, and 292 boulder star coral colonies that will remain in the area of the offshore platform and be affected by the construction and operation of the platform
- 31 – 54 future lobed star coral colonies for a total of up to 1,890 over the 35-year operational lifetime of the project, 707 – 1,220 future mountainous star coral colonies for a total of up to 42,700 over the 35-year operational lifetime of the project, and 1 future boulder star coral colony for a total of 35 over the 35-year operational lifetime of the project

Abundance

The star coral complex has historically been dominant on coral reefs in the Caribbean and has been the major reef builder in the Caribbean since elkhorn and staghorn corals began to decline in abundance. However, multiple examples indicating the population of corals from the star coral complex are in decline are reported from various countries including the U.S. (Florida, Keys, USVI, and Puerto Rico), Curaçao, Belize, and Colombia, among others. Corals from this species complex are still distributed throughout the greater Caribbean. The proposed action will not affect the life history vulnerabilities of lobed star, boulder star, and mountainous star corals. The listing rule concluded that despite decreases in populations of these corals, species from this complex continue to be reported as the dominant coral taxa. The rule states that the major threats faced by these corals are high vulnerability to ocean warming, acidification, disease, sedimentation, and nutrients with some susceptibility to trophic effects of fishing and sea level rise. The proposed action will not increase the magnitude of the species' vulnerability to disease, ocean warming, acidification, tropic effects of fishing, and nutrient enrichment in the action area; however, the proposed action will cause increases in sedimentation in the action area. These affects will be chronic in the area of the proposed offshore platform where lobed star, boulder star, and mountainous star coral colonies are located. As for other areas in the Caribbean, corals from the star coral complex dominate in the action area where the project is located.

We conclude that this action will result in a reduction in numbers of these species. There will be 26 lobed star, 146 mountainous star, and 15 boulder star coral colonies transplanted outside the in-water pile footprint from the proposed offshore platform location. Of these, we anticipate that up to 3 of the lobed star, 15 of the mountainous star, and 1 of the boulder star coral colonies will suffer mortality as a result of transplant. The other colonies to be transplanted are not expected to suffer full mortality but they are expected to be temporarily affected by the stress of transplantation. The remaining 499 lobed star, 2,832 mountainous star, and 292 boulder star coral colonies are expected to experience stress from sediment resuspension and transport during construction and operation of the facility, discharges of superheated water and brine from the FSRU, and discharge of copper ions. Given that the estimated operational lifetime is 35 years, we expect these colonies to suffer full or partial mortality as a result of chronic stress. We also anticipate up to 1,890 future lobed star coral colonies, up to 42,700 future mountainous star coral colonies, and up to 35 future boulder star coral colonies will be lost over the 35-year operational lifetime of the project as a result of the seawater intakes on the FSRU. These impacts represent a reduction in numbers of the 3 species from the star coral complex in the action area. The reduction in numbers of these corals in the action area is also expected to result in a loss of reproductive potential, as described below.

Reproductive Potential

Based on information from a limited coral demographic survey completed for the project, we estimate that approximately 9% of the *Orbicella* spp. colonies that will be affected by the proposed action are sexually mature. Only mountainous star corals were encountered and measured during the demographic survey, so we use the information for this species as the best available data for the other 2 star coral species from this species complex because a study done in Puerto Rico found that all 3 of the species in this complex had the same minimum size at reproduction (Szmant et al. 1997). This means that up to 2 of the lobed star, 13 of the mountainous star, and 1 of the boulder star coral colonies to be transplanted could be sexually mature. Because 3 lobed star, 15 mountainous star, and 1 boulder star coral colony are expected to suffer mortality due to transplantation, all of the sexually mature corals from each species may die and be removed from the pool of sexually mature individuals. Even if all the transplanted colonies of each species survive, they would be temporarily lost from the reproductive pool for 1 – 2 years due to transplant stress based on our observations of the time it takes for sexually mature corals to recover following other relocation projects.

In the area of the offshore platform, 45 of the 499 lobed star, 255 of the 2,832 mountainous star, and 26 of the 292 boulder star coral colonies that will remain at the site and experience mortality are expected to be sexually mature. There will also be a loss of 1,890 lobed star, up to 42,700 mountainous star, and up to 35 boulder star coral future recruits of each species over the estimated 35-year operational lifetime of the project as discussed above and in Section 6.3 due to entrainment of coral larvae in seawater intakes. The potential sediment impacts to coral habitat in the offshore platform location during project construction will also result in some additional losses of future sexual and asexual recruits due to impacts to settlement habitat. Despite the estimated loss of sexually reproductive individuals due to the proposed action, we do not believe that sexually mature lobed star, mountainous star, and boulder star corals in the action area will be affected to a degree that will cause short or long-term damage to the species' ability to sexually reproduce. We base this conclusion in part on the data collected by the limited demographic survey conducted for the project indicating that many of the *Orbicella* corals in the area are small and could therefore be expected to grow to sexual maturity if the pattern observed in the study applies to other areas of the same reef complex.

Distribution
Although we believe the project will lead to a loss of reproductive potential related to the loss of sexually mature lobed star, mountainous star, and boulder star coral colonies and future colonies and the temporary loss of reproductive potential due to transplant stress, we do not expect that the proposed action will alter the geographic range for the species. Therefore, we do not expect that the proposed action will result in a reduction in the overall distribution of lobed star, mountainous star, and boulder star corals.

Likelihood of Survival
Whether the reduction in numbers and reproduction of these species would appreciably reduce their likelihoods of survival depends on the probable effect these changes would have relative to current population levels and trends. Information on the distribution and cover of lobed star, mountainous star, and boulder star corals around Puerto Rico indicate that they are dominant on mesophotic reefs in Puerto Rico and USVI at depths up to 90 m, although boulder star coral tends to be the most dominant species at greater depths. Species from this complex often make up the largest proportion of coral cover on Caribbean reefs, including survey sites on several reefs in Puerto Rico despite impacts from the 1998 and 2005 mass bleaching events. Lobed star coral alone has been estimated as having an absolute abundance of at least tens of millions of colonies in the Florida Keys and Dry Tortugas combined. Mountainous star coral's absolute population abundance has been estimated as at least tens of millions of colonies in each of several locations including the Florida Keys, Dry Tortugas, and USVI. Boulder star coral's absolute population abundance has been estimated as at least tens of millions of colonies in the Dry Tortugas and USVI. All 3 species' range wide abundances are higher than the estimate from these locations due to the occurrence of the species in many other areas throughout their ranges.

Information in the listing rule indicates that fertilization success is general low for all 3 *Orbicella* species and successful sexual recruitment has seemingly always been rare. All 3 species are largely self-incompatible meaning that the number of colonies spawning can affect the success of fertilization. Species from the star coral complex occur throughout the Caribbean and western Atlantic and the corals in the action area account for a very small portion of the total numbers of or area occupied by these 3 species. The species' absolute abundances are in the tens of millions of colonies for each species based on estimates from several locations. The loss of the reproductive potential represented by the loss of 3 lobed star, 15 mountainous star, and 1 boulder star coral colony due to transplant mortality; 499 lobed star, 2,832 mountainous star, and 292 boulder star coral colonies due to chronic stress; and up to 1,890 lobed star, 42,700 mountainous star, and 35 boulder star coral future recruits from the action area of 35 years will not measurably impact the species' abundance in Puerto Rico or throughout the species' range. Impacts to the areal coverage of all 3 species would also likely be undetectable on a range-wide scale. Therefore, we believe the loss of colonies of lobed star, mountainous star, and boulder star corals due to the construction and operation of the Aguirre Offshore GasPort project will not appreciably reduce the likelihood of these species' survival in the wild.

Likelihood of Recovery

As stated previously for the other species that were listed in September 2014 that will also be affected by the proposed action, there is no recovery plan for these species. However, the recovery plan developed by NMFS (available at http://sero.nmfs.noaa.gov/protected_resources/coral/documents/recovery_outline.pdf) is meant to serve as interim guidance to direct recovery efforts and planning until a full recovery plan is finalized. The Summary Assessment in the recovery outline concludes that overall, available data indicate *Orbicella* coral populations are on the decline and that recovery will depend on successful reproduction and reducing mortality of extant populations. The key challenges will be moderating the impacts of ocean warming associated with climate change and decreasing susceptibility to disease which may be furthered through a reduction of local stressors. The recovery vision statement in the outline states that populations of lobed star, mountainous star, and boulder star corals should be present across their historic ranges with populations large enough and genetically diverse enough to maintain ecosystem function. Given that many of the important threats to the recovery of these species are not directly manageable, the recovery strategy must pursue actions both in the short and long-term to address both global and local threats. The initial focus of the recovery action plan will be to protect extant populations and the species' habitat through reduction of threats. Specific actions identified for early in the recovery process are reducing locally-manageable stress and mortality sources (e.g., acute sedimentation, nutrients, contaminants, and over-fishing).

Therefore, to determine if the proposed action will appreciably reduce the likelihood of these species' recovery, we will evaluate the proposed action's impacts, if any, on the key elements of the recovery outline discussed above. These species' life history characteristics of large colony size and long life span have enabled them to remain relatively persistent despite slow growth and low recruitment rates, thus moderating vulnerability to extinction. However, the buffering capacity of these life history characteristics is expected to decrease as colonies shift to smaller size classes as has been observed in locations throughout their ranges. The proposed action will not affect these life history vulnerabilities. The proposed action will not increase the magnitude of or the species' vulnerability to ocean warming, disease, nutrient enrichment, or acidification; however, the proposed action will cause and increase in sedimentation in the action area. These effects will be chronic in the 4.1 ac area of the proposed offshore platform where mountainous star coral colonies were observed and lobed and boulder star corals are also likely to be present,. Effects to these habitats are likely to result in the loss of larval attachment substrate into the foreseeable future. In addition, the reproductive potential of all 3 species will be diminished either temporarily due to transplant stress or permanently due to operation of the offshore platform. The area affected is a small portion of these species' ranges and, as stated in the listing rule, the absolute abundance and habitat heterogeneity of these species allows for variation in the responses of individuals to threats to play a role in moderating vulnerability to extinction. The proposed action will cause mortality to coral colonies, particularly of mountainous star coral, as well as the loss of future recruits of all 3 species due to the entrainment of coral larvae in seawater intakes over the 35-year operational lifetime of the project. The species are still common in Puerto Rico and the losses will not affect overall density and distribution of the species or impede sexual reproduction. Therefore, we believe the increased sedimentation resulting from the proposed action will not increase the magnitude of this threat range wide to levels that will appreciably reduce these species' ability to recover in the wild.

Habitat improvement is vital to recovery of ESA-listed species and may lead to increased survival. The loss of 4.1 ac of habitat in the area of the proposed offshore platform is not likely to affect future recruitment, growth and survival of lobed star, mountainous star, and boulder star corals in the action area given the small percentage of habitat the 4.1 ac represent in comparison to available coral habitat in the action area. The applicant is not proposing compensatory measures to offset any loss of habitat availability and function at the offshore platform site.

The area affected is a small portion of the species' range and as stated in the listing rule, the habitat heterogeneity of the species allows for variation in the responses of individuals to threats to play a role in moderating vulnerabilities to extinction. The proposed action will cause the mortality of up to 502 existing lobed star, 2,847 existing mountainous star, and 293 existing boulder star coral colonies and the loss of 1,890 future colonies of lobed star, 42,700 future colonies of mountainous star, and 35 future colonies of boulder star corals. The data from EPA indicate that there are other colonies of the star coral complex present in the action area so losses will not affect overall density and distribution of any of the species or lead to detectable effects to reproduction of any of the species in the action area. Therefore, we believe that the increased sedimentation and other impacts to lobed star, mountainous star, and boulder star corals resulting from the proposed action will not increase the magnitude of the threats that led to the listing of all 3 species as threatened range wide to levels that will appreciably reduce these species' ability to recover in the wild.

We conclude the proposed action is not likely to jeopardize the continued existence of lobed star, mountainous star, and boulder star coral in the wild.

8.2 Critical Habitat Destruction/Adverse Modification Analysis

When determining the potential impacts to critical habitat for this Opinion, NMFS relies on the regulatory definition of "destruction or adverse modification" of critical habitat from the final rule issued by NMFS and USFWS (81 FR 7214) on February 11, 2016. Under the final rule, destruction or adverse modification means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features.

Ultimately, we seek to determine if, with the implementation of the proposed actions, critical habitat would remain functional (or retain the current ability for the essential features to become functional) to serve the intended conservation role for the species. This analysis takes into account the geographic and temporal scope of the proposed actions, recognizing that "functionality" of critical habitat necessarily means that it must now and must continue in the future to support the conservation of the species and progress toward recovery. The analysis must take into account any changes in amount, distribution, or characters of the critical habitat that will be required over time to support the successful recovery of a/the species.

Within the Puerto Rico elkhorn and staghorn coral critical habitat marine unit, approximately 292 mi^2 (756 km^2) are likely to contain the essential element of ESA-designated elkhorn and staghorn coral critical habitat, based on the amount of coral, rock reef, colonized hard bottom, and other coralline communities mapped by NOAA's NOS Biogeography Program in 2000 (Kendall et al. 2001). The key objective for the conservation and recovery of Atlantic acroporid corals that is the basis for the critical habitat designation is the facilitation of an increase in the incidence of sexual and asexual reproduction. Recovery cannot occur without protecting the essential feature of coral critical habitat from destruction or adverse modification because the quality and quantity of suitable substrate for ESA-listed corals affects their reproductive success. As noted in the rule designating acroporid coral critical habitat (73 FR 72210, November 26, 2008), the loss of suitable habitat is one of the greatest threats to the recovery of listed elkhorn and staghorn coral populations. Man-made stressors have the greatest impact on habitat quality for listed elkhorn and staghorn corals.

The loss of the essential feature or a diminution in the function of the essential feature affects the reproductive success of listed elkhorn and staghorn corals because substrate for sexual recruits to settle is lost or unavailable. Critical habitat was designated for elkhorn and staghorn corals, in part, because further declines in the low population sizes for these species could lead to an Allee effect (decline in individual fitness at low population size or density that can result in critical population thresholds below which populations crash to extinction), and a reduced source of fragments for asexual reproduction and recruitment. In other words, colonies may be separated by too much distance for successful sexual reproduction to occur. Isolation of settlement habitat and declines in the quality of habitat for coral larvae to settle and grow exacerbate the problem.

Therefore, the key conservation objective of designated acroporid coral critical habitat is to increase the potential for successful sexual and asexual reproduction, which in turn facilitates increases in the species' abundance, distribution, and genetic diversity. To this end, our analysis seeks to determine whether or not the proposed action is likely to destroy or adversely modify designated critical habitat, in the context of the Status of Elkhorn and Staghorn Coral Critical Habitat (Section 4.2.3), the Environmental Baseline (Section 5), the Effects of the Action (Section 6.3), and Cumulative Effects (Section 7). Ultimately, we seek to determine if critical habitat would remain functional to serve the intended conservation role for the species with the implementation of the proposed action, or whether the conservation function and value of critical habitat is appreciably diminished through alterations to the physical or biological features essential to the conservation of a species or because of significant delays in the development of these features. The first step in this analysis is to evaluate the project's expected effects on the species' ability to meet identified recovery objectives relevant to the key conservation objective of critical habitat, given the effects of the proposed action.

The most directly relevant recovery objective in the *Acropora* Recovery Plan related to the proposed Aguirre Offshore GasPort on critical habitat is Criterion 6.

> **Criterion 6: Loss of Recruitment Habitat (Listing Factor A)**
> Abundance (Criterion 1) addresses the threat of Loss of Recruitment Habitat because the criterion specifies the amount of habitat occupied by the 2 species. If [Abundance] Criterion 1 is met, then this threat is sufficiently abated;
>
> or
>
> Throughout the range of these 2 species, at least 40% of the consolidated reef substrate in 1 – 20 m depth within the forereef zone remains free of sediment and macroalgal cover as measured on a broad reef to regional spatial scale.

As indicated below, Abundance Criterion 1 is not expected to be met, so this analysis focuses on the proposed action's effects on the second, alternative prong of Criterion 6. The proposed action is expected to eliminate 0.2 ac of the essential feature in depths of 60 ft (18 m) at the offshore platform with an additional 3.9 ac at this depth likely to suffer chronic impacts as a result of project operation. On the south coast of Puerto Rico in areas such as the action area that includes the reef system in Salinas and Ponce there are coral reefs and colonized hard bottom but many of these areas no longer have high coral cover, likely due to stressors from coastal development that lead to the transport of land-based pollutants to nearshore waters (Garcia-Sais et al. 2008). Jobos Bay is the second largest estuary in Puerto Rico but has more than 3 times the shoreline of any other estuarine area on the island (Zitello et al. 2008), including the shorelines along the cays fringing the bay. Coral reefs are one of the most productive habitats associated with Jobos Bay (Whitall et al. 2011). As discussed previously, the fringing reef system in the action area was found to contain high levels of coral cover and well-developed coral communities based on unpublished data from EPA's coral surveys.

Based on benthic surveys conducted for the Aguirre Offshore GasPort project and EPA's coral surveys, within the fringing reef system, the coral community in the area of Boca del Infierno has high coral cover and diversity. An inventory of the reefs in Puerto Rico published in 1979 identified this reef system as having moderate to high coral cover with cover increasing westward from Cayos de Pájaros and Cayos de Barca toward Cayos Caribe and Boca del Infierno (Goenaga and Cintrón 1979). Based on surveys conducted in 1995, 2003, and 2013, species of coral, including lobed star coral, that were some of the most vulnerable species to the 2005 mass bleaching event did not show measurable differences in live cover over time in this reef system (Garcia-Sais et al. 2014) suggesting that this reef system is important in maintaining populations of sensitive coral species. The system historically contained elkhorn coral in shallow areas, including those that are almost exposed during low tide, but now has mainly standing dead relict colonies (Garcia-Sais et al. 2014), although the EPA survey data contradict some of the findings of Garcia-Sais et al. (2014) because EPA found areas, such as Boca del Infierno, with living elkhorn coral colonies. Staghorn corals are found in deeper waters based on unpublished data from EPA coral surveys and surveys conducted for this project. There are approximately 533.75 ac of coral reef and hard bottom habitats in the action area based on NOAA benthic mapping.

The loss of 4.1 ac represents a 0.7% (4.1 ac divided by 533.75 ac of essential feature times 100) reduction in reef and hard bottom habitat on a broad reef scale from the Jobos Bay fringing reef system. A study by Zitello et al. (2008) characterized the 9 watersheds that make up the Jobos Bay system and found that several of the agricultural and urban watersheds contribute significant amounts of total nitrogen, total phosphorus and sediment to the bay. Pollutant and sediment loading from watersheds that drain into Jobos Bay were buffered by the extensive coastal wetlands and marine habitats in the bay itself while the Barrio Jobo sub-watershed on the west with its developed lands (residential and industrial) was a major contributor of sediment, total nitrogen and total phosphorus to nearshore waters in and outside the bay (Zitello et al. 2008). The reefs off this portion of Guayama are part of a protected area that adjoins JBNERR. Surveys of the reefs in 2013 found only standing dead elkhorn coral colonies and high algal cover (Garcia-Sais et al. 2014) that may be partially attributed to this loading of land-based sources of pollutants from the watershed. On the other hand, both live and dead elkhorn coral colonies were found on the reefs off the cays fringing Jobos Bay, potentially due to the limited human disturbance in this reef area versus Guayama. Recent studies from the USVI have found that sediment levels as low as 3 mg per cm^2 per day can cause large increases in the proportion of corals experiencing impairment, partial mortality, and bleaching if sediment is terrigenous in nature (Smith et al. 2013b). Monitoring sites along the southwest coast of Puerto Rico with similar reef structure were found to have higher coral cover as distance from shore and light attenuation increased (Garcia-Sais et al. 2008).

Based on the current information, the essential feature in the Puerto Rico unit has been significantly affected by development, sedimentation, and increased macroalgal cover, though to a lesser extent in the action area because portions of the area are within JBNERR. The proposed action will cause the loss of 0.2 ac in the direct impact footprint of the offshore platform and chronic episodic degradation of another 3.9 ac in 18 m water depth associated with the operation of the offshore platform. The loss of 4.1 ac from the project would comprise about 0.002% of total hard bottom and coral reef for the entire island of Puerto Rico and a 0.7% loss of hard bottom and coral reef from the fringing reef system in the action area. Actual percent losses of the essential feature may be higher, given the impacted baseline of the hard bottom around Puerto Rico from sedimentation (especially terrigenous sediments) and macroalgal cover. However, extensive areas of coral reef and colonized hard bottom where staghorn and elkhorn coral are known to occur based on surveys by EPA are present in the action area. In addition, the patch reefs where the offshore platform is proposed are not as well developed as the fringing reef complex associated with the coral cays based on benthic surveys completed by the applicant and NOAA surveys conducted in the action area. Patch reef habitat is present outside the area to be impacted by the offshore platform as well and appears to be more extensive than the habitat where the platform is proposed based on information from the applicant. Shallow water depths on the fringing reefs are within the preferred water depth zone of elkhorn coral and the areas where this species has been observed in surveys conducted for this project, by NOAA and by the EPA. While water depths at the offshore platform site are favorable for staghorn coral growth, no colonies were reported from the video surveys of the area conducted by the applicant to date. Therefore, the coral reefs and colonized hard bottom outside the impact footprint from construction and operation of the offshore platform are expected to continue to provide high quality settlement habitat for elkhorn and staghorn corals. Based on this we believe that the proposed action will not appreciably reduce the Puerto Rico unit's ability to reach recovery Criterion 6 for elkhorn coral and staghorn coral.

The effects of the proposed action on acroporid recruitment habitat will also affect the essential feature's ability to support recovery criteria 1 and 3. These objectives encompass recruitment and abundance increases that are the key conservation objective for designated critical habitat.

> ***Criterion 1**: Abundance*
> **Elkhorn coral:** Thickets are present throughout approximately 10 percent of consolidated reef habitat in 1 to 5 m water depth within the forereef zone. Thickets are defined as either a) colonies ≥ 1 m diameter in size at a density of 0.25 colonies per m^2 or b) live elkhorn coral benthic cover of approximately 60 percent. Populations with these characteristics should be present throughout the range and maintained for 20 years.
>
> **Staghorn coral:** Thickets are present throughout approximately 5 percent of consolidated reef habitat in 5 to 20 m water depth within the forereef zone. Thickets are defined as either a) colonies ≥ 0.5 m diameter in size at a density of 1 colony per m^2 or b) live staghorn coral benthic cover of approximately 25 percent. Populations with these characteristics should be present throughout the range and maintained for 20 years.
>
> ***Criterion 3: Recruitment*** (for elkhorn and staghorn**)**
> Observe recruitment rates necessary to achieve Criteria 1 and 2 (Genotypic Diversity) over approximately 20 years;
> and
> Observe effective sexual recruitment (i.e., establishment of new larval derived colonies and survival to sexual maturity) in each species' population across their geographic range.

The proposed action will result in the loss of 0.2 ac in 18 m in the footprint of the platform and the degradation of 3.9 additional ac in 18m in an area we believe will play an important role in the recovery of elkhorn and staghorn corals given the relatively undisturbed nature of the site and the lack of land-based pollutant impacts based on studies in the area (Garcia-Sais et al. 2014; Zitello et al. 2008). McLaughlin et al. (2002) found that when distributions of coral species become isolated because of habitat loss, populations become more vulnerable to climate change and other threats. The loss and degradation of the habitat patches within the impact footprint of the offshore platform will affect the availability of areas for coral larvae to settle. Information on current movement provided by the applicant indicates that wind-driven transport dominates and is mainly to the west. The area of Boca del Infierno and the associated fringing reef complex outside Jobos Bay is one of the few areas where live elkhorn coral colonies are present along this portion of the coast (Garcia-Sais et al. 2014) and where staghorn coral colonies are common, which means that the area is likely a source of sexual recruits . Larvae are only viable for a short time so larger distances between areas of suitable habitat for elkhorn and staghorn corals make settlement and recruitment less likely. However, because there are no elkhorn or staghorn coral colonies reported on the patch reefs in the footprint of the offshore platform, but these corals are reported from various locations along the fringing reefs in the action area, we do not believe the ability of larvae of these species to settle will be significantly affected. In addition, elkhorn and staghorn corals' primary mode of reproduction is through fragmentation. A branch of elkhorn or staghorn coral may be carried by waves and currents away from the parent colony, and fragments cleaved from the colony may grow into new colonies (Highsmith et al. 1980; Bak and Criens 1982; Highsmith 1982; Rogers et al. 1982). Genetically identical clones have been found separated by distances that range from 0.1 to 100 m (0.3 to 328 ft), but usually less than 30 m (98 ft) (Baums et al. 2006a). The horizontal length of the opening in Boca del Infierno is approximately 2000 ft so we expect elkhorn corals to continue to reproduce asexually in the area of Boca del Infierno. Staghorn corals, although not found during limited surveys performed at the offshore platform site by the applicant would also be able to continue reproducing asexually in the Boca del Infierno area and along other portions of the fringing reefs as well as potentially other patch reef habitats in deeper waters if colonies are present. As no colonies of elkhorn or staghorn corals were reported in the area where the offshore platform is proposed and given the distance from the fringing reef areas where these species were observed during EPA surveys, it is unlikely that fragments would be transported to the offshore platform location versus settling near existing colonies. If fragments were transported to the offshore platform site, it is unlikely they would successfully grow there due to the probability of continuous sediment resuspension, inputs of copper, and other chronic impacts to benthic habitat at the offshore platform site during operation of the project as discussed in this document.

As discussed above, the loss of 4.1 ac from the project would comprise about 0.002 % of hard bottom for the entire island of Puerto Rico and a 0.7% loss from the Cayos Caribe/Pájaros/Barca/Morillo reef system. Actual percent losses are likely higher, given the impacted baseline of the hard bottom around Puerto Rico from sedimentation (especially terrigenous sediments) and macroalgae. The proposed action will marginally reduce areas for effective recruitment and population growth due to lack of settlement habitat in the area of the offshore platform.

The effects of sedimentation and macroalgal growth on acroporid recruitment habitat discussed above and in our analysis of Criterion 6, indicates the second prong of abundance Criterion 1 for elkhorn coral is less likely to be met in the area of the offshore platform as a result of the proposed action. However, because there are no elkhorn coral colonies reported in the area of the offshore platform and the site is outside the preferred depth range of the species of 1.5 – 14 m, we believe the proposed action will not appreciably reduce the chances of the Puerto Rico unit achieving recovery Criterion 1 and 3 for elkhorn coral.

Criteria 1 for staghorn coral calls for thickets present throughout approximately 5 percent of consolidated reef habitat in 5 to 20 m water depth within the forereef zone or live staghorn coral benthic cover of approximately 25%. The proposed action will cause the loss of 4.1 ac of essential feature in 18 m water depth. As discussed above, surveys completed in the action area found high numbers of staghorn coral colonies on some of the reefs in the action area, particularly in the Boca del Infierno area. No staghorn coral colonies were found during limited surveys by the applicant at the offshore platform site but could be present. However, we believe the proposed action will not appreciably reduce the chances of the Puerto Rico unit achieving recovery Criterion 1 and 3 for staghorn coral because the habitat area to be lost represents a small fraction of the available area containing the essential feature in the action area and there are numerous staghorn coral colonies reported in other reef and colonized hard bottom sites around the proposed offshore platform.

Based on the above, we conclude that the conservation value of designated critical habitat in the Puerto Rico unit will not be appreciably diminished for elkhorn and staghorn coral due to the proposed action.

Whether the effects of the action will appreciably diminish the conservation value of critical habitat depends on the impacts on designated critical habitat as a whole, not just in the area where the action takes place. The question we must ask is whether the adverse effects in that one part of the critical habitat will diminish the conservation value of the critical habitat overall in such a manner that we can discern a difference in the recovery prospects of the species due to the effects of the project. For example, if we conclude that the effects of the proposed action on designated critical habitat will delay recovery, or make recovery more difficult or less likely, we will conclude the effects of the project are likely to destroy or adversely modify designated critical habitat.

In the status of the species section, we document that there has been a significant decline of elkhorn and staghorn coral throughout their ranges, with recent population stability at low percent coverage. We also concluded that absolute abundance is at least hundreds of thousands of colonies for elkhorn corals and tens of millions of colonies for staghorn, but likely to decrease in the future with projected increases in threats. The above analysis has shown despite increasing sedimentation and macroalgal cover in Puerto Rico, the proposed action will not appreciably diminish the Puerto Rico unit’s conservation value. The critical habitat designation for elkhorn and staghorn corals identified 4 units within the jurisdiction of the United States where the physical feature essential to the species’ conservation is protected from destruction or adverse modification: Florida, Puerto Rico, St. Thomas/St. John, and St. Croix. Given the extremely low current abundance of elkhorn and staghorn coral and characteristics of their sexual reproduction (e.g., limited success over long ranges), we determined that protecting the essential feature throughout the species’ range and throughout each of the four specific areas is extremely important for conservation of these species. As discussed above, the best evidence of recovery would come from scientific evidence showing an increase in the overall amount of living tissue of these species, growth of existing colonies, and an increase in the number of small corals arising from sexual recruitment. None of these trends are currently observed or expected to be promoted by the proposed action but the action area does contain a significant number of elkhorn and staghorn coral colonies and a large amount of habitat containing the essential feature of elkhorn and staghorn coral critical habitat. The impacts to this habitat from the proposed action is a very small fraction of the habitat in the action area and the Puerto Rico unit as a whole available to elkhorn and staghorn corals for settlement, growth, and sexual and asexual recruitment. We expect the rest of the habitat containing the essential feature in the action area to continue providing these functions. Thus, recovery of these species in Puerto Rico will not be delayed or made more difficult as a result of the proposed action. Because there will be no appreciable reduction in the Puerto Rico unit's conservation value for elkhorn and staghorn coral, the project impacts will not cause an appreciable reduction in the designated critical habitat’s conservation value rangewide. Therefore, we believe that the proposed action will not destroy or adversely modify designated *Acropora* critical habitat for elkhorn and staghorn coral.

9 CONCLUSION

After reviewing the current status of elkhorn, staghorn, pillar, rough cactus, lobed star, mountainous star, and boulder star corals and elkhorn and staghorn coral critical habitat, the environmental baseline, the effects of the proposed action, and cumulative effects, it is NMFS's Biological Opinion that the proposed action in not likely to jeopardize the continued existence of elkhorn, staghorn, pillar, rough cactus, lobed star, mountainous star, and boulder star corals; and will not lead to the destruction or adverse modification of critical habitat designated for elkhorn and staghorn coral.

10 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and federal regulations issued pursuant to Section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively. Section 7(b)(4) of the ESA requires NMFS to issue a statement specifying the amount and impact of any incidental take on listed species, which results from an agency action otherwise found to comply with Section 7(a)(2) of the ESA. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct. Incidental take is defined as take that is incidental to, and the purpose of, the carrying out of an otherwise lawful activity. Incidental take statements serve a number of functions, including providing reinitiation triggers for all anticipated take, providing exemptions from Section 9 liability for prohibited take, and identifying reasonable and prudent measures that will minimize the impact of anticipated incidental take.

10.1 Amount or Extent of Take

NMFS anticipates:

- the lethal take of 2 pillar, 1 rough cactus, 3 lobed star, 15 mountainous star, and 1 boulder star coral colonies and the nonlethal take of 19 pillar, 5 rough cactus, 23 lobed star, 131 mountainous star, and 14 boulder star coral colonies that will be transplanted from the offshore platform pile footprints

- the take of up to 287 future elkhorn, 54 future staghorn, 179 future pillar, 54 lobed star, 1,220 future mountainous star, and 1 future boulder star coral colonies annually due to the effects of seawater entrainment associated with the operation of the offshore platform based on estimates of the likely distribution of ESA-listed coral species in the action area from survey data provided by the applicant and EPA and the probability of survival to settlement for coral larvae. Because it is not possible to identify larvae to species, we use total coral larvae as a surrogate for species-specific take estimates. The applicant estimated that 82 million coral larvae would be taken annually due to seawater intake during project operation. We base this on a conservative estimate that ESA-listed coral species are the only invertebrate larvae collected during sampling, which occurs associated with coral mass spawning. Coral larvae surveys shall be required to determine whether this take occurs and ensure estimated take is not exceeded. The monitoring will provide an assessment of our assumptions. If the coral larval density in the vicinity of the seawater intakes at the offshore platform exceed our estimate, our assumptions would be invalidated and reinitiation would be required.

- the take of 417 pillar, 125 rough cactus, 499 lobed star, 2,832 mountainous star, and 292 boulder star coral colonies that will remain at the offshore platform site due to operational effects

- the take of 17 green, 14 hawksbill, 1 loggerhead, and 1 leatherback sea turtle and up to 155 leatherback and 157 hawksbill hatchlings if nesting occurs during pile driving at the offshore platform site due to injurious and behavioral effects associated with the acoustic impacts of pile-driving for the installation of the piles to support the offshore platform. We base the number of hatchlings on the infrequent reporting of nesting in the action area that led to our assumption of a total of 4 leatherback and 2 hawksbill nests that could be laid during pile-driving activities associated with offshore platform construction. We will use the number of nests coupled with known mortality of hatchlings as they travel from the nest to the sea as a surrogate of hatchling take estimates due to the difficulty in observing hatchlings in the water. Using in-water and nesting surveys before, during, and after pile driving the number of nests, if any, will be documented. The surveys will also be used to document hatching success if monitoring corresponds to an emergence event, count the number of animals observed in the water, and look for stranded animals. If the nesting surveys reveal that more nests are laid than estimated, our assumptions would be invalidated and reinitiation would be required.

- the take of 1 adult female hawksbill and 1 adult leatherback sea turtle, 157 hawksbill hatchlings, and 155 leatherback hatchlings annually due to disorientation associated with lighting at the offshore platform during project operation. As for pile driving, we base the number of hatchlings on the infrequent reporting of nesting in the action area that led to our assumption of a total of 4 leatherback and 2 hawksbill nests that could be laid each year the project is operational. We will use the number of nests coupled with known mortality of hatchlings as they travel from the nest to the sea as a surrogate of hatchling take estimates due to the difficulty in observing hatchlings in the water. Using in-water and nesting surveys during peak nesting seasons (June to November for hawksbills and May to July for leatherback) will be used to document the number of nests, if any. The surveys will also be used to document hatching success if monitoring corresponds to an emergence event, count the number of animals observed in the water, and look for stranded animals. If the nesting surveys reveal that more nests are laid than estimated, our assumptions would be invalidated and reinitiation would be required.

10.2 Effects of the Take

In the accompanying Biological Opinion, NMFS determined that this level of anticipated take is not likely to jeopardize the continued existence of the species identified above.

10.3 Reasonable and Prudent Measures

Section 7(b)(4) of the ESA requires that RPMs necessary or appropriate to minimize the impacts of incidental take and the terms and conditions to implement those measures must be provided in the ITS. Only incidental taking by the federal agency or applicant identified in the ITS is authorized.

The RPMs and terms and conditions are specified as required by 50 CFR 402.14 (i)(1)(ii) and (iv) to document the incidental take by the proposed action and to minimize the impact of that take on ESA-listed species. These measures and terms and conditions are non-discretionary, and must be implemented by FERC and the USACE. FERC and the USACE have a continuing duty to regulate the activity covered by this ITS. To monitor the impact of the incidental take, FERC, the USACE or the applicant, as applicable, must report the progress of the action and its impact on the species to NMFS as specified in this ITS [50 CFR 402.14(i)(3)].

NMFS has determined that the following RPMs are necessary and appropriate to minimize impacts of the incidental take of elkhorn, staghorn, pillar, rough cactus, lobed star, mountainous star, and boulder star coral colonies during the proposed action. The following RPMs and associated terms and conditions are established to implement these measures, and to document incidental takes.

1. Environmental Monitoring Plan. Implement an environmental monitoring plan to track the condition of ESA-listed corals and sea turtles due to the construction and operation of the project as a requirement of all licenses and permits issued for the project in order to minimize the potential impacts of the construction and operation of the gasport on these ESA resources.

2. Species Effects Minimization Plans. Implement effects minimization plans for ESA-listed corals and minimization plans for ESA-listed sea turtles as a requirement of all licenses and permits to minimize the effects of take expected and unexpected impacts of the construction and operation of the pipeline and gasport.

3. Lighting Minimization Plan. Implement a lighting plan as a requirement of all licenses and permits to monitor and minimize for effects to ESA-listed resources from the impacts of lighting at the offshore platform, along the pipeline, and at the existing Aguirre power plant facilities associated with the construction and operation of the project.

4. Acoustic Minimization Plan. Implement an acoustic monitoring and minimization plan as a requirement of all licenses and permits to monitor and minimize effects to ESA-listed sea turtles from the expected and unexpected impacts of pile-driving associated with the construction of the offshore platform.

5. Turbidity and Sediment Minimization Plan. Implement a sediment and turbidity monitoring plan as a requirement of all licenses and permits to monitor and minimize effects to ESA-listed resources from expected and unexpected impacts of sediment resuspension and transport associated with project construction and operation.

6. The applicant must provide NMFS, FERC and USACE with all data collected and all reports related to any additional benthic surveys conducted prior to construction and associated with the implementation of the required monitoring plans.

10.4 Terms and Conditions

FERC, the USACE or the applicant, as applicable, must comply with the following Terms and Conditions (T&Cs), which implement the RPMs described above. These terms and conditions are non-discretionary. The plans detailed below as part of the T&Cs for each of the RPMs shall include monitoring and use of minimization measures where needed for project effects including but not limited to: 1) during construction - temporary and permanent impacts to benthic habitat used by ESA-listed corals and sea turtles, sediment resuspension and transport, and acoustic impacts of pile driving, and 2) effects to ESA-listed corals and sea turtles during project operation such as vessel operation, discharges and seawater intakes at the offshore platform, and lighting.

1. The environmental monitoring plan shall be finalized in coordination with NMFS, FERC, and the USACE, and NMFS shall approve the plan content prior to any resubmission or reactivation of the USACE permit application for the project. The plan shall be implemented prior to the commencement of any in-water construction activities. The plan shall include pre- and post-construction determinations of the condition of benthic habitat utilized by ESA-listed corals and sea turtles including colonized hard bottom, coral reef, and seagrass and colonies of ESA-listed corals (that will not be transplanted) within the established footprints of temporary and permanent impacts associated with the construction of the pipeline and offshore platform. Pre-construction monitoring, including monitoring of sedimentation rates shall begin at least two months prior to any in-water construction activities. Sedimentation rates shall be measured to the nearest millimeter using fixed sediment samplers. Sediment samplers shall be placed in one inshore and one offshore control station where modeling indicates no sediment transport from in-water construction activities will occur and in at least two inshore and two offshore stations within the modeled sediment plumes from pipeline installation and HDD entry point excavation. The location of sediment samplers within the predicted sediment plumes should include a station in the area of greatest predicted impacts and another in an area where predicted impacts are less.
    a. Pipeline Impacts: Permanent transects or quadrats shall be established to determine whether benthic habitats within the temporary construction footprint recover naturally following pipeline installation. The plan is required to monitor a minimum of 50% of each benthic habitat type within the temporary and permanent impact area. Monitoring shall include pre-, during, and post-construction phases of the proposed project. All ESA-listed corals within the transects or quadrats will be identified and their GPS location logged. These corals will be photographed using methods to ensure that photos taken during each monitoring event are at the same location and distance from the coral to ensure any use of photos to measure colony size is accurate and coral condition (including % mortality and % recent mortality) will be recorded.

b. Offshore Gasport Impacts: The monitoring plan shall continue during operation of the offshore gasport as part of FERC license requirements to determine the extent to which vessel operation, super-heated brine discharges, shading, and seawater intakes, and sediment resuspension and transport associated with these operations affect ESA-listed corals, sea turtles, and their habitat.
    i. Permanent transects or quadrats shall be established in areas under and adjacent to the offshore platform containing colonized hard bottom, ESA-listed corals, and seagrass. The plan is required to monitor at least 50% of each benthic habitat within the temporary and permanent impact area. The plan will identify all ESA-listed corals and identify the location and area of all hardbottom. All ESA-listed corals within the transects or quadrats that will not be transplanted outside the temporary and permanent impact footprint will be identified and their GPS location logged. These corals will be photographed using methods to ensure that photos taken during each monitoring event are at the same location and distance from the coral to ensure any use of photos to measure colony size is accurate and coral condition (including % mortality and % recent mortality) will be recorded.

c. Monitoring will include entrainment and impingement using the same methodology as applied to coral larvae and ichthyoplankton surveys conducted for the project and impingement assessment for sea turtle hatchlings. The plan will identify avoidance and minimization measures to be taken should impingement and/or entrainment of these animals be observed (see T&C No. 2 below).

d.The plan shall also include monitoring for sea turtles during operation of the offshore platform and measures to be taken to avoid and minimize potential vessel interactions with these animals. As part of the sea turtle monitoring, a logbook for detailing sea turtle sightings during construction and operation of the offshore platform shall be developed in coordination with NMFS that will include personnel training and reporting requirements. (RPM No. 1)

2. The mitigation plans for the impacts to ESA-listed corals and sea turtles and their habitat shall be finalized in coordination with NMFS, FERC, and the USACE, and NMFS shall approve the plan content prior to any resubmission or reactivation of the USACE permit application for the project. Implementation of the plans shall begin prior to any in-water construction.
    a. Mitigation plans shall include detailed procedures and measures for coral colony and seagrass removal and transplant from the in-water construction footprint along the pipeline and at the offshore gasport, as well as monitoring requirements. Monitoring of transplants shall cover a minimum of two years post-transplant unless the USACE mitigation requirements stipulate a longer monitoring period. Relocation procedures shall be based on industry standard protocols. The final number of ESA-listed coral colonies and acreage of seagrass to be transplanted will be determined based on pre-construction surveys conducted as part of RPM No. 1 in all temporary and permanent construction impact footprints along the pipeline and at the offshore platform. The recipient site or sites will be included in the plans and shall be selected to ensure the same oceanographic and depth

conditions as the areas from which ESA-listed coral colonies and seagrass will be removed. All ESA-listed coral colonies with a diameter of 4 cm or greater shall be transplanted outside of the direct impact footprint of the pipeline or structural piles for the offshore platform prior to commencement of any in-water construction activities. A subset of the transplants at each recipient site shall be monitored to determine transplant success such that a minimum of 50% of transplants at each recipient site are monitored. Seagrass along portions of the pipeline that will be buried and restored to grade may also be stockpiled as sod blocks or plugs or rolled mats (depending on the species for replanting once pipeline burial is complete).

b. If monitoring in T&C No. 1 indicates that unexpected damage to or the unexpected accumulation of sediment on elkhorn and staghorn coral critical habitat has occurred beyond the 4.1 ac area at the offshore platform site or along the pipeline during pipeline construction, the plans shall include restoration of the area of recruitment habitat impacted by substrate damage or sedimentation. Accumulations of sediment on coral recruitment habitat greater than 1.5 mm will be considered temporary impacts and greater than 5 mm will be considered permanent impacts. (RPM No. 2)

3. The lighting plan shall be finalized in coordination with NMFS and USFWS and NMFS shall approve the plan content prior to resubmission or reactivation of the USACE permit application for the project and implemented prior to commencement of any construction activities. In order to develop the lighting plan, pre-and post-construction lighting inspections should be done from the shoreline and from the water to assess existing lighting along the shoreline at the Aguirre power plant facilities and on or near the cays and existing nesting beaches on the cays and at Punta Pozuelo and to evaluate the effectiveness of the lighting plan in minimizing impacts to sea turtles once the project construction is complete. Nesting surveys should also be conducted at Punta Pozuelo during operation of the platform in months of peak nesting by hawksbill (June to November) and leatherback (May to July) sea turtles to determine whether nesting occurs. If nesting is observed, in-water observations to look for sea turtle hatchlings should be conducted to determine whether turtles are disoriented by project lighting. Monitoring of lighting impacts on ESA-listed coral in terms of sexual recruitment (number of gravid individuals, timing of spawning, larval settlement and growth) versus areas outside the area affected by lighting of the platform shall also be included in the plan in order to determine whether additional measures are needed to offset impacts to ESA-listed corals related to lighting during project operation. (RPM No. 3)

4. The acoustic mitigation plan shall be developed and implemented in coordination with NMFS and USFWS and NMFS shall approve the plan content prior to resubmission or reactivation of the USACE permit application for the project and implemented prior to commencement of in-water construction activities. Pile driving activities at the offshore platform shall require the use of confined bubble curtains or other noise abatement methods which are demonstrated to NMFS to be of equal or greater efficacy by a contractor who can demonstrate experience using this system as part of pile driving of large steel piles such as those proposed for this project in open water. On days when the

operation of bubble curtains or other noise abatement method is not possible due to oceanographic conditions, no pile driving activities will take place. Similarly, no pile driving activities at the offshore platform site shall take place during hawksbill and leatherback sea turtle peak nesting seasons. A 12-hour rest period shall be maintained with no pile driving activities taking place to ensure turtles have a recovery period. Acoustic monitoring shall determine the effectiveness of the bubble curtains or other abatement method and whether the calculated acoustic impact zone for sea turtles is larger than estimated. Sea turtle monitoring shall be expanded during pile driving activities at the offshore platform and shall include the largest estimated acoustic impact zone, which is that of cumulative SEL in the case of this project. If monitoring determines that the acoustic impact zone is larger than calculated in this Opinion, then the area where sea turtle monitoring shall be conducted will be expanded accordingly. If acoustic monitoring determines that the bubble curtains are not effective in minimizing injurious noise levels, then additional engineering measures shall be implemented prior to continuation of pile driving activities at the offshore platform site. During all pile driving activities at the offshore platform site, sea turtle monitoring shall be continuous with no breaks during the day or night and shall continue for 2 weeks following completion of all pile driving activities. This monitoring will look for dead or injured animals. Injured animals shall be rehabilitated following guidelines such as those of WIDECAST, which will be included in the acoustic mitigation plan. (RPM No. 4)

5. The sediment and turbidity monitoring plan for in-water construction activities shall be finalized in coordination with NMFS, FERC, and the USACE and NMFS shall approve the plan content prior to resubmission or reactivation of the USACE permit application for the project. The plan shall be implemented prior to the commencement of any in-water construction activities. The plan shall include baseline monitoring over a 2-month period at stations within and adjacent to the pipeline and offshore platform footprint during normal and storm conditions in order to determine the natural range of turbidities and TSS in different areas in Jobos Bay and offshore. The location of the monitoring stations will be included in the monitoring plan as a map and will be determined based in part on current and wind patterns in the project area. The baseline monitoring shall be used to establish turbidity and TSS limits that will be used during all construction activities to determine the effectiveness of in-water turbidity and sediment control measures and the effectiveness of cleanup of drilling fluids. During in-water construction work, monitoring will be done at least twice daily at least 3 hours apart 1 m below the surface and 1 m above the seafloor. If it is determined that elevated turbidity and/or TSS outside in-water turbidity barriers and other in-water control measures is due to the construction of the project, temporary work stoppage and other additional control measures (to be detailed in the monitoring plan) shall be implemented to abate the effects of sediment resuspension and transport outside the construction footprint on ESA resources. (RPM No. 5)

6. The applicant must provide NMFS, FERC and USACE with all data collected as part of additional pre-construction benthic surveys and the implementation of monitoring plans. This information can be submitted to nmfs.ser.esa.consultations@noaa.gov with copy to Mark Lamb (mark.lamb@noaa.gov) (RPM No. 6)

The RPMs, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. If, during the course of the action, this level of incidental take is exceeded, such incidental take represents new information requiring reinitiation of consultation and review of the RPMs provided. FERC or the USACE must immediately provide an explanation of the causes of the taking and review with NMFS the need for possible modification of the RPMs.

11 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs federal agencies to, in consultation with the Services, use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Conservation recommendations identified in Biological Opinions can assist action agencies in implementing their responsibilities under Section 7(a)(1). Conservation recommendations are discretionary activities designed to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

The following conservation recommendations are discretionary measures that NMFS believes are consistent with this obligation and therefore should be carried out by the federal action agency:

1. We recommend that the Manatee Protection Plan developed by the applicant be renamed the Marine Mammal Protection Plan and expanded to encompass all marine mammals, particularly ESA-listed whales, and to include observer requirements, log sheets, and the training program for all construction and vessel operation personnel, as well as an observer sighting and reporting program for during project operation, particularly of the offshore platform and associated vessel traffic in order to ensure potential impacts of vessel collisions with ESA-listed whales are avoided and minimized. The Marine Mammal Protection Plan should be finalized in coordination with NMFS and the USFWS prior to commencement of any construction activities. The plan should include reporting requirements to ensure NMFS and USFWS receive regular reports of marine mammal sightings and to ensure any collisions, injuries or stranded animals are reported immediately to the appropriate NMFS, USFWS and PRDNER offices.

2. We request that the survey to determine whether the platform and associated lighting lead to aggregations of species at the platform (that is part of the FERC license requirements, Appendix, Environmental Conditions #28) include an assessment of predatory species preying on any aggregations that are observed. The results of surveys associated with assessments of the effectiveness of the lighting plan in minimizing effects to ESA-listed Nassau grouper should be provided to NMFS.

3. We recommend that the mitigation measures for entrainment and impingement of ESA-listed species due to seawater intakes associated with project operation and 3-year monitoring study required as part of the FERC license requirements (Appendix, Environmental Conditions, #29) be expanded to address impingement and/or entrainment

of various life stages of Nassau grouper. The plan required by FERC is currently focused only on larval stages of this species. The plan should be finalized in coordination with NMFS prior to commencement of any construction activities. The plan should include reporting requirements for informing NMFS of monitoring results, as well as measures to be taken should impingement and/or entrainment of different life stages of Nassau grouper be observed. Note that documented impingement and/or entrainment of this species may require reinitiation of consultation.

4. We recommend that any specific Nassau grouper and marine mammal avoidance and minimization measures developed by the applicant be included as part of the USACE permit special conditions and FERC license requirements to protect these ESA-listed resources.

5. We recommend that the acoustic monitoring to be implemented during pile driving activities at the offshore platform include fish to determine whether pile driving activities result in injury to or death of Nassau grouper, scalloped hammerhead sharks, or giant manta rays to enable us to improve our evaluation of acoustic effects to these species.

6. We recommend that the spill response plan that will be developed for the project include spill response requirements and protocols to address accidental spills from construction vessels during project construction. We also recommend that the plan address not only hydrocarbon releases associated with operation of the offshore gasport but also potential releases of other compounds that will be used or generated at the offshore platform once it is operational. These changes will ensure that the proper tools for cleaning up accidental spills are immediately available in order to minimize potential impacts to ESA resources.

7. We request that NMFS Southeast Region Protected Resources Division be provided with copies of all pre-construction surveys and pre-during, and post-construction monitoring reports completed for the project associated with Nassau grouper (ichthyoplankton) and marine mammal surveying and monitoring.

Please notify NMFS if the federal action agency carries out any of these recommendations so that we will be kept informed of actions that are intended to improve the conservation of listed species or their designated critical habitats.

12 REINITIATION OF CONSULTATION

This concludes NMFS’s formal consultation on the proposed actions. As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary federal action agency involvement or control over the action has been retained, or is authorized by law, and if: (1) the amount or extent of incidental take is exceeded, (2) new information reveals effects of the agency action on listed species or designated critical habitat in a manner or to an extent not considered in this Opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat not considered in this Opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

Reinitiation triggers specific to this BO include, but are not limited to, the following:

(1) Take of Nassau grouper, scalloped hammerhead sharks, or giant manta rays occurs as a result of pile driving noise and/or the acoustic impact zone is found to be larger than calculated in this Opinion
(2) Impingement or entrainment of ESA-listed species other than ESA-listed corals (such as Nassau grouper) occurs or the extent of entrainment of ESA-listed corals is greater than calculated in this Opinion
(3) Sediment accumulation is found to be more extensive in area, sedimentation rate, or sediment depth based on required monitoring resulting in permanent impacts to ESA-listed corals including future recruits due to loss of elkhorn and staghorn coral critical habitat
(4) The use of HDD results in unanticipated releases or other impacts to ESA-listed corals along the pipeline route leading to full or partial mortality of coral colonies.
(5) Surveys conducted prior to commencement of in-water construction in the area of the offshore platform demonstrate that the number of ESA-listed corals present in the temporary and permanent footprint of the platform was underestimated and the amount of authorized take will be exceeded.
(6) Nesting surveys prior to, during, and after pile driving activities and once the project is operational reveal that more sea turtle nesting occurs in the area than was estimated and the amount of authorized take associated with pile driving and lighting will be exceeded
(7) New information reveals effects of the agency action on listed species or designated critical habitat in a manner or to an extent not considered in this Opinion
(8) The identified action is subsequently modified in a manner that causes an effect on the listed species or critical habitat not considered in this Opinion
(9) A new species is listed or critical habitat designated under the ESA that may be affected by the action.

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Appendix A

HORIZONTAL DIRECTIONAL DRILLING

CONSTRUCTION SPECIFICATION

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1 GENERAL

1.1 SUMMARY

This Specification describes the requirements for installing the proposed product pipe using horizontal directional drilling (HDD) construction methods. The Contractor is responsible for furnishing of all labor, equipment, supplies and materials necessary to support (marine operations) and use HDD construction practices to install the product pipe between the locations in accordance with the Contract Documents and all applicable federal, state, and local requirements.

1.2 GENERAL REQUIREMENTS

1.2.1 The Contractor shall not proceed with the work before the Owner approves the HDD Contractor's supervisor, driller, project specific personnel, vendors, drilling plan and schedule.

1.2.2 The Contractor is responsible for satisfying himself as to the soil conditions associated with the HDD installation. The Owner shall provide the Contractor with documentation of geotechnical/soil borings and subsurface investigations. The Contractor is responsible for determining suitability of Owner-supplied documentation, and the Owner is not responsible for the completeness and accuracy of such documentation.

1.2.3 The Contractor shall be responsible for all work necessary for containment, collection, disposal and transporting of drilling fluids and soil/bedrock cuttings from the job site, and shall be responsible for all costs. Disposal of drilling fluids and soil/bedrock cuttings shall be at an approved facility, subject to prior Owner approval.

1.2.4 Contractor shall provide a mud engineer/technician on-site actively monitor all phases of the drilling process. Mud specialist shall monitor and adjust drilling fluid properties during the installation.

1.2.5 Site Access: The Contractor shall allow full access to the Owner and Owner's Authorized Representatives and shall provide assistance and cooperation to aid the Owner in observing the work.

1.2.6 Sample Collection: The Contractor shall allow and assist the Owner in collecting spoil samples from shaker screens at a minimum of once per drill pipe stem, and whenever changes in geologic conditions are observed. The Contractor shall provide results of Contractor sampling to Owner/representatives.

1.3 TERMS CONTAINED IN THIS SPECIFICATION

1.3.1 Glossary and Abbreviations:

TABLE 1.3.1 – GLOSSARY

Term	Definition

Horizontal Directional Drilling (HDD)	A surface-to-surface pipeline installation technique used to install pipelines or conduits along pre-determined straight and curved alignments in soil and rock environments. The installation technique is comprised of four primary stages including pilot bore drilling, reaming pass(es), swab pass, and product pipe installation. Tracking of the drilling string shall be achieved using downhole wireline survey tools that may be augmented with an energized wire grid at the ground surface. Walk-over tracking devices are not permitted.
Pilot Bore	The first stage of the installation process whereby a guided and steerable pilot bore is drilled along a planned alignment from an entry location to an exit location.
Reaming Pass(es)	The second stage of the installation process whereby a reamer(s) is used to increase the diameter of the bore to its final diameter. This shall include multiple reaming passes/diameters where necessary.
Swab Pass	The third stage of the installation process whereby the reamed hole is prepared for product pipe installation by making a pass through the hole with tooling to collect residual cuttings and loose materials in the hole that may impede pipe installation.
Product Pipe Installation	The final stage of the installation process whereby the product pipe is installed within the bore.
Primary Drill Rig Location	The drill rig that is located in the shallower water depth and is furthest away from the reef structure.
Drilling Fluid/Mud	A mixture of water, bentonite and/or polymers specially designed for HDD operations and continuously pumped through the drilling equipment to facilitate the installation process and stabilize the bore.
Installation / Pullback Loads	The tensile load or force that is applied to the drill string and product pipe and required to install the product pipe.
Obstruction	Any object lying completely or partially within the bore path that prevents forward advancement of the drill pipe, reamer, and/or product pipe along the proposed alignment, after all reasonable efforts by the Contractor to advance past or around the object have failed.

TABLE 1.3.2 – ABBREVIATIONS

Term	Definition
API	American Petroleum Institute
ARO	Abrasion Resistant Overlay
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
CPAR	Construction Productivity Advancement Research
EDR	Electronic Drill Recorder
EMP	Environmental Management Plan
FBE	Fusion Bonded Epoxy

HDD	Horizontal Direction Drilling
MSDS	Material Safety Data Sheet
NACE	National Association of Corrosion Engineers
NPS	Nominal Pipe Size
PRCI	Pipeline Research Council International, Inc.
ROW	Right of Way
SMYS	Specified Minimum Yield Strength
A_{avg}	Total Change in Inclination (for R_V) over $L_{Drilled}$
$L_{Drilled}$	Length drilled over three joints of drill pipe
R_C	Combined compound curve drilled radius over $L_{Drilled}$
R_H	Average drilled radius over $L_{Drilled}$ in the horizontal plane
R_V	Average drilled radius over $L_{Drilled}$ in the vertical plane

1.4 REGULATIONS, CODES, SPECIFICATIONS AND STANDARDS

1.4.1 The Work shall be carried out in strict accordance with, but not limited to, the requirements of the latest edition of the following Acts, Standards and Regulations:

1.4.1.1 NACE TM0102-2002 - Measurement of Protective Coating Electrical Conductance on Underground Pipelines

1.4.1.2 Horizontal Directional Drilling Good Practices Guidelines (2008). HDD Industry Consortium, Bennett, Ariaratnam, and Como, North American Society of Trenchless Technologies.

1.4.1.3 Installation of Pipelines by Horizontal Directional Drilling: An Engineering Design Guide (1995). Pipeline Research Committee, American Gas Association, PR-227-9424.

1.4.1.4 Installation of Pipelines Beneath Levees Using Horizontal Directional Drilling (1998). US Army Corp of Engineers, Construction Productivity Advancement Research (CPAR) Program, CPAR-GL-98-1.

1.4.1.5 Applicable Federal, Provincial/State and Territorial Occupational Health and Safety – General Safety Regulations.

1.4.1.6 ASCE Manual of Practice No. 108 Pipeline Design for Installation by Horizontal Directional Drilling.

2 QUALITY ASSURANCE / QUALITY CONTROL

2.1 QUALIFICATIONS AND EXPERIENCE

2.1.1 The Contractor shall prepare and maintain a project specific quality assurance/quality control plan and document management plan throughout the project's duration. All applicable documentation and records shall be compiled in accordance with provisions of this plan.

2.1.2 The Contractor shall provide resumes of key personnel including site superintendent(s), drill rig operator(s), project manager, mud engineer, mud plant personnel, and guidance/steering hand.

The superintendent(s) and drill rig operator(s) shall have at least three (3) years of successful experience using HDD installation techniques on at least five (5) projects with similar diameter, installation length, pipe material, and geologic conditions to those identified in the Geotechnical Data Report. Key personnel shall have completed at least two (2) installations that terminated in water or were completed using a barge to barge setup. Resumes shall include project details including project name, Owner name, Owner contact information, location, diameter, pipe material, length, depth, and ground conditions.

2.1.3 The Contractor shall sign and date the information provided and certify that to the extent of his knowledge, the information is true and accurate, and that the supervisory personnel for the HDD operations will be directly involved with this project for the duration.

2.1.4 The Contractor shall provide adequate personnel to supervise all aspects of the directional drilling process. The Owner has the right to reject any supervisory personnel changes during construction. The Contractor shall submit 72-hour notification of any supervisory personnel changes during construction to Owner for prior approval.

3 SUBMITTALS

3.1 GENERAL REQUIREMENTS

3.1.1 The Contractor shall submit a project specific work plan with its bid for Owner review. The successful bidder shall update and finalize this work plan for the crossing location for Owner review and approval prior to start of work. Approval of the work plan by the Owner does not relieve the Contractor of any responsibility or liability for safety, jobsite and environmental damages, compliance with permits and regulations, accuracy, and adequacy of the plan for execution of the project.

3.1.2 Any operational deviation from the submitted plan, including change in reaming size, shall be presented to the Owner's Authorized Representative in written form, with sufficient time for the Owner's Engineering Department to review and comment on changes. The work plan shall not override or change requirements of the Contract Documents including specifications and drawings without written approval from the Owner.

3.1.3 Any Contractor recommended deviations from the Contract Documents and specifications, including justification for the Contractor's proposed alternative methodology, shall be submitted to the Owner for review and approval prior to implementation.

3.1.4 All requested calculations shall be stamped by a Professional Engineer licensed in Puerto Rico.

3.2 BID PACKAGE LEVEL PROJECT-SPECIFIC WORK PLAN REQUIREMENTS

3.2.1 The following shall be included in the project-specific work plan submitted with the Contractor's respective bid package.

3.2.1.1 Any proposed/recommended deviations or alternatives from the contract scope of work or specifications.

3.2.1.2 Drill rig type, size, manufacturer, noise ratings, torque, and pullback/thrust capacities (include appropriate drawings and photographs).

3.2.1.3 Marine support, goal posts, and barge anchoring details including confirmation of maximum thrust/pullback capability for drill rig.

3.2.1.4 Pilot bore drilling methodology/diameter, reaming methodology/strategies/direction (including number and diameter of proposed reaming passes), and swab pass strategies/direction/diameters.

3.2.1.5 Diameter, type, and grade of drill pipe.

3.2.1.6 Downhole tooling including bits, reamers/hole openers, and mud motors (include manufacturer, size and type).

3.2.1.7 Number, type, manufacturer, and flow capabilities of mud pumps.

3.2.1.8 Separation plant details (include type, manufacturer, components, cleaning capacities, tank volumes, and quantities of components).

3.2.1.9 Preliminary drilling fluid compositions and additives including material safety data sheet (MSDS). Included materials anticipated for mixing and pumping lost circulation materials to seal encountered preferential flow pathways.

3.2.1.10 Pilot bore wire-line survey equipment type, accuracies and specifications.

3.2.1.11 Overall drilling and product pipe installation methodology.

3.2.1.12 Methodology to be used to install temporary conductor casings prior to and removal following completion of drilling operations. Include details on the proposed cutting shoe on the leading edge of each casing diameter. Strategy for installing intermediate casing to centralize the pilot bore and reaming operations. Include details and procedure to allow free passage of drill bits and reamer/hole opener/pulling head through the leading edge of the casing pipe. Include details of centralizing casing.

3.2.1.13 Length, grade, wall thickness, and diameter of conductor casing. Indicate if casing pipe will be telescoped and provide details of each diameter.

3.2.1.14 Methodology for welding, installing, sealing, and removing temporary conductor casing.

3.2.1.15 Methodology for removing drilling fluids from each side of the HDD installation during and after drilling operations. Detail location of drilling fluid extraction depth on each side of the crossing.

3.2.1.16 Preliminary calculations of maximum required and maximum allowable drilling fluid pressures for the pilot bore phase of the project. Detail all assumptions and provide a chart showing the ground surface, HDD alignment, allowable drilling fluid pressure and anticipated operating pressure range. A factor of safety of 2.0 shall be used for the maximum allowable drilling fluid pressure.

3.2.1.17 Detailed plans for buoyancy control during product pipe pullback (including calculations, pumping rates, etc.).

3.2.1.18 Drawing of marine anchoring system and on-loading/offloading site layouts. Include details of goal post locations (on both sides of the crossing).

3.2.1.19 Drawing of typical site layouts showing staging of all equipment for HDD entry and exit locations.

3.2.1.20 Drilling fluid management plan detailing procedures, equipment, personnel, and materials to be used to prevent, contain and cleanup a drilling fluid release at any location along the HDD alignment.

3.2.1.21 Resumes of key personnel including those identified in Section 2.0.

3.2.1.22 Electronic Drilling Recorder (EDR) type and functions monitored.

3.3 DETAILED LEVEL PROJECT-SPECIFIC WORK PLAN REQUIREMENTS (FOLLOWING AWARD)

3.3.1 The following additional items shall be included in the Contractor's project-specific work plan submitted for Owner review and approval 30 days prior to the start of construction. This plan shall be updated following detailed design of the HDD and during all HDD related operations. All plans shall be submitted for Owner review and approval.

3.3.1.1 Updates to the information provided in the Contractor's project-specific work plan at time of bid.

3.3.1.2 Quality assurance/quality control and document management plan.

3.3.1.3 Guidance system calibration certification documentation. Provide operating procedures and measures to verify the accuracy of readings.

3.3.1.4 Location of survey probe in relation to drill bit.

3.3.1.5 Type and location of real-time downhole pressure monitoring system (to monitoring downhole annular pressures) in reference to the drill bit.

3.3.1.6 Third Party Inspection verification that all drill pipe has been inspected and is fit for use.

3.3.1.7 Anticipated and maximum penetration rates for the geotechnical formation indicated for this project (bedrock materials and soil conditions) for each of the pilot bore and reaming stages.

3.3.1.8 Quantity of fresh water required for drilling operations with estimated maximum daily usage rate.

3.3.1.9 Estimated volumes of spoil and drilling fluids requiring disposal.

3.3.1.10 Disposal plans for spoil and excess drilling fluid. Identify the disposal facilities/location(s) and provide a letter from the disposal facility(ies) documenting the willingness and legal authority to accept the described and anticipated waste products including drilling fluids, spoil/cuttings, waste oil, fuel, discharge water, etc.

3.3.1.11 Pulling head assembly design including swivel pull back capacities.

3.3.1.12 Calculations of maximum required drilling fluid pressures for each stage of the installation process.

3.3.1.13 Calculations of anticipated HDD product pipe installation loads and stresses.

3.3.1.14 Drawing indicating product pipe pullback break-over design at pipe entry location including lifting point locations, heights, radius of curvature, pipe entry angle, and lifting point loads to ensure pipe is not over-stressed or damaged during installation. Include number and size of lifting equipment.

3.3.1.15 Spare equipment and parts inventory.

3.3.1.16 Hydrostatic plan, as required.

3.3.1.17 Project Specific Safety Plan, including electric strike action plan.

3.3.1.18 A separate Environmental Response and Remediation Contingency Plan shall be submitted. The plan shall be able to demonstrate the capacity, mobilization strategy, and contingency resources necessary to immediately and effectively investigate all potential release of drilling fluids, and begin remediation of all confirmed releases of drilling fluids concurrent with, and if necessary to supplant all other active project operations. Remediation activities shall continue until the Chief Environmental Inspector, in collaboration with resource agencies, gives final approval. Delays in implementing this plan is only allowable in accordance with safe operation conditions identified in the site Safety Plan.

3.3.2 Schedule: The Contractor shall submit a detailed schedule for prior Owner approval showing all major construction activities and durations, prior to the start of construction. As a minimum the schedule shall include the following activities:

3.3.2.1 Site preparation and equipment mobilization.

3.3.2.2 Pipe fabrication and hydrostatic testing of pull-back pipe.

3.3.2.3 Dates for move in, drill start, reaming operations, pull-back completion, and move out.

3.3.2.4 Temporary conductor casing installation durations (if specified or required).

3.3.2.5 Survey baseline and guidance system setup.

3.3.2.6 Pilot bore drilling, reaming, swab passes, and pullback operations.

3.3.2.7 Conductor casing removal (if specified or required).

3.3.2.8 Final hydrostatic testing and internal inspection.

3.3.2.9 Cleanup and backfilling of excavations.

3.3.2.10 Surface restoration and demobilization.

3.3.3 The Contractor shall submit contingency plans to the Owner a minimum of 30 days prior to the start of construction, for the following problems that may occur during drilling operations:

3.3.3.1 Obstruction encountered within the bore path.

3.3.3.2 Hydraulic fracturing / inadvertent returns at ground surface and / or within ocean environment.

3.3.3.3 Deviation from planned bore path.

3.3.3.4 High installation loads that exceed the strength of the product pipe.

3.3.3.5 Broken or dislodged downhole tools, drill bits, reamers, drill pipe or other applicable items.

3.3.3.6 High installation stresses such that the pipe collapses or deforms.

3.3.3.7 Snagging of downhole tooling at the leading edge of installed conductor casings (where installed).

3.3.4 Daily Logs and Records: The Contractor shall submit complete, legible, written daily logs and records as construction progresses during the Pilot Bore Stage, Reaming/Swab Stages and Product Pipe Installation Stage for the entire project duration to the Owner. Submit records by noon of the following business day after which the records were written. These records shall include, but not be limited to:

3.3.4.1 Contractor crew, equipment, and shifts/time/date/day worked.

3.3.4.2 Copy of directional survey report, three joint and single joint radii, data verification report and report from survey tracking.

3.3.4.3 Pipe number, drilling times per pipe, footage completed.

3.3.4.4 Maximum observed machine torque, machine thrust, drill pipe and annular space drilling fluid pressures, and flow rates (per drill pipe).

3.3.4.5 Calculated vertical, horizontal, and combined drilled bend radii based on the calculation method specified in these Specifications.

3.3.4.6 Records of continuously monitored drilling fluid pressures and flow rates and the distance from the drill bit to the downhole annular pressure sensor.

3.3.4.7 Drilling fluid details including mud mixed, additives, fluid losses/inadvertent returns, quantities, and the following fluid and slurry return properties:

3.3.4.7.a Mud weight.

3.3.4.7.b Funnel viscosity.

3.3.4.8 Vertical and horizontal deviations from the planned bore path and subsequent steering corrections made.

3.3.4.9 Monitor and record installation loads once per drill pipe. Provide the conversion factors from hydraulic pressure to force for the drill rig thrust/pullback.

3.3.4.10 Product pipe pullback records including date, time, constant pipe footage progress, mud flow rates, pulling forces required, and torque readings (per drill pipe).

3.3.4.11 Daily total fresh water use and total water use to date.

3.3.4.12 Quantity of drilling fluid lost or released.

3.3.4.13 Quantity and type of any loss circulation materials used on site.

3.3.5 The Contractor shall submit weekly construction progress reports to the Owner throughout the duration of construction activities. The reports shall include summary of work performed to date for all applicable phases, updated installation schedule, updated cost monitoring documentation (including life-to-date project cost, remaining projected cost, and projected cost at completion), key planned upcoming work activities and any key issues requiring attention.

3.3.6 As-Built Records:

3.3.6.1 Contractor shall submit an as-built plan and profile of the pilot bore within 3 days of completing the pilot bore.

3.3.6.2 The as-built drawings shall be generated with AutoCAD and provided electronically in PDF and native DWG format using the contract document plan horizontal and vertical scales.

4 PRODUCTS

4.1 EQUIPMENT

4.1.1 All equipment shall have the capacity, stability and necessary safety features required to fully comply with the Contract Documents without showing evidence of undue stress or failure. It shall be the responsibility of the Contractor to assure that all equipment is in sound operating condition. Backup equipment shall be required in the event of an equipment breakdown and where the condition of the equipment to be used indicates that routine component replacement or repair will likely be necessary during the work.

4.1.2 The HDD rig shall be provided with the required ancillary equipment necessary to complete the installation. This shall include drill pipe, soil and rock drilling bits, reamers and hole openers, auger flights, swivels, cross over subs, expanders, control cabin, generators, lighting, mud pump, mixing equipment, separation plant for drilling fluid returns, shaker screens, hydrocyclones, downhole survey equipment, pipe handling equipment, cranes, backhoe, side boom equipment, rollers, and fluid pressure and flow rate monitoring equipment.

4.1.3 The Contractor shall provide high quality drill pipes that have been properly inspected and maintained. Bent, cracked, or fatigued drill pipes are prohibited.

4.1.4 Drilling equipment shall be capable of advancing through the anticipated geologic conditions along the bore. Sufficient drilling equipment shall be available to replace worn out or broken tooling necessary to excavate the geologic materials.

4.1.5 The anchoring system for the drill rig and work barge shall be sufficient to allow the full capacity of the HDD rig during drilling operations.

4.1.6 Drilling fluid and spoil separation systems shall be capable of achieving and maintaining the rates of drilling fluid and slurry pumping, spoil separation and cleaning necessary for the Contractor's anticipated production rates in the anticipated geologic conditions along the bore.

4.1.7 The Contractor shall use a Slimdril gyroscopic tooling (or equivalent) and an approved downhole steering system. The Contractor shall provide technicians and directional drillers experienced in the operation of the above equipment. The Contractor shall also provide sufficient spares for the above equipment to maintain directional capability at all times.

4.1.8 The mud pump must be capable of supplying the required flow rate and pressures at the anticipated drilling fluid viscosity at all times.

4.1.9 The Contractor shall provide and maintain calibrated instrumentation which accurately measures the drilling fluid pressure within the annular space of the pilot bore hole. The annular space pressure monitoring equipment shall be located as close to the drill bit as possible. The Owner shall have access to these instruments and their readings at all times.

4.1.10 Pipe handling equipment (rollers, lifters, etc.) shall be used for pipe assembly and to transition the product pipe into the bore during pullback operations. The required equipment shall be determined by the Contractor and shall be sufficient to ensure that the product pipe is not over-stressed or damaged. Equipment to be used shall be subject to prior Owner approval.

4.1.11 The Contractor shall provide and maintain electronic data recorder (EDR) instrumentation that will continuously and accurately monitor (at a minimum) tank pit volumes, mud flow (pump and return), pressure (annular bore pressure/standpipe), instantaneous rate of penetration, drill pipe axial and torsional loads (push/pull force and rotary torque), bit depth, and drill string rotations per minute. The electronic information shall be accessible to the Owner's Authorized Representative onsite and will form part of the records required at the end of the project. Data files including all electronically recorded data shall be provided to the Owner on a daily basis. Online access shall be provided to the Owner or its Authorized Representative. The EDR shall record each of the above listed parameters on a one (1) minute basis or at least every four (4) inches, whichever is more frequent.

4.2 MATERIALS

4.2.1 Product pipe and other applicable materials shall be in accordance with the Owner's specifications and drawings.

4.2.2 Drilling fluids, including makeup water, bentonite, polymers, or other additives shall be designed for the anticipated geologic conditions along the bore.

4.2.3 The Contractor shall use new wireline for all trips into the bore during pilot bore drilling..

5 EXECUTION

5.1 GENERAL

5.1.1 The Contractor's key personnel shall participate in a pre-construction meeting to be conducted in advance of construction activities to discuss the Contractor's work plan and crossing-specific requirements.

5.1.2 The Contractor's key personnel shall participate in weekly meetings to discuss construction progress.

5.1.3 The Contractor shall immediately notify the Owner in writing when any significant problems are encountered or if ground conditions are considered to be materially and significantly different than those represented within the Contract Documents.

5.1.4 Drill and intersect installation strategy may be used at Contractor's discretion, upon approval by the Owner.

5.1.5 A second drill rig spread may be used for drill pipe and drilling fluid handling at the exit location during the reaming and swabbing process.

5.1.6 The Contractor shall take all necessary precautions to ensure the drilling fluid pressure in the drilled hole does not exceed the calculated allowable fluid pressure that can be contained by the overburden soil.

5.1.7 The Contractor shall use real-time, downhole pressure monitoring equipment to monitor drilling fluid pressures within the annular space during pilot bore drilling operations.

5.1.8 The Contractor shall use appropriate downhole tooling to maximize drilling fluids returns and prevent unnecessarily increasing downhole bore pressures due to selection of inappropriate equipment.

5.1.9 The Contractor shall make every effort to maintain full annular circulation and maximize recirculation of the drilling fluid throughout the drilling operation. The Contractor shall be responsible for monitoring drilling fluid returns at all times during drilling operations.

5.1.10 The Contractor shall provide return handling equipment or fluid tanks on both sides of the HDD crossing. The fluid tanks shall be of sufficient number and size to contain all drilling fluids resulting from the drilling operations.

5.1.11 The Contractor shall ensure all drilling fluids are contained within the drilled hole, the drill pit or the fluid tanks, to the maximum extent possible as monitored by the Chief Environmental Inspector and inspection crew.

5.1.12 The Contractor shall be responsible for removal and disposal of all fluids and solids collected during drilling and upon completion of pullback operations. Disposal shall be at the designated and approved disposal site provided in the Contractor's Plan of Work, upon crossing completion.

5.1.13 The Contractor shall not discharge water, drilling fluid or cuttings into any watercourse, or area surrounding the drilling site.

5.1.14 All potential (based on mud pressure loss) releases shall be investigated immediately and all confirmed releases shall be remediated immediately in accordance with Environmental Response and Remediation Contingency Plan (3.2.1.20) and as soon as allowable in accordance with safe operating conditions as outlined in the Project Specific Safety Plan (3.3.1.17).

5.2 TEMPORARY CONDUCTOR CASING (STARTER CASING PIPE)

5.2.1 The Contractor is responsible for furnishing and installing (and ultimately disposing of) temporary casing pipe in applicable locations, as indicated on the Contract Drawings. The Contractor is responsible for determining all casing length, grade, wall thickness, and diameter at each HDD entry/exit location, to be submitted for Owner approval prior to its installation.

5.2.2 Where specified or required, the Contractor shall install casing pipe into a firm soil or bedrock formation that will enable the drill to proceed with no loss of drilling fluids at the interface. The casing shall be sized adequately to ensure free passage of all tooling and the product pipe through the casing ends.

5.2.3 Intermediate casing pipe shall be used to center the drilling tools within the started casing pipe to prevent assembly seizure or twist off while entering the casing. Intermediate casing shall be used for all pilot bore, reaming and swab passes.

5.2.4 All temporary conductor casings shall be removed after product pipe installation, in a manner so as not to cause damage to the product pipe. Casing pipe removal methodology shall be reviewed and approved by the Owner prior to casing removal.

5.2.5 The Contractor shall be responsible for insuring all welds required for the casing pipe are sufficient to resist the loads necessary to install the casing prior to the pilot bore and to remove the casing following completion of drilling and pullback operations.

5.3 LOST OR LODGED TOOLS

5.3.1 The Contractor shall report any tools lost or lodged down-hole to the Owner. Objects shall be fully recovered prior to pipe pullback operation unless specifically approved otherwise by the Owner. Failure to recover metal objects lost or lodged downhole within a reasonable time period constitutes just cause for rejecting the drill hole by the Owner.

5.4 DRILLING FLUID MIGRATION AND RELEASE

5.4.1 The Contractor shall immediately cease drilling, dispatch observers to determine if inadvertent return or a plume is visible, and notify the Owner upon detection of a reduction in drilling fluid return volume and mud release to the ocean environment.

5.4.2 In the event drilling fluid returns are lost or decrease in volume, the Contractor shall take immediate measures to restore full drilling fluid circulation. This shall include, but not limited to one or more of the following:

- Tripping out several drill pipe while pumping minimal to no drilling fluids to clear any blockage that may exist behind the drill bit or reamer assembly;
- Modifications to drilling fluid properties;
- Pulling back several drill pipe and redirecting the pilot bore along a slightly deeper alignment to avoid the area where losses have occurred;
- Pumping of lost circulation material downhole;
- and/or localized grouting (as a last resort).

If returns cannot be restored and return issues occur in an area not expected drilling fluid return issues (in areas away from the HDD entry or exit locations), the Contractor shall trip their drill string completely back to the entry location. The Contractor shall consider the use of washover casing pipe to help provide a conduit for drilling fluid returns back to the primary drill rig location.

5.4.3 Operation shall not resume without Owner approval of the Contractor's action plan to mitigate any future drilling fluid migration and rectify any damage caused by the drilling fluid release.

5.4.4 All areas contaminated by drilling fluid migration and release shall be cleaned up and restored to Owner's specifications and regulatory/permit requirements at Contractor's expense. All potential (based on mud pressure loss) releases shall be investigated immediately in accordance with 3.3.1.18 and 5.1.14, or as soon as allowable in accordance with safe operating conditions in the Project Specific Safety Plan. Investigations of potential releases shall include the use of divers. All confirmed releases shall be remediated immediately, or as soon as allowable in accordance with the Project Specific Safety Plan. The Safety Plan should address safe working conditions for boats and divers.

5.4.5 Contractor shall submit a report of the quantity of any drilling fluid released, location, and clean up activity. Report shall include photographs of release areas prior to and following cleanup activities.

5.5 PILOT BORE DRILLING, TRACKING AND SURVEY

5.5.1 General:

5.5.1.1 The Contractor shall drill the pilot hole along the path shown on the plan and profile drawing, in accordance with the Specifications and Drawings.

5.5.1.2 The Contractor shall perform a profile survey of the proposed crossing location to verify the Owner supplied crossing drawings. The survey shall include the location of the drill entry point, the angle of the hole to be drilled, horizontal and vertical curve(s) geometry, and the drill exit locations in accordance with the Project Drawings. If the Contractor detects any discrepancies it shall notify the Owner immediately.

5.5.1.3 The Contractor shall monitor the drill string position using a gyroscopic down-hole survey tool.

5.5.1.4 The Contractor shall compute the position in the X, Y and Z-axis relative to ground surface from down-hole survey data a minimum of once per length of each drill pipe.

5.5.1.5 Upon the drill pipe exit of the pilot hole, the Contractor shall take the final survey dimensions at the ground elevation. This survey shall be tied-in to the actual exit location.

5.5.1.6 The pilot drill shall follow the path shown on the Drawings within the following tolerances, unless otherwise stated in Contract.

TABLE 5.5.1 – ABBREVIATIONS

Item	Tolerance
Pilot entry angle	Increase angle up to 1° (steeper), but no decrease in angle allowed.
Pilot entry location	No changes without Owner approval.
Pilot exit angle	Decrease angle up to 2° (flatter), but no increases in exit angle allowed.
Pilot exit location	Up to thirty (30) feet longer but no shorter.
Pilot depth	Up to five (5) feet shallower allowed. Up to 30 feet increase in pipe design depth (deeper) allowed.
Pilot alignment	Between five (5) feet left and five (5) feet right of the Owner survey centerline but not within ten (10) feet of the right-of-way/easement boundary.

5.5.2 Pilot Bore Radius:

5.5.2.1 The minimum allowable pilot bore bending radius shall be at least equal to or greater than the minimum bending radius. The specified minimum pilot bore bend radius refers to the resulting drilled pilot bore bend radius from the combined effects of steering in both the vertical and horizontal planes.

5.5.2.2 Calculations of the minimum drilled pilot bore bend radius shall be completed in accordance with this Specification.

5.5.2.3 Where a compound curve (where steering simultaneously occurs in the vertical and horizontal planes) is drilled, the minimum drilled bend radius of each component shall be used to calculate the combined compound curve pilot bore drill radius. For compound curve pilot bore bores, the minimum allowable bend radius refers to the resulting drilled compound curve bend radius from steering inputs from each plane concurrently. The resulting compound curve bend radius shall be equal to or higher than the minimum allowable bending radius stated on the Drawings and/or Contract documents.

5.5.2.4 Under no circumstances shall the stated minimum allowable bending radius be used to compare individual vertical and/or horizontal bend radii separately where a compound curve is drilled.

5.5.2.5 The pilot hole shall be drilled at a radius equal to or greater than the minimum allowable bending radius (provided on the Drawing(s), averaged over each consecutive three (3) joint range (calculated as a moving average).

5.5.2.6 For steering solely within either the vertical or horizontal plane, the Contractor shall calculate the drilled pilot bore bend radius over all consecutive three (3) joint segments using the following formula:

$$R_V \text{ or } R_H = (L_{Drilled}/A_{avg}) * (360 / 2\pi)$$

Where: R_V = average drilled radius over $L_{Drilled}$ in the vertical plane

R_H = average drilled radius over $L_{Drilled}$ in the horizontal plane

$L_{Drilled}$ = length drilled over three (3) joints of drill pipe, approximately 100 feet

A_{avg} = total change in inclination (for R_V) or azimuth (for R_H) over $L_{Drilled}$

5.5.2.7 The total change in angle (A_{avg}) shall be computed using the Minimum Curvature Method.

5.5.2.8 For steering along a compound curve, where steering occurs simultaneously (concurrently) within the vertical and horizontal planes, the Contractor shall calculate the combined compound curve drilled bend radius over any three (3) joint segments using the following formula:

$$R_C = \sqrt{\frac{R_V^2 R_H^2}{R_V^2 + R_H^2}}$$

Where: R_C = combined compound curve drilled radius over $L_{Drilled}$

R_V = drilled vertical radius over $L_{Drilled}$ as calculated above

R_H = drilled horizontal radius over $L_{Drilled}$ as calculated above

5.5.2.9 The combined compound curve drilled radius shall not exceed the stated minimum allowable bending radius indicated on the Drawings or Contract Documents.

5.5.3 Pilot Drill Survey:

5.5.3.1 The Contractor shall notify the Owner of any measured deviations or projected deviations from the pilot-hole tolerances. The Contractor shall correct any deviations from these tolerances or present an alternate drilling plan to the Owner for change order approval.

5.5.3.2 The maximum spacing between coordinate points shall be every joint of drill pipe (approximately every 30 feet).

5.5.3.3 The Contractor shall furnish the As-Built drawing within three (3) days after the pilot hole is complete. The drawing shall be signed by a qualified Contractor representative and is subject to Owner review, comment and correction/edit prior to the Owner's acceptance.

5.5.4 Pilot Drill Corrections:

5.5.4.1 The Contractor shall notify Owner's Authorized Representative of any pilot hole failing to meet the specifications. The Contractor shall re-drill or pull-back and correct the pilot hole and provide documentation to prove the pilot hole is within the Owner's specifications.

5.6 REAMING AND SWAB PASSES

5.6.1 The Contractor shall determine the required final borehole diameter for successful product pipe pullback based on ground conditions encountered, in accordance with the requirements herein and subject to prior Owner approval.

5.6.2 All reaming passes may be completed in a forward ream direction with respect to the primary (shallower) drill rig spread to maintain drilling fluid returns to this location for as long as possible.

5.6.3 All reaming passes may be stopped prior to punch out at the HDD exit location to allow for successively reaming passes with drilling fluid returns to the primary (shallower) drill rig spread unless the Contractor is able to effectively collect drilling fluid returns from the secondary (deep water) drill rig spread during the installation.

5.6.4 The minimum reamed diameter shall be 1.5 times the product pipe outside diameter for pipelines equal to or less than 24 inches in nominal diameter, and 12 inches larger than the product pipe outside diameter for pipelines greater than 24 inches in nominal diameter.

5.6.5 For larger diameter product pipe installations (greater than or equal to 20-inch nominal diameter), the Contractor shall execute multiple reaming passes in a step-up in diameter manner so as not to ream the borehole from pilot hole diameter to final diameter in one reaming pass. Multiple additional reaming passes are to be executed based on the soil conditions, product pipe diameter and other pertinent factors. The Contractor shall propose the number and diameter of its proposed reaming passes for prior Owner approval.

5.6.6 Upon the completion of the last reaming pass, the Contractor shall make at least one (1) cleaning pass (swab pass) to remove excess cuttings from the previously reamed hole to ensure an adequate, open borehole. This swab pass shall be completed in the direction of the product pipe installation. The Swab pass diameter (to be approved by the Owner) shall be less than final borehole diameter unless otherwise agreed to by the Owner. Additional swab passes shall be performed if necessitated by borehole conditions.

5.6.7 The Contractor shall keep the hole clean and in good condition for pipe installation until the pull-back operation starts.

5.6.8 The Contractor shall consult with the Owner and review reaming and swab pass data before the product pipe pull-back begins. The Contractor shall provide documentation/data/information to the Owner to justify commencement of pull-back. If the Owner is not satisfied with this justification, then the Owner has the option to require Contractor to perform additional swab pass(es) or other measures until the Owner is satisfied that pull-back can safely commence.

5.6.9 The Contractor shall not proceed with pull-back operations until the above consultation has occurred and Owner allows pull-back to proceed.

5.7 PRODUCT PIPE INSTALLATION

5.7.1 The Contractor shall have sufficient equipment and storage on-site to manage excess drilling fluids displaced by the pullback section.

5.7.2 The maximum permissible tensile load imposed on the pull section shall be calculated using the following formula:

Max Pull Load = (SMYS * Pipe Area) * 0.8

Where: SMYS = specified minimum yield strength of pipe

Pipe Area = area of pipe section(s)

5.7.3 Pulling force exerted on the pipe during pullback shall not exceed the maximum working strength of the weakest pulling assembly component and drill pipe.

5.7.4 The Contractor shall monitor and record the maximum pull forces for each joint of drill pipe pulled during the pullback operation.

5.7.5 The Contractor shall complete the pull-back in one (1) continuous operation (unless insufficient area exists for staging a single pipe string). Installation shall not cease until pull-back operation is complete.

5.7.6 The Contractor shall not use any hammering device to aid in the pipeline installation unless the Contractor submits plan for such activity to the Owner for engineering analysis and approval. The Contractor's proposal shall only be consider if all other means for completing the drill have been exhausted.

5.7.7 The Contractor shall provide buoyancy modification as required and/or when conditions necessitate.

5.8 SITE CLEAN-UP AND RESTORATION

5.8.1 The Contractor shall be responsible for performing all site clean-up and restoration to the Owner's satisfaction and approval to at least the site cleared, pre-construction condition, and in accordance with all Contract Documents and permit conditions. All recoverable drilling fluid returns and releases shall be contained (5.1.11) and cleaned up (5.1.14). Recoverable drilling fluids shall be determined by the Chief Environmental Inspector in coordination with the relevant resource agencies.

5.8.2 Contractor shall remove all equipment, materials, drilling fluid, muck, waste, and other debris from the site as part of the demobilization process. Final washing and cleaning of equipment and materials shall be performed in a manner so as not to cause contamination or environmental issues.

END OF SECTION

Appendix B

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
263 13th Avenue South
St. Petersburg, FL 33701

SEA TURTLE AND SMALLTOOTH SAWFISH CONSTRUCTION CONDITIONS

The permittee shall comply with the following protected species construction conditions:

a. The permittee shall instruct all personnel associated with the project of the potential presence of these species and the need to avoid collisions with sea turtles and smalltooth sawfish. All construction personnel are responsible for observing water-related activities for the presence of these species.

b. The permittee shall advise all construction personnel that there are civil and criminal penalties for harming, harassing, or killing sea turtles or smalltooth sawfish, which are protected under the Endangered Species Act of 1973.

c. Siltation barriers shall be made of material in which a sea turtle or smalltooth sawfish cannot become entangled, be properly secured, and be regularly monitored to avoid protected species entrapment. Barriers may not block sea turtle or smalltooth sawfish entry to or exit from designated critical habitat without prior agreement from the National Marine Fisheries Service's Protected Resources Division, St. Petersburg, Florida.

d. All vessels associated with the construction project shall operate at "no wake/idle" speeds at all times while in the construction area and while in water depths where the draft of the vessel provides less than a four-foot clearance from the bottom. All vessels will preferentially follow deep-water routes (e.g., marked channels) whenever possible.

e. If a sea turtle or smalltooth sawfish is seen within 100 yards of the active daily construction/dredging operation or vessel movement, all appropriate precautions shall be implemented to ensure its protection. These precautions shall include cessation of operation of any moving equipment closer than 50 feet of a sea turtle or smalltooth sawfish. Operation of any mechanical construction equipment shall cease immediately if a sea turtle or smalltooth sawfish is seen within a 50-ft radius of the equipment. Activities may not resume until the protected species has departed the project area of its own volition.

f. Any collision with and/or injury to a sea turtle or smalltooth sawfish shall be reported immediately to the National Marine Fisheries Service's Protected Resources Division (727-824-5312) and the local authorized sea turtle stranding/rescue organization.

g. Any special construction conditions, required of your specific project, outside these general conditions, if applicable, will be addressed in the primary consultation.

Revised: March 23, 2006
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Vessel Strike Avoidance Measures and Reporting for Mariners NOAA Fisheries Service, Southeast Region

Background
The National Marine Fisheries Service (NMFS) has determined that collisions with vessels can injure or kill protected species (e.g., endangered and threatened species, and marine mammals). The following standard measures should be implemented to reduce the risk associated with vessel strikes or disturbance of these protected species to discountable levels. NMFS should be contacted to identify any additional conservation and recovery issues of concern, and to assist in the development of measures that may be necessary.

Protected Species Identification Training
Vessel crews should use an Atlantic and Gulf of Mexico reference guide that helps identify protected species that might be encountered in U.S. waters of the Atlantic Ocean, including the Caribbean Sea, and Gulf of Mexico. Additional training should be provided regarding information and resources available regarding federal laws and regulations for protected species, ship strike information, critical habitat, migratory routes and seasonal abundance, and recent sightings of protected species.

Vessel Strike Avoidance
In order to avoid causing injury or death to marine mammals and sea turtles the following measures should be taken when consistent with safe navigation:

1. Vessel operators and crews shall maintain a vigilant watch for marine mammals and sea turtles to avoid striking sighted protected species.

2. When whales are sighted, maintain a distance of 100 yards or greater between the whale and the vessel.

3. When sea turtles or small cetaceans are sighted, attempt to maintain a distance of 50 yards or greater between the animal and the vessel whenever possible.

4. When small cetaceans are sighted while a vessel is underway (e.g., bow-riding), attempt to remain parallel to the animal's course. Avoid excessive speed or abrupt changes in direction until the cetacean has left the area.

5. Reduce vessel speed to 10 knots or less when mother/calf pairs, groups, or large assemblages of cetaceans are observed near an underway vessel, when safety permits. A single cetacean at the surface may indicate the presence of submerged animals in the vicinity; therefore, prudent precautionary measures should always be exercised. The vessel shall attempt to route around the animals, maintaining a minimum distance of 100 yards whenever possible.

NMFS Southeast Region Vessel Strike Avoidance Measures and Reporting for Mariners; revised February 2008.

6. Whales may surface in unpredictable locations or approach slowly moving vessels. When an animal is sighted in the vessel's path or in close proximity to a moving vessel and when safety permits, reduce speed and shift the engine to neutral. Do not engage the engines until the animals are clear of the area.

Additional Requirements for the North Atlantic Right Whale

1. If a sighted whale is believed to be a North Atlantic right whale, federal regulation requires a minimum distance of 500 yards be maintained from the animal (50 CFR 224.103 (c)).

2. Vessels entering North Atlantic right whale critical habitat are required to report into the Mandatory Ship Reporting System.

3. Mariners shall check with various communication media for general information regarding avoiding ship strikes and specific information regarding North Atlantic right whale sighting locations. These include NOAA weather radio, U.S. Coast Guard NAVTEX broadcasts, and Notices to Mariners. Commercial mariners calling on United States ports should view the most recent version of the NOAA/USCG produced training CD entitled "A Prudent Mariner's Guide to Right Whale Protection" (contact the NMFS Southeast Region, Protected Resources Division for more information regarding the CD).

4. Injured, dead, or entangled right whales should be immediately reported to the U.S. Coast Guard via VHF Channel 16.

Injured or Dead Protected Species Reporting

Vessel crews shall report sightings of any injured or dead protected species immediately, regardless of whether the injury or death is caused by your vessel.

Report marine mammals to the Southeast U.S. Stranding Hotline: 877-433-8299
Report sea turtles to the NMFS Southeast Regional Office: 727-824-5312

If the injury or death of a marine mammal was caused by a collision with your vessel, responsible parties shall remain available to assist the respective salvage and stranding network as needed. NMFS' Southeast Regional Office shall be immediately notified of the strike by email (takereport.nmfsser@noaa.gov) using the attached vessel strike reporting form.

For additional information, please contact the Protected Resources Division at:

NOAA Fisheries Service
Southeast Regional Office
263 13th Avenue South
St. Petersburg, FL 33701
Tel: (727) 824-5312
Visit us on the web at http://sero.nmfs.noaa.gov

NMFS Southeast Region Vessel Strike Avoidance Measures and Reporting for Mariners; revised February 2008.