NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7
BIOLOGICAL OPINION

Title:	Programmatic Biological and Conference Opinion on the United States Army Corps of Engineers (USACE) Underwater Investigation and Cleanup for Formerly Used Defense Sites (FUDS) in and around Culebra and Desecheo Islands, Puerto Rico
Consultation Conducted By:	Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce
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List of Acronyms

AFTT – Atlantic Fleet Training and Testing

ATON – Aids-to-Navigation

BIP – Blow-in-Place

AUV – Autonomous Underwater Vehicle

CFMC – Caribbean Fishery Management Council

CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act

CFR – Code of Federal Regulations

CPUE – Catch per Unit of Effort

CRCP – Coral Reef Conservation Program

DERP – Defense Environmental Restoration Program

DGM – Digital Geophysical Mapping

DGPS – Digital Global Positioning System

DOD – Department of Defense

DPS – Distinct Population Segment

EEZ – Exclusive Economic Zone

EM – Electromagnetic

EOD – Explosive Ordnance Disposal

EPA – U.S. Environmental Protection Agency

ESA – Endangered Species Act

FGBNMS – Flower Garden Banks National Marine Sanctuary

FKNMS – Florida Keys National Marine Sanctuary

FMP – Fishery Management Plan

FR – Federal Register

FUDS – Formerly Used Defense Sites

GPS – Global Positioning System

HP – High Powered

HFD – Hazardous Fragment Distances

HTW – Hazardous and Toxic Waste

INPR – Inventory Project Report

ISO – Industry Standard Objects

ITS – Incidental Take Statement

IUCN – International Union for Conservation of Nature

IVS – Instrument Verification Strip

LBL – Long Base-Line

MC – Munitions Constituents

MEC – Munitions and Explosives of Concern

MD – Munition Debris

MMPA – Marine Mammal Protection Act

MPA – Marine Protected Area

MPPEH – Material Potentially Presenting an Explosive Hazard

MRS – Munitions Response Site

NCCOS – National Centers for Coastal Ocean Science

NCRMP – National Coral Reef Monitoring Program

NEW – Net Explosive Weight

NMFS – National Marine Fisheries Service

NOAA – National Oceanic and Atmospheric Administration

NOS – National Ocean Service

NWR – National Wildlife Refuge

OPR – Office of Protected Resources

PBF – Physical and Biological Features

PDC – Project Design Criteria

PDA – Personal Digital Assistant

pH – Potential Hydrogen

PRDNER – Puerto Rico Department of Natural and Environmental Resources

PTS – Permanent Threshold Shift

QC – Quality Control

ROV – Remotely Operated Vehicle

RMS- Root Mean Square

RPM – Reasonable and Prudent Measure

RTK – Real-Time Kinematic

SCL – Straight Carapace Length

SCTLD – Stony Coral Tissue Loss Disease

SCUBA – Self-Contained Underwater Breathing Apparatus

SEFSC – Southeast Fishery Science Center

SEL – Sound Exposure Level

SERO – Southeast Regional Office

SOPs – Standard Operating Procedures

SPAGS – Spawning Aggregations

SPP – Systematic Project Planning

TEMA – Towed Electromagnetic Array

TNT – Trinitrotoluene

TL – Total Length

TTS – Temporary Threshold Shift

USBL Ultra-Short Baseline

USACE – U.S. Army Corps of Engineers

USCG – U.S. Coast Guard

U.S.C. – United States Code

USFWS – U.S. Fish and Wildlife Service

USVI – U.S. Virgin Islands

UIT – Underwater Investigation Team

UXO – Unexploded Ordnance

1 INTRODUCTION

The ESA of 1973, as amended (16 U.S.C. 1531 et seq.) establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat they depend on. Section 7(a)(2) of the ESA requires federal agencies to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Federal agencies must do so in consultation with the NMFS for threatened or endangered species (ESA-listed species), and designated critical habitat under NMFS's jurisdiction (50 CFR §402.14(a)) that may be affected by the action. If a federal action agency determines that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and NMFS concurs with that determination for species under NMFS jurisdiction, consultation concludes informally (50 CFR §402.14(b)).

Section 7(b)(3) of the ESA requires that, at the conclusion of consultation, NMFS provides an opinion stating whether the Federal agency's proposed action is likely to jeopardize ESA-listed species or destroy or adversely modify designated critical habitat. If NMFS determines that the action is likely to jeopardize listed species or destroy or adversely modify critical habitat, NMFS provides a reasonable and prudent alternative that allows the proposed action to proceed in compliance with section 7(a)(2) of the ESA. If an incidental take is expected, section 7(b)(4) requires NMFS to provide an ITS, which exempts take incidental to an otherwise lawful action, and specifies the impact of any incidental taking, including RPMs to minimize such impacts and terms and conditions to implement the RPMs.

Amendments to the regulations governing interagency consultation (50 CFR Part 402) became effective on October 28, 2019 (84 FR 44976). On July 5, 2022, the U.S. District Court for the Northern District of California issued an order vacating the 2019 regulations that were revised or added to 50 CFR part 402 in 2019 ("2019 Regulations," see 84 FR 44976, August 27, 2019) without making a finding on the merits. On September 21, 2022, the U.S. Court of Appeals for the Ninth Circuit granted a temporary stay of the district court's July 5 order. On November 14, 2022, the Northern District of California issued an order granting the government's request for voluntary remand without vacating the 2019 regulations. The District Court issued a slightly amended order two days later on November 16, 2022. As a result, the 2019 regulations remain in effect, and we are applying the 2019 regulations here. For purposes of this consultation and in an abundance of caution, we considered whether the substantive analysis and conclusions articulated in the biological opinion and ITS would be any different under the pre-2019 regulations. We have determined that our analysis and conclusions would not be any different.

The Federal action agency for this consultation is the USACE Jacksonville District. The USACE proposes the investigation and the implementation of removal/remedial actions to address underwater munitions offshore of FUDS around Culebra Island and its surrounding islands and cays (FUDS Property No. I02PR0068) and Desecheo Island (FUDS Property No. I02PR0069), Puerto Rico. This programmatic consultation consults on activities by the USACE that will be conducted in phases through the completion of remedial activities in areas within and around Culebra Island and its surrounding islands and cays and Desecheo Island.

This document represents the NMFS biological and conference opinion on the effects of the proposed action (Section 3) on giant manta ray (*Manta birostris*); Nassau grouper (*Epinephelus striatus*); oceanic whitetip (*Carcharhinus longimanus*) and scalloped hammerhead sharks (*Sphyrna lewini*; Northwest and Western Central Atlantic DPS; queen conch (*Alger gigas*; proposed); lobed star (*Orbicella annularis*), mountainous star (*Orbicella faveolata*), boulder star (*Orbicella franksi*), elkhorn (*Acropora palmata*), staghorn (*Acropora cervicornis*), pillar (*Dendrogyra cylindrus*), and rough cactus corals (*Mycetophyllia ferox*); green (*Chelonia mydas*; North Atlantic and South Atlantic DPSs), leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*), and loggerhead sea turtles (*Caretta*; Northwest Atlantic Ocean DPS); blue (*Balaenoptera musculus*), fin (*Balaenoptera physalus*), sei (*Balaenoptera borealis*), and sperm whales (*Physeter microcephalus*); designated critical habitat for the North Atlantic DPS of green sea turtle and elkhorn and staghorn coral; and proposed critical habitat for Nassau grouper, lobed star, mountainous star, boulder star, pillar, and rough cactus corals. During consultation, the USACE requested to conference on species proposed for ESA listing and proposed critical habitat designations.

This consultation was conducted by the NMFS OPR ESA Interagency Cooperation Division (hereafter referred to as “we”, “us”, or “our”). A complete record of this consultation is on file at NMFS OPR in Silver Spring, Maryland.

Programmatic Consultations

The USFWS and NMFS (the Services) have developed a range of techniques to streamline the procedures and time involved in consultations for broad agency programs or numerous similar activities with predictable effects on listed species and critical habitat.

Programmatic ESA section 7 consultations allow the Services and action agencies to consult on the effects of programmatic actions such as: (1) multiple similar, frequently occurring or routine actions expected to be implemented in particular geographic areas; and (2) a proposed program, plan, policy, or regulation providing a framework for future proposed actions (50 CFR §402.02). Mixed programmatic action means, for purposes of an ITS, a Federal action that approves action(s) that will not be subject to further section 7 consultation, and also approves a framework for the development of future action(s) that are authorized, funded, or carried out at a later time and any take of a listed species would not occur unless and until those future action(s) are authorized, funded, or carried out and subject to further section 7 consultation (50 CFR §402.02). NMFS is required to issue an ITS for those portions of the program that are authorized at the program level, not subject to a future section 7 consultation, and are reasonably certain to cause take (50 CFR §402.14(i)(6)). Any future actions within the framework that will be subject to step-down consultations when the future actions are authorized, funded, or carried out may require an ITS for the incidental take associated with those actions.

A programmatic ESA section 7 consultation should identify PDCs or standards that will be applicable to all future projects implemented under the program. PDCs are conservation measures that serve to prevent adverse effects to listed species, or to limit adverse effects to predictable levels that will not jeopardize the continued existence of listed species or destroy or adversely modify critical habitat. Avoidance and minimization of adverse effects to species and their designated or proposed critical habitat is accomplished by implementing PDCs at the individual project level or taken together from all projects under the programmatic consultation. For those activities that meet the PDCs, there is no need for project-specific consultation. For actions that do not meet the PDCs but are within the scope of the proposed action, or for which specifics of individual activities are not yet known, project-specific review may be required and step-down consultations may be needed.

This consultation, biological opinion (opinion), and associated ITS were completed in accordance with ESA section 7, associated implementing regulations (50 CFR §§ 402.01-402.16), and agency policy and guidance. The consultation was conducted as a programmatic with some actions that will not be subject to further ESA section 7(a)(2) consultation and a framework for the development of future actions and associated submission of project-specific information, as well as procedures for step-down consultations under the programmatic framework for future actions for which NMFS cannot fully analyze the effects at this time. Because this opinion results from a programmatic consultation that includes a "mixed programmatic action,", an ITS is included for the activities for which enough information was available to allow a detailed effects analysis in order to estimate the amount of incidental take in keeping with the 2015 ITS rule (50 CFR §402.02). For mixed programmatic actions, an ITS is required at the programmatic level only for those program actions that are reasonably certain to cause take and are not subject to further section 7 consultation (50 CFR §402.14(i)(6)).

1.1 Background

The DOD is responsible for investigating and remediating contamination from former DOD activities at FUDS. In accordance with the DERP statute (10 U.S.C. §2701), the FUDS program is responsible for the clean up of environmental contamination at properties formerly owned, leased, possessed, or used by the military services (Army, Navy, Air Force, or other Defense agencies). The DOD designated the Department of the Army as the Executive Agent for the FUDS program. The Secretary of the Army further delegated the program management and execution responsibility of the FUDS program to the USACE. In managing and executing the FUDS program, the USACE must comply with the DERP statute, the Comprehensive

Environmental Response, Compensation, and Liability Act (CERCLA) (42 U.S.C. §9601 et seq.), Executive Orders (EOs) 12580 and 13016, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), substantive requirements of Federal and State environmental laws, and all applicable Department of Defense (DoD) and Army policies, including Engineering Regulation 200-3-1. The goal of the FUDS program is to reduce risk to people and the environment through effective, legally compliant, and cost-effective actions for contamination attributable to DOD activities.

The USACE is responsible for the day-to-day management and execution of FUDS cleanup activities in sites around Puerto Rico. FUDS are properties that were under the jurisdiction of the military and owned, leased, or otherwise possessed by the United States government and transferred from DOD control prior to October 17, 1986. The Culebra Island FUDS property was used by the U.S. Navy and the Marines from 1903 to 1975 as a live practice range for small arms, bombing, and weapons testing. Other uses included a camp area, motor pool, and an airport. These sites make up the MRSs within Culebra where USACE FUDS cleanup activities occur (Figure **1**). MRSs are sites that are known or suspected to contain UXO, discarded military munitions, or MC.

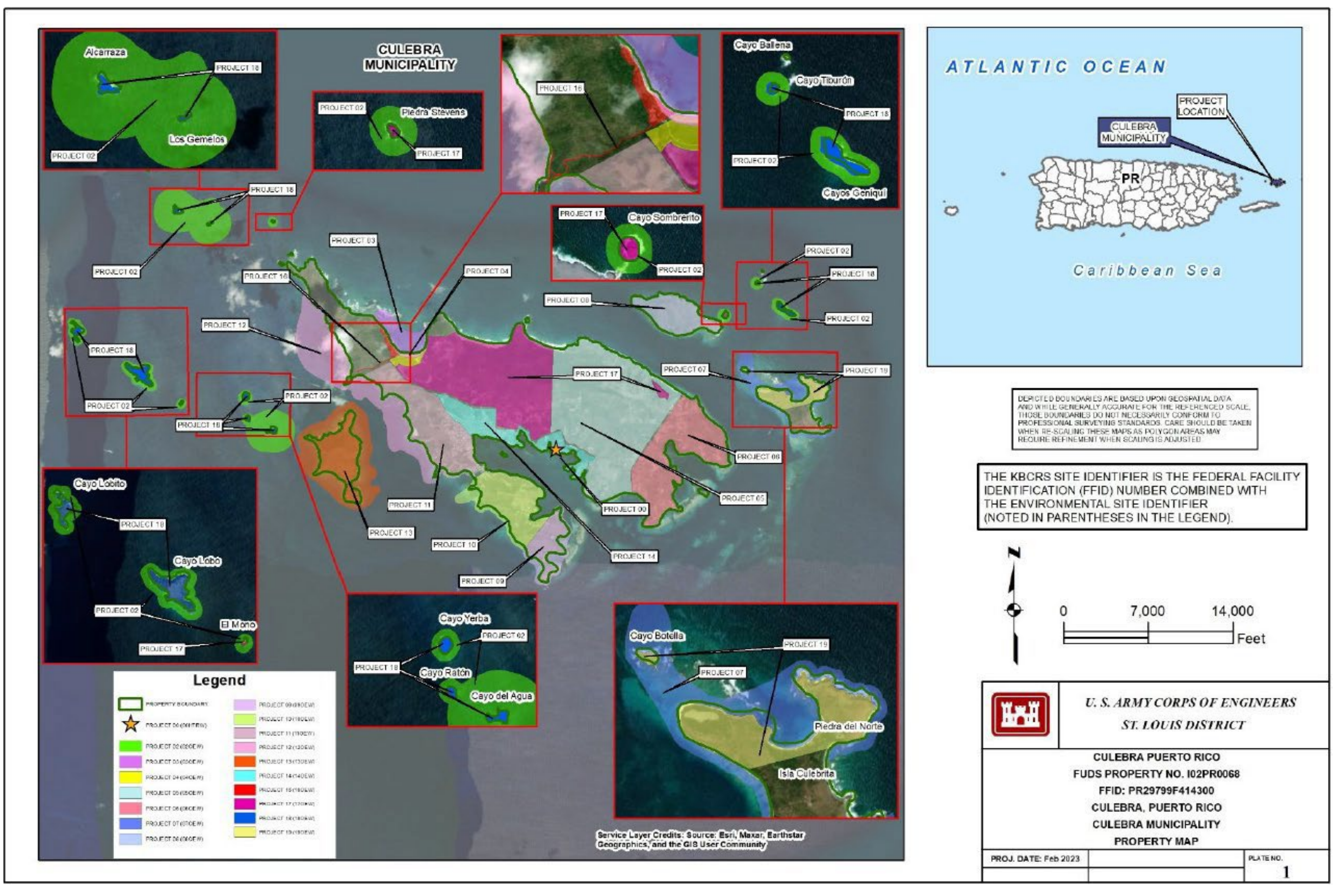

Figure 1. Culebra Project Areas (also known as MRSs)

Beginning in 1978, all of the land acquired by the military on Culebra Island and the surrounding cays were given to the Department of the Interior or transferred to the government of Puerto Rico by quitclaim deed. Currently, most of the main island of Culebra is privately owned or managed by PRDNER or the Municipality of Culebra. Culebra has a population of approximately 1,792 individuals (U.S. Census Bureau 2020). A small portion of the main island of Culebra, the surrounding cayos, and Culebrita make up the Culebra NWR, which is managed by the USFWS as a part of the Caribbean Islands NWR Complex. In 1909, portions of the Culebra Archipelago were designated as a wildlife reserve in accordance with an Executive Order signed by President Theodore Roosevelt. Onsite administration of the NWR was established in 1983. Approximately one-quarter of the Culebra archipelago's total land mass is now included within the Culebra NWR, encompassing approximately 6.1 square kilometers (1,510 acres). MRSs 02, 07, and 13 are located completely within the Culebra NWR. Recreational activities in underwater portions of Culebra include fishing, swimming, snorkeling, and SCUBA diving. Other activities conducted in underwater portions of Culebra include research and habitat improvement activities conducted by PRDNER, USFWS, and NOAA.

The former Desecheo Island Bombing Range, also referred to as Ramey Bombing Range No. 1, was used by the U.S. Navy and the U.S. Air Corps/Air Force for high-level radar bombing and gunnery exercises between 1940 and 1964. The former bombing range comprised of two bombing range target areas, the East Bombing Range Target Area and the West Bombing Range Target Area (see Figure 2). Together, these two former target areas encompass the MRS for Desecheo Island. The two bombing range target areas included the majority of the 1.45 square kilometer (360 acre) island, and extended into the open water areas surrounding the island. Due to the limited size of the island and its rugged terrain, no permanent targets or other features were constructed on the island; instead, natural features of the island and adjacent waters were selected as target centers. Desecheo Island was transferred to the USFWS in 1976 and designated a NWR. Currently, the island is uninhabited. Resource agency staff members occasionally camp on the island and it is intermittently used by trespassers for camping, hunting, and fishing, though public access to the island is prohibited. Waters around Desecheo are also used by divers and the PRDNER designated waters up to ½ nautical mile around the island as a marine reserve where fishing is prohibited.

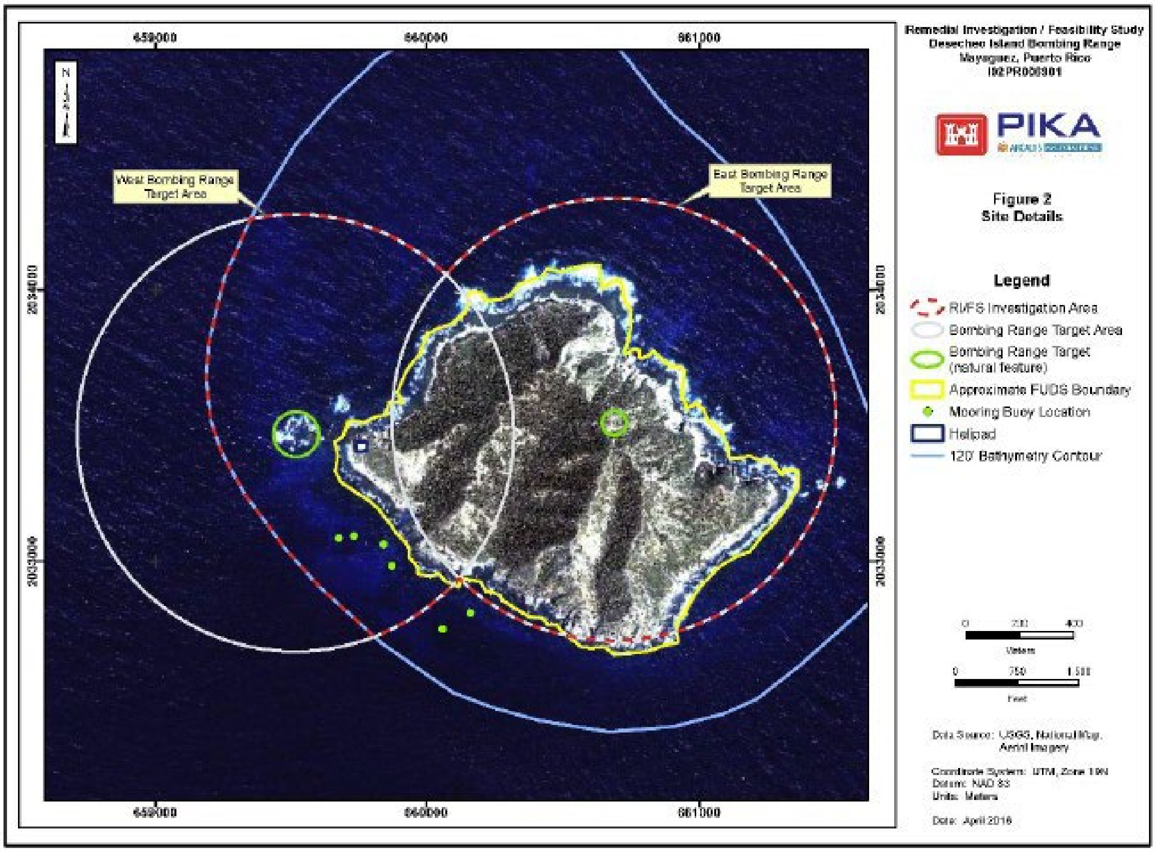

Figure 2. Former Desecheo Bombing Range Target Areas

On August 5, 1991, an INPR (USACE Jacksonville District 2005) was signed establishing Culebra and Desecheo Islands as FUDS projects. The Findings and Determination of Eligibility from the INPR concluded each site was eligible for inclusion in the DERP-FUDS program. These projects fall under the DERP-FUDS program because the properties at Culebra and Desecheo Islands were formerly owned by, leased to, or otherwise possessed by the U.S. under the jurisdiction of the Secretary of Defense at the time of the actions leading to contamination by hazardous substances and were transferred from DoD control prior to October 17, 1986

In 2005, the INPR was revised to further clarify the military use of Culebra Island and some of its surrounding islands and cays and divide the original Culebra FUDS into 14 separate MRSs or project sites. One HTW project was identified and assigned the number 00, and 14 MRSs were identified and assigned Risk Assessment Code scores. Project number 15 for Culebra deals specifically with community relations for the project and does not have a site location. Also, Project 16 was added to address congressionally authorized cleanup areas in Culebra's Northwest Peninsula (See Figure 1. MRS 01 for Culebra was not defined.)

1.2 Consultation History

NMFS SERO Protected Resources Division began working with the USACE in 2008, providing technical assistance for investigations and removal/remedial activities being conducted by the USACE in accordance with CERCLA on Culebra Island and surrounding islands and cays. During this time, SOPs for field work were developed to avoid and minimize potential effects of vessel transit and underwater investigation and removal activities on ESA resources as part of informal consultations. In anticipation of underwater field work at Culebra that could result in take of ESA-listed species, the USACE submitted a "request for coordination" and a listed species analysis for Culebra's MRS 02 and 07 to NMFS on March 18, 2016 (USACE 2016). After continued coordination and technical assistance, the scope of the coordination for the FUDS action was expanded to incorporate additional underwater investigation and site cleanup activities in Desecheo Island's MRS 01 and Culebra Island's MRSs 03, 10, 11, 12, and 13. NMFS SERO transferred responsibility for coordination with the USACE, including technical assistance and ESA section 7 consultations related to USACE activities in Culebra, to OPR in January 2017.

This opinion is based on information provided by the USACE, including listed species analyses, briefings, underwater feasibility studies, remedial investigation reports, coordination letters, and additional information documents (USACE 2016; USACE 2020; USACE 2021a; USACE 2021b; USACE 2021c; USACE 2021d; USACE 2022a; USACE 2022b). Our communication with the USACE regarding this programmatic consultation is summarized as follows:

- **February 2, 2018**: NMFS and the USACE agreed to expand the scope of the proposed action to all Culebra MRSs and met in San Juan, Puerto Rico on February 2, 2018 to discuss. After the meeting, a list of additional information for each site was requested by NMFS. To address the request for additional information at each site, the USACE developed and submitted an example analysis to NMFS for MRS 13 in July 2018, which NMFS agreed would be adequate to address remaining information needs.
- **September 21, 2020:** The USACE sent a response to our 2018 request for additional information via email with reports on sea turtles, marine mammals, and the presence of anomalies in areas containing ESA-listed corals and coral critical habitat.
- **October 14, 2020**: NMFS and the USACE conducted a conference call to discuss remaining information needed to initiate consultation.
- **August 11, 2021:** The USACE submitted additional information requested by NMFS for Culebra's MRSs 02, 03, 07, 12 and 13.
- **August 27, 2021:** NMFS submitted questions to the USACE upon review of the additional information regarding the locations where activities will take place in the MRSs, new technologies that may be used during the activities, and the USACE's effects determinations for newly listed species in the action area.

- **September 16, 2021:** NMFS and the USACE conducted a phone conference to discuss questions that NMFS submitted to the USACE on August 27, 2021. During the meeting, the USACE confirmed that the proposed action area includes Desecheo Island's MRS 01 and Culebra Island's MRSs 02, 03, 07, 10, 11, 12, and 13. The USACE also noted that an effects analysis was not provided for some of the underwater removal technologies and that it would provide an effects analysis for these missing activities in an updated letter to NMFS. Further, the USACE agreed to submit more information on its effects determinations for newly listed species and proposed critical habitat in the action area in the follow-up letter.
- **February 28, 2022:** The USACE submitted a follow-up letter to NMFS providing more information on its effects determinations for newly listed species and critical habitat in the action area and additional technology to be used in underwater investigations and cleanup during implementation of activities under the proposed action. In addition, the USACE provided revised versions of the documents originally submitted on August 11, 2021.
- **March 23, 2022:** NMFS submitted questions to the USACE upon review of the additional information and follow-up letter asking for more information on the removal technologies and updates to SOPs.
- **June 2, 2022:** NMFS requested a final determination table from the USACE to account for any updates to species' determinations made in the USACE's 2016 "request for coordination."
- **July 13, 2022:** The USACE submitted a final determination table to NMFS and provided more information on its effects analysis for newly proposed removal technologies. NMFS acknowledged receipt of the table and information and, on July 22, 2022, sent a letter with an initiation date of July 13, 2022.
- **July 27, 2022:** NMFS submitted a draft description of the proposed action to the USACE for review via email.
- **August 17, 2022:** The USACE sent NMFS their comments and edits to the draft proposed action via email.
- **August 25, 2022:** The USACE sent NMFS its estimates on the number of ESA-listed corals near remaining MEC/MPPEH items in the Culebra and Desecheo MRSs.
- **September 12, 2022:** The USACE and NMFS met to discuss and resolve comments on the draft proposed action.
- **September 15, 2022:** The USACE hosted an SPP Meeting on underwater areas of MRSs 03 and 12 in Culebra. Additional information on the use of hazard buoys and mooring devices that may be installed as part of the USACE proposed action was provided to NMFS.

- **February 8, 2023:** NMFS sent the USACE the draft programmatic biological opinion via email for review and comment.
- **March 30, 2023:** The USACE sent NMFS their comments and edits to the draft programmatic biological opinion via email.

2 THE ASSESSMENT FRAMEWORK

This opinion includes a jeopardy analysis for ESA-listed species and a destruction or adverse modification of critical habitat analysis.

"Jeopardize the continued existence of" means 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 an ESA-listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR §402.02).

"Destruction or adverse modification" means a direct or indirect alteration that appreciably diminishes the value of designated critical habitat for the conservation of an ESA-listed species as a whole (50 CFR §402.02).

The 2019 ESA regulations define "effects of the action" to incorporate direct, indirect, interrelated, and interdependent effects into a single classification. In doing so, we also retained the concepts that the consequences of the action were attributable to the action if they were caused by or would not occur "but for" the action and were "reasonably certain to occur." This definition did not change the standard for requiring section 7(a)(2) consultation, which remains any action that "may affect" listed species or their critical habitat. As such, this consultation considers both species and critical habitat "likely to be adversely affected" by the action as well as those "not likely to be adversely affected."

An ESA section 7 assessment involves the following steps:

Description of the Proposed Action (Section 3): In this programmatic consultation, a description of the proposed action on the part of the USACE includes those activities that will not require further consultation and those activities for which project-specific review and potentially step-down consultations will be required in the future, if they may affect listed species or designated critical habitat, because the specifics are not known at this time. This section also includes the PDCs for avoidance and minimization of impacts to proposed and ESA-listed species and critical habitat, and information regarding the procedures for submitting project-specific reviews and step-down consultation requests, and conducting regular reviews under the programmatic consultation. We also discuss the potential stressors we expect to result from the USACE's proposed action, including those that will not require further review and those that will require project-specific review and potentially step-down consultation under the programmatic.

Action Area (Section 4)*:* We describe the action and those aspects (or stressors) of the action that may have effects on the physical, chemical, and biotic environment. We describe the action area with the spatial extent of the stressors from those actions.

Potential Stressors (Section 5): We discuss the potential stressors we expect to result from the action for both the activities that will not require further consultation and for activities that will require step-down consultations.

Species and Critical Habitat in the Action Area (Section 6): We identify the proposed and ESA-listed species and designated and proposed critical habitat under NMFS jurisdiction that co-occur in space and time with the stressors caused by the proposed action within the action area and may be affected by the proposed action. We then identify the ESA-listed species that are not likely to be adversely affected by the proposed action (Section 6.1). The remaining species and critical habitats in the action area are anticipated to experience adverse effects as a result of exposure to stressors caused by the proposed action. We evaluate the status of those species and critical habitats (Section 6.2) and discuss these species and critical habitats in the remaining sections of the opinion.

*Environmental Baseline (*Section 7): We describe the environmental baseline as the "condition of the proposed and listed species and designated and proposed critical habitat in the action area, without the consequences to the species or critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process. The consequences to proposed and listed species from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline" (50 CFR §402.02).

Effects of the Action (Section 8): "Effects of the action are all consequences to proposed and listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action" (50 CFR §402.02). The effects of the action section includes analyses of exposure, response, and risk for the species and critical habitat that are likely to be adversely affected by the action.

Cumulative Effects (Section 9): Cumulative effects "are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation" (50 CFR §402.02). Effects from future federal actions that are unrelated to the proposed action are not considered because they require a separate ESA section 7 jeopardy analysis.

Integration and Synthesis (Section 10): In this section, we complete our assessment of the effects of the action to species and critical habitat because of implementing the proposed action. We add the effects of the action (Section 8) and cumulative effects (Section 9) to the environmental baseline (Section 7), taking into account the status of the species and critical habitat (Section 6), to formulate the agency's biological opinion and determination of the effects of the action on listed resources. This final determination assesses whether the action could reasonably be expected to:

Reduce appreciably the likelihood of survival and recovery of proposed and ESA-listed species in the wild by reducing their numbers, reproduction, or distribution, and state our conclusion as to whether the action is likely to jeopardize the continued existence of such species; or

Appreciably diminish the value of designated and proposed critical habitat as a whole for the conservation of an ESA-listed species, and state our conclusion as to whether the action is likely to destroy or adversely modify designated or proposed critical habitat.

Conclusion (Section 11): The conclusion section summarizes the results of our jeopardy and destruction or adverse modification analyses.

If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of proposed and ESA-listed species or destroy or adversely modify designated and proposed critical habitat, then we must identify Reasonable and Prudent Alternatives (RPAs) to the action, if any, or indicate that to the best of our knowledge there are no RPAs (50 CFR §402.14).

Incidental Take Statement (Section 12): An ITS is included for those actions for which take of ESA-listed species is reasonably certain to occur in keeping with the revisions to the regulations specific to ITSs (80 FR 26832, May 11, 2015; ITS rule). The ITS specifies the life stages affected, the form of take, and establishes appropriate RPMs to minimize the impact of the take, if possible. Further, it identifies the specific terms and conditions to implement each RPM (ESA section 7 (b)(4); 50 CFR §402.14(i)).

We also provide discretionary Conservation Recommendations (Section 13) that may be implemented by the action agency (50 CFR §402.14(j)) to further aid in the conservation of the species.

Finally, we identify the circumstances in which Reinitiation of Consultation (Section 14) is required (50 CFR §402.16).

To comply with our obligation to use the best scientific and commercial data available (16 U.S.C. §1536(a)(2); 50 CFR §402.14), we collected information identified through searches of *Google*

Scholar, and cited sections of peer reviewed articles, species listing documentation, and reports published by government and private entities. This opinion is based on our review and analysis of various information sources, including:

- Information submitted by the USACE
- Government reports
- Peer-reviewed scientific literature

These resources were used to identify information relevant to the potential effects and associated stressors and responses of proposed and ESA-listed species and designated and proposed critical habitat under NMFS' jurisdiction that may be affected by the proposed action to draw conclusions on risks the action may pose to the continued existence of these species and the value of designated and proposed critical habitat for the conservation of proposed and ESA-listed species.

3 Description of the Proposed Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies (50 CFR §402.02). Because this is a mixed programmatic consultation, the description of the proposed action includes details of actions that will not be subject to further ESA section 7 consultation and the framework for the development of future actions that are authorized, funded, or carried out at a later time that may be subject to further ESA section 7 consultation. The USACE proposes the removal of suspected MEC items and MPPEH from underwater areas throughout MRSs around Culebra Island and Desecheo Island, Puerto Rico. MEC and MPPEH may be present because of historic aerial bombing, amphibious training, and artillery/gunnery firing, among other military actions, as part of past military training on and around Culebra Island and its surrounding islands and cays and Desecheo Island. Preliminary USACE investigations of the Culebra and Desecheo MRSs indicate that there are approximately 19,216 MEC/MPPEH that may be present within underwater areas (USACE 2022b).

3.1 Authorities under which the Action will be Conducted

The action analyzed here falls under the DERP, (10 USC § 2700 et seq.). Under the DERP, the DOD conducts cleanup at active installations, FUDS, and Base Realignment and Closure locations. As noted above, the DOD designated the Department of Army as the Executive Agent for the FUDS program. The Secretary of the Army further delegated the program management and execution responsibility for FUDS to the USACE. The USACE is responsible for the daily management and execution of FUDS cleanup activities in Puerto Rico and is therefore the Federal action agency for this consultation. The work conducted for this project will be performed in accordance with Sections 104 and 121 of CERCLA; Executive Order 12580; and the National Oil and Hazardous Substances Pollution Contingency Plan. A general overview of the CERCLA process is displayed in Figure 3 below. All activities involving work in areas possibly containing MPPEH is conducted in full compliance with the USACE, DOD, Department of the Army, and local requirements regarding personnel, equipment, and procedures.

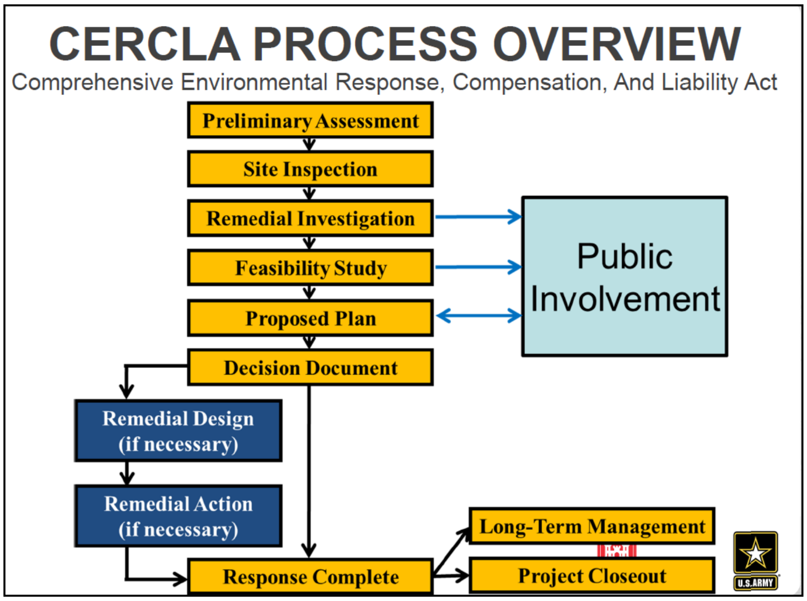

Figure 3. CERCLA Overview

Through the CERCLA process, a lead regulatory agency for a cleanup site is established. The PRDNER is the lead regulatory agency for the Culebra Island and Desecheo Island site cleanup and coordinates with the USACE through the framework of the Defense Commonwealth Memorandum of Agreement and the Commonwealth Management Action Plan to ensure environmental issues with FUDS in Puerto Rico are addressed. The process for identifying project objectives and designing data collection for programs at FUDS properties is specified by the SPP and its team members. The SPP assists in ensuring that the requisite type and quality of data are obtained to satisfy project objectives that lead to informed decisions and project/property closeout. The SPP Team is comprised of stakeholders from NMFS, NOAA's Office of Response and Restoration, PRDNER, the Authority for the Conservation and Development of Culebra, the EPA, and the USFWS.

3.2 Proposed Activities

Proposed activities within the action area include:

- Underwater investigations using digital geophysical mapping technology and testing of new detection technologies;
- Location and removal of underwater munitions items from on or beneath the seafloor;

- Biological monitoring;
- Collection of surface water and marine sediment samples;
- Installation and maintenance of structures, such as anchor systems and marker buoys;
- General boating and helicopter operation; and
- Relocation/transplantation of coral.

All of these activities will be conducted during daylight hours.

The following subsections provide details on the activities noted above. These activities will incorporate the appropriate PDCs (Section 3.3.1) to avoid and minimize impacts to proposed and ESA-listed species and their designated or proposed critical habitat. Many of these PDCs were already part of the SOPs the USACE developed in coordination (e.g., technical assistance) with NMFS and USFWS for investigations of MEC and/or MPPEH in MRS sites 02, 03, 07, 10, 11, 12, and 13 around Culebra Island and its surrounding islands and cays and MRS 01 in Desecheo Island (USACE 2015b). The effects of these activities are considered in this opinion (Section 6 and Section 8) to the extent possible and take incidental to the proposed activities is exempted through the ITS (Section 12). Some of the activities will require project-specific review and may require step-down consultation under this opinion, as described further in the subsections below.

3.2.1 Non-Intrusive Underwater Investigations

Environmental Baseline Surveys were conducted to establish baseline environmental conditions of the investigation areas due to potential sensitive benthic habitats. A two-stage data collection approach was implemented to delineate the benthic habitats present within the underwater portions of the action area, with the goal of utilizing the data to plan subsequent transect locations for DGM mapping. Environmental Baseline Surveys provided essential data on the sea bottom conditions and depths to better determine the type of platform system to be implemented during non-intrusive DGM transect surveys. In order to identify the location of MEC/MPPEH contained in the underwater portions of MRSs around Culebra and Desecheo Islands, the USACE performs DGM of each site for the preliminary identification of geophysical anomalies. This consists of mapping transects identified from past Environmental Baseline Surveys of the action area (e.g., USACE 2014).

All non-intrusive underwater investigation work will be conducted by qualified and trained divers and snorkelers or UXO Technicians and will be planned in a manner that avoids, to the maximum extent practicable, direct impacts to proposed, threatened, and endangered species and their designated or proposed critical habitat within the action area. When assessing shallow water areas between 0.9 and 1.2 meters (three and four feet) deep, targets are investigated using either UXO-qualified snorkelers or UXO Technicians on paddleboards or small survey vessels (e.g., kayaks) at high tide to limit contact with coral. Prior to initiation of daily operations, the UIT will check the weather conditions, inspect the vessel and verify that all the required equipment is available, in good condition, working correctly, and calibrated. The UIT will maintain a log detailing equipment inspections and will make sure that underwater conditions (e.g. visibility, current speeds) and weather are suitable for diving to ensure safety for divers and snorkelers and sensitive underwater habitats. The number of divers and snorkelers on the UIT in the water will be determined by the USACE or its contractor conducting the investigation and will be based on site conditions.

To support or supplement underwater non-intrusive investigation activities, the following equipment may be used: ROVs, side-scan sonar towfish, portable depth sounders, underwater cameras, marking buoys, floats, GPS, and personal digital assistants (PDAs). Examples of towfish utilized during underwater investigations include the EM-61 arrays and side-scan sonar systems.

One example of a towed EM-61 array is the TEMA-MK3 that was used during DGM investigations at Culebra MRS 03 and 12. The TEMA-MK3 is approximately five meters (16 feet) long and three meters (9.8 feet) wide, with an overall height of just over one meter (3.2 feet) at the tail. While being towed and actively flown, the data collection is along lines of equal water depth (i.e., contouring). This minimizes the need to perform sharp turns. When a turn is required, the TEMA-MK3 is brought up to the surface. The TEMA-Lite is three meters (9.8 feet) wide by four meters (13.1 feet) long. The TEMA-Lite platform is pushed in front of a custom purpose-built hovercraft, which results in a vessel and instrument draft of approximately 7.62 to 10.16 centimeters (three to four inches). Both systems are equipped with the high-powered variant of the Geonic EM 61-MK2-HP sensors. Each array consists of three 0.5-meter (1.6 feet) by 1.0-meter (3.2 feet) coils, with the long axis of each coil oriented perpendicular to the array. The effective width of the array is approximately three meters (10 feet). Data are digitally collected at a rate of approximately 12 to 15 hertz, and real-time positioning is provided by a Global Acoustic Positioning System USBL and/or high-resolution RTK-GPS systems. More details on underwater detection technologies that may be used during non-intrusive underwater investigations are discussed in Section 3.2.3, which details the MEC/MPPEH investigation process.

Proper operation of equipment is reviewed prior to use. Snorkeling teams utilize handheld equipment operated from the surface. Equipment such as cameras, GPS, PDAs, and portable depth sounders will be operated from a kickboard or attached to the snorkeler at all times. All equipment will be used in a manner to avoid physical contact or harassment of NMFS proposed and ESA-listed species and will not interfere with snorkeling operations. For example, handheld equipment carried by snorkelers will not contact corals or disturb the bottom or seagrass in the area. Site conditions, marine structures present, real-time information and existing water depth will be constantly monitored by trained operators to determine the appropriate use of equipment needed to minimize the risk of physical contact with protected species and critical habitat.

Before DGM is used to identify potential MEC/MPPEH, the USACE will test mapping equipment through the use of IVS. The purpose of IVS is to ensure successful DGM instrument functionality prior to collecting geophysical anomaly data within a site. Sites are surveyed before IVS installation using an analog instrument and/or DGM to ensure the site is free of anomalies or other metallic objects, leaving the IVS suitable for seeding. After the geophysical background survey is completed and the site is verified by the Site Geophysicist to be clean, the contractor team installs small, medium, and large ISOs as seed items acting as munition surrogates to ensure DGM equipment are able to properly detect ISOs. The locations are then surveyed. Per the PDCs in Section 3.3.1.1, sites will be verified to ensure no proposed and ESA-listed marine species are in the area where ISOs or equipment are expected to contact the substrate. Once the single or multi-day survey is complete, ISOs are retrieved and DGM data collection objectives are measured and documented in an IVS Report. The report presents the IVS construction details (including seed positions), describes IVS seeding, DGM data collection surveys and results, and summarizes the performance metrics. Once IVS data are collected, USACE and/or its contractors proceed with the DGM survey of potential MEC/MPPEH within the survey area.

During typical underwater investigation mapping operations, field technicians will conduct the following procedures:

1) Technicians collect pre-operation daily QC checks, warm-up and test/calibrate equipment, and conduct IVS for dynamic positioning and repeatability.
2) During DGM, technicians continually monitor the acquisition track path, sensor signal intensity, battery strength, RTK lock, and memory capacities of all instrumentation for operations.
3) Technicians document all activities such as switching out batteries, changing acquisition personnel duties, replacing cable, and note all significant weather changes.
4) Technicians collect post-operations QC procedures.
5) Site personnel are notified when the surveying of each designated area is completed.
6) One member of the team is responsible for maintaining the logbook/electronic log sheet and recording the following information:
    a. Grid or survey area identification
    b. Time survey started
    c. Time survey completed
    d. Names of team members
    e. Weather conditions
    f. Geophysical team designation

Once DGM concludes, the following procedures are accomplished at the end of each day.

1) All field equipment is secured in an appropriate safe location.

2) Documentation and logbook pages are photocopied and placed in the appropriate folder located in the site office.
3) The data files are submitted to the processing center data manager by the geophysical team leads.
4) The completed survey areas are recorded in the tracking log.
5) The positioning track maps and logbook pages are accessible for verification by the UXO QC Specialist.

3.2.2 MEC/MPPEH Location and Removal

Location and removal of MEC/MPPEH requires the use of vessels as diving and/or equipment platforms. Certified UXO divers/snorkelers will conduct MEC/MPPEH investigations of detected anomalies to investigate and identify MEC/MPPEH within the underwater portions of MRSs. Some of the detection technologies detailed below are proposed for use during MEC/MPPEH investigations (i.e., analog detection instrumentation). Identification of MEC/MPPEH will be conducted in advance of any removal activities or may be conducted the same day as removal activities in case of emergency. If the anomaly is resting on the seafloor, the investigation will be completed without disturbing the area or item and, if the anomaly is buried in sediment, it will be uncovered by excavating down to the anomaly using hand tools, then the investigation will be performed to determine if the anomaly is munitions-related and the appropriate removal process.

Surface exposed MEC/MPPEH locations may be identified using previously obtained underwater video footage; by diver visual inspection; through underwater geophysical surveys using DGM sensors, ROVs, towed arrays, and floats; AUVs with sonar sensors; and by UXO diver inspections with handheld metal detectors, magnetometers, or other non-intrusive methods. Detected subsurface metal anomalies can include debris, munitions debris, or MEC/MPPEH and require exposure by hand to enable identification. It is anticipated that the maximum depth of hand exploration will be approximately 61 centimeters (24 inches) using hand tools such as spades, trowels, or shovels. The use of other tools (e.g., water jets) may extend depth of investigation beyond 61 centimeters (24 inches).

In general, when MEC/MPPEH are found, notes and potentially photos and/or videos will be taken of the item, the surrounding habitat, and the presence and proximity of proposed and ESA-listed species in the vicinity of the item. This information is used to develop a description of the item, consider if and how the item can be removed safely, and, if present, determine how potential effects to proposed and ESA-listed species and critical habitat can be avoided or minimized. During these operations, the USACE and its contractors will identify exclusion zones to be monitored during the location and removal of underwater MEC/MPPEH items to minimize the potential for impacts to proposed and ESA-listed species and critical habitat from a nonintentional detonation or BIP. Exclusion zones are areas within which MEC/MPPEH removal activities will temporarily cease or be modified to protect specific biological resources from a non-auditory or an auditory injury to the maximum extent practicable. The USACE and its contractors may utilize passive acoustic monitoring to detect marine mammal vocalizations when animals are not readily observable at the surface (USACE 2015b).

3.2.3 MEC/MPPEH Detection and Positioning (MEC/MPPEH Investigations)

Methods for detecting munitions in the subsurface consist primarily of using geophysical instruments such as metal detectors and electromagnetometers combined with technical knowledge to process and analyze the geophysical data. Both DGM and analog detection instrumentation are available for a remedial action.

The detection method is selected based on MEC properties (size and type), suspected depth, (surface or subsurface) and the physical characteristics of the site (sediment type, topography, and local geology). The viability of detection technologies is affected by site conditions, including subsurface terrain, and water depth. The probability of detection is a function of signal-to-noise ratio. Therefore, with enough signal, an object is detectable, and for all analog and digital sensors, signal strength is a function of sensor-to-object distance, object orientation/inclination, and object size. Consequently, the closer the sensor is to the seafloor, the better its probability of detection.

The detection instruments are integrated with the equipment and methods used for location positioning, mapping, and reacquisition. In addition, sensor platforms are needed to support DGM detection instrumentation in an underwater environment. Examples of sensor platforms and MEC/MPPEH detection/positioning technologies that may be used during remedial investigations and removal actions are described below.

EM Sensor Platforms

During MEC/MPPEH investigations, marine DGM surveys are generally conducted aboard a vessel with the approximate dimensions of a 9.1 meter (30 foot) fiberglass or aluminum boat with a three meter (10 foot)-wide beam and 0.7 meter (2.5 foot) draft. An on-board or portable generator is required for alternating current power supply. In addition, a 5.2 to 7.9 meter (17 to 26 foot) work boat may serve as a support vessel to aid with GPS survey equipment (i.e., signal repeater), and to provide exclusion zone control while surveys are being conducted.

There are multiple DGM platforms that can support MEC/MPPEH detection in an underwater environment. The selected platform employed during activities associated with the proposed action will be based on the depth of water (determined from bathymetry data) and type of environment on the seafloor. The EM platform types may include the EM towed array, the EM ROV, and the EM float. A brief summary of each type of platform is provided below.

EM Towed Array. The EM towed array (or sled) is designed to keep a transmit/receive (Tx/Rx) coil as close to the seafloor as possible to maximize the detection depth of buried MEC/MPPEH. Towed arrays can rapidly map large areas in water depths greater than or equal to six meters (20 feet) in salt water. The sled may have a forward-facing camera mounted on it with a real-time feed to the survey vessel. The sled will be positioned with a Real-Time Kinematic Differential GPS (RTK-DGPS) antenna mounted on a mast, if used in shallow water, or using a USBL or LBL acoustic positioning system in deeper water. The sled may be towed across the seafloor on skids in unconsolidated sediments where no corals or obstructions are present, or flown above the seafloor. The primary disadvantage of towed arrays is maintaining a less than 1.98 meter (6.5 foot) height above the bottom of the seafloor while maintaining avoidance of proposed and ESA-listed species and their habitat, potentially limiting MEC/MPPEH detection.

EM ROV. The EM ROV platform is equipped with a pressure sensor, altimeter, pitch sensor, roll sensor, and video cameras so that real-time monitoring of the coil is possible. The EM coil is mounted in front of the ROV so it is in the camera view at all times. The ROV is maintained under positive control by the ROV operator at all times, lending the ability to maneuver the ROV/EM coil around challenging bottom types (coral heads/boulders). Positioning for the ROV and coil can be supplied by a USBL system set up between the survey vessel and the ROV system. The altitude would be monitored in real-time by the ROV operator, and the survey would be conducted with the coil within one meter (3.2 feet) of the seafloor as conditions allow. As corals often grow taller than 0.91 meters (three feet), the ROV will either divert around or go over the corals as needed and return to the preplanned transect/altitude as soon as it can safely do so. This platform performs well for the completion of transects in a coral environment deeper than six meters (20 feet) of salt water because it can be flown over the tops of the coral reef without impact to corals or their habitat. However, the system production rates vary significantly (between less than 0.5 acres/day to greater than one acre/day) depending on sea states and currents.

A type of ROV that may be used during USACE detection activities is a crawler. A crawler is no larger than 1.5 meters (five feet) wide by three meters (10 feet) long. It is a tethered or untethered underwater tracked robot/vehicle that contains clawed arms and is remotely operated by a trained human operator. The tracked or wheeled ROV crawls along the ocean floor where hard bottom and seagrass are not present. Other amphibious bottom crawler-based sensing can include large, motorized, wheeled or tracked vehicles that directly contact the seafloor, towing a platform with various metal detecting sensors. This platform would only be used in unconsolidated sediment (i.e., sand or mud without colonizing organisms such as seagrass), and would not be used in hard bottom habitats, reefs, or seagrass habitats because of the potential for physical damage to sensitive resources. Other than leaving temporary imprints/tracks across sand or mud substrate, operation of a tracked bottom crawler is expected to have temporary and minimal impact on these habitat types. These include localized short-term turbidity impacts due to resuspension of unconsolidated sediments (sand/mud). Crawlers also include control lines, hoses, a tether, and a support vessel. Crawlers may also be used for removal activities as noted in Section 3.2.4 below. A live-feed real-time camera or camera system will be used on ROVs to aid in detection/removal operations and provide sufficient camera footage to avoid impacts to corals, sensitive habitats, and ocean life. Localized noise impacts during crawler operation are possible but are expected to be minor.

EM Float. The EM Float system consists of a floating raft that supports a rigid mast. This floating raft can either be tied to the side of a vessel, towed behind the vessel, or it can be pushed by snorkelers for data collection. A Tx/Rx coil is rigidly attached to the bottom of the mast. This allows for the EM coil to be deployed beneath the water surface at a fixed depth that can be adjusted depending on the depth of the planned transect. The EM floating platform provides a means to float the Tx/Rx coil in shallow waters over coral reefs or areas with obstructions along the bathymetric contour line. An RTK-DGPS provides real-time positioning using an antenna mounted on the floating platform that is centered over the Tx/Rx coil at the bottom of the rigid mast. The coil would be set at a depth so that it is within 0.91 meters (3.3 feet) of the bottom along the pre-planned transect. The EM Float platform is the preferred platform for the completion of transects in shallow water environments (0.3 to 1.22 meters [one to four feet]) of salt water. Similar to the EM ROV, the coil can be flown over the tops of the coral reef without impact to the habitat. The production rate of the EM Float is better than the EM ROV at one acre/day. The production rate can be increased by adding an additional EM61 coil to the EM platform. For the float system, the maximum practical towed underwater array width is three meters (10 feet). The typical sensor width is 0.98 meters (3.3 feet), and for EM systems, the number of coils depend on coil size, but typical width includes three feet wide coils.

DGM TDMI Detection Technologies

A DGM time-domain electromagnetic induction (TDEMI) metal detector (e.g., Geonics EM61 MK2) induces a pulsed magnetic field beneath the transmitter coil, which in turn causes a secondary magnetic field to emanate from nearby objects that have conductive properties. TDEMI detectors will be used to digitally map the action area for both ferrous and non-ferrous metals. TDEMI detectors are effective for surveying in the depth range that characterizes the action area. These instruments are used in combination with GPSs or acoustic positioning systems to provide accurate locations of DGM anomalies. The EM61 MK2 has been tested on numerous geophysical prove outs and is supported by a database with detection responses collected over several known munitions at known orientations and depths. The EM61 MK2 is capable of detecting munitions of interest and smaller ferrous and non-ferrous metal objects in a geology that contains a high iron content. The high-powered EM probability of detection ranges from 90 to 100 percent, depending on sensor height above bottom, object burial depth and orientation/inclination, and the sensor platform’s lateral offset from anomaly sources.

DGM Cesium Vapor Magnetometers

Cesium vapor magnetometers (CVM) are effective in greater depths of water (4.57 to 7.62 meters [15 to 25 feet] of sea water) to digitally map the survey area; however, they are only effective at detecting ferrous metals. The CVM offers a significant detection range for a large MEC item (12.7 centimeter [five inch] projectiles and larger). For total field CVM systems, an 80 to 100 percent probability of detection can be achieved for larger ferrous objects (e.g., 81 millimeter [3.2 inch] mortars). This detection rate is dependent on the sensor's height above the bottom, the object burial depth/orientation/inclination, and the sensor platform's lateral offset from anomaly sources. CVM would be most effective at detecting ferrous metallic objects in areas with reduced "hot rock" (e.g., naturally ferrous-bearing soils and rocks).

Analog FDEMI Detection Technology

Frequency domain electromagnetic induction (FDEMI) metal detectors (e.g., underwater White's all metals detector) generate one or more defined frequencies in a continuous mode of operations that detect both ferrous and non-ferrous metallic objects. FDEMI metal detectors have depth of detection capabilities that are related to the size of the coils and transmitter power. Handheld FDEMI metal detectors typically have smaller coils and less transmitter power than their digital counterparts; therefore, typically have more shallow maximum depths of detection than their digital counterparts. Analog detectors do not provide an electronic record of the magnetic response or a geo-referenced location of data and anomalies. Therefore, the effectiveness is dependent upon the skill and experience of the instrument operator. Instrument operators place flags to mark anomalies based on audio output of the instruments or dig anomalies immediately. Developing rigorous QC measures that are capable of assessing the consistency of each operator's effectiveness and performance for the duration of the survey is more challenging and less precise than for digital geophysical methods. Handheld detectors are generally light, compact, and ergonomic. Analog sensors can get closer to the seafloor than most EM sensors and can achieve a 50 to 100 percent probability of detection depending on sensor height above bottom, object burial depth and orientation/inclination, and diver's ability to follow survey lines. The higher probability of detection is for shallow objects, with a more rapid decrease in probability of detection for deeper objects. The false positive rate for analog systems is higher than digital systems. The primary use of analog detection technology in the action area will be during removal/excavation of selected geophysical anomalies.

Shark Marine Detection Technologies

Shark Marine Technologies Inc., developed the Navigator, which is a diver-held sonar imaging and navigation system. The Navigator can be integrated and configured with multiple options to provide a useful tool for underwater navigation and detection of ferrous and non-ferrous metal objects on the seafloor surface and subsurface. The EagleRay is a portable propulsion system that can be added to the Navigator. The EagleRay's small size and light weight make it easy to maneuver while searching for targets using the Navigator's sonar or keeping on course with its Track screen while reducing diver fatigue. It can be used to pull the diver through the water or help them fight the current. The Ebinger 725K is an all-metals underwater detector. When integrated with the Navigator, its abilities are further enhanced with the addition of a visual data display and the navigational features of the system. When combined with the USBL positioning with RTK-DGPS, the diver can navigate to known GPS locations mapped during DGM data collection to investigate anomalies.

Visual Detection

Visual detection of surface MEC/MPPEH may be completed through the use of grid installation or transect surveys. The type of visual detection method is decided based on whether the USACE and/or its contractors want to investigate 100% of an area (e.g., remedial action) or a sampling of the area (e.g., most remedial investigations). For grid surveys, UXO technicians use SCUBA equipment to swim established lanes within the grids. This method provides an efficient means for surface clearance in the consolidated hard bottom/coral reef areas. Visual detection is coupled with the use of analog underwater metal detectors because MEC/MPPEH may be concealed/covered in algae or coral. Also, visual detection can be done remotely with cameras/video feeds based on water clarity/project goals.

RTK-DGPS

The RTK-DGPS is a worldwide positioning system that uses satellites as reference points to calculate positions on the Earth's surface. Higher accuracy GPS, like the RTK-DGPS, can provide locations to centimeter accuracy in real-time. Additional components, such as a base station, are required to supply the RTK corrections to the system GPS.

USBL/LBL Acoustic Positioning Systems

Underwater sensor positioning systems such as USBL and LBL are used to improve DGM sensor location accuracies. LBL systems are unique in that they use networks of seafloor-mounted baseline transponders as reference points for navigation. USBL is easily deployed and does not require an array of bottom transponders. USBL accuracy requires speed of sound in water calibration. The accuracy of USBL positioning degrades significantly in shallow water (e.g., depths less than six meters [20 feet] of salt water). LBLs perform better in deep water, and the multiple transponders provide observation redundancy.

3.2.4 MEC/MPPEH Removal

If a MEC item is deemed acceptable to move by hand or remotely using an underwater lifting balloon, the following procedures will be implemented:

1. All notifications will be made per the Explosives Site Plan (ESP) or ESS (Explosives Safety Submission) which would be used for remedial/removal actions; notifications to the Regulators and Stakeholders will be made by the USACE and/or its contractor.
2. Support vessels will be used to enforce separation distances.
3. A consolidation point will be identified that is in-route to the disposal site where a MEC item can be lowered and staged should something happen at the beaching location that requires the operation to be temporarily halted. Beaching sites within the safe separation distances will be secured.
4. A lifting balloon, or suitable alternative, will be attached securely to the MEC item by UXO divers.
5. The ESP will be consulted to provide a safe pull (tow) distance for the boat from the MEC item.
6. The beaching team will establish a channel with channel buoys to guide the vessel to a munition reference buoy placed at the mouth of the channel with the beaching tow line attached.
7. The boat tow line will be connected to the beaching tow line at the buoy allowing the beaching team to take over the tow and beaching of the munition.
8. The channel will be inspected by snorkelers or divers to ensure the route is free of proposed or threatened species in depths at which the munition item may contact the seafloor while under tow.

Using these techniques, MEC/MPPEH will be removed from its original location to a designated underwater collection point (if authorized) or onshore to be further evaluated. During the removal process, a variety of MEC/MPPEH removal technologies may be used, including manual excavation or mechanized excavation. Manual and mechanical excavation require specially trained personnel who are experienced and qualified to handle and assess military munitions. The effectiveness of the implementation of the removal method depends on various factors, including the anomaly density, types of MEC/MPPEH anticipated, and the physical characteristics of the area (e.g., depth of water, access to the assessment area, and depth of targets). Consideration of the below technologies must take into account that all operators will be properly trained to identify sensitive habitat. All operation plans will include identification, protection, and restoration measures. Environmental surveys by scientific professionals with regulatory oversight will be included in planning for use of any of the below technologies. The USACE and/or its contractors will use the *Final Standard Operating Procedures for Endangered Species Conservation and their Critical Habitat* (USACE 2015b) when considering all technologies. The SOPs are measures to avoid or minimize potential impacts to proposed and ESA-listed species during geophysical surveys, MEC/MPPEH investigations, environmental sampling, and planned detonation activities conducted around Desecheo and Culebra Islands. The technologies the USACE may use for MEC/MPPEH removal are described below.

Hand Removal

Hand excavation, which is considered the industry standard for MEC/MPPEH removal, can be completed using commonly available hand tools. Hand excavation is suitable for surface and subsurface MEC/MPPEH removal in unconsolidated sediment up to 61 centimeters (24 inches) beneath the seafloor, or after mechanical removal or "lifts" to the depth of detection. Hand excavation is suitable for surface and subsurface removal in seagrass areas. Any excavation in seagrass areas will be conducted in accordance with the process/method established in the *Final Standard Operating Procedures for Endangered Species Conservation and their Critical Habitat* (USACE 2015b). Hand tools used to remove MEC/MPPEH items embedded in consolidated hard bottom/coral reef may damage the substrate making it susceptible to erosion. Therefore, removal of embedded items will be coordinated with stakeholders to determine whether the item can be removed or should remain in place (see leave-in-place below). Hand removal of unattached items resting on consolidated hard bottom/coral reef is acceptable. If an unattached MEC/MPPEH item has corals attached to it and/or retrieval may cause damage (scarring or removing a thin layer of reef structure), the attached corals will be removed from the item, if possible, and transplanted and/or the affected area will be patched to ensure no erosion of substrate will occur. The USACE considers hand removal the best option as it is the least invasive and presents reduced risks to proposed and listed species and their designated or proposed critical habitat.

Diver-Operated Mechanized Excavation

Diver-Operated Mechanized Excavation uses commonly available handheld mechanical equipment (e.g., a UXO-qualified diver operating lifting baskets, lifting bags, water jets [i.e., a water hose for excavating around items via washing away sediment/debris], cutting water jets, and other techniques) to remove overburden above and around individual anomalies. The cutting water jet uses ultra-high pressure abrasive entrainment waterjets to cut and disarm an ordnance and may be fixed to a rig/frame, lowered by davit/crane and positioned by divers. Lift baskets are steel or composite grated baskets to facilitate the vertical movement of MEC/MPPEH through the water column.

Diver-operated mechanized excavation techniques are typically applied in conjunction with hand excavation for excavations in deeper sand, sediment, or mud (generally deeper than 45.7 centimeters [18 inches]) to save time and mitigate immediate backfill common in this substrate medium. This technique is moderately destructive to the marine habitat and, per USACE (2021b), restoration would be required after operations are completed. This technique should primarily be used in known bottom types where potential damage can be minimized (e.g., uncolonized areas with sand, sediment, or mud). Trained divers who operate these systems can use discretion to recognize and take appropriate actions regarding the protection and conservation of potentially sensitive habitat. When diving using surface supplied systems, divers may be monitored by video camera from the surface to ensure that any sensitive habitat is not disturbed or damaged during excavation operations. Supporting ROVs can also be employed to monitor divers during operations.

Hand dredging includes the use of an airlift to suspend the captured sediment in the water column and reduce the probability of limiting visibility. Sediment capture with a hand dredge is necessary. The sediment can be stored in large burlap bags that sit on the bottom with the mouth of the bag suspended by floats during dredging. Upon completion of the clearance activity, the sediment is redistributed in its original location. Hand dredging suction hoses, water jet (excavating), and peripheral equipment will be suspended from the seafloor by buoy/weight systems in areas with ESA-listed corals and critical habitat to avoid impacts.

Remote Removal – Diver Placed Mechanized Operations

Remote removal techniques use UXO-qualified divers for mechanized operations. Removal techniques may consist of divers placing an apparatus or rigging on the MEC/MPPEH while the device is operated remotely or diver assisted, as the situation dictates. This includes diver placed mechanized operations such as raising or lifting, towing, and transporting or beaching MEC/MPPEH with a lifting balloon, magnetic lift, or a specialized cam with an appropriate salvage bag, prefilled lift balloon, or large buoy via a towboat. Due to the remote use of these devices, there is a reduced risk to human safety during MEC/MPPEH removal. Remotely operated movement devices will be used when there is sufficient reason to believe that moving the item may result in personnel casualties, property damage, or damage to threatened and endangered species or their critical habitat.

Magnetic lifts utilize an electromagnet crane/winch with a control system. These are effective for the removal of smaller, discrete items in localized shallow water (six meters [20 feet]), although bottom type can affect performance. Magnetic lifts require accurate remote positioning and near-direct contact with MEC/MPPEH.

For large or heavy items, use of a lift bag/balloon or boat winch will be considered to assist UXO personnel. The lift bag/balloon will be appropriately sized to manage the estimated weight of the item to which it will be attached directly, or attached to the attachment line or bridle to be installed by a UXO diver on the item. UXO personnel will then inflate the lift bag/balloon and guide the item to the surface where it will be retrieved by the topside retrieval boat. Remote removal of an item may also involve the use of a tripod system; the legs of the tripod touch the ocean floor but will be placed in a manner to avoid impacting ESA-listed corals. UXO divers will attach a bridle or line directly to the item for either method. A buoy with a line that exceeds the depth of water by approximately 25 percent will be attached directly to each item to help make its location visible to topside personnel. A pull line will be attached to the lift bag/balloon or item and used to pull the attached assembly off the seafloor. The pull line and other lines used as part of these operations will be made of polypropylene or suitable substitute so they float and, therefore, can be seen on the water surface and do not impact benthic habitat. The lift bag/balloon method is considered to have a very low probability of impacting coral located greater than about three meters (10 feet) from an item in approximately 1.2 meters (four feet) or greater water depths.

Other remotely operated devices that may be used for removal of MEC/MPPEH include ROVs (e.g., crawlers) and robotics. ROVs/robots use a tethered or untethered underwater robot/vehicle remotely operated by a trained human operator. ROVs/robots are able to operate 24/7 and are effective for very short range manipulator/grapple work, although hourly production rates may be lower than those of divers. ROVs/robotics may have tethers that limit maneuverability and can act as a source of drag in high current environments, as well as entangling in coral and rocks. As a result, an experienced operator is required for these activities. Larger ROVs require larger support vessels and, while robotics are easy to mobilize, they require more effort than ROVs to move within a work area but they may be preprogrammed to carry out tasks underwater.

Nonintentional Detonation

A nonintentional detonation during the handling of underwater munitions items is considered to be highly unlikely based on terrestrial and underwater activities conducted by the USACE since 1991. If a nonintentional detonation were to occur, it would present a risk to proposed and ESA-listed marine mammals, sea turtles, fishes, and invertebrates, and designated and proposed critical habitat for ESA-listed corals, fish and sea turtles due to the acoustic impacts from the detonation, associated sediment resuspension and transport, and potential structural damage to substrate from the detonation.

As noted above and in the PDCs below (Section 3.3.1), the USACE and its contractors will identify exclusion zones to be monitored during the location and removal of underwater MEC/MPPEH items to minimize the potential for impacts to proposed and ESA-listed species and critical habitat from a nonintentional detonation.

If removal activities target items that UXO personnel have determined to be a known or suspected significant detonation hazard (versus items UXO personnel have determined are expended materials or present a low risk of detonation), a project-specific review will be required and a step-down consultation may be required as described in this opinion (See Section 3.3.2). Any project-specific reviews and step-down consultations will evaluate the proposed exclusion zone and whether additional PDCs or an ITS are needed for a particular removal activity. In addition, if removal activities result in nonintentional detonations, a step-down consultation or reinitiation of consultation may be necessary in order to determine whether additional PDCs and/or incidental take exemptions are required to be sufficiently protective of proposed and ESA-listed species and designated and proposed critical habitat in the action area.

The use of bubble curtains, physical barriers, and other mitigation techniques to dampen the shock wave from detonations will be considered and their use specified in the relevant work plan and any project-specific review packages. The effectiveness of mitigation techniques may vary depending on the environment (e.g., currents and water depth), number, NEW of the explosives used, and other project details.

Encapsulation

The encapsulation of MEC discovered during remedial investigations will be accomplished using diver-placed encapsulation techniques. Munitions are left in place and encapsulated using methods and materials such as underwater cements, epoxies, geotextiles, and artificial/concrete reefs installed by divers. Encapsulation prevents biological receptors from directly contacting or interacting with the MEC. Any encapsulation method will be coordinated with the SPP Team prior to implementation and a project-specific review and potentially a step-down consultation may be needed for encapsulation activities.

Leave-in-Place

If a MEC/MPPEH item is attached to the consolidated hard bottom/coral reef in a manner such that removing it would damage the surrounding environment, it will be cataloged (photographed, GPS coordinates, etc.). Coordination with PRDNER, NMFS, USCG, and stakeholders, as deemed appropriate, will be completed in accordance with the most current version of the SOPs to determine if a MEC/MPPEH item can be removed or if it should be left in place. If the regulatory agencies concur with the removal of the MEC/MPPEH item, mitigation/restoration will be performed as needed in accordance with the Federal ESA Applicable or Relevant and Appropriate Requirements (ARARs) and the procedures specified in USACE (2015b). Items identified as unacceptable to move due to potential explosive hazard will be left in place, classified as MEC/MPPEH as appropriate, photographed, and the coordinates recorded using GPS. The MEC/MPPEH will be left-in-place until a final determination is made and/or new technology is available to address the removal of the item in a manner that potential impacts may be minimized or if a method such as encapsulation is selected to address the explosive hazard associated with leaving an item in place.

Land Detonation/Consolidated Shot/Contained Detonation Chambers

Underwater MEC/MPPEH that is determined to be acceptable to move will be transferred by a UXO dive team to a designated shoreline location for treatment (land detonation) and disposal in accordance with the practices that have been established for terrestrial munitions response activities in Culebra and Desecheo FUDS. The consolidated detonation will meet the NEW requirement in the explosives safety submission for maximum fragmentation distances. Furthermore, the use of technology to produce a low order detonation (e.g., Vulcan shaped charge system) will be considered/used to minimize potential impacts. Underwater

MEC/MPPEH may be moved to a treatment location via remote means, such as a lifting balloon or a deep-water lift system. Consolidated detonations on land will be performed in accordance with RCRA 40 CFR Part 264, Subpart X.

Contained Detonation Chambers (CDCs) were developed for disposal of non-chemical munitions encountered at former military ranges. CDCs may be used in land operations. The USACE is not aware of underwater CDCs that could be employed at this time. CDCs are large, heavy structures that are made to contain the metal fragments, noise, heat, shockwave, and gases produced by an explosion. Within the CDC, munitions are loaded into a large, double-walled steel chamber along with bags of water for thermal control and steam generation. The floor of the chamber is covered with gravel, which absorbs some of the blast energy. To avoid major damage to the chamber, only a limited number of explosives can be processed at a time. The use of detonation chambers is a slow process, they would be administratively and logistically difficult to place on site, and they have high maintenance costs. Transporting the large heavy structures to and around MRSs within the action area would be technically challenging due to their size and the lack of developed roads in many areas around the islands. To use a CDC, the munitions items must be determined as acceptable to move and the site workers must handle munitions repeatedly. CDCs designed for field use are limited in the amount of explosives they can contain, the types of munitions they can handle, and their throughput capability. Portable units have size constraints and are not designed to destroy munitions larger than 81 millimeter (3.2 inch) high-explosive (HE) or 4.5 kilograms (10 pounds) of octahydro-1,3,5,7-tetrazocine (HMX); therefore, they would not be effective for many of the artillery items reportedly used in the MRSs historically that are expected to be part of the items to be removed. Non-portable units can handle munitions up to 155 millimeters (6.1 inches) or 45.3 kilograms (100 pounds) of HMX (59-kilogram [130-pound] trinitrotoluene equivalent); therefore, they would be effective for most but not all of the artillery items reportedly used historically in the MRSs. CDCs increase the risk to the public because items need to be transported to the CDC chamber. Exclusion zones need to follow each item to the portable or stationary CDC. These activities extend the time to complete removal activities, increasing the amount of time that MEC may be encountered by residents, tourists, and wildlife managers. In the case of stationary blast chambers, the ability to safely transport the munitions to the chamber's location at a facility is required, making the use of these methods for treatment of MEC unlikely given the conditions and location of the action area.

Blow-In-Place (BIP)

For BIP operations, each munitions item is individually detonated at the location where it was discovered. BIP is typically used when the risk of moving the MEC is deemed unacceptable. Underwater detonations are the least favored means of MEC/MPPEH removal in terms of human health and safety and protection of ESA resources because the underwater shock wave can travel significant distances (depending on the depth of the water and the explosive weight of the detonation), potentially causing injury to proposed and ESA-listed species and/or damage to critical habitat PBFs.

The USACE anticipates rarely using underwater BIP of munitions. The USACE anticipates that items will mostly be left-in-place or removed from the water and taken to an onshore location for further explosive hazard management. This will be a case-by-case determination. If a determination is made to use BIPs to remove or reduce the threat of underwater MEC to human health and safety, a step-down consultation will be conducted as described in this opinion. As noted, the use of bubble curtains, physical barriers, and other mitigation techniques to dampen the shock wave from detonations will be considered and their use specified in the relevant work plan. Also, an in-water visual search for protected marine species will be performed a minimum of 30 minutes prior to detonation within the entire exclusion zone. If divers are used during the demolition, they will be instructed to scan subsurface areas around the removal site for the presence/absence of proposed and ESA-listed species during the course of removal operations.

3.2.5 Biological Monitoring

Beach monitoring occurs in some MRS sites where sea turtle nesting is reported. Beach monitoring consists of walking the beach areas to identify sea turtle tracks, hatchings, or nests. The presence or absence of sea turtles and signs of sea turtle nesting, including tracks, hatchings, or nests are documented on a daily log sheet along with weather conditions, visibility, and sea conditions prior to and during terrestrial activities or the use of terrestrial areas for explosive management.

Observation of ESA-listed species in the water is conducted as part of in-water work and consists of logging sightings from a boat. The appropriate SOPs to minimize the potential for interactions with animals are followed during in-water activities. Once in-water activities commence, a qualified observer approved by the USACE surveys 91.4 meters (300 feet) around the survey vessel every day of fieldwork. Shifts last for the entire duration of in-water investigation work. The observer is stationed on the roof or on a point of the vessel that could provide 360-degree visibility. All threatened and endangered species sightings are documented on a daily log form.

The USACE may appoint qualified observers who meet the following minimum standards. Qualified observers must be trained in watch program procedures for marine mammal and sea turtles, as well as being familiar with the required SOPs and other avoidance and minimization measures. Qualified personnel include persons with a minimum of two to four years of experience in related work, working independently under general supervision. Each team performing beach and boat monitoring include qualified personnel to accompany the MRS monitors and review daily log forms.

Divers and snorkelers also log sightings of mobile listed species while performing underwater work, including sea turtles, marine mammals, and fish.

3.2.6 Collection of Surface Water and Marine Sediment Samples

Sampling for MC is conducted to determine the potential for impact to surrounding media if a breached MEC, specifically with small hairline cracks or pinholes, is found during implementation of the MEC program or as a result of underwater demolition activities. Sampling is conducted to determine the presence or absence and nature and extent of any MC contamination.

3.2.6.1 Surface Water Sampling

If required to look for MC, collection of surface water will be in locations deep enough so the sample bottles can be completely submerged, in an area with minimal flow or surface disturbance and free of suspended material. Disturbances during wading will be avoided. At locations where both surface water and sediments will be collected, the surface water samples will be collected before sediment samples. The process for collecting surface water samples is as follows:

1. Carefully submerge pre-labeled sample bottles in the upright position to prevent the loss of preservative into the water for the metal and nitrate/nitrite analyses sample bottles which have acid preservation. Sediment should not be disturbed during the collection of surface water samples.
2. Allow sample bottle to fill and use bottle cap if necessary to fill the bottle completely.
3. After the sample bottle is filled, the cap will be placed on the bottle and the bottle will be packaged for shipment.

3.2.6.2 Marine Sediment Samples

Collection of discrete marine sediment samples will be conducted by a dive-qualified UXO Technician at select MEC/MPPEH items in which explosives were exposed to the marine environment and at selected MD locations. Sediment samples will be collected in Ziploc bags from a depth interval of zero to 15.24 centimeters (zero to six inches) at MEC/MPPEH locations in areas where sufficient media is present. The amount of sufficient media for sample collection is anticipated to be in areas with 2.54 centimeters (one inch) or more of sediment. Also, samples will be collected in unconsolidated sediments. If only coral, rocks, or bedrock are present, no samples will be collected.

As part of the underwater investigation, marine sediment samples are collected from within the MRS boundaries to evaluate the presence of MC from MEC/MPPEH resulting from DOD activities. The location and number of samples collected are determined by MEC/MPPEH/MD findings during intrusive operations (i.e., MEC/MPPEH location and removal). Samples are analyzed for explosives and CERCLA hazardous substances associated with munitions located at the site.

3.2.7 Installation and maintenance of in-water structures (i.e., mooring fields,

demarcation, mooring, and hazard buoys)

The USACE is responsible for the coordination and installation of in-water structures such as marker and mooring buoys if implemented as part of the selected remedial action. The USCG and PRDNER will be involved with the planning, execution, and documentation phases for the installation of any in-water structures as well.

A mooring field provides a safe anchoring point for boaters and protects habitat from boat anchors. Hazard warning buoys inform the public of the military's past use of Culebra and Desecheo Islands and the potential to encounter dangers associated with munitions, as well as actions to take should they encounter or suspect they have encountered a munition.

Mooring fields will be preferentially installed in consolidated hard bottom. Pin anchors secured with hydraulic cement into the hard bottom will be used to secure the buoys using coring and drilling techniques. The depth of drilling to install the Halas mooring system, which is a type of pin anchor, is estimated as 45.72 to 61 centimeters (18 to 24 inches) with a 15.24 (6-inch) diameter hole. The estimated footprint for this system is 180.65 square centimeters (28 square inches). When consolidated hard bottom is not available, Manta Ray® anchors or helix anchors will be used in unconsolidated sediment. The depth to which the anchor system will be driven into the unconsolidated sediment is a minimum of 1.07 meters (3.5 feet). If the sediment does not provide the holding strength needed, an extension to the anchor can be added and the system can be driven down to 2.13 meters (seven feet). Helix anchors will have a footprint of 503.2 square centimeters (78 square inches) and Manta Ray® of 387 square centimeters (60 square inches). Surface MEC/MPPEH clearance and subsurface MEC/MPPEH avoidance measures will be conducted using DGM and analog technologies. Annual maintenance of the mooring field is proposed but will be specified in any Land Use Controls Implementation Plan established for an MRS. Some elements of the mooring field (i.e., down lines and pickup lines) may require more frequent inspections. Inspections include cleaning the mooring buoys and associated lines and hardware of marine growth.

3.2.8 Vessel/Vehicle

Boating operations are required to support the activities described in this opinion, as well as for visually inspecting beach conditions, biological monitoring, transporting equipment and/or personnel, or monitoring exclusion zones during terrestrial detonations of MEC/MPPEH that are part of the CERCLA activities in the action area. All boats will utilize existing mooring buoys or the anchoring procedures listed in the PDCs (Section 3.3.1.7). If vehicles need to be used on beaches during the proposed activities, the USACE and its contractors will follow PDCs discussed in Section 3.3.1.8.

Boats typically used for water operations include, but may not be limited to, the following:

- A 5.2 to 7.9 meter (17 to 26 foot) boat will serve as a support vessel to aid with GPS survey equipment (signal repeater) and to provide exclusion zone control while conducting surveys (to protect towfish cables from being cut by other vessels);
- Nine to 10.4 meter (29.5 to 34-foot) aluminum or fiberglass survey vessels with a three meter (10 foot)-wide beam and draft of 0.76 meters (2.5 feet) for DGM surveys;
- Containment vessel for Mechanical Excavation - Portable Hand Operated Dredging
- Kayak for species' monitoring

During the proposed activities boats will mostly depart from Ensenada Honda (Ceiba) and Fajardo to access the MRSs around Culebra Island. To access Desecheo Island, boats will depart from Rincón. The departure point for vessels transiting to/from the MRSs will be at the discretion of the USACE and its contractors. All vessels will preferentially follow deepwater routes whenever possible (See Section 3.3.1.8). After departure, the boat captain will decide the best route to travel to a specific MRS. Initial paths to Culebra MRSs from Ensenada Honda are shown in green in Figure 4 below. Vessel transit to and from ports on Culebra to the main island of Puerto Rico and from the main island to Desecheo is considered part of the proposed action in this opinion.

Figure 4. Initial Vessel Paths to Culebra MRSs

As noted in the PDCs below (Section 3.3.1), field teams shall receive a boating safety briefing and information regarding location and identification of coral reefs, colonized hard bottom and seagrasses. The boat operator shall carry and consult appropriate NOAA nautical charts and real-time data (e.g. GPS with nautical chart and depth finder on boat) to monitor depths and location. Boats shall be tied up to mooring buoys, or if no moorings are available, the motorboat will be kept idle in the water until the field activities are complete or anchor in sandy areas away from coral reefs, colonized hard bottom and seagrasses so the anchor, chain and line do not contact or damage these resources. When boats are not in use, they will be hauled out of the water daily (smaller boats), tied to existing moorings, or have temporary moorings installed for task-specific purposes using one of the smaller anchor systems described in Section 3.2.7.

3.2.9 Relocation/Transplantation of Coral and Seagrass Due to Munitions Removal

Coral relocation in conjunction with munitions removal will be performed to the extent practicable. The USACE has estimated the potential number of ESA-listed corals on or adjacent to potential MEC/MPPEH as discussed in later sections of this opinion. UXO-qualified personnel will determine whether coral adjacent to or attached to a MEC item is safe to remove. If safe, a scientific diver will remove the coral under the supervision of UXO personnel; otherwise, the UXO personnel may be required to perform the coral removal while following instructions from the scientific diver. If coral colonies can be safely removed from a munitions item to which they are attached, these corals will be transplanted from the munition to the site that was occupied by the munition. If corals cannot be reattached at the munitions removal site, they may be transported to locations having habitat conditions similar to the removal site, or otherwise suitable for the species being transplanted. Location conditions to be considered include general health of existing wild populations of corals (e.g., no obvious bleaching or prevalence of diseases), suitable water depth, optimal bottom type (i.e., hard bottom), good water quality (e.g., constant water flow, good light penetration), and limited biological stressors (e.g., coral predators and benthic space competitors such as algae and encrusting organisms). In addition to ESA-listed corals, non-ESA-listed hard and soft corals that are likely to be damaged or destroyed because of the removal action will also be considered for relocation.

To the extent possible, coral relocations will be conducted the same day as their removal. Removed coral specimens will be temporarily held in separate containers (e.g., plastic buckets) to prevent colonies from contacting each other, kept submerged in water, and held in protected conditions (e.g., temporarily staged underwater in open or vented containers near the removal site for quick re-attachment following item removal, or in a cooler or shaded conditions on the support boat).

Before transplanting, all fouling organisms and sediment will be cleared from the substrate using wire brushes or scrapers. Materials used to secure corals will be appropriate for the coral species, size of the coral transplant, substrate characteristics, and typical current or wave energy in the area. The most common attachment materials are two-part epoxy, hardened masonry nails, and nylon cable ties or coated wires, and Portland cement. Using masonry nails and cable ties is a good method for attaching branching corals, while Portland cement is the best option for large boulder corals.

Relocation-specific information will be collected at the time of transplantation including the GPS coordinates of transplanted ESA-listed corals. Individual colonies or colony clusters will also be field marked using a nylon cable tie with a number-coded "cattle tag" attached to a nominal 7.62 centimeter (3-inch) hardened masonry nail driven into the substrate near the transplant(s). Encrusting growth on the tags can be scraped off to reveal the number, as necessary, and the metal nail may be relocated using a metal detector, if necessary. Photographs of transplanted colonies with a ruler or other object showing the size of the colony will be taken at the time of transplant. A map of all transplanted ESA-listed corals will be maintained as transplants are conducted.

Success monitoring may be conducted when divers are near transplanted corals during subsequent munitions removal activities. Inspections may be conducted using an ROV or by a scientific diver. Inspections will include, to the extent possible, documentation (including photos) of colony size and condition such as healthy and growing, partial or complete mortality, presence of disease, significant damage from coral predators (corallivores) such as fish, snails, or other invertebrates, and overgrowth or encrustation by organisms such as algae, sponges, tunicates, and cnidarians.

Location and removal or encapsulation of surface and subsurface munitions may affect coral substrate. Patching of substrate and coral restoration of the affected area will be performed in accordance with the PDCs to ensure no erosion of substrate will occur. Substrate patching will be performed after removal or encapsulation of the item. UXO personnel trained by a marine biologist experienced in methods and procedures for patching/replanting coral will be used for this work.

Location and removal or encapsulation of surface and subsurface munitions may affect seagrass. Following a removal from seagrass habitat, a qualified person (e.g., scientific diver) will inspect the location and determine the type of seagrass restoration measures, if necessary, that should be implemented. Qualified personnel (e.g., scientific divers) with experience in seagrass restoration techniques will conduct all seagrass restoration. Any void created on the seafloor by an inadvertent impact will be backfilled with adjacent sediment so the grade of the impacted area is approximately flush with the surrounding grade.

The methods used to restore seagrass will be specific to the condition of the impacted seagrass and the seagrass species affected. Displaced rhizome segments or small seagrass plugs will be re-planted by hand, using biodegradable pins, if necessary. In instances where larger subsurface items are being investigated, an area of seagrass can be cut on three sides and rolled up to allow better access to the anomaly. Afterwards, the excavated area will be backfilled with the removed substrate and the seagrass rolled back into place and pinned (for plugs greater than approximately 20.32 centimeters [eight inches] across) with biodegradable stakes. Small areas of disturbance are those that are expected to backfill and recolonize naturally and will not require seagrass restoration.

3.3 Programmatic Consultation Requirements and Procedures

This section details the non-discretionary PDCs the USACE will require for activities implemented as part of the USACE cleanup activities under the DERP-FUDS program within the action area to avoid or minimize potential adverse effects on proposed and ESA-listed species and designated and proposed critical habitat. The section also describes the procedures for streamlined project-specific review and for step-down consultations. Finally, the section details the periodic comprehensive review procedures for the program.

The action includes specific activities that are (1) not likely to adversely affect proposed and ESA-listed species and their designated and proposed critical habitat because their effects are insignificant or discountable regardless of the implementation of PDCs (2) not likely to adversely affect proposed and ESA-listed species and their designated and proposed critical habitat with implementation of applicable PDCs, and (3) are likely to adversely affect proposed and ESA-listed species and their designated and proposed critical habitat, even with implementation of PDCs. While some activities have ESA section 7 determinations made under this opinion, there are others that will require project-specific review and potentially step-down consultations. For activities that may result in take of ESA-listed species an ITS is included in this opinion and additional RPMs to reduce or minimize the effect of the take may be developed as part of future step-down consultations under this programmatic.

3.3.1 Project Design Criteria

The PDCs included in this opinion are taken from the SOPs outlined in USACE Guidance Documents referenced in Chapter 11 of the *Environmental Baseline Survey Work Plan Culebra Island Site Puerto Rico* (USACE 2014), the *Supplemental Standard Operating Procedures for Endangered Species Conservation and their Critical Habitat DERP-FUDS Property No. I02PR0068 Culebra, Puerto Rico* (USACE 2015b), *Draft Final Standard Operating Procedures for Protected Species Conservation and their Habitat DERP-FUDS Project No. I02PR006901 Desecheo, Puerto Rico* (USACE 2015a), *NMFS' Biological Opinions for Naval Underwater Cleanup Activities off the Coast of Vieques Island, Puerto Rico* (NMFS 2020), *Department of Defense Explosives Safety Board Regulations* (DDESB 2019) and the conservation measures the USACE included in its underwater feasibility studies (USACE 2020; USACE 2021a; USACE 2021b; USACE 2021c).

PDCs have been developed to mitigate environmental impacts during underwater investigations; the identification and removal of MEC/MPPEH; sampling, installation and maintenance of in-water structures, boating operations (e.g., vessel transit), and transplantation of coral and seagrass associated with MEC removal. Some PDCs related to location and removal of items are meant to reduce the possibility for a nonintentional detonation to occur, but a project-specific review and potentially a step-down consultation will be required for removal of items suspected to present a significant detonation hazard as described in Section 3.3.2.

An exhaustive list of PDCs for BIP have not been included in this opinion because the USACE does not anticipate using this removal method at this time. However, because BIP is under the scope of activities considered under this programmatic opinion, general PDCs are included. Similarly, PDCs for encapsulation have not been included because more information on the specific encapsulation action will be required to prepare necessary or appropriate PDCs and/or RPMs for this activity. Therefore, if BIP or encapsulation are proposed in the future, project-specific review and potentially step-down consultation will be required.

The PDCs also include additional requirements NMFS believes are necessary to avoid and minimize potential adverse effects of the action on proposed and ESA-listed species and designated and proposed critical habitat beyond those included in the SOPs and other measures employed by the USACE and its contractors as part of on-going investigations. These PDCs, when applied to in-water activities associated with USACE activities in the action area, minimize the negative effects of these activities to proposed and ESA-listed species and designated and proposed critical habitat. PDCs presented in Section 3.3.1.1 are applicable to all activities discussed in the Proposed Action (Section 3.2).

3.3.1.1 General PDCs

Prior to initiating in-water or beach work, field personnel will receive training or briefings, as applicable, regarding the potential presence of threatened and endangered species, their physical characteristics, preferred habitats (including designated and proposed critical habitat), how they can be identified, actions to be taken if sighted, and avoidance measures to be followed as detailed in the PDCs in this opinion. This training or briefing will be prepared and offered by qualified personnel (e.g., biologist, marine biologist, environmental scientist) approved by the USACE with experience identifying these species.

In addition to training and briefing requirements, the following PDCs are applicable to all activities considered under this programmatic consultation:

- All operations will take place during daylight hours.
- All workers associated with the proposed action, irrespective of their employment arrangement or affiliation (e.g. employee, contractor, etc.) will be fully briefed on required PDCs and the requirement to adhere to them for the duration of their involvement in this project.
- Constant vigilance shall be kept for the presence of proposed and ESA-listed marine species and their designated or proposed critical habitat during all aspects of the proposed action, particularly in-water activities such as boat operations, diving, and

deployment of anchors and mooring lines. All on-site project personnel are responsible for observing water-related activities for the presence of proposed and ESA-listed species

- The USACE and/or its contractors shall designate an appropriate number of competent observers to survey the areas adjacent to the in-water activities for proposed and ESA-listed marine species. Competent observers shall meet the same minimum criteria listed under section 3.2.5 and will be approved by the USACE. Information on observers, including resumes/CVs, will be provided as an attachment to the work plan submitted to the USACE for review.
- Visual surveys within the vicinity of the work areas for that day shall be made prior to the start of work each day, and prior to resumption of work following any break of more than one half hour. Periodic additional surveys throughout the work day are strongly recommended.
- If a marine mammal or sea turtle is sighted within 91.44 meters (100 yards) of the project area, all appropriate precautions shall be implemented by the USACE and/or its contractors to ensure protection of these species. These precautions shall include the operation of all moving equipment no closer than 91.44 meters (100 yards) of whales and 45.7 meters (50 yards) of sea turtles. If a whale is closer than 91.44 meters (100 yards) or a sea turtle is closer than 45.7 meters (50 yards) to moving equipment or other operations, the equipment shall be shut down and all activities shall cease to ensure protection of the animals. Underwater activities shall not resume until the marine mammal(s) or sea turtle(s) have left the project area of their own volition. Should the animal not show signs of leaving, the diver team will leave the location and return to complete the work later. Animals must not be herded away or harassed into leaving.
- If an ESA-listed fish is sighted within 91.44 meters (100 yards) of the project area, all appropriate precautions shall be implemented by the USACE and/or its contractors to ensure protection of the animal(s). To the extent practicable, these precautions shall include the operation of all moving equipment no closer than 45.7 meters (50 yards) of ESA-listed fishes. If an ESA-listed fish is closer than 45.7 meters (50 yards) to moving equipment or other operations, the USACE and its contractors will use best judgment to avoid harassing the species which may include shutting down equipment and ceasing activities to ensure protection of the animals.
- Special attention will be given to verify that no proposed and ESA-listed marine species are in the area where equipment or material is expected to contact the substrate before that equipment/material may enter the water.
- If queen conch is located within the project area and is likely to come in contact with equipment/material from the proposed action, divers should relocate animals to an adjacent location by hand. The USACE and/or its contractors will relocate the animal(s)

to an adjacent area with similar substrate/habitat that is free from any barriers to movement.

- Personnel will not feed, touch, ride, or otherwise intentionally interact with any marine mammals, sea turtles, and/or ESA-listed fishes. Interaction with ESA-listed corals during investigation and removal activities should be minimized to the extent practicable, except when relocating/transplanting coral colonies.
- Personnel will be advised that there are civil and criminal penalties for harming, harassing, killing, or otherwise altering the natural behavior or condition of threatened or endangered species protected under the ESA.
- Personnel will be briefed that the disposal of waste materials into the marine environment is prohibited. All crew will attempt to remove and properly dispose of all marine debris discovered during the propped action, to the maximum extent possible.
- A log detailing endangered or threatened species sightings in marine habitats will be maintained during implementation of the activities within the action area described in this opinion. The log shall include, but not be limited to, the following information: date and time of sighting, location coordinates using a GPS unit, species identification (when possible), behavior of the animals, one or more photographs (if possible), and any actions taken because of the sighting during the work period. Copies of the logs will be submitted to NMFS OPR Interagency Cooperation Division as part of the reporting requirements for the annual programmatic review.
- Each team performing work will be accompanied by qualified and experienced biological personnel (e.g., biologists, marine biologists, or environmental scientists) approved by the USACE in order to identify the presence of threatened or endangered species in the work area and direct avoidance measures as needed.
- Work will be coordinated with the SPP Team prior to commencement. USACE and/or its contractors will provide a preliminary schedule and the areas (including the proposed transects and grids) where investigation will be performed and the equipment to be used. Changes to the schedule and working areas will be provided to the SPP Team. The Contractor will make any required project notifications to the appropriate USACE personnel, who will in turn notify the regulators and resource agencies.
- The USACE and/or its contractors shall identify any onshore staging areas needed for execution of investigations so that sea turtle nest monitoring can be conducted prior to initiating mobilization to ensure no impacts occur to the species during project activities.
- The field team must ensure, through physical inspection, that all materials and equipment transported to Desecheo Island are free of rodents and manage any mainland areas commonly used for storing or staging gear intended for the island so as not to attract rodents (Appendix D of USACE 2015a).
- All diver/snorkeler operations will follow these general procedures:

- The team lead will make sure that underwater conditions (e.g., visibility, currents) and weather are suitable for diving to ensure diver safety and to avoid damaging ESA-listed corals and designated or proposed critical habitat.
- The point of entry and exit will be carefully selected to avoid damaging coral or other underwater habitats, such as seagrass beds.
- Divers/Snorkelers will ensure that all equipment is well secured before entering the water.
- Divers/Snorkelers will ensure that they are neutrally buoyant to the extent practical. If neutral buoyancy is not possible, divers will ensure their points of contact with the bottom or hard substrate are not on ESA-listed corals.
- Good finning practice and body control will be followed to avoid accidental contact with coral or stirring up the sediment.
- Divers/Snorkelers will limit physical contact with the benthic environment to the minimum extent needed to effectively conduct the work. As standard practice, impacts to any hard or soft corals shall be avoided to the greatest extent practicable. All equipment shall be used in a manner to avoid physical contact with corals.
- Divers/Snorkelers will stay off the bottom and will never stand or rest on corals or other sessile benthic invertebrates.

3.3.1.2 PDCs Applicable to Underwater Investigations/MEC Location

The following PDCs are applicable to any underwater investigation and/or MEC location activities conducted by the USACE and its contractors (See Sections 3.2.1 and 3.2.2). These PDCs are broken out by non-intrusive and intrusive investigation activities.

Non-Intrusive Investigations

- All transect sections with scattered coral, reef, or colonized hard bottom will be surveyed using a method that results in no contact with the seafloor or with coral heads that extend close to the water surface. Detailed information on the appropriate equipment to be used will be provided in the work plan and coordinated with the SPP Team. The equipment/system used in any underwater MRS portion will depend primarily on personnel safety, depth of water, and type of habitat present.
- While several systems and EM platforms may be used during geophysical surveys, it is possible that in areas with varying amounts of submerged aquatic vegetation (e.g. seagrass) a system that is designed to come in contact with the seafloor may be used. For Quality Control (QC) purposes, prior to conducting the survey, a single transect across an area of submerged aquatic vegetation coverage will be surveyed using the proposed system. Qualified personnel will perform an assessment of the test area to determine if any adjustment is necessary to minimize disturbance to sand, macro algae and seagrass.

- After any bottom-tending systems have been used to conduct surveys, the surveyed area will be inspected by the USACE and/or its contractors to ensure no impact to submerged aquatic vegetation has occurred.
- In shallow water areas (0.3 to 1.22 meters [one to four feet]) where contact with the bottom is not desired, the EM coil will be floated or will be suspended beneath a floating platform.
- In areas with coral that are too deep for the EM float, or in areas containing coral heads with high relief, an ROV platform may be used to propel the EM coil along the transect while ensuring contact with coral is avoided. If a ROV EM platform is not suitable for selected transect segments, these segments will be surveyed by divers or snorkelers as an instrument-aided visual transect.
- QC will be maintained at all times to ensure appropriate pre-selected equipment is used throughout underwater investigation work as coordinated with the SPP Team.

MEC/MPPEH Investigations

- UXO divers/snorkelers conducting MEC/MPPEH investigations in seagrass areas will be careful to maintain root systems as much as possible. Pre- and post-investigation pictures shall be taken and shall include a measurement of the area investigated. Should intact plugs of seagrass be removed, they will be replanted following the removal of the anomaly. As a possible method, the seagrass can be cut on three sides and rolled up. After work is complete, the excavated area will be filled with sand, if necessary, then the seagrass will be rolled back into place and staked with biodegradable stakes to enable the grass to reestablish quickly.
- Divers will film and photograph the area around the anomaly to be investigated. If the anomaly is located in corals or hard bottom areas, divers will investigate an area with a six meter (20 foot) radius, the center of which is the anomaly. Within that area, divers will determine the distance to and location of all listed coral. The pictures shall include measurements of the distance between anomalies and listed coral colonies and the size of the items. Care will be taken to avoid damaging corals or seagrass, if present, during investigations.
- Each MEC/MPPEH item will be evaluated as a separate scenario. A Decision Matrix will be developed to provide timely decisions and methods of relocation and disposal. The Decision Matrix will be included in the work plan to the SPP Team for review and comment.
- Excavations will be conducted in unconsolidated sediments and seagrass areas only. If the anomaly is located within coral or hard bottom areas, the anomaly will be investigated visually only. When feasible, if the anomaly is not munition-related, is not cemented in hard substrate, and ESA-listed corals are not attached to it, it will be brought to the surface and relocated to the designated terrestrial processing area for

appropriate disposal. If non-listed corals are attached to an item, as feasible and as detailed in Section 3.3.1.9, the recommended Coral Relocation and Reattachment Protocol will be followed.

- Visual devices placed next to suspected MEC/MPPEH to mark the location for later investigation shall have enough weight to remain in place without skipping along the bottom. Once the investigation is complete, the device will be removed.
- MEC/MPPEH that are deeply buried or that are located in areas where removal of the item could result in damage to ESA-listed coral species or damage to designated or proposed critical habitat will be accurately mapped by GPS and left in place.
- The areas surrounding the MEC/MPPEH will be filmed paying particular attention to corals and biology in the immediate vicinity. If the anomaly is located in coral or hard bottom areas, divers will investigate an area with a three-meter (9.8-foot) radius, the center of which is the anomaly. Within that area, divers will determine the distance to and location of all ESA-listed coral. The pictures shall include measurements of distance between the MEC/MPPEH and ESA-listed corals, and the size of the item. The videos will be used later when identifying a suitable method for disposal. If it is determined that BIP is required and it is estimated that the potential blast impact radius is greater than 3 meters (9.8 feet), additional investigation may be required.
- During the MEC/MPPEH investigation process, qualified personnel approved by the SPP Team will verify the locations of listed corals, designated and proposed critical habitat, and seagrass within the immediate vicinity. This includes documenting the amount of seagrass and/or coral critical habitat in square feet or acres and the number and types of ESA-listed corals in the immediate vicinity. This information will be provided in a work plan to the USACE for review and comment before MEC/MPPEH removal operations.

3.3.1.3 PDCs Applicable to MEC/MPPEH Removal Operations

PDCs applicable to removal operations, including operations using certain equipment, are included here. The following PDCs are applicable to all removal operations:

- GPS will be used as a means for personnel in the work vessel to identify the location of each target item.
- Only certified UXO divers/snorkelers will conduct MEC/MPPEH investigations.
- If an anomaly is at the sediment surface, the investigation will be completed without disturbing the area or item. If an anomaly is buried in sediments, it will be uncovered by excavating down to the anomaly using hand tools, then an investigation will be performed to determine if the anomaly is munitions-related and identify the appropriate removal process.
- All qualified and experienced biological personnel are considered non-essential personnel with respect to UXO operations and must remain outside of the exclusion

zone when removal operations are ongoing. Video and photographs collected during the removal activities, and post removal surveys will be the primary method used to verify impacts to non-motile ESA-listed resources (i.e., corals and critical habitats).

- Prior to the MEC/MPPEH removal effort, qualified personnel will verify the locations of listed corals, designated and proposed critical habitat, and seagrass within the immediate vicinity. Listed coral species' locations will be identified with temporary underwater buoys or visual devices as a visual aid for the UXO team while setting up equipment for the removal. All removal actions shall be documented. Pre and post pictures of the area shall be taken with a scale measure next to the MEC/MPPEH.
- When sessile species in the removal zone cannot be identified by a qualified UXO technician prior to critical UXO movements, the qualified biological personnel on site may enter the water to verify the species. If SCUBA gear is required, the biologist will be a certified diver and be listed in the Dive Plan. If the biological personnel do not enter the water, an attempt to capture pictures or video of the species must be made to verify the species.
- No MEC/MPPEH investigation, MEC/MPPEH removal, or MEC/MPPEH handling in MRSs adjacent to beaches will be conducted during the 48-hour period following the emergence of sea turtle hatchlings.
- If a boat-mounted winch is used for extremely heavy items, it will only be used in areas where the water depth is sufficient to ensure the boat will not be at risk of contacting the seafloor or benthic biota while maneuvering at or around the item.
- If an underwater item that may have historic or archaeological value is encountered, the item will not be disturbed in any way. The item will be photographed, GPS coordinates of the location will be collected, and the USACE will be notified. The USACE will coordinate the collected information with the Puerto Rico State Historic Preservation Office in compliance with the National Historic Preservation Act.
- For soft sediment and seagrass areas, once an anomaly is reacquired, the MEC/MPPEH UXO investigation team will expose and recover the anomaly using hand tools (such as spades, trowels, shovels). For coral and hard bottom areas, if the anomaly is not encrusted, can be easily removed by hand, and has no colonization by listed corals, it can be removed and relocated to the designated processing area. The MEC/MPPEH UXO investigation team will transfer recovered MEC/MPPEH to the underwater collection point, the shore, or designated terrestrial location for processing and disposal.
- MEC/MPPEH that are acceptable to move but will cause an unacceptable risk to divers due to size and weight of MEC/MPPEH will be moved remotely. Care will be taken to avoid damaging corals or seagrass during removal.
- The terrestrial processing site for a removal activity will be located within the boundaries of a Munition Response Area (MRA). The potential location will be provided in a work plan to the SPP Team for review and comment.

- The requirements of DESR 6055.09 VOLUME 7: UXO, Munitions Response, Waste Military Munitions, And Material Potentially Presenting an Explosive Hazard (MPPEH) paragraph v7.e4.5.8.3.5 for mechanized UXO processing operations (DDESB 2019) will be applied.
- Turbidity (from sediment resuspension) will be minimized to the extent possible during all underwater work activities. Although excessive turbidity is not expected to be generated by the underwater work activities, turbidity will be visually monitored and prudent measures will be taken to minimize turbidity generation to the extent possible.
- Diving safety procedures will be followed in accordance with USACE policy and guidance during all excavation using divers, including hand excavation and operation of water jets or airlifts.
- Care will be taken to avoid damaging corals or seagrass during MEC/MPPEH removal or encapsulation. If corals are damaged during MEC/MPPEH removal or encapsulation because they are attached or in contact with the MEC/MPPEH item, as feasible, the recommended Coral Relocation and Reattachment Protocol will be followed. Breaks or scarring of hard substrate will be filled with Portland cement or another suitable adhesive after coordination with resource agencies.

Lift Bags and Baskets

- If a lift bag/balloon is used for items that cannot be removed by hand, UXO personnel will inflate it and guide the item to the surface for retrieval by personnel on the work vessel. All operations will be conducted in a way that minimizes contact with the seafloor and surrounding benthic organisms, including ESA-listed corals.
- A lift bag/balloon will only be used in areas that have one meter (3.2 feet) or greater water depths and no ESA-listed coral species within approximately three meters (10 feet) of the item to be removed. If ESA-listed coral species are located within less than three meters (10 feet) of the item, USACE and/or its contractors will provide additional information and measures to be taken to avoid damaging listed coral species to the SPP Team consideration and concurrence.
- Floating lines made of polypropylene or suitable substitute will be used during removal actions with lift bags/balloons to minimize the potential for lines to affect benthic habitat.
- All objects will be lowered to the bottom (or installed) in a controlled manner. This may include the use of buoyancy controls such as lift bags, or the use of cranes, winches, or other equipment that affect positive control over the rate of descent.
- In-water tethers, as well as mooring lines for vessels and marker buoys, shall be kept to the minimum lengths necessary, and shall remain deployed only as long as needed to properly accomplish the required task.

- Equipment that may pose an entanglement hazard will be removed from the action area if not actively being used.

Robotics/ROVs

- Robotic/ROV operators must be on the lookout for tether snag locations (spars) or pinch points (v-shaped notches). While inspecting around rocky substrate, docks, mooring lines or coral outcrops, attention must be given to any loose lines to prevent lines from being caught in thrusters or entangling the propeller trapping the ROV.
- ROV operators will have the training necessary to maintain and operate these vehicles at a depth above the seafloor and coral structures in order to avoid contact.
- Stiff line materials will be used for towing or operating all equipment and kept taut during operations as practicable to reduce the potential for entanglement of animals or in bottom features such as coral habitats.

Magnetic Lift Systems

- If a lift system is used to remotely remove items from the seafloor, coral or seagrasses growing at and within approximately one meter (3.2 feet) of the planned item lift will be evaluated for possible relocation prior to item removal (including coral growing on the item itself).
- If a lift system is used, it will be secured to the seafloor using sand bags, metal weights, or a suitable substitute to minimize the potential for it to move during removal operations.

3.3.1.4 PDCs Applicable to Detonations

PDCs applicable to removal detonations, including in-water detonations, are included here. The measures noted below will be implemented during all detonations to the extent practicable. All demolition operations will be coordinated with the SPP Team and detailed information will be provided prior to the demolition event.

- The lowest NEW per detonation will be used to complete the work for a particular detonation activity. Using smaller NEWs is associated with smaller exclusion zones. Technology to produce a low order detonation (e.g., Vulcan shaped charge system) will be considered/used to minimize potential impacts.
- Exclusion zones will be calculated by the EOD team for each MEC item targeted for removal. The exclusion zone will represent the predicted average distance to a temporary threshold shift (TTS) for ESA-listed species in the work area. Based on the NEW and depth of the MEC/MPPEH item, the longest (and therefore most conservative) distance to onset of TTS for species that are expected to occur in the work zone will be identified as the exclusion zone.

- The use of delays between individual blasts should be maximized to separate the total NEW into a blast episode, creating a series of discrete, consecutive blasts. A blast episode consists of a single blast or a series of blasts that are detonated with a delay to lower the overpressure at a received distance in the environment. Discrete detonations using delays effectively reduce the exclusion zone. For delay intervals less than 25 milliseconds, exclusion zones for protected species shall be estimated by calculating the distances for the summed explosive weight detonated per 25 millisecond period.
- The use of bubble curtains, physical barriers, and other mitigation techniques to dampen the shock wave from detonations should be considered and their use specified in the relevant work plan. The effectiveness of mitigation techniques may vary depending on the environment (e.g., currents and water depth), number and NEW of the explosives used, and other project details.
- The perimeter of exclusion zones should be established and demarcated (e.g., with landmarks or brightly colored buoys) for visual reference when conditions permit. Land or vessel-based observations may use binoculars and the naked eye to monitor the zones of influence. Fixed focus, vector binoculars are useful to establish distance from the project site and identify species.
- Qualified observers, approved by the USACE, should have completed an approved training program to monitor the exclusion zones. Each observer should be equipped with a two-way radio dedicated to protected species communication, polarized sunglasses, binoculars, a red flag or other backup communication, and any necessary data recording equipment.
- Monitoring should be conducted from the highest vantage point(s) and/or other locations that provide the best, clearest view of the entire zone of influence. These vantage points may be on the structure being removed or on nearby surface vessels such as crew boats.
- A sufficient number of observers should be used to effectively monitor the established exclusion zones under variable charge sizes and environmental conditions. The number of observers used may be dependent on numerous factors including whether vessel/shore-based observations are used, the size of the exclusion zones, distance from shore, sea state, and observer fatigue.
- For large exclusion zones, or to augment visual observations, passive acoustic monitoring may be utilized to detect vocal species of marine mammals when animals are not readily observable at the surface. However, passive listening should not be used as a replacement for an adequate number of visual observers.
- If divers are used during the demolition, they should be instructed to scan subsurface areas around the removal site for the presence/absence of proposed and ESA-listed species during the course of removal operations.

- The chief observer should have the authority to immediately halt activities should an ESA-listed species be observed within the exclusion zone, or in the watch zone and in imminent danger of injury by heading toward the exclusion zone.
- Surveys should be conducted before and after each blast episode. The duration and method of surveys should be determined in coordination with NMFS. Post-detonation observations are to start at the removal site and proceed in the direction of wind and current movement from the blast location.
- Protected species surveys should be conducted in environmental conditions adequate for effective visual observation. Detonations should be delayed until conditions improve sufficiently for monitoring to be effectively completed.
- When a proposed or ESA-listed species is detected within the exclusion zone by divers or other observers, detonations should be postponed until it is verified to be outside of the exclusion zone.
- Detonation of scare charges to intentionally harass marine mammals, sea turtles, or fishes into leaving a project area is prohibited. Scare charges using detonation cord are potentially harmful to fishes (California Department of Fish and Game 2002) if the mass of the explosives is not considered.
- All ESA-listed species entering the exclusion zone should be allowed to move out of the area under their own volition. Enticing marine mammals to bow-ride or intentionally harassing animals into leaving the area is prohibited. All “shock-tubes" and detonation wires should be recovered and removed after each blast.
- Underwater MEC/MPPEH will be relocated to a designated suitable terrestrial area for detonation as long as it is deemed acceptable to move and it can physically be moved. The Senior UXO Supervisor and UXO Safety Officer must agree that the item is acceptable to move.

Underwater Blow-In-Place (BIP)

- Appropriate sand substrate areas will be chosen during all phases of the investigation as potential underwater MEC disposal sites based on safety considerations and in order to minimize impacts to resources of concern to the maximum extent practicable. These areas will be used only if MEC/MPPEH are unstable or represent a safety concern.
- To the extent practicable, the USACE and its contractors will not conduct BIP in proposed critical habitat for Nassau grouper within Desecheo’s MRS 01.
- To the extent practicable, prior to any detonation (24 hours minimum), contractors and USACE shall contact NMFS, FWS, EPA, PRDNER and the USCG to inform them of a planned underwater detonation.
- No detonation shall occur when mobile proposed or ESA-listed species (excluding queen conch) are known or suspected within the exclusion zone. If ESA-listed corals are

detected within the maximum HFD of the MEC/MPPEH proposed for detonation, the USACE will coordinate with NMFS to transplant the corals prior to detonation. If queen conch are detected within the maximum HFD of the MEC/MPPEH, the USACE will coordinate with NMFS to relocate the animal(s) prior to detonation.

- An in-water visual search for protected marine species will be performed a minimum of 30 minutes prior to detonation within the entire exclusion zone. Should an ESA-listed marine mammal, sea turtle, or fish be observed, the detonation shall be postponed until the animal has been observed outside of the exclusion zone, or more than 30 minutes have elapsed since it was last sighted.
- Constant vigilance throughout the exclusion zone will be maintained for a minimum of 30 minutes following a detonation, and a thorough water surface inspection of the zone shall be completed immediately following a detonation to search for injured or dead ESA-listed marine species. Measures for reporting dead or injured ESA-listed species are noted in *PDCs Applicable to Injured or Dead Protected Species Reporting* below.
- All observed strandings of protected marine species should be reported to the appropriate hotline, regardless of whether or not the stranding is the result of a detonation or other component of the project.
- To the extent practicable and depending on the ordnance type, appropriate techniques will be implemented to avoid and minimize damage to marine habitat from underwater BIP. Detailed information will be provided in the work plan to the SPP Team for review and comment.

Terrestrial MEC/MPPEH Disposal/Detonation Site

- The USACE and/or its contractors shall identify any onshore staging areas needed for execution of investigations so that sea turtle nest monitoring can be conducted prior to initiating mobilization to ensure no impacts occur to this species during project activities.
- Sea turtle nest monitoring will be limited to the areas used by the USACE and contractor personnel. The beach monitoring efforts will consist of nests sighting and identification. The USACE and its contractors will avoid any sea turtle nests that are encountered. Any nest encountered shall be clearly marked (e.g. using flagging). Personnel shall stay at least eight meters (26 feet) away from the marked area to avoid impacts to the nest(s). All nest sightings and actions taken shall be documented.
- Staging areas shall not require any removal of coastal vegetation. These areas shall consist of temporary tents or similar structures that can be easily removed.
- Any areas proposed for use as staging area that form part of the Culebra NWR shall be closely coordinated with the refuge manager.
- Smaller offshore cays should not be used as staging areas; only cays that can be safely accessed by boats should be identified for use. Temporary mooring buoys should be

employed to access staging areas to avoid repeated anchoring and impacts to marine bottom.

- Monitoring shall be conducted daily by qualified personnel (e.g. biologist, marine biologist, environmental scientist, among others) to identify the potential presence of new nests or sea turtle tracks during the activity period.
- If sea turtle nests are found, the Contractor personnel will notify USACE, who will notify the USFWS, NMFS, and PRDNER POC. If agreed, the nest locations will be clearly marked and the staging area will be relocated. This information shall be documented.
- The USACE and its contractors will follow USFWS Sea Turtle Conservation Measures for Ground Intrusive Beach Work and for Designation of Beach Zones for Vegetation Removal and Munitions Detonation (USACE 2015b).

3.3.1.5 PDCs Applicable to Staging Areas and Sea Turtle Nest Monitoring

- Sea turtle nest monitoring will be limited to the areas used by the USACE and contractor personnel. The beach monitoring efforts will consist of nest sighting and identification. The USACE and its contractors will avoid any sea turtle nests that are encountered. Any nest encountered shall be clearly marked (e.g. using flagging). Personnel shall stay at least eight meters (26 feet) away from the marked area to avoid impacts to the nest(s). All nest sightings and actions taken shall be documented.
- Staging areas shall not require any removal of coastal vegetation. These areas shall consist of temporary tents or similar structures that can be easily removed.
- Any areas proposed for use as a staging area that form part of the Culebra NWR shall be closely coordinated with the refuge manager.
- Smaller offshore cays should not be used as staging areas; only cays that can be safely accessed by boats should be identified for use. Temporary mooring buoys should be employed to access staging areas to avoid repeated anchoring and impacts to marine bottom.
- Monitoring shall be conducted daily by qualified personnel (e.g. biologists, marine biologists, or environmental scientists) to identify the potential presence of new nests or sea turtle tracks during the activity period.
- If sea turtle nests are found, the Contractor personnel will notify USACE, who will notify the USFWS, NMFS, and PRDNER POC. If agreed, the nest locations will be clearly marked and the staging area will be relocated. This information shall be documented.
- The USACE and its contractors will follow FWS Sea Turtle Conservation Measures for Ground Intrusive Beach Work and for Designation of Beach Zones for Vegetation Removal and Munitions Detonation (USACE 2015b).

3.3.1.6 PDCs Applicable to Marine Sediment Sampling

- Samples will only be taken in locations where breached MEC/MD/MPPEH items are observed.
- Any sampling work shall avoid impacts to proposed and ESA-listed marine species.
- Sediment sampling will generally be limited to non-coral areas or sand channels within reef areas where sufficient unconsolidated sediment for sampling can be found.
- If sediment samples are collected from habitats containing seagrass, divers will restore disturbed or uprooted plants following the PDCs for transplant of seagrass (below).

3.3.1.7 PDCs Applicable to Installation and maintenance of In-Water Structures

- Mooring buoy locations shall be coordinated with the USCG and PRDNER.
- To avoid impacts to listed coral species and designated or proposed critical habitat, the installation of mooring buoys to access cays requiring cleanup activities will be conducted if the cleanup activities will take place for more than two weeks, as practicable.
- Prior to installation of mooring buoys at any given location in Culebra waters, the proposed locations shall be assessed for presence/absence of UXO and to select final locations in unvegetated, sandy bottom. If the mooring buoys are not installed, the contractor will use a transit vessel to transport personnel to a site near each cay. The transit vessel will not weigh anchor and personnel will access the cays via an inflatable craft.
- Seagrass habitat will be avoided to the extent possible for anchor installation. If anchors have to be installed in seagrass, a location with minimum seagrass cover will be identified for anchor installation. Subsurface buoys will be installed to keep any chain slack from impacting seagrass.
- New anchor points for sand screws will be located where there will be the least potential for environmental impacts while allowing marker buoys to be securely anchored and in a location where they will be effective in terms of being readily viewed by boaters.
- Anchor point locations must not contain live or dead coral and live or dead coral must not be located within the potential reach of the anchor chain (i.e., live or dead coral must not be within three meters [10 feet] of the estimated swing radius of the chain).
- Sand screws will be preferentially located in deep unconsolidated sediment with limited biological cover of macroalgae and/or seagrass.
- In locations where marker buoys will be anchored in hard substrate, the anchor location must be bare rock or rock covered with macroalgae with no live or dead coral. Pin anchors will be used in hard substrate in areas where existing ESA-listed corals are beyond the reach of any attached chains or equipment. A subsurface buoy will be

attached along the anchor chain to prevent scouring of hard bottom habitat or damage to future coral recruits.

- If it is determined that modifications to an in-water structure, including specific types of system components and final system design or types of anchors to be used, are necessary at the time of installation, NMFS will be notified of these modifications prior to installation. Modifications that increase the type or extent of adverse effects evaluated in this opinion may require a step-down consultation or reinitiation of consultation.
- If helical anchors need to be removed or replaced, these can be turned out of the sediment without damaging the habitat. Manta Ray® anchors, and pin anchors will be left in place because removal activities are likely to result in more damage than simply maintaining these anchors at their original location.
- Coral recruits observed on anchors will be left undisturbed.
- Coral recruits greater than five centimeters (1.96 inches) that are on chains or buoys, which must be maintained and eventually removed from the water, will be removed and transplanted as feasible.

3.3.1.8 PDCs Applicable to Vessel/Vehicle Operations

Vessel Strike Minimization Measures

- Vessels shall be maintained away from areas with corals and seagrasses. Operations shall be conducted in such a manner that bottom scour or prop dredging will be avoided when corals or seagrasses are present.
- All vessels shall operate at "no wake/idle" speeds at all times while in waters where the draft of the vessel provides less than a 1.2-meter (four-foot) clearance from the bottom.
- From the water’s surface, coral areas appear golden-brown. These areas should be avoided to keep from running aground. The operator should maintain maximum safe distance, if possible, 15.24 meters (50 feet) from coral areas.
- All vessels will preferentially follow deep-water routes whenever possible. Boats used to transport personnel shall be shallow-draft vessels (i.e., all vessels will have at least one foot of clearance from the marine bottom or the tops of coral colonies), preferably of the light-displacement category, where navigational safety permits.
- The motorboat operator shall carry and consult appropriate NOAA nautical charts to monitor depths and use onboard depth sounders and GPS to prevent boat contact with the seafloor and coral colonies that extend toward the surface.
- When whales, sea turtles, or ESA-listed fishes (particularly elasmobranchs) are sighted while a vessel is underway, the operator will reduce speed while slowly moving away from the animal. The vessel operator will avoid excessive speed or abrupt changes in direction until the animal has left the area.

- Vessel operators shall use caution, be alert, maintain a vigilant lookout and reduce speeds, as appropriate, to avoid collisions with ESA-listed marine mammals, sea turtles, and fishes (particularly elasmobranchs) and to avoid accidental groundings during the course of normal operations.
- Marine mammals, sea turtles, and ESA-listed fishes shall not be encircled or trapped between multiple vessels or between vessels and the shore.
- When piloting vessels, vessel operators shall alter course to remain at least 91.44 meters (100 yards) from whales, and at least 45.7 meters (50 yards) yards from other marine mammals, sea turtles, and ESA-listed fishes, particularly elasmobranchs.
- If, despite efforts to maintain the distances and speeds described above, an ESA-listed marine mammal, sea turtle, or fish, particularly elasmobranchs, approaches the vessel, put the engine in neutral until the animal is at least 15.24 meters (50 feet) away, and then slowly move away to the prescribed distance stated in the bullet above.
- Reduce vessel speed to 10 knots or less when piloting vessels at or within the ranges described above from marine mammals and sea turtles. Operators shall be particularly vigilant to watch for turtles at or near the surface in areas of known or suspected turtle activity, and if practicable, reduce vessel speed to five knots or less.
- If the vessel runs aground on coral, the operator shall perform the following:
    - Turn off the engine.
    - Do not try to use the engine to power off the reef, hard bottom or seagrass.
    - Raise the propeller and allow the boat to drift free.
    - Radio the USCG, Marine Patrol or VHF Channel 16 for assistance.

Anchoring/Mooring

- Mooring bumpers shall be placed on all vessels wherever and whenever there is a potential for a marine mammal or sea turtle to be crushed between two moored vessels. The bumpers shall provide a minimum stand-off distance of 1.2 meters (four feet).
- Limit anchoring to sandy areas well away from coral and seagrasses, so the anchor, chain and line do not contact or damage coral or seagrass areas.
- Anchoring on established seagrass beds will be avoided as much as possible. However, if anchoring within seagrass beds cannot be avoided, field teams should attempt to only anchor small boats in areas with sandy bottoms in waters with depths of at least 1.2 meters (four feet), and avoid anchoring directly on seagrass leaves and roots to the maximum extent practicable. An ROV and underwater camera can be utilized to survey the underwater area to ensure the condition of the sea floor is known prior to anchoring. If mooring buoys are available, these will be used rather than weighted anchors.
- If required to anchor within seagrass areas in order to complete an effective underwater survey, the anchor will be lowered from the support boat in a controlled manner and the boat will complete minimal maneuvering to seat the anchor into the sea floor. During

retrieval, the support boat will slowly advance on the anchor line. Once the support boat is over the anchor, vertical pressure will be exerted on the line in order to break the seating of the anchor from the sea floor. The anchor will quickly be retrieved in a vertical direction through the water column with the support boat performing minimal maneuvering. All actions will be executed to avoid dragging the anchor across the sea floor during insertion/extraction to minimize impact to seagrass beds.

Marine Access Points

- For beach access from the ocean, should landing a vessel on the beach be necessary, the landing site shall be coordinated with the FWS Culebra or Desecheo NWR personnel and PRDNER. The route of the vessel shall be determined using nautical charts and benthic habitat maps, including those developed during previous site investigation activities in the action area to ensure that impacts to critical habitat and listed coral species are avoided. However, landing vessels on beaches should be regarded as a measure of last resort.
- Beach activities on Culebrita need to be coordinated with NMFS and USFWS. The following vessel access points will be used to minimize impacts to sea turtle refuge and foraging habitat, designated critical habitat, and listed coral species:
    - Culebrita will be accessed by entering Bahia Tortuga, the bay north of Beach E (as identified in the Engineering Evaluation/Cost Analysis for the cleanup of beaches on Culebrita and Flamenco Beach on Culebra). Contractors will tie boats to existing mooring buoys or, if the draft of vessels is shallow, anchor in the unvegetated, sandy zone between the seagrass beds and the beach.
    - No additional access points to beaches A, B, C, or D will be established as the contractor will bring all equipment and supplies to Beach E for offloading and transport overland or will offload personnel and equipment from an unanchored vessel into an inflatable craft that will then transit to access points previously established in coordination with NMFS and USFWS. These access points do not currently exist and would have to be agreed upon.
- For Cayo Botella, the USACE and its contractors will use the Culebrita Island access in the bay northwest of the largest beach (Beach E) or anchor boats in the sandy bottom area south of the cay and use an inflatable craft, kayak, or swim to access the cay from the southeast where there is a small sand channel between areas of coral reefs.
- Cayo Lobo – boats can anchor in unvegetated sandy bottom in the bay on the southeast side of the cay and anchors will not be dropped in areas containing coral colonies or seagrass beds.
- For Desecheo Island, marine access shall occur on the small beach in the western portion of the island or via mooring buoys in coordination with the USFWS and

PRDNER, including to determine whether it will be necessary to monitor for hawksbill sea turtle nesting on the beach prior to using it as a disembarkation point.

Vehicular Traffic in the Culebra Action Area

- Driving on sand beaches of Culebra Island within MRSs as a means of site access should be regarded as a measure of last resort after all other site access options have been explored.
- A designated entrance and an exit at the beach area, and monitoring of nesting events by qualified and experienced personnel is needed for vehicular beach access. If vehicular access is needed, vehicular access should be limited to the intertidal zone (where ocean meets land between high and low tides) during low tide. Driving above the intertidal zone or in the water should not be allowed.
- If vehicular access on a beach is needed, all known nests should be marked by stake and survey tape or string in an area at least six meters (20 feet) in any direction from the center of the nest. No activities should occur in this marked area. Other alternative routes should be explored to avoid driving on sea turtle nesting beaches.

3.3.1.9 PDCs Applicable to Coral Collection/Relocation

- All underwater work personnel will be familiar with the identification of ESA-listed coral species and coral critical habitat, and will be required to follow the procedures to prevent impacts to these species or habitats during work activities. These required procedures are codified in the *Coral Reattachment and Relocation Protocols* (Appendix C of USACE 2015b).
- To avoid transmission of possible disease agents, tools including collection bags, sampling gear, transect tapes, clipboards, underwater slates, weight belts, and other equipment that comes in contact with the bottom will be decontaminated using diluted chlorine bleach. All tools should be soaked before moving to new sites. Gear and tool decontamination should follow the Office of National Marine Sanctuary protocol (NMFS 2019) or the field manual (Woodley 2008). Also, corals will be thoroughly examined and a visual health assessment will be conducted before collection and relocation to inspect for any signs of disease (See Visual Health Assessment in Appendix A). Diseased corals will not be collected/relocated.
- The following actions are prohibited:
    - walking on, sitting on or standing on coral
    - collecting coral (dead or alive), unless for relocation
    - anchoring on coral
    - touching coral with hands or equipment (unless required for removal of MEC and coral transplant protocols will be adhered to)

- UXO qualified personnel will determine whether coral adjacent to or attached to an MEC item is safe to remove. If safe, the scientific diver will remove the coral under supervision of UXO personnel; otherwise the UXO personnel may be required to perform the coral removal following instructions from the scientific diver.
- Removed corals will be temporarily held in separate containers (for example, plastic bags) and in protected conditions (for example, in a cooler or in shaded conditions) on the support boat.
- After the MEC/MPPEH item has been removed, divers will return to the removal location and reattach the coral onto suitable substrate via cement or marine epoxy using established NOAA methodology. In some instances, corals may need to be transported to a different location with comparable habitat conditions. To the extent possible, relocations will be conducted the same day as their initial removal. General guidance on coral reattachment is provided in the following two videos:
    - http://www.youtube.com/watch?v=_XaUttAUHv4 (NOAA, 2009)
    - http://www.youtube.com/watch?v=qRlfOu7fERw (NOAA, 2011)
- Prior to coral reattachment, the USACE will thoroughly inspect the relocation site to ensure MEC/MPPEH are not present.
- When transplanting corals, the USACE will use tagging methods (e.g., cow tags or other PRDNR recommended coral tags) to prevent potential misidentification of transplanted corals during any subsequent monitoring activities, should these be conducted.
- Prior to initiating the mobilization to any MRS, the MEC removal field team shall receive a boating safety briefing and information regarding location and identification of coral habitats.

3.3.1.10 PDCs Applicable to Contamination Prevention

- No contamination of the marine environment shall result from project-related activities.
- A contingency plan to control hazardous materials is required.
- Appropriate materials to contain and clean potential spills shall be stored at the terrestrial and in-water work site and be readily available.
- All project-related materials and equipment placed in the water (excluding vessels) shall be free of pollutants. Hazardous materials including petroleum products from vessels and equipment in operation during the proposed action will be controlled in accordance with Federal and Commonwealth laws and regulations governing vessel waste and discharge.
- The USACE and/or its contractors and heavy equipment operators shall perform daily pre-work equipment inspections for cleanliness and leaks. All heavy equipment operations shall be postponed or halted should a leak be detected, and shall not proceed until the leak is repaired and equipment cleaned.

- For operations in and around Culebra, fueling of vessels shall be conducted at approved fueling facilities to the extent practicable.
- The transport of sediment and land-based pollutants from project-related work shall be minimized and contained through the appropriate use of erosion control and runoff management practices and, when appropriate, through the curtailment of work during adverse weather and tidal/flow conditions. Further, the use of effective silt containment devices such as turbidity barriers shall be applied to minimize transport of land-based contaminants or resuspended sediments in the water.

3.3.1.11 PDCs Applicable to Injured or Dead Protected Species Reporting

- Report sightings of any injured or dead protected species immediately, regardless of whether the injury or death is caused by project activities.
- Report marine mammals to the Stranding Hotline: (877) 433-8299.
- Report sea turtles to NMFS SERO: (727) 824-5312.
- All sightings should also be reported to PRDNER (787) 645-5593.
- If the injury or death of a marine mammal or sea turtle was caused by a collision with a project related vessel or equipment, responsible parties should remain available to assist the respective salvage and stranding network as needed. NOAA/NMFS should be immediately notified of the strike by email (takereport.nmfsser@noaa.gov) and the following information must be provided:
    - The time, date, and location (latitude/longitude) of the incident.
    - The name and type of the vessel involved.
    - The vessel's speed during the incident.
    - A description of the incident.
    - Water depth.
    - Environmental conditions (e.g. wind speed and direction, sea state, cloud cover, and visibility).
    - The species identification or description of the animal, if possible; and
    - The fate of the animal.
- If any coral is injured, whatever activity causing the damage will be stopped, the injured coral will be left in place and the USCG, NMFS SERO, and PRDNER should be immediately notified. If elkhorn or staghorn corals are injured, the USACE and/or its contractor shall also contact the NOAA Office of Law Enforcement at 1-800-853-1964. The following information must be provided:
    - The time, date, and location (latitude/longitude) of the incident. The name and type of the vessel involved.
    - The vessel's speed during the incident.
    - A description of the incident.
    - Water depth.

- Environmental conditions (e.g. wind speed and direction, sea state, cloud cover, and visibility).
- The type of coral or description, if possible.
- A description of the damage caused to any coral, if possible.

3.3.2 Project-Specific Review and Step-Down Consultation

This programmatic consultation is based on the information available at the time of consultation. Later activities may include the need for BIP, encapsulation, new measures used to encourage or enhance settlement and recruitment of coral reefs, the use of new technologies for survey or removal activities, or other activities within the scope of the proposed action for which we do not have detailed information at this time. Therefore, an activity-specific review must be completed to ensure all of the relevant PDCs are met and determine whether additional PDCs are required once a work plan is submitted. Work plans are required for all activities contemplated under the proposed action.

NMFS anticipated that step-down consultations may be required for some activities to be conducted under this programmatic consultation. These activities may require project-specific review in order for NMFS to determine whether additional PDCs or RPMs are necessary to minimize the effects to ESA resources. More information is needed and step-down consultations may be required for the following activities because of the uncertainty in estimating the extent of take of ESA-listed species or extent of adverse effects to critical habitat as a result of the activity, the potential need for MMPA authorization, the potential for changes in some of these activities as technology evolves, or because details of the activity are not known at this time:

- BIPs: The USACE may determine BIP needs to be used as a removal method upon further in-field investigation, but this will be reserved for MEC with degraded structural material condition that renders the item unsafe to move.
- Encapsulation: Similar to BIP, the USACE may determine that items are unsafe to move but the explosive hazard they present could be sufficiently mitigated through encapsulation.
- Removal of in-water items known or suspected to present a significant explosive hazard because of the possibility for unplanned detonation.
- Changes in the technology and methods for surveying and/or removal activities.
- Installation of floating barriers.
- Other activities for which sufficient details were not available at the time this opinion was written such as the use of aerial operations, including the use of a helicopter to ferry personnel and equipment to/from Desecheo.

For the above activities requiring project-specific review, the USACE will certify compliance with the applicable PDCs along with the information described below. The USACE will submit this information to NMFS OPR via email (nmfs.hq.esa.consultations@noaa.gov) and send a copy to NMFS SERO via email (nmfs.ser.esa.consultations@noaa.gov). The subject line should include a reference to "OPR-2016-00017, Programmatic Consultation on the USACE Underwater Investigation and Cleanup FUDS for Culebra and Desecheo." Based on the information provided, NMFS will communicate its determination as to whether a step-down consultation is needed for a particular activity within 30 days of the receipt of the request. The USACE may request an expedited determination if the particular activity is time sensitive. If a step-down consultation is needed and we agree to an expedited consultation, the USACE and NMFS will establish a timeline for completion of the consultation process (CFR § 402.14(l)). In some cases, the project-specific information may reveal that the project does not fall within the scope of this programmatic opinion and will require a stand-alone consultation. The project-specific submission will include the following information:

1. Location: This should include the location where the activities will take place within the action area.
2. Transit routes: This should include information as to whether the transit routes to be used during a particular project and associated activities will be the same or different from the general transit routes analyzed in this opinion. This information will enable NMFS to determine whether there may be changes to the action area that will affect the activity-specific effects analysis and the PDCs and thus determine if step-down consultation is necessary.
3. BIP: When considering the use of BIP, the USACE will conduct pre-monitoring of the detonation site to determine the presence of ESA-listed species within the estimated zone of PTS and TTS (based on thresholds for marine mammals, sea turtles, and fish) and the presence of listed invertebrates. This information will be used to conduct an ecological risk assessment, the results of which will be provided to NMFS as part of the project-specific review package to determine whether additional PDCs or RPMs are necessary for a particular activity.
4. PDCs: Acknowledge whether or not all of the applicable required PDCs in this document will be met as part of the proposed activities. Identify whether there are some activities or some aspects of the activities that require further analysis because they cannot meet the PDCs or can only partially meet them.
5. Project-specific information: Timing, scale, and description of the activities proposed as part of the project and any proposed changes to the activities that were analyzed in this opinion. This information must be detailed enough to enable NMFS to determine the potential effects specific to a particular project on ESA resources in the action area and assess the risk to these resources because of the implementation of the project. The information will also enable NMFS to determine whether additional protective measures for avoidance and minimization of effects of a particular new activity or technology are required and whether a step-down consultation is needed.

6. Timeline: If there are timeline considerations to be aware of due to USACE funding or other requirements, information regarding any deadlines or other timing considerations should be included in the notification.

Should NMFS determine that a step-down consultation is required, we will work with the USACE to identify the information needed to complete this consultation under the programmatic. The USACE may request an expedited consultation if the particular activity is time sensitive. If we agree to an expedited consultation, the USACE and NMFS will establish a timeline for completion of the consultation process (CFR § 402.14(l)).

If a project-specific review has been conducted but a change is proposed to a particular activity, OPR should be notified via email as soon as the USACE becomes aware of the change. Email notifications should follow the format described above and a response must be received from NMFS prior to commencing in-water work.

Marine mammals protected under the MMPA including the ESA-listed whales identified in Table 1, and other non-ESA-listed species such as bottlenose dolphins (*Tursiops truncatus*) occur in the action area and may be affected by activities under the proposed action, including BIP or unintentional detonation. If these marine mammals may be adversely affected by the proposed action, a take authorization under the MMPA may be necessary. OPR's Permits and Conservation Division should be contacted for more information regarding MMPA requirements at 301-427-8401 (see also https://www.fisheries.noaa.gov/topic/marine-mammal-protection).

3.3.2.1 Programmatic Review

The USACE and NMFS will conduct an annual programmatic review meeting of the proposed activities considered in this opinion beginning at the end of each fiscal year with the first review starting at the end of fiscal year 2023. This review will evaluate, among other things, whether the scope of the operations being implemented is consistent with the description of the proposed activities; whether the nature and scale of effects predicted continue to be valid; whether the PDCs are being complied with and continue to be appropriate; and whether the project-specific and step-down consultation procedures are being complied with and are effective.

To assist in this annual review, the USACE will submit a comprehensive summary 30 days prior to the end of each review period with the first summary report due at the end of fiscal year 2024. The submission will be via email to OPR (nmfs.hq.esa.consultations@noaa.gov) with a copy to SERO (nmfs.ser.esa.consultations@noaa.gov) with the subject line "OPR-2016-00017, Programmatic Review for the USACE Underwater Investigation and Cleanup FUDS for Culebra and Desecheo."

The comprehensive summary will include:

- the in-water activities conducted during each 12-month period in MRSs around Culebra Island and Desecheo Island;
- information regarding the implementation of required PDCs and their efficacy, if known, in avoiding and minimizing impacts of the program on proposed and ESA-listed species and their critical habitat based on any issues identified by the dedicated observers, vessel captain or other crew member, divers or other personnel engaged in the activity;
- copies of sighting logs from vessel-based observers for ESA-listed fish, marine mammals and sea turtles; and reports of sightings of ESA-listed fish, marine mammals, sea turtles, and invertebrates by divers or snorkelers during in-water work, including as part of munitions reporting;
- information regarding the relocation, transplant and/or restoration of seagrass and coral colonies as part of removal activities and quantification of the seagrass and coral habitat area affected by activities implemented under the program; and
- monitoring and reporting of take of ESA-listed species per the RPMs and implementing terms and conditions in the ITS.

The summary of activities and associated effects during each programmatic reporting period will allow NMFS to review the information to determine whether activities completed under the programmatic were within the scope of the opinion and any tiered (step-down) opinions and whether adjustments are needed to the implementing requirements under the programmatic.

4 Action Area

Action area means all areas affected directly, or indirectly, by the Federal action, and not just the immediate area involved in the action (50 CFR § 402.02). The proposed actions will take place in Desecheo Island's MRS 01 and Culebra Island's MRSs 02 (Culebra Adjacent Cays), 03 (Flamenco Bay Water Area), 07 (Culebrita and Cayo Botella Impact Area), 10 (Punta Soldado), 11(Playa Sardinas), 12 (Luis Peña Channel Water Area), and 13 (Cayo Luis Peña Impact Areas) (identified in Figure 5).

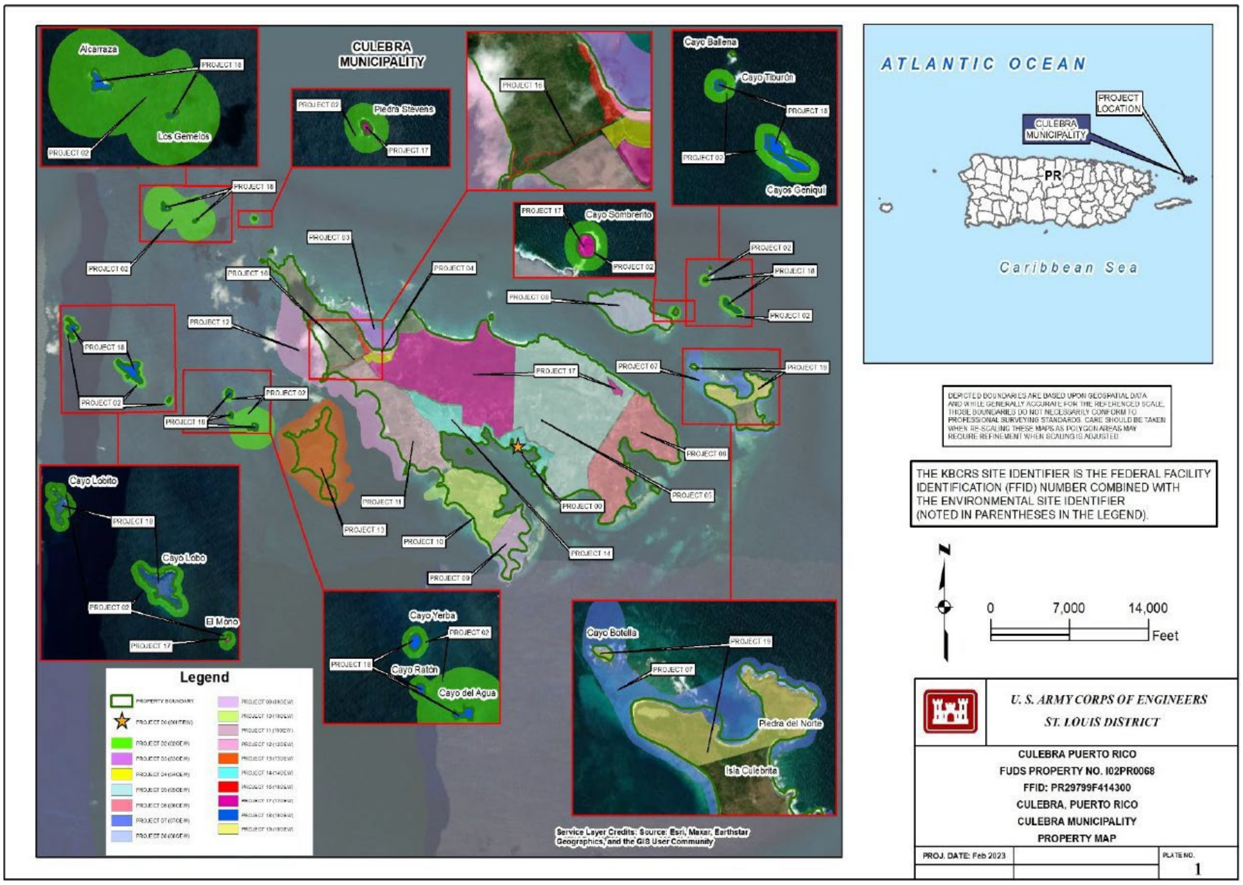

Figure 5 Action Area

As noted in Section 3.2.8, during the proposed activities, boats will mostly depart from Ensenada Honda and Fajardo to access the MRSs around Culebra Island. Also, in the past, vessels used for marine operations have also transited between the main island of Puerto Rico, particularly Rincón, to Desecheo. Therefore, we include possible transit routes between Fajardo and Culebra and between Rincón and Desecheo in the action area (Figure 6).

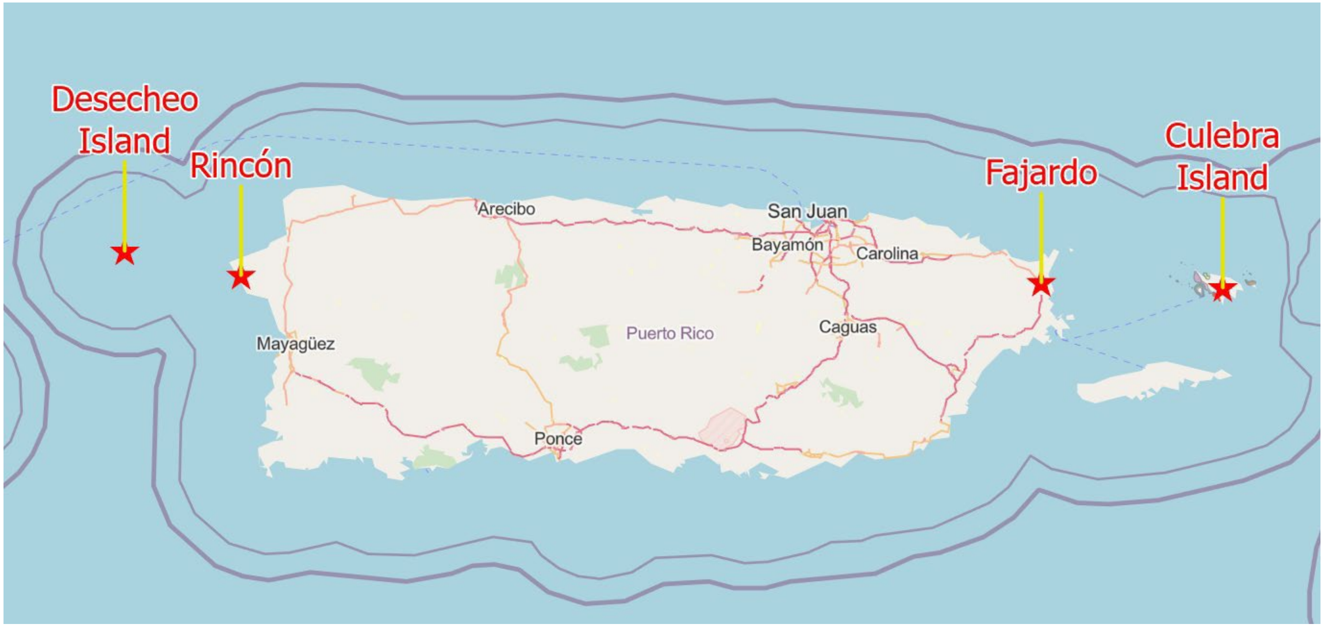

Figure 6. Desecheo and Culebra Island in relation to the main island of Puerto Rico.

5 Potential Stressors

Stressors are any physical, chemical, or biological agent, environmental condition, external stimulus or event that may induce an adverse response in a proposed or ESA-listed species or their designated or proposed critical habitat. During consultation, we deconstructed the proposed action to identify stressors that could reasonably result from the proposed activities. The action consists of location and removal of underwater surface and subsurface MEC/MPPEH, collection of samples (water and sediment), installation and maintenance of in-water structures, underwater investigations using digital geophysical mapping technology to look for MEC, boating operations associated with in-water activities, biological monitoring, and transplant of coral and seagrass associated with some removal activities. The major categories of stressors from the actions identified in this section (Table 1) are:

- strikes from vessels, ROVs, towed equipment, or other moving equipment;
- vessel anchoring, propeller wash and scarring, accidental grounding, and beaching;
- vessel discharges and marine debris;
- sound from different sources (e.g., vessel noise, sonar and other sensors used during underwater investigations, nonintentional detonation, and BIP);
- entanglement (e.g., in tackle associated with in-water structures such as buoys, with towlines and cables of ROVs, and towed sensors/equipment);
- sediment resuspension and transport from various activities (e.g., propeller wash, sediment sampling, anchor installation for in-water structures, and use of bottom-operated sensor equipment);

- habitat loss and/or damage (e.g., installation and maintenance of mooring buoys, bottom moving sensor equipment, use of lift bags/balloons or tripods for MEC removal, nonintentional detonation, temporary marker placement during investigation and removal activities, diver breakage, abrasion, nonintentional detonation, BIP, and encapsulation); and
- contaminants released from MEC/MPPEH during removal activities and associated sediment sampling.

MEC that is left-in-place is covered in the *Environmental Baseline* under Section 7.1.6.

Table 1. Summary of Stressors Associated with the Categories of Activities Proposed

Stressor	Vessel Operation*	Diver Operation**	Location and Removal	Water & Sediment Sample Collection	Installation and Maintenance of In-Water Structures	Underwater Investigation Equipment	Land Detonation/ Consolidated Shot
Vessel Strikes/Equipment Collisions	X		X			X	
Vessel Anchoring/Beaching/Propeller Wash/Scarring/Accidental Grounding	X						
Vessel Discharges/Marine Debris	X						
Noise	X		X		X	X	
Entanglement			X		X	X	
Sediment Resuspension	X	X	X	X	X	X	
Habitat Loss or Damage	X	X	X	X	X	X	
Organism Collection and Transplant			X		X		
Contaminant Release	X		X	X	X		X

* Vessel Operation and associated stressors apply across all activities including biological monitoring which is not listed here. All stressors to NMFS proposed and ESA-listed species and critical habitat from biological monitoring are caused by vessel operations.
** Diver Operation and associated stressors apply to location and removal, sample collection, in-water structures, and underwater investigation activities.

6 Species and Critical Habitat in the Action Area

This section identifies the proposed and ESA-listed species and designated and proposed critical habitats that potentially occur within the action area (Table 2) that may be affected by the proposed FUDS activities.

Table 2. Threatened or Endangered Species That May Be Affected By Proposed Action

Species	***ESA Status***	***Critical Habitat***	***Recovery Plan***
Marine Mammals – Cetaceans			
Blue Whale *(Balaenoptera musculus*)	E – 35 FR 18319	-- --	11/2020
Fin Whale *(Balaenoptera physalus*)	E – 35 FR 18319	-- --	75 FR 47538 07/2010
Humpback Whale *(Megaptera novaeangliae)* – Cape Verde Islands/Northwest Africa DPS	E – 81 FR 62259	-- --	11/1991
Sei Whale *(Balaenoptera borealis)*	E – 35 FR 18319	-- --	12/2011
Sperm Whale *(Physeter macrocephalus)*	E – 35 FR 18319	-- --	75 FR 81584 12/2010
Sea Turtles			
Green Turtle *(Chelonia mydas)* – North Atlantic DPS	T – 81 FR 20057	63 FR 46693	10/1991 – U.S. Atlantic
Green Turtle *(Chelonia mydas)* – South Atlantic DPS	T – 81 FR 20057	-- --	63 FR 28359
Hawksbill Turtle *(Eretmochelys imbricata*)	E – 35 FR 8491	Not in action area	57 FR 38818 08/1992 – U.S. Caribbean, Atlantic, and Gulf of Mexico
Leatherback Turtle *(Dermochelys coriacea)*	E – 35 FR 8491	44 FR 17710	10/1991 – U.S. Caribbean, Atlantic, and Gulf of Mexico

Species	ESA Status	Critical Habitat	Recovery Plan
Loggerhead Turtle *(Caretta caretta)* – Northwest Atlantic Ocean DPS	T – 76 FR 58868	Not in action area	74 FR 2995 10/1991 – U.S. Caribbean, Atlantic, and Gulf of Mexico 01/2009 – Northwest Atlantic
Fish			
Giant Manta Ray *(Manta birostris)*	T – 83 FR 2916	-- --	-- --
Nassau Grouper *(Epinephelus striatus)*	T – 81 FR 42268	87 FR 62930 (Proposed)	8/2018- Outline
Oceanic Whitetip Shark *(Carcharhinus longimanus)*	T – 83 FR 4153	-- --	9/2018- Outline
Scalloped Hammerhead Shark *(Sphyrna lewini)* – Central and Southwest Atlantic DPS	T – 79 FR 38213	-- --	-- --
Marine Invertebrates			
Boulder Star Coral *(Orbicella franksi)*	T – 79 FR 53851	85 FR 76302 (Proposed)	3/15- Outline
Elkhorn Coral *(Acropora palmata)*	T – 79 FR 53851	73 FR 72210	80 FR 12146
Lobed Star Coral *(Orbicella annularis)*	T – 79 FR 53851	85 FR 76302 (Proposed)	3/15- Outline
Mountainous Star Coral *(Orbicella faveolata)*	T – 79 FR 53851	85 FR 76302 (Proposed)	3/15- Outline
Queen conch (*Aliger gigas*)	T – 87 FR 55200	-- --	-- --
Rough Cactus Coral (*Mycetophyllia ferox*)	T – 79 FR 53851	85 FR 76302 (Proposed)	3/15- Outline
Staghorn Coral *(Acropora cervicornis)*	T – 79 FR 53851	73 FR 72210	80 FR 12146
Pillar Coral *(Dendrogyra cylindrus)*	T – 79 FR 53851	85 FR 76302 (Proposed)	3/15- Outline
ESA= Endangered Species Act, FR=Federal Register, DPS=Distinct Population Segment, T=Threatened, E=Endangered			

6.1 Species and Critical Habitat Not Likely to be Adversely Affected

NMFS uses two criteria to identify the ESA-listed species that are not likely to be adversely affected by the action. The first criterion is exposure, or some reasonable expectation of a co-occurrence, between one or more potential stressors associated with the proposed activities and

ESA-listed species. If we conclude that an ESA-listed species is not likely to be exposed to the activities, we must also conclude that the species is not likely to be adversely affected by those activities.

The second criterion is the probability of a response given exposure. ESA-listed species that co-occur with a stressor of the action but are not likely to respond to the stressor are also not likely to be adversely affected by the action. We applied these criteria to the ESA-listed species in Table 1 and we summarize our results below.

In the case of the proposed action, ESA-listed species occur in waters affected by the underwater activities detailed in Section 3.2 that will take place in the action area.

The probability of an effect on a species is a function of exposure intensity and susceptibility of a species to a stressor's effects (i.e., probability of response). An action warrants a "may affect, not likely to adversely affect" finding when its effects are wholly beneficial, insignificant, or discountable.

Beneficial effects have an immediate positive effect without any adverse effects to the species or habitat. Insignificant effects relate to the size or severity of the impact and include those effects that are undetectable, not measurable, or so minor that they cannot be meaningfully evaluated. Insignificant is the appropriate effect conclusion when plausible effects are going to happen, but will not rise to the level of constituting an adverse effect. Discountable effects are those that are extremely unlikely to occur. For an effect to be discountable, there must be a plausible adverse effect (i.e., a credible effect that could result from the action and that would be an adverse effect if it did affect a proposed or listed species), but it is very unlikely to occur (NMFS and USFWS 1998).

6.1.1 Fin, Sei, Blue, Cape Verde DPS Humpback Whales

Fin, sei, Cape Verde DPS humpback, and blue whales are offshore, deep-water species. Fin and sei whales have only been observed in Puerto Rico north of Mona Island and south of Cayo Ratones, Salinas, and records indicate blue whales are not regular inhabitants of the Caribbean (Lesage et al. 2017). Cape Verde DPS humpback whales are extremely rare in the area. It is estimated that only 0.04 percent of the humpback whales occurring in the Southeast Caribbean Sea (i.e., in the vicinity of the islands from Antigua southward) would be from this DPS (NMFS 2021). Humpback whales that may overlap with the action area are from the non-listed West Indies DPS.

The USACE does not have data indicating any of these species have been observed during in-water activities associated with underwater surveys and cleanup activities in the action area. A review of our consultation files, and current literature reviews of cetacean sightings off the coast of Puerto Rico (e.g., Rodriguez et al. 2019) indicate that these four species are not reported in waters near the action area (See Figure 6).

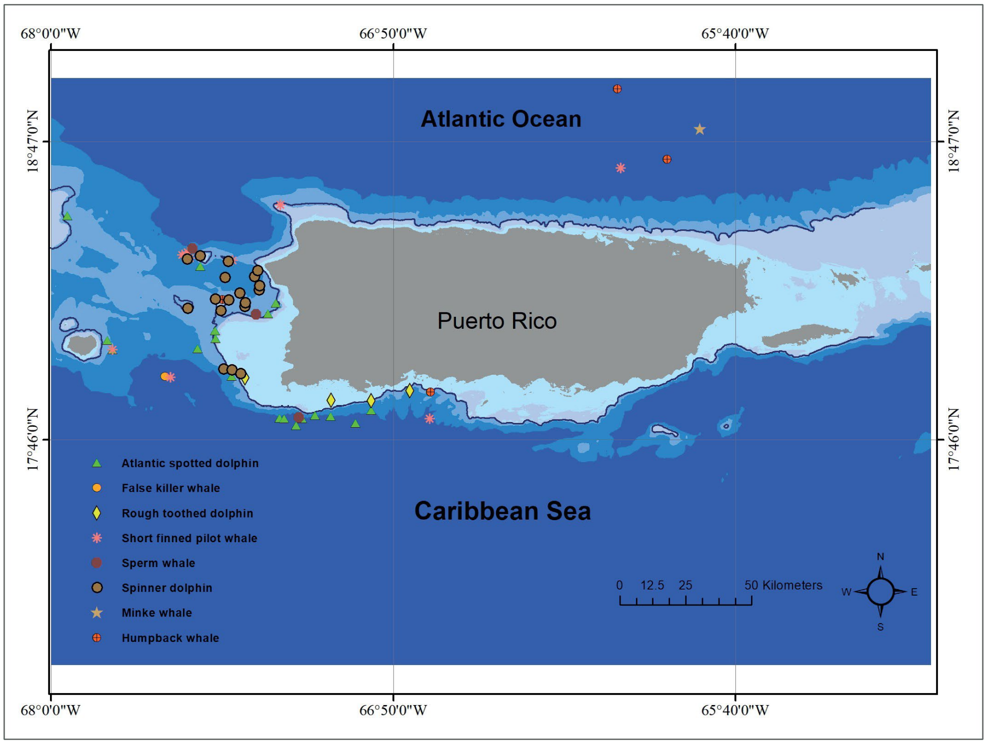

Figure 7. Geographic location of reported cetacean species 1995-2018 in Puerto Rico. Blue line represents the 200 meter (656 foot) isobath (Rodriguez et al. 2019).

Only a few comprehensive cetacean surveys around Puerto Rico have been conducted. The first field surveys were carried out by NOAA Fisheries aboard the *Oregon II* (Roden and Mullin 2000) and by the NMFS using both acoustic and visual techniques throughout the U.S. Caribbean (Swartz et al. 2002).

The majority of activities that are part of this consultation will be conducted in nearshore, shallow waters of the Culebra MRSs and are not expected to have any effect on these four whale species. Although Desecheo Island is surrounded by deep water, as shown in Figure 6, individuals representing these four species have not been observed in this portion of the action area in the most recent surveys available. Vessel transit to and from the MRSs, as well as between ports and harbors in the action area that include the main island of Puerto Rico, could result in encounters with ESA-listed whale species. However, the rarity of these four species and the fact that reported sightings do not include any areas that fall within the action area for this consultation mean that vessel strikes or other effects to fin, sei, Cape Verde DPS humpback, and blue whales as a result of the action are extremely unlikely to occur and thus discountable. Therefore, we believe the action may affect, but is not likely to adversely affect these four species of ESA-listed whales.

6.1.2 Loggerhead Sea Turtles

Loggerhead hatchlings use floating mats of *Sargassum* while adults and juveniles may be present along the shelf edge and in shallow habitats such as estuaries, reefs, and natural and artificial hard bottom. Limited loggerhead nesting has been reported on the east coast of the main island of Puerto Rico and on Culebra Island, but is apparently not frequent. Loggerhead sea turtles could be present in nearshore and offshore waters of the Culebra MRS action area. No nesting of loggerheads has been reported on the small beach on Desecheo. Unpublished stranding data from the PRDNER indicate that no loggerhead sea turtles have been reported as stranded from 1987-2021 (PRDNER unpublished data) within the action area, indicating that the Northwest Atlantic Ocean DPS of loggerhead is not likely to be found in the action area. While there was a sighting in 2022 of a loggerhead in the waters near Culebra, this was a very rare occurrence (C. Diez, PRDNER, pers. comm. to R. Driskell, NMFS, June, 15, 2022).

Stressors from vessel operation and associated discharges and potential generation of marine debris, noise, entanglement and entrapment, and sediment resuspension and transport during the proposed activities have the potential to affect juvenile and adult life stages of loggerhead sea turtles. Vessel transit to, from, and within the action area, including between ports and harbors, could result in encounters with loggerhead sea turtles. Stranding and nesting data from PRDNER indicate that this species can occasionally be found along the eastern coast of the main island of Puerto Rico, including nesting on some beaches, but nesting and stranding events involving the species do not occur frequently. Therefore, because of the rarity of loggerhead sea turtles around Puerto Rico and the lack of nesting, stranding and sighting data indicating they are present in the action area for this consultation, vessel strikes or other effects as a result of the action are extremely unlikely to occur and are therefore discountable. Thus, we believe the action is not likely to adversely affect the Northwest Atlantic Ocean DPS of loggerhead sea turtle.

6.1.3 ESA Listed Elasmobranchs

Giant Manta Ray

Giant manta rays are typically found offshore in the open ocean, though these animals are sometimes found around nearshore reefs and estuarine waters, which are some of the habitats present in the action area. Giant manta rays feed in the water column on plankton. Giant manta ray have been observed infrequently by NMFS biologists near the entrance to San Juan Bay, particularly near channel marker buoys, and infrequent observations of this species have also been reported in deeper waters off bays and over deep reefs around the 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, particularly the portion around Culebra, has similar habitat as the sites around the USVI where these animals have occasionally been sighted, it is possible that they periodically transit through the action area. The USACE and its contractors have not documented sightings of giant manta rays during numerous in-water surveys conducted as part of the on-going evaluation of potential MEC/MPPEH.

Oceanic Whitetip Shark

Data from the Marine Recreational Information Program (MRIP) from Puerto Rico show 132 oceanic whitetip sharks were landed in 2015 by recreational charter boats using vertical line gear within Puerto Rico's territorial waters, which extend to nine nautical miles from shore (NMFS, Fisheries Statistics Division, pers. comm. to J. Molineaux, NMFS, October, 21, 2022). The oceanic whitetip shark is a truly pelagic species, generally remaining offshore in the open ocean, on the outer continental shelf, or around oceanic islands in water depths greater than 184 meters (603.6 feet), and occurring from the surface to at least 152 meters (499 feet) deep (Young et al. 2017). Oceanic whitetip sharks are highly mobile and prefer open ocean conditions, including for foraging. Shark tagging data show movements by juveniles of this species in the Gulf of Mexico, along the east coast of Florida, Mid-Atlantic Bight, Cuba, Lesser Antilles, central Caribbean Sea, from east to west along the equatorial Atlantic, and off Brazil, Haiti, and Bahamas (Young et al. 2017). Fisheries data also indicate that, while catch of this species has declined, it has been part of fishery landings in the U.S. Caribbean (Young et al. 2017) meaning that the species is likely to be present in offshore waters of Puerto Rico in waters greater than 152 meters (499 feet). The waters in most of the action area, particularly around Culebra, are less than 36.6 meters (120 feet) deep and oceanic whitetip sharks are not common in these areas. Waters around Desecheo are deeper than 36.6 meters (120 feet); however, cleanup activities are confined to the marine environment out to the 36.6-meter (120-foot) depth contour (USACE 2022b).

Determination for ESA-listed Elasmobranchs

Stressors from vessel operation and associated discharges and potential generation of marine debris, noise, and entanglement are those with the potential to affect giant manta ray and oceanic whitetip sharks. Vessel transit to, from, and within the action area, including between ports and harbors, could result in encounters with giant manta rays and oceanic whitetip sharks. However, because of the apparent rarity of these species in the action area and the lack of sighting reports or other data indicating they are present, vessel strikes or other effects to these species as a result of the action are extremely unlikely to occur and therefore discountable. Thus, we believe the proposed action may affect, but is not likely to adversely affect giant manta rays and oceanic whitetip sharks.

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

This opinion examines the status of sperm whales; green (North and South Atlantic DPSs), leatherback, and hawksbill sea turtles; Nassau grouper; Northwest and Western Central Atlantic DPS of scalloped hammerhead shark; queen conch (proposed); elkhorn, staghorn, rough cactus, pillar, lobed star, mountainous star, and boulder star corals; designated critical habitat for green sea turtles (North Atlantic DPS) and elkhorn and staghorn coral (Puerto Rico unit), and proposed critical habitat for Nassau grouper and lobed star, mountainous star, boulder star, pillar, and rough cactus corals that may be affected by the action.

The evaluation of adverse effects in this opinion begins by summarizing the biology and ecology of those species that are likely to be adversely affected and what is known about their life histories in the action area and the condition of designated critical habitat within the applicable critical habitat unit. The status is determined by the level of risk that the proposed and ESA-listed species and designated and proposed critical habitat face based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This helps to inform the description of the species' current "reproduction, numbers or distribution" that is part of the jeopardy determination as described in 50 CFR §402.02. This section also examines the condition of critical habitat throughout the designated area (such as various coastal and marine environments that make up the designated area), and discusses the condition and current function of designated or proposed critical habitat, including PBFs that contribute to that conservation value of the critical habitat. More detailed information on the status and trends of these proposed and ESA-listed species, and their biology and ecology can be found in the listing regulations and critical habitat designations published in the Federal Register, status reviews, recovery plans, and on the NMFS Web site: [https://www.fisheries.noaa.gov/topic/endangered-species-conservation].

6.2.1 Status of Sperm Whale

The sperm whale is a widely distributed species found in all major oceans (Figure 7). Sperm whales were first listed under the precursor to the ESA, the Endangered Species Conservation Act of 1969, and remained on the list of threatened and endangered species after the passage of the ESA in 1973 (35 FR 18319, December 2, 1970).

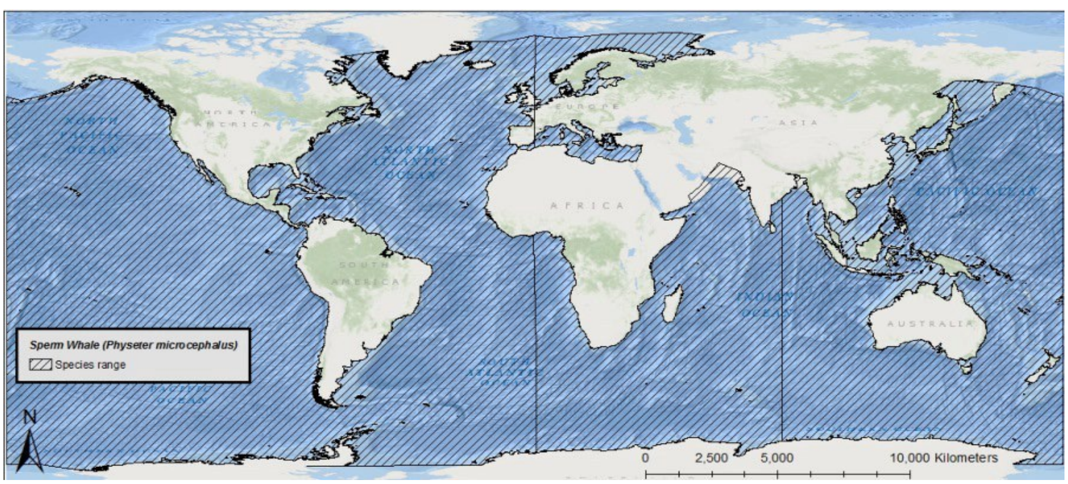

Figure 8. Map identifying the range of the endangered sperm whale

Life History

The social organization of sperm whales, and with most other mammals, is characterized by females remaining in the geographic area in which they were born and males dispersing more broadly. Females group together and raise young. For female sperm whales, remaining in the region of birth can include very large oceanic ranges over which the whales need to successfully forage and nurse young whales. Male sperm whales are mostly solitary, disperse more widely, and can mate with multiple female populations throughout a lifetime.

The average lifespan of sperm whales is estimated to be at least 50 years (Whitehead 2009). They have a gestation period of one to one and a half years, and calves nurse for approximately two years. Sexual maturity is reached between seven and thirteen years of age for females with an average calving interval of four to six years. Male sperm whales reach full sexual maturity in their twenties. Sperm whales have a strong preference for waters deeper than 1,000 meters (3281 feet; Reeves and Whitehead 1997; Watkins 1977), although Berzin (1971) reported that they are restricted to waters deeper than 300 meters (984 feet). While deep water is their typical habitat, sperm whales are occasionally found in waters less than 300 meters (984 feet) in depth (Clarke 1956; Rice 1989). Sperm whales have been observed near Long Island, New York, in water between 40-55 meters deep (131.2 to 180.4 feet; Scott and Sadove 1997). When they are found relatively close to shore, sperm whales are usually associated with sharp increases in topography where upwelling occurs and biological production is high, implying the presence of a good food supply (Clarke 1956). Such areas include oceanic islands and along the outer continental shelf. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed primarily on squid; other prey includes octopus and demersal fish (including teleosts and elasmobranchs).

Population Dynamics

The sperm whale is the most abundant of the large whale species, with a global population of between 300,000 and 450,000 individuals (Whitehead 2009). The higher estimates may be approaching population sizes prior to commercial whaling, the reason for ESA listing. In Puerto Rico and the USVI there is inadequate population data. There is insufficient data to evaluate trends in abundance and growth rates of sperm whales at this time.

There are six recognized stocks of sperm whales that exist in U.S. waters: California/Oregon/Washington (N= 1,997, N_{min}= 1,270), Hawaii (N= 5,707; N_{min}= 4,486), Northern Gulf of Mexico (N= 1,180, N_{min}= 983), North Pacific (no reliable population estimate at this time), North Atlantic (N= 4,349; N_{min}= 3,451), and Puerto Rico and the USVI (insufficient population data) (Carretta et al. 2022; Hayes et al. 2022; Muto 2022).

Ocean-wide genetic studies indicate sperm whales have low genetic diversity, suggesting a recent bottleneck, but strong differentiation between matrilineally related groups (Lyrholm and

Gyllensten 1998). Consistent with this, two studies of sperm whales in the Pacific indicate low genetic diversity (Mesnick et al. 2011; Rendell et al. 2012). Furthermore, sperm whales from the Gulf of Mexico, the western North Atlantic, the North Sea, and the Mediterranean Sea all have been shown to have low levels of genetic diversity (Engelhaupt et al. 2009). As none of the stocks for which data are available have high levels of genetic diversity, the species may be at some risk to inbreeding and 'Allee' effects, although the extent to which is currently unknown.

Sperm whales have a global distribution and can be found in relatively deep waters in all ocean basins (Figure 7). While both males and females can be found in latitudes less than 40º, only adult males venture into the higher latitudes near the poles. In the western North Atlantic, sperm whales range from Greenland south into the Gulf of Mexico and the Caribbean, where they are common, especially in deep basins off of the continental shelf (Romero et al. 2001; Wardle et al. 2001). The northern distributional limit of female/immature pods is probably around Georges Bank or the Nova Scotian shelf (Whitehead et al. 1991). Seasonal aerial surveys confirm that sperm whales are present in the northern Gulf of Mexico in all seasons (Hansen et al. 1996; Mullin et al. 1994). Sperm whales distribution follows a distinct seasonal cycle, concentrating east-northeast of Cape Hatteras in winter and shifting northward in spring when whales are found throughout the Mid-Atlantic Bight. Distribution extends further northward to areas north of Georges Bank and the Northeast Channel region in summer and then south of New England in fall, back to the Mid-Atlantic Bight. In the eastern Atlantic, mature male sperm whales have been recorded as far north as Spitsbergen (Øien 1990). Recent observations of sperm whales and stranding events involving sperm whales from the eastern North Atlantic suggest that solitary and paired mature males predominantly occur in waters off Iceland, the Faroe Islands, and the Norwegian Sea (Christensen et al. 1992a; Christensen et al. 1992b; Gunnlaugsson and Sigurjónsson 1990; Øien 1990).

Vocalization and Hearing

Sound production and reception by sperm whales are better understood than in most cetaceans. Sperm whales produce broadband clicks in the frequency range of 10 hertz (Hz) to 30 kilohertz (kHz) that can be extremely loud for a biological source (André et al. 2017). Evidence suggests that the clicks produced during foraging dives are directional with an intense, forward-directed beam at levels as high as 236 decibels (dB) re: 1 micro Pascal (μPa) at one meter (3.2 feet; Mohl et al. 2003). Most of the energy in sperm whale clicks is concentrated at around 2-4 kHz and 10-16 kHz (Goold and Jones 1995; NMFS 2006d; Weilgart and Whitehead 1993). The multipulsed nature of sperm whale clicks led to the dominating theory of sound production mechanics by Norris and Harvey (1972), who explained the interpulse interval of the click by properties of the nasal anatomy (Mohl et al. 2003). This theory has been supported by sound-transmission experiments within the spermaceti complex (Mohl et al. 2003). Clicks are also used in short patterns (codas) during social behavior and intragroup interactions (Weilgart and Whitehead

1993) and may also aid in intra-specific communication. Another class of sound, “squeals”, are produced with frequencies of 100 Hertz (Hz) to 20 kHz (e.g., Weir et al. 2007).

Our understanding of sperm whale hearing stems largely from the sounds they produce. The only direct measurement of hearing was from a young stranded individual from which auditory evoked potentials were recorded (Carder and Ridgway 1990). From this whale, responses support a hearing range of 2.5-60 kHz. However, behavioral responses of adult, free-ranging individuals also provide insight into hearing range; sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins et al. 1985; Watkins and Schevill 1975). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Because they spend large amounts of time at depth and use low-frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999).

Status

The sperm whale is endangered because of past commercial whaling. Although the aggregate abundance worldwide is probably at least several hundred thousand individuals, the extent of depletion and degree of recovery of populations are uncertain. Sperm whale populations probably are undergoing the dynamics of small population sizes, which is a threat in and of itself. In particular, the loss of sperm whales to directed Soviet whaling likely inhibits recovery due to the loss of adult females and their calves, leaving sizeable gaps in demographic and age structuring (Whitehead 2003). Continued threats to sperm whale populations include ship strikes, entanglement in fishing gear, competition for resources due to overfishing, pollution, loss of prey and habitat due to climate change, and noise. The species’ large population size shows that it is somewhat resilient to current threats.

Critical Habitat

No critical habitat has been designated for the sperm whale.

Recovery Goals

The Recovery Plan (NMFS 2010) identifies recovery criteria geographically across three ocean basins: the Atlantic Ocean/Mediterranean Sea, the Pacific Ocean, and the Indian Ocean. This geographic division by basin is due to the wide distribution of sperm whales and presumably little movement of whales between ocean basins. See the 2010 Final Recovery Plan for the sperm whale for complete down listing/delisting criteria for both of the following recovery goals.

1. Achieve sufficient and viable populations in all ocean basins.
2. Ensure significant threats are addressed.

6.2.2 Status of North and South Atlantic DPSs of Green Sea Turtle, Hawksbill Sea Turtle, and Leatherback Sea Turtle

6.2.2.1 General Threats Faced by Green (North and South Atlantic DPS) and Hawksbill Sea Turtles

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, and those identified in this section are discussed in a general sense for all sea turtles. Threat information specific to a particular species is 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; NMFS and USFWS 1992; NMFS and USFWS 1993; NMFS and USFWS 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 U.S. 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, hand lines, and rod-reel]), pound nets, and trap fisheries. (Refer to the Environmental Baseline section of this opinion [Section 7] 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 U.S. 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 U.S., 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 (Bouchard et al. 1998; Lutcavage et al. 1997). 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; Witherington et al. 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 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 (Garrett 2004; Grant and Ross 2002; Hartwell 2004; Iwata et al. 1993). 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 affect 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 sub-lethal effects or caused environmental damage that will affect other sea turtles into the future.

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 (Laist et al. 1999; Lutcavage et al. 1997). Schuyler et al. (2015) estimated that, globally, 52 percent 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 percent of loggerheads had plastic in their gut. A Brazilian study found that 60 percent 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 may be 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 (Laist et al. 1999; Lutcavage et al. 1997; NRC 1990).

Climate Change

See Section 7.2 for a discussion of the threat of climate change to sea turtles.

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. These mammals, as well as ghost crabs, laughing gulls, and the exotic South American fire ant (*Solenopsis invicta*), prey upon emergent hatchlings. 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 affecting hundreds or thousands of animals.

6.2.2.2 Status of Green Sea Turtle (North and South Atlantic DPSs)

The green sea turtle (*Chelonia mydas*) is the largest of the hardshell marine turtles. It has a circumglobal distribution, occurring throughout nearshore tropical, subtropical and, to a lesser extent, temperate waters. The species was listed under the ESA on July 28, 1978 (43 FR 32800). On April 6, 2016, NMFS listed 11 DPSs of green sea turtles as threatened or endangered under the ESA (Figure 8; 81 FR 20057). Eight DPSs are listed as threatened: Central North Pacific, East Indian-West Pacific, East Pacific, North Atlantic, North Indian, South Atlantic, Southwest Indian, and Southwest Pacific. Three DPSs are listed as endangered: Central South Pacific, Central West Pacific, and Mediterranean.

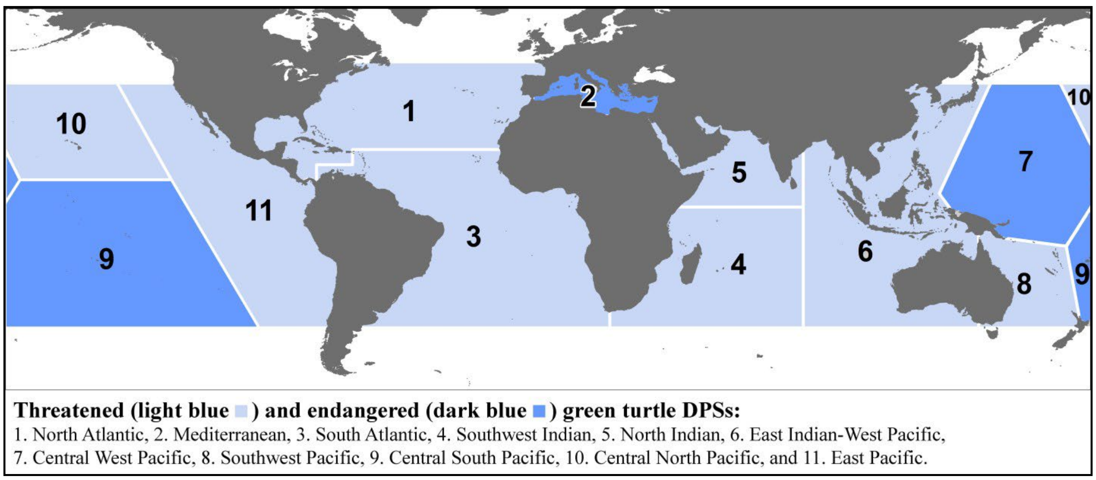

Figure 9 Map depicting DPS boundaries for green turtles.

Life History

Age at first reproduction for females is 20 - 40 years. Green sea turtles lay an average of three nests per season with an average of 100 eggs per nest. The remigration interval (i.e., return to natal beaches) is two to five years. Nesting occurs primarily on beaches with intact dune structure, native vegetation and appropriate incubation temperatures during summer months. 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. Adult turtles exhibit site fidelity and migrate hundreds to thousands of kilometers from nesting beaches to foraging areas. Green sea turtles spend the majority of their lives in coastal foraging grounds, which include open coastlines and protected bays and lagoons. Adult green turtles feed primarily on seagrasses and algae, although they also eat jellyfish, sponges and other invertebrate prey.

Population Dynamics

North Atlantic DPS

Green turtles from the North Atlantic DPS range from the boundary of South and Central America (7.5 degrees [°] N, 77°W) in the south, throughout the Caribbean, the Gulf of Mexico, and the U.S. Atlantic coast to New Brunswick, Canada (48°N, 77°W) in the north. The range of the DPS then extends due east along latitudes 48°N and 19°N to the western coasts of Europe and Africa (Figure 9).

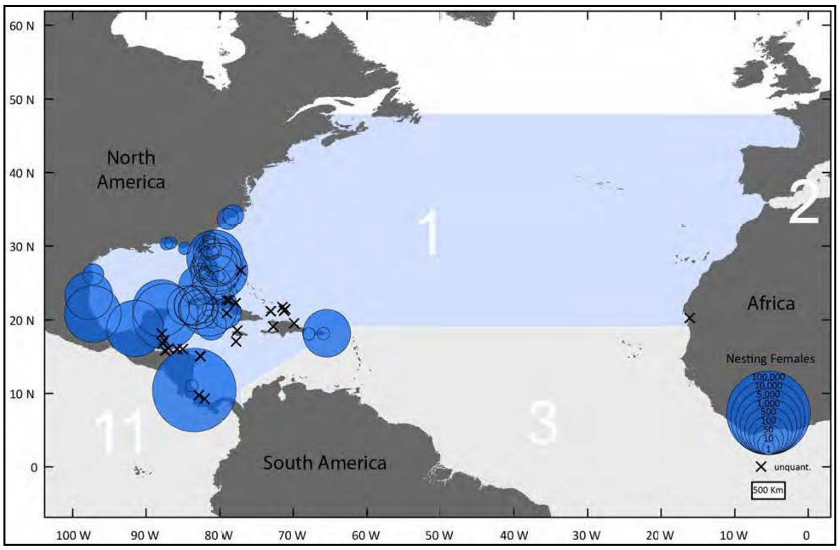

Figure 10. Geographic range of the North Atlantic DPS, with location and abundance of nesting females (from Seminoff et al. 2015).

South Atlantic DPS

The range of the South Atlantic DPS begins at the border of Panama and Colombia at 7.5ºN, 77ºW, heads due north to 14ºN, 77ºW, then east to 14ºN, 65.1ºW, then north to 19ºN, 65.1ºW, and along 19ºN latitude to Mauritania in Africa. It extends along the coast of Africa to South Africa, with the southern border being 40ºS latitude (Figure 10).

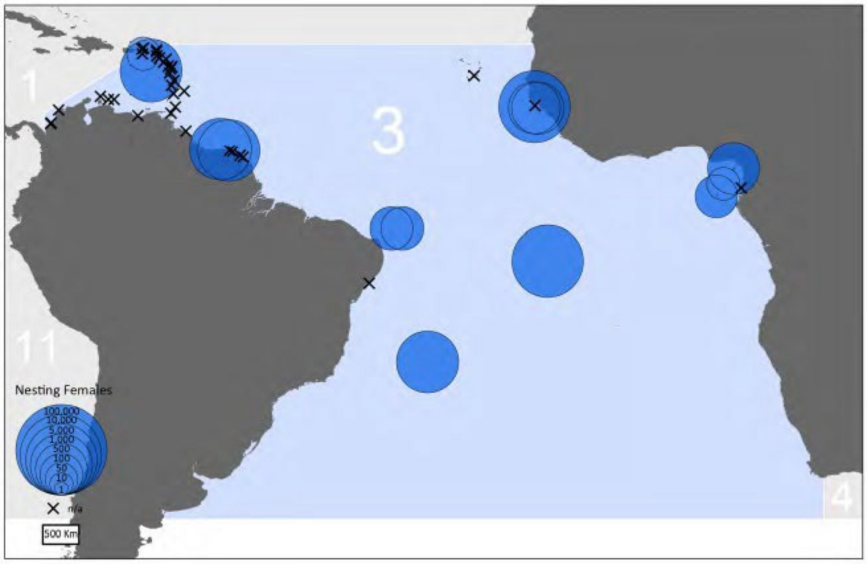

Figure 11. Geographic range of the South Atlantic DPS green turtle, with location and abundance of nesting females (from Seminoff et al. 2015).

Genetic Diversity

North Atlantic DPS

The North Atlantic DPS has a globally unique haplotype, which was a factor in defining the discreteness of the population for the DPS. Evidence from mitochondrial DNA studies indicates that there are at least four independent nesting subpopulations in Florida, Cuba, Mexico and Costa Rica (Seminoff et al. 2015). More recent genetic analysis indicates that designating a new western Gulf of Mexico management unit might be appropriate (Shamblin et al. 2015).

South Atlantic DPS

Individuals from nesting sites in Brazil, Ascension Island, and western Africa have a shared haplotype found in high frequencies. Green turtles from rookeries in the eastern Caribbean however, are dominated by a different haplotype.

Abundance

North Atlantic DPS

Compared to other DPSs, the North Atlantic DPS exhibits the highest nester abundance, with approximately 167,424 females at 73 nesting sites; Figure 9), and available data indicate an increasing trend in nesting. The largest nesting site in the North Atlantic DPS is in Tortuguero, Costa Rica, which hosts 79 percent of nesting females for the DPS (Seminoff et al. 2015).

South Atlantic DPS

The South Atlantic DPS has 51 nesting sites, with an estimated nester abundance of 63,332. The largest nesting site is at Poilão, Guinea-Bissau, which hosts 46 percent of nesting females for the DPS (Seminoff et al. 2015).

Population Growth Rate

North Atlantic DPS

For the North Atlantic DPS, the available data indicate an increasing trend in nesting. There are no reliable estimates of population growth rate for the DPS as a whole, but estimates have been developed at a localized level. Modeling by Chaloupka et al. (2008) using data sets of 25 years or more show the Florida nesting stock at the Archie Carr NWR growing at an annual rate of 13.9 percent, and the Tortuguero, Costa Rica, population growing at 4.9 percent.

South Atlantic DPS

There are 51 nesting sites for the South Atlantic DPS, and many have insufficient data to determine population growth rates or trends. Of the nesting sites where data are available, such as Ascension Island, Suriname, Brazil, Venezuela, Equatorial Guinea, and Guinea-Bissau, there is evidence that population abundance is increasing.

Vocalization and Hearing

Sea turtles primarily detect low frequencies with typical hearing frequencies from 30 Hz to two kHz, with a range of maximum sensitivity between 100 to 800 Hz (Bartol and Ketten 2006; Bartol et al. 1999b; Lenhardt 1994; Lenhardt 2002; Ridgway et al. 1969). Piniak et al. (2016) found green turtle juveniles capable of hearing underwater sounds at frequencies of 50 Hz to 1,600 Hz (maximum sensitivity at 200 to 400 Hz). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994). Other studies have similarly found greatest sensitivities between 200 to 400 Hz for the green turtle with a range of 100 to 500 Hz (Bartol and Ketten 2006; Ridgway et al. 1969).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 to 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above three kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above one kHz and almost no responses beyond three to four kHz (Patterson 1966).

Status

The status for both the North and South Atlantic DPS of green sea turtle is discussed below. See Section 6.2.2.1 for more information on general threats to sea turtles.

North Atlantic DPS

Historically, green turtles in the North Atlantic DPS were hunted for food, which was the principal cause of the population's decline. Apparent increases in nester abundance for the North Atlantic DPS in recent years are encouraging but must be viewed cautiously, as the datasets represent a fraction of a green sea turtle generation, up to 50 years. While the threats of pollution, habitat loss through coastal development, beachfront lighting, and fisheries bycatch continue, the North Atlantic DPS appears to be somewhat resilient to future perturbations.

South Atlantic DPS

Though there is some evidence that the South Atlantic DPS is increasing, there is a considerable amount of uncertainty over the impacts of threats to the South Atlantic DPS. The DPS is threatened by habitat degradation at nesting beaches, and mortality from fisheries bycatch remains a primary concern.

Critical Habitat

As of September 2, 1998, all waters surrounding Culebra from the high-water mark out three nautical miles were designated as critical habitat for the green sea turtle. Critical habitat for the green sea turtle includes water extending seaward three nautical miles from the mean high water line of Culebra Island, Puerto Rico, including outlying keys (Cayo Norte, Cayo Ballena, Cayos Geniquí, Isla Culebrita, Arrecife Culebrita, Cayo de Luís Peña, Las Hermanas, El Mono, Cayo Lobo, Cayo Lobito, Cayo Botijuela, Alcarraza, Los Gemelos, and Piedra Steven). As noted above, on April 6, 2016, the NMFS and the USFWS issued a final rule (81 FR 20058) to list 11 DPSs of the green sea turtle (which had previously been listed as the entire species). The final rule stated that the existing 1998 critical habitat designation, i.e., waters surrounding Culebra Island, remains in effect for the North Atlantic DPS of green sea turtle. PBFs of green sea turtle critical habitat are not precisely defined; however, critical habitat was designated to provide protection for important developmental and resting habitats. Seagrass is the principal dietary component of juvenile and adult green sea turtles. Coral reefs and other topographic features within the waters surrounding Culebra provide shelter from predators. Nearby sandy beaches provide nesting grounds for adult females.

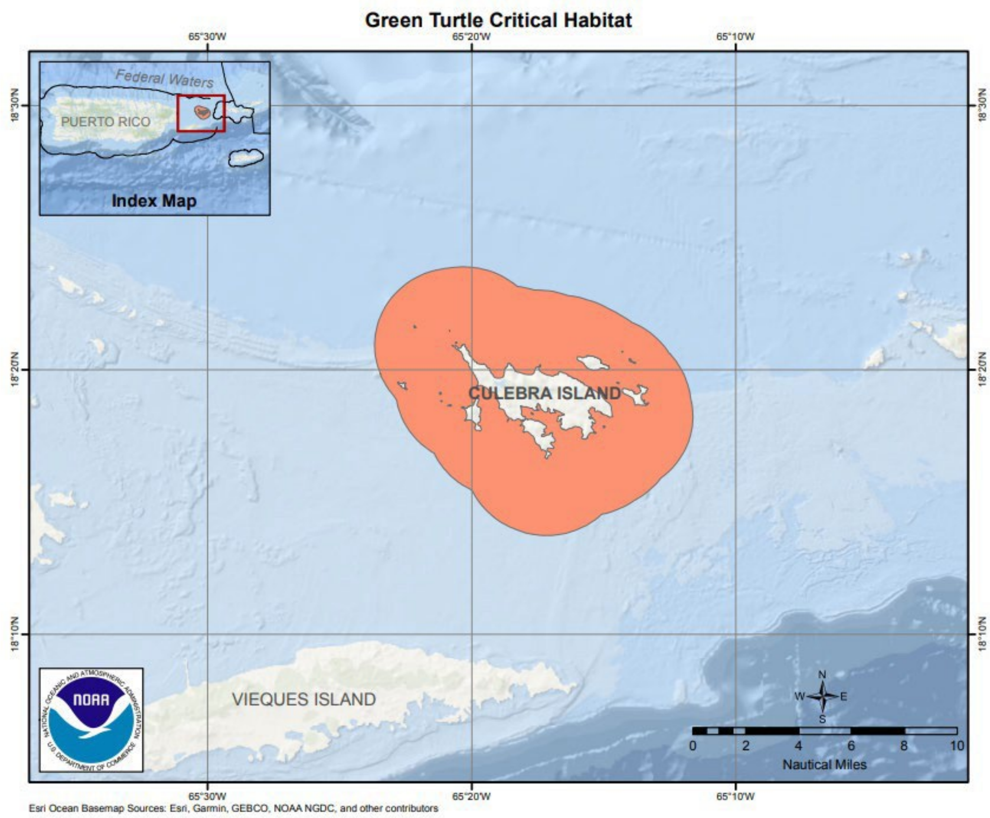

Figure 12. Map identifying critical habitat for green sea turtle

Recovery Goals

See the 1991 recovery plan for the U.S. Atlantic populations of green turtles for complete down-listing/delisting criteria for recovery goals of the species (NMFS 1991). Broadly, recovery plan goals emphasize the need to protect and manage nesting and marine habitat, protect and manage populations on nesting beaches and in the marine environment, increase public education, and promote international cooperation on sea turtle conservation topics. For the U.S. Atlantic, which encompasses the North and South Atlantic DPSs, the recovery objectives are:

- The level of nesting in Florida has increased to an average of 5,000 nests per year for at least six years. Nesting data must be based on standardized surveys.
- At least 25 percent (105 kilometers [65.24 miles]) of all available nesting beaches (420 kilometers [261 miles]) is in public ownership and encompasses at least 50 percent of the nesting activity.
- A reduction in stage class mortality is reflected in higher counts of individuals on foraging grounds.

- All priority one tasks have been successfully implemented.

6.2.2.3 Status of Hawksbill Sea Turtle

Hawksbill sea turtles were first listed under the Endangered Species Conservation Act (35 FR 8491) and listed as endangered under the ESA since 1973. The hawksbill turtle has a circumglobal distribution throughout tropical and, to a lesser extent, subtropical oceans (Figure 12).

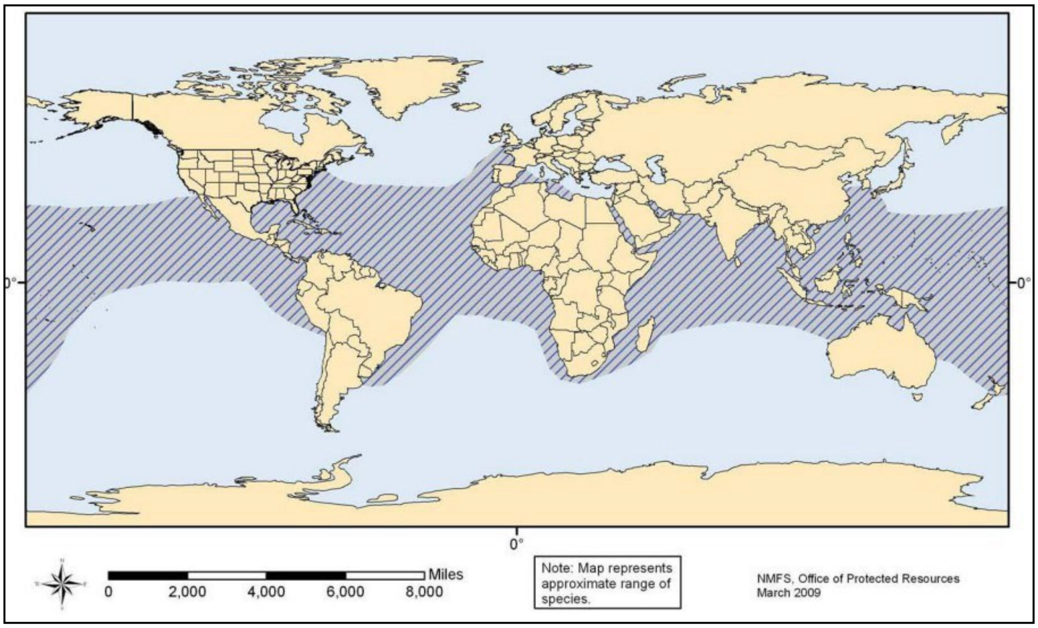

Figure 13. Map identifying the range of the endangered hawksbill sea turtle

Life History

Hawksbill sea turtles reach sexual maturity at 20 to 40 years of age. Females return to their natal beaches every two to five years to nest (an average of three to five times per season). Clutch sizes are large (up to 250 eggs). Sex determination is temperature dependent, with warmer incubation producing more females. Hatchlings migrate to and remain in pelagic habitats until they reach approximately 22 – 25 centimeters (nine to 10 inches) in straight carapace length. As juveniles, they take up residency in coastal waters to forage and grow. As adults, hawksbills use their sharp beak-like mouths to feed on sponges and corals. Hawksbill sea turtles are highly migratory and use a wide range of habitats during their lifetimes (Musick and Limpus 1997; Plotkin 2003). Satellite tagged turtles have shown significant variation in movement and migration patterns. Distance traveled between nesting and foraging locations range from a few hundred to a few thousand kilometers (Horrocks et al. 2001; Miller 1998).

Population Dynamics

Distribution

The hawksbill has a circumglobal distribution throughout tropical and, to a lesser extent, subtropical waters of the Atlantic, Indian, and Pacific Oceans. In their oceanic phase, juvenile hawksbills can be found in *Sargassum* mats; post-oceanic hawksbills may occupy a range of habitats that include coral reefs or other hard bottom habitats, sea grass, algal beds, mangrove bays and creeks (Bjorndal and Bolten 2010; Musick and Limpus 1997).

Genetic Diversity

Populations are distinguished generally by ocean basin and more specifically by nesting location. Our understanding of population structure is relatively poor. Genetic analysis of hawksbill sea turtles foraging off the Cape Verde Islands identified three closely-related haplotypes in a large majority of individuals sampled that did not match those of any known nesting population in the western Atlantic, where the vast majority of nesting has been documented (Monzón-Argüello et al. 2010). Hawksbills in the Caribbean seem to have dispersed into separate populations (rookeries) after a bottleneck roughly 100,000-300,000 years ago (Leroux et al. 2012).

Abundance

Surveys at 88 nesting sites worldwide indicate that 22,004 – 29,035 females nest annually (NMFS and USFWS 2013a). In general, hawksbills are doing better in the Atlantic and Indian Ocean than in the Pacific Ocean, where despite greater overall abundance, a greater proportion of the nesting sites are declining.

Population Growth Rate

From 1980 to 2003, the number of nests at three primary nesting beaches (Rancho Nuevo, Tepehuajes, and Playa Dos) increased 15 percent annually (Heppell et al. 2005); however, due to recent declines in nest counts, decreased survival at other life stages, and updated population modeling, this rate is not expected to continue (NMFS and USFWS 2013a).

Status

Long-term data on the hawksbill sea turtle indicate that 63 sites have declined over the past 20 to 100 years (historic trends are unknown for the remaining 25 sites). Recently, 28 sites (68 percent) have experienced nesting declines, 10 have experienced increases, three have remained stable, and 47 have unknown trends. The greatest threats to hawksbill sea turtles are overharvesting of turtles and eggs, degradation of nesting habitat, and fisheries interactions. Adult hawksbills are harvested for their meat and carapace, which is sold as tortoiseshell. Eggs are taken at high levels, especially in Southeast Asia where collection approaches 100 percent in some areas. In addition, lights on or adjacent to nesting beaches are often fatal to emerging hatchlings and alters the behavior of nesting adults. The species' resilience to additional perturbation is low. See Section 6.2.2.1 for more information on general threats to sea turtles.

Critical Habitat

On September 2, 1998, NMFS established critical habitat for hawksbill sea turtles around Mona and Monito Islands, Puerto Rico (63 FR 46693). Aspects of these areas that are important for hawksbill sea turtle survival and recovery include important natal development habitat, refuge from predation, shelter between foraging periods, and food for hawksbill sea turtle prey. This critical habitat is not present within the action area.

Recovery Goals

The 1992 and 1998 Recovery Plans for the U.S. Caribbean, Atlantic and Gulf of Mexico (NMFS and USFWS 1993), and U.S. Pacific (USFWS and NMFS 1998a) populations of hawksbill sea turtles, respectively, contain complete down listing/delisting criteria for each of their respective recovery goals. The following items were the top recovery actions identified to support in the Recovery Plans:

- Identify important nesting beaches
- Ensure long-term protection and management of important nesting beaches
- Protect and manage nesting habitat; prevent the degradation of nesting habitat caused by seawalls, revetments, sand bags, other erosion-control measures, jetties and breakwaters
- Identify important marine habitats; protect and manage populations in marine habitat
- Protect and manage marine habitat; prevent the degradation or destruction of important [marine] habitats caused by upland and coastal erosion
- Prevent the degradation of reef habitat caused by sewage and other pollutants
- Monitor nesting activity on important nesting beaches with standardized index surveys
- Evaluate nest success and implement appropriate nest-protection on important nesting beaches
- Ensure that law-enforcement activities prevent the illegal exploitation and harassment of sea turtles and increase law-enforcement efforts to reduce illegal exploitation
- Determine nesting beach origins for juveniles and sub-adult populations

6.2.2.4 Status of Leatherback Sea Turtle

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. The leatherback sea turtle is unique among sea turtles for its large size, wide distribution (due to thermoregulatory systems and behavior), and lack of a hard, bony carapace. It ranges from tropical to subpolar latitudes, worldwide (Figure 13). Leatherbacks are the largest living turtle, reaching lengths of six feet long, and weighing up to one ton. Leatherback sea turtles have a distinct black leathery skin covering their carapace with pinkish white skin on their belly.

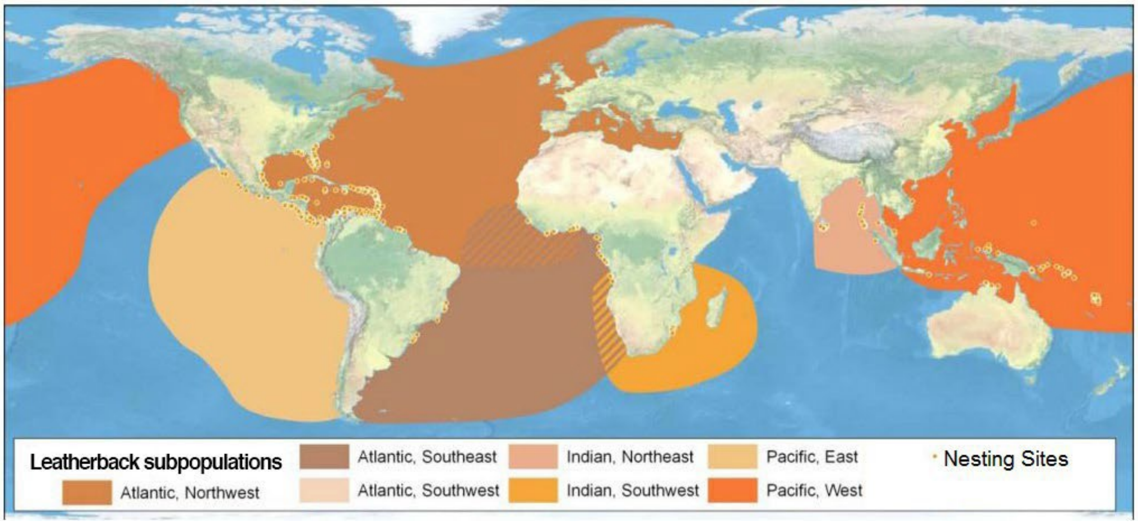

Figure 14. Map identifying the range of the endangered leatherback sea turtle (adapted from Wallace et al. 2013b)

Life History

The age of maturity for leatherback sea turtles has been difficult to ascertain, with estimates ranging from five to 29 years (Avens et al. 2009; Spotila et al. 1996). Females lay up to seven clutches per season, with more than 65 eggs per clutch and eggs weighing >80 g (Reina et al. 2002; Wallace et al. 2007). The number of leatherback hatchlings that make it out of the nest on to the beach (i.e., emergent success) is approximately 50 percent worldwide (Eckert et al. 2012). Females nest every one to seven years. Natal homing, at least within an ocean basin, results in reproductive isolation between five broad geographic regions: eastern and western Pacific, eastern and western Atlantic, and Indian Ocean. Leatherback sea turtles migrate long, transoceanic distances between their tropical nesting beaches and the highly productive temperate waters where they forage, primarily on jellyfish and tunicates. These gelatinous prey are relatively nutrient-poor, such that leatherbacks must consume large quantities to support their body weight. Leatherbacks weigh ~33 percent more on their foraging grounds than at nesting, indicating that they probably catabolize fat reserves to fuel migration and subsequent reproduction (James et al. 2005; Wallace et al. 2006). Sea turtles must meet an energy threshold before returning to nesting beaches. Therefore, their remigration intervals (the time between nesting) are dependent upon foraging success and duration (Hays 2000; Price et al. 2004).

Population Dynamics

Distribution

Leatherback sea turtles are distributed in oceans throughout the world (Figure 13). Leatherbacks occur throughout marine waters, from nearshore habitats to oceanic environments (Shoop and Kenney 1992). Movements are largely dependent upon reproductive and feeding cycles and the oceanographic features that concentrate prey, such as frontal systems, eddy features, current boundaries, and coastal retention areas (Benson et al. 2011).

Genetic Diversity

Analyses of mitochondrial DNA from leatherback sea turtles indicates a low level of genetic diversity, pointing to possible difficulties in the future if current population declines continue (Dutton et al. 1999). Further analysis of samples taken from individuals from rookeries in the Atlantic and Indian oceans suggest that each of the rookeries represent demographically independent populations (NMFS 2013a).

Abundance

Leatherbacks contain nesting beaches in the Pacific, Atlantic, and Indian oceans. Detailed population structure is unknown, but is likely dependent upon nesting beach location. Based on estimates calculated from nest count data, there are between 34,000 and 94,000 adult leatherbacks in the North Atlantic (TEWG 2007). In contrast, leatherback populations in the Pacific are much lower. The Western Pacific population exhibits low hatching success and decreasing nesting population trends due to past and current threats, which are likely to further lower abundance and increase the risk of extinction (NMFS and USFWS 2020). Martin et al. (2020) provided a median estimate of the total number of nesting females (i.e., over one, 3-year, remigration interval) at Jamursba Medi and Wermon index beaches in Indonesia of 790 females in 2017. Based on the Martin et al. (2020) estimate of 790 nesting females at Jamursba Medi and Wermon beaches, the total number of nesting females in the West Pacific population is estimated to be 1,054. The current juvenile and adult population size of the West Pacific leatherback population is around 100,000 sea turtles. The East Pacific leatherback population has undergone dramatic declines over the last three generations (NMFS and USFWS 2020; Wallace et al. 2013a), and to date there is no sign of recovery. Using the best data available for the East Pacific population, NMFS and USFWS (2020) calculated the index of total nesting females to be a minimum of 755 females. Population abundance in the Indian Ocean is difficult to assess due to lack of data and inconsistent reporting. Available data from southern Mozambique show that approximately 10 females nest per year from 1994-2004, and about 296 nests per year counted in South Africa (NMFS 2013a).

Population Growth Rate

Population growth rates for leatherback sea turtles vary by ocean basin. Counts of leatherbacks at nesting beaches in the western Pacific indicate that the subpopulation has been declining at a rate of almost six percent per year since 1984 (Tapilatu et al. 2013). The median trend in annual nest counts estimated for Jamursba Medi nesting beaches from data collected from 2001-2017 was -5.7 percent annually (NMFS and USFWS 2020). The median trend in annual nest counts estimated for Wermon nesting beaches from data collected from 2006 to 2017 (excluding 2013–2015 due to low or insufficient effort) was -2.3 percent annually (NMFS and USFWS 2020). In the absence of population trend data on other leatherback life history stages, we consider these trends in annual nest counts an index of the population's growth rate. Leatherback subpopulations in the Atlantic Ocean however are showing signs of improvement. Nesting females in South Africa are increasing at an annual rate of four to 5.6 percent, and from nine to 13 percent in Florida and the USVI (TEWG 2007), believed to be a result of conservation efforts.

Hearing and Vocalizations

Little is known about sea turtle sound use and production. Nesting leatherback turtles have been recorded producing sounds (sighs, grunts or belch-like sounds) up to 1,200 Hz with maximum energy from 300 to 500 Hz (Cook and Forrest 2005; Mrosovsky 1972). Although these sounds are thought to be associated with breathing (Cook and Forrest 2005; Mrosovsky 1972). In addition, leatherback embryos in eggs and hatchlings have been recorded making low-frequency pulsed and harmonic sounds (Ferrara et al. 2014). More information on sea turtle hearing is discussed in *Hearing and Vocalizations* in Section 6.2.2.2.

Status

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 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). Nesting data for the Northern Caribbean stock is available from Puerto Rico, St. Croix (USVI), 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 percent (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). The West African nesting stock of leatherbacks is large and important, but it is a mostly unstudied aggregation. Two other small but growing stocks nest on the beaches of Brazil and South Africa.

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 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 and USFWS (2013b) suggests the leatherback nesting population is stable in most nesting regions of the Atlantic Ocean.

Critical Habitat

On March 23, 1979, leatherback critical habitat was identified adjacent to Sandy Point, St. Croix, Virgin Islands from the 183 meter (600 foot) isobath to mean high tide level between 17° 42'12" N and 65°50'00" W (44 FR 17710). This habitat is essential for nesting, which has been increasingly threatened since 1979, when tourism increased significantly, bringing nesting habitat and people into close and frequent proximity; however, studies do not support significant critical habitat deterioration. This critical habitat is not present within the action area.

On January 20, 2012, NMFS issued a final rule to designate additional critical habitat for the leatherback sea turtle (50 CFR 226). This designation includes approximately 43,798 square kilometers (16,910 square miles) stretching along the California coast from Point Arena to Point Arguello east of the 3,000 meter (9,842 feet) depth contour; and 64,760 square kilometers (25,004 square miles) stretching from Cape Flattery, Washington to Cape Blanco, Oregon east of the 2,000 meter (6,562 foot) depth contour. The designated areas comprise approximately 108,558 square kilometers of marine habitat and include waters from the ocean surface down to a maximum depth of 80 meters (262 feet). They were designated specifically because of the occurrence of prey species, primarily scyphomedusae of the order Semaeostomeae (i.e., jellyfish), of sufficient condition, distribution, diversity, abundance and density necessary to support individual as well as population growth, reproduction, and development of leatherbacks. This critical habitat is not present within the action area.

Recovery Goals

See the 1998 and 1991 Recovery Plans for the U.S. Pacific (USFWS and NMFS 1998b) and U.S Caribbean, Gulf of Mexico and Atlantic (NMFS and USFWS 1991) leatherback sea turtles for complete down listing/delisting criteria for each of their respective recovery goals. The following items were the top five recovery actions identified to support in the Leatherback 5-Year Action Plan:

1. Reduce fisheries interactions
2. Improve nesting beach protection and increase reproductive output
3. International cooperation
4. Monitoring and research
5. Public engagement

6.2.3 Status of Nassau Grouper

NMFS listed the Nassau grouper as threatened under the ESA effective July 29, 2016 (81 FR 42268, June 29, 2016). The Nassau grouper's confirmed distribution currently includes "Bermuda and Florida (USA), throughout the Bahamas and Caribbean Sea" (Hill and Sadovy de Mitcheson 2013).

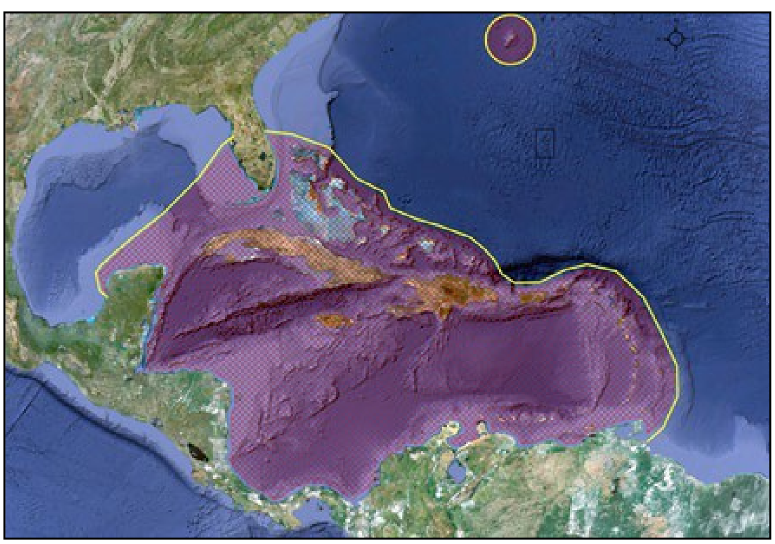

Figure 15. Range of Nassau grouper (*Epinephelus striatus*)

Life History

The Nassau grouper, *Epinephelus striatus* (NMFS 2013b), is a moderate-sized serranid fish. As with many serranids, the Nassau grouper is slow-growing and long-lived; estimates range up to a maximum of 29 years (Bush et al. 1996). Using length-frequency analysis, which tends to exclude younger animals, a theoretical maximum age at 95 percent asymptotic size is 16 years. Individuals of more than 12 years of age are not common in fisheries, with more heavily fished areas yielding much younger fish on average. Most studies indicate a rapid growth rate for juveniles, which has been estimated to be about 10 milometers (0.4 inches) per month TL for small juveniles, and 8.4-11.7 milometers (0.33 to 0.46 inches) per month TL for larger juveniles (Beets and Hixon 1994; Eggleston 1995). Maximum size is about 122 centimeters (48 inches) TL and maximum weight is about 25 kilograms (Froese 2010; Heemstra 1993; Humann and DeLoach 2002). Generation time (the interval between the birth of an individual and the subsequent birth of its first offspring) is estimated as 9-10 years (Sadovy and Eklund 1999). Male and female Nassau groupers reach sexual maturity at lengths between 40 and 45 centimeters (15.7 to 17.7 inches) standard length, about four to five years old. It is thought that sexual maturity is more determined by size, rather than age. Otolith studies indicate that the minimum age at maturity is between four and eight years; most groupers have spawned by age seven (Bush et al. 2006). Nassau groupers live to a maximum of 29 years.

Nassau groupers spawn once a year in large aggregations, in groups of a few dozen to thousands spawning at once. Nassau groupers move in groups towards the spawning aggregation sites parallel to the coast or along the shelf edge at depths between 20 and 33 (65.6 meters to 108.3 meters). Spawning runs occur in late fall through winter (i.e., a month or two before spawning is likely). Sea surface temperature is thought to be a key factor in the timing of spawning, with spawning occurring at waters temperatures between 25 and 26 ° Celsius. Spawning aggregation sites are located near significant geomorphological features, such as reef projections (as close as 50 meters [164 feet] to shore) and close to a drop-off into deep water over a wide depth range (six to 60 meters [19.7 to 197 feet]). Sites are usually several hundred meters in diameter, with soft corals, sponges, stony coral outcrops, and sandy depressions. Nassau groupers stay on the spawning site for up to three months, spawning at the full moon or between the new and full moons. Spawning occurs within twenty minutes of sunset over the course of several days. There have been about fifty known spawning sites in insular areas throughout the Caribbean; many of these aggregations no longer form. Current spawning locations are found in Mexico, Bahamas, Belize, Cayman Islands, the Dominican Republic, Cuba, Puerto Rico (i.e., Bajo de Sico which is approximately 10 miles south of the Desecheo action area), and the USVI.

Fertilized eggs are transported offshore by ocean currents. Thirty-five to forty days after hatching, larvae recruit from oceanic environment to demersal habitats (at a size of about 32 millimeters [4.8 inches] TL). Juveniles inhabit macroalgae, coral clumps, and seagrass beds, and are relatively solitary. As they grow, they occupy progressively deeper areas and offshore reefs, where they may form schools of up to forty individuals. When not spawning, adults are most commonly found in waters less than one hundred meters deep. Nassau grouper diet changes with age. Juveniles eat plankton, pteropods, amphipods, and copepods. Adults are unspecialized piscivores, bottom-dwelling ambush suction predators (NMFS 2013b).

Population Dynamics

Distribution

The occurrence of Nassau grouper from the Brazilian coast south of the equator as reported in Heemstra (1993) is "unsubstantiated" (Craig et al. 2011). The Nassau grouper has been documented in the Gulf of Mexico, at Arrecife Alacranes (north of Progreso) to the west off the Yucatan Peninsula, Mexico (Hildebrand et al. 1964). Nassau grouper is generally replaced ecologically in the eastern Gulf by red grouper (*Epinephelus morio*) in areas north of Key West or the Tortugas (Smith 1971). They are considered a rare or transient species off Texas in the northwestern Gulf of Mexico (Gunter and Knapp 1951; in Hoese and Moore 1998). The first confirmed sighting of Nassau grouper in the FGBNMS, which is located in the northwest Gulf of Mexico approximately 180 km southeast of Galveston, Texas, was reported by (Foley et al. 2007). Many earlier reports of Nassau grouper up the Atlantic coast to North Carolina have not been confirmed.

Genetic Diversity

Recent studies on Nassau grouper genetic variation has found strong genetic differentiation across the Caribbean subpopulations, likely due to barriers created by ocean currents and larval behavior (Jackson et al. 2014a).

Nassau grouper is distributed throughout the Caribbean, south to the northern coast of South America (Figure 14). Current Nassau grouper distribution is considered equivalent to its historical range, although abundance has been severely depleted.

Abundance

There is no range-wide abundance estimate available for Nassau grouper. The species is characterized as having patchy abundance due largely to differences in habitat availability or quality, and differences in fishing pressure in different locations (81 FR 42268). Although abundance has been reduced compared to historical levels, spawning still occurs and abundance is increasing in some locations, such as the Cayman Islands and Bermuda.

Population Growth Rate

There is no population growth rate available for Nassau grouper. However, the available information from observations of spawning aggregations has shown steep declines (Aguilar-

Perera 2006; Claro and Lindeman 2003; Sala et al. 2001). Some aggregation sites are comparatively robust and showing signs of increase (Vo et al. 2014; Whaylen et al. 2004).

Hearing and Vocalization

While spawning, Nassau grouper produce an assortment of low frequency sounds related to courtship displays, agonistic interactions, and distress or alarm. The fish produce a pulse train sound thought to be associated with distress or alarm. This call includes six to thirteen pulses, with an individual pulse length of 0.09 seconds, and average peak of 77 Hertz (DOSITS 2021). Nassau grouper also produce a tonal sound (average peak frequency of 99 Hertz) that lasts from 0.9 to 2.3 seconds. This sound is most often associated with courtship behaviors, and is sometimes accompanied by behavioral displays by males directed towards females. A third sound has also been recorded for Nassau grouper during an agonistic interaction of two males following a pregnant female. This sound is composed of three parts beginning with a series of grunts, followed by paired pulses that have a rhythm that resembles the sound of a human heartbeat. The first part is composed of a series of repeated grunts with mean duration of 0.008, and average peak frequency 199 Hz, followed by alternating repetitions of part 2 (duration 0.01, 128 Hz) and part 3 (duration 0.02, 160 Hz) (DOSITS 2021).

Status

Historically, tens of thousands of Nassau grouper spawned at aggregation sites throughout the Caribbean. Since grouper species were reported collectively in landings data, it is not possible to know how many Nassau grouper were harvested, or estimate historic abundance. That these large spawning aggregations occurred in predictable locations at regular times made the species susceptible to over-fishing and was a cause of its decline. At some sites (e.g., Belize), spawning aggregations have decreased by over 80 percent in the last 25 years (Sala et al. 2001), or have disappeared entirely (e.g., Mexico; Aguilar-Perera 2006). Nassau groupers are also targeted for fishing throughout the year during non-spawning months. In some locations, spawning aggregations are increasing. Many Caribbean countries have banned or restricted Nassau grouper harvest, and it is believed that the areas of higher abundance are correlated with effective regulations (81 FR 42268). Because Nassau groupers are dependent upon coral reefs at various points in their life history, loss of coral reef habitat due to climate change will affect the abundance and distribution of the species. Increasing water temperatures may change the timing and location of spawning. Habitat degradation due to water pollution also poses a threat to the species. Nassau grouper populations have been reduced from historic abundance levels, and remain vulnerable to unregulated harvest, especially the spawning aggregations. NMFS determined that the species warrants listing as threatened.

In a review of the status of the Nassau and goliath (*Epinephelus itajara*) grouper populations, (Sadovy and Eklund 1999), reported that approximately 30 percent of the 67 known Nassau grouper aggregations in the wider Caribbean had disappeared by 1998, and less than five percent had not shown signs of rapidly declining numbers of spawners. One of the main factors for this decline has been the collapse of spawning aggregations due to intense fishing pressure (Schärer et al. 2012). Fish spawning aggregations (FSAs) are defined as a group of conspecific fish gathered to reproduce in numbers much higher than their density at other times (Schärer et al. 2012). Epinephelus striatus form site-specific transient aggregations, in which reproduction lasts for a period of days or weeks during a specific portion of the year (Schärer et al. 2012). These aggregations have been reported during the week of the full moon of December, January, and February (Schärer et al. 2012). Long-distance (up to 250 km) spawning migrations have been reported for E. striatus (Schärer et al. 2012), although it is not known how individuals locate aggregation sites. Since there is no evidence that collapsed FSAs re-form at the same location (Bijoux et al. 2013), protective measures for remaining FSAs are essential to enable the recovery of Nassau grouper populations. Juvenile Nassau grouper use nearshore seagrass beds, embayments, backreefs, and other shallower habitats while adults are common in deeper reef areas.

Critical Habitat

On October 17, 2022, NMFS proposed to designate critical habitat for the threatened Nassau grouper pursuant to section 4 of the ESA (87 FR 62930). Specific occupied areas proposed for designation as critical habitat contain approximately 2,353.19 square kilometers (908.57 square miles) of aquatic habitat located in waters off the coasts of southeastern Florida, Puerto Rico, Navassa, and USVI (Figure 15).

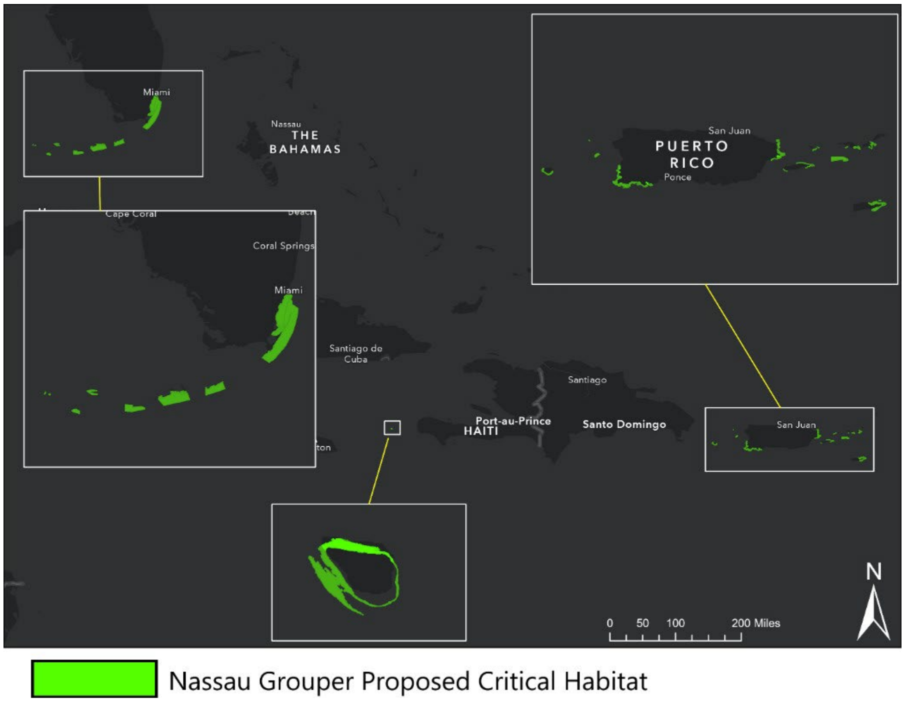

Figure 16. Map identifying proposed critical habitat for Nassau Grouper

PBFs for Nassau grouper proposed critical habitat are recruitment and developmental habitat and spawning habitat. Recruitment and developmental habitat includes areas from nearshore to offshore necessary for recruitment, development, and growth of Nassau grouper containing a variety of benthic types that provide cover from predators and habitat for prey. These habitats consist of:

- Nearshore shallow subtidal marine nursery areas with substrate that consists of unconsolidated calcareous medium to very coarse sediments (not fine sand) and shell and coral fragments and may also include cobble, boulders, whole corals and shells, or rubble mounds, to support larval settlement and provide shelter from predators during growth and habitat for prey;
- Intermediate hard bottom and seagrass areas in close proximity to the nearshore shallow subtidal marine nursery areas that provide refuge and prey resources for juvenile fish. The areas include seagrass interspersed with areas of rubble, boulders, shell fragments, or other forms of cover; inshore patch and fore reefs that provide crevices and holes; or substrates interspersed with scattered sponges, octocorals, rock and macroalgal patches, or stony corals.
- Offshore Linear and Patch Reefs in close proximity to intermediate hard bottom and seagrass areas that contain multiple benthic types, for example, coral reef, colonized hard bottom, sponge habitat, coral rubble, rocky outcrops, or ledges, to provide shelter from predation during maturation and habitat for prey.

- Structures between the subtidal nearshore area and the intermediate hard bottom and seagrass area and the offshore reef area including overhangs, crevices, depressions, blowout ledges, holes, and other types of formations of varying sizes and complexity to support juveniles and adults as movement corridors that include temporary refuge that reduces predation risk as Nassau grouper move from nearshore to offshore habitats.

Spawning habitat consists of marine sites used for spawning and adjacent waters that support movement and staging associated with spawning.

Recovery Goals

NMFS has prepared a recovery outline for Nassau grouper to provide interim guidance to direct recovery efforts, including recovery planning, for the species until a full recovery plan is developed and approved (NMFS 2018c). The recovery vision statement for the species is for Nassau grouper spawning aggregations to occur across their historical range in numbers sufficient to produce larvae to increase adult abundance. These aggregations must be of sufficient size and distribution to support successful larval recruitment across the range. In turn, the growth of juveniles to the sub adult and adult life stages must increase and be maintained over many years in order to realize an increase of reproductive adults in the spawning aggregations. Recovery will require conservation of habitats for all life stages.

6.2.4 Status of Scalloped Hammerhead (Central and Southwest Atlantic DPS)

Four scalloped hammerhead shark DPSs were listed under the ESA effective September 2, 2014 (79 FR 38213, July 3, 2014): Eastern Pacific DPS and Eastern Atlantic DPS (entirely foreign) were listed as endangered and the Central and Southwest Atlantic DPS and Indo-West Pacific DPS were listed as threatened. Only the Central and Southwest Atlantic DPS is found in the action area. The Central and Southwest DPS of scalloped hammerhead confirmed distribution is shown in Figure 16.

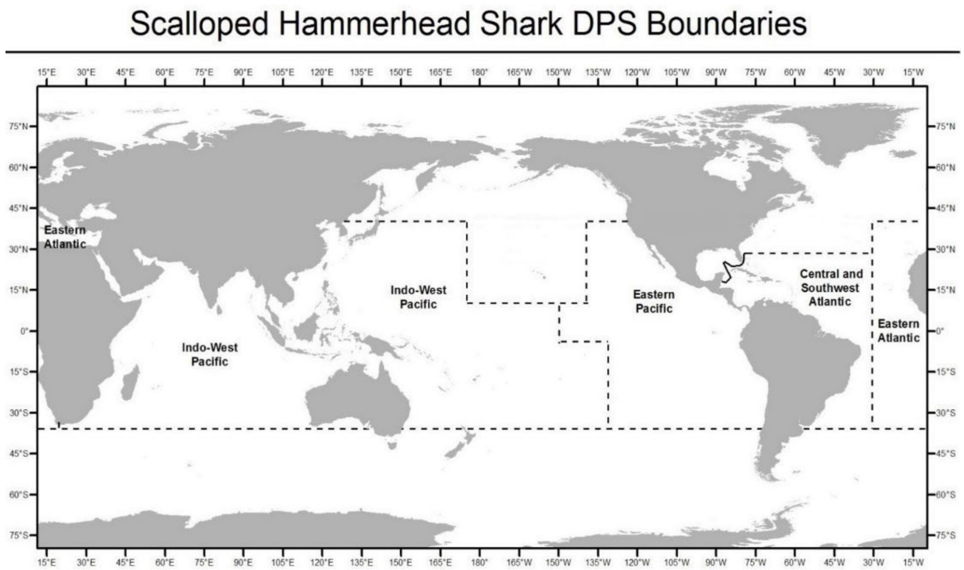

Figure 17. Map depicting DPS boundaries for scalloped hammerhead.

Hammerhead sharks are recognized by their laterally expanded head that resembles a hammer, hence the common name “hammerhead.” The scalloped hammerhead shark is distinguished from other hammerheads by a noticeable indentation on the center and front portion of the head, along with two more indentations on each side of this central indentation, giving the head a “scalloped” appearance. It has a broadly arched mouth and the back of the head is slightly swept backward.

We used information available in the 2014 recent status review (Miller et al. 2014), the final ESA-listing rule, and the scientific literature to summarize the life history, population dynamics, and status of the species, as follows.

Life History

The scalloped hammerhead shark gives birth to live young (i.e., “viviparous”), with a gestation period of nine to 12 months (Branstetter 1987; Stevens and Lyle 1989) which may be followed by a one-year resting period (Liu and Chen 1999). Females attain maturity around 2.0 to 2.5 meters (6.6 to 8.2 feet) in length, while males reach maturity at smaller sizes between 1.3 to 2.0 meters (4.2 to 6.6 feet). The age at maturity differs by region. For example, in the Gulf of Mexico, Branstetter (1987) estimated that females mature at about 15 years of age and males at around nine to 10 years of age. In northeastern Taiwan, Chen et al. (1990) calculated age at maturity to be four years for females and 3.8 years for males. On the east coast of South Africa, age at sexual maturity for females was estimated at 11 years (Dudley and Simpfendorfer 2006). Parturition, however, does not appear to vary by region and may be partially seasonal (Harry et al. 2011), with neonates present year round but with abundance peaking during the spring and summer months (Adams and Paperno 2007; Duncan and Holland 2006; Harry et al. 2011; Noriega et al. 2011). Females move inshore to birth, with litter sizes anywhere between one and 41 live pups. Off the coast of northeastern Australia, Noriega et al. (2011) found a positive correlation between litter size and female shark length, as did White et al. (2008) in Indonesian waters. However, off the northeastern coast of Brazil, Hazin et al. (2001) found no such relationship. Size at birth is estimated between 0.3 to 0.6 m.

Scalloped hammerheads are found over continental shelves and the shelves surrounding islands, as well as adjacent deep waters, but is seldom found in waters cooler than 22° Celsius (71.6 (Compagno 1984; Schulze-Haugen and Kohler 2003). They range from the intertidal and surface to depths of up to 450-512 meters (1,476.4 to 1,679.8 feet; Klimley 1993), with occasional dives to even deeper waters (Jorgensen et al. 2009). They have also been documented entering enclosed bays and estuaries (Compagno 1984). Neonates and juveniles inhabit nearshore nursery habitats for up to one year or more as these areas provide valuable refuge from predation (Duncan and Holland 2006). They are high trophic level, opportunistic predators whose diet includes crustaceans, fish and cephalopods.

Population Dynamics

Distribution

Scalloped hammerheads are moderately large coastal pelagic sharks found worldwide in coastal warm temperate and tropical seas in the Atlantic, Pacific and Indian Oceans between 46°N and 36°S (Miller et al. 2014). Scalloped hammerhead sharks are highly mobile and partly migratory and are likely the most abundant of the hammerhead species (Maguire 2006); however the risk of local depletions is of concern.

Genetic Diversity

Based on information related to genetic variation among populations, behavior and physical factors, and differences in international regulatory mechanisms, the scalloped hammerhead Extinction Risk Analysis team identified six DPSs: Northwest Atlantic and Gulf of Mexico; Central and Southwest Atlantic; Eastern Atlantic; Indo-West Pacific; Central Pacific; and Eastern Pacific (Miller et al. 2014).

Abundance and Population Growth Rate

Scalloped hammerhead sharks have a life history that is susceptible to overharvesting, and according to the most recent stock assessment the Northwestern Atlantic and Gulf of Mexico stock has declined to a relatively low level of abundance in recent years (Hayes et al. 2009). Populations in other parts of the world are assumed to have suffered similar declines, however data to conduct stock assessments on those populations are currently lacking. There are currently no reliable population size or growth rate estimates for Central and Southwest Atlantic DPS scalloped hammerheads.

Vocalization and Hearing

Scalloped hammerhead sharks are elasmobranchs and like all fish, have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Hastings and Popper 2005; Myrberg 2001; Popper and Schilt 2009). However, unlike most teleost fish, elasmobranchs do not have swimbladders, and thus are unable to detect sound pressure (Casper et al. 2012). The lack of a swimbladder also means elasmobranchs are not capable of producing many of the sounds produced by teleost fish that have swim bladders. In fact, elasmobranchs likely produce very few sounds, if any, and instead focus on listening to the sounds of their prey (Myrberg 2001).

Data for elasmobranchs fishes, including scalloped hammerheads, suggest they can detect sound between 20 Hz to one kHz with the highest sensitivity to sounds at lower ranges (Casper et al. 2012; Casper et al. 2003; Casper and Mann 2006; Casper and Mann 2009; Ladich and Fay 2013; Myrberg 1978; Myrberg 2001; Olla 1962). A study involving unidentified hammerhead sharks of the genus *Sphyrna*, indicates attraction to low frequency sound between 20 and 60 Hz (Nelson and Gruber 1963). However, a study specifically on scalloped hammerheads found no attraction to similar low frequency sound (Klimley and Nelson. 1981).

Status

Based on a combination of fisheries dependent and fisheries independent data, it is estimated that hammerhead shark populations have experienced drastic population declines, in excess of 90 percent, in several parts of their global range (Gallagher et al. 2014). While scalloped hammerhead sharks in the northwest Atlantic may currently be in a rebuilding phase, populations found further south in the Atlantic could still be in danger of decline (Miller et al. 2014). Historical landings data indicate that large numbers of hammerhead sharks were removed by longliners off the coast of Brazil in the late 20th century (Amorim et al. 1998). Although abundance estimates and quality catch data are unavailable for this DPS, the evidence of heavy fishing pressure on this species off the coast of Brazil, Central America, and the Caribbean, with documented large numbers of juvenile and neonate landings, suggests this DPS is likely approaching a level of abundance and productivity that places its current and future persistence in question (Miller et al. 2014). Overutilization by industrial/commercial fisheries combined with high at-vessel fishing mortality were ranked by the Extinction Risk Analysis team as the greatest risks to the persistence of this DPS. Overutilization by artisanal fisheries, lack of adequate regulatory mechanisms, illegal, unreported and unregulated fishing, and the schooling behavior of the species were ranked as moderate risks.

Critical Habitat

No critical habitat has been designated for the scalloped hammerhead shark.

Recovery Goals

NMFS has not prepared a recovery plan for the scalloped hammerhead shark.

6.2.5 Status of Queen Conch

NMFS proposed to list the queen conch as threatened under the ESA on September 8, 2022 (87 FR 55200). The queen conch is distributed throughout the Caribbean Sea, the Gulf of Mexico, and around Bermuda. Its range includes the following countries, territories, and areas: Anguilla, Antigua and Barbuda, Aruba, Barbados, The Bahamas, Belize, Bermuda, Bonaire, British Virgin Islands, Brazil, Cayman Islands, Colombia, Costa Rica, Cuba, Curaçao, Dominican Republic, Grenada, Guadeloupe and Martinique, Guatemala, Haiti, Honduras, Jamaica, Mexico, Montserrat, Nicaragua, Panama, Puerto Rico, Saba, St. Barthelemy, St. Martin, St. Eustatius, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Trinidad and Tobago, Turks and Caicos, USVI, the U.S. (Florida), and Venezuela (Horn et al. 2022).

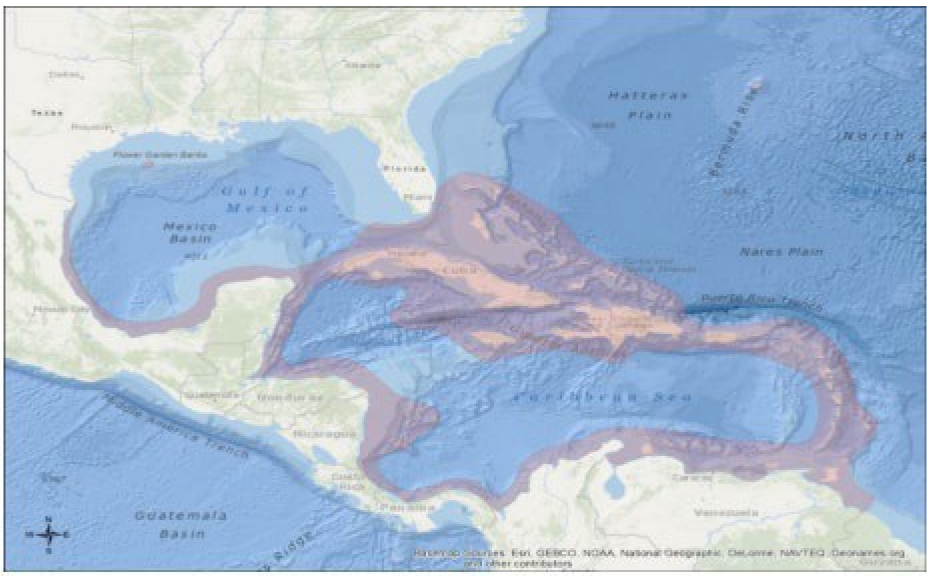

Figure 18. Map of the geographic distribution of queen conch.

Life History

After the eggs hatch, queen conch larvae (veligers) drift in the water column up to 30 days depending on phytoplankton concentration, temperature, and the proximity of settlement habitat. These veligers are found primarily in the upper few meters of the water column where they feed on phytoplankton (Stoner and Appeldoorn 2021). When the veligers are morphologically and physiologically ready, they metamorphose into benthic animals in response to trophic cues from their seagrass habitat (Stoner and Appeldoorn 2021). The key trophic cues shown to induce metamorphosis are epiphytes associated with macroalgae and sediment (Stoner and Appeldoorn 2021). Settlement locations are usually areas that have sufficient tidal circulation and high macroalgae production.

Juvenile queen conch are primarily associated with native seagrass, such as *Thalassia testudinum*, in large parts of their range in the Caribbean and the southern Gulf of Mexico (Boman et al. 2019). However, juvenile queen conch can occur in a variety of habitat types. Randall (1964) reported that juvenile conch in the USVI were most abundant in shallow coral-rubble environments, with lower densities on bare sand and in seagrass beds. A similar association was reported from Puerto Rico, with high numbers in coral rubble compared with sand, seagrass, and hard bottom (NMFS 2014a). In Florida, juveniles are found in a variety of habitats, including reef rubble, algae-covered hard bottom, and secondarily in mixed beds of algae and seagrass, depending upon general location (Glazer and Berg Jr. 1994). In Cuba, the Turks and Caicos Islands, Venezuela, and The Bahamas, juvenile conch are associated primarily with native seagrass (NMFS 2014a). In St. Croix, USVI, densities of juvenile and adult queen conch were the highest in habitats characterized as 50-90 percent and 10-50 percent patchy seagrass, respectively (NMFS 2014a).

After the veligers settle on the bottom, they bury into the sediment. This submerged life phase makes it difficult to survey and therefore they are often under-sampled. They emerge about a year later as juveniles at around 60 millimeter (2.4 inch) shell length (NMFS 2014a).

Most conch nursery areas occur primarily in back reef areas (i.e., shallow sheltered areas, lagoons, behind emergent reefs or cays) of medium seagrass density, depths between two to four meters (3.3 to 13.1 feet), with strong tidal currents, and frequent tidal water exchanges (Horn et al. 2022). Seagrass is thought to provide both nutrition and protection from predators (Horn et al. 2022). The structure of the seagrass beds decreases the risk of predation, which is very high for juveniles (Horn et al. 2022). Posada et al. (1997) observed that the most productive nurseries for queen conch tended to occur in shallow seagrass meadows (less than five to six meters [16.4 to 19.7 feet] deep).

Adult conch can be found in a wide range of environmental conditions (Stoner et al. 1994) such as in sand and algal or coral rubble (Acosta 2001; Stoner and Davis 2010). Adult queen conch are rarely, if ever, found on soft bottoms composed of silt and/or mud, or in areas with high coral cover (Horn et al. 2022). Adult conch are found in shallow, clear water of oceanic or near-oceanic salinities at depths generally less than 75 meters (246 feet), and are most often found in waters less than 30 meters (98.4 feet; McCarthy 2007). It is believed that depth limitation is based mostly on light attenuation limiting their photosynthetic food source (McCarthy 2007; Randall 1964).

Population Dynamics

Distribution

Queen conch inhabit a range of habitat types during their life cycle. As conch develop they use different habitat types including seagrass beds, sand flats, algal beds, and rubble areas from a few centimeters deep to approximately 30 meters (98.4 feet; NMFS 2014a).

Genetic Diversity

Early genetic studies of queen conch using electrophoretic methods found a high degree of gene flow among populations dispersed over the species' geographic distribution, with definitive separation observed only between populations in Bermuda and those in the Caribbean basin (Mitton et al. 1989). Although Mitton et al. (1989) found limited evidence of population structure in the Caribbean, the authors hypothesized that the complex ocean currents of the Caribbean may restrict gene flow among Caribbean populations, even though larvae may disperse long distances throughout the Caribbean during their 16-28 day pelagic larval duration. Truelove et al. (2017) used microsatellite markers and a comprehensive sampling strategy to perform a detailed study of queen conch spatial genetic structure across the greater Caribbean seascape. Microsatellite genetics identified significant levels of genetic differentiation among Caribbean sub regions (e.g., Florida Keys, Mesoamerican Barrier Reef, Lesser Antilles, Honduran/Jamaican Banks, Greater Antilles, and Bahamas) and between the eastern and western Caribbean regions (Truelove et al. 2017). The connectivity model from Vaz et al. (2022) indicates there are several important jurisdictions that act as steppingstones in facilitating population connectivity in the Caribbean region. For example, loss of Puerto Rico mesophotic populations would likely result in the loss of the genetic connectivity between the southeastern and western Caribbean. Furthermore, the connectivity model and literature suggest that the Nicaraguan rise, which includes the territorial seas of Honduras, Nicaragua, Colombia, and Jamaica, is likely to be an important region for maintaining population connectivity over larger spatial scales. These findings are similar to those observed in Truelove et al. (2017). Many of these jurisdictions are currently overexploiting their conch populations. If this trend continues, those populations will likely continue to decrease to the point of impaired reproduction in the foreseeable future, further disrupting the flow of larvae throughout the region and decreasing genetic diversity.

Abundance

Total population abundance estimate for queen conch ranges from 451 million to 1.49 billion individuals, based on the 10th and 90th percentile abundance estimates across jurisdictions (Horn et al. 2022). Those estimates, however, required numerous assumptions, in particular the assumed extent of conch habitat. In addition, for many areas, available survey data were limited, were outdated (may have been collected decades ago), or were unavailable. In many cases, survey methods and data collected (e.g., was abundance of adults or of all conch reported) were poorly described (Horn et al. 2022).

Population Growth Rate

Many queen conch populations are presently below the densities required to support reproductive activity due to low encounter rates or mate finding. Based on the available data, it is likely that recruitment failure is occurring throughout a large portion of the species' range. Continued declines in abundance and evidence of overfishing suggest that population growth rates are below replacement. There are only a handful of jurisdictions [i.e., St. Lucia, Saba, Jamaica (Pedro Bank), Nicaragua, Turks and Caicos, Costa Rica, Cuba, Colombia (Serrana Bank), and The Bahamas (Cay Sal Bank and Jumentos and Ragged Cays)] that have adult conch densities (>100 adult conch per hectare) sufficient to sustain successful reproductive activity. The majority of jurisdictions have adult densities below the critical threshold of 50 adult conch per hectare required for any reproductive activity (i.e., Anguilla, Antigua and Barbuda, Aruba, The Bahamas' Western/Central Great Bahama's Bank, Little Bahama's Bank, Barbados, Belize, Bermuda, Bonaire, British Virgin Islands, Colombia's mainland, Quitasueño and Serranilla Bank, Curaçao, Dominica, Dominican Republic, Grenada, Guadeloupe, Haiti, Martinique, Mexico, Montserrat, Panama, St. Maarten, St. Vincent and the Grenadines, St. Barthelemy, Trinidad and Tobago, Florida, Puerto Rico, USVI, and Venezuela). Several additional jurisdictions have densities that are below the 100 adult conch per hectare minimum threshold for successful reproductive activity (i.e., Cayman Islands, Honduras, St. Eustatius, Saint Kitts and Nevis, and Puerto Rico's mesophotic reef). In other words, the population growth rates in the majority of jurisdictions are likely below replacement levels given their lower densities and thus are at increased risk for negative impacts due to depensatory processes. There is also evidence of growth overfishing of queen conch, such as in Belize, which has led to the development of smaller adult conch. Since smaller conch are thought to be less productive (i.e., lower mating frequencies, smaller gonads, fewer eggs), the decrease in the sizes of adult queen conch will likely lead to decreases in abundance and lower densities, further contributing to declines in populations in the foreseeable future (Horn et al. 2022).

Status

Queen conch has been fished in the western tropical Atlantic since prehistoric times, but in the last four decades, fishing has increased and industrial scale fishing has developed (NMFS 2014a). In most range states, conch fishing continues although population densities are quite low; with conch populations, either experiencing reduced reproductive activity or densities are insufficient to support consistent reproductive activity. The Status Review Team for queen conch identified the threats of commercial and artisanal fishing, illegal and/or unreported fishing, existing regulations, enforcement, and climate change as threats that are significantly contributing to the species' extinction risk. The combination of continued exploitation, depleted reproductive potentials, and unquantified fishing pressures is cause for concern for the status of queen conch.

Critical Habitat

No critical habitat has been proposed for queen conch at this time.

Recovery Goals

NMFS has not prepared a recovery plan for queen conch because it is currently proposed for listing.

6.2.6 Status of ESA-Listed Atlantic/Caribbean Corals

6.2.6.1 General Threats Faced by ESA-Listed Corals

Corals face numerous natural and man-made threats that shape their status and affect their ability to recover. Because many of the threats are 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, which are discussed further in Section 7.2.

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 (Knowlton 2001). 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 (Knowlton 2001).

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 (Dao et al. 2021). Further, the frequency of warm-season temperature extremes (warming events) in reef-building coral habitat has increased during the past two 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 carbon dioxide (CO_2) in the atmosphere that results in greater releases of CO_2 that is then absorbed by seawater, causing lower pH and reduced availability of calcium carbonate. 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 affects 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 (Bove et al. 2022).

Because of the increase in CO_2 and other greenhouse gasses 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 (Bove et al. 2022). 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 (Cróquer et al. 2021).

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 (Grottoli et al. 2021). 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 (Grottoli et al. 2021).

Since 2014, SCTLD has emerged to affect at least 24 Caribbean coral species, including lobed star, mountainous star, boulder star, pillar, and rough cactus corals. Elkhorn and staghorn coral are not affected by SCTLD (Moulding and Ladd 2022). SCTLD was first reported in Miami, Florida in 2014 and then increased throughout the Florida reef tract over the next several years.

Since then, SCTLD has proliferated throughout much of the Caribbean and has been reported along the Mesoamerican Reef, Bahamas, Greater Antilles, and as far south as St. Lucia in the Lesser Antilles (Moulding and Ladd 2022). In Puerto Rico, the first report of SCTLD occurred off the west coast of Culebra in November 2019. As of September 2021, the disease continues to spread westward from reef to reef in the north and south of mainland Puerto Rico. The disease has been documented in shallow sites, as well as in mesophotic sites (PRDNER 2021a). A map of outbreaks and confirmed sightings of SCTLD are provided on the following webpage: https://www.agrra.org/coral-disease-outbreak/.

SCTLD is unprecedented in its temporal and geographic scope, as well as the number of susceptible species, prevalence, and rates of mortality. The disease appears to be both water-born and transmissible through direct contact (Moulding and Ladd 2022). Unlike other coral diseases, SCTLD does not appear to be seasonal or subside with cooling water temperature. In almost all affected species, tissue loss occurs rapidly and leads to full colony mortality, which has caused the mortality of millions of coral colonies across several species. For example, at study sites in southeast Florida, prevalence of the disease was recorded in 67 percent of all coral colonies and 81 percent of colonies of those species susceptible to the disease (Precht et al. 2016). In a survey of 134 sites conducted between October 2017 and April 2018, approximately four percent of mountainous star and lobed star corals, nine percent of rough cactus corals, and six percent of boulder star corals were affected (Neely 2018). Also, coral cover has declined significantly at sites where SCTLD is already established in Puerto Rico; for example, up to an estimated 50 percent mortality has been observed in sites affected by SCTLD since 2019 (PRDNER 2021a).

Predation

Elkhorn and staghorn coral are highly susceptible to predation. Predation continues to be a chronic stressor that can lower colony growth and survival rates through removal of tissue. In a study of survival of staghorn colonies outplanted in the Dominican Republic for restoration, the most common cause of mortality both in the coral nursery and in outplanted colonies was predation by the fireworm, *Hermodice carunculata* (Calle-Triviño et al. 2020). In a study in Florida, predation from damselfish on staghorn coral was more prevalent (22 percent of colonies) than prevalence of other stressors such as competitive overgrowth, other predators, or disease (Schopmeyer and Lirman 2015). Predation from damselfish produced more tissue mortality (35 percent more) than the other stressors, and coral growth rates of colonies with damselfish lawns were almost half as much as those without. However, the occurrence of damselfish decreased predation by other corallivores such as *Coralliophila* snails and *Hermodice* fireworms (Schopmeyer and Lirman 2015).

Research was published on the impacts of predation on elkhorn coral. Monthly surveys were conducted for a year following a series of large swells in March 2008 that caused colony fragmentation of 30-93 percent of elkhorn colonies at three sites in St. Thomas and St. John, US

Virgin Islands. *C. abbreviata*, a corallivorous snail, was 46 percent more prevalent on damaged than undamaged colonies (Bright et al. 2016). In a long term study in the Florida Keys, predation by corallivorous snails contributed to one quarter of the tissue lost on elkhorn coral in monitoring plots over seven years. Removal of all *C. abbreviata* on elkhorn colonies and on all coral species within monitoring plots both reduced prevalence of feeding scars and snail abundance (Williams et al. 2014).

Pillar coral is also susceptible to predation from the corallivorous snail, *C. abbreviata*, and from damselfish gardens and nests. However, these are chronic stressors that generally have low prevalence (approximately one percent of colonies) and result in low amounts (on average less than or equal to one percent) of tissue loss (Neely et al. 2021).

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 (Ainsworth and Mumby 2015). 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 (Brown et al. 2018).

In the Caribbean, parrotfishes can graze at rates of more than 150,000 bites per square meter (10.8 square feet) per day (Carpenter 1986), and thereby remove up to 90-100 percent 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 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 (Junjie et al. 2014). Some coral species can tolerate complete burial for several days. Corals that cannot remove sediment will be smothered and die. Sediment can also cause sub-lethal effects such as reductions in tissue thickness, polyp swelling, zooxanthellae loss, and excess mucus production (Junjie et al. 2014). 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.

A new study examined the effects of algal turf and algal turf plus sediment on elkhorn and mountainous star coral settlement (Speare et al. 2019). It found the presence of turf algae alone did not reduce settlement, but the presence of naturally accumulating sediment reduces settlement 10-fold for elkhorn coral and 13-fold for mountainous star coral compared to turf algae alone. This result was corroborated by field surveys in the Florida Keys that showed a strong negative relationship between the abundance of turf algae plus sediment and the abundance of juvenile corals (Speare et al. 2019).

Nutrient Enrichment

Elevated nutrient concentrations in seawater affect corals through two 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.

6.2.6.2 Elkhorn Coral (Acropora palmata) and Staghorn Coral (Acropora cervicornis)

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 50 centimeters (20 inches) wide and range in thickness from about four to five centimeters (1.5-2 inches). Individual colonies can grow to at least two meters (6.5 feet) in height and four meters (13 feet) 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.

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

Elkhorn coral and staghorn coral occur throughout coastal areas in the Caribbean, Gulf of Mexico, and southwestern Atlantic (Figure 18). Elkhorn and staghorn corals are the only large, branching species of coral to produce and occupy vast complex environments within the Caribbean Sea's reef system.

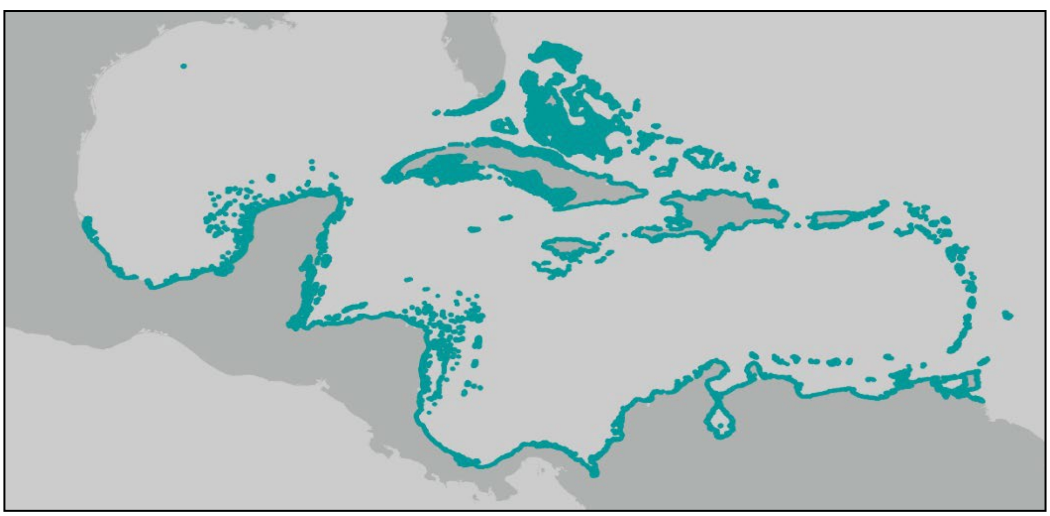

Figure 19. Map showing range of elkhorn and staghorn corals

Life History

<u>Elkhorn</u>

Elkhorn coral 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 two-month period) has been reported from the Florida Keys Fogarty et al. (2012). The estimated size at sexual maturity is approximately 1,600 square centimeters (250 square inches), 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. 2005; 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 nine months are high based on settlement experiments (Szmant and Miller 2005).

Reproduction occurs primarily through asexual reproduction, generating multiple genetically identical colonies. Elkhorn coral can quickly monopolize large spaces of shallow ocean floor through fragment dissemination. A branch of elkhorn coral can be carried by waves and currents away from the mother colony to distances that range from 0.1-100 meters (0.32-328 feet), but fragments usually travel less than 30 meters (98.4 feet; NMFS 2005).

Because large colonies of elkhorn coral contain several thousand partially autonomous polyps, growth rates for the species are conveyed through the measurement of linear extensions of the organisms' skeletal branches. Depending on the size and location of the colony, physical growth rates for elkhorn corals range from approximately four to 11 centimeters (1.6-4.3 inches) per year. Branches are up to approximately 50 centimeters (20 inches) wide and range in thickness of about four to five centimeters (1.6-two inches). Individual colonies can grow to at least two meters (6.6 feet) in height and four meters (13 feet) in diameter (NMFS 2005). Total lifespan for the species is unknown (NMFS 2014b).

Staghorn

Staghorn coral is a hermaphroditic broadcast spawning species. 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 (Szmant 1986; Vargas-Angel et al. 2006). The estimated size at sexual maturity is approximately six inches (17 centimeters; 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 that facilitate larval settlement and post-settlement survival (Ritson-Williams et al.).

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.

Population Dynamics

Information on elkhorn and staghorn coral population dynamics is limited throughout its range. Comprehensive and systematic census and monitoring has not been conducted. Thus, population dynamics must be inferred from the few locations from which data exist.

<u>Elkhorn</u>

Distribution

Elkhorn coral occurs in turbulent water on the back reef, fore reef, reef crest, and spur and groove zone in water ranging from one to thirty meters (3.3 to 98.4 feet) in depth. Historically, elkhorn coral inhabited most waters of the Caribbean between one to five meters (3.3 to 16.4 feet) depth. This included a diverse set of areas comprising of zones along Puerto Rico, Hispaniola, the Yucatan peninsula, the Bahamas, the southwestern Gulf of Mexico, the Florida Keys, the Southeastern Caribbean islands, and the northern coast of South America as seen in Figure 18 (Dustan and Halas 1987; Goreau 1959; Jaap 1984; Kornicker and Boyd 1962; Scatterday 1974; Storr 1964). While the present-day spatial distribution of elkhorn coral is similar to its historic spatial distribution, its presence within its range has become increasingly sparse due to declines in the latter half of the 20th century from a variety of abiotic and biotic threats.

Genetic Diversity

There appear to be two distinct populations of elkhorn coral, a western Caribbean population and an eastern (Baums et al. 2005) based on genetic analyses. Genetic samples from 11 locations throughout the Caribbean indicate that elkhorn coral populations in the eastern Caribbean (St. Vincent and the Grenadines, USVI, 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. 2005). 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. 2005). Models suggest that the Mona Passage between the Dominican Republic and Puerto Rico promotes dispersion of larval and gene flow between the eastern Caribbean and western Caribbean (Baums et al. 2006a).

The western Caribbean is characterized by genetically poor populations with lower densities (0.13 ± 0.08 colonies per square meter [10.8 square feet]). The eastern Caribbean populations are characterized by denser (0.30 ± 0.21 colonies per square meter [10.8 square feet]), genotypically richer stands (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 for elkhorn coral. From the survey data, it can be inferred that genetic variability is more common in colonies within eastern populations as opposed to western. At two sites in the Florida Keys, only one genotype per site was detected out of 20 colonies sampled at each site (Baums et al. 2005). In contrast, sites within the eastern Caribbean displayed high variability. 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 percent 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. The study suggests that there is a restriction of gene flow between some reefs in close proximity in the La Parguera reefs resulting in greater population structure (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 percent of the samples with high genetic diversity (Mège et al. 2014). The recent results support two 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. (2006b).

Abundance

Based on population estimates from both the Florida Keys and St. Croix, USVI, there are at least hundreds of thousands of elkhorn coral colonies. Absolute abundance is higher than estimates from these two 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 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.

There is some density data available for elkhorn corals in Florida, Puerto Rico, the USVI, and Cuba. In Florida, elkhorn coral was detected at zero to 78 percent of the sites surveyed between

1999 and 2017. Average density ranged from 0.001 to 0.12 colonies per square meter (10.8 square feet; NOAA, unpublished data). Elkhorn coral was encountered less frequently during benthic surveys in the USVI from 2002 to 2017. It was observed at zero to seven percent of surveyed reefs, and average density ranged from 0.001 to 0.01 colonies per square meter (10.8 square feet; NOAA, unpublished data). Maximum elkhorn coral density at ten sites in St. John, USVI was 0.18 colonies per square meter (10.8 square feet; Muller et al. 2014). In Puerto Rico, average density ranged from 0.002 to 0.09 colonies per square meter (10.8 square feet; Muller et al. 2014) in surveys conducted between 2008 and 2018, and elkhorn coal was observed on one to 27 percent of surveyed sites (NOAA, unpublished data). Density estimates from sites in Cuba range from 0.14 colonies per square meter (10.8 square feet; Alcolado et al. 2010) to 0.18 colonies per square meter (10.8 square feet; González-Díaz et al. 2010).

Population Growth Rate

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. The research team claims that the postulated geographic differences in the contribution of reproductive modes to population structure may be related to habitat characteristics, possibly the amount of shelf area available.

Hurricanes Irma and Maria caused substantial damage in Florida, Puerto Rico, and the USVI in 2017. Hurricane impacts included large, overturned, and dislodged coral heads and extensive burial and breakage. At 153 survey locations in Puerto Rico, approximately 45 to 77 percent of elkhorn corals were impacted (NOAA 2018a). Survey data for impacts to elkhorn corals are not available for the USVI or Florida, although qualitative observations indicate that damage was widespread but variable by site.

Staghorn

Distribution

Staghorn coral is distributed throughout the Caribbean Sea, in the southwestern Gulf of Mexico, and in the western Atlantic Ocean. Fossil records indicate 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 five to 20 meters (16 to 65.6 feet) in depth, though it occurs in depths of 16-30 meters (52-98 feet) at the northern extent of its range, and has been rarely found to 60 meters (196.8 feet) in depth.

Precht and Aronson (2004) suggest that coincident with climate warming, staghorn coral 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 and

Aronson 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. 2014a).

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 (Cairns 1982; Davis 1982; Gilmore and Hall 1976; Goldberg 1973; Jaap 1984; Miller et al. 2008; Wheaton and Jaap 1988). Historically it grew in thickets in water ranging from approximately 5-20 meters (16-65.6 feet) in depth; though it has rarely been found to approximately 60 meters (196.8 feet; Davis 1982; Jaap et al. 1989; Jaap 1984; Schuhmacher and Zibrowius 1985; Wheaton and Jaap 1988). At the northern extent of its range, it grows in deeper water, 16-30 meters (52-98 feet; Goldberg 1973). Historically, staghorn coral was one of the primary constructors of mid-depth 10-15 meters (32.8-49 feet) 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 (i.e., 5 - 22 meters [16 to 72 feet]; 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).

Genetic Diversity

Vollmer and Palumbi (2007) examined 22 populations of staghorn coral from nine regions in the Caribbean (Panama, Belize, Mexico, Florida, Bahamas, Turks and Caicos, Jamaica, Puerto Rico, and Curaçao) and concluded that populations greater than approximately 500 kilometers (310.7 miles) 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 two kilometers (1.2 miles), suggesting that gene flow in staghorn coral may not occur at much smaller spatial scales (Garcia Reyes and Schizas 2010; Vollmer and Palumbi 2007). 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 *Acropora 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 USVI, Puerto Rico, Bahamas, and Navassa (Baums et al. 2010), indicating little to no larval connectivity overall. However, some potential connectivity between the USVI and Puerto Rico was detected and also between Navassa and the Bahamas (Baums et al. 2010).

Abundance

Miller et al. (2013) 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 30 centimeters (12 inches) diameter. Further, partial mortality was reported as highest in 2005 with up to 80 percent mortality observed and lowest in 2007 with a maximum of 30 percent. In 2012, partial mortality ranged from 20-50 percent 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 60 centimeters (23.6 inches) and density ranged from one to ten colonies per 15 square meters (161 square feet; García-Sais et al. 2013).

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 two 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 periods. 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.

Population Growth Rate

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. 2011). 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. 2011). In locations where quantitative data are available (Florida, Jamaica, USVI, Belize), there was a reduction of approximately 92 to greater than 97 percent 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 (staghorn and elkhorn) decreasing up to an additional 50 percent or more (Colella et al. 2012; Lundgren and Hillis-Starr 2008; Muller et al. 2008; Rogers and Muller 2012; Williams et al. 2008). There are some small pockets of remnant robust populations such as in southeast Florida (Vargas-Angel et al. 2003), Honduras (Keck et al. 2005; Riegl et al. 2009), and Dominican Republic (Lirman et al. 2010b). Additionally, Lidz and Zawada (2013) observed 400 colonies of staghorn coral along 70.2 km (44 mi) 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 percent in 1995 to 10.5 percent 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 percent in 1996 to 0.14 percent in 1999 after the Caribbean bleaching event in 1998 and mortality from runoff associated with a Category 5 hurricane. Staghorn coral cover further declined to 0.09 percent in 2005. Staghorn coral colony frequency decreased 71 percent between 1997 and 1999. In sharp contrast, offshore bank reefs near Roatan had dense thickets of staghorn coral with 31 percent 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).

While cover of staghorn coral increased from 0.6 percent in 1995 to 10.5 percent in 2004 (Idjadi et al. 2006) and 44 percent in 2005 on a Jamaican reef, it collapsed after the 2005 bleaching event and subsequent disease to less than 0.5 percent 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 percent; Schopmeyer et al. 2012). Walker et al. (2012) report increasing size of two thickets (expansion of up to 7.5 times the original size of one of the thickets) monitored off southeast Florida, but also noted that cover within monitored plots concurrently decreased by about 50 percent 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 percent of reefs), remained relatively stable at 30 percent through the 1990s, and decreased to approximately 20 percent of the reefs in 2000-2004 and approximately 10 percent in 2005-2011 (Jackson et al. 2014a).

Hurricanes Irma and Maria caused substantial damage in Florida, Puerto Rico, and the USVI in 2017. At 153 survey locations in Puerto Rico, approximately 38 to 54 percent of staghorn coral colonies were impacted (NOAA 2018a). In a post-hurricane survey of 57 sites in Florida, all of the staghorn coral colonies encountered were damaged (Florida Fish and Wildlife Conservation Commission, unpublished data). Survey data are not available for the USVI, though qualitative observations indicate that damage was also widespread but variable by site.

Status

<u>Elkhorn</u>

The decline in the total abundance of elkhorn coral has been attributed to a series of stressors consisting of disease, temperature-induced bleaching, excessive sedimentation, nitrification, pollution (i.e. oxybenzone from sunscreen), and large hurricanes/tropical storms (Brainard et al. 2011; Downs et al. 2016; Hernandez-Delgado et al. 2011; Mayor et al. 2006; Rogers and Muller 2012). It is believed that these effects act synergistically with one another, thereby increasing the overall damage to already-stressed elkhorn coral colonies that have undergone disturbance by another threat. The current population trend appears to be steady, although there are places where populations continue to decrease and others where there appears to be modest or contained recovery (Miller et al. 2013). However, even if growth and recruitment end up surpassing mortality, this species requires prompt analysis and monitoring on a regional scale. Reasoning for this includes the current presence of areas with low genetic diversity and density within western Caribbean populations along with localized high rates of disease and bleaching (Miller et al. 2013).

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.

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 hurricanes 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 one percent 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 percent 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 five to 10 percent of hundreds of reef sites surveyed throughout the Caribbean during the four periods of 1990-1994, 1995-1999, 2000-2004, and 2005-2011 (Jackson et al. 2014b).

Overall, frequency of occurrence decreased from the 1980s to 2000, stabilizing in the first decade of 2000. There are locations such as the USVI where populations of elkhorn coral appear stable or possibly increasing in abundance and some such as the Florida Keys where population numbers are 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. Events like hurricanes continue to heavily impact local populations and affect projections of persistence at local scales. We conclude there has been a significant decline of elkhorn coral throughout its range as evidenced by the decreased frequency of occurrence and that population abundance is likely to decrease in the future with increasing threats.

Staghorn

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 over the foreseeable future because staghorn coral is limited to areas with high, localized human impacts and predicted increasing threats. Staghorn coral commonly occurs in water ranging from five to twenty meters (16.4 to 65.6 feet) in depth, though it occurs in depths of 16-30 meters (52-98 feet) at the northern extent of its range and has been rarely found to 60 meters (196.8 feet) 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 over the foreseeable future 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 two 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.

Critical Habitat

Critical habitat for elkhorn and staghorn corals was designated in 2008. The PBF essential to the conservation of Atlantic *Acropora* species is substrate of suitable quality and availability in water depths from the mean high water line to 30 meters (98 feet) 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 four locations within the jurisdiction of the U.S. (Figure 19): the Florida area, which comprises approximately 3,442 square kilometers (1,329 square miles) of marine habitat; the Puerto Rico area, which comprises approximately 3,582 square kilometers (1,383 square miles) of marine habitat; the St. John/St. Thomas area, which comprises approximately 313 square kilometers (121 square miles) of marine habitat; and the St. Croix area, which comprises approximately 326 square kilometers (126 square miles) of marine habitat. The total area covered by the designation is thus approximately 7,664 square kilometers (2,959 square miles).

As defined in the final rule, critical habitat does not include areas subject to the 2008 Naval Air Station Key West Integrated Natural Resources Management Plan; all areas containing existing (already constructed) federally authorized or permitted man-made structures such as ATONS, artificial reefs, boat ramps, docks, pilings, maintained channels, or marinas; or twelve federal maintained harbors and channels.

The PBF 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 PBF. The proximity of this habitat to coastal areas subjects this feature to impacts from multiple activities including dredging and disposal activities, stormwater runoff, 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, increased algal dominance since the 1980s has impeded coral recruitment. The overexploitation of grazers through fishing has also contributed to fleshy macroalgae persistence 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 (Birrell et al. 2005; Connell et al. 1997; Edmunds et al. 2004; Hughes 1985; Rogers et al. 1984; 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 three 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 two 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.

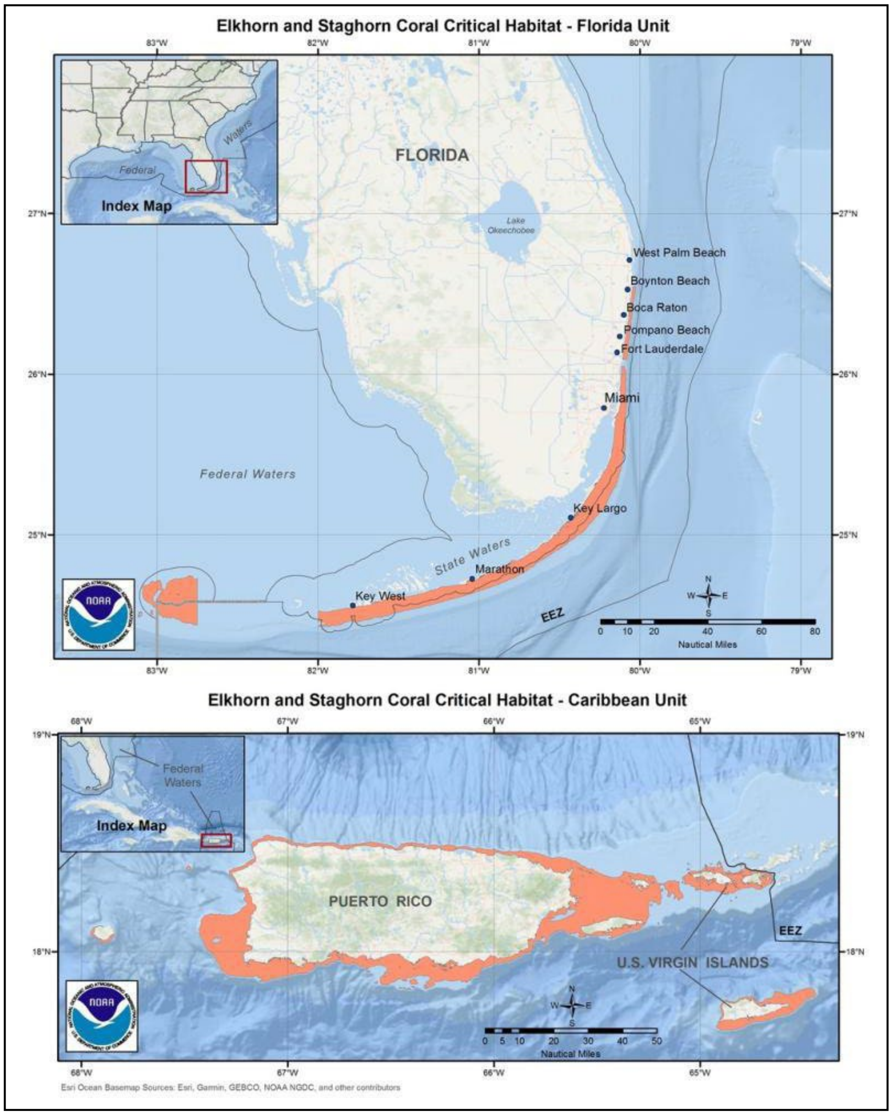

Figure 20. Florida, Puerto Rico, and Two USVI Critical Habitat Units for Elkhorn and Staghorn Corals

Elkhorn and staghorn corals require hard, consolidated substrate, including attached, dead coral skeleton, devoid of turf or fleshy macroalgae for their larvae to settle. The 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).

Long-term monitoring of marine habitats in natural reserves around Puerto Rico, begun in 1999 and now at full capacity indicates statistically significant declines in live coral cover (Garcia-Sais et al. 2008). The most pronounced declines in coral cover were observed between the 2005 and 2006 surveys, corresponding to the dramatic bleaching event that occurred because of high sea surface temperatures in 2005. Declines of up to 59 percent were measured in surveyed reefs and a proportional increase in turf algae was observed (Garcia-Sais et al. 2008). Together with bleaching-associated mortality, coral disease led to the recorded loss of 50 to 80 percent live coral cover from reefs in La Parguera, Culebra, Mona, and Desecheo, Puerto Rico, and other important reefs in the northeast and southern Caribbean between 2005 and 2011 (Bastidas et al. 2012; Bruckner and Hill 2009; Croquer and Weil 2009; Hernández-Pacheco et al. 2011; Weil et al. 2009). Thus, changes that have affected elkhorn and staghorn corals and led to significant decreases in their numbers and cover have also affected the suitability and availability of habitat for these species.

Recovery Goals

The 2015 Elkhorn Coral (*Acropora palmata*) and Staghorn Coral (*A. cervicornis*) Recovery Plan (NMFS 2015c) contains complete downlisting/delisting criteria for each of the two following recovery goals:

- Ensure population viability
    - Specific criteria include: 1) Preserving Abundance; 2) Maintaining Genotypic Diversity; and 3) Properly Observing and Recording Recruitment Rates
- Eliminate or sufficiently abate global, regional, and local threats
    - Specific criteria include: 1) Developing quantitative recovery criterion through research to identify, treat, and reduce outbreaks of coral disease; 2) Controlling the Local and Global Impacts of Rising Ocean Temperature and Acidification; 3) Reducing the Loss of Recruitment Habitat (if criterion 1, preserving abundance, is met then this objective is complete; 4) Reducing sources of nutrients, sediments, and contaminants; 5) Developing and adopting appropriate and effective regulatory mechanisms to abate threats; 6) Reducing impacts of natural and anthropogenic abrasion and breakage; and 7) Reducing impacts of predation.

6.2.6.3 Pillar Coral (Dendrogyra cylindrus)

On September 10, 2014, NMFS listed pillar star coral as threatened (79 FR 53851). Pillar coral is present in the western Atlantic Ocean and throughout the greater Caribbean Sea, though absent from the southwest Gulf of Mexico (Figure 20). Pillar corals form tubular columns on top of encrusted foundations. Colonies are generally grey-brown in color and may reach approximately three meters (9.8 feet) in height. Polyp tentacles remain extended during the day, giving columns a furry appearance.

Figure 21. Range map for pillar coral (from Aronson et al. 2008a)

Life History

Reported average growth rates for pillar coral have been documented to be approximately 1.8-2.0 centimeters (0.7 to 0.79 inches) per year in linear extension within the Florida Keys, compared to 0.8 centimeters (0.3 inches) 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 percent of 185 colonies surveyed in Colombia), while the amount of partial mortality per colony is generally low (average of three percent of tissue area affected per colony).

Pillar coral is a gonochoric broadcast spawning species with relatively low annual egg production for its size. The combination of gonochoric spawning with persistently low population densities is expected to yield low rates of successful fertilization and low larval supply. Sexual recruitment of this species is low, and reports indicate juvenile colonies are lacking in the Caribbean. Spawning has been observed to occur several nights after the full moon of August in the Florida Keys (Neely et al. 2013; Waddell and Clarke 2008) 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.

Population Dynamics

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

Brainard et al. (2011) 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 (FFWCC 2013). Pillar coral inhabits most reef environments in water depths ranging from approximately one to 25 meters (3.2 to 82 feet), but it is most common in water between approximately five to 15 meters deep (16.4 to 49.2 feet; Acosta and Acevedo 2006; Cairns 1982; Goreau and Wells 1967).

Benthic cover is generally less than one percent in monitoring studies. Mean density of pillar coral was approximately 0.5 colonies per ten square meters (5.4 square feet) in the Florida Keys between 2005 and 2007. In a study of pillar coral demographics at Providencia Island, Colombia, 283 pillar coral colonies were detected in a survey of 1.66 square kilometers for an overall density of approximately 450 colonies per square mile.

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. 2013). Pillar coral was seen only on the ridge complex and mid-channel reefs at densities of approximately one and 0.1 colonies per 10 square meters (107.6 square feet), 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 two percent of sites surveyed and ranged in density from 0 to 0.4 colonies per square meter with an average density of 0.004 colonies per 10 square meter (107.6 square feet; NOAA NCRMP). In 2014, there were 714 known colonies of pillar coral along the Florida reef tract from southeast Florida to the Dry Tortugas. However, a rapid decline in the population has occurred due to SCTLD. Pillar coral is particularly susceptible to SCTLD, which was first reported in Florida in 2014 and then in the U.S. Caribbean in 2019. The first known SCTLD observation on Florida pillar coral occurred in February 2016 in Biscayne National Park. Infections occurred throughout the Upper Keys population in 2016. By 2017, many of these colonies had suffered tissue loss, and over half (57 percent) suffered complete mortality due to disease, most likely associated with multiple years of warmer than normal temperatures (Lewis et al. 2017). In the Middle Keys, SCTLD was first observed at Conch Reef in February 2017, progressed southwest through Long Key in December 2017, and reached the Sombrero Reef area in April 2018. The uppermost sites within the Lower Keys were also affected in April 2018, with southwestern progression continuing through all but the Dry Tortugas colonies by late 2020 (Figure 21; Neely et al. 2021).

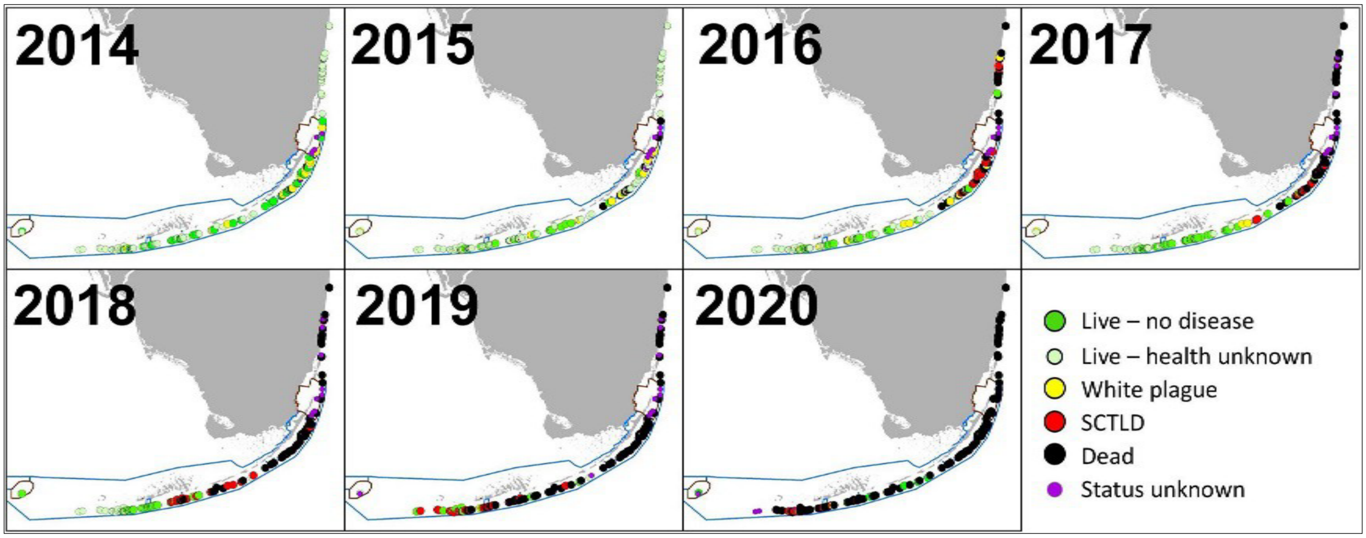

Figure 22. Condition of known pillar coral colonies in Florida between 2014 and 2020 (Neely et al. 2021)

Density of pillar corals in other areas of the Caribbean is also low and on average less than 0.1 colonies per 10 square meters (107.6 square feet). The average number of pillar coral colonies in remote reefs off southwest Cuba was 0.013 ± 0.045 colonies per 10 meter (32 feet) transect, and the species ranked sixth rarest out of 38 coral species (Alcolado et al. 2010). 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 square kilometers (0.6 square miles) for an overall density of approximately 0.000017 colonies per 10 square meters (107.6 square feet; Acosta and Acevedo 2006). In Puerto Rico, density of pillar coral ranged from 0.003 to 0.01 colonies per square meter (10.8 square feet) with an average density of 0.03 colonies per square meter (10.8 square feet); it occurred in one to 18 percent of the sites surveyed between 2008 and 2018 (NOAA NCRMP). In the USVI, average density of pillar coral ranged between 0.0003 and 0.005 colonies per meter (10.8 square feet); it occurred in one to six percent of the sites surveyed between 2002 and 2017 (NOAA NCRMP).

Hurricanes Irma and Maria caused substantial damage in Florida, Puerto Rico, and the USVI in 2017. At 153 survey locations in Puerto Rico, approximately 46 to 77 percent of pillar corals were impacted (NOAA 2018b). In a post-hurricane survey of 57 sites in Florida, no pillar coral colonies were encountered, potentially reflecting their much reduced population from disease (Florida Fish and Wildlife Conservation Commission, unpublished data). Survey data are not available for the USVI, although qualitative observations indicate that damage was widespread but variable by site.

Benthic cover is generally less than one percent in monitoring studies. Pillar coral's average cover was 0.002 percent on patch reefs and 0.303 percent 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 percent with an average of 0.0002 percent (NOAA NCRMP). In Puerto Rico, cover of pillar coral ranged between zero and four percent with an average of 0.02 percent in surveys conducted between 2001 and 2016 (NOAA NCRMP). In Dominica, pillar coral comprised less than 0.9 percent cover and was present at 13.3 percent of 31 surveyed sites (Steiner 2003). Pillar coral was observed on one of seven fringing reefs surveyed off Barbados, and cover was 2.7 ± 1.4 percent (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 percent in 1996 to 1.67 percent in 1999 and then declined to 0.44 percent in 2003 and to 0.43 percent in 2005 (Riegl et al. 2009).

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.

Status

Pillar coral survival is susceptible to a number of threats, and there is evidence of rapid population declines along the Florida Reef Tract due to SCTLD (Neely and Lewis 2020). 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 over the foreseeable future because pillar coral is limited to an area with high, localized human impacts and predicted increasing threats. Pillar coral inhabits most reef environments in water depths ranging from one to 25 meters (3.2 to 82 feet), but is naturally rare. Estimates of absolute abundance are at least tens of thousands of colonies in the Florida Keys, and absolute abundance is higher than estimates from this location due to the occurrence of the species in many other areas throughout its range. 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. In addition, low sexual recruitment 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.

Critical Habitat

Critical habitat has been proposed for pillar coral. See Section 6.2.6.6 for more information.

Recovery Goals

No final recovery plans currently exist for pillar coral; however, a recovery outline was published in 2015 (NMFS 2015b). The following short and long-term recovery goals are listed in the document:

Short-Term Goals:

- Increase understanding of population dynamics, population distribution, abundance, trends, and structure through research, monitoring, and modeling
- Through research, increase understanding of genetic and environmental factors that lead to variability of bleaching and disease susceptibility
- Decrease locally manageable stress and mortality sources (e.g., acute sedimentation, nutrients, contaminants, and over-fishing).
- Prioritize implementation of actions in the recovery plan for elkhorn and staghorn corals that will benefit *D. cylindrus*, *M. ferox*, and *Orbicella* spp.

Long-Term Goals:

- Cultivate and implement U.S. and international measures to reduce atmospheric carbon dioxide concentrations to curb warming and acidification impacts and possibly disease threats.
- Implement ecosystem-level actions to improve habitat quality and restore keystone species and functional processes to maintain adult colonies and promote successful natural recruitment.

6.2.6.4 Rough Cactus Coral (Mycetophyllia ferox)

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

Rough cactus coral occurs in the western Atlantic Ocean and throughout the wider Caribbean Sea (Figure 22).

Figure 23. Range map for rough cactus coral (from Aronson et al. 2008e)

Life History

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.

Rough cactus coral is a hermaphroditic brooding species. Colony size at first reproduction is greater than 100 square centimeters (15.5 square inches). Recruitment of rough cactus coral appears to be very low, even in studies from the 1970s. Rough cactus coral has a lower fecundity compared to other species in its genus (Morales Tirado 2006). Over a ten-year period, no colonies of rough cactus coral were observed to recruit to an anchor-damaged site in the USVI, although adults were observed on the adjacent reef (Rogers and Garrison 2001). No other life history information appears to exist for rough cactus coral.

Population Dynamics

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

According to the IUCN Species Account and the CITES species database, rough cactus coral occurs throughout the U.S. waters of the western Atlantic but has not been reported from Flower Garden Banks (Hickerson et al. 2008) or in Bermuda. The following areas include locations within federally protected waters where rough cactus coral has been observed and recorded (cited in Brainard et al. 2011): Dry Tortugas National Park; Virgin Island National Park/Monument; FKNMS; Navassa Island NWR; Biscayne National Park; Buck Island Reef

National Monument. It inhabits reef environments in water depths of five to ninety meters (16.4 to 295.3 feet), including shallow and mesophotic habitats (e.g., > 30 meters [98.4 feet]).

Rough cactus coral is uncommon or rare according to published and unpublished records. In benthic surveys conducted in the USVI between 2002 and 2018, rough cactus corals were encountered in less than half of the survey years, and density was less than or equal to 0.001 colonies per m^2 at the one to two percent of sites where they occurred (NOAA, unpublished data). Rough cactus corals were present at eight percent of sites surveyed in Puerto Rico in 2008, but in surveys conducted between 2010 and 2018, they were found at one to four percent of surveyed sites at an average density of <0.001 to 0.004 colonies per m^2 (NOAA NCRMP). Rough cactus corals were encountered in two to 10 percent of sites surveyed in Florida between 1999 and 2006, but in surveys between 2007 and 2017, they were only encountered in three survey years and at only one percent of sites at an average density of <0.001 colonies per m^2 (NOAA, unpublished data). Density of rough cactus coral in southeast Florida and the Florida Keys was approximately 0.8 colonies per approximately 10 square meters (107.6 square feet) between 2005 and 2007 (Wagner et al. 2010). In a survey of 97 stations in the Florida Keys, rough cactus coral declined in occurrence from 20 stations in 1996 to four stations in 2009 (Brainard et al. 2011). At 21 stations in the Dry Tortugas, rough cactus coral declined in occurrence from eight stations in 2004 to three stations in 2009 (Brainard et al. 2011). Taken together, these data indicate that the species has declined in Florida and potentially also in Puerto Rico over the past one to two decades.

Average benthic cover of rough cactus coral in the Red Hind Marine Conservation District off St. Thomas, USVI, which includes mesophotic coral reefs, was 0.003 percent in 2007, accounting for 0.02 percent of coral cover, and ranking 19 out of 21 coral species (Nemeth et al. 2008; Smith et al. 2010). In the USVI between 2001 and 2012, rough cactus coral appeared in 12 of 33 survey sites and accounted for 0.01 percent of the colonized bottom and 0.07 percent of the coral cover, ranking as 13th most common coral on the reef (Smith 2013).

In other areas of the Caribbean, rough cactus coral is also uncommon. In a survey of Utila, Honduras between 1999 and 2000, rough cactus coral was observed at eight percent 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 one of 38 reef-front sites, where average abundance was 0.004 colonies per approximately 10 square meters (107.6 square feet); this was comparatively lower than the other three *Mycetophyllia* species observed (Alcolado et al. 2010). Between 1998 and 2004, rough cactus coral was observed at three of six sites monitored in Colombia, where their cover ranged from 0.3 to 0.4 percent (Rodriguez-Ramirez et al. 2010).

Rough cactus coral has been reported to occur on a low percentage of surveyed reefs 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 one colony per approximately 10 square meters (107.6 square feet) and cover of less than 0.1 percent. 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 percent loss) and decreased encounter frequency in Puerto Rico indicate the population has declined. Based on declines in Florida and assumed declines elsewhere, we conclude rough cactus coral has likely declined throughout its range and will continue to decline based on increasing threats. As a result, it is presumed that genetic diversity for the species is low.

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. Its depth range of five to 90 meters (16.4 to 292.2 feet) moderates vulnerability to extinction over the foreseeable future 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 over the foreseeable future 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 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.

Critical Habitat

Critical habitat has been proposed for rough cactus coral. See Section 6.2.6.6 for more information.

Recovery Goals

No final recovery plan currently exists for rough cactus coral, however a recovery outline was developed in 2015 (NMFS 2015b) to serve as interim guidance to direct recovery efforts, including recovery planning, until a final recovery plan is developed and approved for the five coral species listed in September 2014. The recovery goals are the same for all five species with short and long-term goals (see *Recovery Goals* in Section 6.2.6.3).

6.2.6.5 Lobed Star, Mountainous Star, and Boulder Star Coral (Orbicella annularis, Orbicella

faveolata, and Orbicella franksi)

On September 10, 2014, NMFS listed lobed star, mountainous star, and boulder star coral as threatened (79 FR 53851). Lobed, mountainous, and boulder star coral occur in the western Atlantic and greater Caribbean as well as the Flower Garden Banks. Lobed and mountainous star coral may be absent from Bermuda (Figure 23).

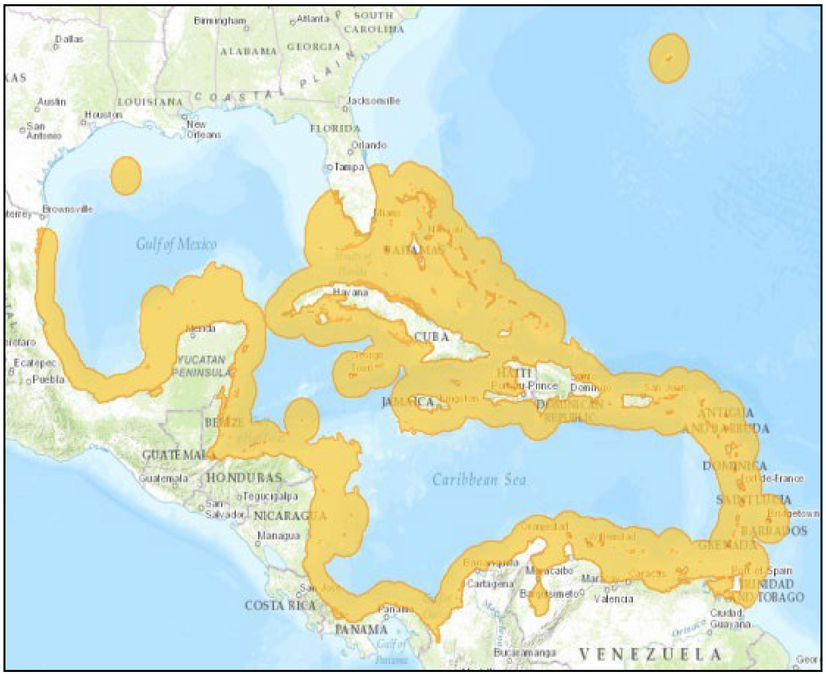

Figure 24. Range map for lobed, mountainous, and boulder star corals. Note that only boulder star corals are reported in the Bahamas (from Aronson et al. 2008b; Aronson et al. 2008c; Aronson et al. 2008d)

Lobed star coral (*Orbicella annularis*), mountainous star coral (*Orbicella faveolata*), and boulder star coral (*Orbicella franksi*) are the three species in the *Orbicella annularis* star coral complex. These three species were formerly in the genus *Montastraea*; however, recent work has reclassified the three 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 Knowton (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 three 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 three 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 three separate species.

Life History

Lobed Star Coral

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

Lobed star coral is reported from most reef environments within the Caribbean (except for Bermuda) in depths of approximately 0.5-20 meter (1.6 – 65.6 feet). The star coral species complex is a common, often dominant component of Caribbean mesophotic (e.g., >30 meters [98.4 feet]) reefs, suggesting the potential for deep refuge across a broader depth range, but lobed star coral is generally described with a shallower distribution.

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 two star coral species. Colony diameters can reach up to 10 meter (33 feet) with heights of four to five meters (13-16 feet).

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 10-20 meters (33-66 feet) in fore-reef environments. The depth range of mountainous star coral has been reported as approximately 0.5-40 meters (1.5-132 feet), though the species complex has been reported to depths of 90 meters (295 feet), indicating mountainous star coral's depth distribution is likely deeper than 40 meters (132 feet). Star coral species are a common, often dominant component of Caribbean mesophotic reefs (e.g., > 30 meters [98.4 feet]), suggesting the potential for deep refugia for mountainous star coral.

Boulder Star Coral

Boulder star coral contains large, unevenly arrayed polyps that give the colony its characteristic irregular surface distinguish boulder star coral. The colony form is variable, and the skeleton is dense with poorly developed annual bands. Colonies of boulder star coral can reach up to five meters (16.4 feet) with a height of up to two meters (6.6 feet).

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 two species in the *Orbicella* species complex. It occupies most reef environments and has been reported from water depths ranging from approximately five to 50 meters (16-165 feet), with the species complex reported to 90 meters (250 feet). *Orbicella* species are a common, often dominant, component of Caribbean mesophotic reefs (e.g., >30 meters [98.4 feet]), suggesting the potential for deep refugia for boulder star coral.

Population Dynamics

Lobed Star Coral

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

Lobed star coral has been described as common overall. Demographic data collected in Puerto Rico over nine years before and after the 2005 bleaching event showed that population growth rates were stable in the pre-bleaching period (2001–2005) but declined one year after the bleaching event. Population growth rates declined even further two 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 (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 90 centimeter (36 inch) size class in 2012 compared to 2005 and 2009. Partial colony mortality was lowest at less than 10 centimeters (four inches; as low as approximately five percent) and up to approximately 70 percent 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. 2013).

Colony density varies by habitat and location, and ranges from less than 0.1 to greater than one colony per approximately 10 square meters (107.6 square feet). 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 10 square meters

(107.6 square feet) 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 10 square meters [107.6 square feet]) compared to Palm Beach and Broward Counties (0.04 colonies per 10 square meters [107.6 square feet]; 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 10 square feet (107.6 square meters; Wagner et al. 2010). Off southwest Cuba on remote reefs, lobed star coral density was 0.31 ± 0.46 (SE) per approximately 10 meters (30 feet) transect on 38 reef-crest sites and 1.58 ± 1.29 colonies per approximately 10 meters (30 feet) 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 100 centimeters (40 inches; Alcolado et al. 2010).

Hurricanes Irma and Maria caused substantial damage in Florida, Puerto Rico, and the USVI in 2017. At 153 survey locations in Puerto Rico, approximately 43-44 percent of lobed star corals were impacted by hurricanes Irma and Maria in 2017 (NOAA 2018a). In Florida, approximately 80 percent of lobed star corals surveyed at 57 sites were impacted (Florida Fish and Wildlife Conservation Commission, unpublished data). Survey data are not available for the USVI, though qualitative observations indicate that damage was widespread but variable by site.

Population trends are available from a number of studies. In a study of sites inside and outside a MPA 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 percent in permanent monitoring stations in the Florida Keys (Waddell and Clarke 2008). Cover of lobed star coral declined 71 percent in permanent monitoring stations between 1996 and 1998 on a reef in the upper Florida Keys (Porter et al. 2001).

Mountainous Star Coral

Information on mountainous star coral status and population dynamics is infrequently documented throughout its range. Comprehensive and systematic census and monitoring has not been conducted. Thus, the status and population dynamics must be inferred from the few locations where 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 three well-defined populations based on five genetic markers, but the populations were not stratified by geography, indicating they were shared among the three 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 three genotypes (Levitan et al. 2011) potentially indicating 30 percent clonality.

Hurricanes Irma and Maria caused substantial damage in Florida, Puerto Rico, and the USVI in 2017. At 153 survey locations in Puerto Rico, approximately 12-14 percent of mountainous star corals were impacted by hurricanes Irma and Maria in 2017 (NOAA 2018a). In Florida, approximately 24 percent of mountainous star corals surveyed at 57 sites were impacted (Florida Fish and Wildlife Conservation Commission, unpublished data).

Extrapolated population estimates from stratified random samples in the Florida Keys were 39.7 ± 8 million (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 10-20 centimeter (four to eight inch) and 20-30 centimeter (eight to 12 inch) size classes in all survey years, but there was a fairly large proportion of colonies in the greater than 90-centimeter (36-inch) size class. Partial mortality of the colonies was between 10 percent and 60 percent 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 10-20 centimeter (four to eight inch) and 20-30 centimeter (eight to 12 inch), but there was a large proportion of colonies in the greater-than-90 centimeter (36-inch) size class. Partial mortality of the colonies ranged between approximately two percent and 50 percent. 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. 2013).

In a survey of 31 sites in Dominica between 1999 and 2002, mountainous star coral was present at 80 percent of the sites at 1-10 percent cover (Steiner 2003). 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 (three meter [ten feet] to five meters [16.5 feet] depth) spanning 240 kilometers (149 miles) in the Florida Keys, mountainous star coral was the third most abundant coral species comprising seven percent of the 17,568 colonies encountered. It was present at 95 percent 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 percent of sites visited (Miller et al. 2011). In 2003 on the East Flower Garden Bank, mountainous star coral comprised 10 percent of the 76.5 percent coral cover on reefs 32-40 meters (105-132 feet), 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 10 square meters (107.6 square feet) 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 10 square feet (107.6 square meters; Wagner et al. 2010). On remote reefs off southwest Cuba, density of mountainous star coral was 0.12 ± 0.20 (SE) colonies per 10 meters (33 feet) transect on 38 reef-crest sites and 1.26 ± 1.06 (SE) colonies per 10 meters (33 feet) transect on 30 reef-front sites (Alcolado et al. 2010). 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 10 square meters (107.6 square feet) 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 10 square meters (107.6 square feet) compared to 0.11 colonies per 10 square meters (107.6 square feet) in Palm Beach and Broward Counties (Burman et al. 2012).

Boulder Star Coral

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

Reported density is variable by location and habitat and is reported to range from 0.002 to 10.5 colonies per 10 square meters (107.6 square feet). Benthic surveys conducted in Florida between 1999 and 2017 recorded an average density of 0.01 to 0.36 colonies per square meter (10.8 square feet) and boulder star coral was observed at five to 45 percent of surveyed sites (NOAA, unpublished data). In Puerto Rico, boulder star coral was observed at three to 50 percent of sites, and average density ranged from 0.002 to 0.13 colonies per square meter (10.8 square feet) in surveys conducted between 2008 and 2018 (NOAA NCRMP). In the USVI, boulder star coral was present at a density of 0.02 to 0.24 colonies per square meter (10.8 square feet) in 19 to 69 percent of sites surveyed between 1999 and 2018 (NOAA, unpublished data). Limited surveys in the Flower Garden Banks reported a relatively stable density of 0.91 to 1.05 colonies per square meter (10.8 square feet) between 2010 and 2015, and boulder star coral was present at 90 to 100 percent of surveyed sites (NOAA NCRMP). In a survey of 31 sites in Dominica between 1999 and 2002, boulder star coral was present in seven percent of the sites at less than one percent cover (Steiner 2003). On remote reefs off southwest Cuba, colony density was 0.08 colonies per ~10 square meters (107.6 square feet) at 38 reef-crest sites and 1.05 colonies per ~10 square meters (107.6 square feet) at 30 reef-front sites (Alcolado et al. 2010). 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 one (i.e., less than approximately 50 centimeter [20 inch]) that had similar frequency of colonies with and without partial mortality (Alcolado et al. 2010).

Abundance at some sites in Curaçao and Puerto Rico appeared 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 nine sites off Mona and Desecheo Islands, Puerto Rico. In 1998, four percent of all corals at six sites surveyed off Mona Island were boulder star coral colonies, and approximately five percent were boulder star corals in 2008; at Desecheo Island, about two percent of all coral colonies were boulder star coral in both 2000 and 2008 (Bruckner and Hill 2009).

Hurricanes Irma and Maria caused substantial damage in Florida, Puerto Rico, and the USVI in 2017. At 153 survey locations in Puerto Rico, approximately 10-14 percent of boulder star corals were impacted by hurricanes Irma and Maria in 2017 (NOAA 2018a). In Florida, approximately 23% of boulder star corals surveyed at 57 sites were impacted (Florida Fish and Wildlife Conservation Commission, unpublished data).

The star coral species complex has growth rates ranging from 0.06-1.2 centimeter (0.02- 0.47 inches) per year and averaging approximately one-centimeter (0.39-inch) linear growth per year. Boulder star coral is reported to be the slowest of the three species in the complex (Brainard et al. 2011). They grow slower in deep or murky waters.

Of 351 boulder star coral colonies observed to spawn at a site off Bocas del Toro, Panama, 324 were unique genotypes. Over 90 percent 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 two to four spatially adjacent clones of each. Individuals within a genotype spawned more synchronously than individuals of different genotypes. Additionally, within five meters (16.4 feet), colonies nearby spawned more synchronously than farther spaced colonies, regardless of genotype. At distances greater than five meters (16.4 feet), spawning was random between colonies (Levitan et al. 2011).

Status

<u>Lobed star coral</u>

Lobed star coral was historically considered one of the most abundant species in the Caribbean (Weil and Knowton 1994). Percent cover has declined to between 37 percent and 90 percent over the past several decades at reefs at Jamaica, Belize, Florida Keys, The Bahamas, Bonaire, Cayman Islands, Curaçao, Puerto Rico, USVI, 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 two locations given the presence of this species in many other locations throughout its range. Lobed star coral remains common in occurrence. Abundance has decreased in some areas to between 19 percent and 57 percent and shifts to smaller size classes have occurred in locations such as Jamaica, Colombia, The Bahamas, Bonaire, Cayman Islands, Puerto Rico, USVI, 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.

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 (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 90 centimeters (35.4 inches) size class in 2012 compared to 2005 and 2009. Partial colony mortality was lowest at less than ten centimeters (four inches; as low as approximately five percent) and up to approximately 70 percent 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. 2013).

As noted previously, in a study of sites inside and outside a MPA in Belize, lobed star coral cover declined significantly over a ten-year period (1998/99 to 2008/09; Huntington et al. 2011). In a study of ten 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 percent in permanent monitoring stations in the Florida Keys (Waddell and Clarke 2008). Cover of lobed star coral declined 71 percent in permanent monitoring stations between 1996 and 1998 on a reef in the upper Florida Keys (Porter et al. 2001).

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 percent and 86 percent (thus, 14-82 percent 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.

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 two 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 over the foreseeable future because lobed star coral is limited to an area with highly localized human impacts and predicted increasing threats. Star coral occurs in most reef habitats 0.5-20 meters (1.6 to 65.6 feet) in depth which moderates vulnerability to extinction over the foreseeable future 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.

Mountainous Star Coral

Population trend data for mountainous star coral exists for several locations. At nine 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 percent and 48 percent at Mona and Desecheo Islands, respectively (Bruckner and Hill 2009). In 1998, 27 percent of all corals at six sites surveyed off Mona Island were mountainous star coral colonies, but this statistic decreased to approximately

11 percent in 2008 (Bruckner and Hill 2009). At Desecheo Island, 12 percent of all coral colonies were mountainous star coral in 2000, compared to seven percent in 2008.

In a survey of 185 sites in five 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 percent. The total live area occupied by mountainous star coral declined by a mean of 65 percent, and mean colony size declined from 4005 to 1413 square centimeters (43 to 15 square feet) At the same time, there was a 168 percent increase in small tissue remnants less than 500 square centimeters (five square feet), while the proportion of completely live large (1,500- 30,000 square centimeters [1.6 to 32 square feet]) colonies decreased. Mountainous star coral colonies in Puerto Rico were much larger and sustained higher levels of mortality compared to the other four 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 2012).

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 USVI. Absolute abundance is higher than the estimate from these three 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 percent loss in mountainous star coral cover across five countries. Losses of mountainous star coral from Mona and Desecheo Islands, Puerto Rico include a 36-48 percent reduction in abundance and a decrease of 42-59 percent 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. We conclude that mountainous star coral has declined and 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.

<u>Boulder Star Coral</u>

Information on boulder star coral status and population dynamics is infrequently documented throughout its range. Comprehensive and systematic census and monitoring has not been conducted. Thus, the status and population dynamics must be inferred from the few locations where 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 (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 10-20 centimeters (four to eight inches) and approximately 20-30 centimeters (8-12 inches). Partial colony mortality ranged from zero to approximately 73 percent and was generally higher in larger colonies (Miller et al. 2013).

In the Dry Tortugas, Florida, boulder star coral ranked fourth 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 20-30 centimeters (eight to 12 inches) 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 three feet (90 centimeters). Partial colony mortality ranged from approximately 10-55 percent. 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 three feet (90 centimeters) remained consistent. Partial colony mortality ranged from approximately 15-75 percent (Miller et al. 2013).

In 2003, on the east Flower Garden Bank, boulder star coral comprised 46 percent of the 76.5 percent coral cover on reefs approximately 32-40 meters (105-131 feet) 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 seven percent of the sites at less than one percent cover (Steiner 2003).

Reported density is variable by location and habitat and is reported to range from 0.02 to 1.05 colonies per approximately (~) 10 square meters (107.6 square feet). 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 ~10 square meters (107.6 square feet) 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 ~10 square meters (107.6 square feet) compared to 0.02 colonies ~10 square meters (107.6 square feet) 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 ~10 square meters (107.6 square meters; Wagner et al. 2010). On remote reefs off southwest Cuba, colony density was 0.083 ± 0.17 (SD) per ~10 square meters (107.6 square feet) transect on 38 reef-crest sites and 1.05 ± 1.02 colonies per ~10 square meters (107.6 square feet) transect on 30 reef-front sites (Alcolado et al. 2010). 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 one (i.e., less than ~50 centimeters [20 inches]) that had similar frequency of colonies with and without partial mortality (Alcolado et al. 2010).

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 nine sites off Mona and Desecheo Islands, Puerto Rico. In 1998, four percent of all corals at six sites surveyed off Mona Island were boulder star coral colonies and approximately five percent in 2008; at Desecheo Island, about two percent of all coral colonies were boulder star coral in both 2000 and 2008 (Bruckner and Hill 2009).

Based on population estimates, there are at least tens of millions of colonies present in both the Dry Tortugas and USVI. Absolute abundance is higher than the estimate from these two 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. In some locations, colony size has decreased over the past several decades. Bruckner (2012) conducted a survey of 185 sites (2010 and 2011) in five 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 percent. Overall, the total live area occupied by boulder star coral declined by a mean of 38 percent, and mean colony size declined from 1356 to 845 square centimeters (210 to 131 square inches). At the same time, there was a 137 percent increase in small tissue remnants, along with a decline in the proportion of large (1,500 to 30,000 square centimeters [232.5 to 4,650 square inches]), 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 2012).

A decrease in boulder star coral percent cover by 38 percent and a shift to smaller colony size across five 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.

Critical Habitat

NOAA Fisheries has proposed to designate critical habitat for the threatened Caribbean corals: *Orbicella annularis*, *O. faveolata*, *O. franksi*, *Dendrogyra cylindrus*, and *Mycetophyllia ferox*. Twenty-eight mostly overlapping specific occupied areas containing physical features essential to the conservation of all these coral species are being proposed for designation as critical habitat; these areas contain approximately 15,000 square kilometers (5,900 square miles of marine habitat. In Puerto Rico, there are seven largely-overlapping specific areas, one for each species, that surround each of the islands. The difference between each of the areas is the particular depth contours that create the boundaries. For example, *Dendrogyra cylindrus*' specific area in Puerto Rico extends from the one meter (three foot) contour to the 25 meter (82 foot) contour, which mostly overlaps the *Orbicella annularis* specific area that extends from the 0.5 meter (1.6 meter) contour to the 20 meter (65.6 meter) contour. Overlaying all of the specific areas for each species results in the maximum geographic extent of these new critical habitat designations, which cover 1.6 to 295 feet (0.5-90 meters) water depth around all the islands of Puerto Rico.

Recovery Goals

No final recovery plan currently exists for lobed star, mountainous star or boulder star coral; however, a recovery outline was developed in 2015 (NMFS 2015b) to serve as interim guidance to direct recovery efforts, including recovery planning, until a final recovery plan is developed and approved for the five coral species listed in September 2014. The recovery goals are the same for all five species with short and long-term goals (see *Recovery Goals* in Section 6.2.6.3).

6.2.6.6 Status of Proposed Atlantic/Caribbean Coral Critical Habitat

In the final listing rule for lobed star coral, mountainous star coral, boulder star coral, pillar coral, and rough cactus coral, NMFS identified the major threats contributing to the species extinction risk as ocean warming, disease, ocean acidification, tropic effects of reef fishing, nutrient enrichment, and sedimentation. Of these threats, all but disease affect corals in part by changing coral habitat, making it unsuitable for corals to carry out the essential functions at all life stages. NMFS determined that protecting the essential features of coral habitat from these threats will facilitate recovery of these five species.

In 2020, 28 mostly overlapping specific occupied areas containing PBFs essential to the conservation of five species of ESA-listed corals (lobed star coral, mountainous star coral, boulder star coral, pillar coral, and rough cactus coral) were proposed to be designated as critical habitat. These areas contain approximately 15,000 square kilometers (4,373.3 square nautical miles) of marine habitat. The proposed critical habitat boundaries are described in Table 3 which includes the locations of the critical habitat units for the five species of Atlantic/Caribbean corals. Depth contours or other identified boundaries form the boundaries of the critical habitat units. Specifically, the Convention on the International Regulations for Preventing Collisions at Sea (COLREGS, 1972) Demarcation Lines (33 CFR 80), the boundary between the South Atlantic Fishery Management Council and Gulf Council (50 CFR 600.105), the FKNMS boundary (15 CFR Part 922 Subpart P, Appendix I), and the Caribbean Islands Management Area (50 CFR Part 622, Appendix E) create portions of the boundaries in several of the proposed critical habitat units.

There are five or six specific areas per species within which the individual species' specific areas are largely overlapping. The difference between each of the areas is the particular depth contours used to create the boundaries. Overlaying the specific areas for each species results in the maximum geographic extent of the areas under consideration for designation, which covers 0.5-90 meters (1.6-295 feet) water depth around all the islands of Puerto Rico, USVI, and Navassa, FGBNMS, and from St. Lucie Inlet, Martin County to Dry Tortugas, Florida.

Within the geographic area occupied by these five ESA-listed coral species, proposed critical habitat consists of specific areas where the PBFs essential to the conservation of each species are found. The PBF essential to the conservation of these five ESA-listed corals (lobed star coral, mountainous star coral, boulder star coral, pillar coral, and rough cactus coral) is reproductive, recruitment, growth, and maturation habitat found in the Caribbean, Florida, and Gulf of Mexico. Sites that support the normal function of all life stages of these five threatened coral species are natural, consolidated hard substrate or dead coral skeleton, which is free of algae and sediment at the appropriate scale at the point of larval settlement or fragment reattachment, and the associated water column. Several attributes of these sites determine the quality of the area and influence the value of the associated feature to the conservation of the species:

1. Substrate with the presence of crevices and holes that provide cryptic habitat, the presence of microbial biofilms, or the presence of crustose coralline algae;
2. Reefscape with no more than a thin veneer of sediment and low occupancy by fleshy and turf macroalgae;
3. Marine water with levels of temperature, aragonite saturation, nutrients, and water clarity that have been observed to support any demographic function; and
4. Marine water with levels of anthropogenically-introduced (from humans) chemical contaminants that do not preclude or inhibit any demographic function.

Naval Air Station Key West, which includes the land and waters generally out to 45.7 meters (50 yards) adjacent to the base for a total of approximately 3.23 square kilometers (800 acres) is excluded from the proposed critical habitat designation. The Integrated Natural Resources

Management Plan (INRMP) for the base was determined by NMFS to provide a benefit to the four threatened coral species (pillar coral, lobed star, mountainous star, and boulder star) found within the in-water area of the base.

Table 3. Locations of the proposed critical habitat units for five species of Caribbean, Florida, and Gulf of Mexico corals.

Species	Critical Habitat Unit Name	Location	Geographic Extent	Water Depth Range
Lobed Star Coral (*Orbicella annularis*)	OANN-1	Florida	Lake Worth Inlet, Palm Beach County to Government Cut, Miami-Dade County	2 to 20 meters (6.6 to 65.6 feet)
	OANN-1	Florida	Government Cut, Miami-Dade County to Dry Tortugas, Monroe County	0.5 to 20 meters (1.6 to 65.6 feet)
	OANN-2	Puerto Rico	All Islands	0.5 to 20 meters (1.6 to 65.6 feet)
	OANN-3	USVI	All Islands of St. Thomas and St. John	0.5 to 20 meters (1.6 to 65.6 feet)
	OANN-4	USVI	All Islands of St. Croix	0.5 to 20 meters (1.6 to 65.6 feet)
	OANN-5	Navassa	Navassa Island	0.5 to 20 meters (1.6 to 65.6 feet)
	OANN-6	Flower Garden Banks (FGB)	East FGB and West FGB	17 to 90 meters (55.8 to 295.3 feet)
Mountainous Star Coral (*Orbicella faveolata*)	OFAV-1	Florida	St. Lucie Inlet, Martin County to Government Cut, Miami-Dade County	2 to 90 meters (6.6 to 295.2 feet)

	OFAV-1	Florida	Government Cut, Miami-Dade County to Dry Tortugas, Monroe County	0.5 to 90 meters (1.6 to 295.2 feet)
	OFAV-2	Puerto Rico	All Islands of Puerto Rico	0.5 to 90 meters (1.6 to 295.2 feet)
	OFAV-3	USVI	All Islands of St. Thomas and St. John	0.5 to 90 meters (1.6 to 295.2 feet)
	OFAV-4	USVI	All Islands of St. Croix	0.5 to 90 meters (1.6 to 295.2 feet)
	OFAV-5	Navassa	Navassa Island	0.5 to 90 meters (1.6 to 295.2 feet)
	OFAV-6	FGB	East FGB and West FGB	17 to 90 meters (55.8 to 295.2 feet)
Boulder Star Coral (*Orbicella franksi*)	OFRA-1	Florida	St. Lucie Inlet, Martin County to Government Cut, Miami-Dade County	2 to 90 meters (6.6 to 295.2 feet)
	OFRA-1	Florida	Government Cut, Miami-Dade County to Dry Tortugas, Monroe County	0.5 to 90 meters (1.6 to 295.2 feet)
	OFRA-2	Puerto Rico	All Islands of Puerto Rico	0.5 to 90 meters (1.6 to 295.2 feet)
	OFRA-3	USVI	All Islands of St. Thomas and St. John	0.5 to 90 meters (1.6 to 295.2 feet)
	OFRA-4	USVI	All Islands of St. Croix	0.5 to 90 meters (1.6 to 295.2 feet)
	OFRA-5	Navassa	Navassa Island	0.5 to 90 meters (1.6 to 295.2 feet)

	OFRA-6	FGB	East FGB and West FGB	17 to 90 meters (55.8 to 295.2 feet)
Pillar Coral (*Dendrogyra cylindrus*)	DCYL-1	Florida	Lake Worth Inlet, Palm Beach County to Government Cut, Miami-Dade County	2 to 25 meters (6.6 to 82 feet)
	DCYL-1	Florida	Government Cut, Miami-Dade County to Dry Tortugas, Monroe County	1 to 25 meters (3.2 to 82 feet)
	DCYL-2	Puerto Rico	All Islands	1 to 25 meters (3.2 to 82 feet)
	DCYL-3	USVI	All Islands of St. Thomas and St. John	1 to 25 meters (3.2 to 82 feet)
	DCYL-4	USVI	All Island of St. Croix	1 to 25 meters (3.2 to 82 feet)
	DCYL-5	Navassa	Navassa Island	1 to 25 meters (3.2 to 82 feet)
Rough Cactus Coral (*Mycetophyllia ferox*)	MFER-1	Florida	Broward County to Dry Tortugas, Monroe County	5 to 90 meters (6.6 to 295.2 feet)
	MFER-2	Puerto Rico	All Islands of Puerto Rico	5 to 90 meters (6.6 to 295.2 feet)
	MFER-3	USVI	All Islands of St. Thomas and St. John	5 to 90 meters (6.6 to 295.2 feet)
	MFER-4	USVI	All Islands of St. Croix	5 to 90 meters (6.6 to 295.2 feet)
	MFER-5	Navassa	Navassa Island	5 to 90 meters (6.6 to 295.2 feet)

USVI=U.S. Virgin Islands, FGB=Flower Garden Banks

Much of the proposed critical habitat overlaps with the existing designated critical habitat for elkhorn and staghorn coral (Section 6.2.6.2) with the exception of some additional areas of deeper waters due to the greater depth range of some of five listed coral species in comparison to the Atlantic acroporid corals. Therefore, the current status of the proposed coral critical habitat is as described for elkhorn and staghorn coral critical habitat.

7 ENVIRONMENTAL BASELINE

The "environmental baseline" refers to the condition of the listed species or its designated and proposed critical habitat in the action area, without the consequences to the listed species or designated and proposed critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions, which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR §402.02; 84 FR 44976 published August 27, 2019).

The environmental baseline for this opinion includes the effects of several activities that affect the survival and recovery of sperm whales; green, leatherback, and hawksbill sea turtles, Nassau grouper; Central and Southwest Atlantic DPS scalloped hammerhead shark; queen conch; elkhorn, staghorn, lobed star, mountainous star, boulder star, pillar, and rough cactus corals; designated critical habitat for green sea turtle, elkhorn and staghorn coral; and proposed critical habitat for lobed star, mountainous star, boulder star, pillar, and rough cactus corals. The following information summarizes the status of each species in the action area and the principal natural and human-caused phenomena in the action area believed to affect the survival and recovery in the wild of ESA-listed species and designated and proposed critical habitat that are likely to be adversely affected by the proposed action.

7.1 Status of the Species and Critical Habitats within the Action Area

7.1.1 Sperm Whales

Sperm whales are widely distributed in the Caribbean and are common in the deep-water passages between islands and along continental slopes (CH2M Hill 2018). Sperm whales inhabit the deep ocean near Puerto Rico from January through about August. There have been seven documented sperm whale sightings around Puerto Rico from 1994-2014 (Rodriguez et al. 2019) The first sighting reports one individual traveling, and the other two sightings were of a mother and its calf swimming at the surface, with occasional breaching. In one of these sightings (10 September 2014), the adult female of the pair had a distinctive mark close to the melon area. The picture was also sent to the Guadeloupe Sperm whale project for possible identification, however no match was obtained (Rodriguez et al. 2019). This is the only sighting reported in this note which slightly differs from the seasonality proposed by Mignucci-Giannoni et al. (2000), late fall to early winter, and gives insight into how little we know about this species in Puerto Rican waters (Rodriguez et al. 2019). Two of the sightings occurred within the Mona Channel and the other sighting off the insular slope along the south coast of Lajas. Mignucci-Giannoni et al. (2000) suggested that the waters south of Vieques may be important nursing grounds for some marine mammal species, including sperm whales, and may be part of the calving grounds for this species.

The best abundance estimate available for the Puerto Rico and USVI stock of sperm whales is unknown. A line-transect survey was conducted during January-March 1995 on NOAA Ship Oregon II, and was designed to cover a wide range of water depths surrounding Puerto Rico and the Virgin Islands. However, due to the bottom topography of the region and the size of the vessel, most waters surveyed were >200 meters (656 feet) deep. Eight sightings of sperm whales were made, six of which occurred in and near U.S. waters (Roden and Mullin 2000). Another line transect survey for humpback whales was conducted during February-March 2000 aboard NOAA Ship Gordon Gunter in the eastern and southern Caribbean Sea. A portion of the survey effort occurred in U.S. waters during transit, and eight sightings of sperm whales were made in and near U.S. waters. During February-March 2001 a line transect survey was conducted in waters of the eastern Bahamas, eastern Dominican Republic, Puerto Rico and Virgin Islands. Five sightings of sperm whales were made near Puerto Rico and the Virgin Islands (in and near U.S. waters). It was not possible to estimate abundance from these surveys using line-transect methods due to so few sightings.

There are no population estimates for sperm whales in the action area. The best available estimate for Northern Gulf of Mexico sperm whales is 1,665, based on 2003-2004 data, which are insufficient data to determine population trends (Waring et al. 2008).

7.1.2 Green, Leatherback, and Hawksbill Sea Turtles

The Archipelago of Culebra is composed of several cays, including its main island, Culebra, which is a municipality of Puerto Rico. Culebra Island is located midway between Fajardo, Puerto Rico and St. Thomas, USVI. It has approximately 25 sandy beaches totaling approximately 10 linear kilometers (6.2 miles) and corresponding to more than 15 named beaches or beach sections (Figure 24). Three marine turtle species are known to nest on Culebra and its adjacent cays, in order of increasing importance: the leatherback turtle (*Dermochelys coriacea*), the hawksbill turtle (*Eretmochelys imbricata*), and the green turtle (*Chelonia mydas*).

Figure 25. Index Beach Nesting Survey Beaches Culebra Archipelago, Puerto Rico

The Culebra Archipelago harbors one of most important breeding populations for leatherback and hawksbill turtles in Puerto Rico. Green turtles have been reported nesting but in very low numbers (<5 nests; Diez 2016).

Desecheo Island is a NWR surrounded by a narrow benthic shelf sloping down to a depth of about 50 meters (164 feet) with diverse coral formations in an array of patch reefs and walls at 19.3 kilometers (12 miles) from the west coast of the main island of Puerto Rico (Valdés-Pizzini et al. 2011). Juvenile hawksbill and green sea turtles are located in coral habitat close to the rocky shores of Desecheo Island. On the seabed of Desecheo Island, *Geodia neptuni*, a marine sponge, serves as the primary food for hawksbill sea turtles (van Dam and Diez, 1996 as cited in Valdés-Pizzini et al. 2011). On the west coast of Desecheo, evidence of hawksbill sea turtle nesting on the gravel beach has been observed (Valdés-Pizzini et al. 2011). Desecheo is 19.3 kilometers (12 miles) from mainland Puerto Rico indicating that adults and hatchlings may transit through the area. Confirmed sightings of adult green and hawksbill sea turtles have been made in the area (Valdés-Pizzini et al. 2011).

Our estimated population numbers of turtles in the Culebra and Desecheo portions of the action area are discussed below and are based on capture studies, nest counts, and monitoring data. While nester data is more accurate (Piacenza et al. 2019), we used best available data and long standing methods to reach our density and abundance assumptions.

Leatherback Sea Turtles

Leatherback sea turtle nesting activity occurs on beaches around the main island of Puerto Rico, with the highest amount of leatherback nesting taking place on beaches along the northeastern coast of the island. Leatherback nesting also occurs around offshore islands of Puerto Rico, including Culebra where a number of beaches are used by this species (Figure 24). Culebra Archipelago is an important nesting ground for leatherbacks in the Caribbean, yielding up to 420 nests in its highest season (1998). However, since nesting counts began in 1985 the number of nests have dropped dramatically, only surpassing 100+ nests once since 2010 in 2014 with 112 nests counted. The nest counts now averaged 48 nests per year from 2010-2022 where from 2000-2010 the average was 170 nests per year and 1990-2000 198 nests per year were observed by PRDNER (Figure 25).

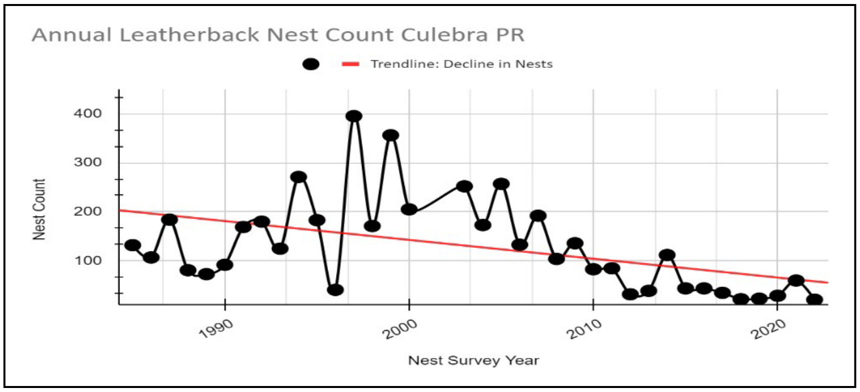

Figure 26. Leather Back Nests Culebra: data provided by PRDNER

Even with the decline in nest numbers, the average nest productivity was measured to be 55 percent; which is considered normal for leatherback nests world-wide. Nest loss is primarily caused by washout due to wave action from passing storms. Beach erosion was observed in important nesting beaches as Resaca, Brava and Zoni, but beach profiles didn't report this erosion occurring during leatherback nesting season; only by the effect of occasional storm events. A standardized Index Beach Nesting Survey (IBNS) was implemented to have a more accurate estimation of the nesting trends. This index consists of counting the number of nests laid during the main nesting season (mid-April- end of June for leatherbacks, and September to December for hawksbills turtles). In the case of leatherbacks, the index beaches are Brava, Resaca, and Zoni (see Figure 24). The first two beaches are considered by USFWS as important sites for leatherbacks because of their high nesting activity. In addition, Brava and Resaca beaches have so far been unaffected by development due to their inaccessibility and protected status. In recent years, an increase in nest numbers at Zoni Beach has been reported. Therefore, Zoni Beach is included as part of the IBNS program.

In order to calculate a population of leatherback turtles for the Culebra portion of the action area, we used the largest annual leatherback nest count data surveyed in Culebra over the past ten years. These data were derived from 2014 leatherback nest counts totaling 112 nests. These nest counts included data from both index beaches and non-index beaches.

Leatherback nesting on Desecheo Island has not been observed and there is not suitable nesting habitat for this species on the island. Little to no observations of the species have been made in waters in and around the island. However, adults and hatchlings from nesting areas at Rincón and Añasco may transit in deep waters past Desecheo as they migrate from nesting beaches (Valdés-Pizzini et al. 2011). Due to limited data on leatherback sea turtle sightings in and around Desecheo, we conservatively estimate that approximately 10 percent of the adults and hatchlings that are found in nesting areas in Rincón and Añasco may also be present in and around Desecheo as they migrate to deep water. In 2022, approximately 180 leatherback nests were counted at Añasco and 11 at Rincón (Diez 2022a).

Based on these data, we assumed 4,347 hatchlings for Culebra and 737 for Desecheo using the following formulas:

Culebra

77 eggs per nest (NMFS 2020) X 112 nests (PRDNER unpublished data) X 72 percent emergent success rate (Eckert and Eckert 1990; Stewart and Johnson 2006; Tucker 1988) - 30 percent hatchling mortality rate (Frazer 1992; Pilcher 1999)

Desecheo

77 eggs per nest (NMFS 2020) X 19 nests (Diez 2022a) X 72 percent emergent success rate (Eckert and Eckert 1990; Stewart and Johnson 2006; Tucker 1988) - 30 percent hatchling mortality rate (Frazer 1992; Pilcher 1999)

To get the number of adult leatherback sea turtles in the Culebra action area, we divide the total number of 112 nests by the number of times an adult female leatherback sea turtle nests per season, on average (4.475; NMFS 2020), and calculate there are approximately 25 adult females. Similarly, for Desecheo if we use the number of nests from individuals that may migrate from Rincón and Añasco and divide this number (19) by the number of times an adult female leatherback sea turtle nests per season, on average (4.475; NMFS 2020), we calculate there are approximately four adult females. If we then conservatively assume a 1:1 sex ratio as specified in NMFS (2020), there would be 50 adults for the Culebra action area and eight adults for Desecheo.

Hawksbill Sea Turtles

Hawksbills turtles also nest in the Culebra Archipelago, indicating stable nesting numbers ranging from 50 to 80 nests among seasons with a nest productivity of 86 percent (Figure 26). Even though the Culebra hawksbill breeding population does not have as high a number of nests as other areas in the Caribbean, it is considered important since it provides genetic diversity to other populations such as Humacao and other rookeries. The use of IBNS has been a predictor of abundance for the hawksbill nesting population in Mona Island, Puerto Rico (Diez and Van Dam

2002; Ditmer and Stapleton 2012) and other areas in the world (e.g., Florida, USA). For hawksbill turtles, index beaches are Playa Larga, Cayo Norte, and all beaches of Culebrita (Figure 24). Other beaches visited are: Luis Peña, Carlos Rosario, Blanca, Flamenco, Resaca, Mosquito, and Punta Soldado (See Figure 24). High swells and beach erosion by natural conditions were considered the main threat for these nests. Ninety percent of the total number of hawksbill and leatherback sea turtles nested on protected areas or isolated, undeveloped beaches. The distribution of hawksbill sea turtle nesting activity in Culebra makes up a small percentage of the overall nesting activity around Puerto Rico when compared to Mona Island, where the most important hawksbill nesting areas are located. Hawksbill clutch size is approximately 140 eggs and emergent success at nesting beaches in the Caribbean is approximately 80 percent (Ditmer and Stapleton 2012).

Nesting on Desecheo Island has been observed at least once on the gravel beach located on the western side of the island (Valdés-Pizzini et al. 2011). Based on this information and to be conservative, we will estimate that five nests may occur on Desecheo Island annually. Furthermore, adults and hatchlings from nesting areas at Mona Island may transit to Desecheo. Based on recapture data from Desecheo, 1 out of 83 turtles recaptured on Desecheo were originally captured at Mona Island (Diez et al. 2019). Based on recapture data, we estimate that 1.2 percent of adult and hatchling sea turtles from Mona Island may transit in waters within or near Desecheo. In 2021, approximately 1,088 hawksbill nests were counted at Mona Islands (Diez 2022b).

If we assume there are 140 eggs per hawksbill nest and 81 nests are lain annually in Culebra based on 2014 nest count data, which was the largest annual nest count in the past 10 years based on PRDNER unpublished data, there could be 6,350 hatchlings in the Culebra action area. For Desecheo, we conservatively estimate that five nests may be lain on Desecheo Island annually, and individuals from 13 nests on Mona Island (1.2 percent of 1,088 nests) may transit near or within Desecheo waters. If we assume 140 eggs per hawksbill nest and 18 nests, there could be 1,411 hatchlings in the Desecheo action area. We derive these numbers from the following formulas:

Culebra

140 eggs per nest (Ditmer and Stapleton 2012) X 81 nests (PRDNER unpublished data) X 80 percent emergence success rate (Ditmer and Stapleton 2012) - 30 percent hatchling mortality rate (Frazer 1992; Pilcher 1999)

Desecheo

140 eggs per nest (Ditmer and Stapleton 2012) X 18 nests (conservative estimates based on sparse sightings data from Valdés-Pizzini et al. (2011), recapture data from Diez et al. (2019),

and nesting data from Diez (2022b)) X 80 percent emergence success rate (Ditmer and Stapleton 2012) - 30 percent hatchling mortality rate (Frazer 1992; Pilcher 1999)

In addition to hatchlings, we estimated there are 119 juvenile hawksbill sea turtles in Culebra and 68 juvenile hawksbill sea turtles in Desecheo based on capture/sightings data from Rincon Diaz et al. (2011) and Bjorndal et al. (2016). For the number of adult hawksbill sea turtles in the Culebra and Desecheo action areas, we divide the total number of nests by the number of times an adult female hawksbill sea turtle nests per season, on average (2.4425; NMFS 2020), and calculated approximately 33 adult females for Culebra and seven adult females for Desecheo. If we then assume a 1:1 sex ratio, there would be 66 adult hawksbill sea turtles for Culebra and 14 adults for Desecheo.

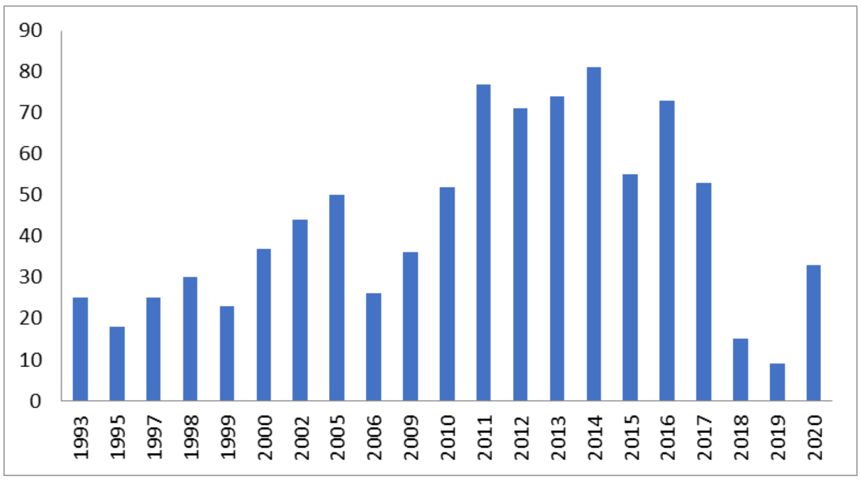

Figure 27. Hawksbill nests counts at index beaches of Culebra Archipelago during 1993, 1995 to 2019. Note: For missing dates, data was not available (Chelonia de Puerto Rico-Investigación y Conservación de Tortugas Marinas 2022)

Green Sea Turtles

Green sea turtle nesting activity is low in Puerto Rico when compared to other areas in the Caribbean and Atlantic. The main green sea turtle nesting sites in Puerto Rico are beaches on the northeast coast of Vieques Island and the beach on the southeast coast of Caja de Muertos Island (Diez 2022a). Reports of green turtle nesting in Culebra exist but indicate nesting occurs in very low numbers (<5 nests; Diez 2016), and there are a limited number of observations of adult green sea turtles in the area. For example, green sea turtle capture studies conducted from 1997 to 2011 off the coast of Tortuga Bay and Puerto Manglar resulted in 665 green sea turtle captures none of which were adults (Diez 2016). Also, PRDNER's Protected Species Program has never observed or captured live adult green sea turtles in the waters near-by Culebra (C. Diez, PRDNER, pers. comm. to J. Molineaux, NMFS, January 6, 2023), although two adult green sea turtles were found stranded off the coast of Culebra in 1998 and 2001 (PRDNER unpublished stranding data). Feeding-grounds around the Culebra Archipelago are known as developmental habitats for juvenile and sub-adult green sea turtles. Once sub-adult green sea turtles reach a size of 60 centimeters (23.6 inches) SCL in Culebra waters, they usually migrate to different areas, particularly to Nicaragua and Florida (C. Diez, PRDNER, pers. comm. to J. Molineaux, NMFS, January 6, 2023).

In order to come up with an estimate for adult green sea turtles around Culebra, we used 2014 to 2019 USACE monitoring data from each MRS within the Culebra action area presented in USACE (2022b). Throughout the course of 817 monitoring dates, the USACE and its contractors observed 23 instances of adult green sea turtles. Twenty of these observations occurred in MRS 13 and 9 and many sightings occurred on the same date at similar times indicating some may have been repeat sightings of the same individual(s). The most adult green sea turtles observed at a single time was three. To be conservative, we use all sightings of individuals and a 1:1 sex ratio to estimate that approximately 12 adult female and 12 adult male green sea turtles are in the Culebra portion of the action area.

To estimate the number of hatchling green sea turtles in Culebra we calculated 199 using the following formula:

114 eggs per nest (NMFS 2020) X five nests (Diez 2016) X 50 percent emergence success rate (Brost et al. 2015) - 30 percent hatchling mortality rate (Frazer 1992; Pilcher 1999)

For juveniles in the Culebra action area, we used capture data from Patricio et al. (2014). Patricio et al. (2014) captured approximately 305 individual sea turtles off the coast of Tortuga Bay and Puerto Manglar from 1997 to 2011. Although these data are limited to only two locations in Culebra, it was noted that green sea turtles captured in these areas can be found throughout the entire Culebra archipelago and can be used to estimate the population size at least for juvenile and sub-adult life stages for Culebra (C. Diez, PRDNER, pers. comm. to J. Molineaux, NMFS, August, 29, 2022).

Data for green sea turtles off the coast of Desecheo are limited. Due to the lack of green sea turtle nesting in the area, hatchlings are not expected to be in the area. Similar to hawksbill sea turtles, confirmed sightings of juvenile and adult green sea turtles have been made in the waters of Desecheo, but counts have been smaller than the number of hawksbill sea turtles observed (Valdés-Pizzini et al. 2011). To be conservative and due to a lack of data on juvenile and adult green sea turtles found near Desecheo, we use the same estimates obtained for adult and juvenile hawksbill sea turtles found near Desecheo. Thus, we estimate 14 adults and 68 juvenile green sea turtles in and around the Desecheo portion of the action area.

7.1.3 Nassau Grouper

Nassau grouper was previously one of the most commercially important coral reef species supporting fisheries in the Caribbean. Historic spawning aggregation sites for Nassau grouper are off the west coast of Puerto Rico in the area of Desecheo along Bajo de Sico Bank (18°14′N, 67°26′W), approximately 27 km (16.8 miles) of the west coast of Puerto Rico (Tuohy et al. 2015). Fishers also identified potential sites around Culebra, including the eastern point of Culebra (Figure 16; Ojeda-Serrano et al. 2007a). There are known historical Nassau grouper spawning aggregation sites in Luis Peña Reserve, which is near MRS 02 and 07 (Figure 27; Ojeda 2007). The status of these aggregations is unknown, but Nassau grouper may occur in the waters around the MRS cays. Furthermore, there are historic spawning aggregation of Nassau grouper off the north coast of Vieques and several areas around Culebra (Ojeda-Serrano et al. 2007a) and, due to the presence of large seagrass beds and reef habitat, it is likely that juveniles are located throughout the Culebra action area. For the Culebra MRSs, sightings data from surveys conducted by Garcia-Sais et al. (2020) in El Seco, which is approximately 25 kilometers (15.5 miles) south of Culebra, are available. Garcia-Sais et al. (2020) surveyed 27,701.1 square meters (6.85 acres) of habitat in depths between 23 to 50 meters (75.45 to 164.04 feet) in mesospheric reef areas in El Seco. For surveys off El Seco, only two individuals were observed.

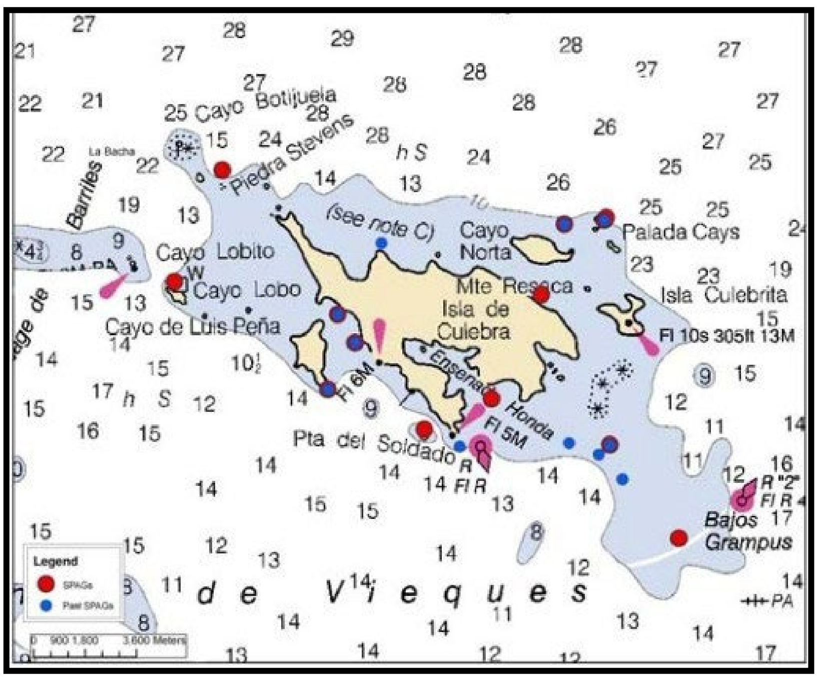

Figure 28. Historic spawning aggregation sites for Nassau grouper near Culebra PR

Sightings data for Nassau grouper are available for the Desecheo action area. From 2018 to 2020, Garcia-Sais et al. (2020) surveyed 33,152.8 square meters (8.19 acres) of habitat in depths between 25 to 50 meters (82.03 to 164.04 feet) in mesospheric reef areas around Desecheo Island. For Desecheo, Garcia-Sais et al. (2020) observed nine Nassau grouper.

In addition to the data noted above, a total of 52 Nassau grouper individuals were identified within mesophotic habitats of Bajo de Sico in the 25 – 50 meter (82 – 164 foot) depth range during the 2011 baseline and the 2018-2020 monitoring surveys (Garcia-Sais et al. 2020). The 2011 size distribution was skewed toward the larger individuals with the main mode at 60 centimeter (23.6 inch) TL. Individuals larger than 60 centimeters (23.6 inches) represented 64.1 percent of the total population surveyed in 2011. Modes at 60 centimeters (23.6 inches) and 65 centimeters (25.6 inches) prevailed during 2018-20, with 37.5 percent of individuals larger than 60 centimeters (23.6 inches). Differences of size distributions between surveys were not statistically significant (Kolmogorov-Smirnov, $p > 0.10$) due in part to the small sample size (García-Sais et al. 2014).

The size at maturity of Nassau grouper was reported at 48 centimeters (18.9 inches; Froese et al. 2019), therefore all individuals observed within belt-transects in the 2011 baseline survey were adults, whereas 37.7 percent of the total individuals observed in the 2018-20 monitoring survey were juveniles. These data are indicative that the 169 percent increment of *E. striatus* mean density at Bajo de Sico was largely explained by juvenile recruitment into mesophotic habitats. Additional observations are needed to explain the decline of very large individuals from Bajo de Sico. It is possible that some of the larger individuals were able to migrate to deeper waters to avoid the turbulent conditions related to extreme events of wave action associated with the passing of hurricanes in 2017 and winter storm Riley in 2018, or to reach lower temperature waters.

NOAA NCRMP also noted observations of Nassau grouper. In their last three surveys in 2016, 2019, and 2021, only six sightings of Nassau grouper were confirmed for all sites surveyed around Puerto Rico (J. Blondeau, NOAA Southeast Fisheries Science Center Fish Ecology Unit, pers. comm. to J. Molineaux, NMFS, September 15, 2022).

There is no population estimate for Nassau grouper available for the action area based on the scarcity of data.

7.1.3.1 Nassau Grouper Critical Habitat

As shown in Figure 15, Desecheo and Culebra Islands are two units of proposed critical habitat for Nassau grouper. Proposed critical habitat off the coast of Desecheo includes all waters from the southwest shoreline out to the edge of the coral reef habitat in depths up to about 30 meters (98.4 feet). Proposed critical habitat off the coast of Culebra includes all waters from the southeastern shoreline of the island out to the reef ledge in depths of about 15 meters (49.2 feet) between Punta del Soldado and Cabeza de Perro, excluding the bays of Puerto del Manglar and Ensenada Honda. In addition, Culebra Island critical habitat includes all waters from the southern shoreline of Culebrita out to the nearshore reef in depths of about five meters (16.4 feet) between the western point of the island and Punta del Este.

Nearshore PBFs that support development and recruitment, such as seagrass areas and coral reefs make up most of the Culebra and Desecheo action area. Based on NCCOSS survey data, the

USACE determined that 6.59 square kilometers (1630.53 acres) within the Desecheo and Culebra MRSs or 71.1 percent of the benthic habitat in this area contains coral reef and hard bottom. Approximately 2.5 square kilometers (618.9 acres) or 26 percent of all of the MRSs contains seagrass (NCCOS 2002), with seagrass only present in the Culebra MRSs and none for Desecheo. In addition, historic spawning areas located in adjacent marine waters are also present (Figure 27).

Nearshore PBFs are particularly susceptible to impacts from human activity in the Culebra portion of the action area because of the close proximity of the PBFs to coastal and in-water construction, dredging and disposal activities, beach nourishment, stormwater runoff, wastewater and sewage outflow discharges, and point and non-point source pollutant discharges. Coastal and in-water construction, channel dredging, and beach nourishment activities can directly remove PBFs that support development and recruitment of Nassau grouper by dredging or by depositing sediments, and making habitat unavailable. Otaño-Cruz et al. (2017) notes that an increasing trend of unsustainable development, alteration of coastal watersheds, and bare soil exposure have increased sediment delivery to Culebra's coastal waters during heavy rainfall events and have caused a live coral cover decline. This illustrates that impacts from coastal development combined with natural factors (e.g., major storm events) can significantly affect Nassau grouper critical habitat in the Culebra action area. Furthermore, stormwater runoff, wastewater and sewage outflow discharges, and point and nonpoint source pollutant discharges can adversely impact seagrass and coral habitat by allowing nutrients and sediments from point and non-point sources, including sewage, stormwater and agricultural runoff, river discharge, and groundwater. Hernández-Delgado et al. (2018) revealed strong water quality impacts associated with eutrophication in Ensenada Honda Bay as a result of multiple non-point sources of land-based pollution, sedimentation, and illegal sewage dumping. Therefore, nearshore PBFs that support development and recruitment of Nassau grouper off the coast of Culebra will likely continue to be negatively impacted by some or all of these factors that are part of the environmental baseline.

Desecheo Island experiences little to no impacts from coastal development because the entire island is a NWR, however, limited impacts to nearshore PBFs from pollution and vessel beaching may exist from unauthorized vessel beaching (see Section 7.6).

7.1.4 Scalloped Hammerhead

The Puerto Rican waters within the action area are used by Central and Southwest Atlantic DPS scalloped hammerhead sharks for nearshore reproductive, developmental, and foraging habitat. The only area of the action area that may overlap with scalloped hammerheads are the waters off Culebra where scalloped hammerhead nursery habitat is suspected to occur. Therefore, we only expect neonate, juvenile, and a small number of adult hammerhead sharks to be adversely affected by the USACE's proposed action. Data from MRIP indicate the presence of scalloped hammerheads around Puerto Rico with 797 sharks landed from 2001 – 2016 (NMFS, Fisheries

Statistics Division, pers. comm. to J. Molineaux, NMFS, October, 21, 2022), although some of the sharks may have been misidentified. Also, recent fishery-dependent survey data conducted by the Puerto Rico Shark Research and Conservation Program detected 46 scalloped hammerhead sharks around Puerto Rico from February 2019 to August 2021. All individuals observed were juveniles with an equal number of males and females. Scalloped hammerhead sharks were the second most observed species during these surveys (Puerto Rico Shark Research and Conservation Program 2022). Additional fishery independent surveys from 2017 to 2021 identified 13 individual scalloped hammerhead sharks around Puerto Rico from June 2017 to August 2021. All individuals identified in this survey were juveniles with one recapture (Puerto Rico Shark Research and Conservation Program 2022). While these data do not include specific instances of sightings in Culebra, sightings of neonates, juveniles, and adults have been confirmed in areas within or around MRS 02 and 07 (i.e., Culebrita; R. Espinoza, Conservacion Con Ciencia, pers. comm. to J. Molineaux, NMFS, January, 19, 2023). Only adult scalloped hammerheads are found in waters around Desecheo as no nurseries are confirmed in this area. These adult individuals are usually located in deeper waters outside of MRS 01.

We believe that no individual scalloped hammerhead shark is likely to be a permanent resident of the action area, although some individuals may be present at any given time. Once juvenile scalloped hammerhead sharks in the action area mature they will migrate to pelagic waters further offshore in other areas that the Central and Southwest Atlantic DPS is predicted to occur (See Figure 16). Therefore, the status of the scalloped hammerhead in the action area is considered the same as the status discussed in Section 6.2.4.

There is no population estimate for scalloped hammerhead available for the action area due to limited data.

7.1.5 Queen Conch

Queen conch populations in Puerto Rico showed signs of steady decline beginning in the 1980s. (NMFS 2014a). Estimated fishing mortality exceeded estimates of natural mortality, catch continued to decline while effort increased through 2011, and the catch became increasingly skewed to smaller sizes, all suggesting that Puerto Rican populations have been overfished for decades (NMFS 2014a). Surveys conducted in 2013 observed larger size distributions, higher adult queen conch densities (compared to three previous studies, but lower than the density reported in 2006), an increase in the proportion of older adults, and evidence of sustained recruitment, suggesting that Puerto Rico's conch populations were recovering to some extent (Baker et al. 2016 as cited in Horn et al. 2022).

Density information for queen conch in Puerto Rico are only available for adults. In shallower areas (i.e., areas less than 30 to 40 meters [98.4 to 131.2 feet]), densities of adult queen conch are estimated at 6.1 individuals per hectare whereas, in deeper areas (i.e., mesophotic reefs), densities were estimated to be 54.6 individuals per hectare (Horn et al. 2022). Due to this, and given that there are approximately 359 hectares of shallow water in the action area, juvenile and adult queen conch habitat within all of the Culebra and Desecheo MRSs (i.e., the total sum of seagrass, microalgae, sand habitat, scattered coral-rock, patch reef, and spur/grove areas), is estimated as 2,189 individual adult queen conch. Using a global conversion ratio of 0.46 (Horn et al. 2022) for the total number of adults to juveniles provides an estimate of 2,569 juveniles.

There are several regulations associated with the Queen Conch Resources Fishery Management Plan of Puerto Rico and the U.S. Virgin Islands (CFMC 1996 as cited in Horn et al. 2022). Recently, the Secretary of Commerce approved new FMPs for the fishery resources managed by the CFMC in Federal waters of the U.S. Caribbean. The Puerto Rico FMP will transition fisheries management to an island-based approach.

In 1997 the U.S. Caribbean EEZ (with the exception of St. Croix) was closed to queen conch fishing and a territorial waters closed season (July 1 through September 30) was implemented. In 2004 additional regulations implemented in local waters included a 22.86 centimeter (nine inch) minimum shell length or 9.5 millimeter (0.37 inch) minimum lip thickness and daily bag limits of 150 per person and 450 per boat. Minimum shell length and meat weight regulations are unreliable since large juveniles can have larger shells and more meat than mature adults can. The seasonal closure was amended to August 1 through October 31 in 2012.

In 2013, PRDNER implemented an administrative order that lifted the prohibition on extracting conch meat from the shell while underwater (PRDNER Administrative Order 2013-14). The administrative order is still valid today. The elimination of an important accountability mechanism to ensure compliance and enforcement with the minimum size regulations (i.e., the requirement that conch be landed whole), occurred while populations were still considered severely depleted and subjected to continued fishing pressure. Furthermore, shell length is not a reliable indicator of maturity in queen conch. Shell lip thickness is the most reliable indicator of maturity in queen conch; however, the available information indicates that the 9.5 millimeter (0.37 inch) lip thickness regulation is not high enough to prevent immature conch from being harvested. Based on this, existing regulations are likely inadequate to reverse the decline of queen conch in Puerto Rico.

7.1.6 ESA-Listed Corals

There are hard bottom and reef habitats containing coral colonies of ESA-listed corals in waters around Culebra and Desecheo based on recent NOAA contracted surveys and previous NCCOS surveys (CSA Ocean Sciences Inc. 2021; NCCOS 2002). Mountainous star and lobed star coral were found to be the dominant live coral species on reef and hard bottom habitats in sampling sites around Culebra (CSA Ocean Sciences Inc. 2021). Staghorn coral was observed in 12 percent of the surveys while elkhorn was observed in one percent, but this may also be a function of the depths where surveys were conducted as elkhorn prefers depths up to five meters (16.4 feet). Data from coral transect surveys by CSA Ocean Sciences Inc. (2021) in the Culebra and

Desecheo portion of the action area found that elkhorn corals make up 10.21 percent of ESA-listed corals, staghorn 19.94 percent, pillar coral 0.96 percent, lobed star coral 33.49 percent, boulder star coral 1.44 percent, and mountainous star coral 33.97 percent.

The USACE estimated that there could be up to 1,555 ESA-listed coral colonies affected by the activities that are part of the proposed action. This is based on past USACE survey data of MEC/MPPEH in the action area and on the estimate of 6.59 square kilometers (1630.53 acres) of coral and hard bottom habitat data derived from NCCOS habitat data (NCCOS 2002). There are likely to be more ESA-listed coral colonies than this as the estimate only includes colonies likely to be adversely affected by the proposed action due to their location in relation to MEC/MPPEH. In addition, no coral survey data are detailed enough to enable a determination of the numbers of colonies of each ESA-listed coral species in the action area because surveys only covered small transects of the total action area.

7.1.6.1 ESA-Listed Atlantic/Caribbean Coral Critical Habitat

As noted, it is estimated that 6.59 square kilometers (1,630.53 acres) of coral and hard bottom habitat exists within the Culebra and Desecheo action area based on previous NOAA benthic data (NCCOS 2002). Of this acreage, hard bottom in the form of colonized bedrock, pavement, and pavement with sand channels comprises of 5.39 square kilometers (1,332.7 acres) and hard bottom and coral reef in the form of linear reef, scattered coral-rock, aggregated patch reefs, and spur and groove comprises 0.95 square kilometers (235.8 acres). Unknown and uncolonized hard bottom types comprises of 0.25 square kilometers (62.2 acres).

CSA Ocean Sciences Inc. (2021) conducted transect surveys in coral and hard bottom habitat areas within the action area. Based on data from these transect surveys, it is estimated that approximately 90 percent of the coral and hard bottom areas in the Culebra and Desecheo action area contains the PBFs for ESA-listed Atlantic/Caribbean coral critical habitat. Similar to Nassau grouper critical habitat discussed in Section 7.1.3.1, the status of coral critical habitat PBFs in nearshore areas around the Culebra action area has been impacted by unsustainable development and alteration of coastal watersheds. Effects from coastal and in-water construction, dredging and disposal activities, beach nourishment, stormwater runoff, wastewater and sewage outflow discharges, and point and non-point source pollutant discharges have and will continue to negatively impact coral critical habitat PBFs in the Culebra action area. Also, limited impacts to nearshore PBFs from pollution and vessel beaching may exist from unauthorized vessel landings on Desecheo Island (see Section 7.6).

7.2 Climate Change

There is a large and growing body of literature on past, present, and future impacts of global climate change, exacerbated and accelerated by human activities (Lynas et al. 2021; Powell 2017). Effects of climate change include sea level rise, increased frequency and magnitude of severe weather events, changes in air and water temperatures, and changes in precipitation patterns, all of which are likely to affect ESA resources. NOAA's climate information portal provides basic background information on these and other measured or anticipated climate change effects (see https://www.climate.gov).

Over the last 150 years the world has warmed as humans have continued to add heat-trapping greenhouse gases to the atmosphere (Figure 28; Hayhoe et al. 2018; IPCC 2022). This warming has triggered many changes in the earth's climate. Numerous independent lines of evidence have documented these changes, from the atmosphere to the ocean to the poles. This warming, primarily in response to human activities, is causing widespread effects in the physical environment, including more intense storms, melting glaciers, disappearing snow cover, shrinking sea ice, rising sea levels, changes in rainfall patterns, and shifting droughts (Wuebbles et al. 2017). Globally, surface temperatures have increased by 0.99 degrees Celsius in recent decades (2001-2020) compared to the pre-industrial average from 1850-1900 (IPCC 2022). This warming has occurred over nearly the entirety of the earth's surface. Precipitation has also increased as the earth's atmosphere warms and contains more water vapor. But the changes in precipitation are uneven, with patterns of wetting and drying interspersed around the planet. As the earth warms, melting ice from land surfaces and expanding ocean volume has resulted in global mean sea levels to rise by 0.20 meters (0.65 feet) between 1901 and 2018 (IPCC 2022).

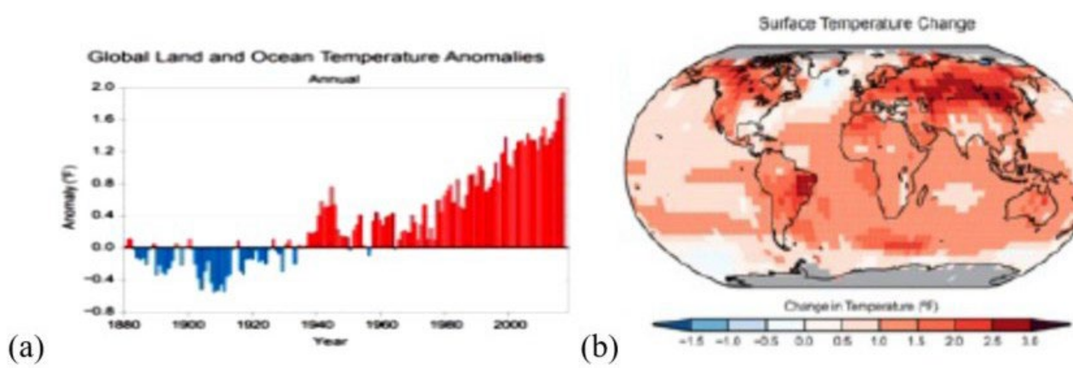

Figure 29. Global annual average temperature (a) Red bars show temperatures above the 1901-1960 average, and blue bars indicate temperatures below the average. (b)From 1986 -2016 global average surface temperature increased by 0.7 degrees Celsius compared to 1901-1960 (Wuebbles et al. 2017) and by 0.99 degrees Celsius from 2001-2020 compared to 1850-1900 (IPCC 2022).

Using the prior generation of global climate models (CMIP5-Coupled Model Intercomparison Project phase 5; Tebaldi et al. 2021), the annual mean temperature change within the Caribbean was compared against global mean warming targets of 1.5 degrees Celsius, 2.0 degrees Celsius and 2.5 degrees Celsius above preindustrial levels for a climate forcing scenario corresponding to lower levels of greenhouse gas emissions (RCP4.5; Thomson et al. 2011). The comparison illustrates the projected temperature within the Caribbean intensifies above 2.0 degrees Celsius including extreme changes in temperature.

For instance, the projected number of warm spells goes up drastically with additional warming - extension of 70 days from 1.5 degrees Celsius to two degrees Celsius global warming. A follow-up study used a set of regional climate model projections to better quantify climate change projections within the Caribbean for the same global warming targets (Campbell et al. 2021). The Caribbean islands were found to warm faster than the surrounding oceans by 0.5 degrees Celsius to 1.5 degrees Celsius with the largest warming occurring during the cooler months. The regional climate model projections also indicate differential warming within the Caribbean with the largest warming occurring over the northern Caribbean. This is an indication that increased warming may favor more homogenous temperatures from south to north.

The rising concentrations of greenhouse gases in the atmosphere, now higher than any period in the last 800,000 years, have also affected the chemistry of the ocean, causing it to become more acidic. These large-scale changes in the earth's climate are in turn causing changes locally to Puerto Rico's climate and environment. PRCC (2022) notes that Puerto Rico is expected to warm faster than the global average, with increases in both mean and extreme temperatures. Concern for these threats led the Puerto Rico government to sign into law in 2019 the Climate Change Mitigation, Adaptation and Resilience Act requiring the island of Puerto Rico to reduce its greenhouse gas emissions over the course of the next five years by 50 percent (PRCC 2022).

Several of the most important threats contributing to the extinction risk of proposed and ESA-listed species, particularly those with a calcium carbonate skeleton such as corals and mollusks as well as species for which these animals serve as prey or habitat, are related to global climate change. The main concerns regarding impacts of global climate change on coral reefs and other calcium carbonate habitats generally, and on proposed and ESA-listed corals and mollusks in particular are the magnitude and the rapid pace of change in greenhouse gas concentrations (e.g., carbon dioxide 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; IPCC 2014). As carbon dioxide concentrations increase in the atmosphere, more carbon dioxide is absorbed by the oceans, causing lower pH and reduced availability of calcium carbonate. Because of the increase in carbon dioxide and other greenhouse gases 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 (IPCC 2014).

Changes in the marine ecosystem caused by global climate change (e.g., ocean acidification, salinity, oceanic currents, DO levels, nutrient distribution) could influence the distribution and abundance of lower trophic levels (e.g., phytoplankton, zooplankton, submerged aquatic vegetation, crustaceans, mollusks, forage fish), ultimately affecting primary foraging areas of proposed and ESA-listed species including marine mammals, sea turtles, fish, and mollusks. Marine species ranges are expected to shift as they align their distributions to match their physiological tolerances under changing environmental conditions (Doney et al. 2012). McMahon and Hays (2006) predicted increased ocean temperatures will expand the distribution of leatherback turtles into more northern latitudes. The authors noted this is already occurring in the Atlantic Ocean and is likely to occur in the Pacific.

Similarly, climate-related changes in important prey species populations are likely to affect predator populations. Pecl and Jackson (2008) predicted climate change will likely result in squid that hatch out smaller and earlier, undergo faster growth over shorter life-spans, and mature younger at a smaller size. This could have negative consequences for species such as sperm whales, whose diets can be dominated by cephalopods. For ESA-listed species that undergo long migrations, if either prey availability or habitat suitability is disrupted by changing ocean temperatures regimes, the timing of migration can change or negatively impact population sustainability (Simmonds and Eliott 2009).

Macleod (2009) estimated that, based upon expected shifts in water temperature, 88 percent of cetaceans would be affected by climate change, 47 percent would be negatively affected, and 21 percent would be put at risk of extinction. Changes in core habitat area means some species are predicted to experience gains in available core habitat and some are predicted to experience losses (Hazen et al. 2012). Such range shifts could affect marine mammal and sea turtle foraging success as well as sea turtle reproductive periodicity (Pike 2013; Silber et al. 2017).

Genetic analyses and behavioral data suggest that sea turtle populations with temperature-dependent sex determination may be unable to evolve rapidly enough to counteract the negative fitness consequences of rapid global temperature change (Hays 2008 as cited in Newson et al. 2009). Altered sex ratios have been observed in sea turtle populations worldwide (Fuentes et al. 2009; Mazaris et al. 2008; Reina et al. 2008; Robinson et al. 2008). This does not yet appear to have affected population viabilities through reduced reproductive success, although average nesting and emergence dates have changed over the past several decades by days to weeks in some locations (Poloczanska et al. 2009). A fundamental shift in population demographics may lead to increased instability of populations that are already at risk from several other threats. In addition to altering sex ratios, increased temperatures in sea turtle nests can result in reduced incubation times (producing smaller hatchling), reduced clutch size, and reduced nesting success due to exceeded thermal tolerances (Azanza-Ricardo et al. 2017; Fuentes et al. 2010; Fuentes et al. 2011; Fuentes et al. 2009).

Global climate change may affect Nassau grouper. Thermal changes of just a few degrees Celsius can substantially alter fish protein metabolism (Mccarthy and Houlihan 1997), response to aquatic contaminants (Reid et al. 1997), reproductive performance (Van Der Kraak and Pankhurst 1997), species distribution limits (Mccarthy and Houlihan 1997), and community structure of fish populations (Schindler 2001). Apart from direct changes to fish survival, increased water temperatures may alter important nursery, refuge, and foraging habitats such as coral reefs. Increased ocean acidification may also have serious impacts on fish development and behavior (Raven et al. 2005), including sensory functions (Bignami et al. 2013) and fish larvae behavior that could affect fish populations (Munday et al. 2009).

In the NMFS final rule to list 20 coral species as threatened (79 FR 53851, September 10, 2014), ocean warming and acidification, associated with climate change, were identified as two of the most important threats to the current or expected future extinction risk of reef building corals. Reef building organisms are predicted to decrease the rate at which they deposit $CaCO_3$ in response to increased ocean acidity and warmer water temperatures (Raymundo et al. 2008). Further, the most severe coral bleaching events observed to date have typically been accompanied by ocean warming events such as the El Niño-Southern Oscillation (Glynn 2001). Bleaching episodes result in substantial loss of coral cover, and result in the loss of important habitat for associated reef fishes and other biota. Corals can typically withstand mild to moderate bleaching, but severe or prolonged bleaching events can lead to coral colony death (79 FR 53851). While the susceptibility to ocean warming and acidification associated with climate change is expected to vary by species and specific coral colony (based on latitude, depth, bathymetry, etc.; 79 FR 53851), climate change is expected to have major impacts on the coral species considered in this opinion.

Within the action area, severe hurricanes such as those during the 2017 hurricane season and severe swells such as those during the summer of 2019, coral bleaching from elevated sea surface temperatures, and sea level rise are affecting sea turtle nesting beaches and in-water habitat for the Nassau grouper, and ESA-listed corals and their designated critical habitat (Gould et al. 2018).

7.3 Fisheries

Commercial whalers once targeted sperm whales. Once commercial whaling ended, the species was expected to rebuild; however, a study in the eastern Caribbean indicates that unit size, numbers of calves, and calving rates in a well-studied population have continued declining (Gero and Whitehead 2016). Fishing gear used in the Caribbean, including Puerto Rico, includes gillnets, which have been shown to cause entanglement of sperm whales. Two were reported entangled in 2015 in the eastern Caribbean (Gero and Whitehead 2016). There are no reported entanglements of sperm whales in the action area, but the population in the eastern Caribbean is the same population that travels through the action area so entanglement due to fishing gear in and outside the action area could contribute to population declines. Stranding of sperm whales because of interactions with fisheries has not been reported in the action area and, given the artisanal nature of the fisheries in the action area in both federal and Commonwealth waters, is not likely to occur.

Fishing gears used throughout the action area adversely affect threatened and endangered sea turtles. Based on stranding data from Commonwealth waters (PRDNER unpublished stranding data), net and hook-and-line gear have been documented as interacting with sea turtles in Puerto Rico. Illegal fishing targeting sea turtles accounted for 33 percent of reported sea turtle strandings around Vieques for the period from 1991–2008 with no incidental capture of sea turtles in fishing gear reported (PRDNER unpublished stranding data). All of the turtles affected by illegal fishing (i.e., harpooning) were hawksbills. Abandoned or lost fishing gear can also affect the quality of refuge and foraging habitat for green and hawksbill sea turtles as abandoned gear can lead to abrasion and breakage in hard bottom and coral reef habitats. They also have shading impacts on seagrass and macroalgae if the gear is large enough, such as traps and nets. Gear used over areas containing corals also has the potential to affect ESA-listed corals and designated critical habitat for elkhorn and staghorn corals.

NMFS has implemented FMP developed by the Caribbean Fishery Management Council (Council) that manages fishery resources in the U.S. Caribbean exclusive economic zone (EEZ), and promulgates regulations implementing those plans.

The Comprehensive FMP for the Puerto Rico EEZ (Puerto Rico FMP) transitioned management of fisheries in the U.S. Caribbean, including the reef fish fishery, from Caribbean-wide FMPs to island-based FMPs. The future operation of the reef fish fishery is managed under island-based FMPs.

The Puerto Rico fishery is small-scale or artisanal in nature, and is comprised of commercial, recreational, and subsistence participants. The total area of fishable habitat (less than or equal to 100 fathoms) in all waters off Puerto Rico (Commonwealth and federal waters, combined) is estimated to be 5,823 square kilometers (2,248 square miles). However, only 410 square kilometers (158 square miles) of that area, approximately seven percent, is located in federal waters. All fishery resources are consumed on the island; there is little or no export. Commercial fishing provides sustenance and employment, while recreational fishing provides food and leisure activity for local residents and visitors. In general, commercial and recreational fishers target similar species of fish and shellfish, including reef fish, offshore pelagic fish, and spiny lobster, among others. Persons engaged in commercial and recreational fishing also engage in subsistence fishing, or fishing for household consumption. The following description provides a general characterization of the Puerto Rico fishery operating in federal waters, for purposes of this consultation.

The Puerto Rico FMP manages 51 species of reef fish, nine pelagic finfish species, three species of rays, spiny lobster, queen conch, and all species of coral, sea urchin, and sea cucumber that occur in federal waters off Puerto Rico. Fishing permits are not required to commercially harvest species managed under the Puerto Rico FMP from federal waters off Puerto Rico. However, under Puerto Rico law, to sell fish caught in waters off Puerto Rico, a commercial fishing license is required from Puerto Rico's Department of Natural and Environmental Resources (DNER). As an obligation of the license, commercial fishers are required to submit monthly catch reports to the DNER, which contain landings information for all fish caught by commercial fishers, in both federal (9-200 nautical miles) and commonwealth (less than nine nautical miles from shore) waters.

Geographically, Puerto Rico's west coast is the most productive area due to relatively shallow and extended shelf; by contrast, the north coast is the least productive because it has a narrow insular shelf (Hernandez-Avila et al. 1979).

In 2018, there were 1,277 commercially licensed fishers in Puerto Rico (764 full-time, 134 part-time, and 379 beginner fishers) (D. Matos, DNER Fisheries, pers. comm. to M. López, NMFS SERO, February 2019). The number of commercial fishers that submitted catch reports in 2016 (pre-hurricane Maria) was 811 and, in 2018 (post-hurricane Maria), was 720. The total number of fishing trips reported in 2016 was 29,292 and, in 2018, was 26,349. Of the catch reports submitted, 33 percent of the 2016 fishers and 36 percent of the 2018 fishers reported operating primarily in federal waters and 11 percent of the total fishing trips in each year were reported in federal waters. Additionally, a percentage of the commercial landings data were reported from an "unknown" location (43 percent of the 2016 commercial fishers; 33 percent of the 2018 commercial fishers; 10 percent of the trips taken in 2016; 4 percent of the trips taken in 2018), either because the fishers were not certain if the fishing location was in Commonwealth or federal waters, or because the location field on the catch report was left blank. It is possible that some of those "unknowns" occurred in federal waters, but the percentage is unquantifiable at this time.

In 2018, a total of 671 commercial fishing vessels and three commercial charter vessels were registered with the U.S. Coast Guard and thus available to operate in federal waters. Commercial fishing vessels in Puerto Rico are relatively small, averaging six meters (20 feet) in length (Matos-Caraballo 2009). The majority of vessels are composed of a fiberglass hull or, less often, fiberglass and wood, with even fewer made of wood (Matos-Caraballo 2009). Most vessels feature a single outboard gas engine with an average 80 horsepower (Matos-Caraballo and Agar 2011). The vessels can also have one or two electric winches used on the shelf edge or in deep fishing banks to capture deep-water snappers (i.e., silk and queen snappers), and may have GPS and depth sensors, which aid in the identification of fishing areas (Valdés-Pizzini et al. 2012).

Commercial fishers target multiple species using multiple gear types during the same fishing trip. Nearly two-thirds of fishers (63.2 percent) use at least three gear types during a fishing trip (Griffith et al. 2013). The information from Griffith et al. (2013) is general to all fishing off Puerto Rico, and this analysis assumes that commercial fishers operating in federal waters use the same gear types and the same amounts. Historically, trap gear dominated the catch by commercial fishers in Puerto Rico, but their use has declined over time leading to a more balanced fishery using lines, traps, and spears (Merten et al. 2018). Gear types principally used by commercial fishers in federal waters are hook-and-line, fish and lobster traps, spears, snares, and SCUBA.

The fishery for Atlantic Highly Migratory Species is known to incidentally capture large numbers of leatherback and loggerhead sea turtles, particularly in the pelagic longline component. Pelagic longline, pelagic driftnet, bottom longline, and/or purse seine gear have all been documented taking sea turtles. Thousands of sea turtles have been caught in this fishery throughout the Atlantic since 1992, and a portion of these interactions occurred in the Caribbean. A subset of these animals were landed dead, and another subset likely experienced post-release mortality, a number which was substantial (NMFS 2004). A permanent prohibition on the use of driftnet gear in the swordfish fishery was published in 1999. NMFS reinitiated consultation on the pelagic longline component of this fishery (NMFS 2004) because the authorized number of incidental takes for loggerheads and leatherbacks sea turtles, species not likely to be adversely affected by the proposed actions under consultation in this Opinion, were exceeded. The resulting Biological Opinion stated the long-term continued operation this sector of the fishery was likely to jeopardize the continued existence of leatherback sea turtles, but reasonable and prudent alternatives were identified allowing for the continued authorization of the pelagic longline fishing that would not jeopardize leatherback sea turtles. Reinitiation of consultation has been conducted again and a biological opinion issued in 2020; jeopardy to any species is not expected. In the U.S. Caribbean, commercial tuna and swordfish fishers primarily use pelagic longline (PLL), rod and reel, and handline gear (NMFS 2012). Longline vessels targeting Atlantic Highly Migratory Species in the Caribbean set fewer hooks per set, on average and fish deeper in the water column than the fleets in other areas (e.g., Northeast Distant).

The take authorized for the Puerto Rico fishery under the Puerto Rico FMP, (SERO 2020) using a three year time period is for the monitoring of anticipated take is noted in Table 4.

Table 4. Puerto Rico FMP anticipated fisheries take.

Species	Lethal Take	Non-Lethal Take
Sea Turtle- green*	6 individuals	0
Sea Turtle- hawksbill	6 individuals	0
Scalloped Hammerhead Shark	0	0
Nassau Grouper	0	0
Oceanic Whitetip Shark	33 individuals	**
Elkhorn Coral	619.5ft^2	**
Staghorn Coral	566.7 ft^2	**
Rough Cactus Coral	36.6 ft^2	**
Pillar Coral	89.1 ft^2	**
Lobed Star Coral	420.9 ft^2	**
Mountainous Star Coral	982.8 ft^2	**
Boulder Star Coral	510.6 ft^2	**

***Up to 6 takes of green sea turtles, total, from any combination of the NA and SA DPSs**	**Additional non-lethal take of these species as a result of the effect to corals from the harvest of the herbivorous fish (loss of grazing capacity).

Anticipated levels of take under the Spiny Lobster FMP (NMFS 2011) are 12 lethal takes of green and hawksbill sea turtles over three years and nine lethal takes of leatherback sea turtles over three 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 are not likely to adversely affect ESA-listed sea turtles.

Nassau grouper were an important component of the fishery and were targeted in federal and Commonwealth fisheries until fishing was prohibited (in federal waters in 1990 and in Commonwealth waters in 2004). Fishing in Commonwealth waters occasionally targeted juveniles in nearshore areas in addition to adults. As the fishery became more diminished, younger life stages were targeted, leading to the prohibition of fishing for this species year-round in federal and Commonwealth waters.

In the USVI and Puerto Rico, reef fish are primarily caught by fish trap with some spearfishing and handlining. Fishers have targeted Nassau grouper spawning aggregations since the 1950s. According to fisher interviews, Nassau grouper landings from Mona Island ranged from 227 kilograms (500 pounds) to 681 kilograms (1,500 pounds) per five to seven day trip before the 1980s, but subsequently declined so that fishing trips to Mona Island were no longer economically feasible (Nemeth et al. 2007). Puerto Rico has long collected some landings data at the species level from its fishing communities. It is thus well-documented that the Nassau grouper, dominant in the 1950s to 1970s, has since vanished from the commercial fishery (Matos-Caraballo 2009). The species was evidently heavily fished, including during its spawning periods, with smaller (immature sized) fish taken in fish traps (Sadovy and Eklund 1999). During the early 1980s, landings declined and, by 1988-1989, Nassau grouper, the dominant commercial grouper since the 1950s, was rare and represented only two percent of all grouper landings and 0.2 percent of all demersal fish species (Tonioli and Agar 2011). It was considered extinct commercially before 1990 (Matos-Caraballo 2009); although the species still appears in landings reports where it averaged approximately 11,000 pounds a year from 1994-2006.

Similar long-term declines were seen in commercial landings from Puerto Rico and the USVI. Commercial landings of Nassau grouper in Puerto Rico represented a major component of the fishery in the late 1800s (Nichols 1929) but declined to an insignificant component by the 1990s. Appeldoorn et al. (1992) reported that Nassau grouper accounted for 141 out of 26,294 total fishes sampled in 1985 and only 38 out of 26,054 fish sampled in 1990 (Bohnsack 2003).

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. NMFS then reinitiated consultation again for the Spiny Lobster and Reef Fish FMPs on September 26, 2016 because of the 2014 listing of pillar, rough cactus, lobed star, mountainous star, and boulder star corals. On January 19, 2016, NMFS determined the authorization of fishing managed by the Spiny Lobster and Reef Fish FMPs was not likely to adversely affect these corals.

Globally, 6.4 million tons of fishing gear is lost in the oceans every year (Wilcox et al. 2015). Marine mammal and sea turtle entanglement and bycatch is a global problem that every year results in the death of hundreds of thousands of animals worldwide. Entrapment and entanglement in fishing gear is a frequently documented source of human-caused mortality in cetaceans (see Dietrich et al. 2007). Materials entangled tightly around a body part may cut into tissues, enable infection, and severely compromise an individual's health (Derraik 2002). Entanglements also make animals more vulnerable to additional threats (e.g., predation and vessel strikes) by restricting agility and swimming speed. The majority of marine mammals that die from entanglement in fishing gear likely sink at sea rather than strand ashore, making it difficult to accurately determine the extent of such mortalities. In excess of 97 percent of entanglement is caused by derelict fishing gear (Baulch and Perry 2014).

Marine mammals are also known to ingest fishing gear, likely mistaking it for prey, which can lead to fitness consequences and mortality. Necropsies of stranded whales have found that ingestion of net pieces, ropes, and other fishing debris has resulted in gastric impaction and ultimately death (Jacobsen et al. 2010). As with vessel strikes, entanglement or entrapment in fishing gear likely has the greatest impact on populations of ESA-listed species with the lowest abundance (e.g., Kraus et al. 2016). Nevertheless, all species of marine mammals may face threats from derelict fishing gear.

In addition to these direct impacts, cetaceans may also be subject to indirect impacts from fisheries. Reductions in fish populations, whether natural or human-caused, may affect the survival and recovery of ESA-listed marine mammal populations. Even species that do not directly compete with human fisheries could be indirectly affected by fishing activities through changes in ecosystem dynamics (Garcia et al. 2003). However, in general the effects of fisheries on whales through changes in prey abundance remain unknown in the action area.

Fishery interaction remains a major threat to sea turtle recovery. Wallace et al. (2010) estimated that worldwide 447,000 sea turtles are killed each year from bycatch in commercial fisheries. Although sea turtle excluder devices and other bycatch reduction devices have significantly reduced the level of bycatch of sea turtles and other marine species in U.S. waters, mortality still occurs.

Fishers from certain ports off the main island, especially those located in the southwest quadrant, have larger vessels and land larger quantities of mainly deep-water snappers (Tonioli and Agar 2011), while high liners in ports may land large quantities of mainly queen conch (*Strombus gigas*), but these fishers represent the exception in what is effectively a small-scale fishery.

Directed harvest of sea turtles and their eggs for food and other products has existed for years and was a significant factor causing the decline of several species, including the green turtle, hawksbill turtle, Kemp's ridley turtle, leatherback turtle, and loggerhead turtle considered in this consultation. In the U.S., the harvest of nesting sea turtles and eggs is now illegal; however, poaching is a problem on some beaches (Ehrhart and Witherington. 1987). Nesting adults and eggs continue to be harvested legally and illegally in other nations (Benson et al. 2007; Benson et al. 2011). There has been a dramatic decrease in poaching of eggs and slaughter of nesting females due to the presence of sea turtle community groups since 2012, although it is possible some poaching is occurring undetected. However, inwater feeding areas still suffer from poaching. For example, in 2018, slaughtering of hawksbill was recorded in several keys off the south coast of Puerto Rico (C. Diez, Programa de Especies Protegidas-DRNA-PR, pers. comm. to P. Opay, NMFS SERO PRD, March 27, 2019; SERO 2020).

Several examples of sea turtle poaching in areas near the action area have occurred over the past two decades. In 2013 a man plead guilty to felony violation of the Lacey Act for illegal sale of sea turtle meat and carapaces from endangered hawksbill sea turtles (*Eretmochelys imbricata*) and meat from a threatened green sea turtle (*Chelonia mydas*), while knowing that the sea turtles had been taken in violation of the ESA. The illegal sales took place in 2009-2010 around Playa Añasco. The case resulted from a joint-undercover operation by the NOAA Office of Law Enforcement and the Federal Bureau of Investigation (U.S. DOJ 2013). Furthermore, in July 2013, eight people were arrested in Puerto Rico on charges of selling endangered sea turtles for human consumption. The suspects were involved in selling the meat of 15 hawksbill turtles and seven green turtles, an undercover operation revealed (Gannon 2013).

7.4 Vessel Operation and Traffic

Potential sources of adverse effects from federal vessel operations in the action area include operations of NOAA vessels, anchor and propeller damage and accidental groundings. 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 SEFSC lead the NOAA NCRMP efforts that take place every two years at randomly selected sampling sites around Puerto Rico. NMFS OPR completed a programmatic ESA section 7 consultation for NOAA's CRCP for coral restoration, monitoring, and other activities that receive some or all CRCP funding (NMFS 2022b). EPA conducts coral surveys at different locations around Puerto Rico, often annually. In the past, EPA used a large research vessel to complete these surveys. However, the agency no longer owns the vessel so coral survey operations are done using smaller motorized vessels, typically through rental agreements with local operators. EPA has not initiated an ESA section 7 consultation for their coral survey program at this time.

NMFS and the USCG completed an informal programmatic section 7 consultation for the Caribbean Marine Event Program for marine events in USVI and Puerto Rico in December 2017. As a result of this consultation, the USCG includes guidelines to avoid and minimize potential impacts of marine events, especially events involving motorized vessels such as speedboat races, to ESA-listed species and their habitat as permit conditions the event participants must follow. NMFS has also completed a national programmatic formal consultation with the USCG to cover maintenance of federal ATONs throughout Puerto Rico and the entire U.S, and recently reinitiation this consultation. 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. ATONs are present in some portions of the action area, particularly ports and dock areas.

Through the ESA section 7 process, where applicable, NMFS will establish RPMs and/or federal agencies will propose conservation measures for vessel operations to avoid or minimize adverse effects to proposed and ESA-listed species in the action area from vessel transit, anchoring, and other vessel operations. However, vessel operations do present the potential for some level of interaction with proposed and ESA-listed species in the action area.

Commercial and recreational vessel traffic can have adverse effects on sperm whales, ESA-listed sea turtles and corals and their habitat via propeller injuries and boat strike injuries (turtles), and accidental groundings, propeller scarring, and propeller wash (corals, mollusks, and habitat for sea turtles and corals). NMFS did not find records of vessel collisions with sperm whales but, because deeper waters of the action area include routes for shipping traffic, there is a possibility of vessel collision, some of which may be unreported. PRDNER stranding data indicate that 13 green sea turtles and 16 hawksbill sea turtles could be confirmed to have been impacted by boats in the action area from 1989-2009. 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. The action area also includes the east coast of Puerto Rico where port and marina expansion and dock construction occur and other areas around Vieques that are not federally managed. As part of the section 7 consultation 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 marine mammals, sea turtles, and fish and any measures to avoid and minimize injurious and behavioral acoustic impacts to these animals.

Commercial and recreational vessel traffic in the action area is also associated with commercial and private diving activities. There are several areas around Culebra that are visited by commercial dive operations from Culebra and the east coast of Puerto Rico and by private individuals. Anchoring of these vessels at reef sites can lead to impacts to corals and habitat used by proposed and ESA-listed sea turtles, corals, and queen conch.

Vessel strikes are a poorly-studied threat to sea turtles, but have the potential to be highly significant given that they can result in serious injury and mortality (Work et al. 2010). All sea turtles must surface to breathe and several species are known to bask at the sea surface for long periods. Although sea turtles can move somewhat rapidly, they apparently are not adept at avoiding vessels that are moving at more than four kilometers per hour (2.6 knots); most vessels move far faster than this in open water (Hazel and Gyuris 2006; Hazel et al. 2007; Work et al. 2010). Both live and dead sea turtles are often found with deep cuts and fractures indicative of a collision with a vessel hull or propeller (Hazel et al. 2007). Hazel et al. (2007) suggests that green turtles may use auditory clues to react to approaching vessels rather than visual cues, making them more susceptible to vessel strike or vessel speed increases.

7.5 Research Activities

Regulations developed under ESA section 10(a)(1)(A) allow for the issuance of permits authorizing take of certain ESA-listed species for the purpose of scientific research. The impacts of these research activities pose both benefits and risks. In the short term, adverse effects to ESA-listed marine mammals and sea turtles may occur in the course of scientific research. However, these activities have a great potential to benefit ESA-listed species in the long-term. Most importantly, the information gained during research and monitoring activities can assist in planning for the recovery of listed species. Information obtained from scientific research is essential for understanding the status of ESA-listed species, obtaining specified critical biological information, and achieving species recovery goals.

Prior to issuance of any section 10 permit, the proposal must be reviewed for compliance with section 7 of the ESA. Sperm whales, sea turtles, and elkhorn and staghorn corals have “take” prohibitions due to their listing as endangered or the promulgation of a 4(d) rule. For elkhorn and staghorn coral, the 4(d) rule enables permits issued by the Commonwealth to be used in lieu of section 10 permits issued by NMFS for export or take resulting from conducting scientific research or enhancement directed at these two coral species (50 CFR 223.208(c)(1)). PRDNER has coral monitoring sites around Culebra that have been funded by a section 6 grant, as well as by NOAA's CRCP. PRDNER has also held permits from NMFS for conducting research on various life stages of green and hawksbill sea turtles at locations around Puerto Rico, including Culebra. NMFS SEFSC has also held permits from NMFS OPR for conducting research on all ESA-listed sea turtle species in the Atlantic Ocean, Gulf of Mexico, and the Caribbean Sea, though the majority of their research is not conducted in the U.S. Caribbean.

In addition to authorization under the ESA, the MMPA requires that researchers obtain authorization for directed and incidental take of marine mammals. The issuance of these authorizations (under both the ESA and MMPA), often require section 7 consultation with NMFS OPR by the NMFS Permits and Conservation Division so many of the permits identified above have also undergone section 7 consultation.

MMPA authorizations in the action area include one for the Navy (that expired in July 2019) to conduct research on marine mammals, including sperm whales, in the Atlantic Ocean, Caribbean Sea, Gulf of Mexico, and Sargasso Sea, and an incidental take authorization for the SEFSC to take marine mammals incidental to fisheries research in the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea.

CRCP has also funded survey work by NCCOS to evaluate benthic habitats and fish in areas around Culebra. In addition, the NCRMP randomly selects sites to survey every other year in Puerto Rico and sites can include areas around Culebra or off the east coast of Puerto Rico that are within the action area. However, survey work by NCCOS and under the NCRMP is non-intrusive so impacts to proposed and ESA-listed species, particularly sea turtles, corals, and mollusks, if they occur at all, would be minor and short-term from diver operations.

7.6 Coastal and Marine Development

Anthropogenic sources of marine pollution, while difficult to attribute to a specific federal, state, local, or private action, may indirectly affect sea turtles, queen conch, ESA-listed fishes and corals, and elkhorn and staghorn coral critical habitat in the action area. Because sperm whales are not permanent residents in the action area and are an offshore species, these effects are not likely to be measurable for this species.

Sources of pollutants in the action area include atmospheric loading of pollutants, stormwater runoff from coastal towns, and runoff into water bodies that empty into bays and groundwater. However, because the project is located within the Culebra NWR, development has not occurred in this area. Development is not expected to occur in the future in areas of FUDS Culebra where waters are adjacent to lands managed within the Culebra NWR.

A study of abandoned road segments in Culebra found the average sediment production rate was 0.84 megagram per hectare (0.37 tons per acre) per year and the range of observed values was 15 to 50 times higher than measured erosion rates from undisturbed areas with similar soil and slope characteristics (Ramos-Scharrón 2018). Areas with higher slopes had greater annual erosion rates. Yuan et al. (2015) found that, in watersheds with high percentages of natural vegetation cover, suspended sediment loading was low even in areas with steep terrain during events with high rainfall. Sediment eroded from mountainous areas and deposited downstream during the period of clearing of large areas of land for agriculture and later for urban development is still being transported in rivers to nearshore waters. Nitrogen and phosphorus concentrations in river waters may be within regulatory limits but are ten times greater than estimated presettlement levels and fecal coliform and fecal streptococcus concentrations in many rivers are at or above regulatory limits (Larsen and Webb 2009). There is evidence of strong gradient impacts associated to sediment- and nutrient-laden runoff pulses, in combination with sewage pollution pulses in Culebra. Water quality studies by Hernández-Delgado et al. (2009) showed both significant spatial and temporal fluctuations, largely responding to heavy rainfall and subsequent runoff pulses. Hernández-Delgado et al. (2009) note that a lack of sewage treatment facilities in Culebra have resulted in a proliferation of poorly designed and constructed septic tanks, septic tanks constructed below the coastal water table, and numerous illegal raw sewage discharges to stormwater sewers and culverts. Another study noted, the Cabra subwatershed is a significant source of fecal pathogens and nutrients from the Culebra wastewater treatment plant. Electricity is used to pump and process sewage at the wastewater treatment plant. Thus, when the electrical grid is down sewage is not adequately treated (if at all) and is subsequently discharged directly to Ensenada Honda where it directly impacts seagrass and coral reef habitats (Protectores de Cuencas 2017).

Coastal runoff, marina and dock construction, dredging, increased underwater noise, and boat traffic can degrade marine habitats used by sea turtles, queen conch, and ESA-listed corals. Many of these activities will be limited in areas of Culebra FUDS, because they comprise parts of the Culebra NWR, but other locations in the action area, such as along the east coast of Puerto Rico and in the town in Culebra, have been experiencing increases in in-water construction and boating. In addition, the departure of the Navy from Vieques and closure of the Roosevelt Roads Naval Station has resulted in an increase in tourism development on the island, including hotels, houses, and marine facilities. An increase in the number of docks built increases boat and vessel traffic. Fueling facilities at marinas can sometimes discharge oil, gas, and sewage into sensitive coastal habitats. Although these contaminant concentrations do not likely affect the more pelagic waters, the species of sea turtles analyzed in this opinion travel between nearshore and offshore habitats and may be exposed to and accumulate these contaminants during their life cycles.

There have been 10 accounts of undocumented immigrant landings in Culebra and Desecheo over the past five years (four landings in Desecheo and six in Culebra). Landing events on Desecheo have included the use of 6.7 to 8.5 meter (22 to 28 foot) fishing boats made out of wood and, on Culebra, the use of power boats has been observed. The boats on Desecheo are usually destroyed on site or sunk (E. Colon, U.S. Border Patrol pers. comm. to R. Driskell, NMFS, January, 26, 2023). These activities increase beach pollution and could impact sea turtle nesting.

7.7 Natural Disturbance

Hurricanes and large coastal storms can significantly alter habitats used by ESA-listed sea turtles and corals. As discussed in section 7.2 climate change is also expected to increase the frequency of extreme weather and climate events including, but not limited to, hurricanes/cyclones, tropical storms, heat waves, and droughts (IPCC 2014). In addition, early life stages of sea turtle species can be transported by currents and waves to areas that are not suitable for the animals or where they cannot find adequate food, leading to mortality. Waves and currents can also cause breakage and overturn coral colonies, as well as deposit sediment and debris on colonies, leading to breakage and abrasion.

Historically, large storms potentially resulted in asexual reproductive events, particularly for branching coral species, if the fragments encountered suitable substrate, attached, and grew into new colonies. However, recently, 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, during years with high sea surface temperatures, as they lower temperatures providing fast relief to corals during periods of high thermal stress (Heron et al. 2008). This reduction in temperature also benefits hawksbill sea turtles because the sponge species they prefer to eat can suffer from thermal stress and bleach or die.

Between 1867 and 2022, Puerto Rico received the direct impact of 30 hurricanes, including nine major hurricanes above category 3. Major hurricanes have caused significant losses in coral cover and changes in the physical structure of many reefs in Puerto Rico, as well as loss or damage to seagrass beds from blowouts and sediment movement. Tropical storms and hurricanes can result in severe flooding, leading to significant sediment transport to nearshore waters from terrestrial areas, as well as shifting of marine sediments. In addition to affecting sessile benthic organisms such as ESA-listed corals, 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.

Based on NOAA hurricane data and data from the Federal Emergency Management Agency, there have been a total of 11 hurricanes and tropical storms that have affected Puerto Rico between 1975 and 2017. Hurricane David in 1979 caused extremely violent sea conditions along the south coast of the island and severe flooding across the island and on associated islands including Culebra. Hurricane David was followed five days later by Tropical Storm Frederick resulting in additional flooding. Hurricane Hugo in 1989 also led to violent sea conditions and major flooding across the island and associated islands. Hurricanes Marilyn (in 1995) and Hortense (in 1996), though not as intense, led to additional impacts to reefs and seagrass beds already suffering damage from Hurricane Hugo. When Hurricane Georges hit Puerto Rico in 1998, many nearshore marine habitats had already been impacted by previous storms and associated land-based sources of pollution due to flooding. Hurricane Irene in 2011 affected the north and northeast coasts of Puerto and associated islands including Culebra through extremely violent sea conditions and flooding.

Hurricanes Irma and María damaged shallow coral reefs and seagrass habitats across the northeastern Caribbean region, including Culebra Island, Puerto Rico. At its closest point to Culebra, the eyewall of category 5 Hurricane Irma passed just 20 kilometers (12.4 miles) off the north coast on September 6, 2017, with sustained winds of 300 kilometers per hours (186 miles per hour), and estimated gusts of up to 360 kilometers per hour (223.7 miles per hour; Cangialosi et al. 2018). On September 20, 2017, Hurricane Maria was also a category 5 hurricane at its closest point to Culebra, at approximately 32 km south of the island, with sustained winds of 280 kilometers (174 miles) per hour, and estimated gusts over 320 kilometers per hour (198.8 miles per hour; Pasch et al. 2018). Wave action exceeded 10 meters (32.8 feet) around Culebra during both hurricanes, which resulted in severe impacts to exposed shallow coastal ecosystems (Toledo-Hernández et al. 2018). Also, rainfall was estimated to range from 250 to 750 millimeters (9.8 to 29.5 inches) across the eastern Puerto Rico region.

In 2017, when Hurricanes Irma and Maria, categories 5 and 4, respectively, reached Puerto Rico, they significantly changed the landscape as intense winds, heavy rainfall, storm surge, and riverine flooding damaged vegetation and infrastructure throughout the archipelago. Hurricane Maria was the strongest storm to hit Puerto Rico since 1992, bringing maximum sustained winds of 135 knots, 96.5 centimeters (38 inches) of rain, flooding up to 1.5 meters (five feet) above ground level, and 2.7 meters (nine feet) of storm surge. The storms also led to high levels of damaged coral, particularly along the northeast (including Culebra and Vieques), north, and west coasts of the island (NOAA 2018b), where the strongest waves occurred.

Severe damage to nearshore coral and seagrass habitats also occurred due, in part, to the debris and contaminants generated by the storm and transported to nearshore waters (Norat-Ramírez et al. 2019; Toledo-Hernández et al. 2018). Hurricane damage, including destabilized, broken, and loose corals, was observed at approximately 12 percent of shallow reefs assessed in Puerto Rico. Damage varied between geographic regions, sites, and species. The most severely impacted coral species included four listed as threatened under the ESA: pillar, elkhorn, lobed star, and staghorn corals. Considerable variability was observed between assessment sites in the extent of wave impacts to corals and reefs, likely due to reef exposure to the dominant wave energy and coral species, abundance, size, and morphology (Viehman et al. 2020). Based on the random transect surveys, coral reef sites that experienced the most severe damage were found in the Northeast (including Culebra), North, Vieques, and West regions. Based on the roving diver surveys, which were specifically targeted to find damage, the Northeast, North, Vieques, and West regions all sustained approximately twice the amount of damage than the Southeast and Southwest. In March 2019, 1,200 corals were reattached in Culebra, Puerto Rico by the NOAA Restoration Center as part of a project for addressing physical impacts on coral reefs. This stabilization effort took place 18 months after the storms affected the islands, indicating that viable corals may be available for some time after an incident, although this depends on subsequent wave energy (Viehman et al. 2020).

In 2022, Hurricane Fiona hit southwestern Puerto Rico, made landfall in Cabo Rojo with 140 kilometers per hour (85 miles per hour) winds on September 18. The storm caused flooding across the island, which still had not recovered from 2017's Hurricane Maria, leading to millions of dollars in economic damage and leaving hundreds of people homeless. Some areas and cities received up to 55.9 centimeters (22 inches) of rain in a few hours. The entire island lost power. At time of writing this opinion, the full economic damages and impacts had not been assessed.

7.8 Disease and Non-native Species Introductions (Corals)

A disease known as fibropapillomatosis is a major threat to green turtles in some areas of the world. Fibropapillomatosis is characterized by tumorous growths, which can range in size from very small to extremely large, and are found both internally and externally. Large tumors can interfere with feeding and essential behaviors, and tumors on the eyes can cause permanent blindness (Foley et al. 2005). Fibropapillomatosis was first described in green turtles in the Florida Keys in the 1930s.

Puerto Rico has the most long-term data on fibropapillomatosis incidence in the Caribbean, with 24 years of information (Patrício et al. 2011; Patricio et al. 2017). Fibropapillomatosis tumors were officially reported in 1985 at several locations within the main coast of PR. A total of 840 cases of green turtles have been reported as stranding since 1985. From those, 268 (32 percent) had fibropapillomatosis tumors (Diez and Patrício 2016). Efforts to study fibropapillomatosis prevalence have been concentrated in the Culebra Archipelago (located 17 kilometers [10.5 miles] off the east coast of PR), where there are two high density foraging aggregations of juvenile green turtles with high recapture rates, and a CMR program has been ongoing for 18 years (1997 – 2014). Molecular studies and long distance tag recoveries indicate that these aggregations are mixed stocks from rookeries of the Wider Caribbean (Velez-Zuazo and Kelez 2010). From 2000 to the present, multifactorial studies have been conducted at two specific study sites within the Culebra Archipelago (i.e., Puerto Manglar and Tortuga Bay-Culebrita cay) to measure several aspects of fibropapillomatosis in immature green turtles. Captures ranged in size from 26.0 to 81.0 centimeters SCL (10.2 to 31.9 inches; mean = 53.3 centimeters [21 inches]; SD = 11.7 [4.6 inches], n = 765), indicating a juvenile and sub-adult aggregation (Diez and Patrício 2016; Patrício et al. 2011; Patricio et al. 2017).

Studies on blood chemistry and fibropapillomatosis pathology were published by Kang et al. (2008) and Page-Karjian et al. (2012). One of the most significant results of these studies was the presence of the virus in non-tumored turtles (Page-Karjian et al. 2012). Ongoing analyses on fibropapillomatosis dynamics at Culebra's aggregations indicate that smaller turtles (< 40 cm [15.7 inches] SCL) do not exhibit fibropapillomatosis tumors and mid-sized turtles (~ 50–60 cm [19.7 to 23.6 inches] SCL) are the most affected (Patrício et al. 2016). Over 15 years of fibropapillomatosis presence (2000 onwards), 59 percent of the turtles with fibropapillomatosis were only mildly affected, 36 percent moderately, and only 6 percent had severe fibropapillomatosis (Patrício et al. 2016). Additionally, a disease recovery rate of 31 percent was estimated after 1.5 – 4.0 years of tumor expression (Patrício et al. 2016). In summary, green turtles with fibropapillomatosis tumors are ubiquitous in the Greater Caribbean, but information on prevalence is scarce. Studies in Puerto Rico suggest that fibropapillomatosis is not currently a major threat to green turtle populations and that higher disease prevalence was potentially associated with human contamination.

Protectores de Cuencas Inc. helped lead efforts in Culebra to complete a community-based Watershed Management Plan, meeting EPA's nine key elements that are critical for improving water quality (also known as the EPA's A through Criteria for Watershed Planning)[1]. The effort identified over 20 sources of contamination on this small island with 1,900 residents and is working with EPA, PRASA, USDA Rural Development, and the municipality to address the sources of contamination, which include: leaking sewage, failing septic systems, an underperforming sewage treatment plant, and illicit discharges from schools, residences and businesses. As part of the implementation of the Culebra Watershed Management Plan, Protectores de Cuencas led the implementation efforts at Tamarindo Beach to stabilize bare soils and control stormwater runoff. One of the goals was to address runoff from the adjacent roads and bare soil areas prior to being discharged to the marine environment. Another organization that assisted in the project site selection and prioritization for restoration is the Society of Marine Environment. The organization and its Student Chapter (CESAM) were able to demonstrate adverse effects in the form of sedimentation on reefs from Playa Tamarindo impacting their efforts to restore coral reefs in the area through its coral farming and out-planting. The Tamarindo Grande beach project is also part of the Sustainable Forestry Network the PRDNER Bureau coordinated through the Forest Service, and program initiatives by PRDNER's Coastal

[1] See https://www.epa.gov/sites/default/files/2015-12/documents/watershed_mgmnt_quick_guide.pdf for more information on the EPA's nine key elements for improving water quality.

Zone Management Division. The project also had the endorsement of the Puerto Rico Tourism Company. Funding for this project came from the NOAA CRCP.

7.9 Pollutants

In 1909, portions of the Culebra archipelago were designated as a wildlife reserve in accordance with an executive order from President Theodore Roosevelt. Administration of the Culebra lands was the responsibility of the U.S. Navy, and the wildlife reserve designation was subject to naval and lighthouse purposes. Several of the small islands of the archipelago, as well as the Flamenco Peninsula, were used for gunnery and bombing practice by the U.S. Navy and Marine Corps until their departure in 1976. The following year, portions of the Navy-administered lands were transferred to the Commonwealth of Puerto Rico and jurisdiction over other portions was transferred to the USFWS. On-site administration of the refuge was established in 1983. Approximately one-quarter of the Culebra archipelago's total land mass is now included within the refuge.

Activities that may result, or may have already resulted, in marine pollution in the action area include those related to military practices and cleanup activities to remove surface and subsurface MEC/MPPEH from land and water, which are discussed in Section 3. Since Culebra and Desecheo Islands became included in the FUDS program, the USACE and its contractors have conducted various terrestrial detonations on the beaches of Culebra and Desecheo. To the extent practicable, post-detonation sampling has been required to confirm that no unacceptable impacts to human or ecological receptors have occurred from MEC/MPPEH/MD contaminant release. MEC/MPPEH/MD contaminants from terrestrial detonations are discussed further in Section 8.1.9. In addition to terrestrial detonations, only a limited number of underwater detonations have occurred within the Culebra MRSs since Culebra became included in the FUDS program. MEC/MPPEH items in Culebra have led to at least three detonation events within and near the water in 2015, 2014, and 2013 but these events were separate from the USACE FUDS operations. The 2015 event occurred off Carlos Rosario but the MEC/MPPEH item contained no explosive filler. The 2014 detonation event occurred when a snorkeler discovered a 45.36 kilogram (100 pound) bomb off the coast of Flamenco Beach in Culebra's MRS 03. A Navy EOD team detonated the bomb in shallow water (Ellison 2014). In 2013, a young girl was exposed to white phosphorous from a MEC/MPPEH item in an onshore area on Flamenco Beach (Mayfield 2022). There have been no confirmed reports of injuries to NMFS ESA-listed species as a result these detonation events in and around Culebra and Desecheo.

Coastal and stormwater runoff, marina and dock construction, dredging, PCB loading, and groundwater and other discharges can degrade marine habitats. The development of marinas and docks in inshore waters can negatively impact nearshore habitats. An increase in the number of docks built increases boat and vessel traffic. Fueling facilities at marinas can sometimes discharge oil, gas, and sewage into sensitive estuarine and coastal habitats. Although these contaminant concentrations do not likely affect the more pelagic waters where sperm whales are located, the species of sea turtles, Nassau grouper, and juvenile scalloped hammerhead analyzed in this biological opinion travel between nearshore and offshore habitats and may be exposed to and accumulate these contaminants during their life cycles.

There are studies on organic contaminants and trace metal accumulation in green and leatherback sea turtles (Aguirre et al. 1994). Further, omnivorous loggerhead turtles had the highest organochlorine contaminant concentrations in all the tissues sampled, including those from green and leatherback turtles (Storelli et al. 2008). It is thought that dietary preferences were likely to be the main differentiating factor among species. Decreasing lipid contaminant burdens with turtle size were observed in green turtles, most likely attributable to a change in diet with age.

In addition to sea turtles, the proximity of coral and queen conch habitat to coastal areas in the action area subjects these proposed and ESA-listed species to impacts from multiple activities including dredging and disposal activities, stormwater runoff, 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 proposed and threatened species to successfully sexually and asexually reproduce.

7.10 Marine Debris

Marine debris is an ecological threat that is introduced into the marine environment through ocean dumping, littering, or hydrologic transport of these materials from land-based sources (Gallo et al. 2018). Even natural phenomena, such as tsunamis and continental flooding, can cause large amounts of debris to enter the ocean environment (Watters et al. 2010). Marine debris has been discovered to be accumulating in gyres throughout the oceans. Marine mammals often become entangled in marine debris, including fishing gear (Baird et al. 2015). Despite debris removal and outreach to heighten public awareness, marine debris in the environment has not been reduced (NRC 2008) and continues to accumulate in the ocean and along shorelines within the action area.

Derelict and illegal fishing traps are a prevalent problem in nearshore waters around Puerto Rico. These traps can cause physical damage to sensitive habitats, such as coral reefs, while trapping and killing target and non-target organisms, including endangered and protected species. In 2020 to combat this problem, the Ocean Foundation and Conservacion ConCiencia collaborated with the local fishing industry to remove derelict fishing gear, particularly lobster and fish traps, from waters around Eastern Puerto Rico including Culebra. During removal activities, valuable data on the location, weight of debris, cost of gear, disposal of gear, type of gear, and species captured by lost traps were recorded. The NOAA Marine Debris Program provided $150,000 in federal funding under the Community Based Removal funding mechanism under Grant ID:NA20NOS9990019 from November 2020 to October 2022.

Throughout the Caribbean, there are threats to wildlife include habitat loss, degradation and alteration, and increasing levels of pollution. Marine debris poses a threat to species that nest on sandy shorelines such as plovers and other shorebirds, as well as to seabirds when nesting on offshore cays and feeding in offshore waters. Marine debris is also a threat to sea turtles hatchlings when emerging from the nest and entering the surrounding waters.

Marine debris affects marine habitats and marine life worldwide, primarily by entangling or choking individuals that encounter it (Gall and Thompson 2015). Entanglement in marine debris can lead to injury, infection, reduced mobility, increased susceptibility to predation, decreased feeding ability, fitness consequences, and mortality for ESA-listed species in the action area. Entanglement can also result in drowning for air breathing marine species including marine mammals and sea turtles. The ingestion of marine debris has been documented to result in blockage or obstruction of the digestive tract, mouth, and stomach lining of various species and can lead to serious internal injury or mortality (Derraik 2002). In addition to interference with alimentary processes, plastics lodged in the alimentary tract could facilitate the transfer of pollutants into the bodies of whales and dolphins (Derraik 2002). Law et al. (2010b) presented a time series of plastic content at the surface of the western North Atlantic Ocean and Caribbean Sea from 1986 through 2008. More than 60 percent of 6,136 surface plankton net tows collected small, buoyant plastic pieces. Data on marine debris in the action area is largely lacking; therefore, it is difficult to draw conclusions as to the extent of the problem and its impacts on populations of ESA-listed species in the Atlantic Ocean, but we assume similar effects from marine debris documented within other ocean basins could also occur to species from marine debris.

Cetaceans are also impacted by marine debris, which includes: plastics, glass, metal, polystyrene foam, rubber, and derelict fishing gear (Baulch and Perry 2014). Over half of cetacean species (including sperm whales) are known to ingest marine debris (mostly plastic), with up to 31 percent of individuals in some populations contain marine debris in their guts and marine debris implicated as the cause of death for up to 22 percent of individuals found stranded on shorelines from one study (Baulch and Perry 2014).

Ingestion of marine debris can be a serious threat to sea turtles. When feeding, sea turtles (e.g., leatherback turtles) can mistake debris (e.g., tar and plastic) for natural food items, especially jellyfish, which are a primary prey. Some types of marine debris may be directly or indirectly toxic, such as oil. One study found plastic in 37 percent of dead leatherback turtles and determined that nine percent of those deaths were a direct result of plastic ingestion (Mrosovsky et al. 2009). Plastic ingestion is very common in leatherback turtles and can block gastrointestinal tracts leading to death (Mrosovsky et al. 2009). Other types of marine debris, such as discarded or derelict fishing gear and cargo nets, may entangle and drown sea turtles of all life stages.

Plastic debris is a major concern because it degrades slowly and many plastics float. The floating debris is transported by currents throughout the oceans and has been discovered accumulating in oceanic gyres (Law et al. 2010a). Additionally, plastic waste in the ocean chemically attracts hydrocarbon pollutants. Marine mammals, sea turtles, and fish can mistakenly consume these wastes containing elevated levels of toxins instead of their prey. It is expected that marine mammals, sea turtles, and fish may be exposed to marine debris over the course of the action although the risk of ingestion or entanglement and the resulting impacts are uncertain at the time of this consultation.

7.11 Synthesis of Baseline Impacts

Collectively, the stressors described above have had, and are likely to continue to have, lasting impacts on sperm whales; green (North and South Atlantic DPS), leatherback, and hawksbill sea turtles; Nassau grouper; queen conch (proposed); ESA-listed corals; North Atlantic DPS green sea turtle critical habitat; elkhorn and staghorn coral critical habitat; and proposed critical habitat for Nassau grouper, lobed star, mountainous star, boulder star, pillar, and rough cactus corals within the action area. Some of these stressors, such as fishing, result in mortality or serious injury to individual animals, whereas others result in more indirect (e.g., water quality degradation from coastal development) or non-lethal (e.g., research activities) impacts.

We consider the best indicator of the environmental baseline on proposed and ESA-listed resources to be the status and trends of those species. As noted in Section 6.2, some of the species considered in this consultation appear to have stable populations, others are declining, and for others, their population trends remain unknown. Taken together, this indicates the environmental baseline is affecting species in different ways. The species with stable populations are not declining despite the potential negative impacts of the environmental baseline. Therefore, while the baseline may slow their recovery, recovery is not being prevented. For the species that may be declining in abundance, it is possible that the suite of conditions described in this *Environmental Baseline* section is limiting their recovery. However, it is also possible that their populations are at such low levels (such as for Nassau grouper, which was at the level of commercial extinction by 1986 in the U.S. Caribbean) that even when the species' primary threats are removed, the species may not be able to achieve recovery. At small population sizes, species may experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their limited population size to become a threat in and of itself. A thorough review of the status and trends of each species for which NMFS has found the action is likely to cause adverse effects is discussed in *Status of Species and Critical Habitat Likely to be Adversely Affected* (Section 6.2) of this opinion.

8 EFFECTS ANALYSIS

Section 7 regulations define "effects of the action" as all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (50 CFR § 402.02).

This effects analysis section is organized following the stressor, exposure, response, and risk assessment framework described in Section 2 above.

In this section, we further describe the potential stressors associated with the proposed actions, the probability of individuals and designated and proposed critical habitat of proposed and ESA-listed species being exposed to these stressors based on the best scientific and commercial evidence available, and the probable responses of those individuals and critical habitats (given their probable exposures) based on the available evidence. For any responses that would be expected to reduce an individual's fitness (i.e., growth, survival, annual reproductive success, or lifetime reproductive success) or adversely affect the PBFs of designated or proposed critical habitat, the assessment will consider the risk posed to the viability of the population(s) those individuals comprise and to the overall conservation value of their designated or proposed critical habitat.

8.1 Discountable and Insignificant Effects

We have determined that the effects of some stressors from the proposed action (Section 5) to proposed and ESA-listed species and critical habitat will be either discountable or insignificant, and therefore are not likely to result in adverse effects. These stressors are discussed below.

8.1.1 Vessel Strikes/Equipment Collisions

Vessel operations associated with all of the activities that are part of the proposed action could lead to collisions with sperm whales and green, hawksbill, and leatherback sea turtles. There are no reports of vessel collisions with sperm whales except for a strike 20 miles south of the main island of Puerto Rico in the Caribbean Sea in 2001, which was not by a USACE vessel (Jensen et al. 2003). An analysis of known sea turtle strandings for all of Puerto Rico from 1987-2021 revealed at least four sea turtles that had injuries consistent with vessel collisions around Culebra and Fajardo and at least two off the coast of Rincón. There were no accounts of strandings from vessel collision around Desecheo (PRDNER unpublished stranding data). The USACE has been conducting in-water activities around Culebra and Desecheo Island since 1991 and has not reported sightings of sperm whales or any vessel collisions with whales or sea turtles. Furthermore, the USACE uses a suite of vessel strike avoidance measures during all of its in-water cleanup activities that include maintaining low speeds when in the vicinity of ESA-listed species and separation distances of no closer than 91.44 meters (100 yards) to whales and 45.72 meters (50 yards) to sea turtles or ESA-listed fishes. If the USACE and/or its contractors are not able to maintain these distances due to ESA-listed species approaching the vessel, vessel operators will put the engine in neutral until the animal is at least 15.24 meters (50 feet) away, and then slowly move away to the prescribed distance (USACE 2015b). Based on the implementation of these measures and the fact that, despite years of on-going investigations and cleanup activities the USACE and its contractors have not reported vessel collisions with listed species, we believe that the effects of vessel collisions associated with the proposed action on sperm whales and ESA-listed sea turtles will be extremely unlikely to occur and thus discountable and therefore not likely to adversely affect these species.

Vessel collisions are expected to have no effect on Nassau grouper and scalloped hammerhead shark because these fish do not need to surface to breathe and larger individuals that could be struck by vessels prefer to be in deeper water.

Activities associated with the location and removal of MEC/MPPEH and underwater investigations also have the potential to result in collisions with vessels and/or equipment with sperm whales, green, leatherback, and hawksbill sea turtles, Nassau grouper, queen conch, and ESA-listed corals. MEC/MPPEH items that are thought to be unstable and must be removed remotely require towing of the items. The majority of removal operations are expected to occur in nearshore waters along coastlines and within embayments where sperm whales would not be present. Sperm whales and sea turtles are expected to be observed by vessel crew members and/or divers engaged in removal activities and sea turtles are expected to move away from these activities in response to the noise and movement. Large Nassau grouper and adult scalloped hammerhead sharks are also expected to move away from the disturbance associated with removal activities, but given the rarity of large groupers and scalloped hammerhead sharks within the action area, it is unlikely that any will be present during removal activities. Vessel operators are likely to sight sharks and divers would sight sharks and grouper in the immediate area of activities and could warn personnel of their presence in order to reduce the chances of encounters between the animals and any equipment or munitions items. Juveniles of both species are more likely to be in nearshore waters but would likely swim away from any disturbance associated with removal activities.

Collisions with ROVs and remote sensing and other towed equipment are also possible. However, the USACE has been performing survey work using ROVs and towed equipment for a number of years around Culebra and Desecheo Islands and there have been no reported collisions with ESA-listed species. Also, as noted in the PDCs, if a marine mammal, sea turtle, or ESA-listed fish is closer than 45.72 meters (50 yards) to moving equipment or the project area, the equipment shall be shut down and all activities shall cease to ensure protection of the species. Underwater activities shall not resume until the marine mammal(s), sea turtle(s), or ESA-listed fish(es) have left the project area naturally. Should the animal not show signs of leaving, it will not be herded away or harassed into leaving, and the diver team will leave the location and return to complete the work later (Section 3.3.1.1). Also, the PDCs state that special attention will verifying that no proposed and ESA-listed marine species are in the area where equipment or material is expected to contact the substrate (i.e., queen conch) before that equipment/material enters the water (Section 3.3.1.1). We believe that collisions associated with MEC/MPPEH removal activities and the use of ROVs and towed equipment with sperm whales, green, leatherback, and hawksbill sea turtles, scalloped hammerhead sharks, Nassau grouper, and queen conch will be extremely unlikely to occur and thus discountable and therefore not likely to adversely affect these species.

The effects of collisions with ESA-listed corals are discussed in Section 8.2.

8.1.2 Vessel Anchoring, Beaching, Propeller Wash and Scarring, and Accidental Groundings

Vessel anchoring, beaching, propeller wash and scarring could affect in-water habitats used by green and hawksbill sea turtles, scalloped hammerhead sharks, Nassau grouper, and queen conch. This includes designated critical habitat for green sea turtles (North Atlantic DPS), proposed critical habitat for Nassau grouper, seagrass beds, and coral habitats which are abundant in the action area and are used by listed sea turtles, Nassau grouper, and queen conch. Vessel anchoring, beaching, and impacts from propellers being operated in water depths that are not appropriate for the vessel draft or in areas with coral heads close to the water surface could affect elkhorn and staghorn coral and their designated critical habitat; and lobed star, mountainous star, boulder star, pillar, and rough cactus corals and their proposed critical habitat. However, many of the vessels used by the USACE and/or its contractors in the action area have shallow drafts, and the USACE follows a number of PDCs developed in coordination with NMFS for in-water surveys to minimize potential impacts of vessel operations to benthic habitats (USACE 2015b). Section 3.3.1.8 of the PDCs in this opinion specify that vessels shall operate away from areas with corals and seagrasses and operations shall be conducted in such a manner that bottom scour or prop dredging will be avoided when corals or seagrasses are present. Furthermore, coral areas should be avoided to keep from running aground and the vessel operator should maintain a maximum safe distance, if possible, of 15.24 meters (50 feet) from coral areas. Sections 3.3.1.7 and 3.3.1.8 of the PDCs also state that vessel anchoring should be limited to sandy areas well away from corals and seagrass or mooring fields should be used. Also, beaching shall only occur in designated areas. If vessels need to anchor in seagrass areas, measures will be taken to avoid dragging the anchor across the seafloor. If anchors for mooring fields or demarcation/hazard buoys have to be installed in seagrass, a location with minimum seagrass cover will be identified for anchor installation and subsurface buoys will be installed to keep any chain slack from impacting seagrass, in addition to selecting an anchor type that minimizes impacts to seagrass habitat. Seagrass makes up approximately 26 percent of the total benthic habitat for the Culebra portion of the action area, which reduces the likelihood of seagrass overlapping with vessel anchoring, beaching, and propeller wash and scarring. We believe the effects on habitat used by green and hawksbill sea turtles, scalloped hammerhead sharks, Nassau grouper, and queen conch and green sea turtle (North Atlantic DPS) critical habitat from vessel anchoring, beaching, and propeller wash and scarring will be insignificant. Also, we believe the effects of vessel anchoring, beaching, and propeller wash and scarring on elkhorn and staghorn coral and their designated critical habitat; and lobed star, mountainous star, boulder star, pillar, and rough cactus corals and their proposed critical habitat will be discountable due to the measures that will be implemented to minimize potential impacts to coral species and their habitats. Therefore, vessel anchoring, beaching, and propeller wash and scarring are not likely to adversely affect green and hawksbill sea turtles, scalloped hammerhead sharks, Nassau grouper, queen conch, ESA-listed Atlantic/Caribbean corals, designated critical habitat for green sea turtles and elkhorn and staghorn coral critical habitat, and proposed critical habitat for lobed star, mountainous star, boulder star, pillar, and rough cactus corals.

Sperm whales do not use shallow water habitat; therefore, vessel anchoring and propeller wash and scarring will have no effect on these animals. Similarly, leatherbacks do not use nearshore benthic habitat other than as transit areas during nesting season as these animals are pelagic and forage on prey in ocean waters; therefore, vessel anchoring and propeller wash and scarring will have no effect on sperm whales and leatherback sea turtles.

A review of accidental vessel groundings in the action area from 2017 to 2022 revealed at least 59 vessel grounding incidents. This includes three off Rincón, 30 off Fajardo, and 26 off Culebra. No vessel groundings have been recorded around Desecheo. Grounding events have ranged from small motorized vessels such as jet skis to larger vessels such as tug boats and barges (NOAA Restoration Center unpublished vessel grounding data; PRDNER 2021b). While these groundings have affected ESA-listed corals, and critical habitat for green sea turtles and corals, as well as habitats used by green and hawksbill sea turtles, Nassau grouper, and queen conch, none of the vessels were associated with activities carried out by the USACE and/or its contractors in the action area. Furthermore, since the start of its cleanup activities around Culebra in 1991, the USACE and/or its contractors have not reported any accidental vessel groundings. Similarly, no accidental vessel groundings have been reported as part of work by the USACE or its contracts around Desecheo Island. We believe the effects of accidental vessel grounding associated with the proposed action on ESA-listed corals, designated critical habitat for elkhorn and staghorn coral, and proposed critical habitat for lobed star, mountainous star, boulder star, pillar, and rough cactus corals are extremely unlikely to occur and thus discountable. We also believe that the effects of vessel groundings to habitat used by queen conch, green and hawksbill sea turtles, and Nassau grouper will be insignificant given the extent of available habitat in the action area, the lack of vessel groundings by vessels engaged in work associated with the proposed action, and the required PDCs associated with vessel operation. We conclude the effects from accidental vessel grounding may affect, but are not likely to adversely affect ESA-listed and proposed species and designated and proposed critical habitat.

8.1.3 Vessel Discharges/Marine Debris

NOAA's ResponseLink (https://responselink.orr.noaa.gov) does not contain documented incidents of oil spills off the coast of Desecheo or Culebra Islands. Per NOAA's ResponseLink, the closest documented oil spill near Desecheo was 53 kilometers (33 miles) northwest of the island. This incident involved a vessel grounding in 2015 that resulted in the release of 800 gallons of diesel fuel into the marine environment. Two potential oil spill events occurred close to Culebra Island in the past decade. One was associated with a vessel collision between a pleasure craft and a fishing vessel in September 2014 with both vessels having 200 to 250 gallons of fuel on board and was not reported to have resulted in an oil spill. The other was associated with the 2017 grounding of Merchant Vessel (M/V) *Ferrel* off the coast of Vieques Island, Puerto Rico, which was lost during Hurricane Maria. The M/V *Ferrel* ended up stranded and a lightering operation was performed in February 2018 to remove approximately 7,800 gallons of fuel from the vessel's tanks in order to minimize the potential for an oil spill. No oil spills have been reported because of ongoing USACE survey and cleanup operations in and around Culebra and Desecheo Islands.

In addition to accidental spills, vessels regularly discharge into marine waters as part of normal operations. Discharges include deck runoff, leaching of antifouling products, bilgewater, and other waste streams, which vary depending on the size and type of vessel. Some of the vessels used for transit from the main island of Puerto Rico to Culebra and Desecheo Islands by the USACE and its contractors as part of the proposed action may have toilets, kitchens, showers, or other sources of discharges. The majority of vessels used to conduct the activities that are part of the proposed action are small vessels such as Boston whalers or zodiacs with only a center console. Vessel motors often discharge a small amount of petroleum products during normal operation as well. There are regulations (largely under the authority of EPA) governing the location where certain discharges, such as sanitary wastewater, may occur and required controls for some discharges that contain contaminants to minimize their release into marine waters. Vessels also generate marine debris such as lost equipment and trash that falls into the water. Because divers are used in the majority of activities that are part of the proposed action, most equipment or gear that falls in the water during operations can be retrieved. Gear and equipment is stored while underway, which also reduces the potential for items to fall into the water. Except for potential overnight stays on Desecheo Island, most work does not involve overnight stays on the water and some work is done from the shoreline. As a result, trash generation is expected to be minimal.

Based on the information above, we believe the effects of accidental spills, vessel discharges, and marine debris on sperm whales, green, leatherback and hawksbill sea turtles, scalloped hammerhead shark, Nassau grouper, queen conch, ESA-listed coral, designated critical habitat for green sea turtles and elkhorn and staghorn coral, and proposed critical habitat for Nassau grouper, and lobed star, mountainous star, boulder star, pillar, and rough cactus corals will be extremely unlikely to occur and thus discountable. Therefore, these effects may affect, but are not likely to adversely affect these species and critical habitats.

8.1.4 Noise

Vessel and equipment noise may affect ESA-listed marine mammals, sea turtles, and fishes. The effects of these noise types are discussed below and noise from nonintentional detonation and BIPs are discussed in Section 8.2.

Vessel Noise

Underwater sound from vessels is generally at relatively low frequencies, usually between five and 500 Hertz (Hz) (Hildebrand 2009; NRC 2003; Southall et al. 2017; Urick 1983; Wenz 1962). Low frequency vessel noise sources include propeller noise (cavitation, cavitation modulation at blade passage frequency and harmonics, unsteady propeller blade passage forces), propulsion machinery such as diesel engines, gears, and major auxiliaries such as diesel generators (Ross 1976). High levels of vessel traffic are known to elevate background levels of noise in the marine environment (Andrew et al. 2011; Chapman and Price 2011; Frisk 2012; Miksis-Olds et al. 2013; Redfern et al. 2017; Southall 2005). Anthropogenic sources of vessel noise from the proposed action are generated from small vessels such as Boston whalers or zodiacs.

One potential effect from vessel noise is auditory masking that can lead animals to miss biologically relevant sounds that species may rely on, as well as eliciting behavioral responses such as an alert, avoidance, or other behavioral reaction (NRC 2003; NRC 2005; Williams et al. 2015). There can also be physiological stress from changes to ambient and background noise. The effects of masking can vary depending on the ambient noise level within the environment, the received level, frequency of the vessel noise, and the received level and frequency of the sound of biological interest (Clark et al. 2009; Foote et al. 2004; Parks et al. 2010; Southall et al. 2000). In the open ocean, ambient noise levels are between about 60 and 80 dB re: 1 μPa, especially at lower frequencies (below 100 Hz; NRC 2003). When the noise level is above the sound of interest, and in a similar frequency band, auditory masking could occur (Clark et al. 2009). Any sound that is above ambient noise levels and within an animal's hearing range needs to be considered in the analysis. The degree of masking increases with increasing noise levels. A noise that is just detectable over ambient levels is unlikely to cause any substantial masking above that which is already caused by ambient noise levels (NRC 2003; NRC 2005).

The hearing range of marine mammals is highly variable and sperm whales are likely to detect a range of sounds, including motor noise from small vessels used during the proposed action. Numerous studies of interactions between surface vessels and marine mammals, sea turtles, and fishes have demonstrated that free-ranging animals engage in avoidance behavior when surface vessels move toward them. Most of the investigations reported that animals tended to reduce their visibility at the water's surface and move horizontally away from the source of disturbance or adopt erratic swimming strategies (Corkeron 1995; Lundquist et al. 2012; Lusseau 2003; Lusseau 2004; Nowacek et al. 2001; Van Parijs and Corkeron 2001; Williams et al. 2002a; Williams et al. 2002b). In the process, their dive times increased, vocalizations and surface-active behaviors were reduced (with the exception of beaked whales), individuals in groups moved closer together, swimming speeds increased, and their direction of travel took them away from the source of disturbance (Baker and Herman 1989; Edds and Macfarlane 1987; Evans et al. 1992; Kruse 1991). Some individuals also dove and remained motionless, waiting until the vessel moved past their location. Several authors suggest that the noise generated during motion is probably an important factor (Blane and Jaakson 1994; Evans et al. 1992; Evans et al. 1994). Although many studies focus on small cetaceans, studies of large whales have reported similar results for fin and sperm whales (David 2002). Sperm whales generally react only to vessels approaching within several hundred meters; however, some individuals may display avoidance behavior, such as quick diving (Magalhaes et al. 2002; Wursig et al. 1998). One study showed that after diving, sperm whales showed a reduced timeframe from when they emitted the first click than before vessel interaction (Richter et al. 2006).

Less is understood about the hearing sensitivities to anthropogenic sounds for other non-marine mammal ESA-listed species such as sea turtles, fishes, and mollusks. Given that much less is known about how they use sound, the impacts of anthropogenic sound are difficult to assess (Nelms et al. 2016; Popper et al. 2014). Nonetheless, depending on the circumstances, exposure to anthropogenic sounds may result in auditory injury; changes in hearing ability; masking of important sounds used for activities such as navigation, prey location, or predator avoidance (Piniak 2012a); behavioral responses; and other physical and physiological responses.

The functional hearing ranges of ESA-listed sea turtles are not well understood and vary by species. Piniak et al. (2016) found juvenile green and hawksbill sea turtles capable of hearing underwater sounds at frequencies of 50 Hz to 1,600 Hz (maximum sensitivity at 200 to 400 Hz). Piniak (2012a) measured hearing of leatherback sea turtle hatchlings in water and in air and observed reactions to low frequency sounds, with responses to stimuli occurring between 50 Hz and 1.6 kHz in air and between 50 Hz and 1.2 kHz in water (lowest sensitivity recorded was 93 dB re: 1 μPa at 300 Hz).

Very little research exists on sea turtle responses to vessel noise disturbance. Currently, there is nothing in the available literature specifically aimed at studying and quantifying sea turtle response to vessel noise. However, a study examining vessel strike risk to green sea turtles suggests that sea turtles may habituate to vessel sound from vessels traveling two knots or greater and may be more likely to respond to the sight of a vessel rather than the sound of a vessel, although both may play a role in prompting reactions (Hazel et al. 2007). Regardless of the specific stressor associated with vessels to which turtles are responding, they only appear to show responses (i.e., avoidance behavior) at approximately 10 meters (32.8 feet) or closer when vessels traveling at speeds two knots or greater (Hazel et al. 2007). Therefore, the noise from vessels is not likely to affect sea turtles from further distances, and disturbance may only occur if a sea turtle hears a vessel nearby or sees it as it approaches. These responses appear limited to non-injurious, minor changes in behavior based on the limited information available on sea turtle response to vessel noise.

All fish species can detect vessel noise due to its low-frequency content and their hearing capabilities. Therefore, scalloped hammerhead and Nassau grouper could be exposed to a range of vessel noises from the USACE's proposed action, depending on the source and context of the exposure. Because of the characteristics of small vessel noise, sound produced from the USACE vessels are unlikely to result in direct injury, hearing impairment, or other trauma to fishes. Moreover, fish in the near field, depending on their location in the water column, can detect water motion as well as visually locate an oncoming vessel. For example, fishes that are at or near the surface have an increased potential to detect vessels either visually, or via sound and motion in the water and would be capable of avoiding the vessel or move away from the area affected by vessel sound. Thus, these fish are more likely to react to vessel noise at close range than to vessel noise emanating from a greater distance away. Fishes that are deeper in the water column may be less likely to visually detect the vessel but would still be able to detect a vessel's low-frequency noise. Reactions to these sounds may include physiological stress responses, or avoidance behaviors that would not lead to significant disruptions to breeding, feeding, or sheltering.

Based on available information and other consultations such as those for the use of military vessels in training and testing activities, we conclude that sperm whales, green and hawksbill sea turtles, scalloped hammerhead sharks, and Nassau grouper in the action area are likely to either not react or exhibit avoidance behavior in response to vessel noise and movement. Most avoidance responses will consist of movement away from vessels, perhaps accompanied by slightly longer dives by sperm whales and turtles (NMFS 2015a). Most of the temporary changes in behavior will consist of a shift from behavioral states with low energy requirements like resting, to states with higher energy requirements like active swimming, with the animals then returning to the lower energy behavior. For behavioral responses to result in energetic costs that result in long-term harm, such disturbances need to be sustained for a significant duration or extent, which is not expected for activities that are part of this consultation due to the temporary and transient nature of vessel activities resulting from the action. Thus, we do not expect sperm whales, green, leatherback and hawksbill sea turtles, scalloped hammerhead sharks, and Nassau grouper to measurably respond to vessel noise or in ways that would significantly disrupt normal behavior patterns including breeding, feeding, or sheltering. Therefore, we believe the effects of noise from vessel operation associated with the proposed action will be insignificant and thus not likely to adversely affect these animals.

Equipment Noise

USBL acoustic positioning systems may be used by vessels to aid in navigation. These devices measure the roundtrip time it takes for a pulse of sound to travel from the source at the vessel to the sea bottom and return. When sonar is mounted to the vessel, it is called a fathometer. The typical frequency for the USBL is 21.5 kHz and the maximum source level for the device is 196 dB re: 1 µPa at one meter (3.2 feet; rms). Transducers can be classified according to their beam width, frequency, and power rating. Beam width is determined by the frequency of the pulse and the size of the transducer. In general, lower frequencies produce a wider beam and, at a given frequency, a smaller transducer produces a wider beam. Lower frequencies penetrate deeper into the water, but have less resolution at depth. Higher frequencies have a greater resolution in depth, but less range.

Remote sensing equipment will be used in some of the activities that are part of the proposed action, such as underwater investigations of the location of suspected MEC/MPPEH. This equipment includes side-scan sonar, multibeam echosounders, and altimeters, which the USACE notes will be operated in a frequency range of 230 to 900 kHz. Surveys will be conducted over several days to weeks along transects in different locations within the action area so exposure to sound from these surveys is temporary. Remote sensing equipment is also used to reacquire the location of suspected MEC/MPPEH as part of removal activities. The use of equipment for this purpose is even shorter term than for surveys.

Sperm whales have a generalized hearing range of 150 Hz to 160 kHz (NMFS 2018a). While this hearing range overlaps with the USBL, this source is not likely to result in noise that would significantly disrupt normal behavior patterns, especially because vessels will maintain a separation distance of 91.44 meters (100 yards) from sperm whales. ESA-listed sea turtles and fishes are not expected to detect signals emitted by navigational or remote sensing equipment. The operating frequency range is well outside the hearing range of sea turtles, which appears to be 1,600 Hz (Piniak et al. 2016). The vast majority of fish species studied cannot hear sounds above 0.5-1.5 kHz (BOEM 2014). Fishes with swim bladders that do not extend forward to the inner ear (e.g., Nassau grouper) and fishes without swim bladders (e.g., scalloped hammerhead sharks) have lower hearing frequency ranges and are not expected to detect signals emitted by USACE navigational or remote sensing equipment. Therefore, we believe the effects of sound from the USACE's use of navigation and survey equipment on sperm whales, green, leatherback and hawksbill sea turtles, scalloped hammerhead sharks, and Nassau grouper will be insignificant and thus not likely to adversely affect these animals.

The installation of in-water structures such as buoys and associated anchor systems will also result in temporary impacts associated with noise. This noise is generated by coring and drilling equipment used to bore holes in hard substrate to install anchor pins and hydraulic jacks used to install Manta Ray® anchors in sand and other unconsolidated bottom substrates. Anchor pins are installed using a hydraulic drill or corer with a diameter up to four inches. Hydraulic jacks used to push Manta Ray® anchors into the sediment may generate more noise than drills used to install anchor pins and the noise may last up to an hour, depending on the depth to which the anchors are being installed. Noise produced by hydraulic drills used in underwater construction ranges from 164.2 to 179.2 dB re: 1 µPa at one meter (3.2 feet; rms) reported for sound pressure levels examined at frequency bands of 50-1000 Hz and 100-400 Hz (Reine et al. 2014). However, none of the sound produced by the installation of anchors for in-water structures will be of long duration and the frequencies and source levels are not expected to cause anything other than temporary disturbance of animals, including green, leatherback and hawksbill sea turtles, scalloped hammerhead shark, and Nassau grouper. None of the structures are expected to be installed in deeper waters so sperm whales will not be affected by noise associated with the installation of in-water structures. We believe the effects to green and hawksbill sea turtles, scalloped hammerhead shark, and Nassau grouper from the noise associated with the installation of in-water structures, including drilling and coring and the use of a hydraulic jack, will be insignificant and thus not likely to adversely affect these animals.

8.1.5 Entanglement

Desecheo Island's MRS 01 and portions of MRS 02 in the Culebra action area are the only locations where activities may potentially overlap with sperm whales due to the water depth. However, cleanup activities are confined to the marine environment out to the 36.6 meter (120 foot) depth contour (USACE 2022b) where sperm whales are rarely found. Activities such as investigations using towed equipment and removal activities requiring remote lifting and tow of suspected munitions items could pose an entanglement risk to sperm whales, but minimum vessel separation distances of 91.44 meters (100 yards) from whales makes it unlikely that sperm whales will become entangled in lifting or towing gear.

Several of the activities that are part of the proposed action will result in lines in the water that could pose an entanglement risk for green, hawksbill, and leatherback sea turtles. Based on a review of unpublished sea turtle stranding data for Puerto Rico from 1989-2021 (PRDNER), dead sea turtles have been found entangled in fishing nets and line and abandoned cargo nets. Also, one stranding in 2005 was attributable to a juvenile green sea turtle with fibropapillomatosis entangled in a buoy line off the coast of Culebra. No entanglement of leatherback or hawksbill sea turtles in buoy lines were recorded in stranding data (PRDNER). While green sea turtles with fibropapillomatosis may have a higher risk of entanglement due to reduced swimming ability or skewed vision (Page-Karjian 2019), instances of this disease are rare in Puerto Rico and have declined over the past few years (Muñoz Tenería et al. 2022; Patrício et al. 2016). Also, per the PDCs, the USACE will avoid seagrass habitat to the extent possible for anchor installation, further reducing the risk of potential overlap of green sea turtles with buoy lines. Further, if anchors are placed in seagrass areas, subsurface buoys will be installed, reducing chain slack and entanglement risk. Therefore, we believe the effects to sperm whales, and green, leatherback, and hawksbill sea turtles from entanglement in towlines and lines associated with in-water structures will be discountable and, thus, not likely to adversely affect these animals.

Fish entanglement in tackle associated with the installation of in-water structures and towing of munitions items, which takes place near the water surface, have not been reported. These activities are not expected to result in encounters with ESA-listed fish, which will swim away from the disturbance.

Adult queen conch bury themselves into sediment and juveniles are only found in nearshore environments extremely close to shore where the risk of entanglement is not present. As a result, entanglement stressors from the proposed action will have no effect on queen conch.

Entanglement in lines associated with towed equipment and in-water structures could result in breakage and abrasion of ESA-listed coral colonies and reef/hard substrate areas where PBFs for designated critical habitat for elkhorn and staghorn coral, and proposed critical habitat for Nassau grouper, lobed star, mountainous star, boulder star, pillar, and rough cactus corals occur. However, slack in towlines only occurs when the tow vessel is not underway and would not occur in shallow water areas containing corals based on the SOPs developed and implemented by the USACE. In addition, entanglement of towlines in corals would potentially lead to damage of the equipment being towed. Entanglement of towlines used to move MEC/MPPEH suspected to present a detonation hazard would jeopardize worker safety. For these reasons, the SOPs developed by the USACE include the use of observers and procedures to minimize slack on the towline. In addition to towlines, lines from in-water structures are not expected to touch live or dead coral. Per the PDCs noted in Section 3.3.1.7, anchor point locations must not contain live or dead coral and anchor chains must not be within three meters (10 feet) of the estimated swing radius of live or dead coral. Furthermore, in locations where marker buoys will be anchored in hard substrate, the anchor location must be bare rock or rock covered with macroalgae with no live or dead coral. Pin anchors will be used in hard substrate in areas where existing ESA-listed corals are beyond the reach of any attached chains or equipment, and a subsurface buoy will be attached along the anchor chain to prevent scouring of hard bottom habitat or damage to future coral recruits. Therefore, we believe the effects of entanglement on ESA-listed corals and designated critical habitat for elkhorn and staghorn coral, and proposed critical habitat for Nassau grouper, lobed star, mountainous star, boulder star, pillar, and rough cactus corals will be extremely unlikely to occur and thus discountable. The entanglement stressor may affect, but is not likely to adversely affect these ESA resources.

8.1.6 Sediment Resuspension

Many of the activities associated with the proposed action have the potential to disturb the bottom, including removal of MEC/MPPEH from the marine bottom, sediment sampling, underwater investigations requiring excavations, and associated vessel anchoring during operations. Bottom disturbance is expected to cause sediment resuspension and transport. Any sediment resuspension and transport would be temporary and in shallow water, which would have no effect on sperm whales.

Because sand bottoms interspersed with seagrass beds and coral habitats characterize the majority of areas within the action area where activities will disturb bottom sediments, sediment resuspension and transport is expected to be minimal because of the large grain size and weight of sand, which leads to sand resettling to the bottom quickly after a disturbance (Guillou and Glass 1957). In addition, areas with seagrass will have little sediment resuspension and transport because the seagrass serves as a natural sediment trap, unless large areas are excavated, which is not expected to be required as part of the proposed action unless large bombs are found near the surface in areas with seagrass beds. Similarly, disturbance in coral habitats will not generate large amounts of sediment because coral habitats are not characterized by high sediment content and excavation of coral habitat is not expected as part of the proposed action. The activities associated with the proposed action are expected to be completed over the course of several days to weeks in different sites within the action area, with work occurring only during daylight hours. Sediment cores associated with sediment sampling for MC will be done by hand using a collection tube in uncolonized bottom substrate and are not expected to lead to measurable sediment resuspension. Therefore, we believe the effects to green, leatherback and hawksbill sea turtles, scalloped hammerhead sharks, Nassau grouper, queen conch, ESA-listed corals, designated critical habitat for green sea turtles and elkhorn and staghorn coral, and proposed critical habitat for Nassau grouper, and lobed star, mountainous star, boulder star, pillar, and rough cactus corals due to sediment resuspension and transport will be insignificant and thus not likely to result in adverse effects to these species or habitat.

If changes are proposed in the future that would result in large excavations of seagrass and/or coral areas with the potential to generate measurable concentrations of sediment in the water column for longer periods of time, reinitiation of consultation may be required.

8.1.7 Habitat Loss or Damage

Green and hawksbill sea turtle refuge and foraging habitat (including green sea turtle critical habitat) and habitat used by juvenile scalloped hammerhead sharks, Nassau grouper (including proposed critical habitat for Nassau grouper), and queen conch could be damaged or lost because of the installation and operation of in-water structures and sediment sampling, as well as removal of munitions items requiring excavation.

Sediment sampling activities will be limited to small areas and amounts of sediment that will be collected in Ziploc bags from a depth interval of zero to six inches. As a result, impacts to proposed and ESA-listed species and critical habitat from sediment sampling will be so small as to be difficult to quantify and thus insignificant given the extent of benthic habitat available to listed and proposed species in the action area.

For the construction of in-water structures, pin anchors and mooring systems will be used in consolidated hard bottom and will be driven to a depth of 45.72 to 61 centimeters (18 to 24 inches) with a total footprint of 180.65 square centimeters (28 square inches). When consolidated hard bottom is not available, Manta Ray® anchors or helix anchors will be used in unconsolidated sediment. The depth of the intrusive activities to drive the anchor system into the unconsolidated sediment is a minimum of 1.07 meters (3.5 feet). If the sediment does not provide the holding strength needed, an extension to the anchor can be added and be driven down to 2.13 meters (seven feet). Helix anchors will have a footprint of 503.2 square centimeters (78 square inches) and Manta Ray® of 387 square centimeters (60 square inches). Given the total existing acreage of seagrass and coral habitats within the Culebra and Desecheo MRSs, estimated as 2.5 square kilometers (618.9 acres) and 6.59 square kilometers (1630.53 acres), respectively (USACE 2022b), we believe the effects to green and hawksbill sea turtles, juvenile scalloped hammerhead shark, Nassau grouper, and queen conch, and green sea turtle critical habitat and proposed Nassau grouper critical habitat as a result of habitat impacts from the installation of different anchor systems for in-water structures will be minor. Also, as noted in the PDCs, seagrass habitat will be avoided to the extent possible during the installation of in-water structures, where structures have to be installed in seagrass a location with minimum seagrass cover will be identified, and an anchor system that minimizes seagrass impacts will be selected. Similarly, the anchor system proposed for hard bottom habitats has a minimal footprint and the PDCs will ensure there is no drag or scour of hard bottom habitat used by listed sea turtles and fishes. Therefore, we believe that effects to green and hawksbill sea turtle refuge and foraging habitat (including green sea turtle critical habitat) and habitat used by juvenile scalloped hammerhead sharks, Nassau grouper (including proposed critical habitat for Nassau grouper), and queen conch will be insignificant and thus not likely to result in adverse effects to these species or their critical habitat.

Green and hawksbill sea turtle habitat (including green sea turtle critical habitat), juvenile scalloped hammerhead shark and Nassau grouper habitat (including proposed critical habitat for Nassau grouper), and queen conch habitat could also be damaged as a result of the removal of MEC/MPPEH and underwater investigations that require excavation in seagrass and unconsolidated bottom or removal of items from the surface in coral habitats, including items that may have colonizing benthic organisms such as sponges that may be eaten by hawksbill sea turtles. There are thousands of potential MEC/MPPEH items within the action area, particularly the portion around Culebra, many of which are in areas containing seagrass beds and coral habitats that may be used by green and hawksbill sea turtles, juvenile scalloped hammerhead sharks, Nassau grouper, and queen conch. Many of the items may be on the surface, in which case habitat disturbance is minimal and the only impacts may be the loss of organisms that could serve as prey species encrusted on removed items. Other items may be below the surface, in which case excavation of unconsolidated substrate, including in areas of seagrass beds, would result in disturbance of habitat used by green and hawksbill sea turtles, juvenile scalloped hammerhead sharks, Nassau grouper, and queen conch. However, the USACE has developed PDCs to minimize this disturbance and, for larger areas where seagrass is not expected to backfill and recolonize naturally, PDCs include cutting and folding back seagrass and then replanting it over the disturbed area once items have been excavated. Based on underwater cleanup completed in the action area, habitat disturbance from the removal of multiple munition items is minimal, even for larger items such as large bombs. For example, field teams are generally limited to hand digging/reacquisition of anomalies to 24 inches below the seafloor surface for safety concerns. In regard to impacts to seagrass from past cleanup activities in the action area, the USACE only documented seagrass disturbance during past removal activities in Culebra's MRS 13. In this area, only 23.48 square meters (252.8 square feet) of seagrass was disturbed. Similarly, the footprint of bottom-operated equipment to locate suspected MEC/MPPEH, which is only used in areas with unconsolidated bottom, is extremely small in comparison to the habitat areas available to sea turtles, juvenile scalloped hammerhead sharks, Nassau grouper, and queen conch within the action area. The footprint of tripods that are mounted around suspected MEC/MPPEH items thought to pose an explosive hazard for remote lifting and towing is also very small in comparison to the area of available habitat within the action area. Also, mobile ESA-listed species can move to adjacent areas with suitable habitat, resulting in minor energetic costs to animal(s). The PDCs also require that observers verify that no ESA-listed marine animals are in the area where equipment or material is expected to contact the substrate before that equipment/material may enter the water (See Section 3.3.1.1). If removal methods will include encapsulation, which is included in this consultation but has not been proposed for use at this time, there would still be hundreds of acres of habitat available for use by green and hawksbill sea turtles, juvenile scalloped hammerhead sharks, Nassau grouper, and queen conch. Therefore, we believe the effects to green and hawksbill sea turtles, juvenile scalloped hammerhead sharks, Nassau grouper, queen conch, green sea turtle critical habitat, and proposed critical habitat for Nassau grouper from habitat impacts resulting from the investigation and removal of suspected MEC/MPPEH in the action area will be insignificant and thus not likely to result in adverse effects to these species or critical habitats.

Habitat loss or damage to elkhorn and staghorn coral designated critical habitat and proposed critical habitat for lobed star, mountainous star, boulder star, pillar, and rough cactus corals associated with the installation of anchor systems in hard bottom and removal of suspected MEC/MPPEH is discussed in Section 8.2. The effects of habitat loss to green and hawksbill sea turtles, juvenile scalloped hammerhead sharks, Nassau grouper, queen conch, ESA-listed corals, designated critical habitat for green sea turtle, and elkhorn and staghorn coral, and proposed critical habitat for Nassau grouper and lobed star, mountainous star, boulder star, pillar, and rough cactus corals from underwater detonation are discussed Section 8.2.

8.1.8 Organism Collection and Transplant

Organism transplanting will occur during some removal of MEC/MPPEH from the action area.

The collection and transplanting of corals, seagrass, and other sessile benthic organisms from areas where the removal of munition items occurs or growing on the items to be removed will result in some loss of or damage to prey items and habitat used by green and hawksbill sea turtles, juvenile scalloped hammerhead shark, and Nassau grouper, as also discussed in Section 8.1.7. As noted, the USACE developed PDCs to ensure that impacts to seagrass from removal activities are minimized, including through replanting and transplanting seagrass to other areas when necessary and feasible. The USACE also developed PDCs to minimize the loss and degradation of coral habitats associated with removal activities (See Section 3.3.1.2). As discussed in the previous section regarding habitat impacts from investigation and removal activities, the collection and transplant of organisms associated with removal activities will involve small portions of habitat in comparison to the total available for use by green and hawksbill sea turtles, scalloped hammerhead sharks, and Nassau grouper. We believe the effects to these species and designated and proposed critical habitat for green sea turtles and Nassau grouper, respectively, will be insignificant and thus not likely to adversely affect these animals.

The effects of collection and transport on ESA-listed corals, queen conch, elkhorn and staghorn coral designated critical habitat, and proposed critical habitat for lobed star, mountainous star, boulder star, pillar, and rough cactus corals are discussed in Section 8.2.

8.1.9 Contaminant Release

Munitions compounds may leach from on land detonations or underwater MEC/MPPEH into the water column and sediments, be released due to breakage or spillage during removal activities, or be present in sediments that are resuspended during underwater investigation and removal activities. Coral cell toxicity assays were conducted to test three nitrotoluene munitions compounds: TNT and two of its major breakdown products (2,4-DNT and 2,6-DNT); two nitroamines: RDX and HMX; and one nitrophenol: picric acid (2,4,6-trinitrophenol). Woodley and Downs (2014) found picric acid to be the most toxic overall with the lowest LC_{50} (concentration of the compound that is lethal for 50 percent of the exposed population) at 10.5 µg/L for *Pocillopora damicornis* calicoblast cells (which are involved in the production of the coral skeleton). On the other hand, 2,4,6-TNT was found to be the most toxic for gastrodermal cells (which form the lining of the gastrovascular cavity) of this coral and an LC_{50} could not be determined for RDX or HMX under any of the laboratory conditions (Woodley and Downs 2014). The sensitivity of coral cells to TNT was also found to be more pronounced in the presence of light versus in dark conditions (Woodley and Downs 2014). Woodley and Downs (2014) also tested calicoblast and gastrodermal cells from three species of corals to determine whether there was a between-species difference in sensitivity to munitions compounds, specifically 2,6-DNT, which was used in the laboratory tests. There was a marked difference between species in terms of sensitivity though the gastrodermal cells of all three species were found to be more sensitive than the calicoblast cells by orders of magnitude. *Pocillopora damicornis* was more sensitive than *Porites divaricata* and *Porites lobata* with an LC_{50} for gastrodermal cells of 1,844 µg/L (Woodley and Downs 2014).

Woodley and Downs (2014) also tested the toxicity of munitions compounds of *Symbiodinium* sp. (species that are coral zooxanthellae) and found TNT was the most toxic of the nitrotoluenes with an EC_{50} (effects concentration at which 50 percent of the organisms show an adverse response) of 544 µg/L for cell growth (2,4,6-TNT) and an EC_{50} of 2,810 µg/L for photosynthetic efficiency (2,3-DNT). Coral fragments were also used to conduct exposure/response studies using 96-hour exposures to three munitions compounds, RDX, 2,3-DNT, and TNT. Woodley and Downs (2014) found signs of lethal toxicity in *Pocillopora damicornis* of 2,3-DNT at concentrations of 2,000 µg/L and higher within 18 hours of exposure and sub-lethal effects at 292 µg/L. Woodley and Downs (2014) also found TNT showed toxic effects in *Porites divaricata* fragments with changes in polyp behavior and tissue integrity, and necrosis at concentrations of 100 µg/L and higher. The concentrations at which toxic effects of munitions compounds were observed in the Woodley and Downs (2014) laboratory experiments are not likely to be representative of the concentrations at which compounds are present in the environment within the action area. Whitall et al. (2016) sampled queen conch from three sites around Vieques, Puerto Rico for metals, pesticides, and energetic compounds associated with munitions and found that concentrations of pollutants were within the range of values reported in other studies in the Caribbean where military practices have not occurred. Munitions compounds were not detected in any samples.

Environmental samples typically show that concentrations of MC in water and sediment in sites contaminated with military debris are generally very low, meaning ecological risk is thought to be low (Beck et al. 2018). However, there could be sub-lethal genetic and metabolic effects for organisms with chronic exposure to these compounds (Beck et al. 2018). A proof-of-concept study was conducted near the Culebra action area off of Vieques, Puerto Rico to evaluate the ecological risk from exposure to MC using grab sampling and Polar Organic Chemical Integrative Samplers (passive sampling devices). The concentrations detected by the passive samplers were 10 to 1,000,000 times lower than hazardous concentrations to five percent of species generated from the most up-to-date and comprehensive species sensitivity distributions (Rosen et al. 2017). Similarly, an assessment of chemical contamination in Bahia Salinas del Sur found only one of six coral samples collected from the stern of the USS *Killen* (a vessel that served as a target during live-fire military exercises) contained detectable residues of TNT, 252 micrograms per grams of TNT (Porter et al. 2011). Seawater samples were found to contain high levels of TNT within one centimeters (0.4 inches) of a submerged bomb but the concentrations of TNT and other munitions compounds were orders of magnitude lower within 10 centimeters (four inches) of the bomb and the concentrations of munitions compounds in sediment samples showed a similar decline to no detection two meters (6.56 feet) from the bomb (Porter et al. 2011). Therefore, while it is possible that corals growing on a munitions item could demonstrate sub-lethal responses such as declines in growth, concentrations of munitions compounds leaking from munitions items would have to be at or above those found by Woodley and Downs (2014) to cause sub-lethal effects to corals and their zooxanthellae. None of the studies of organisms or chemical concentrations of compounds in organisms, the water column, or sediments in MEC/MPPEH cleanup areas close to Culebra (Díaz et al. 2018; Porter et al. 2011; Rosen et al. 2017; Whitall et al. 2016), other than those by Porter et al. (2011) at a submerged bomb off the coast of Vieques, Puerto Rico were close to these concentrations.

USACE MC sampling data from 16 locations in Culebra's MRS 02 and 07 showed no explosive concentrations greater than human health screening values; however MC metals, including antimony, chromium (III), and chromium (VI) were detected at levels greater than human health screening values in MRS 02. No explosive compounds were found at detectable concentrations except for a small detection of TNT in a single sample in MRS 02 with a concentration of 0.12 milligrams per kilogram. Antimony was found at levels of 3.8 milligrams per kilogram, chromium (III) at 21 milligrams per kilogram, and chromium (VI) at 3.6 milligrams per kilogram. USACE underwater sampling did not take place within other Culebra MRSs as no MEC/MPPEH found in these areas were breached or contained hairline cracks, exposing explosive filler. Also, the USACE has not provided underwater sampling data from Desecheo's MRS 01. Although antimony and chromium levels in MRS 02 were greater than human health screening values, the USACE assessed the level of risk these materials presented based on exposure through ingestion and physical contact in an ecological risk assessment. This assessment used several ecological receptors to screen for toxicity, including West Indies manatee, fishing bats, green heron, spotted sandpiper, and white-cheeked pintail. Each of these species have primary dietary sources of at least one of the following: fish, benthic invertebrates, aquatic vegetation, and seagrass. The ecological risk assessment was conducted to evaluate the potential for ecological impacts of exposures to chemicals in sediment. Seventeen explosive compounds and eight metals were initially screened to retain preliminary chemicals of potential ecological concern for the risk evaluation. The risk analysis indicated minimal to no risk for adverse effects on ecological receptors from exposure to explosive compounds or metals in MRS 02. A significant risk for adverse effects was not identified for direct or dietary exposure of ecological receptors in underwater area sediment of MRS 02. All explosive compounds were excluded from further evaluation based on concentrations that were lower than the analytical detection limit and/or their ecological screening value. Three metals were retained as preliminary chemicals of potential ecological concern for dietary exposure evaluation: copper and chromium, which exceeded the ecological screening value in one of 16 samples analyzed, and zinc as potentially bioaccumulative. Based on low-effect threshold reference values and dietary exposure estimated from maximum sediment concentrations, none of the three metals were identified as posing a risk of adverse effects on wildlife species in the area.

Due to the low levels of explosive compounds and heavy metals detected in the Culebra MRSs, and the fact that mobile ESA-listed species in the action area are not consistently present in areas with MEC/MPPEH items containing exposed filler, we believe the effects of MC released to the water column or in resuspended sediments during investigation and removal activities on sperm whales, green, leatherback and hawksbill sea turtles, scalloped hammerhead shark, Nassau grouper, queen conch, designated critical habitat for green sea turtle, and proposed critical habitat for Nassau grouper will be insignificant and thus not likely to adversely affect these species and critical habitat. Also, while sub-lethal effects on ESA-listed Atlantic/Caribbean corals could occur, these coral would have to colonize on a MEC/MPPEH item with exposed explosive filler. This is not likely to occur based on the low numbers of MEC/MPPEH in the action area that were found to contain exposed explosive filler and the low number of items colonized by ESA-listed corals. Therefore, we believe the effects of munitions compounds on ESA-listed corals will be discountable and therefore not likely to adversely affect these species.

8.2 Exposure, Response, and Risk Analyses

In our assessment of the stressors identified in Section 5, we determined that nonintentional detonation and BIPs, and habitat loss from these activities, are likely to adversely affect proposed or ESA-listed sperm whales, green, leatherback, and hawksbill sea turtles, scalloped hammerhead shark, Nassau grouper, queen conch, ESA-listed Atlantic/Caribbean corals, designated critical habitat for green sea turtle and elkhorn and staghorn coral, and proposed critical habitat for Nassau grouper and lobed star, mountainous star, boulder star, pillar, and rough cactus corals. We also determined that habitat loss or damage from removal and relocation of items from coral habitats when those items are embedded into the hard substrate, encapsulation of items in coral habitats, and anchor system installation in hard bottom habitats are likely to adversely affect ESA-listed Atlantic/Caribbean corals, designated critical habitat for elkhorn and staghorn coral, and proposed critical habitat for lobed star, mountainous star, boulder star, pillar, and rough cactus corals. Collisions of munitions items and towed equipment with ESA-listed Atlantic/Caribbean coral colonies are likely to adversely affect these species. Organism transplanting is likely to adversely affect ESA-listed Atlantic/Caribbean corals and queen conch (proposed).

In the following sections, we consider the exposures that could cause an effect on proposed and ESA-listed species and critical habitat that are likely to co-occur with the stressors identified in the previous paragraph, and identify the nature of that co-occurrence. We consider the frequency and intensity of exposures that could cause an effect on proposed and ESA-listed species and, as possible, the number, age or life stage, and gender of the individuals likely to be exposed to the action's effects and the population(s) or subpopulation(s) those individuals represent. We also consider the responses of proposed and ESA-listed species to exposures and the potential reduction in fitness associated with these responses.

8.2.1 Definition of Take, Harm, and Harass

Section 3 of the ESA defines take as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. We categorize two forms of take, lethal and sub-lethal take. Lethal take is expected to result in immediate, imminent, or delayed but likely mortality. Sub-lethal take is when effects of the action are below the level expected to cause death, but are still expected to cause injury, harm, or harassment. Harm, as defined by regulation (50 CFR §222.102), includes acts that actually kill or injure wildlife and acts that may cause significant habitat modification or degradation that actually kill or injure fish or wildlife by significantly impairing essential behavioral patterns, including, breeding, spawning, rearing, migrating, feeding, or sheltering. Thus, for sub-lethal take we are concerned with harm that does not result in mortality but is still likely to injure an animal.

NMFS has not defined "harass" under the ESA by regulation. However, on October 21, 2016, NMFS issued interim guidance on the term "harass," defining it as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering." For this consultation, we rely on this definition of harass when assessing effects to all proposed and ESA-listed species.

8.2.2 Exposure to Stressors

To estimate exposure to stressors, we examined the number of estimated MEC/MPPEH still remaining within each MRS in Culebra and Desecheo. The number of remaining MEC/MPPEH present in each MRS is shown in Table 5. Remaining MEC/MPPEH ranges in size from small flares with a NEW of less than 0.45 kilograms (1 pound) to 907 kilogram (2,000 pound) bombs with a NEW of 2,083.37 kilograms (945 pounds). As documented in Section 7.9, since the time Culebra Island was labeled a FUDS, at least two underwater detonation events have occurred including one on Flamenco beach and the other on Carlos Rosario beach. The events were conducted by Navy EOD and not by the USACE during its investigation and removal activities and would not be considered part of the proposed action. As a result, we estimate that a small number of detonations (<2) may occur during USACE removal and investigation activities in MRSs shown in Table 5. This is due to the limited number of detonation events occurring in underwater areas of MRSs within Culebra and Desecheo, the total MEC/MPPEH items removed by the USACE, the estimated MEC/MPPEH remaining in each MRS, and the fact that no previous detonation events have occurred as a result of USACE investigation and removal activities.

Table 5. Remaining MEC/MPPEH within Culebra and Desecheo MRSs

MRS	# of MEC Items Removed by USACE	Estimated # of MPPEH/MEC Remaining
01 (Desecheo)	0	2,135
02 (Culebra)	52	12,334
03 (Culebra)	197	229
07 (Culebra)	6	1,308
12 (Culebra)	359	3,131
13 (Culebra)	128	79

Detonations would occur in localized areas and, based on underwater surveys conducted to date, there are limited numbers and locations where large MEC/MPPEH items are present that would result in a larger potential area of influence. Locations with larger MEC/MPPEH items where additional investigation and removal activity will take place include areas of MRS 02, which contain 907 kilogram (2,000 pound), 453.6 kilogram (1,000 pound), 340.2 kilogram (750 pound), 226.8 kilogram (500 pound), and 113.4 kilogram (250 pound) bombs. These bombs are present in offshore areas off Alcarraza, Caro Yerba, Cayos Geniquí, and Cayo Tiburón. In MRS 12, several 45.36 kilogram (100 pound) practice bombs were discovered north of Luis Peña. Also, Desecheo's MRS 01 contains documented accounts of 453.6 kilogram (1,000 pound), 226.8 kilogram (500 pound) and 45.36 kilogram (100 pound) bombs. Other areas such as Culebra's MRS 03, 07, and 13 contain smaller munitions or only MD. To estimate potential exposure, we used the maximum number of larger MEC/MPPEH items that could result in underwater detonation in a given MRS during one cleanup event. Based on information from past USACE activities, we estimate a maximum of one detonation would occur during a USACE cleanup event. To be conservative, we use the largest NEW to determine the estimated area of influence. The largest area of influence resulting from a single detonation event would be from a 907 kilogram (2,000 pound) bomb with a NEW of 2,083.37 kilograms (945 pounds) in MRS 02 off Alcarraza.

Sperm whales in the Caribbean are present largely during their winter migration through the warmer waters of the Caribbean. Recorded sightings of sperm whales within the action area are rare and they are more commonly found in waters south of Desecheo and Culebra Islands. For example, female sperm whales have been observed giving birth in waters off Vieques Island, Puerto Rico, approximately 25 kilometers [15.5 miles] southwest of Culebra, based on observations of mother-calf pairs during past surveys (GMI 2001; Roden and Mullin 2000). Mignucci-Giannoni et al. (2000) suggested that the waters south of Vieques may be important nursing grounds for some marine mammal species, including sperm whales, and may be part of the calving grounds for this species. An immature sperm whale carcass washed up on the beach of Bahia Salinas del Sur in July 2013, indicating that mother-calf pairs are present at certain times of year in deeper waters near the action area (NMFS 2020). In addition to sightings off Vieques, acoustic recordings of sperm whales have been documented off Mona Island which is approximately 50 kilometers (31 miles) southwest of Desecheo Island. In a February 2001 to March 2001 acoustic and visual survey off the coast of Puerto Rico, Swartz et al. (2002) detected "clicks" and "codas" from sperm whales in 12 out of the 135 (nine percent) sonobuoys deployed around Puerto Rico. Most of these sperm whale detections were located to the southwest of Puerto Rico over relatively deep water in the Mona Channel off the coast of Mona Island. Also, two sightings occurred within the Mona Channel (one near Desecheo Islands as show in Figure 6) and the other sighting off the insular slope along the south coast of Lajas, Puerto Rico in from 1995 to 2014. There are unpublished data of a group of five adult sperm whales sighted off the coast of Desecheo in August 2019 (G. Rodriguez, pers. comm. to J. Molineaux, NMFS, October, 20, 2022). There are no population estimates for sperm whales in the action area due to a lack of survey data. Given the sparse data of sperm whales in the action area and due to the PDCs requiring exclusion zones and no operations to occur within 91.44 meters (100 yards) of a whale, we would expect a very low reasonable estimate of proposed activity interactions with sperm whales based on the best available scientific data. In estimating the total amount of area that may affect sperm whales during a 907 kilogram (2,000 pound) bomb detonation event we use a 1,372 meter (4,500 foot) radius around the MEC/MPPEH to estimate the total area that might be exposed to TTS levels, a 747 meter (2,450 foot) radius to estimate PTS, and a 366 meter (1,200 foot) radius to estimate barotrauma injury/mortality. This equates to an area of 5.91 square kilometers (1,460.5 acres) for TTS, 1.75 square kilometers (432.9 acres) for PTS, and 0.42 square kilometers (103.9 acres) for barotrauma injury/mortality. These distances are derived from estimates of the intensity of source level sounds based on NEW using a formula from Sulfredge et al. (2005) and peak marine mammal noise thresholds for explosives derived from NMFS (2018a). Distances to behavioral thresholds were not able to be calculated as Sulfredge et al. (2005) only accounts for peak threshold levels and behavioral thresholds are only derived from SEL. Due to limited sightings data of sperm whales in the action area and due to the potential for blast radii from MEC/MPPEH detonations with high NEW to reach deeper waters in areas adjacent to Desecheo's MRS 01 and Culebra's MRS 02 where sperm whales may occur, we estimate a worst-case scenario of at least one mother-calf pair and a group of five individuals (including juveniles and adults) sperm whales could be exposed to barotrauma injury/mortality, PTS, and/or TTS from nonintentional detonation and BIP during USACE removal activities. Also, if the USACE and its contractors plan any underwater detonation events, MMPA authorization will likely be required.

The largest annual leatherback nest count in Culebra over the past ten years was 112 sea turtle nests surveyed in 2014. This species is only present on beaches and in waters of Culebra during its nesting season, which peaks from April to July. Leatherback sea turtles are pelagic and only enter nearshore waters during their nesting season, therefore we do not predict any juveniles will be in the Culebra or Desecheo portions of the action area. Based on calculations of the potential number of adult and hatchling leatherback sea turtles (see Section 7.1.2), we estimate 50 adults and up to 4,347 hatchlings could be in the Culebra portion of the action area. Also, approximately eight adults and 737 hatchlings could be in the Desecheo portion of the action area.

The largest annual hawksbill nest count in Culebra over the past ten years was 81 sea turtle nests surveyed in 2014. Hawksbill sea turtles are also frequently sighted in waters around Culebra and sightings of juveniles have been made off the coast of Desecheo. Based on calculations of the potential number of adult, juvenile, and hatchling hawksbill sea turtles (see Section 7.1.2), we estimate that 66 adults, 119 juveniles/sub adults, and up to 6,350 hatchlings could be in the Culebra portion of the action area. Also, approximately 14 adults, 68 juveniles/sub adults, and 1,411 hatchlings could be in the Desecheo portion of the action area.

Green sea turtle nests have been documented off Culebra beaches in very low numbers (<5 nests), but the area around the island provides important juvenile and sub-adult habitat, which is why NMFS designated critical habitat for the species around Culebra. Based on calculations of the potential number of adult, juvenile, and hatchling green sea turtles (see Section 7.1.2), we estimate that 24 adults, 305 juveniles/sub adults, and up to 199 hatchlings could be could be in the Culebra portion of the action area. Using hawksbill sea turtle estimates as a conservative surrogate and information on sea turtle strandings and in-water surveys, we also estimate that 14 adults and 68 juvenile/sub-adult green sea turtles could be in the Desecheo portion of the action area. There are no reports of green sea turtle nesting in or near Desecheo, therefore we do not predict any hatchlings will be in this portion of the action area.

In estimating the total amount of area that may be affected by a 907 kilogram (2,000 pound) bomb detonation event for acoustic stressor effects to sea turtles, we use the formula from Sulfredge et al. (2005) and sea turtle hearing thresholds from the U.S. Navy (2017). For sea turtles, the estimated radius distance for TTS is 1,113 meters (3,650 feet), PTS is 610 meters (2,000 feet), and barotrauma injury/mortality is 365.7 meters (1,200 feet). This equates to an area of 3.9 square kilometers (960.8 acres) for TTS, 1.16 square kilometers (288.5 acres) for PTS, and 0.42 square kilometers (103.9 acres) for barotrauma injury/mortality. Sea turtle hatchlings of each species will only be exposed to underwater detonations if they occur at a time of year when hatchlings are emerging from their nests and entering the sea in the early morning, meaning they would be in waters of the action area during removal activities. There is a small possibility for overlap; however due to the limited information on when/where underwater detonations will occur, exposure cannot be estimated at this time and will need to be assessed during future step-down reviews of USACE removal activities that could result in nonintentional detonation and BIP events. Also, adult leatherback sea turtles will be affected only if detonation occurs at night during the mating and nesting season, which peaks from May to July around Puerto Rico. As a result, we do not expect exposure of adult leatherback sea turtle to nonintentional detonation and BIP. Therefore, we only estimated the amount of exposure of adult and sub-adult/juvenile green and hawksbill sea turtles to nonintentional detonation and BIP during USACE activities. Exposure of hatchling green, hawksbill, and leatherback sea turtles to underwater detonations will be estimated during future stepdown reviews of USACE removal activities that could result in nonintentional detonation and BIP events. We only expect a limited number of hatchlings will be exposed compared to the population estimates for Culebra and Desecheo noted above. This is because many hatchlings experience predation once hatched, both on land and once they enter the water (Stewart and Wyneken 2004; Wyneken 2000; Wyneken and Fisher 1998). Also, per the RPMs (Section 12.2), the USACE and its contractors will, to the extent practicable, refrain from conducting BIP during the peak sea turtle nesting season.

To estimate impacts to green sea turtles from a single large detonation event in Culebra, we used fixed passive acoustic telemetry data of green turtles derived from Griffin et al. (2019) taken during the month of March in Manglar Bay. During the month of March, Griffin et al. (2019) observed 16 individual green sea turtles within Manglar Bay's 1.25 square kilometers (308.8 acres) of habitat. Using this information, we estimated a density of 13 green sea turtles per square kilometer. To estimate impacts of hawksbill sea turtles from a single large detonation event, we used CPUE data from Collabra's Carlos Rosario beach derived from Rincon Diaz et al. (2011). The maximum CPUE for hawksbill sea turtles on Carlos Rosario's 0.5 square kilometer (123.5 acre) beach and coastal area was four individual hawksbill sea turtles per hour captured in 2001. Using this information, we estimated a density of eight hawksbill sea turtles per square kilometer. It should be noted that these densities are conservative estimates for green and hawksbill sea turtles as both Manglar Bay and Carlos Rosario beach contain high densities for sea turtles in Culebra. As noted above, underwater detonations of large MEC/MPPEH are predicted to occur in more remote areas of MRS 02. Sea turtle data in these areas are more limited, although biological monitoring conducted by the USACE confirm the presence of both sub-adult/juvenile and adult green and hawksbill sea turtles around the more remote cays of MRS 02 with reports of three green sea turtles in one sighting and at least two sightings of hawksbill sea turtles during three observation events (USACE 2022b). Using the density from Manglar Bay and distances to effects derived from Sulfredge et al. (2005), we estimate that a maximum of 50 green sea turtles may be exposed to TTS, 15 may experience PTS, and five may experience barotrauma injury/mortality. Using a 0.07 proportion of adults to sub-adults/juveniles based on estimated population estimates for green sea turtles in Culebra, we assume 46 sub adult/juvenile and four adult green sea turtles may be exposed to TTS, 14 sub-adults/juveniles and one adult may experience PTS, and five sub-adults/juveniles may be exposed to barotrauma injury/mortality. For hawksbill sea turtles, we use densities from Carlos Rosario beach and distances to effects derived from Sulfredge et al. (2005) to estimate a maximum of 31 individuals may be exposed to TTS, nine may be exposed to PTS, and three may be exposed to barotrauma injury/mortality. Also, using a 0.36 proportion of juveniles to adults based on estimated population estimates for Culebra, we assume 20 sub-adult/juvenile and 11 adult hawksbill sea turtles may be exposed to TTS, six sub-adults/juveniles and three adults may experience PTS, and two sub-adults/juveniles and one adult may be exposed to barotrauma injury/mortality.

To estimate impacts of green and hawksbill sea turtles from a single large detonation event in Desecheo's MRS 01, we used CPUE data from Diez and Van Dam (2018). As noted in Diez and Van Dam (2018), average CPUE data for green and hawksbill sea turtles in Desecheo is 5.3 turtles per hour. By dividing this CPEU by the 1.69 square kilometers (418.49 acres) within the action area, we obtained a density of 3.13 hawksbill and green sea turtles per square kilometer. This density is a conservative estimate for green sea turtles, which are lower in density in Desecheo than hawksbill sea turtles. The largest NEW for MEC/MPPEH found in Desecheo's MRS 01 (a 453.6 kilogram [1,000 pound] bomb) is 201.8 kilograms (445pounds). In estimating the total amount of area that may be affected by a 453.6 kilogram (1,000 pound) bomb detonation event for sea turtles, we use the formula from Sulfredge et al. (2005) and sea turtle hearing thresholds from the U.S. Navy (2017). For sea turtles, the estimated radius distance for TTS is 868.68 meters (2,850 feet), PTS is 474.44 meters (1,550 feet), and barotrauma injury/mortality is 289.56 meters (950 feet). This equates to an area of 2.37 square kilometers (585.8 acres) for TTS, 0.7 square kilometers (173.27 acres) for PTS, and 0.26 square kilometers (65 acres) for barotrauma injury/mortality. Using these areas to effects and densities, we estimate that a maximum of eight hawksbill sea turtles may be exposed to TTS, two may experience PTS, and one may experience barotrauma injury/mortality. Using a 0.17 proportion of adults to sub-adults/juveniles based on estimated population estimates for Desecheo, we assume seven sub-adult/juvenile and one adult hawksbill sea turtles may be exposed to TTS, two sub-adults/juveniles may experience PTS, and one sub-adult may be exposed to barotrauma injury/mortality. While we expect a reduced exposure of green sea turtles, we use the same number of hawksbill exposures as a surrogate for green sea turtles due to limited green sea turtle data in and around Desecheo.

Based on sightings data, neonate, juvenile, and adult scalloped hammerhead sharks and juvenile and adult Nassau grouper have been observed in waters within the Culebra MRSs. Also, adult and juvenile Nassau grouper have been observed in waters within Desecheo's MRS 01 during in-water surveys (R. Espinoza, Conservacion Con Ciencia, pers. comm. to J. Molineaux, NMFS, October, 5, 2022; Garcia-Sais et al. 2020; Ojeda-Serrano et al. 2007b). Only adult scalloped hammerheads are likely to be found in waters around Desecheo as no nurseries are confirmed in this area (R. Espinoza, Conservacion Con Ciencia, pers. comm. to J. Molineaux, NMFS, January, 19, 2023). Seagrass and coral habitats in nearshore waters provide nursery habitat for neonate and juvenile scalloped hammerhead sharks and juvenile Nassau grouper while adult Nassau grouper use reef habitats, usually in deeper waters. Thus, it is likely that neonate, juvenile, and adult scalloped hammerhead sharks and juvenile and adult Nassau grouper could be exposed to nonintentional detonation and BIP during USACE removal activities in the Culebra portion of the action area. Also, it is likely that juvenile and adult Nassau grouper and adult scalloped hammerhead sharks could be exposed to nonintentional detonation and BIP during USACE removal activities in the Desecheo portion of the action area.

Population estimates for scalloped hammerheads in Culebra are not available at this time but fishing effort has shown that approximately 797 sharks were landed in Puerto Rico from 2001 to 2016 (NMFS, Fisheries Statistics Division, pers. comm. to J. Molineaux, NMFS, October 21, 2022), although some of the sharks may have been misidentified. Also, recent fishery-dependent and independent survey data conducted by the Puerto Rico Shark Research and Conservation Program detected approximately 59 scalloped hammerhead sharks around Puerto Rico from February 2017 to August 2021. All individuals observed were juveniles with roughly an equal number of males and females (Puerto Rico Shark Research and Conservation Program 2022). While sightings data exist, there are no confirmed population estimates for scalloped hammerhead sharks in the action area. Based on limited data, we are not able to fully estimate the amount of exposure that a single detonation event would have on scalloped hammerheads. Therefore, due to limited sightings data of the species in the action area, we only estimate that a small number would be exposed to a potential underwater detonation. These estimates will be further refined in a step-down consultation of a BIP or removal activity that could result in a nonintentional detonation.

As noted in Section 7.1.3, during surveys from 2018 to 2020, Garcia-Sais et al. (2020) observed nine individuals of Nassau grouper in waters around Desecheo and two in El Seco, which is approximately 25 kilometers (15.5 miles) south of Culebra. Fifty-two individuals of Nassau grouper were observed in Bajo de Sico by Garcia-Sais et al. (2020) and NOAA's NCRMP observed six sightings of Nassau grouper for all of Puerto Rico in surveys from 2016 to 2021 (J. Blondeau, NOAA Southeast Fisheries Science Center Fish Ecology Unit, pers. comm. to J. Molineaux, NMFS, September, 15, 2022). While sightings data exist, there are no confirmed population estimates for Nassau grouper in the action area. Similar to scalloped hammerhead sharks, based on limited data, we are not able to fully estimate the amount of exposure a single detonation event would have on Nassau grouper. Due to limited sightings data of the species in the action area, we only estimate that a small number would be exposed to a potential underwater detonation. These estimates will be further refined in a step-down consultation of a BIP or removal activity that could result in a nonintentional detonation.

As discussed in Section 7.1.5, the number of queen conch within the action area varies by depth. In shallow waters, densities of adult queen conch are estimated at 6.1 individuals per hectare whereas in deeper areas (i.e., mesophotic reefs), densities were estimated to be 54.6 individuals per hectare. Based on the shallow depths where activities are likely to occur as part of the proposed action and habitat for queen conch, we've estimated there could be 2,189 queen conch adults and 2,569 juveniles in the Culebra and Desecheo MRSs (i.e., seagrass, microalgae, sand, scattered coral-rock, patch reef, and spur/grove habitats). Only a percentage of individuals from this population will be exposed to stressors from nonintentional detonation or BIP due to relocation of individuals before these events would occur and the low densities of individuals in shallower waters. Queen conch habitat is only suspected to overlap with MEC/MPPEH items within certain portions of Desecheo's MRS 01 and Culebra's MRSs 02, 03, 07, 12, and 13 based on the amount of seagrass, microalgae, sand, scattered coral-rock, patch reef, and spur/grove habitat in these areas. Using information obtained from USACE (2022b), which noted the areas of habitat where most munitions were found within each MRS, we were able to identify the total amount of MEC/MPPEH items within queen conch habitat. Information on the percentages of MEC that could be in queen conch habitat are noted in Table 6 below.

Table 6. Estimated number of MEC/MPPEH in Queen Conch Habitat

MRS	# of Estimated MPPEH/MEC Remaining	% of MEC/MPPEH that could be in queen conch habitat	MEC/MPPEH in Queen conch Habitat
1	2,135	7.44%	159
2	12,334	0.00%	0
3	229	6.95%	16
7	1,308	37%	478
12	3,131	50%	1566
13	79	40%	32

From the information presented in Table 6, we determined that 2,250 MEC/MPPEH are estimated to be present in queen conch habitat. From this information, we also determined that there are approximately 0.06 square kilometers (16.2 acres) in the footprint of these MEC/MPPEH items which may contain queen conch that could be exposed to potential underwater detonation and/or relocation activities. This was generated using a 20-foot (six-meter) radius around each MEC/MPPEH item. Using the density of adult queen conch within the Culebra and Desecheo MRSs (individuals per hectare), we estimate that up to 99 adult queen conch may be relocated and/or exposed to a detonation event during investigation and removal activities. Also, using a global conversion ratio of 0.46 (Horn et al. 2022), we estimate up to 116 juveniles may be relocated and/or exposed to a detonation event.

As noted in Section 7.1.6, there are hard bottom and reef habitats containing coral colonies of ESA-listed corals in waters around Culebra based on recent NOAA contracted surveys and previous surveys conducted by NCCOS (Bauer and Kendall 2010; CSA Ocean Sciences Inc. 2021). Mountainous star coral appears to be the dominant live coral species on coral reef and hard bottom habitats around Culebra and Desecheo with lobed star corals also being common. By extrapolating 8,700 square meters (2.15 acres) of transect data from CSA Ocean Sciences Inc. (2021) for the rest of the action area, we can estimate that there are 159,275 lobed star corals, 6,826 boulder star corals, 161,550 mountainous star corals, 94,806 staghorn corals, 48,541 elkhorn corals, and 4,551 pillar and rough cactus corals present in the Culebra and Desecheo MRSs. The USACE estimated that there could be up to 1,555 ESA-listed coral colonies affected by the activities that are part of the proposed action, specifically because of the location of these corals adjacent to or growing on suspected MEC/MPPEH. This number was derived from information on past USACE MEC/MPPEH surveys (USACE 2022b). This includes 1,555 coral colonies affected by collection and relocation, unintentional detonation/BIP, and collisions with MEC/MPPEH and equipment. Based on information from these surveys, the USACE conservatively estimated the percentage of MEC/MPPEH found within 20 feet of ESA-listed corals for each MRS (See Table 7). The USACE then multiplied these percentages with estimates of remaining MEC/MPPEH for each MRS. With the number of estimated coral colonies affected by the USACE's proposed activities, we used the percentage of ESA-listed corals obtained from coral transect survey data in the action area (CSA Ocean Sciences Inc. 2021) to calculate approximately how many colonies of elkhorn, staghorn, pillar, rough cactus, lobed star, boulder star, and mountainous star may comprise this estimate. Data from coral transect surveys in the Desecheo portion of the action area found that elkhorn corals make up 6.78 percent of ESA-listed corals, staghorn coral 10.17 percent, pillar coral 3.39 percent, lobed star coral 47.46 percent, and mountainous star coral 32.20 percent. No sightings of boulder star or rough cactus corals were observed in the Desecheo action area. For the Culebra portion of the action area, CSA Ocean Sciences Inc. (2021) found that elkhorn coral make up 10.56 percent of ESA-listed corals, staghorn 20.95 percent, pillar coral 0.70 percent, lobed star coral 32.04 percent, boulder star coral 1.58 percent, and mountainous star coral 34.15 percent. Rough cactus coral was not found within the USACE's coral transect surveys and there is little abundance data of the species within the action area. Because both pillar and rough cactus coral are rare, we conservatively assume that rough cactus coral makes up the same percentage as pillar coral. Using these percentages, we determined that, of the 1,555 ESA-listed coral colonies the USACE estimates may be affected by the proposed action, 159 could be elkhorn coral colonies, 310 could be staghorn coral colonies, 15 could be pillar coral colonies, 15 could be rough cactus coral colonies, 521 could be lobed star coral colonies, 22 could be boulder star coral colonies, and 528 could be mountainous star coral colonies. However, because there may be significant variability between sites containing ESA-listed corals, including due to differences in water depths, these estimates may not be the most accurate characterization of the numbers of colonies of each ESA-listed coral species that will be exposed to stressors from the action.

Table 7. Estimated number of ESA-listed corals near remaining MEC/MPPEH in Culebra and Desecheo MRSs

MRS	Estimated # of MPPEH/MEC Remaining	Estimated # of ESA-listed Corals Near Remaining MEC/MPPEH
01	2,135	107
02	12,334	733
03	229	23
07	1,308	13
12	3,131	0
13	79	4

Based on NCCOSS survey data, the USACE determined that 6.59 square kilometers (1630.53 acres) within the Desecheo and Culebra MRSs, or 71.1 percent of the benthic habitat in these MRSs, contain coral reef and hard bottom. Approximately 2.5 square kilometers (618.9 acres) or 26 percent of all of the MRSs contains seagrass (NCCOS 2002), with seagrass only present in the Culebra MRSs. To determine the area of impact to coral from a single detonation event, we use HFDs provided by USACE (2021d). For a single underwater detonation event of a 907 kilogram (2,000 pound) bomb, the HFD is 293.5 meters (963 feet). Using this distance, we estimate that a max of 0.27 square kilometers (66.88 acres) of coral habitat in designated critical habitat for green sea turtles could be damaged by detonation. Also, because the largest known MEC/MPPEH item to occur in seagrass is 227 kilograms (500 pounds), the HFD for this area is 209 meters (686 feet). Using these distances, we estimate that a max of 0.14 square kilometers (33.94 acres) of seagrass within green sea turtle critical habitat could be damaged by detonation.

Given the depths within the action area and the information from CSA Ocean Sciences Inc. (2021), PBFs for designated critical habitat for elkhorn and staghorn coral critical habitat and proposed critical habitat for lobed star, mountainous star, boulder star, pillar, and rough cactus corals is present within approximately 90 percent of the 6.59 square kilometers (1,630.53 acres) of coral and hard bottom habitat present within the action area. This totals 5.94 square kilometers (1,467 acres) of coral and hard bottom habitat with PBFs for designated and proposed ESA-listed Atlantic/Caribbean corals, or 61.66 percent of the total area within the underwater portions of the Desecheo and Culebra MRSs. As noted above, a single underwater detonation event during the proposed action could result in damage to approximately 0.27 square kilometers (66.88 acres) of coral habitat, which would affect the PBFs in this area.

As discussed in Section 7.1.3.1, nearshore PBFs for proposed Nassau grouper critical habitat that support development and recruitment include seagrass and coral reef areas, which are present in much of the Culebra and Desecheo MRSs. However, the 4.15 square kilometers (1,025 acres) of proposed Nassau grouper critical habitat off the coast of Culebra does not overlap with any MEC/MPPEH areas as it is only found in underwater portions of MRS 09 and areas where no munitions have been found in MRS 07. MEC/MPPEH may be present in the 0.4 square kilometer (98.8 acre) of proposed critical habitat for Nassau grouper off the coast of Desecheo. However as noted in the PDCs, the USACE and its contractors will, to the extent practicable, refrain from conducting BIP in proposed critical habitat for Nassau grouper within Desecheo's MRS 01. As such, we only expect Nassau grouper critical habitat to be exposed to minimal habitat loss or damage from encapsulation, the installation of in-water structures, and the removal of encrusted items.

8.2.3 Response

Given the exposure discussed above, in this section we describe the range of responses among proposed or ESA-listed sperm whales; green (North and South Atlantic DPSs), leatherback, and hawksbill sea turtles; Central and Southwest Atlantic DPS scalloped hammerhead sharks; Nassau grouper; queen conch, ESA-listed corals, designated critical habitat for North Atlantic DPS green sea turtle, and elkhorn and staghorn coral, and proposed critical habitat for Nassau grouper, and lobed star, mountainous star, boulder star, pillar, and rough cactus corals, as applicable, associated with equipment collisions, underwater detonations, habitat loss or damage, and organism collection and transport associated with activities that will be implemented as part of the action. For the purposes of this consultation, our assessment tries to detect potential lethal, sub-lethal (or physiological), and behavioral responses that might reduce the fitness of individuals.

8.2.3.1 Collisions

Equipment and towed MEC/MPPEH collisions with ESA-listed corals may occur in Culebra's MRSs 02, 03, 07, and 13; and in Desecheo's MRS 01. The estimated numbers of MEC/MPPEH remaining within each MRS and the estimated number of ESA-listed corals that may be within six meters (20 feet) of MEC/MPPEH items are noted in Table 7.

The SOPs for the use of towed equipment, as well as for towing munitions items were incorporated in the PDCs in order to minimize interactions between vessels, equipment, and munitions during surveying and removal activities. While implementation of the PDCs is expected to minimize the potential for collisions with ESA-listed coral colonies, the risk cannot be entirely eliminated, particularly when vessels are towing equipment or MEC/MPPEH items for transport to a disposal area. While equipment and towed MEC/MPPEH collisions with ESA-listed corals have not been confirmed by the USACE during its investigation and cleanup activities off the coast of Culebra and Desecheo, similar work in adjacent areas by the U.S. Navy during its Vieques UXO cleanup activities resulted in the fragmentation of two ESA-listed coral colonies by equipment collision. This led to equipment adjustments to ensure the towed gear had more stability while traveling through the water. Furthermore, during past USACE investigations in the Culebra portion of the action area, an ROV collided with colonized hard bottom, although video footage of the incident did not provide any evidence of affects to ESA-listed corals. Therefore, we believe the loss of or damage to up to two (if we assume the same level of effects as similar work conducted by the U.S. Navy during its Vieques UXO cleanup activities) ESA-listed coral colonies may occur annually from collisions with equipment and towed munitions (CSA Ocean Sciences Inc. 2021; Donovan et al. 2020). Collision events are most likely to occur in Culebra's MRS 02 and Desecheo's MRS 01, but there is also a small potential for collisions to occur in Culebra's MRS 03, 07, and 13 based on water depth and locations of ESA-listed corals in relation to anomalies.

Collisions with ESA-listed corals would cause breakage and abrasion of coral colonies. In addition, colonies affected by breakage or abrasion, which leads to exposed tissue, are more susceptible to bleaching and disease. Collisions with ESA-listed corals during periods of elevated sea surface temperatures and/or disease outbreaks would increase the likelihood that colonies affected by collisions will bleach and/or be infected by disease (e.g., SCTLD). Depending on the size of the colony, the size of the equipment, and the severity of the collision, some or all of the coral colony could be killed by the impact. Fragmented colonies could survive and the fragments could also regrow but reproduction would not occur for one to two years following the collision as the corals would be dedicating resources to regrowth rather than reproduction. Therefore, there could be fitness consequences to a small number of ESA-listed coral colonies associated with equipment or MEC/MPPEH collisions. The effects of collisions with ESA-listed corals by equipment are discussed further in Section 8.2.4.

8.2.3.2 Underwater Detonations

As discussed in the proposed action section, there are approximately 19,216 MEC/MPPEH items remaining on the seafloor within the Culebra and Desecheo Island MRSs. Table 5 lists the estimated number of MEC/MPPEH remaining within each MRS and provides the total number of MEC/MPPEH removed from each area.

Nonintentional detonations, which may occur when a munitions item explodes as a result of movement associated with removal actions, and BIPs to detonate items underwater presenting an explosive hazard, could result in noise levels that cause adverse effects to sperm whales, scalloped hammerhead sharks, Nassau grouper, leatherback, green, and hawksbill sea turtles. Also, depending on the location of the explosion, there could also be physical impacts from the blast to sperm whales, scalloped hammerhead sharks, Nassau grouper, leatherback, green, and hawksbill sea turtles, queen conch, ESA-listed Caribbean corals, designated critical habitat for green sea turtle, and elkhorn and staghorn coral, and proposed critical habitat for Nassau grouper and lobed star, mountainous star, boulder star, pillar, and rough cactus corals.

Nonintentional detonations and BIPs may lead to permanent or temporary loss of hearing sensitivity in sperm whales, and leatherback, green, and hawksbill sea turtles; and temporary loss of hearing sensitivity in scalloped hammerhead sharks and Nassau grouper. Noise-induced loss of hearing sensitivity or threshold shift refers to an ear's reduced sensitivity to sound within frequency bandwidths following exposure to different sound sources; when an ear's sensitivity to sound has been reduced, sounds must be louder for an animal to detect and recognize it. Noise-induced loss of hearing sensitivity is usually represented by the increase in intensity (in decibels) sounds must have to be detected. These losses in hearing sensitivity rarely affect the entire frequency range an ear might be capable of detecting; instead, they affect the frequency ranges that are roughly equivalent to or slightly higher than the frequency range of the noise itself (NMFS 2018a).

For marine mammals in particular, when permanent threshold shift (PTS) occurs, there is physical damage to the sound receptors (hair cells) in the ear that can result in total or partial deafness, or an animal's hearing can be permanently impaired in specific frequency ranges, which can cause the animal to be less sensitive to sounds in that frequency range. Traditionally, investigations of temporary loss of hearing sensitivity, or TTS, have focused on sound receptors (hair cell damage) and have concluded that this form of threshold shift is temporary. Hair cell damage does not accompany TTS in these studies and losses in hearing sensitivity were determined to be short-term and are generally followed by a period of recovery to pre-exposure hearing sensitivity that can last for minutes, days, or weeks. Kujawa and Liberman (2009) reported on noise-induced degeneration of the cochlear nerve that is a delayed result of acoustic exposures producing TTS that occurs in the absence of hair cell damage, which is irreversible. They concluded that the reversibility of noise-induced threshold shifts, or TTS, could disguise progressive neuropathology that would have long-term consequences on an animal's ability to process acoustic information. If this phenomenon occurs in a wide range of species, TTS may have more permanent effects on an animal's hearing sensitivity than earlier studies would lead us to recognize (NMFS 2018a). In addition, there is no way of knowing the severity or degree of TTS an animal sustains from one or multiple exposures, which can either be minor or compounded over time. Due to this, it is likely that TTS in marine mammals can occur with noise exposures that range in magnitude and effect from fully recoverable TTS without tissue damage, through fully recoverable TTS with tissue damage, to the destruction of tissue producing PTS (Houser 2021). TTS is a weighted phenomenon that is fully recoverable at low levels but can lead to tissue damage as it becomes more extreme. Therefore, while TTS is generally considered a less severe impairment compared to PTS, over time, more acute forms of TTS may result in PTS.

Hearing loss may be influenced by several factors such as the exposure frequency, received sound pressure level (SPL), temporal pattern, and duration. The hearing frequencies resulting in hearing loss may vary depending on the exposure frequency, with frequencies at and above the exposure frequency most strongly affected. The amount of hearing loss may range from slight to profound, depending on the ability of the individual to hear at the affected frequencies. In most circumstances, free-ranging animals are not likely to remain in a sound field that contains potentially harmful levels of noise unless they have a compelling reason to do so (for example, if they must feed or reproduce in a specific location). Any behavioral responses that would take an animal out of a sound field or reduce the intensity of its exposure to the sound field would also reduce the animal's probability of experiencing noise-induced losses in hearing sensitivity (NMFS 2018a). Based on the evidence available from empirical studies of animal responses to human disturbance, marine animals are likely to exhibit one of several behavioral responses upon being exposed to anthropogenic sounds considered in this opinion: (1) they may engage in horizontal or vertical avoidance behavior to avoid exposure or continued exposure to a sound that is painful, noxious, or that they perceive as threatening; (2) they may engage in evasive behavior to escape exposure or continued exposure to a sound that is painful, noxious, or that they perceive as threatening, which we would assume would be accompanied by acute stress physiology; (3) they may remain continuously vigilant of the source of the acoustic stimulus, which would alter their time budget. That is, during the time they are vigilant, they are not engaged in other behavior; and (4) they may continue their pre-disturbance behavior and cope with the physiological consequences of continued exposure (NMFS 2018a).

Although the published body of scientific literature contains numerous theoretical studies and discussion papers on hearing impairments that can occur with exposure to a strong sound, only a few studies provide empirical information on noise-induced loss in hearing sensitivity in marine mammals. Hearing loss due to auditory fatigue in marine mammals was studied by numerous investigators (Finneran et al. 2005; Finneran et al. 2002; Finneran et al. 2010; Finneran and Schlundt 2010; Finneran et al. 2000; Kastak et al. 2007; Lucke et al. 2009; Mann et al. 2010; Mooney et al. 2009a; Mooney et al. 2009b; Nachtigall et al. 2003; Nachtigall et al. 2004; Popov et al. 2011; Schlundt et al. 2000; Southall et al. 2007a; Southall et al. 2007b). The studies of marine mammal auditory fatigue were all designed to determine relationships between TTS and exposure parameters such as level, duration, and frequency. In these studies, hearing thresholds were measured in trained marine mammals before and after exposure to intense sounds. The difference between the pre-exposure and post-exposure thresholds indicates the amount of TTS. Species studied include nine individuals of bottlenose dolphin, two beluga whales, a harbor porpoise, two finless porpoises, three California sea lions, a harbor seal, and a northern elephant seal. Some of the more important data obtained from these studies are onset-TTS levels—

exposure levels sufficient to cause a just-measurable amount of TTS, often defined as 6 dB of TTS (for example Schlundt et al. 2000).

Physical injury may be an additional effect of detonations. The likelihood of internal bodily injury from explosive detonations is related to the received impulse of the underwater blast (pressure integrated over time), not peak pressure or energy (Richmond et al. 1973; Yelverton and Richmond 1981; Yelverton et al. 1973; Yelverton et al. 1975). Therefore, impulse is used as a metric upon which internal organ injury can be predicted. Onset mortality and onset slight lung injury are defined as the impulse level that would result in one percent mortality (most survivors have moderate blast injuries and should survive) and zero percent mortality (recoverable, slight blast injuries) in the exposed population, respectively. Criteria for onset mortality and onset slight lung injury were developed using data from explosive impacts on mammals (NMFS 2018a; Yelverton and Richmond 1981).

The impulse required to cause lung damage is related to the volume of the lungs. The lung volume is related to both the size (mass) of the animal and compression of gas-filled spaces at increasing water depth. In terms of gastrointestinal tract (GI) injuries, gas-containing internal organs, such as lungs and intestines, have been shown to be the principle damage sites from shock waves in submerged terrestrial mammals (Greaves et al. 1943; Richmond et al. 1973; Ward and Clark 1943; Yelverton et al. 1973). Slight injury to the gastrointestinal tract may be related to the magnitude of the peak shock wave pressure over the hydrostatic pressure and would be independent of the animal's size and mass (Goertner 1982).

Masking is a phenomenon that affects animals that are trying to receive acoustic information about their environment, including sounds from other members of their species, predators, prey, and sounds that allow them to orient in their environment. Masking these acoustic signals can disturb the behavior of individual animals, groups of animals, or entire populations.

In addition to the potential effects of noise and pressure waves from underwater detonations, depending on the location and magnitude of the explosion in relation to the location of sperm whales, scalloped hammerhead sharks, Nassau grouper, queen conch, and green, leatherback, and hawksbill sea turtles, and ESA-listed Atlantic/Caribbean corals animals could sustain injury or be killed by munition fragments. However, studies of underwater bomb blasts show that fragments are larger than those produced during air blasts and decelerate much more rapidly (O'keeffe and Young 1984; Swisdak Jr. and Montaro 1992), reducing the risk to marine organisms. Strikes of animals from munitions fragments resulting from underwater explosions are unlikely based on PDCs for detonations (i.e., exclusion zones).

Similarly, habitat used by sea turtles, scalloped hammerhead sharks, Nassau grouper, and queen conch, including designated critical habitat for green sea turtles and elkhorn and staghorn coral, and proposed critical habitat for Nassau grouper, and lobed star, mountainous star, boulder star, pillar, and rough cactus corals could suffer damage or destruction due to the physical impacts of a blast and associated blast fragments. Portions of seagrass and coral habitats could be lost should a blast occur in these habitats. Depending on the depth, location, and magnitude of the blast, seagrass roots and rhizomes could be lost or damaged, which would reduce the natural recovery of this habitat, leading to an at least temporary decrease in seagrass habitat available to green and hawksbill (particularly juvenile) sea turtles, juvenile scalloped hammerhead sharks, juvenile Nassau grouper, and queen conch (mostly juveniles) for foraging or shelter. Depending on the location and magnitude of the blast, the hard structure of coral habitat could be lost or damaged. Natural recovery of coral habitat would not be expected where the hard structure is damaged by a blast because it is the result of the growth and death of calcium carbonate organisms over many years. This means there could be a decrease in coral habitat available that sea turtles, juvenile scalloped hammerhead sharks, Nassau grouper, and queen conch may use for refuge and foraging and ESA-listed corals may use for settlement and growth, as well as a loss of the structure and function of a portion of designated critical habitat for green sea turtles and elkhorn and staghorn coral, and proposed critical habitat for Nassau grouper, and lobed star, mountainous star, boulder star, pillar, and rough cactus corals within the action area.

Sperm Whales

As noted in Section 8.2.2, depending on the time and location a detonation event, we estimate a worst-case scenario of at least one mother-calf pair and a group of five individuals (including juveniles and adults) exposed to barotrauma injury/mortality, PTS, and/or TTS from nonintentional detonation and BIP during USACE removal activities. This exposure would most likely occur in deeper waters adjacent to MRS 01 near Desecheo Island during the removal of an estimated 2,135 MEC/MPPEH items remaining in the area, or in deeper waters of Culebra's MRS 02 during the removal of an estimated 12,334 MEC/MPPEH items. Explosive injury to sperm whales would consist of primary blast injury, which refers to those injuries that result from the compression of a body exposed to a blast wave and is usually observed as barotrauma of gas-containing structures (e.g., lung and gut) and structural damage to the auditory system (Corey et al. 1943; General 1991; Richmond et al. 1973). The near instantaneous high magnitude pressure change near an explosion can injure an animal where tissue material properties significantly differ from the surrounding environment, such as around air-filled cavities in the lungs or gastrointestinal tract. Large pressure changes at tissue-air interfaces in the lungs and gastrointestinal tract may cause tissue rupture, resulting in a range of injuries depending on degree of exposure. The lungs are typically the first site to show any damage, while the solid organs (e.g., liver, spleen, and kidney) are more resistant to blast injury (Ward and W. 1943). Recoverable injuries would include slight lung injury, such as capillary interstitial bleeding, and contusions to the gastrointestinal tract. More severe injuries, such as tissue lacerations, major hemorrhage, organ rupture, or air in the chest cavity (pneumothorax), would significantly reduce fitness and likely cause death in the wild. Rupture of the lung may also introduce air into the vascular system, producing air emboli that can cause a stroke or heart attack by restricting oxygen delivery to critical organs.

When estimating the response of sperm whales to an unintentional detonation or BIP, the likelihood of injury depends on the charge size, the geometry of the exposure (distance to the charge, depth of the animal and the charge), and the size of the animal. In general, an animal would be less susceptible to injury near the water surface because the pressure wave reflected from the water surface would interfere with the direct path pressure wave, reducing positive pressure exposure. Susceptibility would increase with depth, until normal lung collapse (due to increasing hydrostatic pressure) and increasing ambient pressures again reduce susceptibility.

Relatively little is known about auditory system trauma in sperm whales resulting from explosive exposure, although it is assumed that auditory structures would be vulnerable to blast injuries. Auditory trauma was found in two humpback whales that died following the detonation of a 5,000 kilogram explosive used off Newfoundland during demolition of an offshore oil rig platform (Ketten et al. 1993), but the proximity of the whales to the detonation was unknown. Eardrum rupture was examined in submerged terrestrial mammals exposed to underwater explosions (Richmond et al. 1973; Yelverton et al. 1973). However, results may not be applicable to the anatomical adaptations for underwater hearing in marine mammals. In this discussion, primary blast injury to auditory tissues is considered gross structural tissue damage distinct from threshold shift or other auditory effects discussed below.

Marine mammals use sound for communication, feeding, and navigation. To better reflect marine mammal hearing, Southall et al. (2007b) recommended that marine mammals be divided into hearing groups, and NMFS made modifications to these groups to divide pinnipeds into two groups and to re-categorize hourglass and Peale's dolphins (*Lagenorhynchus cruciger* and *Lagenorhynchus australis*, respectively) from mid-frequency to high-frequency cetaceans (NMFS 2016; NMFS 2018b; Table 4).

Table 8. Marine Mammal Functional Hearing Groups (NMFS 2016; Southall et al. 2007b)

Hearing Group	Generalized Hearing Range
Low-frequency cetaceans (baleen whales)	7 Hz to 35 kHz
Mid-frequency cetaceans (dolphins, toothed whales, beaked whales, bottlenose whales)	150 Hz to 160 kHz
High-frequency cetaceans (true porpoises, *Kogia*, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger*, *Lagenorhynchus australis*)	275 Hz to 160 kHz
Phocid pinnipeds (underwater) (true seals)	50 Hz to 86 kHz
Otariid pinnipeds (underwater) (sea lions and fur seals)	60 Hz to 39 kHz

The impetus for dividing marine mammals into functional hearing groups was to produce thresholds for each group for the onset of TTS and PTS. The 2016 NMFS guidance and 2018 revisions include a protocol for estimating PTS onset thresholds for impulsive (e.g., airguns, impact hammer pile drivers, explosions) and non-impulsive (tactical sonar, vibratory pile drivers) sound sources. The thresholds serve as a tool to help evaluate the effects of activities employing different sound sources.

The onset of TTS or PTS from exposure to underwater explosions is predicted using sound exposure level-based thresholds in combination with peak pressure thresholds. Based on exposure functions, the onset thresholds for TTS and PTS in sperm whales proposed by the Navy for explosives were developed (NMFS 2018a). The *Criteria and Thresholds for Navy Acoustic Effects Analysis Technical Report* (U.S. Navy 2017) includes non-auditory injury assessments based on exposure thresholds. Increasing animal mass and increasing animal depth both increase the impulse thresholds (i.e., decrease susceptibility; NMFS 2018a). The sound exposure criteria for toothed whales are:

- Onset TTS: 170 dB SEL (weighted) or 224 dB Peak SPL (unweighted)
- Onset PTS: 185 dB SEL (weighted) or 230 dB peak SPL (unweighted)
- Onset injury (impulse):

  Impact Threshold: $65.8M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$

  Threshold for Farthest Range to Effect: $47.5M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$ Pa-s
- Onset injury (peak pressure):

  Exposure Threshold: 243 dB re 1 μPa SPL peak

  Threshold for Farthest Range to Effect: 237 dB re 1 μPa SPL peak
- Onset mortality (impulse):

  Exposure Threshold: $144M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$

  Threshold for Farthest Range to Effect: $103M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$

Where SEL = sound exposure level; SPL = sound pressure level; M = mass of animals (kilograms); D = depth of animals (meters). The threshold for farthest range to effect is the threshold for one percent risk used to assess mitigation effectiveness.

Few data are available on sperm whale responses to impulsive sound sources, with a limited number of studies on responses to seismic surveys, pile driving and construction activity, none of which are part of the proposed activities considered in this consultation. However, the sound resulting from an explosive detonation is considered an impulsive noise and shares important qualities (i.e., short duration and fast rise time) with other impulsive sounds such as those produced by airguns, impact pile driving, and other construction activities. Madsen et al. (2006) and Miller et al. (2009) tagged and monitored eight sperm whales in the Gulf of Mexico exposed to seismic airgun surveys. Sound sources were from approximately two to seven nautical miles away from the whales, and received levels were as high as 162 dB SPL re 1 μPa (Madsen et al. 2006). The whales showed no horizontal avoidance; however, one whale rested at the water's surface for an extended period of time until airguns ceased firing (Miller et al. 2009). While the remaining whales continued to execute foraging dives throughout exposure, tag data suggested there may have been subtle effects of noise on foraging behavior (Miller et al. 2009). Similarly, Weir (2008) observed that seismic airgun surveys along the Angolan coast did not significantly reduce the encounter rate of sperm whales during the 10-month survey period, nor were avoidance behaviors to airgun impulsive sounds observed.

The echolocation calls of toothed whales are subject to masking by high frequency sound. Studies on captive odontocetes by Au (1993), Au et al. (1985), and Au et al. (1974) indicate that some species may use various processes to reduce masking effects (e.g., adjustments in echolocation call intensity or frequency as a function of background noise conditions). There is also evidence that the directional hearing abilities of odontocetes are useful in reducing masking at the high frequencies these cetaceans use to echolocate, but not at the low-to-moderate frequencies they use for communication (Zaitseva et al. 1980). Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses produced by echosounders and submarine sonar (Watkins et al. 1985; Watkins and Schevill 1975). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). However, masking from the sources noted above cannot be directly compared to masking from explosives as there are no direct observations of masking in marine mammals due to exposure to explosive sources (NMFS 2022c). Also, due to the short duration of sound from explosives, the potential for explosives to result in masking that would be biologically significant is limited.

As with hearing loss, auditory masking can effectively limit the distance over which a marine mammal can communicate, detect biologically relevant sounds, and echolocate (odontocetes). Unlike auditory fatigue (temporary loss of hearing after exposure to sound resulting in a temporary shift of the auditory threshold or TTS), which always results in a localized stress response, behavioral changes resulting from auditory masking may not be coupled with a stress response. Another important distinction between masking and hearing loss is that masking only occurs in the presence of the sound stimulus, whereas hearing loss can persist after the stimulus is gone (NMFS 2018a).

Given the above, depending on the size of the munitions item that detonates either due to a BIP or unintentionally and the location of the explosion in relation to the location of animals, sperm whales could suffer primary blast injury, PTS, TTS, or exhibit measurable behavioral responses such as avoidance, stoppage of echolocation and calling, or fleeing the area.

In terms of the possibility of sperm whales being struck during an explosion, the Navy modeled the potential exposure of sperm whales to fragments from non-explosive practice munitions and high-explosive munitions as part of the ESA section 7 consultation with NMFS for the Atlantic Fleet Training and Testing (AFTT; NMFS 2018a). The Navy also reported that no strike from military expended materials has ever been reported or recorded in the AFTT area, which includes Puerto Rico although no active military training occurs currently in the U.S. Caribbean. The Navy used statistical probability modeling to estimate the likelihood of strike by expended materials. Thus, there is the potential for sperm whales to be struck by fragments from an underwater explosion. However, this is unlikely due to the exclusion zones that will be in place. Also, strike is more likely for explosions at the water surface in the immediate area when these animals are present, which is not expected to occur during the activities described in this opinion. This is due to the increased deceleration in velocity that munition fragments have during an underwater detonation (Razic and Miralem 2019). Therefore, the effects of explosions that are likely to result in fitness consequences to a few individuals, likely mother-calf pairs and a group of adults and juveniles, are associated with the noise and pressure wave of the explosion and not potential strikes by expended materials. Noise and pressure wave effects are discussed further in Section 8.2.4.

Nassau Grouper, Scalloped Hammerhead Shark, and Critical Habitat

As noted in Section 8.2.2, we predict juvenile and adult Nassau grouper and neonate, juvenile, and adult scalloped hammerhead sharks will be exposed to nonintentional detonation and BIP during USACE removal activities. Exposures of juvenile scalloped hammerhead sharks and juvenile Nassau grouper will most likely occur in nearshore seagrass habitat within Culebra's MRSs 13, 12, and 07 and nearshore coral reef habitat within Desecheo's MRS 01 and Culebra's MRSs 02, 03, 07, 12, and 13. Furthermore, adult scalloped hammerhead and adult Nassau grouper may overlap with deeper reef habitat within Desecheo's MRS 01 and Culebra MRSs 02, 03, 07, 12, and 13. The number of estimated MEC/MPPEH still remaining in these areas are presented in Table 5. While we cannot predict the exact number of potential exposures of scalloped hammerhead and Nassau grouper from underwater detonations due to limited data on the species in the action area, we only estimate that a small number of each life stage may be exposed to blasts from nonintentional detonations and BIP.

All fish have two sensory systems to detect sound in the water: the inner ear, which functions very much like the inner ear in other vertebrates, and the lateral line, which consists of a series of receptors along the fish's body (Popper 2008). The inner ear generally detects relatively higher-frequency sounds, while the lateral line detects water motion at low frequencies (Hastings and Popper 2005).

Studies of the effects of human-generated sound on fish have been reviewed in numerous places (e.g., Hastings and Popper 2009; Hastings and Popper 2005; NRC 1994; Popper 2003; Popper 2008; Popper and Hastings 2009; Popper et al. 2004; Popper and Schilt 2009). Most results have been in the gray literature (non-peer-reviewed reports - see Hastings and Popper 2009 for extensive critical reviews of this material; Hastings and Popper 2005; Popper 2008).

Concern about potential fish mortality associated with the use of at-sea explosives led military researchers to develop models that predict safe ranges for fish and other animals from explosions of various sizes (see, for instance, Goertner 1982; Goertner et al. 1994; Yelverton et al. 1975). Young (1991) provides equations that allow estimation of the potential effects of underwater explosions on fish possessing swim bladders, which Nassau grouper do, using a damage prediction method developed by Goertner (1982). Young (1991) used the size of the fish and its location relative to the explosive source as parameters but made these independent from environmental conditions such as the water depth where the fish is located and explosive shot frequency.

More recently, in consultations with the Navy, NMFS used the mortality criteria provided in the *2014 American National Standards Institute (ANSI) Guidelines* (Popper et al. 2014), which divides fish according to the presence of a swim bladder and if the swim bladder is involved in hearing. NMFS also used the Navy's AFTT Phase III BA (Department of the Navy 2017) and the AFTT Final EIS (Department of the Navy 2018) impact pile driving and air gun injury thresholds suggested by the ANSI Guidelines as surrogates for numeric thresholds for injury and TTS in fish from explosions (NMFS 2018a). This was done because the 2014 ANSI Guidelines did not suggest numeric thresholds for injury or TTS due to explosives for fish. Nassau grouper have a swim bladder but it is not involved in hearing. The species also lacks hearing specializations and primarily detects particle motion at frequencies below one kHz (NMFS 2018a). Therefore, the sound exposure criteria for mortality, injury, and TTS from explosives for fish with a swim bladder not involved in hearing (that include Nassau grouper) are:

- Onset TTS: >186 dB SEL_{cum}
- Onset of Injury: 203 dB (SEL_{cum}), >207 dB SPL_{peak}
- Onset of Mortality: 229 dB SPL_{peak}

Sound exposure criteria for mortality, injury, and TTS from explosives for fish without a swim bladder (that include scalloped hammerhead sharks) are:

- Onset TTS: No Criteria
- Onset of Injury: 216 dB (SEL_{cum}), >213 dB SPL_{peak}
- Onset of Mortality: 229 dB SPL_{peak}

Where SEL_{cum} = cumulative sound exposure level (dB re 1 μPa^2-s); SPL_{peak} = peak sound pressure level (dB re 1 µPA); and > indicates that the given effect would occur above the reported threshold.

Based on these thresholds, fish located near a BIP or unintentional detonation could be injured or killed. Primary effects related to exposure of fishes with a swim bladder may include damage to the swim bladder and kidney (Dahl et al. 2020). In general, explosives with large net explosive weights produce longer impact ranges. Fishes without a swim bladder are assumed to generally be less susceptible to injury and mortality from noise compared to fishes with swim bladders.

For elasmobranch species, to date, no hearing loss has been demonstrated when exposed to other impulsive acoustic stressors such as air guns and pile driving. For this reason, the risk of it occurring for these species is much lower than those fish species that do possess swim bladders. Therefore, sound exposure ranges for scalloped hammerheads are lower than what is calculated for Nassau grouper given the fact TTS has not been demonstrated at the thresholds, and the criteria for TTS is already based upon a very conservative value for more sensitive fish species with swim bladders. As noted, Nassau grouper do not have any hearing specializations, and do not have swim bladders involved in hearing. Similar to elasmobranchs, we are unaware of any research demonstrating TTS in this species (or others with a swim bladder not involved in hearing) from explosives. Although TTS has not been demonstrated in these species' groups, this does not mean it does not occur. Because we know it can occur from other acoustic stressors, we assume it is possible from exposure to an explosive sound stressor. If TTS does occur, it would likely co-occur with barotraumas, and therefore would be within the range of other injuries these fishes are likely to experience from blast exposures. Depending on the severity of the TTS and underlying degree of hair cell damage, a fish would be expected to recover from the impairment over a period of weeks (for the worst degree of TTS). Most hearing loss associated with TTS would likely be restored to normal hearing ranges within a few hours or days.

Auditory masking refers to the presence of a noise that interferes with a fish's ability to hear biologically relevant sounds. Fish use sounds to detect both predators and prey, and for schooling, mating, and navigating (Popper 2003). Acoustic stressors during spawning migrations of ESA-listed fish species could lead to behavioral responses or auditory masking that affect an individual's ability to find a mate. This is particularly important for SPAGS of Nassau grouper near MRS 01 off the coast of Desecheo Islands, which may congregate during the months of November to late February/early March to spawn (Garcia-Sais et al. 2020). Any noise (i.e., unwanted or irrelevant sound, often of an anthropogenic nature) detectable by a fish can prevent the fish from hearing biologically important sounds including those produced by prey or predators (Popper 2003). The frequency of the sound is an important consideration for fish because many marine fish are limited to detection of the particle motion component of low frequency sounds at relatively high sound intensities (Amoser and Ladich 2003).

Of considerable concern is that human-generated sounds could mask the ability of fish to use communication sounds, especially when the fish are communicating over some distance. In effect, the masking sound may limit the distance over which fish can communicate, thereby having an impact on important components of their behavior. Nassau grouper produce courtship sounds during spawning aggregations that are species-specific. The calls consist of a pulse train with a varying number of short individual pulses and tonal sound in the 30 to 300 Hz band (Ibrahim et al. 2018). Thus, low-frequency sound sources from explosions occurring during spawning events could affect reproductive success, preventing females from hearing the courtship sounds of males. Because most sound production in fish used for communication is generally below 500 Hz (Slabbekoorn et al. 2010), sources with significant low-frequency acoustic energy (i.e., explosives) could affect communication in fish.

One of the problems with existing fish auditory masking data is that the bulk of the studies have been done with goldfish, a freshwater fish with well-developed anatomical specializations that enhance hearing abilities. The data on other species are much less extensive. As a result, less is known about masking in marine species, many of which lack the notable anatomical hearing specializations. However, Wysocki and Ladich (2005) suggest that ambient sound regimes may limit acoustic communication and orientation, especially in animals with notable hearing specializations.

Also potentially vulnerable to masking is navigation by larval fish, although the data to support such an idea are still limited. There is indication that larvae of some reef fish (species not identified in study) may have the potential to navigate to juvenile and adult habitat by listening for sounds emitted from a reef (either due to animal sounds or non-biological sources such as surf action; e.g., Higgs 2005). In a study of an Australian reef system, the sound signature emitted from fish choruses was between 0.8 and 1.6 kHz (Cato 1978) and could be detected by hydrophones three to four nautical miles from the reef (McCauley and Cato 2000). Snapping shrimp in Kaneohe Bay, Hawaii, were found to have clicks with a low-frequency peak between two and five kHz and energy extending out to 200 kHz (Au and Banks 1998). These bandwidths are within the detectable bandwidth of adults and larvae of the few species of reef fish, such as the damselfish, *Pomacentrus partitus*, and bicolor damselfish, *Eupomacentrus partitus*, that have been studied (Kenyon 1996; Myrberg Jr. 1980). There is also evidence larval fish may be using other kinds of sensory cues, such as chemical signals, instead of, or alongside of, sound (Atema et al. 2002). This is relevant to post-larval Nassau grouper that may use noise from non-biological sources such as storms or other kinds of sensory cues for migration (Shenker et al. 1996). However, as stated above, due to the short duration of sound from explosives, the potential for explosives to result in masking effects that would be biologically significant is limited.

Disturbance or strike to scalloped hammerhead sharks and Nassau grouper could result from fragments falling through the water column in small areas. The DOD has not modeled the probability of fragment strike for fish as they did for marine mammals and sea turtles as part of previous consultations for Naval training and testing activities in the U.S., in part because fish are below the water and likelihood of observing an impact is low. In terms of physical damage to habitat, including proposed critical habitat for Nassau grouper, depending on where detonations occur and at what scale, nursery and adult refuge and foraging habitats could be lost or damaged; however, given that the USACE and its contractors will refrain from BIP activities in proposed critical habitat for Nassau grouper within Desecheo's MRS 01 and given the remaining acreage of habitat in the area even after a large explosive event, fitness consequences to individuals are expected to be minimal.

The effects of explosions that are likely to result in fitness consequences to individual scalloped hammerhead sharks and Nassau grouper are discussed further in Section 8.2.4.

Sea Turtles and Critical Habitat

As discussed in Section 8.2.2, a maximum of 46 sub adult/juvenile and four adult green sea turtles may be exposed to TTS, 14 sub adults/juveniles and one adult may experience PTS, and five sub adults/juveniles may be exposed to barotrauma injury/mortality from unintentional detonation/BIP during the USACE's proposed activities in the Culebra MRSs. Also, for hawksbill sea turtles, we estimate 20 sub adult/juvenile and 11 adult hawksbill sea turtles may be exposed to TTS, six sub adults/juveniles and three adults may experience PTS, and two sub adults/juveniles and one adult may be exposed to barotrauma injury/mortality in the Culebra MRSs. This exposure is most likely to occur in Culebra's MRS 12, 13, and 07 where seagrass habitat overlaps with the estimated MEC/MPPEH still remaining in these areas, however it could occur within any MRS in the action area (see Table 5). For Desecheo's MRS 01 we estimate a maximum of six sub adult/juvenile and two adult hawksbill sea turtles may be exposed to TTS, two sub adults/juveniles may experience PTS, and one sub adult may be exposed to barotrauma injury/mortality. We use the same number of exposures of hawksbill sea turtles for green sea turtles in Desecheo. Furthermore, based on the life history of hatchling sea turtles, there is only a small potential for overlap of individuals with USACE nonintentional detonation and BIP events. This exposure, if any, will be assessed in further step-down reviews for USACE BIP/nonintentional detonation events.

Little is known about how sea turtles use sound in their environment. Based on knowledge of their sensory biology (Bartol and Ketten 2006; Moein Bartol and Musick 2003), sea turtles may be able to detect objects within the water column (e.g., vessels, prey, predators) via some combination of auditory and visual cues. However, research examining the ability of sea turtles to avoid collisions with vessels shows they may rely more on their vision than auditory cues (Hazel et al. 2007). Additionally, they are not known to produce sounds underwater for communication.

Available information suggests that the auditory capabilities of sea turtles are centered in the low frequency range (<2 kHz; Bartol et al. 1999a; Lenhardt et al. 1983; Lenhardt et al. 1994; Piniak 2012b; Ridgway et al. 1969), with greatest sensitivity below one kHz. A more recent review of sea turtle hearing and sound exposure indicated that sea turtles detect sounds at less than 1,000 Hz (Popper et al. 2014). Research on leatherback sea turtle hatchlings using auditory evoked potentials showed the turtles respond to tonal signals between 50 and 1,200 Hz in water (maximum sensitivity 100 to 400 Hz; 84 dB re: 1 µPa rms at 300 Hz; Piniak 2012b).

For sea turtles, the Navy developed criteria to determine the potential onset of hearing loss, physical injury (non-auditory), and non-injurious behavioral response to detonation exposure using the weighting function and hearing group developed by compiling sea turtle audiograms available in the literature to create a composite audiogram for sea turtles as a hearing group (U.S. Navy 2017). The sound pressure or blast wave produced from a detonation may also induce physical injuries such as external damage to the carapace and internal damage to organs and blood vessels in addition to affecting hearing (NMFS 2018a). The sea turtle impact threshold criteria (NMFS 2018a) are:

- Onset TTS: 189 dB SEL_{cum} (re: 1 µPa^2-s) and 226 dB SPL (re: 1 µPa)(0-peak)
- Onset PTS: 204 dB SEL_{cum} (re: 1 µPa^2-s) and 232 dB SPL (re: 1 µPa)(0-peak)
- Onset injury (impulse):

  Exposure Threshold: $65.8M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$

  Threshold for Farthest Range to Effect: $47.5M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$ Pa-s
- Onset injury (peak pressure):

  Exposure Threshold: 243 dB re 1 µPa SPL peak

  Threshold for Farthest Range to Effect: 237 dB re 1 µPa SPL peak
- Onset mortality (impulse):

  Exposure Threshold: $144M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$

  Threshold for Farthest Range to Effect: $103M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$

Where M = mass of animals (kilograms); D = depth of animals (meters). The threshold for farthest range to effect is the threshold for one percent risk used to assess mitigation effectiveness.

Sea turtles may exhibit short-term behavioral reactions, such as swimming away or diving to avoid the immediate area around a source based on studies examining sea turtle behavioral responses to sound from impulsive sources. Pronounced reactions to acoustic stimuli could lead to a sea turtle expending energy and missing opportunities to forage or breed. During the nesting season, near nesting beaches, behavioral disturbances may interfere with nesting beach approach. In most cases, acoustic exposures are intermittent, allowing time to recover from an incurred energetic cost, resulting in no long-term consequence (NMFS 2018a).

The Navy conservatively estimated the possibility of a direct strike from military expended materials to a sea turtle based on the distribution and density estimates they had for species and the number of activities in AFTT that would pose a risk (NMFS 2018a). In their study, they noted a direct strike is more likely for explosions at the water surface in the immediate area if these animals are present in the immediate area, which is not likely to be the case during the activities described in this opinion due to exclusion zones described in the PDCs (See Section 3.3.1.4).

The effects to green and hawksbill sea turtles from habitat effects due to underwater detonations could result in fitness consequences for adults and juveniles associated with the need to move to other areas to find refuge and foraging habitat, depending on the location and magnitude of the detonation. This is particularly true for green sea turtles which have designated critical habitat in the action area off the coast of Culebra and juvenile hawksbill sea turtles. Detonations in critical habitat have the potential to destroy seagrass beds that are important foraging habitat for both species in the area. However, BIP and nonintentional detonation can only affect seagrass habitat in Culebra's MRS 12, 13, and 07 and only a maximum of .14 square kilometers (33.94 acres) would be lost in a large scale underwater detonation event. Due to the rare chance of a BIP or nonintentional detonation and the fact that there would be hundreds of acres of seagrass still present if a detonation were to occur in this area, the likelihood of fitness consequences to individual sea turtles from habitat destruction as a result of BIP or nonintentional detonation is small. The effects of explosions that are likely to result in fitness consequences to individual green, hawksbill, and leatherback sea turtles are discussed further in Section 8.2.4.

Queen Conch, ESA-Listed Atlantic/Caribbean Corals, and Critical Habitat

As noted in Section 8.2.2, there are an estimated 2,189 queen conch adults and 2,569 juveniles in the Culebra and Desecheo MRSs. Based on queen conch habitat (i.e., seagrass, microalgae, sand, scattered coral-rock, patch reef, and spur/grove habitats), we only expect exposure of queen conch from BIP and/or nonintentional detonation to occur in limited portions of Desecheo's MRS 01 and Culebra's MRSs 03, 07, 12, and 13 (see Table 6). Using the density of adult queen conch within these MRSs, we estimate that up to 99 adult queen conch may be relocated and/or exposed to a detonation event during investigation and removal activities. Also, using a global conversion ratio of 0.46 (Horn et al. 2022), we estimate up to 116 juveniles may be relocated and/or exposed to a detonation event.

The USACE estimated that up to 1,555 ESA-listed Atlantic/Caribbean corals are near the estimated 19,216 MEC/MPPEH remaining within the Culebra and Desecheo MRSs. These corals could be affected by investigation, removal, and/or relocation activities. Most ESA-listed corals in close proximity to MEC/MPPEH presenting a detonation risk can be collected and transplanted to another location; however, corals that are growing on MEC/MPPEH may be exposed to BIP and/or nonintentional detonation. In all, we estimate that up to 20 percent of the 1,555 ESA-listed corals affected by removal activities may suffer mortality during the transplant process, from nonintentional detonation, or BIP if they cannot be safely removed from the MEC/MPPEH. This is based on previous estimations of transplant mortality for coral transplant work, such as the USACE's restoration project in Port Everglades, Florida (A. Alvarado, USACE, pers. comm. to J. Molineaux, NMFS, October, 19, 2022). However, this is a conservative estimate as coral transplant mortality rates are lower in the Caribbean (e.g., <10 percent; NMFS 2020).

While there have been some recent studies indicating that queen conch veligers and coral planulae (larvae) respond to acoustic cues in order to find suitable substrate for settlement, the sound levels, types of sound, and other factors driving settlement habitat selection are not well-understood. Detonations would result in changes in the soundscape for a short period, but the physical disturbance from detonations is likely to be the more significant stressor so we focus our discussion of response due to physical disturbance.

Physical disturbance affecting queen conch could take the form of mortality or injury. Physical disturbance affecting ESA-listed Caribbean corals and their designated or proposed critical habitat could be breakage or abrasion of coral colonies by the blast and/or fragments from munitions items, fracturing of the substrate forming critical habitat, or pulverizing of the substrate by the blast (the extent of which would depend on the size of the item and location in relation to the animals or habitat). Depending on the location and force of the blast, ESA-listed corals colonies could be completely lost or experience varying degrees of damage while queen conch could experience mortality or injury. Damage and mortality of ESA-listed coral colonies and queen conch would lead to a reduction in reproduction, either temporary in the case of injury or permanent in the case of mortality. In addition, damaged corals are more likely to be susceptible to disease, bleaching, and other stressors, which will increase the potential for mortality and declines in reproduction. Similarly, depending on the location and force of the blast, portions of the structure of designated critical habitat for elkhorn and staghorn coral and proposed critical habitat for lobed star, mountainous star, boulder star, pillar, and rough cactus corals could be lost or significantly altered, which would impact recruitment of corals through a decrease in the availability of habitat for coral settlement. However, habitat loss would be limited as a max of 0.27 square kilometers (66.88 acres) out of 5.94 square kilometers (1,467 acres) of coral habitat containing PBFs due to a large scale detonation event. For juvenile queen conch, a maximum of 0.14 square kilometers (33.94 acres) of the 2.5 square kilometers (618.9 acres) of seagrass habitat could be damaged in a large scale underwater detonation event. The effects of explosions are likely to result in fitness consequences to queen conch and ESA-listed coral colonies, decrease the potential for future recruitment and reproduction, and adversely impact the structure and function of designated critical habitat for elkhorn and staghorn coral and proposed critical habitat for lobed star, mountainous star, boulder star, pillar, and rough cactus corals are discussed further in Section 8.2.4.

8.2.3.3 Habitat Loss or Damage

The responses of green and hawksbill sea turtles, scalloped hammerhead sharks, Nassau grouper, queen conch, ESA-listed corals, designated critical habitat for green sea turtle, and elkhorn and staghorn coral, and proposed critical habitat for Nassau grouper and lobed star, mountainous star, boulder star, pillar, and rough cactus corals to habitat loss or damage associated with underwater detonations were discussed above in Section 8.2.3.2. This section focuses on the responses of designated critical habitat for elkhorn and staghorn coral, and proposed critical habitat for lobed star, mountainous star, boulder star, pillar, and rough cactus corals to habitat loss or damage associated with encapsulation of MEC/MPPEH, installation of in-water structures (such as anchor pins), and removal actions in areas containing coral substrate where items have become embedded in the substrate.

If there are ESA-listed corals that cannot be transplanted before an encapsulation of a MEC/MPPEH, either because of their growth form, the explosive hazard presented by the item, or for another reason, these colonies would be lost. Encapsulation of items in coral habitats that the USACE determines cannot be removed from the substrate but present an explosive hazard would result in the removal of a portion of hard bottom substrate used by recruits of ESA-listed corals. The extent of habitat loss for this activity is unknown and will be assessed during future step-down reviews. However, the extent of habitat loss is based on the size of MEC/MPPEH being encapsulated. For example, encapsulation of larger MEC/MPPEH items may require an anchoring mechanism, increasing the total amount of habitat lost (CH2M Hill 2022). For hard bottom substrates, based on the material used for encapsulation, the area might be recolonized by benthic organisms, including corals, in the future but, at least in the short-term, the encapsulated area would not provide suitable substrate for coral recruitment and growth. This method is expected to provide minimal damage and impact to biological resources within and near the encapsulation area.

Anchor pins are the only component of in-water structures currently proposed for installation in hard bottom habitats, including coral reefs. A single anchor pin will have an impact area of

180.65 square centimeters (28 square inches). In-water structures, such as buoy tackle and floating tackle, may be present in waters in or adjacent to coral habitats containing ESA-listed coral colonies and/or designated or proposed critical habitat. The small footprint where anchor pins are installed would no longer be available for coral recruits to settle and grow. Anchor pins would not be installed in ESA-listed coral colonies or immediately adjacent to these colonies so only future recruits would be affected by the loss of settlement area within the footprint of each anchor pin. The full extent of habitat loss for future recruits is unknown due to limited information on the number of anchor pins that will need to be installed. However, due to the small footprint of a single anchor pin installation, habitat loss is expected to be minimal.

In-water structures such as large can buoys may be located in such a way as to cause shading of ESA-listed corals and could cause the corals to suffer health consequences. A study of the effects of shading by a pier on *Siderastrea siderea* and *Diploria clivosa*, two Caribbean coral species that are considered more tolerant to environmental variability than ESA-listed corals such as elkhorn and staghorn, found tissue growth, calcification, skeletal extension, and mesenterial fecundity were significantly decreased, as well juvenile density for *Siderastrea siderea* in the area most affected by shading by the pier (Durant 2006). *Diploria clivosa* in this area also demonstrated a significant decrease in mesenterial fecundity, as well as a significant increase in zooxanthellae density, indicating that the corals may have been attempting to compensate for the decrease in photosynthetic capacity due to lower light availability by increasing the number of photosynthetic organisms in their tissues (Durant 2006). Thus, shading by in-water structures is likely to reduce the growth and reproductive capacity of ESA-listed coral colonies in the shadow of the structures.

The removal of items that have become encrusted in hard substrate could result in adverse effects to ESA-listed Atlantic/Caribbean corals and their designated and proposed critical habitat. The extent of habitat loss during removal activities depends on the size of the item, the degree to which it has become embedded in hard substrate, and the method of removal. Hand removal will result in smaller scale footprints whereas mechanized extraction may increase the total area affected. During removal, ESA-listed coral colonies could be lost, broken, or abraded if they are within the footprint where the removal activity will take place. As noted in the PDCs, if breaks or scarring of the reef structure occur during removal activities, these areas will be patched after coordination with resource agencies, limiting the extent of adverse effects. Also, some ESA-listed coral colonies may be transplanted outside the removal footprint prior to the removal action if feasible. The response of corals to transplant are discussed further in Section 8.2.3.4, so the discussion in this section focuses on the potential loss or damage to ESA-listed corals. Damage to ESA-listed coral colonies, depending on the severity, could lead to a reduction in reproduction, as corals would dedicate resources to growth rather than reproduction. In addition, damaged corals are more likely to be susceptible to disease, bleaching, and other stressors, which will increase the potential for mortality and declines in reproduction. Removal of encrusted items from areas containing the PBFs for designated critical habitat for elkhorn and staghorn coral and proposed critical habitat for lobed star, mountainous star, boulder star, pillar, and rough cactus coral would result in, at a minimum, damage to these habitats. The function of the area of critical habitat affected by the removal of encrusted items as habitat suitable for settlement and growth of ESA-listed Atlantic/Caribbean corals would be lost. Depending on the scale of the removal action, natural recovery of the habitat may not occur.

Overall, habitat loss or damage due to encapsulation, installation of anchor pins will result in a reduction in fitness for affected ESA-listed coral colonies and a reduction in the function of areas containing the PBFs for designated critical habitat for elkhorn and staghorn coral and proposed critical habitat for lobed star, mountainous star, boulder star, pillar, and rough cactus. The effects of the fitness consequences to ESA-listed corals and loss of function of areas of critical habitat are discussed further in Section 8.2.4.

8.2.3.4 Organism Collection, Relocation, and Transplant

ESA-listed corals and queen conch could be affected by removal activities including collection and transplant of individuals or colonies living on or near items to be removed or within the footprint of areas to be encapsulated or due to BIPs and/or unintentional detonation. If queen conch are detected within the footprint of areas to be encapsulated or where BIPs are proposed, they will be moved to a similar suitable habitat outside of the exclusion zone based on PDCs listed in Section 3.3.1.1 and Section 3.3.1.4. For relocation of queen conch, we expect fitness consequences to individuals including but not limited to minor temporary energetic costs related to stress and/or migration to another area and a loss of reproductive, foraging, or refuge habitat for the animal(s).

Not all ESA-listed coral colonies within the footprint of areas that the USACE may propose to be encapsulated or where BIPs will occur will be candidates for removal and transplant and those that are may be only partially removed from an item or impact footprint for transplant. Whether a coral colony can be removed completely for transplant will depend on the size of the colony, if it is diseased, and its growth form (i.e. encrusting versus other forms), as well as the stability of the area it has colonized and safety risks associated with disturbance of MEC/MPPEH. Any portions of a colony left behind are expected to suffer mortality. As noted above, we expect there could be up to 20 percent mortality of transplanted corals based on previous estimations for coral transplant work, such as that for the USACE for a restoration project in the Port Everglades, Florida (A. Alvarado, USACE, pers. comm. to J. Molineaux, NMFS, October, 19, 2022). As stated, this is a conservative estimate as coral transplant mortality rates are lower in the Caribbean (e.g., <10 percent; NMFS 2020). Transplanted corals could also suffer temporary declines in health due to the stress of transplantation. Temporary declines in the health of coral colonies that survive transplantation would be evidenced by bleaching and/or partial tissue mortality, disease, and a lack of sexual reproduction within one to two years following transplantation.

8.2.4 Risk Analysis

As discussed in previous sections, we believe that one or more stressors resulting from the USACE's proposed activities (including equipment collisions, underwater detonations, habitat loss/damage, and organism collection/relocation) are likely to result in potential injury or harassment of sperm whales, green, hawksbill, and leatherback sea turtles, scalloped hammerhead, Nassau grouper, queen conch, and ESA-listed Atlantic/Caribbean corals; potential behavioral responses in sperm whales, sea turtles, scalloped hammerhead sharks, and Nassau grouper; and potential loss or degradation of designated critical habitat for green sea turtles and elkhorn and staghorn coral, and proposed critical habitat for Nassau grouper and lobed star, mountainous star, boulder star, pillar, and rough cactus corals. The consequences of these responses are discussed further below.

8.2.4.1 Collisions

The annual potential mortality or decrease in fitness of ESA-listed coral colonies due to equipment collisions likely includes the same colonies within the action area that could be impacted by removal activities, including those involving relocation of ESA-listed corals. We believe the fitness consequences to or loss of up to two (if we assume the same level of effects as similar work conducted by the U.S. Navy during its Vieques UXO cleanup activities) ESA-listed coral colonies annually from collisions with equipment and towed munitions will not have a measurable effect on the population because there are estimated to be thousands of colonies in the action area based on surveys by NOAA contractors (CSA Ocean Sciences Inc. 2021). In terms of the potential impact to fitness for two ESA-listed coral colonies in years when underwater equipment is used, mature colonies might not spawn the year in which breakage occurs due to the stress of severe breakage. If injury is severe enough, colonies could die from collisions. Similarly, colonies affected by breakage that bleach or become infected by a disease would not spawn that year and could be lost from the population if bleaching or disease is severe enough to cause full or partial mortality of the colonies. Any colonies that suffer mortality because of collisions or due to stressors that are more likely to affect impacted corals would be removed from the pool of reproductive individuals in the action area. However, we believe the fitness consequences to or loss of up to two ESA-listed coral colonies annually from collisions with equipment will not have a measurable effect on the population because there are estimated to be thousands of colonies in the action area based on surveys by the USACE and its contactors and NOAA (CSA Ocean Sciences Inc. 2021; Donovan et al. 2020). Thus, the proposed action is not likely to result in population-level consequences for ESA-listed corals in the action area or have a measurable effect on reproduction at the population level.

8.2.4.2 Underwater Detonations

Depending on the severity of TTS from underwater detonations, there could be injurious consequences to sperm whales (i.e., tissue damage; Houser 2021). Similarly, if the detonation results in PTS or injuries from the pressure wave, the ability of individual animals to feed, avoid predators, avoid vessels, and communicate, depending on the species affected, could lead to long-term reductions in fitness of individuals.

The last NMFS stock assessment that discussed sperm whales in Puerto Rico was in 2010, but the U.S. Caribbean stock numbers were identified as unknown. Therefore, it is not possible for us to use the stock assessment report to evaluate the population level effects of decreases in fitness because of underwater detonations over the consultation period on the population of sperm whales in the U.S. Caribbean. As noted in Section 8.2.2, based on visual sightings and acoustic data for sperm whales near Culebra and Desecheo, we will assume a worst-case scenario of at least one mother-calf pair and a group of five individuals (including juveniles and adults) in deep-water portions of the action area during underwater detonations that occur during the winter migration period of these animals from approximately November to March compared to the best population estimate of 1,180 for the Gulf of Mexico stock (Hayes et al. 2019). While sperm whale population estimates in the Gulf of Mexico cannot be directly compared to sperm whale populations in the Caribbean, there is evidence that some male individuals from these two areas may overlap. For example, Engelhaupt et al. (2009) conducted an analysis of matrilineally inherited mitochondrial DNA and found significant genetic differentiation between animals from the northern Gulf of Mexico and those from the western North Atlantic Ocean, North Sea and Mediterranean Sea. However, an analysis of biparentally inherited nuclear DNA showed no significant difference between sperm whales sampled in the Gulf and those from the other areas of the North Atlantic, suggesting male-mediated gene flow between the Gulf and North Atlantic Ocean may be occurring (Engelhaupt et al. 2009). Therefore, if we assume sperm whales will suffer fitness consequences in years when underwater detonations occur during months when this species is present in the action area, and that the stock of sperm whales that includes the U.S. Caribbean at least partially overlaps with the Gulf of Mexico population, we conclude the fitness effects annually and cumulatively over the consultation period will not have a measurable effect on the population and are not likely to reduce the population viability of sperm whales.

In terms of the potential impact of fitness consequences to green, hawksbill, and leatherback sea turtles because of significant disturbance, mortality, or injury associated with underwater detonations, we consider the population effects in the context of total annual mortality associated with human activities and the estimated populations of these species. As noted, a maximum of 46 sub-adult/juvenile and four adult green sea turtles may be exposed to TTS, 14 sub-adults/juveniles and one adult may experience PTS, and five sub-adults/juveniles may be exposed to barotrauma injury/mortality from unintentional detonation/BIP during the USACE's proposed activities. Also, for hawksbill sea turtles, we estimate 20 sub-adult/juvenile and 11 adult hawksbill sea turtles may be exposed to TTS, six sub-adults/juveniles and three adults may experience PTS, and two sub-adults/juveniles and one adult may be exposed to barotrauma injury/mortality. Based on the life history of hatchling sea turtles, we were not able to estimate exposure for this life stage. However, impacts to hatchlings will be assessed in further step-down reviews for USACE BIP/nonintentional detonation events. Hatchling leatherback, and adult, sub adult/juvenile, and hatchling green and hawksbill sea turtles could suffer mortality or fitness consequences because of underwater detonations. The North Atlantic DPS of green sea turtles is estimated to have 167,424 nesting females and the South Atlantic DPS to have 63,332 (Seminoff et al. 2015). It is estimated that 22,004 to 29,035 female hawksbill sea turtles nest globally (NMFS and USFWS 2013a). The population of leatherback sea turtles in the North Atlantic is estimated to be 34,000 to 94,000 adults (TEWG 2007). As noted in Section 8.2.2, in the Culebra MRSs there are an estimated 4,347 hatchling leatherback sea turtles; 66 adult, 119 sub adult/juvenile, and 6,350 hatchling hawksbill sea turtles; and 24 adult, 305 sub adult/juvenile, and 199 hatchling green turtles present annually. For Desecheo's MRS 01 there are an estimated eight adult and 737 hatchling leatherback sea turtles; 14 adult, 68 sub adult/juvenile, and 1,411 hatchling hawksbill sea turtles; and 14 adult and 68 sub adult green sea turtles. The number and life stage of sea turtles of each species that suffer fitness consequences because of underwater detonation will depend on the location where underwater BIPs are planned or where nonintentional detonation may occur during cleanup activities due to the instability of underwater munitions. Detonations would occur in localized areas and, based on underwater surveys conducted to date, there are limited numbers and locations where large MEC/MPPEH items are present that would result in a larger potential area of influence for acoustic impacts. However, even when estimating the maximum number of sea turtles that could be impacted by the largest scale detonation event, the numbers of sea turtles affected in Culebra's green and hawksbill adult and sub-adult/juvenile populations are less than 17 percent for TTS, 5.5 percent for PTS, and two percent for barotrauma injury/mortality in Culebra. For Desecheo, when estimating the maximum number of sea turtles impacted by the largest scale detonation event, the numbers of sea turtles affected in Desecheo's green and hawksbill adult and sub-adult/juvenile populations are less than 11 percent for TTS, three percent for PTS, and two percent for barotrauma injury/mortality. In addition, the presence of exclusion zones and biological observers would further mitigate the potential for injury of sea turtles during underwater detonation (Section 3.3.1.4). Therefore, we conclude the fitness effects to different life stages of leatherback, green, and hawksbill sea turtles in years when underwater detonations occur as a result of the proposed action will not have a significant effect on the population and are not likely to reduce the population viability of the North and South Atlantic DPSs of green sea turtles, leatherback sea turtles, and hawksbill sea turtles. The actual numbers of hatchlings likely to suffer fitness consequences will be calculated as part of step-down consultations for removal activities that will use BIPs or that propose the recovery of items that are determined to be unstable and thus present a detonation risk.

Designated critical habitat for green sea turtle encompasses all of the action area off the coast of Culebra Island and surrounding isles and cays within the MRSs. In addition, designated critical habitat for green sea turtles extends beyond the Culebra MRSs, covering approximately 248.41 square kilometers (61,383 acres) of underwater habitat in the surrounding waters around the Culebra archipelago (See Figure 11). As noted in Section 6.2.2.2, PBFs for green sea turtle critical habitat are not precisely defined; however, critical habitat was designated to provide protection for important developmental, foraging, and resting habitats. Important underwater habitats for sea turtles include seagrass, which is the principal dietary component of juvenile and adult green sea turtles, and coral reefs, which provide shelter from predators. These habitat types make up approximately 7.4 square kilometers (1,828.83 acres) or 93.37 percent of the total Culebra portion of the action area. Coral and seagrass areas will no longer be present/functional within the footprint of detonations that occur and natural recovery of the areas within the detonation footprint is not expected for coral habitat and would be very slow for seagrass beds, particularly if the topography of the area was altered. The actual area of green sea turtle critical habitat likely to be lost or damaged due to underwater detonations will be calculated as part of step-down consultations for removal activities that will use BIPs or that propose the recovery of items that pose an explosive hazard. As noted in Section 8.2.2, a max of 0.27 square kilometers (66.88 acres) out of 5.94 square kilometers of coral habitat containing PBFs could be damaged by a single large scale detonation event. Also, a max of 0.14 square kilometers (33.94 acres) out of the 2.5 square kilometers (618.9 acres) of seagrass habitat containing PBFs could be damaged. Therefore, the maximum amount of habitat that could be damaged from a large scale underwater detonation event (0.27 square kilometers [66.88 acres]) is approximately 0.11 percent of the 248.41 square kilometers (61,383 acres) of green sea turtle critical habitat in the surrounding waters of the Culebra archipelago.

In order to assess the potential fitness consequences to scalloped hammerhead sharks and Nassau grouper because of significant disturbance, mortality, or injury associated with underwater detonations, we consider the population effects in the context of total annual mortality associated with human activities and the estimated populations of these two species. Nassau grouper was once naturally abundant in areas with large shelf habitat, including in the Greater Antilles (which includes Puerto Rico) and evidence indicates there is strong genetic differentiation among subpopulations in the Caribbean (Jackson et al. 2014a). Based on the decline in spawning aggregations estimated as 60 percent over the period from 1980 to 2016, the Nassau grouper population was estimated at 3,000 individuals in 2016 (Sadovy et al. 2018) and was expected to continue declining in some areas due to continued fishing pressure. Fisheries data from Puerto Rico based on commercial landings indicate a 99 percent decline in landings from 1998 to 2011, meaning the remaining population of Nassau grouper around Puerto Rico may be very small, though limited population growth has been recorded in Garcia-Sais et al. (2020) which may be a result of the ban on fishing this species in Commonwealth and Federal waters.

The number of scalloped hammerhead sharks in the action area has declined over the past few decades. It is likely that scalloped hammerheads in the Central and Southwest Atlantic DPS have experienced at least the same level of decline as observed in the Northwest Atlantic and Gulf of Mexico DPS since the early 1980s (i.e., 83 percent). However, unlike the Northwest Atlantic and Gulf of Mexico DPS, the Central and Southwest Atlantic DPS continues to see heavy fishing pressure by commercial fisheries off the coast of Brazil and by artisanal fisheries in Central America, the Caribbean, and Brazil. Landings data from MRIP indicate the presence of scalloped hammerheads around Puerto Rico with 797 sharks landed from 2001 – 2016 (NMFS, Fisheries Statistics Division, pers. comm. to J. Molineaux, NMFS, October, 21, 2022), although some of the sharks may have been misidentified. Landed sharks ranged in length from 600 – 800 millimeters (23.6 –31.5 inches), meaning they were likely neonates or juveniles as maturity is reached when males are approximately 1,219 millimeters (48 inches) and females are 1,981 millimeters (78 inches). The number and life stage of scalloped hammerhead sharks and Nassau grouper that suffer fitness consequences because of underwater detonation will depend on the location where underwater BIPs are planned or where nonintentional detonation may occur during cleanup activities due to the instability of underwater munitions. We anticipate that a small percentage of juvenile or neonate scalloped hammerhead sharks and juvenile and adult Nassau grouper that may be present during underwater detonations would be affected because detonations would occur in localized areas and, based on underwater surveys conducted to date, there are limited numbers and locations where large MEC/MPPEH items are present that would result in a larger potential area of influence for acoustic impacts. Therefore, we conclude the fitness effects to scalloped hammerhead sharks and Nassau grouper in years when underwater detonations occur because of the proposed action will not have a measurable effect on the populations and are not likely to reduce the population viability of these two species. The actual numbers and life stages of individuals likely to suffer fitness consequences will be calculated as part of step-down consultations for removal activities that will use BIPs or that propose the recovery of items that are determined to be unstable and thus present a detonation risk.

Proposed critical habitat for Nassau grouper includes portions of both the Culebra and Desecheo action area. As noted in Section 6.2.3, PBFs for Nassau grouper proposed critical habitat are recruitment and developmental habitat and spawning habitat. Important underwater habitats for Nassau grouper in the action area are mainly those that support Nassau grouper recruitment and development such as those noted in Section 6.2.3 (e.g., hard bottom, seagrass areas, inshore patch and fore reefs that provide crevices and holes, and rock outcrops). These habitat types are abundant within the action area and may no longer be present/functional within the footprint of detonations that occur and natural recovery of the areas within the detonation footprint may not occur. The actual area of Nassau grouper proposed critical habitat likely to be lost or damaged due to underwater detonations will be calculated as part of step-down consultations for removal activities that pose an explosive hazard. However, no MEC/MPPEH are within proposed Nassau grouper critical habitat within the Culebra MRSs. Also, because the USACE and its contractors will refrain from conducting BIP in proposed critical habitat for Nassau grouper in Desecheo's MRS 01, we expect the impacts from underwater detonation on proposed critical habitat for Nassau grouper will be negligible.

Based on density data, it is estimated that 1,842 individuals of adult queen conch and 2,162 juveniles may be in the action area. Of this total, it is estimated that 99 adults and 116 juveniles may be exposed to collection/relocation and underwater detonation, which is less than six percent of the population in the action area. Due to PDCs to remove and relocate queen conch from the footprint of a MEC/MPPEH before BIP, we anticipate that only a small number of queen conch may be present during underwater detonations.

The USACE estimated that 1,555 ESA-listed coral colonies within the action area could be affected by removal actions. A portion of these colonies would be affected by any underwater detonations, either as part of BIPs or due to nonintentional detonations. The potential impacts of fitness consequences to ESA-listed corals as a result of mortality or damage associated with underwater detonations are assessed in the context of the estimated populations of each ESA-listed coral species, but it is important to note that we do not have sufficient data to know how many of each species are present in any given location within the action area, excluding small areas where CSA Ocean Sciences Inc. (2021) conducted transect surveys for ESA-listed corals. In the action area, there are an estimated 159,275 lobed star corals, 6,826 boulder star corals, 161,550 mountainous star corals, 94,806 staghorn corals, 48,541 elkhorn corals, and 4,551 pillar and rough cactus corals present in the Culebra and Desecheo MRSs. We anticipate that a small percentage of the total number of ESA-listed coral colonies in locations where underwater detonations occur would be lost or damaged, and their reproductive potential and associated new recruits would be lost either temporarily, as colonies recover from the stress of damage, or permanently in the case of colonies that are destroyed by the blast. Some species, such as pillar coral and rough cactus corals, are naturally rare while others, such as the three star coral species, are more common. Some species are more common in shallow waters, such as elkhorn coral and pillar coral, while others may be present in deeper waters further offshore. Thus, as for other species discussed in this section, the number, species, and life stage (recruit or sexually mature adult) of ESA-listed corals affected by underwater detonations will depend on the location and magnitude of the blast. As noted previously, the USACE estimates that approximately 1,555 ESA-listed coral colonies are present on or immediately adjacent to MEC/MPPEH. These include the coral colonies that would be affected by underwater detonations. Given that no underwater detonations have occurred during underwater cleanup activities conducted to date and that BIPs are unlikely to be used, in addition to the likelihood that many of the ESA-listed coral colonies on and adjacent to MEC/MPPEH will be transplanted prior to movement of items, we believe underwater detonations leading to mortality of a small subset of the ESA-listed corals in the action area will not have a measurable effect on the population of ESA-listed corals in the action area and is not likely to reduce the population viability of ESA-listed corals in the action area. The actual numbers of coral colonies likely to suffer fitness consequences will be calculated based on the estimated area of impact from detonations as part of step-down consultations for removal activities that will use BIPs or that propose the recovery of items that are determined to be unstable and thus present a detonation risk.

Using NCCOS benthic data for Puerto Rico (NCCOS 2002), the USACE and its contractors found that approximately 71.14 percent of benthic habitats within the action area are coral reef and hard bottom habitat. As noted above, CSA Ocean Sciences Inc. (2021) found PBFs present within approximately 90 percent of the 6.59 square kilometers (1,630.53 acres) of coral and hard bottom habitat present within the action area. This totals to 5.94 square kilometers (1,467 acres) of coral and hard bottom habitat with PBFs for designated and proposed ESA-listed Atlantic/Caribbean corals or 61.66 percent of the entire action area. PBFs will no longer be present/functional within the footprint of detonations that occur in areas containing designated and proposed coral critical habitat and natural recovery of the areas within the detonation footprint is not expected. The actual area of critical habitat likely to be lost due to underwater detonations will be calculated as part of step-down consultations for removal activities that will use BIPs or that propose the recovery of items that pose an explosive hazard. However, the detonation footprint and frequency of underwater detonations are expected to be extremely small during the proposed cleanup activities.

8.2.4.3 Habitat Loss or Damage

The annual potential mortality or decrease in fitness of ESA-listed coral colonies due to habitat loss or damage to the corals themselves from encapsulation, in-water structures, and removal of encrusted items likely includes the same colonies within the action area that could be impacted by other stressors associated with the action that are discussed in the other subsections of Section 8.2. To date, encapsulation has not been considered an option for treatment of munitions that pose a human safety risk but, because it may be used in the future, we have included it in the opinion. Only the ESA-listed coral colonies within the encapsulation footprint or the footprint of removal activities for encrusted items that cannot be transplanted would be lost from the population. Similarly, only those colonies within the area shaded by in-water structures would suffer fitness consequences. In terms of the potential impact of fitness consequences to a limited number of ESA-listed coral colonies when encapsulation and/or removal of encrusted items are used in coral habitats where these colonies are present, or in areas affected by shading from in-water structures, mature colonies might not spawn the year in which breakage or damage occurs due to stress. Likewise, colonies affected by breakage or damage that bleach or become infected by a disease would not spawn that year and could be lost from the population if bleaching or disease is severe enough to cause full or partial mortality. Any colonies that suffer mortality would be removed from the pool of reproductive individuals in the action area. In addition, the loss of settlement habitat within the footprint of encapsulation, removal activities where items are encrusted, or in-water structures and their anchor system could reduce the number of future recruits in areas affected by the action. However, we believe the fitness consequences to a small number of ESA-listed coral colonies annually from encapsulation, in-water structures, and/or removal of encrusted items will not have a measurable effect on the population and is not likely to reduce the population viability of ESA-listed corals in the action area.

PBFs for designated critical habitat for elkhorn and staghorn coral critical habitat and proposed critical habitat for lobed star, mountainous star, boulder star, pillar, and rough cactus corals will no longer be present/functional within the footprint of encapsulation, in-water structure anchor systems, or areas where removal of encrusted items occurs. Natural recovery of the areas within the footprint of encapsulation and removal of encrusted items is not expected, although ESA-listed corals may begin to colonize encapsulated areas over time. Also, as noted in the PDCs, if breaks or scarring of the reef structure occur during removal activities, these areas will be patched after coordination with resource agencies, limiting the extent of adverse effects. The area of coral critical habitat impacted by the installation of an anchor pin is 180.65 square centimeters (28 square inches), meaning a large number of anchor pins would have to be installed in the same location in order to result in a measurable loss of habitat area which is not likely to occur. This is minimal compared to the 5.94 square kilometer (1,467 acre) area in the action area with PBFs for Atlantic/Caribbean coral critical habitat. The actual area of ESA-listed Atlantic/Caribbean coral critical habitat likely to be lost due to encapsulation and/or removal of encrusted items will be calculated as part of step-down consultations for removal activities. However, the USACE does not expect to use these removal methods frequently during the proposed cleanup activities.

8.2.4.4 Organism Collection, Relocation, and Transplant

As stated previously, the USACE estimated there are 1,555 ESA-listed coral colonies in the action area that may be affected by the action. This estimate only accounts for ESA-listed corals that are within close proximity (i.e., six meters [20 feet]) of MEC/MPPEH items. Most of these colonies are likely to be star coral species and Atlantic acroporids and most are likely to be affected by removal activities and, in many cases, collection and transplant to remove ESA-listed corals from the impact footprint prior to MEC/MPPEH removal activities. Up to twenty percent of transplanted colonies could suffer mortality due to the stress of transplant while the rest will suffer temporary effects, including to reproduction. Thus, the fitness consequences to individuals include the temporary loss of reproductive potential for corals that survive transplant. A determination of the approximate number and species of ESA-listed corals that will be transplanted will be provided as part of step-down consultations for particular removal actions. However, we believe the fitness consequences to approximately 1,555 ESA-listed coral colonies, including the potential mortality of up to 20 percent of these, or 311 corals, will not have a measurable effect on the population of ESA-listed corals in the action area because the total population is estimated in the hundreds of thousands in the action area and is not likely to reduce the population viability of ESA-listed corals in the action area.

In addition to coral, there are an estimated 1,842 individuals of adult queen conch and 2,162 juveniles in the action area. Due to PDCs to remove and relocate queen conch from the footprint of a MEC/MPPEH before BIP we anticipate that up to 99 adult and 116 juvenile individuals of queen conch may be relocated during the USACE's proposed activities. During relocation, we only predict minor fitness consequences to individuals. Therefore, we conclude that collection and relocation will not have a measurable effect on the population of queen conch in the action area and is not likely to reduce the population viability of queen conch in the action area.

8.2.5 Programmatic Analysis

In the previous sections we evaluated the exposure, response, and risk to proposed or ESA-listed sperm whales, leatherback, green (North and South Atlantic DPSs), and hawksbill sea turtles, Central and Southwest Atlantic DPS scalloped hammerhead sharks; Nassau grouper; queen conch (proposed); ESA-listed Atlantic/Caribbean corals; designated critical habitat for North Atlantic DPS green sea turtles and elkhorn and staghorn coral; and proposed critical habitat for Nassau grouper, and lobed star, mountainous star, boulder star, pillar, and rough cactus corals as a result of the proposed action. In this section we evaluate whether the implementation of the applicable PDCs is sufficient to ensure that the action will not increase the risk to proposed and ESA-listed species or designated and proposed critical habitat associated with the implementation of the proposed action over the consultation lifetime.

Most of the PDCs in this opinion were developed by the USACE in coordination with NMFS based on SOPs used during past survey and removal actions that did not involve any take of ESA-listed species or damage to critical habitat. It is important to consider that most of the activities conducted over the course of the proposed action are those that produce stressors that we do not expect to result in adverse effects to proposed and ESA-listed species or designated and proposed critical habitat. These activities and their effects will be reviewed annually (Section 3.3.2.1). Stressors to proposed and ESA-listed species and their designated and proposed critical habitat from certain activities will be insignificant or discountable (Section 8.1). Other activities will produce stressors that may result in adverse effects to proposed and ESA-listed species, specifically equipment and towed munition collision with ESA-listed corals, underwater detonations, coral habitat loss and damage, and ESA-listed coral transplant. The transplant of corals from underwater munitions to coral habitat is expected to ultimately benefit ESA-listed corals because it will minimize the loss of colonies from the populations within the action area. NMFS regularly recommends that projects whose footprints contain ESA-listed corals include a transplant plan to relocate corals prior to any construction. For activities that produce stressors that may result in adverse effects to proposed or ESA-listed sperm whales, sea turtles, scalloped hammerhead sharks, Nassau grouper, queen conch, and corals, the implementation of the PDCs will reduce the effects of the proposed action such that we do not expect any effects to have population-level consequences over the lifetime of the proposed action. This reduction of impacts to proposed and ESA-listed species due to the implementation of the PDCs further supports our conclusions in 8.2.4 that stressors resulting in adverse effects to proposed or ESA-listed sperm whales, sea turtles, scalloped hammerhead sharks, Nassau grouper, queen conch, and corals will not result in measurable effects to the populations of these species in the action area or reduce their population viability in the action area. Similarly, the implementation of the PDCs will reduce the effects of the action on the PBFs for designated critical habitat for green sea turtles, and elkhorn and staghorn coral, and proposed critical habitat for Nassau grouper, and lobed star, mountainous star, boulder star, pillar, and rough cactus corals in order to maintain the function of the habitat and, thus, not appreciably diminish its conservation value.

8.2.6 Summary of the Effects of the Action

The implementation of the action, particularly surveys and removal actions that include the use of underwater equipment, the potential use of BIPs, nonintentional detonations, encapsulation, removal of encrusted items, in-water structures, and collection and transport of organisms, is expected to result in the take of sperm whales, green, leatherback, and hawksbill sea turtles, scalloped hammerhead sharks, Nassau grouper, queen conch (proposed), and ESA-listed corals, and effects to designated critical habitat for green sea turtle, and elkhorn and staghorn coral, and proposed critical habitat for Nassau grouper, and lobed star, mountainous star, boulder star, pillar, and rough cactus corals.

Underwater detonations from nonintentional detonation and BIP could result in the exposure of:

- Up to 46 sub-adult/juvenile and four adult green sea turtles to TTS, 14 sub-adults/juveniles and one adult to PTS, and five sub-adults/juveniles to barotrauma injury/mortality in the Culebra MRSs;
- Up to 20 sub-adult/juvenile and 11 adult hawksbill sea turtles to TTS, six sub-adults/juveniles and three adults to PTS, and two sub-adults/juveniles and one adult to barotrauma injury/mortality in the Culebra MRSs;
- Up to seven sub-adult/juvenile and one adult green sea turtle to TTS, two sub-adults/juveniles to PTS, and one sub-adult to barotrauma/mortality in Desecheo's MRS 01;
- Up to seven sub-adult/juvenile and one adult hawksbill sea turtle to TTS, two sub-adults/juveniles to PTS, and one sub-adult to barotrauma/mortality Desecheo's MRS 01;
- Up to 99 adult and 116 juvenile individuals of queen conch from injury or mortality;
- Up to 0.27 square kilometers (66.88 acres) out of 5.94 square kilometers of proposed and designated coral habitat containing PBFs for ESA-listed corals in the Culebra and Desecheo MRSs to damage; and
- Up to 0.27 square kilometers (66.88 acres) out of 248.41 square kilometers (61,383 acres) of green sea turtles critical habitat to damage.

Underwater detonations due to BIPs or unintentional detonation of MEC/MPPEH during removal activities could also result in take of up to one mother-calf pair and a group of five individuals (including juveniles and adults) of sperm whales; hatchling green, leatherback, and hawksbill sea turtles; neonate, juvenile, and adult scalloped hammerhead sharks, and juvenile and adult Nassau grouper. However, we are not able to estimate the amount of take at this time due to limited information on species' occurrence in the action area and when/where underwater detonations will occur. Future step-down consultations for specific removal activities proposed by the USACE will be completed to fully assess the potential effects to these species and estimate take. The USACE estimates that 1,555 ESA-listed coral colonies will be affected by the action because of their proximity to or growth on MEC/MPPEH. Although we provided estimates in our exposure analysis based on survey data from coral transects in the action area (Section 8.2.2; CSA Ocean Sciences Inc. 2021), data are not available that would enable us to accurately determine the number of colonies of each species of listed coral included in this estimate though lobed star, mountainous star, and staghorn corals appear to be the most abundant in the action area based on previous surveys (CSA Ocean Sciences Inc. 2021). We anticipate the same colonies would be affected by each of the activities that are expected to result in take of ESA-listed corals.

As discussed in the previous sections, we estimate that collisions from equipment and munition towing during underwater surveys and removal activities could result in the take of two ESA-listed coral colonies annually, most likely lobed, mountainous star, and/or staghorn coral colonies based on the abundance of these corals in the Culebra and Desecheo MRSs.

Organism collection and transport involving the ESA-listed coral colonies or fragments of colonies from areas where removal activities or in-water structure construction will occur and could affect the 1,555 ESA-listed coral colonies estimated by the USACE to be growing on or in the immediate vicinity of MEC/MPPEH. If all of these corals were transplanted, up to 311 would be expected to suffer mortality due to transplant stress. Furthermore, collection, transplant up to 99 adult and 116 juvenile individuals of queen conch may occur.

Similarly, we are not able to estimate the area of ESA-listed coral critical habitat that will be affected by encapsulation and removal of encrusted items from areas containing the PBFs at this time. This will also be part of future step-down consultations for specific removal activities once these effects are known.

9 CUMULATIVE EFFECTS

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR § 402.02). 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.

For this consultation, cumulative effects include climate change, fishing, recreational activities, vessel operation and traffic, research activities, coastal and marine development, and natural disturbance. With continuing climate change, natural disturbance from storms may increase. Climate change continues to cause increasing prolonged periods of elevated sea surface temperatures, which affects the health of ESA-listed corals in particular. Sea level rise has already been measured in Puerto Rico and is projected to continue. These changes due to climate change could lead to shifts in coastal habitats that could contribute additional MEC/MPPEH items to the marine environment over time.

Fishing activity in the Culebra and Desecheo MRSs is limited to mostly recreational fishing; however, potential hook-and-line capture of ESA-listed species due to recreational fishing is possible. Also, recreational fishing, as well as recreational diving and tourism, has led to increases in vessel traffic throughout the Culebra and Desecheo MRSs, increasing potential incidents of vessel strike with ESA-listed species.

Increases in development in coastal areas of Culebra and in-water construction and channel dredging activities have also led to increased adverse effects on ESA-listed species. An increasing trend of unsustainable development, alteration of coastal watersheds, and bare soil exposure have increased sediment delivery to Culebra's coastal waters during heavy rainfall events and have caused a live coral cover decline. As a result, ongoing climate change could exacerbate the effects of any increases in land clearing and development as increased storms would lead to more runoff and the transport of land-based pollutants to nearshore waters used by sea turtles, scalloped hammerhead sharks, Nassau grouper, queen conch, and ESA-listed corals.

10 INTEGRATION AND SYNTHESIS

The *Integration and Synthesis* section is the final step in our assessment of the risk posed to species and critical habitat because of implementing the action. In this section, we add the *Effects of the Action* (Section 8) to the *Environmental Baseline* (Section 7) and the *Cumulative Effects* (Section 9) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a proposed or ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the *Status of the Species and Critical* Habitat (Section 6.2). A summary of each stressor and its associated effects are summarized in Table 9.

Table 9. Summary of Stressors by Activity Type and their Associated Effects on Proposed and ESA-Listed Species and Critical Habitat in the Action Area

Stressor	Vessel Operation *	Diver Operation**	Location and Removal	Water & Sediment Sample Collection	Installation and Maintenance of In-Water Structures	Underwater Investigation Equipment	Land Detonation/ Consolidated Shot
Vessel Strikes/Equipment Collisions	▪		☒ Corals			☒ Corals	
Vessel Anchoring/Beaching/Propeller Wash/Scarring/Accidental Grounding	▪						
Vessel Discharges/Marine Debris	▪						
Noise	▪		▪		▪	▪	
Entanglement/Entrapment			▪		▪	▪	
Sediment Resuspension	▪	▪	▪	▪	▪	▪	
Habitat Loss or Damage	▪	▪	☒ All Proposed and ESA-Listed Species and Critical Habitat Likely to be Adversely Affected by the Action	▪	☒ Corals and Coral Critical Habitat	▪	
Organism Collection and Transplant			☒ Corals & Queen Conch		☒ Corals & Queen Conch		
Contaminant Release	▪		▪	▪	▪		▪

▪ Represents stressors that are not likely to adversely affect the proposed and ESA-listed species and critical habitat present in the Action Area. These stressors were either found insignificant or discountable in Section 8.1.

☒ Represents stressors that are likely to adversely affect the proposed and ESA-listed species and critical habitat. The species and critical habitat these stressors are likely to adversely affect are included in each table cell where this symbol appears.

* Vessel Operation and associated stressors apply across all activities including biological monitoring which is not listed here. All stressors to NMFS proposed and ESA-listed species and critical habitat from biological monitoring are caused by vessel operations.

** Diver Operation and associated stressors apply to location and removal, sample collection, in-water structures, and underwater investigation activities.

Some ESA-listed species are located within the action area but are not expected to be affected by the action or the effects of the action on these ESA resources were determined to be insignificant or discountable. Some activities evaluated individually were determined to have insignificant or discountable effects and thus not likely to adversely affect some or all proposed and ESA-listed species, designated critical habitat, and proposed critical habitat in the action area (Sections 6.1 and 8.1).

The following discussions separately summarize the probable risks the proposed action pose to sperm whales, green (North and South Atlantic DPSs), hawksbill, and leatherback sea turtles, Central and Southwest Atlantic DPS scalloped hammerhead sharks, Nassau grouper, queen conch, ESA-listed corals, designated critical habitat for North Atlantic DPS green sea turtle, and elkhorn and staghorn coral, and proposed critical habitat for Nassau grouper, and lobed star, mountainous star, boulder star, pillar, and rough cactus corals. These summaries integrate the exposure profiles presented previously with the results of our response analyses for each of the activities considered further in this opinion; specifically survey and removal activities involving towing of underwater equipment or MEC/MPPEH, BIPs, nonintentional detonations, encapsulation, removal of encrusted items in coral habitats, and collection and transport of ESA-listed corals. Up to one mother-calf pair and a group of five individuals (including juveniles and adults) of sperm whales may be exposed to TTS, PTS, or barotrauma injury/mortality from underwater detonations. Up to 70 adult and sub-adult/juvenile green sea turtles, and 43 adult and sub-adult/juvenile hawksbill sea turtles may be exposed to TTS, PTS, or barotrauma injury/mortality from underwater detonations in Culebra's MRSs. Up to 11 adult and sub-adult/juvenile hawksbill and 11 adult and sub-adult/juvenile green sea turtles may be exposed to TTS, PTS, or barotrauma injury/mortality from underwater detonations in Desecheo's MRSs. As discussed in Section 8.2.2, green, leatherback, and hawksbill sea turtle hatchlings will only be exposed to underwater detonations if they occur at a time of year when hatchlings are emerging from their nests and entering the sea in the early morning. Due to limited information on when/where underwater detonations will occur, exposure of hatchling green, leatherback, and hawksbill sea turtles cannot be estimated at this time and will need to be assessed during future step-down reviews of USACE removal activities that may result in nonintentional detonation and BIP events. Up to 1,555 ESA-listed coral colonies will be taken as a result of the USACE's proposed action. This includes take from equipment collisions (estimated as two coral colonies per year dead or damaged in the Culebra and/or Desecheo portion of the action area), and up to the total number (1,555) transplanted, of which 311 could suffer mortality. Up to 99 adult and 116 juvenile individuals of queen conch may be collected and relocated during MEC removal activities. Also, up to 0.27 square kilometers (66.88 acres) of coral habitat containing PBFs and up to 0.14 square kilometers (33.94 acres) of seagrass habitat containing PBFs could be damaged by underwater detonation. Additionally, while we discussed the effects of and assessed some take from underwater detonations from BIPs or nonintentional detonations in this opinion, step-down consultations will be required to fully consider the extent and effects of these on hatchling sea turtles, scalloped hammerhead sharks, and Nassau grouper because take of these animals are expected as a result of the physical effects of underwater detonations and noise generated by detonations depending on the location and size of the MEC/MPPEH. Further, while we discussed the effects of encapsulation and removal of encrusted items on coral critical habitat, step-down consultations will be required to fully consider the effects of these activities on critical habitat depending on the size of the area to be encapsulated or excavated.

10.1 Jeopardy Analysis

The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of a listed species," which is "to engage in an action that 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). Therefore, the jeopardy analysis considers both survival and recovery of the species.

Based on our effects analysis, adverse effects to proposed and ESA-listed species are likely to result from the action. The following discussions summarize the probable risks that equipment collisions, underwater detonations, habitat loss/damage, entrapment/entanglement, and organism collection/relocation pose to proposed and ESA-listed species that are likely to be exposed over the lifetime of the action. These summaries integrate our exposure, response, and risk analyses from Section 8.2.

10.1.1 Sperm Whales

Depending on the time and location of the detonation event, we anticipate that up to one mother-calf pair and a group of five individuals (including juveniles and adults) of sperm whales will be exposed to TTS, PTS, and/or barotrauma injury/mortality because of BIP and nonintentional detonation during the USACE's proposed action. The severity of an animal's response to noise associated with underwater detonations will depend on the location of the detonation in relation to the deepwater areas where these animals are more likely to be present during winter months.

Sperm whales are thought to be the most abundant large whale species, though there are insufficient data to evaluate trends in abundance and growth rates in the action area. The marine mammal stock assessment reports indicate the U.S. Caribbean may contain a separate stock of sperm whales but there are insufficient data to assess the population. There are reports indicating that sperm whales frequent the U.S. Caribbean during their winter migration and there have been sightings of mother-calf pairs and a group of five individuals (including juveniles and adults), as well as a stranding of a juvenile in 2013 off the coast of Vieques Island, Puerto Rico which is approximately 25 kilometers (15.5 miles) southwest of Culebra. Thus, we expect that mother-calf pairs, adults, and juveniles are the life stages of sperm whales that may be affected by take in the form of mortality, PTS, TTS, or behavioral changes should underwater detonations occur as a result of the proposed removal activities. Take may have short or long-term consequences, depending on the level of noise from detonations to which animals are exposed. This will be discussed further in step-down consultations for removal activities when we know more about where underwater detonations may occur. The potential take of a mother-calf pair and/or a group of five individuals (including juveniles and adults) in years when underwater detonations occur could lead to a loss of reproduction at an individual level, but is not expected to have a measurable effect on reproduction at the population level.

The action will not affect the current geographic range of sperm whales and no reduction in the distribution of this species is expected as a result of the action. For this reason, we do not expect the take of individuals to result in population-level consequences to sperm whales.

Because we do not anticipate a significant reduction in numbers or reproduction of this species as a result of the action, a reduction in the likelihood of survival for sperm whales is not expected.

The 2010 Recovery Plan (NMFS 2010) for sperm whales identifies recovery criteria geographically across three ocean basins with the following recovery goals:

1. Achieve sufficient and viable populations in all ocean basins.
2. Ensure significant threats are addressed.

No significant changes in population or the extent or magnitude of threats to sperm whales are anticipated as a result of the action. There could be a slight reduction in reproduction, at least in the year when individuals are affected by underwater detonations, should they occur, but this will not have measurable effects on reproduction at the population level. Therefore, we do not anticipate that the action will impede the recovery goals for sperm whales. In summary, the proposed action would not be expected to appreciably reduce the likelihood of the survival of sperm whales in the wild by reducing the reproduction, numbers, or distribution of that species. Similarly, the proposed action would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of sperm whales in the wild. We conclude that the proposed action will not jeopardize the continued existence of sperm whales.

10.1.2 Sea Turtles

As noted, sea turtles may experience take from underwater detonations during the USACE's proposed action. Even if take is non-lethal, individuals may expend more energy fleeing from noise from underwater detonations and suffer hearing impairment. This can result in reduced growth rates, older age to maturity, and lower lifetime fecundity. Nesting females that experience non-lethal take may also have a reduced reproductive output.

Green Sea Turtle, North Atlantic and South Atlantic DPSs

We anticipate up to 46 sub-adult/juvenile and four adult green sea turtles may be exposed to TTS, 14 sub-adults/juveniles and one adult may experience PTS, and five sub-adults/juveniles may be exposed to barotrauma injury/mortality as a result of BIP and nonintentional detonation during the USACE's proposed action in Culebra MRSs 02, 03, 07, 12, and 13. We also anticipate that up to seven sub-adult/juvenile and one adult green sea turtle may be exposed to TTS, two sub-adults/juveniles may experience PTS, and one sub-adult may be exposed to barotrauma/mortality injury as a result of BIP and nonintentional detonation during the USACE's proposed action in Desecheo's MRS 01.Take of hatchling green sea turtles could also occur as a result of underwater detonations from BIPs and nonintentional detonations. The severity of an individual animal's response to detonations will depend on the location and magnitude of the detonation. Hatchling take will be discussed further in step-down consultations for removal activities when we know more details about where underwater detonations may occur.

No reduction in the distribution or current geographic range of green sea turtles from either DPS is expected from the anticipated take.

Whether the potential reduction in numbers due to injurious take or due to impacts to reproductive output would appreciably reduce the likelihood of survival of green sea turtles from either DPS depends on the probable effect the changes in numbers and reproduction would have relative to current population sizes and trends.

The North Atlantic DPS is the largest of the 11 green sea 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). The South Atlantic 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 the number of nesters or trends (Seminoff et al. 2015). While the lack of data is a concern due to increased uncertainty, the overall trend of the South Atlantic DPS was not considered to be a major concern because 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 South Atlantic DPS on beaches of the USVI, primarily on Buck Island and Sandy Beach, St. Croix, although there are not enough data to establish a trend. Due to Culebra's close proximity to the Virgin Islands, it is possible that green sea turtles nesting on the island are from either DPS.

We believe the action is not reasonably expected to cause, directly or indirectly, an appreciable reduction in the likelihood of survival of green sea turtles from either DPS in the wild. Also the potential mortality of various life stages of green sea turtles may occur as a result of the action, particularly noise effects associated with underwater detonations, and would result in a reduction in absolute population numbers, but the population of green sea turtles in either DPS would not be appreciably affected. Likewise, the reduction in reproduction that could occur as a result of mortality of individuals or decreased growth rates of earlier life stages would not appreciably affect reproductive output in the North or South Atlantic DPS. 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 one 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 sea turtles that are not taken as a result of the action. Because the abundance trend information for green sea turtles is increasing (North Atlantic DPS) or stable (South Atlantic DPS), we believe the anticipated takes attributed to the action will not have any measurable effect on the trend for either DPS.

The Atlantic Recovery Plan for the population of Atlantic green sea turtles (NMFS and USFWS 1991) lists the following recovery objective for 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 adult and immature green sea turtles that inhabit coastal areas of the southeastern U.S. and U.S. Caribbean. From 1997 – 2010, sea turtle surveys in Culebra resulted in the capture of 305 individual green sea turtles, all of which were juveniles or sub-adults based on size and testosterone levels thus suggesting Culebra is an important developmental habitat (Patricio et al. 2011). Using USACE monitoring data of adult sea turtles within Culebra's MRS 02, 03, 07, 12, and 13 (USACE 2022b), we estimate a population of 24 adults. For Desecheo, due to limited data for green sea turtles, we use hawksbill sea turtle data as a surrogate for green sea turtles to estimate a population of 14 adults and 68 juveniles/sub-adult green sea turtles (Bjorndal et al. 2016; Rincon Diaz et al. 2011). Also, based on unpublished nesting data from PRDNER (see Section 7.1.2), we estimate a population of up to 199 hatchlings could be in the Culebra portions of the action area.

The potential take of 70 green sea turtles during a large scale detonation event in Culebra, including 46 sub-adult/juvenile and four adult green sea turtles that may be exposed to TTS, 14 sub-adults/juveniles and one adult that may experience PTS, and five sub-adults/juveniles that may be exposed to barotrauma/mortality is not likely to reduce population numbers over time given the current population sizes, trends, and expected recruitment. Also, the potential take of 11 green sea turtles during a large scale detonation event in Desecheo, including seven sub-adult/juvenile and one adult green sea turtle that may be exposed to TTS, two sub-adults/juveniles that may experience PTS, and one sub-adult/juvenile that may be exposed to barotrauma/mortality is not likely to reduce population numbers over time given the current population sizes, trends, and expected recruitment. While we cannot estimate the exact numbers of take of hatchling green sea turtles that may occur as a result of underwater detonations, we do not expect a significant reduction in population numbers due to the stressors associated with these activities. Estimates for take of sub-adult/juvenile adult green sea turtles are conservative and are based on an underwater detonation of the largest NEW for MEC/MPPEH in the action area. Underwater detonations would be extremely rare and are likely to be reduced through conservation measures and RPMs. These include not conducting BIP during the peak sea turtle nesting season and implementing exclusion zones for sea turtles with a sufficient number of observers to effectively monitor the established exclusion zones based on the furthest distance to TTS for marine mammals, sea turtles, and fishes. In addition, the lowest NEW per detonation will be used to complete the work for a particular detonation activity. For underwater BIP of MEC/MPPEH with a NEW equal to or greater than 45.36 kilograms (100 pounds), the USACE and its contractors will use technology that produces a low order detonation (e.g., Vulcan shaped charge system) to the extent practicable. Furthermore, a stepdown consultation will be conducted if the USACE and its contractors determine that a BIP is required. This stepdown consultation will require an ecological risk assessment to determine if additional PDCs or RPMs are necessary.

Thus, the 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 summary, the proposed action would not be expected to appreciably reduce the likelihood of the survival or recovery of North Atlantic DPS or South Atlantic DPS of green sea turtles in the wild by reducing the reproduction, numbers, or distribution of that species. We conclude that the proposed action will not jeopardize the continued existence of the North and South Atlantic DPSs of green sea turtles.

Leatherback Sea Turtle

Take of hatchling leatherback sea turtles could occur as a result of underwater detonations from BIPs and nonintentional detonations. The severity of an individual animal's responses to noise and fragments from detonations will depend on the location and magnitude of the detonation. This take will be discussed further in step-down consultations for removal activities when we know more details about where underwater detonations may occur.

Given these sea turtles generally have large ranges in which they disperse, no reduction in the distribution or current geographic range of leatherback sea turtles is expected as a result of the proposed action.

Take of hatchlings could occur as a result of underwater detonations. This take would result in PTS, TTS, or behavioral responses and could result in a loss of individuals, which would also mean a loss of reproduction. It is not likely this reduction would appreciably reduce the likelihood of survival of leatherback sea turtles. Nesting trends for the Florida and Northern Caribbean populations, including the largest nesting population in the Southern Caribbean, are all either stable or increasing. Nesting by leatherbacks is reported on various beaches in the action area that would not be affected by the installation of in-water structures seaward of nesting beaches, and underwater detonations are expected to be extremely rare, if they occur at all. Thus, we believe the proposed action is not likely to have any measurable effect on overall population trends.

Because we do not anticipate a significant reduction in numbers or reproduction of this species as a result of the action, a reduction in the likelihood of survival for leatherback sea turtles is not expected.

The Atlantic Recovery Plan for the U.S. population of the leatherback sea turtle (NMFS and USFWS 1992) listed 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, USVI; and along the east coast of Florida.

Between 1978 – 2005, leatherback nesting increased in Puerto Rico from a minimum of nine 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 nesting numbers from 1978 – 2005 (USFWS and NMFS 2007b). Based on calculations of the potential number of hatchling leatherback sea turtles using unpublished and published nesting data from PRDNER (see Section 7.1.2), we estimate a population of up to 4,347 and 737hatchlings could be in the Culebra and Desecheo portions of the action area, respectively.

While we cannot estimate the exact numbers of take of hatchling leatherback sea turtles that may occur as a result of underwater detonations, we do not expect a significant reduction in population numbers due to the stressors associated with these activities. 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 summary, the proposed action would not be expected to appreciably reduce the likelihood of the survival or recovery of leatherback sea turtles in the wild by reducing the reproduction, numbers, or distribution of that species. We conclude that the proposed action will not jeopardize the continued existence of leatherback sea turtles.

Hawksbill Sea Turtle

We anticipate up to 20 sub-adult/juvenile and 11 adult hawksbill sea turtles may be exposed to TTS, six sub-adults/juveniles and three adults may experience PTS, and two sub-adults/juveniles and one adult may be exposed to barotrauma injury/mortality as a result of BIP and nonintentional detonation during the USACE's proposed action in Culebra MRSs 02, 03, 07, 12, and 13. We also anticipate that up to seven sub adult/juvenile and one adult hawksbill sea turtle may be exposed to TTS, two sub adults/juveniles may experience PTS, and one sub-adult/juvenile may be exposed to barotrauma/mortality injury as a result of BIP and nonintentional detonation during the USACE's proposed action in Desecheo's MRS 01.Take of adult, juvenile, and hatchling hawksbill sea turtles could occur as a result of underwater detonations from BIPs and nonintentional detonations. The severity of an individual animal's response to noise and fragments from detonations will depend on the location and magnitude of the detonation. This take will be discussed further in step-down consultations for removal activities when more details are known about where underwater detonations may occur.

No reductions in the distribution or current geographic range of hawksbill sea turtles is expected from the anticipated take.

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 are currently the primary information source for evaluating trends in abundance. Mortimer and Donnelly (2008) found that for nesting populations in the Atlantic (especially in the Insular Caribbean and Western Caribbean Mainland), nine of the 10 sites with recent data (within the past 20 years from approximately 1988 to 2008) show nesting increases in the Caribbean. With increasing nesting trends in the Caribbean, we believe the losses expected due to the action will be replaced due to increased nest production. Therefore, we believe the reduction in numbers and reproduction will not appreciably reduce the survival of hawksbill sea turtles in the wild.

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

- 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, sub-adults, and juveniles are increasing, as evidenced by a statistically significant trend on at least five key foraging areas within Puerto Rico, USVI, 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 (St. Croix) – all show increasing trends in the annual number of nests (USFWS and NMFS 2007a). In-water research projects at Mona Island, Buck Island, and the Marquesas, Florida, which involve the observation and capture of juvenile hawksbill sea turtles have been conducted (USFWS and NMFS 2007a). 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. There are no reliable estimates of the number of adult and immature hawksbill sea turtles that inhabit coastal areas of the southeastern U.S. and U.S. Caribbean. We estimated there are 119 juvenile hawksbill sea turtles in Culebra and 68 juvenile hawksbill sea turtles in Desecheo based on capture/sightings data from Rincon Diaz et al. (2011) and Bjorndal et al. (2016). For the number of adult hawksbill sea turtles in the Culebra and Desecheo portions of the action area, we used sea turtle nesting data to estimate 66 adult hawksbill sea turtles for Culebra and 14 adults for Desecheo (PRDNER unpublished data; Valdés-Pizzini et al. 2011). We also used unpublished PRDNER nesting data to estimate 6,350 hatchling hawksbill sea turtles in the Culebra portion of the action area, and nesting/recapture data from Diez (2022b); Diez et al. (2019); and Valdés-Pizzini et al. (2011) to estimate 1,411 hatchling hawksbill sea turtles in the Desecheo portion of the action area.

The potential take of up to 43 hawksbill sea turtles during a large scale detonation event in Culebra due to TTS, PTS and barotrauma/mortality from BIP or nonintentional detonation during removal activities is not likely to reduce population numbers over time given the current population sizes, trends, and expected recruitment. Also, the potential take of 11 hawksbill sea turtles during a large scale detonation event in Desecheo due to PTS, TTS, and barotrauma/mortality is not likely to reduce population numbers over time given the current population sizes, trends, and expected recruitment. While we cannot estimate the exact numbers of take of adult, juvenile, and hatchling hawksbill sea turtles that may occur as a result of underwater detonations, we do not expect a significant reduction in population numbers due to the stressors associated with these activities. As noted for green sea turtles, estimates for take of sub-adult/juvenile adult hawksbill sea turtles are conservative and are based on an underwater detonation of the largest NEW for MEC/MPPEH in the action area. Underwater detonations would be extremely rare and are likely to be reduced through conservation measures and RPMs. These include not conducting BIP during the peak sea turtle nesting season and implementing exclusion zones for sea turtles with a sufficient number of observers to effectively monitor the established exclusion zones based on the furthest distance to TTS for marine mammals, sea turtles, and fishes. In addition, the lowest NEW per detonation will be used to complete the work for a particular detonation activity. For underwater BIP of MEC/MPPEH with a NEW equal to or greater than 45.36 kilograms (100 pounds), the USACE and its contractors will use technology that produces a low order detonation (e.g., Vulcan shaped charge system) to the extent practicable. Furthermore, a stepdown consultation will be conducted if the USACE and its contractors determine that a BIP is required. This stepdown consultation will require an ecological risk assessment to determine if additional PDCs or RPMs are necessary.

Thus, the 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 summary, the proposed action would not be expected to appreciably reduce the likelihood of the survival or recovery of hawksbill sea turtles in the wild by reducing the reproduction, numbers, or distribution of that species. We conclude that the proposed action will not jeopardize the continued existence of hawksbill sea turtles.

10.1.3 Scalloped Hammerhead

Lethal and non-lethal take of Central and Southwest Atlantic DPS juvenile scalloped hammerhead sharks could occur as a result of underwater detonations from BIPs and nonintentional detonations. The severity of an individual animal's response to noise and fragments from detonations will depend on the location and magnitude of the detonation. This take will be discussed further in step-down consultations for removal activities when more details are known about where underwater detonations may occur.

No reductions in the distribution or current geographic range of scalloped hammerhead is expected from the anticipated take. 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 scalloped hammerhead sharks depends on the probable effect the changes in numbers and reproduction would have relative to current population sizes and trends.

There is currently no accurate population estimate for the Central and Southwest Atlantic DPS of scalloped hammerhead sharks. The most recent population estimates for Northwest Atlantic and Gulf of Mexico DPS scalloped hammerhead sharks is 24,850-27,900 individuals (Hayes et al. 2009). (Miller et al. 2014) concluded that abundance numbers for this DPS are either similar to or worse than those found in the Northwest Atlantic and Gulf of Mexico DPS. Therefore, we will base our analysis on the lower population estimate within this range (i.e., 24,850 individuals). Also, as noted, landings data from MRIP indicate the presence of scalloped hammerheads around Puerto Rico with 797 sharks landed from 2001 – 2016 (NMFS, Fisheries Statistics Division, pers. comm. to J. Molineaux, NMFS, October, 21, 2022), although some of the sharks may have been misidentified. Lethal take of juvenile scalloped hammerhead sharks as a result of the action would lead to reductions in reproductive output and non-lethal take could potentially also affect reproductive output. Given the unlikelihood of underwater detonations, as well as the large habitat areas available to juvenile scalloped hammerhead where no removal activities are likely to occur, we believe the number of individuals affected by the action is likely to be a very small percentage of the actual population in the action area. Therefore, we believe the reduction in numbers and reproduction will not appreciably reduce the survival of Central and Southwest Atlantic DPS scalloped hammerhead sharks in the wild.

A recovery plan for scalloped hammerhead sharks is not yet available. However, recovery is the process by which the ecosystems of a species are restored and the threats to the species are removed. Restoring ecosystems and eliminating threats will help support self-populating and self-regulating populations so they can become persistent members of the native biological communities. Thus, the first step in recovering a species is to reduce identified threats; only by alleviating threats can lasting recovery be achieved. The final listing rule for scalloped hammerhead sharks (79 FR 38213, July 3, 2014) noted the following potential threats to the Central and Southwest Atlantic DPS of scalloped hammerhead sharks: 1.) Overutilization in artisanal fisheries, north of Brazil, that operate in nearshore and inshore environments that are likely nursery areas, and overutilization in artisanal and commercial fisheries within Brazil that target scalloped hammerhead sharks. 2.) Operation of domestic artisanal fisheries and foreign commercial fisheries in areas without adequate fisheries regulations and operation of domestic and foreign fisheries in areas without capacity to enforce existing fishery regulations. 3.) Scalloped hammerhead sharks' physiology makes them very susceptible to mortality in fishing gear. They often suffer very high at-vessel fishing mortality (Macbeth et al. 2009), and their schooling behavior increases their likelihood of being caught in large numbers.

To determine if the action will appreciably reduce the likelihood of recovery for Central and Southwest Atlantic DPS scalloped hammerhead sharks, we assess the effects of the proposed action 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 proposed action will not contribute to the overutilization of the species in Brazil nor will it increase impacts from domestic artisanal fisheries, foreign commercial fisheries, or fishing gear. Scalloped hammerhead sharks are present in the action area based on landings and survey data but there are no reliable estimates of the number of these animals present. The proposed action will not affect the species' life history characteristics or increase the magnitude of the species' vulnerability to fishing. The action will cause a small decrease in reproductive potential and will affect habitat used by the species, specifically juvenile habitat, through removal actions. The action area is a small portion of the species' range and the number of individuals that may be affected by the proposed action is likely a small portion of the population of scalloped hammerhead sharks present in the action area.

While we cannot estimate the exact numbers of take of juvenile scalloped hammerhead sharks that may occur as a result of underwater detonations, we do not expect a significant reduction in population numbers due to the stressors associated with these activities. Thus, the action is not likely to impede the recovery priorities for Central and Southwest Atlantic DPS scalloped hammerhead sharks and will not result in an appreciable reduction in the likelihood of this species' recovery in the wild. In summary, the proposed action would not be expected to appreciably reduce the likelihood of the survival or recovery of scalloped hammerhead sharks in the wild by reducing the reproduction, numbers, or distribution of that species. We conclude that the action will not jeopardize the continued existence of Central and Southwest Atlantic DPS scalloped hammerhead sharks.

10.1.4 Nassau Grouper

Lethal and non-lethal take of adult and juvenile Nassau grouper could occur as a result of underwater detonations from BIPs and nonintentional detonations. The severity of an individual animal's response to noise and fragments from detonations will depend on the location and magnitude of the detonation. This take will be discussed further in step-down consultations for removal activities when more details are known about where underwater detonations may occur.

No reductions in the distribution or current geographic range of Nassau grouper is expected from the anticipated take.

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 Nassau grouper 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 but Sadovy et al. (2018) estimated the overall average spawning aggregation to be 3,000 individuals. The highest number of individuals located in an aggregation is estimated to be 5,223 located off Little Cayman Island (Waterhouse et al. 2020). Fishing of Nassau grouper has been prohibited in the U.S. Caribbean and there is some evidence that multispecies spawning aggregations now include Nassau grouper in increasing numbers (Garcia-Sais et al. 2020; Kadison et al. 2009; Schärer et al. 2009). There are no estimates of juvenile abundance but it would be expected to increase as more adults spawn annually. Lethal take of Nassau grouper as a result of the action would lead to reductions in reproductive output and non-lethal take could also potentially affect reproductive output. Given the unlikelihood of underwater detonations, the use of BIP outside of the spawning season for Nassau grouper, and the refrainment from using underwater detonations in proposed critical habitat for Nassau grouper in Desecheo's MRS 01, as well as the large habitat areas available to juvenile and adult Nassau grouper where no removal activities are likely to occur, we believe the number of individuals affected by the action is likely to be a very small percentage of the actual population in the action area. Therefore, we believe the reduction in numbers and reproduction will not appreciably reduce the survival of Nassau grouper in the wild.

A recovery plan is not available for Nassau grouper but NMFS has developed a recovery outline for this species (available at https://www.fisheries.noaa.gov/resource/document/nassau-grouper-recovery-outline). The outline serves 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 Nassau grouper are now at a very small fraction of their historic abundance. Therefore, conservation and recovery of Nassau grouper requires a two-pronged approach focusing on: 1) reproduction and recruitment as essential with spawning aggregations continuing to function throughout the range to provide larvae, and 2) ensuring appropriate habitat is available for settlement and growth across the Caribbean Sea.

To determine if the action will appreciably reduce the likelihood of recovery for Nassau grouper, we assess the effects of the proposed action 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 identified the species' abundance, life history characteristics, and threat vulnerabilities as characteristics that increase extinction risk. Its low abundance compared to its historic population estimates exacerbate its vulnerability to extinction. Nassau grouper are present in the action area based on survey data but there are no estimates of the number of these animals present. The proposed action will not affect the species' life history characteristics or increase the magnitude of the species' vulnerability to fishing, although fishing for this species in the action area and all of the U.S. Caribbean waters is prohibited. The action will cause a small decrease in reproductive potential and will affect habitat used by the species, particularly juvenile habitat in shallow water, through removal actions. The area affected is a small portion of the species' range and the number of individuals that may be affected by the proposed action is likely a small portion of the population of Nassau grouper in the action area.

While we cannot estimate the exact numbers of take of adult and juvenile Nassau grouper that may occur as a result of underwater detonations, we do not expect a significant reduction in population numbers due to the stressors associated with these activities. This is due to the low likelihood of an underwater detonation event to occur, the implementation of BIP outside of the spawning season for Nassau grouper, and the refrainment from using underwater detonations in proposed critical habitat for Nassau grouper in Desecheo's MRS 01. Thus, the action is not likely to impede the recovery priorities identified for Nassau grouper and will not result in an appreciable reduction in the likelihood of Nassau grouper's recovery in the wild. In summary, the proposed action would not be expected to appreciably reduce the likelihood of the survival or recovery of Nassau grouper in the wild by reducing the reproduction, numbers, or distribution of that species. We conclude that the action will not jeopardize the continued existence of Nassau grouper.

10.1.5 Queen Conch

Because queen conch is proposed for listing as a threatened species but has not yet been listed, the opinion expressed here for this species represents a conference opinion only. Should the species be listed, additional steps will be required to determine whether the conference opinion may be adopted as NMFS' biological opinion (See 50 CFR 402.10). As noted earlier in this opinion, up to 99 adult and 116 juvenile individuals of queen conch may be taken by collection and relocation activities during the course of the proposed action. Lethal and non-lethal take of queen conch could also occur as a result of underwater detonations from BIPs and nonintentional detonations. The severity of an individual animal's response to the blast and fragments from detonations will depend on the location and magnitude of the detonation. This take will be discussed further in step-down consultations for removal activities when more details are known about where underwater detonations may occur.

No reductions in the distribution or current geographic range of queen conch is expected from the anticipated take.

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 queen conch 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 but Horn et al. (2022) estimated an abundance ranging from 451 million to 1.49 billion individuals throughout the species' range. Furthermore, in the action area, Horn et al. (2022) noted density estimates of queen conch range from 6.1 to 54.6 adults per hectare with an estimated one million individuals of adult queen conch off the coast of Puerto Rico. While there are no density estimates for juveniles, we used a global conversion ratio of 0.46 from Horn et al. (2022) to estimate a juvenile abundance. Lethal take of queen conch as a result of the action would lead to reductions in reproductive output and non-lethal take could also potentially affect reproductive output. Given the unlikelihood of underwater detonations, as well as the large habitat areas available to queen conch where no removal activities are likely to occur, we believe the number of individuals affected by the action is likely to be a very small percentage of the actual population in the action area. Therefore, we believe the reduction in numbers and reproduction will not appreciably reduce the survival of queen conch in the wild.

A recovery plan for queen conch is not available because the listing status of the species has not yet been determined. However, recovery is the process by which the ecosystems of a species are restored and the threats to the species are removed. Restoring ecosystems and eliminating threats will help support self-populating and self-regulating populations so they can become persistent members of the native biological communities. Thus, the first step in recovering a species is to reduce identified threats; only by alleviating threats can lasting recovery be achieved. The Status Review Team for queen conch identified commercial and artisanal fishing, illegal and/or unreported fishing, existing regulations, enforcement, and climate change as the biggest threats to the recovery of queen conch.

The proposed action will not contribute to increased impacts from commercial and artisanal fishing, illegal and/or unreported fishing, existing regulations, enforcement, and climate change. The action will cause a small decrease in reproductive potential and will affect habitat used by the species, through removal actions. The area affected is a small portion of the species' range and the number of individuals that may be affected by the proposed action is likely a small portion of the population of queen conch present in the action area.

While we cannot estimate the exact numbers of take of queen conch that may occur as a result of underwater detonations, we do not expect a significant reduction in population numbers due to the stressors associated with these activities. Furthermore, take from collection and relocation is only anticipated to result in minor fitness consequences to a small percentage of queen conch in Puerto Rico. Thus, the action is not likely to impede the recovery of queen conch and will not result in an appreciable reduction in the likelihood of queen conch's recovery in the wild. In summary, the proposed action would not be expected to appreciably reduce the likelihood of the survival or recovery of queen conch in the wild by reducing the reproduction, numbers, or distribution of that species. We conclude that the action will not jeopardize the continued existence of queen conch.

10.1.6 ESA-Listed Corals

As discussed in this opinion, 1,555 ESA-listed coral colonies are expected to be adversely affected by the action over the lifetime of the action. We are unable to separate this estimate into the numbers of colonies of each listed coral species that may be affected. However, data from surveys conducted in the action area indicate that lobed and mountainous star corals and staghorn coral are the most abundance species. Pillar and rough cactus corals are naturally rare.

We estimate that two ESA-listed coral colonies will be taken annually due to collisions with towed equipment and towed MEC/MPPEH and all of the 1,555 colonies could be taken due to collection and transplant (assuming they suffered only damage or partial mortality from other activities resulting in take), of which up to 311 would be expected to suffer mortality as a result of handling and transplant stress in the year when this occurs. Additional take of ESA-listed coral colonies could occur as a result of underwater detonations from BIPs or nonintentional detonation depending on the location and magnitude of the detonation. This take will be discussed further in step-down consultations for removal activities where more details are known about underwater detonations may occur.

Elkhorn and Staghorn Corals

The abundance of elkhorn and staghorn coral is a fraction of what it was before mass mortality in the 1970s and 80s and recent population models forecast the extirpation of these corals from some locations over the foreseeable future due to pressures from increasing threats such as disease and bleaching (Cramer et al. 2020; Perry et al. 2015). 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 is 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. For example, after hurricanes Irma and Maria, up to 11,074 staghorn colonies located in coral farms throughout Culebra were destroyed (Toledo-Hernandez et al. 2018).

No reductions in the distribution or geographic range of elkhorn and staghorn coral are expected to occur as a result of the action.

The action is expected to result in the lethal and non-lethal take of elkhorn and staghorn coral colonies. It is not possible for us to estimate the total numbers of colonies of each species that will be taken but these are likely to be a fraction of the total present in the action area. The loss of elkhorn and staghorn coral colonies will result in a reduction in absolute population numbers of these species in the action area. The loss or temporary removal from the reproductive pool of sexually mature colonies due to responses such as transplant stress will also result in the loss of reproductive potential.

Despite the potential loss of elkhorn and staghorn coral colonies and reproductive potential, the Culebra portion of the action area is part of an extensive reef system between the main island of Puerto Rico and the Virgin Islands. 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. In the status of the species section, we concluded there has been a significant decline in 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.

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 its vulnerability to extinction. Also, given elkhorn coral's estimated abundance, the loss of reproductive potential represented by take of elkhorn colonies due to the proposed action will not measurably impact the species' abundance in Puerto Rico or throughout the species' range. Therefore, we believe the loss of elkhorn coral colonies and reproductive potential due to the action 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 two locations. Impacts to the species' areal coverage would also likely be undetectable on a

Caribbean-wide scale. Therefore, we believe the loss of staghorn coral colonies and reproductive potential due to the action will not appreciably reduce staghorn coral's ability to survive in the wild.

The recovery plan for elkhorn and staghorn corals 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 2015c).

As noted in Section 6.2.6.2, the recovery plan for elkhorn and staghorn coral established three recovery criteria associated with the objective of ensuring population viability and seven 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 percent of consolidated reef habitat in one to five meters (3.3 to 16.4 feet) of water depth within the forereef zone. Thickets are defined as either a) colonies $\geq$ one meter (3.2 feet) diameter in size at a density of 0.25 colonies per square meter (2.6 square feet) or b) live elkhorn coral benthic cover of approximately 60 percent. Populations with these characteristics should be present throughout the range and maintained throughout the lifetime of the action.

Staghorn coral: Thickets are present throughout approximately five percent of consolidated reef habitat in five to 20 meters (16.4 to 65.6 feet) water depth within the forereef zone. Thickets are defined as either a) colonies $\geq$ 0.5 meter (1.6 feet) diameter in size at a density of one colony per square meter (2.6 square feet) or b) live staghorn coral benthic cover of approximately 25 percent. Populations with these characteristics should be present throughout the range and maintained throughout the lifetime of the action.

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 two species. If Criterion 1 is met, then this threat is sufficiently abated; or

Throughout the ranges of these two species, at least 40 percent of the consolidated reef substrate in one to 20 meter (3.3 to 65.6 feet) depth within the forereef remains free of sediment and macroalgal cover as measured on a broad reef to regional spatial scale.

In terms of the recovery objectives, the action is not expected to reduce the overall abundance of elkhorn and staghorn corals in the action area. In terms of Recovery Objective 1 and based on information provided by the USACE in its past coral survey efforts in the action area, elkhorn or staghorn coral thickets are not present in the majority of areas where suspected MEC/MPPEH items are present and may be subject to removal. Thus, we do not expect the abundance objective to be affected. Although we do anticipate some effects to elkhorn and staghorn coral critical 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 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. In summary, the proposed action would not be expected to appreciably reduce the likelihood of the survival or recovery of elkhorn or staghorn coral in the wild by reducing the reproduction, numbers, or distribution of that species. We conclude that the proposed action will not jeopardize the continued existence of elkhorn and staghorn corals.

Pillar Coral

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 many of these have suffered full or partial mortality due to SCTLD. Pillar coral is highly susceptible to SCTLD, which was first reported in Florida in 2014 and then in the U.S. Caribbean in 2019. As shown in Figure 21, a rapid decline in the population of pillar coral has occurred due to SCTLD in the Florida Keys. In Culebra, 2019 surveys from October to November off Tamarindo Chico Reef showed an increase in SCTLD prevalence from four percent to 50 percent. SCTLD is now widespread throughout Puerto Rico's eastern, northern and southern coasts, and has even been recorded in mesophotic reef systems (ranging from 23 to 50 meters [75 to 164 feet] depth) off of Vieques (Korein et al. 2021). Pillar coral is naturally uncommon to rare and population estimates for the Caribbean are not available. Pillar coral is distributed throughout most of the greater Caribbean in reef environments between one to 25 meters (3.3 to 82 feet) in depth but the low coral cover of this species makes it difficult to extrapolate monitoring data in order to determine trends in abundance. 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, NCRMP).

No reductions in the distribution or geographic range of pillar coral is expected to occur as a result of the proposed action.

We find that the anticipated lethal and non-lethal take of pillar coral colonies associated with the action will result in a reduction in numbers of this species. Pillar corals are most likely to be affected by underwater detonations and collection and transplant. Transplanted corals are likely to suffer partial tissue mortality and bleaching and up to 20 percent of them are likely to die as a result of the stress of transplantation. The pillar coral colonies affected by the action are expected to be a fraction of those present in the action area.

The reduction in numbers of pillar corals in the action area is expected to result in a loss of reproductive potential over the lifetime of the proposed action. Despite the potential loss of reproductive potential, the action area represents a very small portion of the species' range and, based on information from coral surveys in Puerto Rico and USVI, pillar corals may be more common in the U.S. Caribbean than in other areas within the species' range. Despite the reduction in reproductive potential, we do not believe there will be long-term damage to the species' ability to sexually reproduce as a result of the action. Therefore, although we believe the project will lead to a loss of reproductive potential related to mortality of colonies that are sexually mature and the temporary loss of reproductive potential due to stressors such as transplantation, we do not anticipate that this would represent a detectable reduction in the long-term reproduction of pillar coral in the action area. We believe the lethal and non-lethal take of pillar coral colonies in the action area will not have any measurable effect on the overall population and will not appreciably reduce the species' likelihood of survival in the wild.

A recovery plan is not available for pillar corals but NMFS has developed a recovery outline for this species (available at https://www.fisheries.noaa.gov/resource/document/5-caribbean-coral-species-recovery-outline). The outline serves 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 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 the 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 its historic 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.

To determine if the proposed action will appreciably reduce the likelihood of recovery for pillar corals, we assess the effects of the proposed action 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 identified the species' abundance, life history characteristics, depth distribution, and threat vulnerabilities as characteristics that increase extinction risk. Its low abundance, combined with its geographic location in shallow waters, exacerbate its vulnerability to extinction. Pillar corals are present in the action area in waters up to approximately 25 meters (82 feet; NMFS 2022a). The action will not affect the species' life history characteristics or increase the magnitude of the species' vulnerability to climate change threats such as ocean warming. The action will cause a small decrease in reproductive potential and will affect habitat for the species through removal actions. The area affected is a small portion of the species' range and the number of colonies that may be affected by the action is likely a small portion of the pillar coral colonies present in the action area. Therefore, we believe that the impacts to pillar corals resulting from the action will not increase the magnitude of the threats that led to the listing of the species as threatened to levels that will appreciably reduce this species' likelihood of recovery in the wild. In summary, the proposed action would not be expected to appreciably reduce the likelihood of the survival or recovery of pillar coral in the wild by reducing the reproduction, numbers, or distribution of that species. We conclude the proposed action is not likely to jeopardize the continued existence of pillar corals in the wild.

Rough Cactus Coral

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. Rough cactus coral is one of the least common coral species observed when it is present.

No reductions in the distribution or geographic range of rough cactus coral is expected to occur as a result of the action.

We find that the anticipated lethal and non-lethal take of rough cactus coral colonies associated with the action will result in a reduction in numbers of this species. Rough cactus corals are most likely to be affected by underwater detonations and collection and transplant. Transplanted corals are likely to suffer partial tissue mortality and bleaching and up to 20 percent of them are likely to die as a result of the stress of transplantation. The reduction in numbers of rough cactus corals in the action area is also expected to result in a loss of reproductive potential, both permanent (due to mortality) and temporary (due to things like transplant stress). Whether the expected reduction in reproduction of rough cactus corals will appreciably reduce its likelihood of survival depends on the probable effects 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 concluded that rough cactus coral has likely declined throughout its range. The population of the species is estimated as at least hundreds of thousands based on estimates from two locations, meaning absolute abundance is higher because the species occurs in many other locations throughout its range, although reports from CSA Ocean Sciences Inc. (2021) did not find the species present within any survey transects in the Culebra or Desecheo action area. Rough cactus coral is a hermaphroditic brooding spawner with very low recruitment. The species has been classified as a generalist, weedy, competitive, and stress-tolerant (Darling et al. 2012), however it is highly susceptible to disease (NMFS 2022a). We believe the loss of rough cactus corals as a result of the proposed action will not have a measurable effect on the overall population and is not likely to appreciably reduce the species' likelihood of survival in the wild.

A recovery plan is not available for rough cactus corals but NMFS has developed a recovery outline for this species (available at https://www.fisheries.noaa.gov/resource/document/5-caribbean-coral-species-recovery-outline). The outline serves 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 corals are unknown but the species does appear to have experienced a decline in Florida. No information on status trends in Puerto Rico was provided. 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 the 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 its historic 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.

To determine if the action will appreciably reduce the likelihood of recovery for rough cactus corals, we assess the effects of the action 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 identified the species' abundance, life history characteristics, and threat vulnerabilities as characteristics that increase extinction risk. Its low abundance, combined with its geographic location, exacerbate its vulnerability to extinction. The action will not affect the species' life history characteristics or increase the magnitude of the species' vulnerability to climate change threats such as ocean warming. The action will cause a small decrease in reproductive potential and will affect habitat for the species through removal actions. The area affected is a small portion of the species' range and the number of colonies that may be affected by the action is likely a small portion of the rough cactus coral colonies present in the action area. Therefore, we believe that the impacts to rough cactus corals resulting from the action will not increase the magnitude of the threats that led to the listing of the species as threatened to levels that will appreciably reduce this species' likelihood of recovery in the wild. In summary, the proposed action would not be expected to appreciably reduce the likelihood of the survival or recovery of rough cactus coral in the wild by reducing the reproduction, numbers, or distribution of that species. We conclude the proposed action is not likely to jeopardize the continued existence of rough cactus corals in the wild.

Lobed Star, Boulder Star, and Mountainous Star Corals

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 reports from various countries indicate the populations of corals from the star coral complex are in decline, including the U.S. (Florida, USVI, and Puerto Rico), Curaçao, Belize, and Colombia. As for other areas in the Caribbean, corals from the star coral complex dominate in the action area.

No reductions in distribution or the geographic range of lobed star, boulder star, and mountainous star corals are expected as a result of the action.

We conclude that the action will result in a reduction in numbers of these species. It is not possible for us to estimate the total numbers of colonies of each species that will be taken but these are likely to be a fraction of the total present in the action area given the dominance of these hard coral species in the action area and throughout the Caribbean. The loss of lobed star, boulder star, and mountainous star coral colonies will result in a reduction in absolute population numbers of these species in the action area. The loss or temporary removal from the reproductive pool of sexually mature colonies due to responses such as transplant stress will also result in the loss of reproductive potential. Despite the anticipated loss of reproductive potential due to the action, we do not believe sexually reproductive individuals of these species in the action area would be affected to a degree that will cause short or long-term damage to the species' ability to sexually reproduce.

Whether the reduction in numbers and reproduction of these species would appreciably reduce their likelihoods of survival in the wild depends on the probable effects these changes would have relative to current population status and trends. Information on the distribution and cover of lobed star, boulder star, and mountainous star corals around Puerto Rico indicate that they are dominant on mesophotic reefs in Puerto Rico and USVI at depths up to 90 meters (295 feet), although boulder star coral tends to be the most dominant species at greater depths and lobed star coral in shallow 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,2017 hurricanes, and SCTLD, which, as discussed, is now prevalent throughout Puerto Rico (Korein et al. 2021). Lobed star coral 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 corals' absolute population abundance has been estimated as at least tens of millions of colonies in the Dry Tortugas and USVI. Therefore, we believe the loss of colonies and reproductive potential due to the proposed action will not appreciably reduce the likelihood of survival in the wild of lobed star, mountainous star, and boulder star corals.

As stated previously for the other species that were listed in September 2014 that will also be affected by the action, there is no recovery plan for these species. However, the recovery plan developed by NMFS (available at https://www.fisheries.noaa.gov/resource/document/5-caribbean-coral-species-recovery-outline) 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).

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. The buffering capacity of these life history characteristics is expected to decrease as colonies shift to smaller size classes. The action will not affect these life history vulnerabilities or increase the species' vulnerability to ocean warming, disease, nutrient enrichment, or acidification. The action will cause a small decrease in reproductive potential and will affect habitat for the species through removal actions. The area affected is a small portion of the species' range and the number of colonies of each species that may be affected by the action is likely a small portion of the lobed star, boulder star, and mountainous star coral colonies present in the action area. Therefore, we believe that the impacts to lobed star, mountainous star, and boulder star corals resulting from the action will not increase the magnitude of the threats that led to the listing of these species as threatened to levels that will appreciably reduce these species' likelihood of recovery in the wild. In summary, the proposed action would not be expected to appreciably reduce the likelihood of the survival or recovery of lobed star, boulder star, and mountainous star corals in the wild by reducing the reproduction, numbers, or distribution of that species. We conclude the action is not likely to jeopardize the continued existence of lobed star, mountainous star, and boulder star corals.

10.2 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 revised regulations issued by NMFS and USFWS (84 FR 45016) on August 27, 2019. Under the revised regulations, destruction or adverse modification means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species.

Ultimately, we seek to determine if, with the implementation of the action, critical habitat would remain functional (or retain the current ability for the PBF to become functional) to serve the intended conservation role for the species. This analysis takes into account the geographic and temporal scope of the action, 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 the species. Because critical habitat for Nassau grouper and lobed star, mountainous star, boulder star, pillar, and rough cactus corals are proposed, the opinion expressed here for these critical habitats represent a conference opinion only. Should these habitats be designated, additional steps will be required to determine whether they may be adopted as NMFS’ biological opinion (See 50 CFR §402.10).

Designated critical habitat for green sea turtles extends beyond the Culebra MRSs, covering approximately 248.41 square kilometers (61,383 acres) of underwater habitat in the surrounding waters around the Culebra archipelago (See Figure 11). PBFs for green sea turtle critical habitat are not defined; however, critical habitat was designated to provide protection for important developmental, foraging, and resting habitats. Important underwater habitats for sea turtles include seagrass which is the principal dietary component of juvenile and adult green sea turtles and coral reefs which provide shelter from predators. These habitat types make up approximately 7.4 square kilometers (1,828.8 acres) or 93.37 percent of the Culebra portion of the action area.

As noted in Section 6.2.3, PBFs for Nassau grouper proposed critical habitat include recruitment, developmental, and spawning habitat. Therefore, the key conservation objective of Nassau grouper proposed critical habitat is to support ontogenetic growth from larval settlement in the nearshore to maturity, with appropriate inter-habitat connectivity to support ontogenetic movement from nearshore habitat used for larval settlement, to intermediate areas used by juveniles, and finally to offshore areas used by adults. As discussed in Section 6.2.3, the biggest influence on Nassau grouper's extinction risk are impacts related to overfishing; however, loss of habitats used by groupers during various life stages may influence their distribution, abundance, and survival. For example, alterations or destruction of nearshore nursery areas and degradation of hard bottom habitat can affect Nassau grouper's ability to grow and survive.

PBFs for ESA-listed Atlantic/Caribbean coral critical habitat make up approximately 5.94 square kilometers (1,467 acres) or approximately 61.66 percent of the action area. As noted in the critical habitat designation, the PBFs for elkhorn and staghorn critical habitat is substrate of suitable quality and availability to support successful larval settlement and recruitment, and reattachment and recruitment of fragments. Recovery cannot occur without protecting the PBF of quality and quantity of suitable substrate because it affects their reproductive success. Therefore, the key conservation objective of designated elkhorn and staghorn coral critical habitat is to increase the potential for successful sexual and asexual reproduction, which in turn facilitates increase in the species' abundance, distribution, and genetic diversity. As noted in the rule designating Atlantic 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.

Similar to elkhorn and staghorn critical habitat, the PBFs for proposed critical habitat for lobed star, mountainous star, boulder star, pillar, and rough cactus corals highlight the importance of suitable quality substrate that is available but also cover other indicators of coral health. These PBFs include the following:

- Substrate with presence of crevices and holes that provide cryptic habitat, the presence of microbial biofilms, or presence of crustose coralline algae;
- Reefscape (all the visible features of an area of reef) with no more than a thin veneer of sediment and low occupancy by fleshy and turf macroalgae;
- Marine water with levels of temperature, aragonite saturation, nutrients, and water clarity that have been observed to support any demographic function; and
- Marine water with levels of anthropogenically-introduced (from humans) chemical contaminants that do not preclude or inhibit any demographic function.

The key conservation objective of proposed critical habitat for lobed star, mountainous star, boulder star, pillar, and rough cactus corals is supporting successful reproduction and recruitment, and survival and growth of all life stages, by abating threats to the corals' habitats. Major threats contributing to these five corals' extinction risk include ocean warming, disease, ocean acidification, trophic effects of reef fishing, nutrient enrichment, and sedimentation.

Based on this information, we need to assess whether the potential loss of or damage to critical habitat areas due to stressors that are likely to adversely affect critical habitat (i.e., habitat loss or damage from underwater detonations during BIPs or nonintentional detonations, encapsulation of MEC/MPPEH, removal of items encrusted in hard substrate, and the construction of in-water structures) rise to the level of adversely modifying or destroying the designated and proposed critical habitat when considered as a whole. Other stressors resulting from the USACE's proposed activities that may affect critical habitat were determined to either be discountable or insignificant (Section 8.1.). For stressors that are likely to adversely affect critical habitat, we need to assess whether these will result in diminished function of green sea turtle critical habitat; Nassau grouper recruitment, developmental, and spawning habitat; or the PBFs of coral critical habitat such that settlement and growth of sexual and asexual recruits are impaired or the successful reproduction and recruitment, and survival and growth of all life stages are diminished which will affect the recovery criteria for elkhorn, staghorn, lobed star, mountainous star, boulder star, pillar, and rough cactus corals. To this end, our analysis seeks to determine whether or not the action is likely to destroy or adversely modify designated critical habitat in the context of the Status of the designated and proposed critical habitat (Section 6.2), the Environmental Baseline (Section 7), the Effects of the Action (Section 8), and Cumulative Effects (Section 9).

Our analysis indicates that some removal activities are likely to have permanent effects to small areas of green sea turtle, proposed Nassau grouper, and designated and proposed coral critical habitat, such as the installation of anchor pins in hard substrate, underwater detonations from BIPs and nonintentional detonations, encapsulation of MEC/MPPEH, and removal of items encrusted in hard substrate. Each anchor pin has a footprint of 180.65 square centimeters (28 square inches), meaning the effects of the installation of these pins as anchors for in-water structures such as marker buoys would be minimal. Encapsulation and removal of encrusted MEC/MPPEH in hard substrate in areas with the PBF for coral critical habitat or in seagrass would have a larger footprint, depending on the site of the munitions item or items. However, given the size of the majority of items identified to date by the USACE, we do not anticipate impact footprints larger than several square feet. In addition, these removal methods have not been used and items determined to be inert that are encrusted in hard substrate are more likely to be left in place with no intervention than encapsulated or broken out of the substrate. Encapsulation is likely to be an option only in cases when MEC/MPPEH are encrusted in hard substrate, likely to present an explosive hazard, and likely to be too unstable to be removed from the substrate without increasing the threat of nonintentional detonation. For this reason, removal of encrusted items is unlikely because any items believed to present an explosive hazard would be left in place rather than trying to chisel these from the substrate due to the increased probability of a nonintentional detonation during removal.

BIPs are a removal method that is not likely to be employed, but could have a large habitat impact depending on the location, size, and amount of explosive material both in the munitions item and used to detonate it. Nonintentional detonations could have larger footprints than BIPs if controls are not in place to minimize the magnitude of the blast, should one occur while MEC/MPPEH is being removed from the substrate and towed to a terrestrial disposal location, although PDCs should minimize the potential from this occurring.

We estimate that a max of 0.27 square kilometers (66.88 acres) out of 5.94 square kilometers (1,467 acres) of proposed and designated coral habitat containing PBFs for ESA-listed corals in the Culebra and Desecheo MRSs could be damaged. A maximum of 0.27 square kilometers (66.88 acres) out of 248.41 square kilometers (61,383 acres) of green sea turtle critical habitat could be damaged (this could include up to 0.27 square kilometers [66.88 acres] of coral habitat damaged or up to 0.14 square kilometers [33.94 acres] of seagrass damaged). Estimates of proposed critical habitat for Nassau grouper will be calculated during a stepdown consultation; however, no MEC/MPPEH are within proposed Nassau grouper critical habitat within the Culebra MRSs. Also, because the USACE and its contractors will refrain from conducting BIP in proposed critical habitat for Nassau grouper in Desecheo's MRS 01, we expect the impacts from underwater detonation on proposed critical habitat for Nassau grouper will be negligible.

The estimates of potential critical habitat damaged from underwater detonation are conservative and are based on largest NEW for MEC/MPPEH in the Culebra and Desecheo MRSs. As noted, the USACE and its contractors have not conducted a BIP and no nonintentional underwater detonation has occurred during previous investigation and removal activities. As a result, underwater detonations will be extremely rare and their impacts to critical habitat will be reduced through conservation measures and RPMs. These include using bubble curtains, physical barriers, and other mitigation techniques to dampen the shock wave from detonation and selecting appropriate sand substrate areas during all phases of the investigation as potential underwater MEC disposal sites based on safety considerations and in order to minimize impacts to resources of concern to the maximum extent practicable. Also, the lowest NEW per detonation will be used. For example, to produce a low order detonation methods such as a Vulcan shaped charge system will be considered/used to minimize potential impacts. For underwater BIP of MEC/MPPEH with a NEW equal to or greater than 45.36 kilograms (100 pounds), the USACE and its contractors will use technology that produces a low order detonation (e.g., Vulcan shaped charge system) to the extent practicable. Furthermore, a stepdown consultation will be conducted if the USACE and its contractors determine that a BIP is required. This stepdown consultation will require an ecological risk assessment to determine if additional PDCs or RPMs are necessary.

The approximate footprints for removal of encrusted items will vary based on the MEC/MPPEH item being removed. However, based on limited information of MEC/MPPEH removal, the USACE only documented 23.48 square meters (252.8 square feet) of seagrass disturbed during past activities. As noted in the PDCs, if breaks or scarring to the reef structure occur during removal activities (not including underwater detonations), these areas will be patched after coordination with resource agencies, limiting the extent of adverse effects. The actual area of impacts to green sea turtle, Nassau grouper, and coral critical habitat from removal activities that may include encapsulation, removal of encrusted items, BIPs, and nonintentional detonations, and from installation of anchor pins will be determined as part of step-down consultations.

Impacts to green sea turtle, Nassau grouper, and coral critical habitat from anchor pins and removal activities are expected to be localized and are not expected to result in the loss or degradation of large areas containing the PBFs for proposed critical habitat for Nassau grouper or designated and proposed coral critical habitat. For seagrass we do not expect the installation of anchor pins to have a large impact. As noted in the PDCs, seagrass habitat will be avoided to the extent possible during the installation of in-water structures. If anchors have to be installed in seagrass, a location with minimum seagrass cover will be identified for anchor installation and subsurface buoys will be installed to keep any chain slack from impacting seagrass. Only 23.48 square meters (252.8 square feet) of seagrass has been disturbed from USACE MEC/MPPEH investigation and removal activities in Culebra. Furthermore, CSA Ocean Sciences Inc. (2021) found 5.94 square kilometers (1,467 acres) of habitat with PBFs for ESA-listed Atlantic coral critical habitat within the Culebra and Desecheo MRSs. One hundred percent of the areas surveyed in the Desecheo MRS contained PBFs whereas 87 percent of the surveyed area within Culebra's MRSs contained PBFs. Underwater survey activities conducted in action area to date have identified thousands of potential MEC/MPPEH items, many of which have already been removed from non-coral habitats, and from coral habitats if they were resting on the surface with no ESA-listed corals colonizing them and/or no ESA-listed coral colonies within 20 feet of the items with no nonintentional detonations. Some of these removal activities have included remote lifting and towing of items that were suspected to present an explosive hazard with no incident. The majority of items that may be MEC/MPPEH are on the surface based on information provided by the USACE, making removal with little to no habitat damage likely. Therefore, we do not expect the effects of the action to appreciably diminish the overall value of the designated and proposed critical habitat in the action area. We conclude that the proposed action will not result in the destruction or adverse modification of designated critical habitat for North Atlantic DPS green sea turtles, and elkhorn and staghorn corals, and proposed critical habitat for Nassau grouper, and lobed star, mountainous star, boulder star, pillar, and rough cactus corals.

11 CONCLUSION

After reviewing the current status of the proposed and ESA-listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of sperm whales, green (North Atlantic and South Atlantic DPSs) sea turtles, leatherback sea turtles, hawksbill sea turtles, Central and Southwest Atlantic DPS scalloped hammerhead sharks, Nassau grouper, elkhorn coral, staghorn coral, rough cactus coral, pillar coral, lobed star coral, mountainous star coral, and boulder star coral, or to result in the destruction or adverse modification of designated critical habitat for North Atlantic DPS green sea turtles, and elkhorn and staghorn coral. NMFS' conference opinion similarly concludes that the action is not likely to jeopardize the continued existence of queen conch or result in the destruction or adverse modification of or proposed critical habitat for Nassau grouper, and lobed star, mountainous star, boulder star, pillar, and rough cactus corals.

It is also NMFS' biological opinion that the action is not likely to adversely affect the following ESA-listed species: fin whale, sei whale, blue whale, giant manta ray, oceanic whitetip shark, and loggerhead sea turtle (Northwest Atlantic Ocean DPS).

12 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation to include significant habitat modification or degradation that results in death or injury to ESA-listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering.

Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Section 7(o)(2) provides that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of an ITS.

12.1 Amount or Extent of Take

Section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent of such incidental taking on the species (50 CFR § 402.14(i)(1)(i)). The amount of take represents the number of individuals that are expected to be taken by actions while the extent of take specifies the impact, i.e., the amount or extent of such incidental taking on the species, which may be used if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (see 80 FR 26832).

We anticipate the action associated with the investigation and removal of MEC/MPPEH by the USACE from Culebra and Desecheo Islands is reasonably likely to result in the incidental take of ESA-listed species by death, injury, or harassment. Incidental take will result from stressors of the action that are likely to adversely affect proposed and ESA-listed species and critical habitat as summarized in Table 9. Specifically, we anticipate the following take of ESA-listed corals and queen conch in the action area:

- 70 green sea turtles during an underwater detonation event in Culebra, including 46 sub-adult/juvenile and four adult green sea turtles that may be exposed to TTS, 14 sub-adults/juveniles and one adult that may experience PTS, and five sub-adults/juveniles that may be exposed to barotrauma/mortality.
- 43 hawksbill sea turtles during an underwater detonation event in Culebra, including 20 sub-adult/juvenile and 11 adult hawksbill sea turtles that may be exposed to TTS, six sub-adults/juveniles and three adults that may experience PTS, and two sub-adults/juveniles and one adult that may be exposed to barotrauma/mortality.
- 11 green sea turtles during an underwater detonation event in Desecheo, including seven sub-adult/juvenile and one adult green sea turtle that may be exposed to TTS, two sub-adults/juveniles and one adult that may experience PTS, and one sub-adult/juvenile that may be exposed to barotrauma/mortality.
- 11 hawksbill sea turtles during an underwater detonation event in Desecheo, including seven sub-adult/juvenile and one adult green sea turtle that may be exposed to TTS, two sub-adults/juveniles that may experience PTS, and one sub-adult/juvenile that may be exposed to barotrauma/mortality.
- 1,555 ESA-listed coral species of which two colonies may suffer lethal or non-lethal take annually from collisions with towed equipment or towed MEC/MPPEH, 1,254 may suffer non-lethal take from transplant stress, 311 may suffer lethal take from mortality due to transplant stress; and all colonies may suffer lethal or non-lethal take from underwater detonations, if BIPS or nonintentional detonations occur
- 99 adult and 116 juvenile individuals of queen conch may suffer non-lethal take from collection and relocation stress. Because queen conch has been proposed for listing but is not yet listed, this ITS for this species will not become effective unless NMFS adopts this opinion once the listing is final (50 CFR 402.10(d)).

The take listed above does not include take of sperm whales, scalloped hammerhead sharks, Nassau grouper, and hatchling sea turtles resulting from noise and potential physical effects from underwater detonations, including BIPs and nonintentional detonations for which adverse effects are expected to occur but have not yet been quantified. This take will be determined, as necessary, during step-down consultations. We anticipate mother-calf pairs and a group of five individuals (including juveniles and adults) of sperm whales; hatchling leatherback, green, and hawksbill sea turtles; adult and juvenile scalloped hammerhead sharks; and adult and juvenile Nassau grouper will experience lethal or non-lethal take as a result of underwater detonations from BIPs or nonintentional detonation should these occur during removal activities in certain years, locations, and timeframes over the lifetime of the action. Similarly, we anticipate modification of designated critical habitat for green sea turtle, and elkhorn and staghorn coral, and proposed critical habitat for Nassau grouper, and lobed star, mountainous star, boulder star, pillar, and rough cactus corals from underwater detonations, encapsulation, and removal of encrusted items. Depending on the extent of habitat impacts, there could be take of additional ESA-listed coral colonies or future recruitment. Also, if the USACE and its contractors plan any underwater detonation events, MMPA authorization will likely be required if take of marine mammals is expected to occur. Any further associated take or additional federal actions (e.g., MMPA authorizations) would require future step-down consultations.

12.2 Reasonable and Prudent Measures

RPMs are measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR § 402.02). The RPMs described below are nondiscretionary, and must be undertaken by the USACE so that they become binding conditions for the exemption in section 7(o)(2) to apply. Section 7(b)(4) of the ESA requires that when a proposed agency action is found to be consistent with section 7(a)(2) of the ESA and the proposed action may incidentally take individuals of ESA-listed species, NMFS will issue a statement that specifies the impact of any incidental taking of endangered or threatened species. To minimize such impacts, RPMs and Terms and Conditions to implement the measures, must be provided. Only incidental take resulting from the agency actions described in Table 9 and consistent with specified RPMs and Terms and Conditions identified in the ITS are exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA.

NMFS believes the RPMs described below are necessary and appropriate to minimize the impacts of incidental take on green (North and South Atlantic DPS), hawksbill, and leatherback sea turtles, Central and Southwest Atlantic DPS scalloped hammerhead sharks, Nassau grouper, queen conch, and ESA-listed corals:

1. Towing of MEC/MPPEH from underwater locations to terrestrial locations for disposal, as well as the operation of towed equipment shall be done in water depths and along navigation routes selected to minimize potential collisions with ESA-listed coral colonies.
2. Colonies of coral that are collected and transplanted will be monitored to assess their condition and transplant success.
3. If queen conch are ESA-listed and BIP is required, the USACE and its contractors will perform subsurface diver surveys on the day of the planned detonation. These surveys will inspect pre-detonation sites to collect and relocate queen conch located within the maximum HFD of the MEC/MPPEH.
4. The USACE must provide NMFS with all data collected during monitoring events and all monitoring reports.
5. When performing an underwater BIP of MEC/MPPEH with a NEW equal to or greater than 45.36 kilograms (100 pounds), the USACE must use technology that produces a low order detonation (e.g., Vulcan shaped charge system).

6. To the extent practicable, the USACE and its contractors must conduct BIP activities outside of the peak nesting season for sea turtles (May to November) in and around Culebra and Desecheo, outside of the peak spawning season for corals (August to October) in and around Culebra and Desecheo, and outside out the spawning season for Nassau grouper (November to late February/early March) in and around Desecheo only.

12.3 Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, the USACE must comply with the following terms and conditions. These include the take minimization, monitoring, and reporting measures required by the section 7 regulations (50 CFR § 402.14(i)). If the USACE fails to ensure compliance with these Terms and Conditions to implement the associated RPMs applicable to the authorities of the agency, the protective coverage of section 7(o)(2) may lapse. The terms and conditions detailed below for each of the RPMs include monitoring and minimization measures where needed.

1. For MEC/MPPEH removal activities requiring that items be towed by a vessel to a terrestrial disposal site, and for surveys involving towed equipment, navigation routes shall be selected prior to commencement of work to the extent possible to minimize the potential for collisions with ESA-listed coral colonies, particularly those growing up from the seafloor or on hard substrate with higher relief that may be closer to the water surface (RPM 1).
    a. The route to be taken by the vessel towing the suspected MEC/MPPEH through any areas containing ESA-listed corals, designated critical habitat for green sea turtles, and elkhorn and staghorn coral, and proposed critical habitat for Nassau grouper, and lobed star, mountainous star, boulder star, pillar, and rough cactus corals shall be selected in advance and provided as part of the project-specific data submission requirements detailed in this opinion. Navigation routes will be selected that have adequate water depths under the vessel and item being towed, and expanses of seafloor without ESA-listed coral colonies or seagrass in the swing radius of the tow rope and item to the maximum extent possible. The navigation routes will also have as few turns as possible in order to minimize slack in the line that could lead to items dropping lower in the water.
    b. The route to be taken by vessels towing survey or other equipment shall also be selected in advance and provided as part of the project-specific data submission requirements detailed in this opinion. Contingency measures will be developed and implemented in case collisions occur despite implementation of the appropriate PDCs for underwater investigations.
    c. Any collisions with ESA-listed corals or coral habitats will be documented, including the location, water depth, vessel speed, weather and sea state,

photographs and an assessment of the damage to ESA-listed coral colonies or critical habitat that includes the size of the impact area or measurements of the coral colony area damaged as a result of a collision. This information will be submitted to NMFS within 48 hours of any collisions.

2. The USACE will evaluate whether ESA-listed corals growing on items to be removed or in the footprint of removal activities can be transplanted and will monitor these corals in comparison with ESA-listed corals that were not transplanted to assess transplant success and to identify if incidental take specified in 12.1 is exceeded (RPM 2).

    a. Surveys to determine the number, species, size, and condition of ESA-listed corals growing on items or in areas where removal activities are proposed and the approximate number of these that qualify for transplant will be completed prior to a removal action. This information will be provided to NMFS as part of the annual reporting requirements under this programmatic consultation. The collection and transplant of ESA-listed corals will be done in accordance with the PDCs for transplanting coral (Section 3.3.1.9).

    b. A subset of transplanted ESA-listed corals and a subset of ESA-listed corals that were not transplanted at the same site (whether corals were transplanted back to the site where the removal action occurred or an alternate site) will be monitored. The plan for monitoring transplanted corals and comparing the condition of these with the same species of ESA-listed corals that were not transplanted will be developed in coordination with NMFS at least 90 working days prior to the first transplant of ESA-listed coral colonies under this consultation.

        i. The USACE and/or its contractors will use guidance from the Florida Fish and Wildlife Conservation Commission (FWC) to aid in developing a monitoring plan (See Section VII of Appendix A).

        ii. After the monitoring plan is drafted and before the first transplant of ESA-listed coral colonies, NMFS will host a meeting with the USACE and/or its contractors and NOAA's Coral Reef Monitoring Program to discuss and assess the plan to ensure maximum survival rates for relocated corals.

    c. Should monitoring indicate that mortality rates, disease, bleaching, or other conditions are worse in transplanted corals, the transplant methods will be assessed to determine whether changes are required to improve transplant success. The USACE will meet with NMFS and the NOAA coral program to determine the most appropriate modifications that are needed and changes will be implemented as soon as reasonably possible for the current work.

3. If queen conch are ESA-listed and BIP is required, subsurface diver surveys for queen conch will include the following (RPM 3):
    a. Close inspection of the surface within the HFD will be made to ensure individuals that are partially buried can be located and collected.
    b. If queen conch are collected from the HFD around the planned detonation site, the USACE and its contractors will work with NMFS to identify the best relocation site with suitable habitat to ensure relocated individuals are placed far enough away so that they do not reenter the planned blast zone.
4. The USACE must provide NMFS with all data collected during monitoring events required under these terms and conditions, as well as any monitoring reports generated over the lifetime of the project and following project completion, including as part of the annual programmatic review (RPM 4).
5. Low order detonation of MEC/MPPEH with a NEW equal to or greater than 45.36 kilograms (100 pounds) will require use of bubble curtains, physical barriers, and other mitigation techniques to dampen the shock wave from detonations and their use specified in the relevant work plan (RPM 5).
6. The USACE and its contractors must intentionally schedule BIP events outside of ecologically sensitive time periods for NMFS ESA-listed species defined in RPM 6 to the extent practicable. If BIP must occur during an ecologically sensitive seasonal time period, the USACE and its contractors will work with NMFS to identify the best time of day that a BIP can occur in order to result in the lowest impacts to NMFS proposed and ESA-listed species (RPM 6).

13 Conservation Recommendation

Section 7(a)(1) of the ESA directs federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

The following conservation recommendations are discretionary measures that NMFS believes are consistent with this obligation and therefore should be carried out by the USACE:

1. NMFS recommends that the use of anchor systems other than concrete bulk anchors be explored such as three pyramid anchors (such as Dor-Mor™) or helical anchors be explored for areas containing seagrass beds in order to reduce the potential impacts to and loss of habitat for green sea turtle and Nassau grouper where oceanographic and sediment characteristics allow.

2. NMFS recommends that the USACE transplant seagrass that will be within the footprint of anchors and other components of in-water structures. A transplant and monitoring plan should be designed in coordination with NMFS, including the Habitat Conservation Division, for implementation prior to commencement of in-water structures.
3. NMFS recommends that uncolonized sandy bottom areas be identified and the information marked on nautical charts and provided to contractors for anchoring of work vessels in project-specific work areas associated with all activities that are part of the proposed action.
4. NMFS recommends the USACE conduct a thorough investigation into coral relocation sites and use recommendations provided by the FWC for coral relocation site selection before relocating corals (See Section V of Appendix A). NMFS also recommends that the USACE consult with NMFS and NOAA's Coral Reef Monitoring Program.
5. NMFS recommends the USACE properly maintain coral relocation sites by investigating potential methods for increasing the presence of herbaceous invertebrates to reduce algal biomass and naturalized predators of corallivores (e.g., *Panulirus argus* and *Diadema antillarum*).
6. NMFS recommends the USACE explore consulting with coral farms in Puerto Rico to gain local knowledge on best management practices for coral relocation and maintenance.
7. NMFS recommends the USACE work with NMFS to create an online spatial dashboard to better track the status of coral relocations in the action area.
8. NMFS recommends the USACE explore the use chlorinated epoxy and antibiotic (e.g., Amoxicillin) treatments for relocated corals affected by SCTLD.
9. NMFS recommends the USACE conduct proposed activities outside of the peak nesting season for sea turtles (May to November).
10. NMFS recommends the USACE work with the Florida Atlantic University's Harbor Branch Oceanographic Institute, Conservación ConCiencia, and the Naguabo Fishing Association to assist in providing survey data on queen conch for the NOAA Saltonstall-Kennedy Grant Program-funded project (S-K NOAA Award NA10NMF4270029).

In order for NMFS OPR Interagency Cooperation Division to be kept informed of actions minimizing or avoiding adverse effects on, or benefiting, proposed and ESA-listed species or their critical habitat, the USACE should notify the Interagency Cooperation Division of any conservation recommendations they implement in their final action.

14 REINITIATION

Consistent with 50 CFR §402.16(a), reinitiation of consultation is required and shall be requested by the Federal agency or by the Service, where discretionary Federal involvement or control over the action has been retained or is authorized by law and:

(1) The amount or extent of incidental taking specified in the ITS is exceeded;

(2) New information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not previously considered;

(3) The identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this opinion; or

(4) A new species is listed or critical habitat designated under the ESA that may be affected by the action.

NMFS is considering proposing additional critical habitat for green sea turtle DPSs, which could affect the existing critical habitat designation assessed in this consultation. Therefore, reinitiation of consultation may be necessary should the designated critical habitat for green sea turtles in the action area change.

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16 APPENDIX A

This document "FWC Coral and Octocoral Mitigation Relocation Recommendations" (FWC Recommendations) is specific to coral and octocoral relocation activities that are being conducted statewide for mitigation[1] purposes. This document and referenced documents are living documents and are updated as new information becomes available, or issues that need to be addressed are identified. For this reason, document dates are provided in the lower right-hand corner for reference purposes.

Attention Permit Processors

There are 9 (nine) items identified in text boxes throughout the document for ease of reference that specifically identify permit-related issues and FWC-recommended permit conditions.

I. Definitions

For purposes of these FWC Recommendations and the attached FWC Coral and Octocoral Visual Health Assessment Protocols for Mitigation Relocation Activities (Protocols), a complete list of coral and octocoral terminology definitions is provided in the attached "Definitions of Coral and Octocoral Terminology".

II. FWC Authorization Required

An FWC Relocation Special Activity License (SAL) is required for all marine species relocation activities statewide, including but not limited to mitigation relocation activities. Information on the FWC SAL Program and applications are available here: https://myfwc.com/license/saltwater/special-activity-licenses/

III. Relocation and Mitigation Approach

Relocation of corals and octocorals to suitable sites should occur for all coastal construction projects where complete avoidance is not possible. Coral and octocoral relocation activities should be considered as minimization of project impacts and not as compensatory mitigation. Coral and octocoral relocation activities conducted to minimize project impacts can be accommodated in Florida Uniform Mitigation Assessment Method (UMAM), Habitat Equivalency Analysis (HEA), and Resource Equivalency Analysis (REA) mitigation assessment methodologies, and would result in lower amounts of compensatory mitigation required for a project relative to the amount of mitigation that would be required if coral and octocoral relocation was not performed. Compensatory mitigation should be required for all corals and octocorals that may be impacted by project activities and will not be relocated, and for relocated corals that do not meet permit-established relocation performance standards.

Coral and octocoral relocation activities should not occur during times of severe stress (e.g., localized disease outbreak, coral bleaching, extreme water temperatures (cold or hot), significant algal blooms), or from locations being impacted by significant stress events (e.g., areas being impacted by dredging activities or storm water runoff events), unless there are extreme circumstances that warrant an exception. FWC will support coral and octocoral relocation activities during times of severe stress or from locations being impacted by significant stress events on a case-by-case basis when resource or project impacts are imminent and cumulatively harmful, and when potential benefits outweigh potential risks.

Compensatory Mitigation Considerations

On a case-by-case basis, the FWC will consider and evaluate any request for the relocation of corals from unstable habitats (e.g., rubble) to be used as a compensatory mitigation measure to offset direct effects from a proposed project. Also on a case-by-case basis, FWC will consider and evaluate any request for the relocation of corals that are not otherwise required to be relocated due to size, to be used as a compensatory mitigation measure to offset the loss of indirect effects that are temporary (e.g., temporary reduction in larval output, temporary reduction in settlement).
Evaluation of such requests will be based on the amount of credit that is proposed to be provided for such activities and results from other appropriately monitored and documented relocation activities (e.g., literature, monitoring reports).

[1] For purposes of this document, the term "mitigation" is all-encompassing and includes avoidance, minimization, and compensatory mitigation actions.

Technical Assistance

The FWC is available to provide technical expertise to assist with mitigation assessment (e.g., UMAM, HEA, REA), or the development or review of mitigation plans. The FWC would appreciate the ability to provide additional comments on mitigation assessment, mitigation plans or mitigation plan revisions if such information is not currently available and becomes available in the future.

> ***Attention Permit Processors***
>
> **1. Note**: The FWC does not recommend specific permit language when addressing coral and octocoral relocation activities, but does recommend that any references in permit language to such relocation activities should be identified for purposes of minimization (i.e., to minimize impacts due to project activities) and not be identified for compensatory mitigation purposes (i.e., to offset impacts due to project activities), unless specific case-by case considerations have been made (see above ***Compensatory Mitigation Considerations***).

IV. Resource Surveys

At this time, there are no specific survey methodologies that are recommended for conducting surveys for coral and octocoral resources with the exception of surveying for ESA-listed coral species and associated Critical Habitat. Surveys for listed coral species and associated Critical Habitat must utilize NOAA Fisheries *ESA-Listed Coral Colony and Acropora Critical Habitat Survey Protocol* located here: https://www.fisheries.noaa.gov/southeast/consultations/regulations-policies-and-guidance

At a minimum, resource survey information should specifically identify the percent area surveyed with respect to the total project area, and identify corals and octocorals by species and all sizes (not a minimum size and larger). If the total project area is not surveyed, the data from the surveyed area should be extrapolated and applied to un-surveyed project areas in order to estimate the number of corals and octocorals present within the total project area.

V. Relocation Site Selection

The FWC recommends that the selection of an appropriate relocation site(s) for both corals and octocorals meet the following general criteria:

1) The relocation site must be as close in proximity to the removal site as possible to preserve the functional ecosystem value of the surrounding areas provided by the resources to be relocated, but err conservatively on the side of being slightly farther from expected project-associated direct and indirect impact areas.
2) Relocation site must be of suitable reef habitat, be within the known range of the species or genera, and have historic presence of the species to be relocated (in recent decades).
3) Optimally, the relocation site should be located in similar water depths and have similar physical conditions (e.g., light availability, water flow) to those at the removal site.
4) Optimally, the relocation site should have similar substrate orientation to removal site; i.e., if corals or octocorals are being removed from a vertical or sloped elevated surface, then the relocation site should have similar vertical or sloped areas for relocation. It is recognized that this will not always be possible like in situations where corals and octocorals are relocated from vertical surfaces, and in these cases selecting a relocation site that meets all other relocation site criteria is acceptable.
5) Relocation site must not contain large amounts of loose rubble and should not be located in a high energy environment (Edwards and Clark 1998).
6) Relocation site must not be located within a direct or indirect impact area for any permitted, authorized or reasonably foreseeable marine coastal construction activity (e.g., dock/marina/seawall/rip rap work, dredging, beach nourishment, pipeline or communication cable installations), or within exclusion or buffer areas/zones (e.g., military, aquaculture, resource protection).
7) Relocation site must have adequate and appropriate space to minimize competition and allow for colony growth and tissue re-colonization based on species morphology, growth rates, and maximum size.

V1. Temporary Holding Site Selection

If corals and octocorals will be placed in a temporary holding site after removal and prior to reattachment at the relocation site (for caching, staging, acclimation), the FWC recommends the following criteria be adhered to:

1) The temporary holding site for corals and octocorals must be located in a stable area (e.g., low energy, low sedimentation, minimal freshwater input), and err conservatively on the side of being slightly farther from expected project-associated direct and indirect impact areas.
2) Corals must be maintained in a temporary holding site either by affixing them to an elevated structure or placing them in a suspended container in a manner wherein they are above the sea floor and do not touch each other. If corals are to remain in the temporary holding site for longer than two weeks, they must be cemented or epoxied to an elevated structure or to substrate elevated above the sea floor.
3) Octocorals must be maintained in a temporary holding site either by affixing them to an elevated structure or placing them in a suspended bag in a manner wherein they are above the sea floor and have adequate water flow (i.e., bags should not be crowded). If octocorals are to remain in the temporary holding site for longer than two weeks, they must be attached with zip ties by their holdfast or base to an elevated array or line system previously installed on the sea floor. Orientation is less important, but octocorals must not touch each other while in holding.
4) The installation of any structure or system to facilitate the temporary holding of corals and octocorals prior to reattachment must be authorized by project permits.

> ***Attention Permit Processors***
>
> **2. Note**: The installation of any structure or system to facilitate the temporary holding of corals and octocorals prior to reattachment must be authorized by project permits.

VII. Relocation Plans

At a minimum, Relocation Plans should include the following information:

1) Summary of survey results – a summary of all coral and octocoral species and sizes that were identified during resource surveys. Specific coordinates for each individual coral are not necessary unless they are an ESA-listed species, but coordinates are extremely beneficial for research or restoration salvage and donation activities that may occur prior to or during relocation activities. For ESA-listed species, GPS coordinates of each colony should be documented, or alternatively GPS location of each survey site (unit = decimal degrees and state datum) along with a description of where each colony occurs (measurement along a transect or location within a quadrant); and a site map with locations of each colony should be documented.
2) General criteria for the selection of corals and octocorals that are proposed to be relocated (e.g., species, sizes, susceptibility to SCTLD, potential to contribute to reef building). Any corals that are intended to be donated to qualified entities conducting permitted coral restoration or research activities should be identified along with the qualified entity that has committed to taking them. Reminder – for ESA-listed coral species, donations must be approved by NOAA Fisheries, Protected Resources Division.
3) Reattachment spacing estimates for the relocation site that minimizes competition and provides for colony growth and tissue re-colonization based on species selected for relocation and their morphology, growth rates, and maximum size.
4) Relocation methodologies – identify the methodologies that will be used to remove, transport, temporarily hold (if applicable), and reattach corals/octocorals.

There are a number of current relocation methodologies to successfully remove, relocate and reattach corals and octocorals, and there may be additional successful methodologies developed in the future. As such, the FWC does not prefer to specify methodologies for these activities and would instead prefer to review proposed methodologies or assist with development of methodologies.

It should be noted that many coral relocation contractors have proposed to utilize relocation methodology documents developed by the Florida Keys National Marine Sanctuary (FKNMS)[2] as their complete relocation plan. These documents were developed by FKNMS staff for specific activities and projects within the FKNMS and were not intended to be used for any other purpose. Additionally, these FKNMS documents that specify methodologies do not constitute a complete relocation plan and are not appropriate to be represented as a complete relocation plan for coral and octocoral mitigation relocation activities.

5) Removal site(s) – provide the following information for the removal site(s):
   a. Site coordinates.
   b. Substrate size and substrate type that corals/octocorals are located on (e.g., walls, boulders, rip rap, natural, artificial, metal, concrete,).
   c. Identify presence/absence of Stony Coral Tissue Loss Disease (SCTLD) or other suspect or active disease indicators (review attached FWC Health Protocols for suspect or active disease indicators).
   d. Identify presence/absence of predators/competitors/overgrowth (by species if possible, by genus otherwise) on corals and/or substrate corals are attached to.
   e. Water depth.
   f. Water quality.
   g. Water circulation.
   h. Light availability (PAR level).
   i. Orientation of attachment.
   j. Presence/absence of loose rubble.
   k. Identify if it is a low or high energy environment.

6) Temporary holding site(s) – if a temporary holding site will be used to cache, stage, or acclimate corals/octocorals prior to reattachment, provide the following information for the temporary holding site(s):
   a. Site coordinates.
   b. Proximity to both the removal and reattachment sites.
   c. Estimated length of time corals/octocorals will be maintained in the temporary holding site.
   d. Water depth.
   e. Identify if it is a low or high energy environment.
   f. Level of sedimentation.
   g. Presence/absence of freshwater input.
   h. Verify that the temporary holding site is conservatively further from expected project-associated direct and indirect impact areas.
   i. Identify how corals/octocorals will be maintained in the temporary holding site (e.g., in containers).
   j. Identify if any structures or systems will be installed to facilitate temporary holding of corals/octocorals, and if this activity has been or will be included in the appropriate permit applications for this project.

7) Relocation site(s) – provide the following information for the relocation site(s):
   a. Site coordinates.
   b. Proximity to the removal site.
   c. Identify if there has been historic presence of the species to be relocated at the relocation site within recent decades.
   d. Substrate size and substrate type (e.g., natural substrate, boulder artificial reef) that corals/octocorals will be relocated to.
   e. Identify presence/absence of Stony Coral Tissue Loss Disease (SCTLD) or other suspect or active disease indicators (review attached FWC Health Protocols for suspect or active disease indicators).

[2]"Final Programmatic Environmental Impact Statement for Coral Restoration in the Florida Keys and Flower Garden Banks National Marine Sanctuaries" - dated July 2010; "FKNMS Coral Rescue and Transplant Protocols" - dated November 2011 or May 2013; "FKNMS Coral Rescue & Relocation Protocols" - dated January 2014.

f. Identify presence/absence of predators/competitors/overgrowth (by species if possible, by genus otherwise) on corals and/or substrate corals are proposed to be attached to.
g. Water depth in relation to the removal site.
h. Water quality in relation to the removal site.
i. Water circulation in relation to the removal site.
j. Light availability (PAR level) in relation to the removal site.
k. Orientation of reattachment.
l. Presence/absence of loose rubble.
m. Identify if it is a low or high energy environment.
n. Verify that the relocation site is not located within a direct or indirect impact area for any permitted, authorized or reasonably foreseeable marine coastal construction activity (e.g., dock/marina/seawall/rip rap work, dredging, beach nourishment, pipeline or communication cable installations), or within exclusion or buffer areas/zones (e.g., military, aquaculture, resource protection).
o. Provide information on spatial requirements for the species to be relocated which addresses how the relocation site will provide adequate and appropriate space to allow for: colony growth, tissue re-colonization and plating based on colony size, species growth rates, and maximum size capacity

- ***Technical Assistance***

The FWC is available to provide technical expertise to assist with the development or review of relocation plans, including relocation methodologies. The FWC would appreciate the ability to provide additional comments on relocation plans or relocation plan revisions if such information is not available at this time and becomes available in the future.

Staff of the Florida Department of Environmental Protection – Coral Reef Conservation Program, NOAA National Marine Fisheries Service, and NOAA Florida Keys National Marine Sanctuary (for projects located within Monroe County) are also available to provide technical expertise to assist with the review or development of relocation plans based on lessons learned on the Florida Reef Tract (FRT). Appropriate contacts for each of these agencies respective programs can be provided upon request.

VIII. Relocation Size and Species

The FWC supports coral salvage and donations to qualified entities conducting research and restoration activities. The FWC encourages permit applicants to incorporate activities associated with coral salvage and donations to qualified entities into both their relocation plan and (sub)contracts with coral relocation contractors. The FWC also encourages permit processors to provide for these activities in permit conditions. The FWC SAL program can facilitate identification of entities that are qualified to receive salvaged corals, and inquiries can be made by sending a request for assistance to SAL@MyFWC.com.

The FWC has prioritized coral species for removal and relocation based on susceptibility to Stony Coral Tissue Loss Disease (SCTLD) and conservation value (e.g., ESA-listing status, abundance, growth rate and maximum size, contributions to reef-building, genetic diversity, recruitment rate, post-settlement mortality). The FWC recommends relocation of all corals at the specified size or larger that are identified in the following priority list, unless donated to qualified entities conducting permitted coral research or restoration activities.

- ***Relocate at any size***:

1) *Acropora cervicornis* – ESA-listed; confirmed not susceptible to SCTLD
2) *Acropora palmata* – ESA-listed; confirmed not susceptible to SCTLD; functionally extinct
3) Order *Antipitharia* (black corals) – rare
4) *Cladocora arbuscula* – confirmed not susceptible to SCTLD; rare and small (under 10 cm) on FRT; relocation size may be increased to ≥ 10 cm for areas outside of the Florida Reef Tract
5) *Colpophyllia natans* – SCTLD-susceptible; significantly impacted by SCTLD; showing signs of recruitment within early SCTLD-endemic areas; major reef-building species
6) *Dendrogyra cylindrus* – ESA-listed; SCTLD-susceptible; functionally extinct

7) *Dichocoenia stokesii* – SCTLD-susceptible; significantly impacted by SCTLD; showing signs of recruitment within early SCTLD-endemic areas
8) *Diploria labyrinthiformis* – SCTLD-susceptible; significantly impacted by SCTLD; showing signs of recruitment within early SCTLD-endemic areas; reef-building species
9) *Eusmilia fastigiata* – SCTLD-susceptible; significantly impacted by SCTLD
10) **Favia fragum* – unknown SCTLD susceptibility; functionally extinct; small; does not reach 10 cm
11) *Meandrina meandrites* – SCTLD-susceptible; significantly impacted by SCTLD; showing signs of recruitment within early SCTLD-endemic areas
12) *Millepora complanata* – not susceptible to SCTLD; functionally extinct; reef-building fire coral
13) *Mycetophyllia ferox* – ESA-listed; SCTLD-susceptible; functionally extinct
14) *Orbicella annularis* – ESA-listed; SCTLD-susceptible; major reef-building species
15) *Orbicella faveolata* – ESA-listed; SCTLD-susceptible; major reef-building species
16) *Orbicella franksi* – ESA-listed; SCTLD-susceptible; major reef-building species
17) *Phyllangia* spp. – unknown SCTLD susceptibility; small; does not reach 10 cm
18) *Pseudodiploria strigosa* – SCTLD-susceptible; significantly impacted by SCTLD; showing signs of recruitment within early SCTLD-endemic areas; reef-building species
19) *Scolymia* spp. – unknown SCTLD susceptibility; small; does not reach 10 cm; cryptic

- ***Relocate at ≥ 5 cm, measured as live tissue diameter - continuous live tissue patch with a diameter of 5 cm or greater***:

1) *Agaricia agaricites* – unknown SCTLD susceptibility; sensitive to temperature/light stress
2) *Agaricia fragilis* – unknown SCTLD susceptibility; sensitive to temperature/light stress
3) *Agaricia lamarcki* – unknown SCTLD susceptibility; rare; low recruitment; often found > 60'; sensitive to temperature/light stress; relocation size may be increased to ≥ 10 cm for Tortugas and Pulley Ridge areas
4) *Helioseris cucullata* –assumed SCTLD-susceptible (based on susceptibility of family members); rare in FL; low recruitment; often found in deep water or shallower in cryptic locations
5) *Isophyllia sinuosa* – assumed SCTLD-susceptible (based on susceptibility of family members); rare in FL; low recruitment
6) *Isophyllia rigida* – assumed SCTLD-susceptible (based on susceptibility of family members); rare in FL; low recruitment
7) *Madracis auretenra* – assumed SCTLD susceptibility; uncommon to rare; declining trends in counts and live tissue area in long-term monitoring assessments; low recruitment; sensitive to temperature/light stress;
8) *Madracis decactis* – assumed SCTLD-susceptible (based on susceptibility of congener); low recruitment
9) *Madracis formosa* – assumed SCTLD-susceptible (based on susceptibility of congener); low recruitment
10) *Manicina areolata* – assumed SCTLD-susceptible (based on susceptibility of family members)
11) *Montastraea cavernosa* – SCTLD-susceptible; significantly impacted by SCTLD; showing signs of recruitment within early SCTLD-endemic areas; major reef-building species
12) *Mussa angulosa* – SCTLD-susceptible; significantly impacted by SCTLD; rare; low recruitment
13) *Mycetophyllia aliciae* – SCTLD-susceptible; significantly impacted by SCTLD; rare; low recruitment
14) *Mycetophyllia lamarckiana* – SCTLD-susceptible; significantly impacted by SCTLD; uncommon to rare; declining trends in counts and live tissue area in long-term monitoring assessments; low recruitment
15) *Pseudodiploria clivosa* – SCTLD-susceptible; significantly impacted by SCTLD; reef-building species; uncommon to rare; declining trends in counts and live tissue area in long-term monitoring assessments; low recruitment
16) **Siderastrea radians* – often smaller than 10 cm
17) *Solenastrea bournoni* – SCTLD-susceptible; significantly impacted by SCTLD; uncommon to rare; declining trends in counts and live tissue area in long-term monitoring assessments
18) *Solenastrea hyades* – assumed SCTLD-susceptible (based on susceptibility of congener)

Florida Fish and Wildlife Conservation Commission (FWC)
Coral and Octocoral Mitigation Relocation Recommendations

- ***Relocate at ≥ 10 cm, measured as live tissue diameter - continuous live tissue patch with a diameter of 10 cm or greater***:
  1) *Oculina diffusa* – unknown SCTLD susceptibility
  2) *Oculina robusta* – unknown SCTLD susceptibility
  3) **Porites astreoides* – confirmed not susceptible to SCTLD
  4) **Porites divaricata* – confirmed not susceptible to SCTLD
  5) **Porites furcata* – confirmed not susceptible to SCTLD
  6) **Porites porites* – confirmed not susceptible to SCTLD
  7) **Siderastrea siderea* – SCTLD-susceptible; susceptible to many coral diseases; reef-building species; abundant recruiter
  8) *Stephanocoenia intersepta* – SCTLD-susceptible; reef-building species; abundant recruiter

*If numbers of the species *underlined in red font exceed 50 colonies at the recommended relocation size or larger, the numbers required for relocation may be reduced to 50 colonies or 25% of the total number of colonies, whichever is greater (50 colonies minimum). Reduced numbers of colonies must be selected and prioritized for relocation according to the following criteria:

- Colonies of this species should be removed from locations as spread out as possible across the total project area to increase the probability of capturing greater genetic diversity
- Prioritize larger sizes over smaller sizes
- Prioritize colonies exhibiting fewer stress indicators

Attention Permit Processors

3. Recommended Permit Condition: All species of corals that are not specifically identified in the categories below that measure ≥10 cm and are located within the project area must be relocated prior to the start of construction, unless donated to a qualified entity conducting permitted coral research or restoration activities.

Corals that are specifically identified in the categories below, that are at or above the specified size and are located within the project area, must be relocated prior to the start of construction unless donated to a qualified entity conducting permitted coral research or restoration activities.

Coral Species to be Relocated at Any Size (19 species):

1) *Acropora cervicornis*
2) *Acropora palmata*
3) Order Antipitharia
4) *Cladocora arbuscula*
5) *Colpophyllia natans*
6) *Dendrogyra cylindrus*
7) *Dichocoenia stokesii*
8) *Diploria labyrinthiformis*
9) *Eusmilia fastigiata*
10) **Favia fragum*
11) *Meandrina meandrites*
12) *Millepora complanata*
13) *Mycetophyllia ferox*
14) *Orbicella annularis*
15) *Orbicella faveolata*
16) *Orbicella franksi*
17) *Phyllangia* spp.
18) *Pseudodiploria strigosa*
19) *Scolymia* spp.

Florida Fish and Wildlife Conservation Commission (FWC)
Coral and Octocoral Mitigation Relocation Recommendations

Coral Species to be Relocated at ≥ 5 cm, measured as live tissue diameter - continuous live tissue patch with a diameter of 5 cm or greater (18 species):

1) *Agaricia agaricites*
2) *Agaricia fragilis*
3) *Agaricia lamarcki*
4) *Helioseris cucullata*
5) *Isophyllia sinuosa*
6) *Isophyllia rigida*
7) *Madracis auretenra*
8) *Madracis decactis*
9) *Madracis formosa*
10) *Manicina areolata*
11) *Montastraea cavernosa*
12) *Mussa angulosa*
13) *Mycetophyllia aliciae*
14) *Mycetophyllia lamarckiana*
15) *Pseudodiploria clivosa*
16) **Siderastrea radians*
17) *Solenastrea bournoni*
18) *Solenastrea hyades*

Coral Species to be Relocated at ≥ 10 cm, measured as live tissue diameter - continuous live tissue patch with a diameter of 10 cm or greater (8 species):

1) *Oculina diffusa*
2) *Oculina robusta*
3) **Porites astreoides*
4) **Porites divaricata*
5) **Porites furcata*
6) **Porites porites*
7) **Siderastrea siderea*
8) *Stephanocoenia intersepta*

*If numbers of the species *underlined in red font exceed 50 colonies at the recommended relocation size or larger, the numbers required for relocation are reduced to 50 colonies or 25% of the total number of colonies, whichever is greater (50 colonies minimum). Reduced numbers of colonies must be selected and prioritized for relocation according to the following criteria:

- Colonies of this species should be removed from locations as spread out as possible across the total project area to increase the probability of capturing greater genetic diversity.
- Prioritize larger sizes over smaller sizes.
- Prioritize colonies exhibiting fewer stress indicators.

- ***Coral Fragmentation Upon Removal***

The potential exists for corals to fragment upon removal. It is feasible for all fragments of the same broken coral to be kept together and reconstructed by reattaching fragments as close together as possible (like puzzle pieces – reattached within 0 - 5 cm apart from one another), to promote successful fusing. The re-constructed corals should be considered as one single coral for monitoring purposes. Research has shown that fragments of the same genet are known to readily and successfully fuse (Raymundo and Maypa 2004).

Attention Permit Processors

4. Recommended Permit Condition: Should corals fragment upon removal, all fragments of the same broken coral must be kept together and reconstructed by reattaching fragments as close together as possible (like puzzle pieces – reattached within 0 - 5 cm apart from one another). The re-constructed corals should be considered as one single coral for monitoring purposes.

IX. Octocoral Relocation Size and Species

The FWC supports octocoral salvage and donations to qualified entities conducting research and restoration activities. The FWC encourages permit applicants to incorporate activities associated with octocoral salvage and donations to qualified entities into both their relocation plan and (sub)contracts with octocoral relocation contractors. The FWC also encourages permit processors to provide for these activities in permit conditions. The FWC SAL program can facilitate identification of entities that are qualified to receive salvaged octocorals, and inquiries can be made by sending a request for assistance to SAL@MyFWC.com.

The FWC recommends relocation of all *Gorgonia* species and other octocoral species ≥ 10 cm in height, unless donated to a qualified entity conducting permitted coral research or restoration activities. In the event that all octocoral species ≥ 10 cm in height will not be relocated, the FWC has prioritized octocoral species for relocation. Similar to corals, octocoral species have also been prioritized based on a high conservation value (i.e., state prohibited species, conservation need, local abundance/density, growth rates, relocation success, and ability to recover naturally). In general, more robust rod species are slow growing and have low recruitment, but transplant well and seem to recover quickly from being transplanted (e.g., growing a new holdfast over attachment material) (Brinkhuis 2009). Plumes are low on the list because they recruit very quickly after a disturbance and have high growth rates so their potential for natural recovery is greater.
Additionally, more delicate plume species have less tissue (e.g., thinner tissue = less potential/resources for healing after clipping) and are inferior transplantation candidates. However, plumes can be transplanted successfully (Brinkhuis 2009).

The prioritized list is as follows:

1) *Antillogorgia*
2) *Eunicea*
3) *Gorgonia* (state prohibited species)
4) *Leptogorgia*
5) *Muricea*
6) *Muriceopsis*
7) *Plexaura*
8) *Plexaurella*
9) *Pseudoplexaura*
10) *Pterogorgia*

In addition to the species previously listed, the following are priority genera if deeper relocation sites are targeted (>60 ft. or >18 m):

1) *Diodogorgia*
2) *Ellisella*
3) *Iciligorgia*
4) *Swiftia*
5) *Telesto*

Attention Permit Processors

5. Recommended Permit Condition: All octocoral species (including *Gorgonia* spp.) measuring 10 cm or greater in height must be relocated.

X. Visual Health Assessment

To minimize the risk of disease/predators/competitors being spread from the removal site to a temporary holding or relocation site, the FWC recommends a visual health assessment of each coral or octocoral slated for relocation be conducted immediately prior to removal from the project site, and again prior to removal from a temporary holding site (if one is used), pursuant to the attached "FWC Coral and Octocoral Visual Health Assessment Protocols for Mitigation Relocation Activities" (FWC Health Protocols). Corals and octocorals that do not meet the visual health assessment criteria should not be removed, held temporarily, or relocated.

Exceptions:

- As identified in section "III. Relocation and Mitigation Approach" of these FWC Recommendations, there may be extreme circumstances in which the FWC will support coral and octocoral relocation during times of severe stress or significant stress events. For corals and octocorals that will be relocated during times of severe stress or from locations being impacted by significant stress events, FWC can provide an exception on a case-by-case basis from certain "stress indicators" criterion identified in the FWC Health Protocols. If such an exception is provided by the FWC, these corals and octocorals may be relocated provided that all other criterion in the FWC Health Protocols are met.
- Corals and octocorals surviving in interior waterways have demonstrated resilience in spite of the poor environmental conditions they are growing in and as such, have strong survival capabilities (potentially genetic) that are highly valued. Corals and octocorals that will be relocated from interior waterways are provided with an automatic exception from the "stress indicators" criterion in the FWC Health Protocols and may be relocated provided that all other criterion identified in the FWC Health Protocols are met.

Corals and octocorals held in a temporary holding site should again be visually assessed for health pursuant to the FWC Health Protocols immediately prior to removal from the temporary holding site and reattachment at the relocation site.

Exception **- The visual health assessment does not need to be conducted for corals and octocorals that have been maintained in a temporary holding site for 48 hours or less.** Any corals or octocorals displaying signs of disease in the temporary holding site should either be: a) removed and disposed of, or b) removed and donated for ex- situ research.

Any corals or octocorals that were selected for relocation but were not relocated because they failed the visual health assessment should be documented in the applicable data sheets provided for reporting requirements ("6. Not Relocated Coral Info" or "8. Not Relocated Octocoral Info").

Attention Permit Processors

6. Recommended Permit Condition: Corals and octocorals must be visually assessed for disease immediately prior to removal from the removal site (and again from a temporary holding site if one is used), pursuant to "FWC Coral and Octocoral Visual Health Assessment Protocols for Mitigation Relocation Activities" (FWC Health Protocols). The permittee must follow the most updated version of FWC Health Protocols when relocation activities occur as required by an FWC Special Activity License. Only corals and octocorals that meet the criteria established in the FWC Health Protocols are authorized for removal, relocation and reattachment. Field personnel conducting coral visual health assessments must be proficient with species identification and trained in coral disease, predator/competitor identification and removal, and survey techniques to assure accuracy of the assessment.

XI. Relocation Monitoring and Reporting

The FWC recommends corals and octocorals that are relocated specifically for mitigation purposes are monitored for overall survival and attachment success. This includes baseline data collection conducted at the time of relocation, and subsequent monitoring events at one week (may be conducted at any time during the seven days beginning the day immediately after the day relocation has concluded), at one month, at three months, at six months, and at one-year post-relocation. A two-year monitoring event is optional. The FWC emphasizes the need for all recommended monitoring events during the first year post-relocation to be performed to support identification of potential causes for coral relocation mitigation failure and the potential need for adaptive management measures. The recommended activities to be conducted for each of the recommended monitoring events is provided in the attached "Coral and Octocoral Mitigation Relocation Monitoring and Data Sheet Directions." Eight (8) data sheets are also provided to facilitate capturing the data requested for monitoring and reporting purposes.

Attention Permit Processors

7. Recommended Permit Condition: Baseline data collection and monitoring must be conducted pursuant to the attached "Coral and Octocoral Mitigation Relocation Monitoring and Data Sheet Directions." Baseline data collection must be conducted at time of relocation, and monitoring must be conducted at one week (may be conducted at any time during the seven days beginning the day immediately after the day relocation has concluded), at one month, at three months, at six months, and at one-year post- relocation. A two-year monitoring event is

- ***Monitoring Data to be Collected***

The monitoring data requested to be collected for coral and octocoral mitigation relocation monitoring activities are specific to determining overall survival and attachment success, thus determining achievement of performance standards for mitigation actions (i.e., mitigation success). The data requested to be collected for monitoring activities will also assist with determining potential factors that may have contributed to the inability for mitigation actions to achieve performance standards (i.e., mitigation failure), such as localized disease or bleaching events, severe storm events, relocation contractor performance, etc.

- ***Numbers of Corals/Octocorals to be Monitored***

If the total quantity of corals or octocorals (considered separately for monitoring purposes) to be relocated comprises less than 4,000 colonies – select a representative subset of relocated corals/octocorals to be used for monitoring events, comprising 25% (or 1,000 corals/octocorals maximum) of the total number of corals/octocorals relocated. This subset must be representative of the species composition and size classes of the total relocated corals/octocorals, with no less than 10 corals/octocorals of each species monitored. If less than 10 corals/octocorals are relocated from a species, all relocated corals/octocorals of that species must be included in the subset. It is possible that for smaller-scale relocation projects, one or both of these requirements will result in all of the relocated corals/octocorals (i.e., set) needing to be monitored.

If the total quantity of coral/octocorals to be relocated exceeds 4,000 colonies, the FWC will reach a consensus with the applicant and the permitting agency on the number of representative subset corals/octocorals that will be monitored (the minimum will be 1,000 corals/octocorals).

- ***Reporting Schedule***

Baseline data collected at relocation and data collected during each monitoring event should be submitted according to the following schedule:

- At relocation (baseline) + one-week monitoring event: Submit location map(s), representative photograph(s), and all applicable data sheets with applicable data recorded, prior to initiating the one-month monitoring event or within 21 days post one-week event, whichever occurs first.
- One-month monitoring event through one-year (or two-year if conducted) monitoring events: Submit representative photograph(s) and all applicable data sheets with applicable data recorded, within 30 days post-event.

Attention Permit Processors

8. Recommended Permit Condition:
Baseline data collected at relocation and data collected during each monitoring event must be recorded in the data sheets provided and submitted in Excel format according to the following schedule:

- At relocation (baseline) + one-week monitoring event: Submit location map(s), representative photograph(s), and all applicable data sheets with applicable data recorded, prior to initiating the one-month monitoring event or within 21 days post one-week event, whichever occurs first.
- One-month monitoring event through one-year (or two-year if conducted) monitoring events: Submit representative photograph(s) and all applicable data sheets with applicable data recorded, within 30 days post-event.

- ***Technical Assistance***

The FWC is available to provide technical expertise to assist with the development or review of monitoring plans. The FWC would appreciate the ability to provide additional comments on monitoring plans or monitoring plan revisions if such information is not available at this time and becomes available in the future.

XII. Performance Standards

The performance standard to determine mitigation success for coral relocation activities should be between 65-85% overall survival, with secure substrate attachment, one year after relocation. Overall survival of corals shall be defined as no net loss in pooled (by species) Live Tissue Area Index or an increase in pooled (by species) Live Tissue Area Index.

Live Tissue Area Index is calculated by averaging the coral maximum diameter and coral maximum height, then squaring the average dimension to determine Skeletal Area, then multiplying by the percent live tissue; formula as follows: (D+H)/2)^2*%L (Williams and Miller 2012). All of the metrics needed to determine Live Tissue Area Index are either requested for collection during monitoring activities (e.g., max diameter, max height, percent live tissue), or are auto-populated in the "3. Non-ESA Relocated Coral Info" data sheet provided (e.g., skeletal area). The "Live Tissue Area Index" column in the data sheet will also auto-populate once the needed metrics are recorded.

To calculate pooled Live Tissue Area Index by species for purposes of identifying the overall survival percentage, sum the Live Tissue Area Indices by species (not individual coral) that was auto-populated for each coral colony that was monitored. This percentage should be recorded in the "1. Non-ESA Coral Summary" data sheet.

- ***Coral Species that are ESA-Listed***

There may be additional or separate performance standards to determine mitigation success for coral relocation activities for ESA-listed species dictated by the federal Biological Opinion or federal permits for the project.

- ***Octocorals***

In order to establish mitigation performance standards for octocorals, FWC recommends evaluating overall survival of relocated octocorals via maximum height, and this metric is requested for collection in the "XI. Relocation Monitoring and Reporting" section above and reflected in the "7. Relocated Octocoral Info" data sheet provided. Overall survival shall be defined as no change in maximum height or an increase in maximum height.

The performance standard to determine mitigation success for octocoral relocation activities should be proposed by the applicant and supported by available and appropriate documentation of octocoral relocation activities (e.g., literature, monitoring reports.) FWC request to review these proposals as they are submitted to determine if the documentation

submitted supports the performance standard as proposed. **Note** – there is not a data sheet to summarize monitoring information for octocorals as the performance standard has not yet been determined. A data sheet will need to be developed to accommodate for summarizing octocoral monitoring information to assist with determining mitigation success.

- ***Technical Assistance***

The FWC is available to provide technical expertise to assist with the development or review of performance standards if the recommended performance standards are not incorporated into permits. The FWC would appreciate the ability to provide additional comments on performance standards or performance standard revisions if such information is not available at this time and becomes available in the future.

- **Adaptive Management**

For purposes of these FWC Recommendations, Adaptive Management is defined as a flexible decision-making process employed to address unanticipated events that affect the ability to achieve specified objectives.

In keeping with this definition, Adaptive Management Measures for coral and octocoral mitigation relocation activities are actions that are employed to address unanticipated events (e.g., predation on relocated corals by parrotfish, vessel anchor damage on a relocation site), that may affect the ability to achieve established mitigation performance standards.

Attention Permit Processors

9. Permit Condition Note: The FWC does not recommend specific permit condition language with regards to Adaptive Management, but recommends that a condition is included in the permit that would provide the ability for Adaptive Management Measures to be developed and agreed upon in coordination with the Permittee and permitting/consulting agencies to address unanticipated events that may affect the ability for the Permittee to achieve established mitigation performance standards. This permit condition should also provide advanced authorization to quickly execute agreed upon Adaptive Management Measures without the need to amend permits.

- **Literature Cited**

Brinkhuis VIP (2009) Assessment of gorgonian transplantation techniques offshore Southeast Florida. M.S. Thesis. Nova Southeastern University. pp. 96.

Edwards, AJ, S Clark (1998) Coral transplantation: a useful management tool or misguided meddling? Marine Pollution Bulletin 37: 474-487.

Raymundo, LJ and Maypa, AP. (2004) Getting bigger faster: Mediation of size-specific mortality via fusion in juvenile coral transplants. Ecological Applications 14(1): 281-295.

Williams DE, Miller MW (2012) Attributing mortality among drivers of population decline in *Acropora palmata* in the Florida Keys. Coral Reefs 31: 369-382.

Florida Fish and Wildlife Conservation Commission (FWC)
Coral and Octocoral Visual Health Assessment Protocols
for Mitigation Relocation Activities

For purposes of these Florida Fish and Wildlife Conservation Commission (FWC), Coral and Octocoral Visual Health Assessment Protocols for Mitigation Relocation Activities (Protocols), a complete list of coral and octocoral terminology definitions is provided in the attached "Definitions of Coral and Octocoral Terminology".

Mitigation relocation activities require certification of health as a condition of authorization. The Health Certification process is conducted by authorized personnel and consists of a visual health assessment pursuant to the criteria outlined in these Protocols.

The visual health assessment must be conducted for each coral and octocoral pursuant to the criteria in these Protocols to ensure that all corals and octocorals appear to be in good health, are free from suspected disease and conditions that may impact their health, and that the presence of predators/competitors/overgrowth has been minimized. The visual health assessment must be conducted immediately prior to removal from any in-water location, and may need to be conducted again before the release activity is completed (i.e., immediately prior to removal and again immediately prior to removal from any and all temporary holding locations established to facilitate the release activity).

Corals and octocorals that do not meet the visual health assessment criteria cannot be harvested and released to other in-water locations. If any part of a coral or an octocoral does not meet all of the criteria for the visual health assessment process, no part of the coral or octocoral may be harvested or released even if the affected areas of the coral or octocoral are removed so that the remaining part of the coral does meet the visual health assessment criteria.

Corals and octocorals that are located in any temporary holding location and do not pass the visual health assessment criteria must be removed and appropriately disposed of on land.

- **Field personnel conducting coral and octocoral visual health assessments should be proficient with species identification, and trained in survey techniques, coral condition assessment, coral disease, and predator/competitor/overgrowth identification and removal, to assure accuracy of the assessment.**

Coral Visual Health Assessment Criteria

Each coral must be evaluated and meet the following visual health assessment criteria prior to harvest or release:

1) Each coral harvested or released may not show any visible signs of active or suspect disease based on the presence of:

    a. Stress indicators such as: bleaching, partial bleaching, paling, tissue sloughing (caused by sedimentation), swelling or thinning, and excessive mucous production.

        - **<u>Exception</u>**: Exception to these "stress indicators" criterion is automatically provided for corals that are being harvested or released from interior waterways as identified in the FWC Mitigation Relocation Recommendations, "X. Visual Health Assessment" section, unless observed abnormalities or conditions may be attributed to active or suspect disease.

***Note 1**: Harvest and release of corals from interior waterways with tissue appearing pale to partially bleached (< 100% of coral tissue) is acceptable as color loss is recognized as a part of coral species' normal state when growing in interior waterways.

***Note 2**: Harvest and release of *Siderastrea* spp. from interior waterways with tissue appearing pink or purple is acceptable as such pigmentation is associated with non-pathogenic bacterial/microbial communities

b. Recent mortality greater than 5% tissue loss exposing underlying skeleton not due to predation/competition/overgrowth, and recent mortality greater than 10% tissue loss exposing underlying skeleton due to predation/competition/overgrowth.

   - **Exception**: Old mortality is acceptable for corals that will be harvested or released.

c. Active disease such as: rapid tissue loss, tissue sloughing (not caused by sedimentation), stony coral tissue loss disease (SCTLD), white/black/yellow/red band diseases, white pox or plague diseases, white Beggiatoa mats, dark (purple) spot/blotch diseases, and growth anomalies.

d. Suspect disease indicators such as bands, spots, lesions, microbial mats, and cyanobacteria colonization.

2) Predators such as fireworms (*Hermodice carunculata*) or snails (e.g., *Coralliophila* spp.) must be removed (e.g., peeled off) prior to relocation.

3) Competitors and overgrowth (e.g., sponges, tunicates, ascidians, octocorals, zoanthids, corallimorphs, macroalgae, cyanobacteria) on old mortality must be removed (e.g., peeled, scrubbed using wire or plastic brushes, tweezed) as much as possible prior to harvest or release. Corals that have non-native, encrusting and/or overgrowing species on them (e.g., Genus *Symplegma*, Genus *Botryllus*) that cannot be removed may not be harvested or released.

   - **Exception**: Corals containing boring sponges of the Genus Cliona (e.g., Cliona deletrix) are generally discouraged for harvest and release, but release will be expected if the presence of boring Cliona spp. is small (e.g., occupies <10% of the surface of the colony), and/or the benefits of relocation outweigh the risks of introducing or increasing prevalence of boring Cliona spp. on corals and substrate at a relocation site. The need for the release of corals containing boring Cliona spp. is project-specific and should be discussed in advance of permitting release activities or any relocation activities occurring.

   - **Exception**: Corals with established algal lawns and associated skeletal lesions and pale spots created by farming damselfishes may be harvested and released.

   - **Exception**: Corals containing stramenopile protists that are often confused with competition and overgrowth and appear as white aggregate coatings on the coral surface or embedded in the mucus layer, may be harvested and released.

Florida Fish and Wildlife Conservation Commission (FWC)
Coral and Octocoral Visual Health Assessment Protocols
for Mitigation Relocation Activities

Octocoral Visual Health Assessment Criteria

Each octocoral must be evaluated and meet the following visual health assessment criteria prior to harvest or release:

1) Rod, plume, and sea fan colonies must have at least 10 cm (approx. 4”) of linear growth (height).

2) Each octocoral colony targeted for relocation may not show any visible signs of disease based on the presence of:

   a. Stress indicators such as: bleaching, partial bleaching, tissue sloughing or swelling, excessive mucous production.

      - **Exception**: Exception to this criterion is automatically provided for octocorals that are being removed and relocated from interior waterways as identified in the FWC Recommendations, “X. Visual Health Assessment” section.

***Note**: Octocorals rarely bleach and generally tend to exhibit partial bleaching at their branch tips closest to the water’s surface.

   b. Recent mortality greater than 10% of tissue loss exposing axis.

***Note**: “Old mortality” is not readily determinable from “recent mortality” in octocorals.

   c. Active disease such as: purple spot, aspergillosis, red band disease, black wasting disease, growth anomalies (severely altered morphology of tissues and skeleton).

   d. Suspect disease indicators such as: bands, spots or rings (identified by severe dark purpling (25% or greater) or blackening of tissues), microbial mats, and cyanobacteria colonization.

3) Predators such as *Cyphoma gibbosum* or *Hermodice carunculata* in feeding position along tissue loss margin must be removed (e.g., peeled off) prior to relocation.

      - **Exception**: Colonies of *Gorgonia ventalina* with active predation of the nudibranch *Tritonia hamnerorum* cannot be relocated.

FWC Definitions for Coral and Octocoral Terminology

“Axis” is the central supporting skeletal structure of an octocoral made of proteinaceous gorgonin or calcium carbonate that is commonly dark brown to black in color.

“Bleaching” is the loss of color within coral or octocoral tissue due to the loss or reduction in number of endosymbiotic algae (i.e., zooxanthellae; Genus *Symbiodinium*). During bleaching, tissue is present but is pale to clear in color for corals and pale to white in octocorals, and for corals the white skeleton is visible underneath. A coral or octocoral may be “bleached” where 100% of tissue is affected by loss of zooxanthellae, “partially bleached” where < 100% of tissue is affected by loss of zooxanthellae and a portion of the tissue remains a healthy color, or “pale” where tissues have not completely lost all zooxanthellae and appear lighter in color especially compared to other corals and octocorals of the same species.

“Cache” is a temporary holding location to facilitate coral relocation and transfer activities.

“Coral” is an organism of any life stage or any part thereof (including gametes), that meets a regulatory definition of “coral” for the Florida Fish and Wildlife Conservation Commission, the Florida Department of Environmental Protection, National Marine Fisheries Service (NOAA Fisheries) as it pertains to the Southeast Region, the Florida Keys National Marine Sanctuary, or the National Park Service as it pertains to National Park areas within Florida.

“ESA-listed species” are species that are listed pursuant to the federal Endangered Species Act. “Holdfast” is the

base of an octocoral that attaches the colony to the substrate.

“Interior waterway” is an aquatic area that has experienced physical restructuring of the shoreline (e.g., inner port harbors, marinas, seawalls), or a naturally occurring area of low flushing (e.g., shallow bays).

“Introduction” is the intentional or unintentional release of a coral or an octocoral into an area and/or habitat in which it is not known to have naturally existed.

“Mitigation” is an action that is taken to avoid, minimize or offset potential negative effects from an activity.

“Nursery” is any in-water, over-water or land-based location where authorized coral and octocoral holding, propagation, rearing, acclimation or staging activities occur.

“Octocoral” are anthozoan cnidarians (any part of the species of the Subclass Octocorallia), with polyps bearing eight pinnate tentacles and eight complete septa, excluding encrusting octocorals (e.g., *Erythropodium caribaeorum*, *Briareum asbestinum*).

“Old mortality” is the non-living portion of exposed coral skeleton that has been overgrown by algae and other biofouling organisms, and/or where the corallite structure has eroded over time and may not be identifiable to the species level. “Old mortality” is not readily determinable from “Recent mortality” in octocorals.

“Outplanting” is the removal of a coral from any land or water-based nursery and placing such coral into any in-water location outside of a nursery.

“Plume” is the thin pinnate (feather-like) branches and thin tissue branchlets that extend from all sides of the main branches of an octocoral.

"Recent mortality" as it pertains to coral is the non-living portion of recently exposed coral skeleton (i.e., skeleton is white and corallite structures are intact and identifiable), including the development of fine "fuzz" or limited turf algae on exposed skeleton (i.e., skeleton is yellowish in appearance and corallite structure may be slightly eroded but still identifiable to species level), indicating that the mortality occurred within a couple of days to weeks prior to observation.

"Recent mortality" as it pertains to octocoral is the non-living portion of recently exposed octocoral axis skeleton (i.e., axis is dark brown to black), which can include the development of fine "fuzz" or turf algae on exposed axis, indicating that the mortality occurred within a few days prior to observation. Some dark live tissue around recent mortality can indicate healthy tissue regrowth over the exposed axis.

"Release" is the introduction, reintroduction, outplanting, relocation, transfer, translocation, transplantation of any coral or octocoral into or within any in-water location.

"Relocation" is any movement of a coral or octocoral at any life stage from any in-water location to another in-water location. Relocation includes translocation and transplantation, but excludes outplanting and transfer. Relocation occurs between a "removal site" (the in-water site where a coral or octocoral was harvested from), and a "relocation site" (the in-water location to which the coral or octocoral is physically moved to), and may potentially include a "temporary holding site" (a location where corals or octocorals are temporarily held in cache to facilitate relocation-associated activities).

"Rod" is a thickly branched upright form of octocoral, typically with secondary branches and thick tissues.

"Seafan" is an octocoral that is flat and fan-shaped with interconnected net-like branching with thin tissues.

"Transfer" is the physical conveyance of coral or octocoral between eligible entities.

"Translocation" is the in-water movement of a coral or octocoral from an area of suitable habitat to another area of suitable habitat, with or without consideration of historic distribution.

"Transplantation" is the in-water movement of corals or octocorals from one place to another.