NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7
BIOLOGICAL AND CONFERENCE OPINION AND MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT RESPONSE

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List of Acronyms

AFTT – Atlantic Fleet Training and Testing

ARMS - Autonomous Reef Monitoring Structures

ATON – Aids-to-Navigation

AUV – Autonomous Underwater Vehicle

BA – Biological Assessment

BMP – Best Management Practice

CAP – Conservation Action Plan

CFMC – Caribbean Fishery Management Council

CNMI – Commonwealth of the Northern Mariana Islands

CRCA – Coral Reef Conservation Act

CRCP – Coral Reef Conservation Program

DPS – Distinct Population Segment

EEZ – Exclusive Economic Zone

EFH – Essential Fish Habitat

EPA – U.S. Environmental Protection Agency

ESA – Endangered Species Act

FDM – Farallon De Medinilla

FGBNMS – Flower Garden Banks National Marine Sanctuary

FKNMS – Florida Keys National Marine Sanctuary

FMC – Fund Management Center

FMP – Fishery Management Plan

FUDS – Formerly Used Defense Sites

GC – General Counsel

GHG – Greenhouse Gas

GPS – Global Positioning System

HSTT – Hawaii-Southern California Training and Testing

ITS – Incidental Take Statement

IUCN – International Union for Conservation of Nature

LIDAR – Light Detection and Ranging

MHI – Main Hawaiian Islands

MHI IFKW – Main Hawaiian Islands Insular False Killer Whale

MITT – Mariana Islands Training and Testing

MMPA – Marine Mammal Protection Act

MPA – Marine Protected Area

MSA – Magnuson-Stevens Fishery Conservation and Management Act

NCCOS – National Centers for Coastal Ocean Science

NCRMP – National Coral Reef Monitoring Program

NEPA – National Environmental Policy Act

NESDIS – National Environmental Satellite, Data, and Information Service

NMFS – National Marine Fisheries Service

NOAA – National Oceanic and Atmospheric Administration

NOS – National Ocean Service

NWHI – Northwest Hawaiian Islands

OAR - Oceanic and Atmospheric Research

OHC – Office of Habitat Conservation

ONMS – Office of National Marine Sanctuaries

OPR – Office of Protected Resources

PBF – Physical and Biological Features

PDC – Project Design Criteria

PEIS – Programmatic Environmental Impact Statement

PI – Principle Investigator

PIFSC – Pacific Islands Fishery Science Center

PIRO – Pacific Islands Regional Office

PRDNER – Puerto Rico Department of Natural and Environmental Resources

ROV – Remotely Operated Vehicle

RPM – Reasonable and Prudent Measure

SAFMC – South Atlantic Fishery Management Council

SCTLD – Stony Coral Tissue Loss Disease

SEFSC – Southeast Fishery Science Center

SERO – Southeast Regional Office

SMC – Senior Management Office

SURTASS LFA – Surveillance Towed Array Sensor System Low Frequency Active

TL – Total Length

UAV – Unmanned Aerial Vehicle

USACE – U.S. Army Corps of Engineers

USCG – U.S. Coast Guard

USCRTF – U.S. Coral Reef Task Force

USFWS – U.S. Fish and Wildlife Service

USVI – U.S. Virgin Islands

UXO – Unexploded Ordnance

WPRFMC – Western Pacific Regional Fishery Management Council

WMP – Watershed Management Plan

1 INTRODUCTION

The Endangered Species Act of 1973 (ESA), 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 insure 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 National Marine Fisheries Service (NMFS) for threatened or endangered species (ESA-listed), or designated critical habitat that may be affected by the action that are under NMFS jurisdiction (50 C.F.R. §402.14(a)). 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 concur with that determination for species under NMFS jurisdiction, consultation concludes informally (50 C.F.R. §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 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 action to proceed in compliance with section 7(a)(2) of the ESA. If the action (or a reasonable and prudent alternative) is expected to cause incidental take without violating section 7(a)(2), section 7(b)(4), as implemented by 50 C.F.R. §402.14(i), requires NMFS to provide an incidental take statement (ITS), which species: the impact (i.e., amount or extent of take) of incidental take; reasonable and prudent measures (RPMs) necessary or appropriate to minimize such impacts and terms and conditions to implement the RPMs; and procedures to be used to handle or dispose of any individual species actually taken. Incidental take must also be monitored and reported as the action proceeds and consultation must be immediately reinitiated should the amount or extent of incidental take specified in the ITS be exceeded. Any incidental take that occurs in compliance with the ITS is exempted from the ESA's prohibition on take. The protection from the prohibition on take may lapse if the action agency fails to comply with the RPMs or terms and conditions in the ITS.

This consultation includes an essential fish habitat (EFH) consultation on the proposed action in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA; 16 U.S.C. §1801 et seq.) and implementing regulations at 50 C.F.R Part 500.

The Federal action agency for this consultation is the National Oceanic and Atmospheric Administration Coral Reef Conservation Program (CRCP) led by the Office of Coastal Management in collaboration with other NOAA line offices and programs. The CRCP proposes activities that are funded and carried out under the Coral Reef Conservation Act, to protect, conserve, and restore the nation's coral reefs by maintaining healthy ecosystem functions. Other

NOAA agencies and programs, including the National Ocean Service (NOS) Office of National Marine Sanctuaries (ONMS), NOAA Restoration Center, and NOS National Center for Coastal Ocean Science (NCCOS) are also included as Federal action agencies for this consultation specific to the Mission: Iconic Reefs large-scale coral reef restoration initiative in the Florida Keys.

Programmatic Consultations

NMFS and the U.S. Fish and Wildlife Service (USFWS) have developed a range of techniques to streamline the procedures and time involved in ESA section 7 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 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 C.F.R. §402.02). The Services promulgated changes to the section 7(a)(2) implementing regulations (80 FR 26832, May 11, 2015; ITS rule) that define two types of programmatic actions addressing certain types of policies, plans, regulations, and programs. One type of programmatic action, known as a mixed programmatic action, combines direct approval of actions that will not be subject to further ESA section 7(a)(2) consultation and approval of a framework for the development of future actions that are authorized, funded, or carried out at a later time. For mixed programmatic actions, as defined in the 2015 ITS rule at 50 C.F.R. §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, are reasonably certain to result in incidental take, and are otherwise compliant with ESA section 7(a)(2). Any future actions within the framework that will be subject to tiered 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 project design criteria (PDCs) or standards that will be applicable to all future projects implemented under the program. PDCs[1] 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 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

[1] For this consultation, the PDCs correspond to the best management practices (BMPs) required by the CRCP.

action, or for which specifics of individual activities are not yet known, project-specific review is required and tiered consultations may be needed.

Similarly, programmatic EFH consultations may be appropriate if sufficient information is available to develop EFH conservation recommendations that will address all reasonable foreseeable adverse impacts on EFH of an entire program parts of a program, or a number of similar individual actions occurring within a given geographic area (50 C.F.R. §600.920(j)(1)). A programmatic EFH consultation is a method to implement the consultation requirements efficiently and effectively by incorporating many individual actions that may adversely affect EFH into one consultation.

This consultation, Opinion, and associated ITS were completed in accordance with ESA section 7, associated implementing regulations (50 C.F.R. §§402.01-402.16), and agency policy and guidance. The consultation was conducted as a mixed 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 tiered consultations under the programmatic framework for future actions for which NMFS cannot fully analyze the effects at this time. Because this is a mixed programmatic opinion, 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 C.F.R. §402.02). This consultation was conducted by the NMFS Office of Protected Resources (OPR) Endangered Species Act Interagency Cooperation Division (hereafter referred to as “we” or “our”). We also completed an EFH consultation on the proposed action in accordance with section 305(b)(2) of the MSA and implementing regulations.

This document represents NMFS’ opinion on the effects of these actions on ESA-listed giant manta ray (*Mobila birostris*, formerly *Manta birostris*); smalltooth sawfish (*Pristis pectinate*; U.S. populations); Nassau grouper (*Epinephelus striatus*); oceanic whitetip shark (*Carcharhinus longimanus*); scalloped hammerhead shark (*Sphyrna lewini*; Central and Southwest Atlantic Distinct Population Segment [DPS] and Indo-West Pacific DPS); lobed star (*Orbicella annularis*), mountainous star (*Orbicella faveolata*), boulder star (*Orbicella franksi*), elkhorn (*Acropora palmata*), staghorn (*Acropora cervicornis*), pillar (*Dendrogyra cylindrus*), rough cactus (*Mycetophyllia ferox*), *Acropora globiceps*, *A. jacquelineae*, *A. retusa*, *A. speciosa*, *Euphyllia paradivisa*, *Isopora crateriformis*, and *Seriatopora aculeata* corals; Kemp’s ridley (*Lepidochelys kempii*), Olive ridley (*Lipidochelys olivacea*, Mexico’s Pacific coast breeding population and populations other than Mexico’s Pacific coast breeding population), green (*Chelonia mydas*; North Atlantic DPS, South Atlantic DPS, Central North Pacific DPS, Central South Pacific DPS, and Central West Pacific DPS), leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*), and loggerhead (*Caretta caretta*; Northwest Atlantic DPS, South Pacific DPS, and North Pacific DPS) sea turtles; blue whale (*Balaenoptera musculus*), North Atlantic right whale(*Eubalaena glacialis*), North Pacific right whale (*Eubalaena japonica*), humpack whale (*Megaptera novaeangliae*; Western North Pacific DPS), fin (*Balaenoptera physalus*), sei (*Balaenoptera borealis*), Rice's (*Balaenoptera riceii*), and sperm (*Physeter microcephalus*) whales; false killer whale (*Pseudorca crassidens*; Main Hawaiian Islands Insular DPS); Hawaiian monk seal (*Monachus schauinslandi*); and chambered nautilus (*Nautilus pompilius*); designated critical habitat for smalltooth sawfish, Main Hawaiian Islands Insular DPS false killer whale, Hawaiian monk seal, North Atlantic DPS green sea turtle, hawksbill sea turtle, leatherback sea turtle, Northwest Atlantic DPS loggerhead sea turtle, and elkhorn and staghorn coral; and proposed critical habitat for lobed star, boulder star, mountainous star, pillar, rough cactus, *Acropora globiceps*, *A. jacquelineae*[2], *A. retusa*, *A. speciosa*, *Euphyllia paradivisa*, *Isopora crateriformis*, and *Seriatopora aculeata*[3] corals.

A complete record of this consultation is on file at the NMFS Office of Protected Resources in Silver Spring, Maryland.

1.1 Background

NOAA established the CRCP in 2000 under the Coral Reef Conservation Act (CRCA) to carry out the policies and purposes of the Act (16 U.S.C. §6401 et seq.) and Executive Order 13089, Coral Reef Protection. The CRCP strives to protect, conserve, and restore the nation's coral reef ecosystems. The CRCP supports research and monitoring, including the National Coral Reef Monitoring Program (NCRMP); mapping; forecasting and modeling; watershed and coral restoration; capacity building/technical assistance, education and outreach; and through the U.S. Coral Reef Task Force (USCRTF). The CRCP seeks to address the primary threats faced by coral reefs, including pollution, unsustainable fishing practices, and climate change.

The CRCP organizational structure is shown in (Figure 1). Each participating line office including NMFS Office of Habitat Conservation (OHC), National Environmental Satellite, Data, and Information Service (NESDIS), National Ocean Service (NOS), Oceanic and Atmospheric Research (OAR), has designated a senior manager that together with the Program Manager forms the Coral Reef Senior Management Council (SMC). Each of the line offices have respective tiered Financial Management Centers (FMCs) as shown in the lower right-side box of Figure 1 (Atlantic Oceanographic and Meteorological Laboratory and Ocean Acidification program for OAR; National Centers for Environmental Information and Satellite Applications and Research for NESDIS; NCCOS, Office for Coastal Management, and ONMS for NOS; and OHC, Pacific Islands Fishery Science Center [PIFSC], Pacific Islands Regional Office [PIRO], Southeast Fishery Science Center [SEFSC], and the Southeast Regional Office [SERO] for NMFS). The Program Manager chairs the SMC, which serves as the primary decision forum for CRCP issues,

[2] One colony of this species was reported in 2008 on Tutuila, but the species has not been observed in more recent monitoring, indicating it may no longer be present in U.S. waters (Smith 2021b).
[3] A colony of this species was recorded in Guam in 2008 and another in 2010, but no colonies were recorded in more recent surveys. Colonies of the species were observed in Saipan in 2011, but have not been observed in more recent monitoring, indicating it may no longer be present in U.S. waters (Smith 2021b).

including spend planning, policy development, and program performance. The SMC is responsible for coordinating with their relevant program and staff office liaisons.

From 2001 to 2008, the CRCP was guided by the 13 goals in the National Action Strategy (USCRTF 2000) working closely with the seven states and territories of the USCRTF. In 2007, the CRCP conducted an external review and developed a roadmap that addressed the review findings. In 2009-2010, the CRCP updated/refined the national goals and objectives and worked with the states and territories to develop strategic coral reef management priorities and to assess local management capacity. Following an internal assessment and external science review in 2016, the CRCP issued a new Strategic Plan (Figure 2) in 2018 and initiated three-year implementation plans.

The CRCP also works with other federal agencies, research and academic institutions, non-governmental organizations, and community groups to conserve tropical/subtropical coral reef ecosystems using a targeted approach focused on local priorities. The CRCP also supports capacity building in other nations with coral reef ecosystems.

The CRCP prepared a Programmatic Environmental Impact Statement (PEIS) in accordance with the National Environmental Policy Act (NEPA) for coral reef conservation and restoration activities (see https://coralreef.noaa.gov/about/enviro-compliance.html) as part of the implementation of the 2018 Strategic Plan throughout the U.S. jurisdictions with coral reef ecosystems in the Atlantic Ocean, including the Gulf of Mexico, South Atlantic and Caribbean Sea, and the Pacific Ocean, including the Pacific Islands Region, and priority international areas such as the wider Caribbean, the Coral Triangle, the South Pacific, and Micronesia.

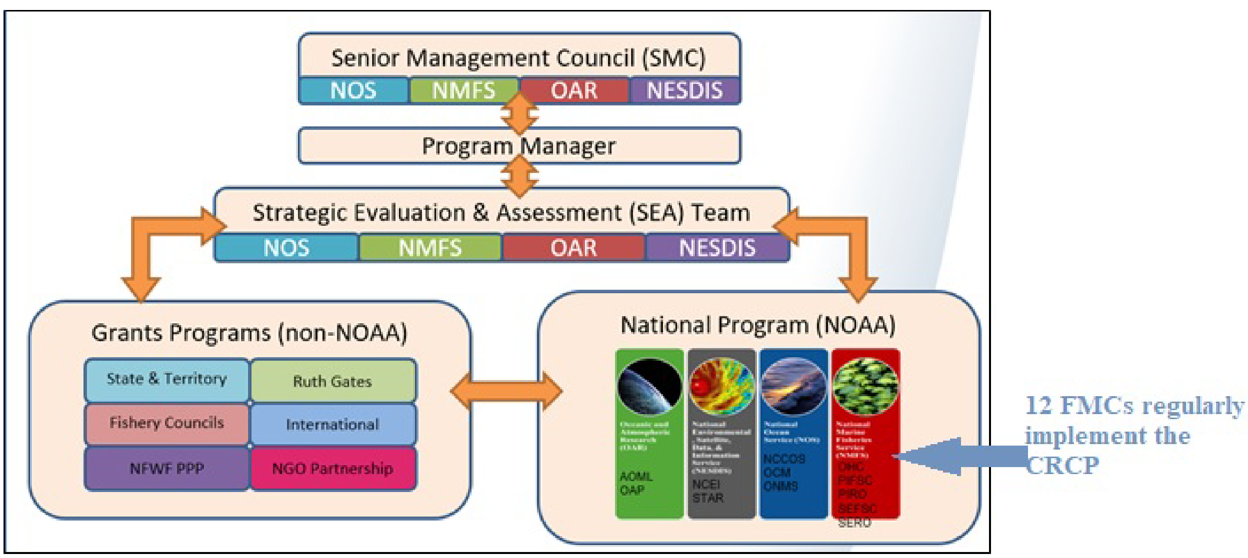

Figure 1. CRCP Organizational Structure (provided by CRCP)

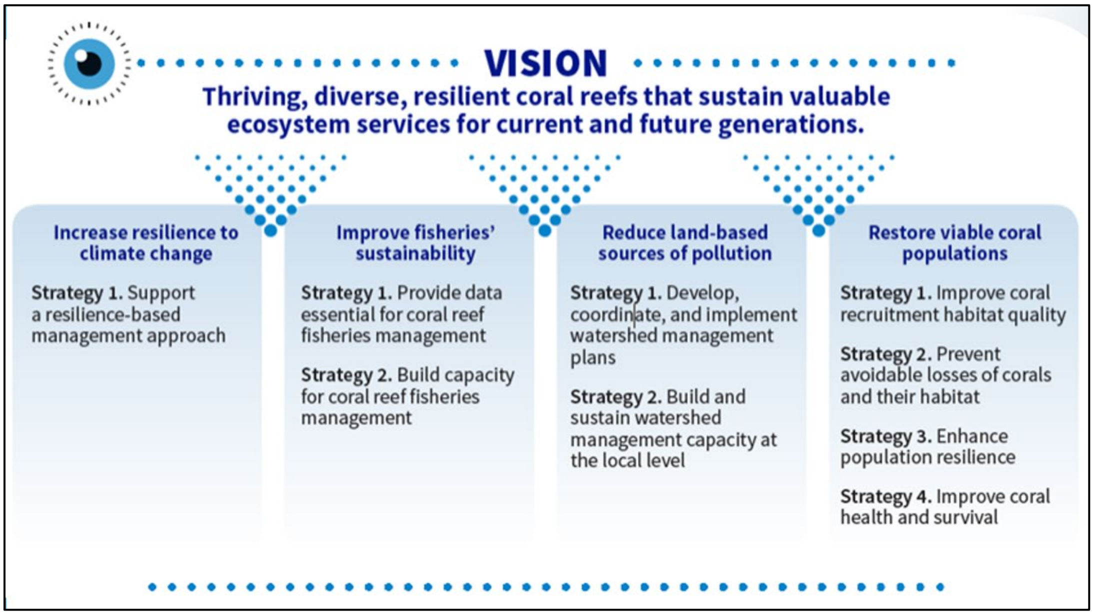

Figure 2. Overview of the current CRCP Strategic Plan (NOAA CRCP 2018)

As part of coordination activities in support of the PEIS, the CRCP began discussions with NMFS regarding the completion of programmatic consultations under section 7 of the ESA and to meet the EFH consultation requirements of the MSA for the program as a whole. Previously, ESA section 7 consultations were completed for individual projects being funded or carried out by CRCP, its partners and/or grantees.

OPR also held discussions with NMFS SERO, some of which included CRCP and/or NOAA Office of General Counsel (GC), regarding a programmatic consultation SERO initiated in October 2016 with approximately 11 Federal action agencies for activities involving research, restoration, and relocation of ESA-listed corals in the Southeast and Caribbean (known as the 3 R's consultation). CRCP activities in that region were included within the scope of the proposed action in the 3 R's consultation, but that formal ESA section 7 consultation process had not been completed as of April 2022 and is more limited in scope than the programmatic consultation covered in this opinion. Therefore, activities funded, authorized or carried out under the CRCP and Mission: Iconic Reefs in the Southeast and by CRCP in the Caribbean will be covered by this programmatic opinion and future tiered consultations, as applicable.

OPR, OHC and CRCP also held discussions with the NMFS Restoration Center regarding the possibility of adding the NOAA Restoration Center as an action agency under this programmatic consultation because the Restoration Center was also a party to the 3 R's consultation in SERO, meaning they may lack ESA coverage because effects have not been fully evaluated as the 3 R's consultation has been ongoing since 2016 without a projected completion date. The Restoration Center determined that they lacked the capacity to provide sufficient information to be a party to this programmatic consultation. However, they did provide information for the Mission: Iconic

Reefs work in which they are engaged and that information was incorporated in this programmatic opinion. Therefore, the activities of the Restoration Center and other NOAA offices associated with the Mission: Iconic Reefs initiative in Florida are components of the action evaluated in this programmatic opinion.

The Mission: Iconic Reefs initiative was developed by NOAA's ONMS, Restoration Center, NCCOS, and CRCP with partners in the Florida Fish and Wildlife Conservation Commission, Florida Department of Environmental Protection, Coral Restoration Foundation, Mote Marine Laboratory and Aquarium, The Nature Conservancy, Reef Renewal, and the National Marine Sanctuary Foundation. The initiative was developed to address the decline in coral reefs in the Florida Keys. Historically, the coral reefs in the Florida Keys had 30 to 40% coral cover[4], but the current cover of stony corals is approximately 2%. The initiative identified seven areas in the Florida Keys for large-scale coral reef restoration: Carysfort Reef, Horseshoe Reef, Cheeca Rocks, Sombrero Reef, Newfound Harbor, Looe Key Reef, and Eastern Dry Rocks. The selected restoration sites represent a diversity of habitats, support a range of human uses, span the full geographic range of the Florida Keys, and show a high probability of restoration success understand that stressors such as climate change could affect the future suitability of some sites (https://www.fisheries.noaa.gov/southeast/habitat-conservation/restoring-seven-iconic-reefs-mission-recover-coral-reefs-florida-keys).

1.2 Consultation History

The NMFS OPR began coordinating with the CRCP in 2018, providing comments on the draft PEIS and technical assistance toward the completion of a programmatic ESA section 7 consultation, including the development of a Biological Assessment (BA) and EFH Assessment.

This Opinion is based on information provided by the CRCP, including the *Endangered Species Act Biological Assessment and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Assessment for the Implementation of the Coral Reef Conservation Program* (NOAA CRCP 2021). Our communication with the CRCP regarding this consultation is summarized as follows:

- **June 25 to September 5, 2018:** NMFS provided comments on draft versions of chapters 1 and 2 of the PEIS and discussed comments with CRCP to resolve them, as well as providing recommendations as to additional information that will be needed for the ESA section 7 consultation that was not in the PEIS.
- **November 19, 2018:** Meeting with CRCP and NMFS Permits and Conservation Division to discuss the existing best management practices (BMPs) for NOAA staff, partners, grantees and others carrying out projects under the CRCP. NMFS discussed ways the

[4] Coral cover is a measure of the proportion of reef surface covered by live stony coral, the primary contributors to coral reef ecosystem health.

BMPs may be integrated in the ESA section 7 consultation and whether MMPA authorization may be needed for some CRCP activities.

- **November 16, 2018 to February 1, 2019:** NMFS provided comments on draft versions of chapter 3 of the PEIS, discussed comments with CRCP, and provided recommendations regarding how to incorporate information from this chapter into the BA being developed for the ESA section 7 consultation.
- **May 16, 2019:** CRCP sent an ESA section 7 consultation initiation request and 7(a)(1)7(d) memo to OPR via email. The request included an overview of the BA development, including a brief description of the action area, planned activities in the action area, ESA-listed species and designated critical habitat in the action area, and mitigation measures to minimize impacts to species and habitats. OPR provided a letter responding to the request for initiation via email on **June 21, 2019** informing the CRCP that we will await submission of the final BA and EFH Assessment to determine whether we have sufficient information to initiate ESA and EFH consultation.
- **July 26, 2019:** OPR received the draft PEIS for review and comment from the CRCP. OPR provided comments on the draft PEIS via email dated **August 16, 2019** focusing on chapter 4 because that was the only chapter we had not yet reviewed. OPR also noted via email to CRCP that additional avoidance and minimization measures may be needed for certain activities to be protective of ESA resources and will be part of the ESA section 7 consultation.
- **March 12, 2020:** OPR and CRCP spoke via telephone about the use of antibiotics to treat corals, which was not included as an activity in the draft PEIS because CRCP was planning to fund some interventions to treat corals affected by Stony Coral Tissue Loss Disease (SCTLD). CRCP then provided details regarding the use of antibiotics to treat diseased corals to OPR via email on **March 19, 2020**. CRCP requested comments on the final language for disease treatment for corals to be used in the PEIS from OPR via email on **June 17, 2020**.
- **March 16, 2020:** CRCP provided a draft of the BA and EFH Assessment via email to OPR and OHC for review and comment. OHC provided comments on the document via email dated **March 28, 2020**. OPR provided comments via email dated **April 2, 2020**.
- **August 28, 2020:** CRCP provided an updated version of the Assessment document to OPR via email. OPR provided comments via email on **September 5, 2020**. PIRO Protected Resources Division provided comments on the draft Assessment on **January 29, 2021**.
- **April 9, 2021:** CRCP provided the final Programmatic BA and EFH Assessment to OPR and OHC. OPR sent a letter dated **May 7, 2021** to CRCP on **May 11, 2021** informing the program that consultation initiated on April 9, 2021 and requesting additional information on some of the content of the BA. OPR informed the CRCP that responses to our

comments on the BA and EFH Assessment were complete via email dated **June 24, 2021**.

- **June 29, 2021:** OPR and OHC met to discuss incorporation of the Mission: Iconic Reefs initiative into the consultation after CRCP sent a write-up specific to this initiative, as well as how to cover directed take of threatened corals and Nassau grouper that do not have a 4(d) rule, BMPs, and potential project-specific review categories. We also discussed a 90-day time extension for the consultation, setting a due date of **November 18, 2021**. NMFS sent an email summarizing the discussion during the meeting and the agreed-upon time extension on **July 6, 2021** and CRCP sent an email confirming the extension the same day.
- **July 9, 2021:** OPR sent a draft description of the action to OHC, CRCP, SERO, and the PIRO for review and comment via email. SERO sent an email on **August 12, 2021** noting that they did not have any substantive comments. A meeting was held between OHC, OPR, CRCP, and GC on **August 10, 2021** to discuss and resolve comments and a revised version was sent by OPR to OHC, GC, CRCP, and the regions via email on **September 1, 2021**. CRCP sent comments on the revised proposed action description via email on **September 22, 2021**.
- **August 31, 2021:** OPR requested that SERO and PIRO provide comments specific to the proposed implementation of the programmatic opinion via email. PIRO sent comments on implementation requirements via email dated **September 15 and 16, 2021**. SERO sent comments on implementation requirements via email dated **September 22, 2021**.
- **December 20, 2021:** OPR requested that OHC, SERO, and PIRO provide comments on the draft opinion via email. SERO sent comments via email on **January 12, 2022** and PIRO sent comments on **January 14, 2022**. OPR edited the document to address these comments.
- **February 10, 2022:** OPR sent CRCP the draft opinion via email for review and comment.
- **March 3, 2022:** OPR, OHC, CRCP, and ONMS met to discuss comments on the draft opinion and CRCP provided an electronic link to the marked-up draft with CRCP and ONMS comments.
- **March 15, 2022:** CRCP sent an updated marked-up draft with CRCP and ONMS comments on reporting requirements and estimated habitat area impacts associated with Mission: Iconic Reefs activities in Florida via email.
- **April 25, 2022:** OPR sent CRCP the revised opinion via email for final review of the changes made to sections including the project-specific and annual review and ITS in response to CRCP comments.
- **April 28, 2022:** CRCP sent additional comments and revisions to the opinion via email.

- **May 13, 2022:** OPR, OHC, and GC met with CRCP and ONMS to discuss additional comments on the revisions to the ITS and the BMPs and PDCs. In anticipation of the meeting, OPR sent the optional CRCP BMPs and the PDCs for discussion.
- **May 26, 2022:** CRCP sent edits and comments on the BMPs to OPR via email May 26, 2022.

2 THE ASSESSMENT FRAMEWORK

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, 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.

"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 C.F.R. §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 C.F.R. §402.02).

This ESA section 7 consultation involves the following steps:

Description of the Action (Section 3): In this programmatic consultation, a description of the action on the part of the CRCP, as well as those engaged in Mission: Iconic Reefs, includes those activities that will not require further consultation and those activities for which project-specific review and tiered 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 ESA-listed species and designated critical habitat, and information regarding the procedures for submitting information for project-specific review and tiered consultation requests, and for submitting reports as part of regular reviews under the programmatic consultation. We also discuss the potential stressors we expect to result from the CRCP and Mission: Iconic Reefs activities, including those that will not require further review and those that will require project-specific review and potentially tiered 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. Thus, we evaluate the effects of stressors such as vessel transit on ESA-listed species and designated critical habitat and so include the approximate footprints of vessel transit routes in this consultation as part of the action area.

Species, Critical Habitat, and EFH in the Action Area that May be Affected (Section 5): We identify the ESA-listed species and designated critical habitat that are likely to co-occur with the stressors from the action in space and time and evaluate the status of those species and habitat. We identify the EFH present in the action area as well. We also identify those *Species and Designated Critical Habitat Not Likely to be Adversely Affected,* detail our effects analysis for these species and critical habitats (Section 5.1) that are not analyzed further in the opinion, and identify the status of the *Species and Critical Habitat Likely to be Adversely Affected* (Section 5.2) that are analyzed further in the opinion.

*Environmental Baseline (*Section 6): We describe the environmental baseline as the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated 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.

Effects of the Action (Section 7): Effects of the action are 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. These are broken into analyses of exposure, response, and risk, as well as a programmatic analysis as described below for the species and/or critical habitat that are likely to be adversely affected by the action. The species and critical habitat included in this section may be subject to future tiered consultations as details of certain activities become known and as the CRCP or those participating in Mission: Iconic Reefs receive funding, authorization, and/or prepare to carry out these activities. We include a section (7.1) for stressors that are not likely to adversely affect the species and critical habitat that are analyzed further in this opinion. The effects of these stressors are not discussed further in the opinion. The exposure and response analyses (Section 7.2) are used to identify the number, age (or life stage), and sex of ESA-listed individuals likely to be exposed to the stressors resulting from the proposed action and the populations or subpopulations to which those individuals belong. We also identify the unit(s) of designated and proposed critical habitat that are likely to be exposed to the stressors. We evaluate the available evidence to determine how individuals of those ESA-listed species are likely to respond given their probable exposure. We also consider how designated critical habitat will respond to exposure in terms of changes in function. Future tiered consultations will further identify the number, age (or life stage), and sex of ESA-listed individuals that are likely to be exposed to the stressors and the populations or subpopulations to which those individuals belong as needed. The effects analysis in tiered consultations will also assess the consequences of the responses of individuals of ESA-listed species that are likely to be exposed to the populations those individuals represent, and the species those populations comprise in more detail as required. We also consider whether the action will result in impacts to the essential physical and biological features (PBFs) and conservation value of designated critical habitat. The programmatic analysis (Section 7.3) evaluates whether the implementation of the applicable PDCs is sufficient to ensure that the action will not increase the risk to ESA-listed species or the function of the PBFs and conservation value of designated critical habitat associated with the implementation of the proposed action over the consultation lifetime.

We also consider the effects of the action on EFH as part of the effects analysis.

Cumulative Effects (Section 8): Cumulative effects are the effects to ESA-listed species and designated critical habitat of future state or private activities that are reasonably certain to occur within the action area (50 C.F.R. §402.02). Effects from future Federal actions that are unrelated to the action are not considered because they require separate ESA section 7 compliance.

Integration and Synthesis (Section 9): With full consideration of the status of the species and designated critical habitat, we consider the effects of the action within the action area on populations or subpopulations and on PBFs when added to the environmental baseline and the cumulative effects to determine whether the action could reasonably be expected to:

- Reduce appreciably the likelihood of survival and recovery of ESA-listed species in the wild by reducing its 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 critical habitat 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 critical habitat.

The results of our jeopardy and destruction and adverse modification analyses are summarized in the *Conclusion* (Section 10). If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of ESA-listed species or destroy or adversely modify designated critical habitat, then we must identify Reasonable and Prudent Alternative(s) to the action that would avoid jeopardy to a listed species or destruction or adverse modification to designated critical habitat, if any, or indicate that to the best of our knowledge there are no reasonable and prudent alternatives (see 50 C.F.R. §402.14(h)(3)).

For a mixed programmatic consultation, an *Incidental Take Statement* (Section 11) is included for those actions where no tiered consultation will occur and incidental take of ESA-listed species is reasonably certain to occur. We anticipate that additional ITSs will be issued for tiered formal consultations for those activities reasonably likely to result in incidental take in keeping with the revisions to the regulations specific to ITSs (80 FR 26832, May 11, 2015; ITS rule). The

ITS specifies the impact of the take, reasonable and prudent measures necessary or appropriate to minimize the impact of the take, terms and conditions to implement the reasonable and prudent measures, procedures for handling injured or dead species, and requirements for monitoring and reporting take (ESA section 7 (b)(4); 50 C.F.R. §402.14(i)).

We provide discretionary *Conservation Recommendations* (Section 12) that may be implemented by the action agency (50 C.F.R. §402.14(j)). Finally, we identify the circumstances in which *Reinitiation of Consultation* (Section 14) is required (50 C.F.R. §402.16).

In Section 15, we present the MSA EFH consultation response, including EFH Conservation Recommendations.

2.1 Evidence Available for the Consultation

To comply with our obligation to use the best scientific and commercial data available, we collected information identified through searches of Google Scholar, NOAA library, literature cited sections of peer reviewed articles, species listing documentation, species status reviews, species recovery plans, and reports published by government and private entities. Searches were used to identify information relevant to the potential stressors (underwater investigations using divers and equipment, installation of in-water structures, biological sampling, vessel transit, and other operations) and responses of ESA-listed species and designated critical habitat. This opinion is based on our review and analysis of various information sources, including:

- Information submitted by the CRCP;
- Government reports; and
- Peer-reviewed scientific literature.

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

3 Description of the Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies. 50 C.F.R. 402.02.

The CRCP proposes the continuation of its support of in-water monitoring, mapping, and research; activities that reduce physical impacts to corals and restore viable coral populations; and implementation of watershed restoration projects throughout the seven U.S. coral jurisdictions. The majority of the in-water activities conducted as part of the proposed action will occur in patch, bank-barrier, barrier, and fringing reefs. The CRCP also proposes to continue its support of periodic in-water monitoring, mapping, and research in the Flower Garden Banks

National Marine Sanctuary (FGBNMS; Gulf of Mexico) and in Papahanaumokuakea Marine National Monument (Northwest Hawaiian Islands; NWHI), and in-water monitoring and potentially mapping in the U.S. Pacific Remote Island Area.

The CRCP, ONMS, Restoration Center, and NCCOS, and their partners, propose to continue supporting the two phases of the Mission: Iconic Reefs initiative in the seven coral reef sites identified as targets for large-scale restoration in the Florida Keys.

3.1 Authorities under which the Action will be Conducted

The Coral Reef Protection Executive Order 13089 was issued in 1998 to "to preserve and protect the biodiversity, health, heritage, and social and economic value of U.S. coral reef ecosystems and the marine environment." This Executive Order established the USCRTF, which meets biannually and is co-chaired by the Department of Interior and the Department of Commerce. Members included 12 federal agencies, seven states and territories, and three freely associated states. The USCRTF oversees implementation of the Executive Order, and coordinates efforts to map and monitor U.S. coral reefs; to research the causes/solutions to coral reef decline; to reduce and mitigate coral reef degradation from pollution, unsustainable fishing, and other causes.

Congress enacted the CRCA in 2000 "to preserve, sustain, and restore the condition of coral reef ecosystems; to promote the wise management and sustainable use of coral reef ecosystems to benefit local communities and the nation; and to develop sound scientific information on the condition of coral reef ecosystems and the threats to these ecosystems." The CRCA requires a national coral reef action strategy, a grants program, and a biennial effectiveness report; and supports the Coral Reef Conservation Fund and the National CRCP.

Activities funded under CRCP or their partners and addressed in this opinion must also comply with all other local or state jurisdictional permits or regulatory requirements. In addition to activities conducted under the authority of the CRCA, the subset of activities described in this programmatic opinion under Mission: Iconic Reefs projects will occur under the authority of the National Marine Sanctuaries Act (16 USC §§ 1431 et seq.) and MSA.

3.2 Proposed NOAA Coral Reef Conservation Program Activities

To meet the goals and objectives in the Strategic Plan, which identifies four major focal areas (Improve Fisheries Sustainability, Address Land-Based Sources of Pollution, Address Climate Change, and Restore Viable Coral Populations), the CRCP conducts a suite of activities some of which are applicable to all focal areas and some of which are specific to one or more (Table 1).

Table 1. Activities implemented under the CRCP related to the strategic plan focus areas (adapted from (NOAA CRCP 2021).

Activity	Improve Fisheries Sustainability	Address Land-Based Sources of Pollution	Address Climate Change	Restore Viable Coral Populations
Monitoring, Mapping, and Research				
Socioeconomic Monitoring	X	X	X	X
Biological Monitoring				
SCUBA and/or Snorkel Surveys	X	X	X	X
Stationary Cameras	X	--	--	X
Fisheries Monitoring and Detection Using Echosounder	X	--	--	X
Geological and Oceanographic Monitoring				
Moored Instruments	X	X	X	X
Drifters and Floats	X	--	X	X
AUVs and ROVs	X	--	X	--
Water Quality Monitoring	X	X	X	X
Coral Reef Mapping				
In-water Echosounder, AUV/ROV, Divers	X	--	X	--
Aerial	X	X	X	X
Satellite	--	X	X	X
Tagging				
Fish, including Sharks	X	--	--	--

Corals	--	--	X	X
Collection of Biological Samples				
Coral	--	X	X	X
Fish and Invertebrates (other than corals)	X	--	--	--
Algae/Seagrass	--	X	X	X
Coral Restoration and Interventions				
Coral Restoration				
Nursery Development/ Enhancement and Maintenance	--	--	--	X
Coral Transplantation/Outplanting	--	--	--	X
Large-Scale Restoration	--	--	X	X
Other Coral Ecosystem Interventions				
Propagation and Outplanting of Herbivores	--	--	--	X
Invasive and Nuisance Species Removal/Control	--	--	--	X
Coral Disease Control	--	--	--	X
Coral Genomics, Stress Hardening, and Survival Analysis	--	--	--	X
Potential Future Coral Intervention Activities	--	--	X	X
Watershed Management and Restoration				
Technical Support for Watershed Management Plans	--	X	--	--
Erosion Control	--	X	--	--

Protection of Sensitive Habitats	--	X	--	--
Stormwater Management	--	X	--	--
Invasive Species Control	--	X	--	--
Reduce Physical Impacts				
Recreational/Day Use Moorings, Storm Buoys, Marker Buoys	--	--	--	X
Debris Removal	--	--	--	X
Outreach/Education, Data Analysis, Program Operations				
Signage	X	--	--	X
***In-situ* Education Activities**	X	X	X	X
Other Outreach Activities	X	X	X	X
Data Analysis and Modeling	X	X	X	X
Program and Interagency Coordination/Administration	X	X	X	X
Operational Activities (Vessels)	X	X	X	X

The following subsections provide details of the activities that will be conducted by the CRCP. These activities will incorporate the appropriate PDCs (Section 3.5.1) to avoid and minimize impacts to ESA-listed species, designated critical habitat, and EFH. These PDCs are the required BMPs developed by the CRCP as part of the standard measures required for implementation as part of CRCP projects with some modifications made in coordination with NMFS to be more protective of ESA and/or EFH resources. The effects of these minimization and avoidance activities are part of the proposed action and their effects are therefore evaluated in this opinion (Sections 5 and 7) to the extent possible. Take incidental to the proposed activities is exempted through the ITS issued with this opinion (Section 11). Some of the activities may require project-specific review and tiered consultations under this programmatic opinion, as described further below (Section 3.5.2).

3.2.1 Monitoring, Mapping and Research

The CRCP supports monitoring, mapping, and research conducted by NOAA offices and programs and external grant recipients. Monitoring supported by the CRCP includes biological, geological and oceanographic monitoring. Biological monitoring includes the use of SCUBA and/or snorkelers to record observations, stationary cameras, and fisheries monitoring and detection using echosounders. Geological and oceanographic monitoring includes the deployment of moored instruments and drifters, monitoring of water quality and marine and terrestrial sediment, the use of autonomous underwater vehicles (AUVs) and remotely operated vehicles (ROVs), and socioeconomic monitoring. Research activities include tagging of fish, including sharks, and corals, and collection of biological samples from coral and other invertebrates, fish, and algae and/or seagrass. Coral reef ecosystem mapping includes the use of in-water echosounders, and aerial and satellite platforms to gather data, and may also employ AUVs, ROVs or divers to collect images and ground-truth maps.

The CRCP funds individual monitoring, mapping, and research projects, but the majority of monitoring activities supported by the CRCP fall under the NCRMP, which documents the status and trends of U.S. coral reef ecosystems to support conservation and management. The CRCP implements the NCRMP across the U.S. Pacific (American Samoa and U.S. Remote Pacific Island Areas, Mariana Archipelago [Guam and the CNMI], and Main Hawaiian Islands [MHI]) on a triannual rotation. Implementation of the NCRMP in the Atlantic/Caribbean rotates biannually between Puerto Rico and USVI, and occurs every other year in Florida. The NCRMP does not conduct diver-based surveys deeper than 30 meter (m; 100 feet [ft]) in depth. The CRCP also provides yearly support to the seven U.S. coral jurisdictions for their annual coral reef monitoring activities.

The NCRMP selects monitoring sites using a random stratified method, and the U.S. coral jurisdictions mainly monitor fixed sites on an annual or biennial frequency using permanent transect markers and/or stratified random sites within the fixed sites. Guam is the only jurisdiction that monitors their fixed sites on a quarterly interval. Monitoring includes biological and geological and oceanographic data collection. As part of the NCRMP and state and territorial monitoring programs, scientific instruments (e.g., HOBO® temperature loggers) may be moored to hard, non-living substrate or previously deployed structures such as transect markers. Additional project-related monitoring activities may take place as part of grants or cooperative agreements with external partners. For example, CRCP has supported diver or ROV biological assessments of mesophotic coral reefs as part of grants/cooperative agreements.

3.2.1.1 Socioeconomic Monitoring

Various methods are used to collect information from the general public and specific user groups of coral reef stakeholders. These methods involve the collection of socioeconomic variables, including demographics in coral reef areas, human use of coral reef resources, and knowledge, attitudes, and perceptions of coral reefs and coral reef management. Some of these methods include resident surveys (primary data collection) in U.S. coral reef jurisdictions. Other data collection approaches may include the collation of information (secondary data collection) from the U.S. Census Bureau and Bureau of Economic Statistics on coral reef-related economic activities. While socioeconomic monitoring is part of the CRCP's action, this activity will have no effect on EFH and ESA resources and is not discussed further.

3.2.1.2 Biological Monitoring

Biological monitoring is the collection of observations related to biological indicators of coral reef ecosystem health. These indicators can include diversity, abundance, size, distribution, and habitat composition and complexity of benthic species, reef fish, and other motile invertebrates. These biological data are using SCUBA divers and/or snorkelers to conduct visual or photographic surveys, or through the placement of stationary cameras in strategic locations to collect images over a period of time.

SCUBA and Snorkel Surveys

Biological monitoring of coral reef ecosystems involving divers/snorkelers includes the following in-water techniques: roving surveys, stationary point counts, radial surveys, towed diver surveys, belt transect surveys, quadrat surveys, and rugosity surveys (Figure 3).

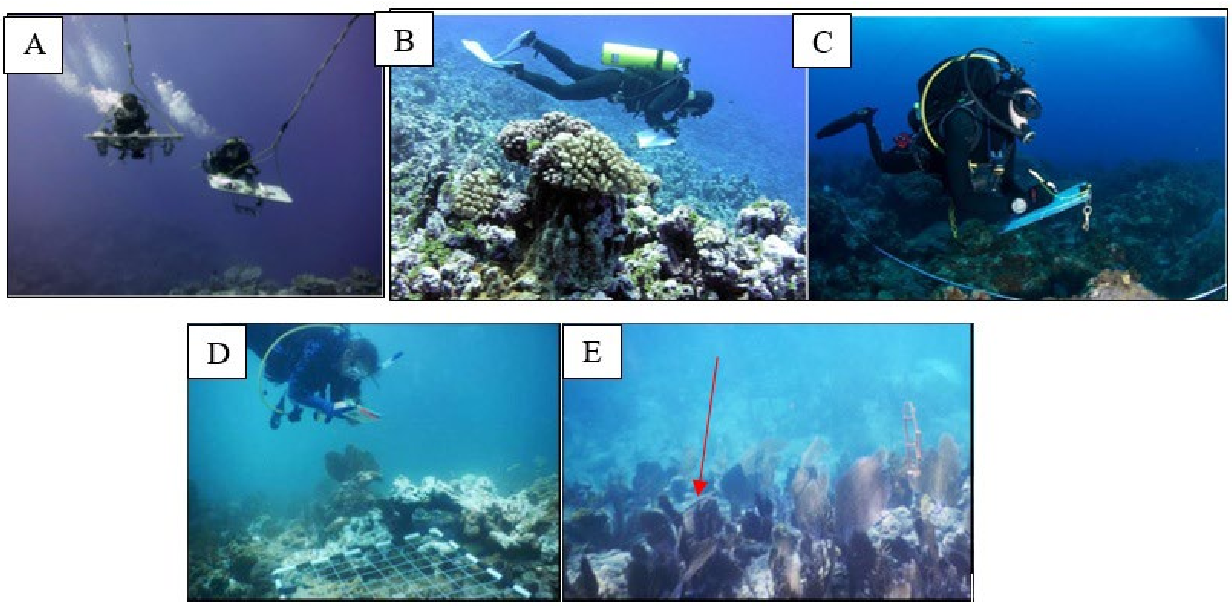

Figure 3. Examples of biological monitoring: A. towed diver surveys; B. and C. belt transect surveys; D. quadrat surveys; and E. rugosity surveys (red arrow indicating the chain placed on the seafloor to measure rugosity) (photo source: A, B, and C NOAA; D and E

These in-water techniques may require the temporary placement of tapes, lightly-weighted chains, or quadrats (i.e., polyvinyl chloride [PVC] or hollow aluminum squares) by hand directly on a reef, seagrass bed, or other benthic habitat. Transect markers may be installed in hard ground, rubble, or sediment areas where they will not affect living corals at permanent transect sites. Permanent transect markers are generally rebar or stainless steel rods or pins (0.63-2.54 centimeters [cm], 0.25-1 inch [in] diameter) that are either hand-driven into the seabed by divers using hand-held hammers or inserted into a hole (1.9-3.2 cm [0.75-1.25 in] diameter) in the seabed created by divers within minutes using a hand-held pneumatic drill. These holes may be filled with a marine epoxy (e.g., All-Fix, Marine Weld™, Splash Zone™) to hold the pin in place. Marine epoxies have two parts that are mixed before entering the water. Once mixed, the epoxies remain pliable for a limited amount of time (up to 72 hours [hrs]) before fully curing (completely hardening). Once cured, marine epoxies are considered non-toxic. To assist divers in locating the markers during subsequent surveys, the rebar/pins may be flagged with small floats on short stainless steel leaders, and labeled with a tag (Figure 4). Divers and snorkelers are required to implement required BMPs during monitoring activities (Section 3.5.1) that include measures to avoid and minimize the effects on corals and other sessile species and on habitats, including critical habitat for ESA-listed corals and sea turtles.

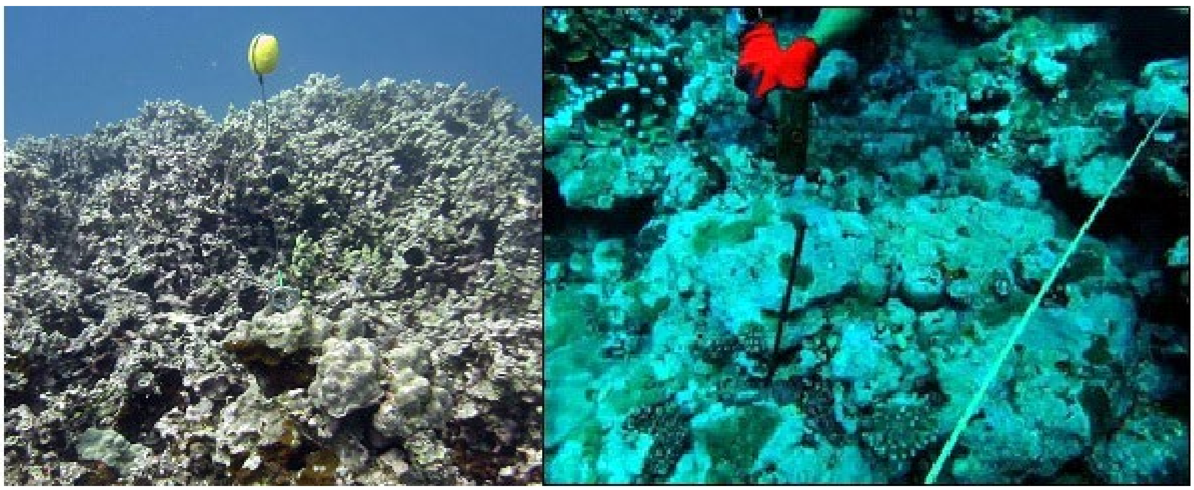

Figure 4. Permanent transect marker examples: left- small float; right- rebar rod (Photo source: The Nature Conservancy [left]; American Samoa Coral Reef Ecosystem Monitoring Program [right])

Stationary Cameras

To monitor reef fish or mobile species, cameras may be deployed to capture images or video to understand the distribution, relative abundance, and size composition of reef fish and associated characteristics of their habitat. In deeper reef areas, baited or non-baited cameras that are buoyed to the vessel may be temporarily deployed (30-60 minutes [mins]) near reefs. Camera-based monitoring is not commonly used by the CRCP and is not a part of yearly monitoring efforts but could be used in future monitoring projects.

Fisheries Monitoring and Detection using Echosounder

Fish aggregations may be located using echosounders. The relatively low-power echosounders are directed at the water column or the seabed directly beneath the vessel. For example, the CRCP has supported activities in Puerto Rico and USVI on the *R/V Nancy Foster* that have used the Kongsberg/Simrad EK60 split-beam echosounder. When in use, the power is set to the lowest possible level, nominally 200 decibel (dB) re: 1 pascal (PA), with a duty cycle of less than 10 hertz (Hz). The beam is maintained at less than a 12-degree angle, which focuses the sound downward, with a small beam width. While CRCP has not recently supported this type of work in other jurisdictions, it is expected that the methods would be similar if implemented elsewhere.

3.2.1.3 Geological and Oceanographic Monitoring

Geological and oceanographic monitoring includes the use of moored instruments, some of which are used to track changes in water quality and physical ocean parameters. Monitoring of water quality includes measurements of water chemistry and nutrients and other contaminants and monitoring of marine and terrestrial sediment, as well as measurements of water temperature. The use of drifters to track ocean circulation and AUVs and ROVs are also part of geological and oceanographic monitoring. Data collected as part of these monitoring activities are used to understand long-term natural processes and their effects and to analyze information from episodic storms and other high-energy events to understand their short-term impacts on coral ecosystems.

Moored Instruments

Many of the geological and oceanographic monitoring activities involve the use of moored instruments to passively collect physical data or to collect samples for laboratory analysis. Instruments may include wave and tide recorders, acoustic Doppler current profilers, salinity sensors, ecological acoustic recorders, fish acoustic tag receivers, subsurface temperature recorders, water samplers, carbon dioxide and pH sensors, sea surface temperature recorders, bioerosion monitoring units (blocks of calcium carbonate), calcification accretion units, Coral Reef Early Warning System buoys, autonomous partial pressure of carbon dioxide (pCO_2) buoys, autonomous reef monitoring structures, and subsurface ocean data platforms. Moored instruments can be attached to existing structures (e.g., non-living substrate, permanent transect markers, other instruments, docks, and bridges); secured with stainless steel poles/rebar installed by hand into the seafloor; attached to sand anchors/screws; attached to eye bolts installed in bare substrate; or held in place with weighted concrete or metal anchors. Weighted anchors and heavy items are hand-placed on the seabed using lift bags to assist in lowering them gradually. Divers or snorkelers carefully place these instruments by hand within coral reefs, seagrass beds, or mangroves avoiding direct contact with sensitive organisms and habitat (Figures 5 and 6). All diving or snorkeling associated with deploying instruments will implement the required BMPs (Section 3.5.1) that include measures to avoid and minimize the effects of placement of items on the seafloor in areas containing corals and other sessile species and important benthic habitats, including critical habitat for ESA-listed corals and sea turtles and EFH.

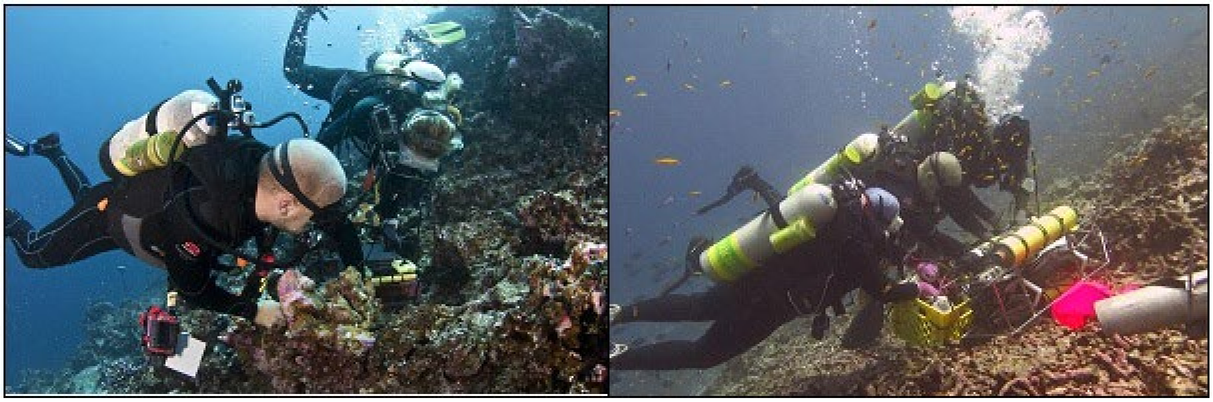

Figure 5. Examples of divers deploying instruments such as water sampling units and the conductivity, temperature, depth, and pH sensors (Photo source: NMFS Pacific Island Fisheries Science Center)

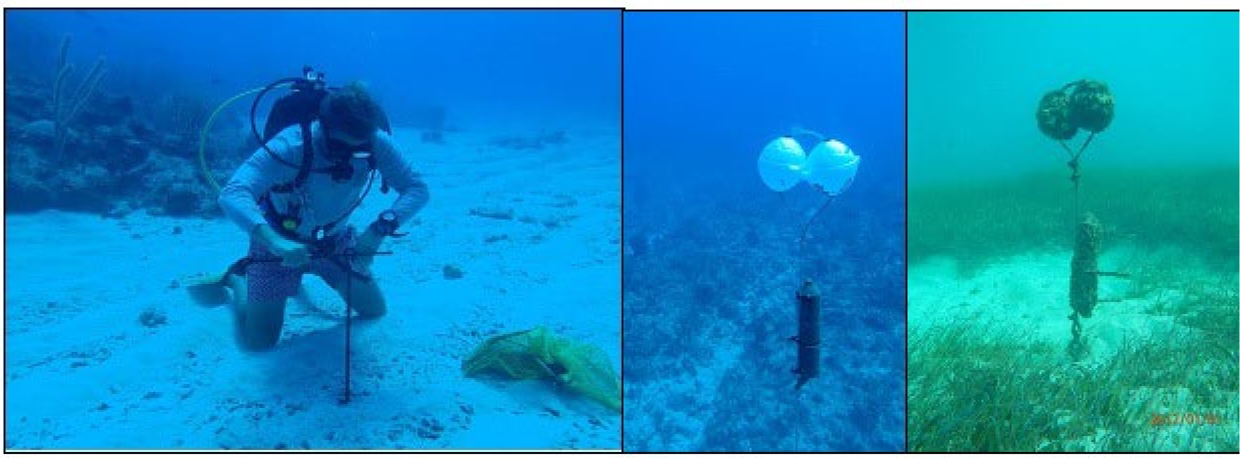

Figure 6. Installation of fish acoustic receivers (Photo source: NOAA NCCOS)

Most of the deployed instruments, such as HOBO® temperature/conductivity loggers or pH sensors, are relatively small (less than 12 square cm [cm^2]; five square in [in^2]) and would have a minimal benthic footprint. Larger moored instruments are attached to non-living substrate, existing structures, or rebar rods using cable ties. The largest deployed instruments are the Coral Reef Early Warning system monitoring buoys (Figure 7), which are attached to bottom anchors in 9-15 m (30-50 ft) depths using StormSoft™ lines attached to nylon lines near the surface. Subsurface lines on the monitoring buoys are coated in plastic and kept taut so that they are not loose or looping.

Figure 7. Coral Reef Early Warning System buoy installation (Photo source: NOAA Atlantic Oceanographic and Meteorological Laboratory)

Many of the automated sensors are temporarily deployed and are retrieved at a later time (hours to days to up to 12 months). However, some instruments can be left for longer periods (years) or indefinitely, which requires periodic (i.e., monthly, quarterly, annual, biennial or triennial) maintenance (i.e., battery changes and sensor cleaning), retrieval, or replacement by divers. For example, in the Pacific, the NCRMP deploys a series of instruments at sites in each jurisdiction for three years to assess climate effects with the exception of a larger multi-instrument platform that is deployed for 24 hrs. The rest of the instruments that are left in place for three years include one Seabird SBE temperature logger, five calcification accretion units, and 5-10 bioerosion units. These instruments require periodic maintenance. Divers conduct light cleaning *in situ* using cloths or brushes to wipe off sensors. Deployed instruments that require more extensive cleaning are brought to land or aboard a vessel to be cleaned and reinstalled in the location from which the instruments were removed. When an instrument is replaced, the new instrument is placed in the same footprint as the removed instrument. The Coral Reef Early Warning System marine environmental monitoring buoys are deployed indefinitely. Currently, the CRCP does not anticipate installing any new Coral Reef Early Warning System buoys, but would continue to support the maintenance of existing buoys.

Multiple instruments may be deployed within a single reef site or within a jurisdiction. Additionally, as part of individual state and territorial coral monitoring programs and external and internal CRCP-funded projects, additional instruments may be deployed in different reef sites for a period up to three years. Current jurisdictional deployments include:

- USVI: one to four temperature loggers per site for a total of 45 throughout the jurisdiction, which are usually attached to rebar;
- Guam: temperature loggers (15 between nine sites for one year), temperature/conductivity loggers (seven in seven sites for one to three years), and Yellow Springs Instruments (YSI) multiparameter data sondes (two sites for one year), which are usually attached to existing structures;
- CNMI: temperature loggers (five at five sites for one year) usually attached to non-living substrate; and

- American Samoa: two temperature loggers per site for a total of 30 that are usually cable-tied to non-living substrates.

The CRCP-supported projects that include installation of moored instruments may use plant-based or petroleum-based lubricants and sealants that are compounded specifically to cling to metal and other surfaces, to provide long-term lubrication and prevent corrosion or rust on instruments. Lubricants seal out water and contaminants. The lubricants are particularly effective on bearings, water pumps, O-rings, gaskets, water filters, motors, and valves that must operate in hot or cold water, along seams, exposed to pool chemicals, or in saltwater. The main type of petroleum-based lubricant used is Aqua Shield™, which may be applied to the moving metal parts (nuts and bolts) in moorings to prevent seizing and allows for functional use of the part during instrument replacement. Aqua Shield™ is insoluble, floats on water, and does not appear to degrade in saltwater because instruments collected after deployment appear to have the same amount of Aqua Shield™ as when deployed years prior. As of 2021, ecological testing has not occurred on this product. The use of lubricants is rare, but when used in CRCP activities, only a small amount (less than 29 milliliter [ml; 1 ounce [oz)]) is applied to deployed instruments. From 2018-2021, there was no use of lubricants or planned use of lubricants on deployed instruments.

Drifters and Floats

The CRCP may support the use of drifters and floats to study ocean currents and eddies and verify satellite data. Drifters or floats typically have three to four major components: (1) body, (2) sails, (3) floats, and (4) a data collection/transmitter package. They can be made of non-biodegradable components such as plastic tubes and cloth or vinyl sails, or made of biodegradable materials such as wood, hemp cloth, and rope. Drifters are typically deployed from vessels and passively move with the currents collecting data for a period of time from days to weeks or indefinitely. The data collection/transmitter package tracks movement using a global positioning system (GPS) and may also collect other data such as surface temperature, salinity, wind speed, or other physical ocean properties. The collected data are transmitted via satellite. Drifters and floats are not regularly used as part of CRCP monitoring but may be used occasionally as part of individual projects or grants. In 2014 and 2017, the CRCP supported the use of Lagrangian drifters. In 2014, four drifters were released off Western Puerto Rico, and, in 2017, 20 drifters were released off eastern Puerto Rico and the USVI. These drifters were made of natural materials including wood, hemp cloth, and biodegradable rope. Currently, there is no planned use of drifters or floats through 2022.

Autonomous Underwater Vehicles and Remotely Operated Vehicles

The CRCP occasionally supports the use of AUVs and ROVs. AUVs are programmed to follow a course of action, and ROVs are tethered to the ship and are under the active control of ship-based operators and observers. Past AUV activities have included the deployment of gliders, including Slocum gliders[5]. ROVs are used for delineation and identification of seafloor habitats. Small ROVs may be launched by hand from shore or small boats. These small units are used for small-scale exploration and site documentation and may also be used to collect water quality data.

Observers controlling ROVs monitor the vehicles during their deployment. ROVs are tethered to the boat and are lowered by a power winch to depths of 10-150 m (32.8-492.1 ft). ROVs operate approximately 1 m (3.3 ft) above the seafloor along a predetermined transect for a set duration, which is controlled/maintained by an operator by adjusting the machine’s thrusters. The ROV and ship speeds are typically 0.5-1 knots during ROV deployments. The ROV provides real-time video display, navigation, and depths. When using a ROV, the operator can maintain the height above the seabed by controlling the amount of tether deployed from the ship.

In general, CRCP-supported ROV and AUV activities are associated with one or two projects per year. The most recent ROV/AUV work supported by CRCP was in Puerto Rico and USVI deploying cameras off the Research Vessel (*R/V*) *Nancy Foster*. Additional planned ROV use will take place in 2022 to assess mesophotic areas around Puerto Rico and USVI. For this work, the ROV will be towed along transects of up to 200 m (656 ft) in seven or eight sites per jurisdiction with three tow depths per site and three replicates per depth, meaning transects will be transited multiple times.

Water Quality and Chemistry Monitoring

Water samples are used to collect information about vertical salinity, temperature structure, chlorophyll-a, nutrients, microbes, microscopic biota, carbonate chemistry, and contaminants. Monitoring of water quality involves the collection of seawater samples at various depths and locations either from a boat using a deployed water sample bottle on a line, or using a diver to collect samples from a certain depth. Depth casts from a boat collect water samples at various intervals and provide information about vertical salinity and temperature structure of the water column. The amount of water collected varies based on the intended analysis and typically ranges from 100 ml (3.38 oz) to 5 liter (L; 1.32 gallons) per sample. Generally, in all jurisdictions, one to three samples are taken per site per point in the water column above coral reefs or seagrass beds. Any diving or snorkeling activities will implement the required BMPs (Section 3.3.1) to avoid and minimize the effects on habitats, including designated critical habitat for ESA-listed corals and sea turtles and EFH.

Marine sediment samples are used to quantify chemical contaminants in the sediments, toxicity of those sediments, and identification of benthic infaunal communities, and are analyzed in laboratory settings for grain size, mineral makeup, and/or contaminants. Sediment collection is

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[5] Glider that is a mobile network component cabable of moving to specific locations and depths and occupying controlled spatial and temporal grids (https://www.whoi.edu/what-we-do/explore/underwater-vehicles/auvs/slocum-glider/).

not a part of CRCP's NCRMP, but is supported as part of individual projects. Sediments are collected using a variety of methods depending on the layer of sediment targeted (surface or subsurface), level of disturbance, and composition. Most collections are taken using subsurface grabs/trowels/hand shovels or gravity/hand cores. Usually a small amount of sediment is collected (about 10-30 ml [0.3-1 oz per sample), but occasionally a greater amount of sediment may be collected (e.g., 5 kilogram [kg; 11 pounds (lbs)] or two 19 L [5 gallon] buckets per site). For hand coring, a diver may push the core to the desired depth in soft sediment or use the metal cap and hammer to drive the core into firmer sediment. Surface sediments are generally collected using grab samplers, which are deployed from a vessel at the water surface, or by hand by a diver using a shovel or trowel. Sediment pore water is sometimes collected to characterize nutrient and/or carbonate chemistry dynamics, as well as measure potentially harmful toxins and contaminants. Sediment pore water is either collected using a manual device such as a PushPoint^{TM} (or similar device), a syringe with a tube (see EPA Pore Water Sampling), or a mechanical device that is used with a gravity corer with tubing in the middle about 5 cm (2 in) in diameter. For manual collection, the tube is about 6.4 millimeter (mm; 0.25 in) in diameter and is inserted into seafloor sediment to known depths, and interstitial waters are removed either by submersible pump or suction after wells have equilibrated with sediment pore waters (several hours to days). Any diving or snorkeling activities associated with in-water sediment collection will implement the required BMPs (Section 3.5.1) that include measures to avoid and minimize potential effects on corals and other sessile species and on habitats, including designated critical habitat for ESA-listed corals and sea turtles and EFH.

The assessment of terrestrially-based sediment and resuspended marine sediments may be done using bulk optic instruments (transmissometers and nephelometers), data loggers, sediment traps (Figure 8), sediment pods, tiles, and by probing a stainless steel ruler through the sediment. Each of these techniques requires temporary (1-24 months) deployment of equipment (i.e., traps, pods, and instruments) in soft sediments near or in coral reefs, seagrass beds, and/or stream mouths. Sediment traps are commonly made from PVC drain pipes (between 2.2-25 cm [1-10 in] in width and 5-76 cm [2-30 in] in length) closed at one end and attached to a length of rebar or PVC pipe that is driven into the sediments. Sediment pods are typically made from concrete-filled large PVC irrigation pipes (15 -51 cm [6-20 in] in diameter and 20-25 cm [8-10 in] in length) with metal eye bolts screwed into the sides, but can be made with flat plates (Figure 8). Sediment pods and other instruments can be weighted with cinder blocks or other weighted bases or held into place using rebar or steel pins hand-driven into soft sediments. The optic instruments and data loggers can be deployed along with the sediment tubes or pods and are also secured to rebar or steel pins hand-driven into soft sediments. Any diving or snorkeling associated with deploying sediment monitoring devices and instruments will implement the required BMPs (Section 3.5.1) that include measures to avoid and minimize potential effects on corals and other sessile species and on habitats, including designated critical habitat for ESA-listed corals and sea turtles and EFH.

Figure 8. Examples of deployed sediment traps. The image on right is a sediment trap and pod together (Photo source: Thomas Stevens, Integral Aqua Pty Ltd. [left and center]; Alex Messina [right])

3.2.1.4 Coral Reef Mapping

U.S. coral reef resources are mapped by the CRCP to support its efforts to manage and monitor coral reef ecosystems. To map U.S. coral reefs, the CRCP uses remote sensing, including aerial and satellite imagery and multibeam echosounders. Divers or ROVs are used to ground-truth the information collected by sensors and in imagery and to assist in the characterization of benthic habitats following the methodology described in Sections 3.2.1.2 and 3.2.1.3, respectively, and in accordance with the appropriate required BMPs (Section 3.5.1). Information regarding the use of AUVs, ROVs, and divers in mapping is not repeated in this section.

In-water Echosounder Mapping

The CRCP echosounder mapping activities typically use NOAA vessels equipped with a downward pointing multibeam echosounder manufactured by Kongsberg (e.g., EM2040, EM710), Reson (e.g., Seabat) or a ME-70 multibeam system, or similar vessel-based systems, but may also use a portable sonar-based mapping system (e.g., Reson T20-P or Kongsberg EM2040C). The Reson Seabat echosounder is a dual frequency system that uses 200 or 400 kilohertz (kHz) with a bandwidth of 1 kHz for operational depths from 10-100 m (32-328 ft). The Kongsberg (e.g., EM2040, EM710) frequencies are between 65-100 kHz with effective operational depths of 100-2,000 m (328-6,562 ft). The ME-70 multibeam system has a frequency range of 70 to 120 kHz. The echosounders on the NOAA boats are downward-oriented from the hull and spread up to 140 degrees across the ship width and 1-3 degrees along the track. Power is set to the lowest possible level (approximately 190-210 dB re: 1 micropascal [µPA]) with a duty cycle or "ping rate" also set to the lowest possible level of 10-30 Hz. The portable systems operate at selectable narrow band frequencies from 200-400 kHz with a downward transducer orientation with a typical swath set to 130 degrees during survey operations. Mapping with the portable system is typically conducted at a speed of 2-2.5 knots. CRCP-supported echosounder mapping takes place in depths below 200 m (656 ft). Recent echosounder activities have taken place off the Florida Keys in 2018 (water depths of 30-200 m [98-656 ft]) and 2019 (water depths of 0-30 m [0-98 ft]). Planned echosounder mapping using the portable system will take place in FY21/FY22 off the South Florida Reef Tract and Florida Keys in water depths of 30-60 m (98-197 ft). The CRCP has not supported echosounder mapping in the Pacific Islands in many years; however, future NCRMP cruises will likely include echosounder mapping.

Aerial Mapping

Aerial mapping may involve hyperspectral sensors on aircraft. The operation of these platforms is done in compliance with Federal regulations. The aircraft maintain a 305 m (1,000 ft) minimum altitude if marine mammals are in the area where flights are being conducted for mapping.

One example of hyperspectral sensors used for mapping is the Light Detection and Ranging (LIDAR) system, which uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth. These light pulses, combined with other data recorded by the airborne system, generate precise, three-dimensional information about the shape of the Earth and its surface characteristics. A LIDAR instrument principally consists of a laser, a scanner, and a specialized GPS receiver. Airplanes and helicopters are the most commonly used platforms for acquiring LIDAR data over broad areas. There are two types of LIDAR: topographic and bathymetric. Topographic LIDAR typically uses a near-infrared laser to map the land, while bathymetric LIDAR uses water-penetrating green light to measure seafloor and riverbed elevations.

Small drones can also be used to map and photograph coral reefs, coastal habitats and watersheds. A drone is a remotely controlled unmanned aerial vehicle (UAV) that can have onboard sensors or a camera to record and transmit data. The duration of a flight varies with mission and drone platform and typically lasts about 30 mins, but multiple flights can be conducted in one day. The sound level generated by drones varies based on the type of drone (i.e., fixed winged, single rotor, or multi-rotor), but ranges between 50-81 dB (Airborne Drones 2020; Kloet et al. 2017; Paine 2019). All drones used must be in compliance with the Federal Aviation Administration operation requirements, which states a maximum allowable altitude of 122 m (400 ft) above the ground. Flight height depends on mapping requirements (e.g., resolution needed) and airspace and generally ranges between 30 m (98 ft) and 122 m (400 ft). Additional factors may also play into flight height; for example, airspace around Kaneohe Bay, Hawaii is controlled by the Marine Corps and their flight ceiling is 30 m (100 ft), which is too low for some mapping needs, although researchers can get a waiver to fly at 61 m (200 ft).

Satellite Mapping

The primary source of data used as of 2021 for production of interpreted shallow-water benthic habitat maps with CRCP funding has been IKONOS imagery. The IKONOS satellite was launched in 1999 and has panchromatic, blue, green, red and near-infrared bands and multiple 11 kilometer (km; 6.83 mile [mi]) swaths can be combined to cover thousands of square kilometers (km^2). The 3.2-4.0 m (10.5-13.1 ft) resolution multispectral imagery has been used for production of the CRCP shallow-water benthic habitat maps that were not produced using aircraft overflights. Remote sensing via satellites is also used for biophysical, geological, and oceanographic monitoring. While satellite mapping is part of the CRCP's action, this activity will have no effect on EFH and ESA resources and is not discussed further in this opinion.

3.2.1.5 Research Activities

Research activities that are often conducted as part of monitoring activities or as separate, stand-alone projects include tagging of fish and corals and the collection of biological samples from fish, coral and other invertebrates, and algae and seagrass.

Tagging

Fish caught for tagging are captured with fish traps, hook-and-line, or nets (Figure 9) and effort is made to minimize gear deployment times. In general, traps can be set for a few hours to a maximum of 24-48 hrs to prevent fish from starving and minimize fish preying upon each other. Nets may be deployed from 15 mins to 12 hrs. Depending on the depth at which fish are captured, effort is made to minimize barotraumas (e.g., injuries caused by pressure changes). The captured fish are measured and tagged with minimal exposure to air, and generally released within a few minutes to minimize post-collection mortality. In some cases, an anesthetic may be used and fish may be held in surface pens for up to 60 mins to allow for recovery and to examine potential negative impacts associated with tagging. In some cases, divers can measure and tag fish at depth of capture to reduce the stress of bringing the fish out of the water, and reduce the potential for barotrauma and release mortality. Sharks are often captured using alternate methods than those used to capture finfish, such as drum lines with circle hooks. Depending on the shark species and location, nets or seines may be used, but the most common gear is a drum line. As of 2021, tagged fish have been non-ESA-listed species though there is the possibly for capture of Nassau grouper (*Epinephelus striatus*) in Florida, Puerto Rico and USVI and ESA-listed sharks, particularly scalloped hammerhead sharks because this species may be in nearshore habitats, especially juveniles. However, Nassau grouper has never been caught and is rarely seen during NCRMP surveys and ESA-listed sharks have not been captured as of 2021.


Figure 9. Examples of nets and cages used to catch fish for tagging (Photo credits: USVI DPNR Division of Coastal Zone Management [left]; Ian Lundgren [right])

From 2018 to 2020, fish-related research activities used nets twice to collect fish in seagrass areas in USVI and once in Puerto Rico. One project used seine nets that were deployed for 15 mins and included nonlethal sampling and release of caught fish. The other project off Culebra, Puerto Rico used small pound nets (50 cm x 50 cm x 50 cm [20 in x 20 in x 20 in] with 0.75 cm^2 [0.3 in^2] mesh made from "vinyl-coated wire") deployed between April and July in seagrass beds for nine hrs to collect juvenile fish. Additional fish research in USVI deployed traps in mangrove sites in 2018, in seagrass in 2019, and in sandy areas near coral reefs in 2020. These traps had a soak time of 24-48 hrs. Only one project in USVI needed to vent air bladders to reduce potential barotrauma injury and exposed fish to anesthetic (e.g., MS222 [tricaine methanesulfonate]) for acoustic tag implants (discussed below). Over the same 2018 to 2020 period, fish research in Hawaii involved collecting/purchasing fish from commercial fishermen, fishing tournaments, or markets.

Typical tags used in fish tagging research include coded wire tags (e.g., external spaghetti tags), elastomer T-bar anchor tags, 8.0 cm (3.1 in) serially-numbered plastic (nylon) dart identification tags, visible implanted fluorescent elastomer tags, and acoustic transmitters. Coded wire, T-bar, and dart tags are external tags that are inserted into the fish near the dorsal fin. Tag sizes vary based on the size of the fish to be tagged. Tag size generally ranges from 5 cm (2 in) in length to 16 cm (6 in) in length with a 0.3 mm (0.003 in) diameter. Visible implanted fluorescent elastomer tags are injected between the rays of the caudal fin, similar to a barcode. Internal acoustic transmitter tags are implanted in a fish. These tags are generally 8-25 mm (0.31-0.98 in) in size and transmit at 69 kHz, 144-158 dB with a battery life of 2 - 24 months. Anesthetics, such as MS-222 and AQUI-S® (active ingredients isoeugenol), may be used ex-situ to sedate fish for tag implantation. Sharks are tagged principally with fin or dart tags. However, the CRCP is not expecting to support tagging of ESA-listed elasmobranchs.

In addition to various internal and external tags, researchers may chemically mark the otoliths of fishes with inorganic fluorescent substances such as oxytetracycline (oxytetracycline hydrochloride at 75 milligram [mg; 0.002 oz] fish body weight). Oxytetracycline belongs to a group of antibiotics used chiefly in treating infections caused by streptococci, staphylococci, Gramnegative bacilli, rickettsiae, and certain protozoans and viruses, and is now the preferred chemical for otolith marking because of its high retention in bony structures. Oxytetracycline may be injected into the coelomic (main body) cavity, or the fish may be bathed in an oxytetracycline solution *ex situ* on a vessel or in a laboratory setting.

ESA-listed and non-ESA-listed corals may be tagged to determine growth rate, spawning potential, or to monitor individual colony health over time. Corals are generally tagged with aluminum or plastic tags that are attached with nails, cable ties, or marine epoxy to the substrate adjacent to the coral colony of interest. Markers that are directly attached to coral colonies are rarely used and, when used, coral colonies have shown rapid tissue growth over the marker. Analysis of 2018-2021 CRCP-supported work indicated that the majority of the coral tagging involves nailing a physical tag at the base of the coral in a non-living substrate. However, in 2020, one project epoxied tags directly on ESA-listed and non-ESA-listed corals as part of SCTLD assessments and coral outplant monitoring.

Alizarin Red S may be used to stain or tag corals in order to provide a baseline growth ring and assess calcification rates. Corals will be removed from their natural habitat and treated with Alizarin Red S in a laboratory setting or in a vessel. Once the Alizarin Red S exposure is complete, the treated coral may be placed back on the reef where it was collected or affixed to a base and secured to the seafloor using methods described in Section 3.2.1.3 for moored instruments for a period of months to two years until removed for laboratory analysis. Alizarin Red S in large amounts is toxic to all living creatures. When applied in running seawater, Alizarin Red S caused mild stress to adult corals, which caused the release of planulae and/or withdrawal of tentacles. Doses higher than 10 parts per million (10 mg/ml) will not be permitted (Lamberts, 1973) when Alizarin Red S is used in CRCP-supported research.

Any diving or snorkeling associated with tagging will implement the required BMPs (Section 3.3.1) that include measures to avoid and minimize potential effects on corals and other sessile species and on habitats, including designated critical habitat for ESA-listed corals and sea turtles and EFH. If tags are placed on diseased corals, the implementation of BMPs related to minimizing the risk of disease transmission to other coral colonies (Section 3.5.1) will be required.

Collection of Biological Samples

Coral fragments or cores may be collected from wild colonies, naturally available coral fragments, corals located on man-made objects such as in-water markers, bridges, seawalls, and towers, or nursery-grown stocks. Coral cores or fragments may be collected from ESA-listed and non-ESA-listed corals in each of the U.S. coral jurisdictions for research, coral nursery propagation, and reef restoration activities. While multiple coral fragments or cores are not typically collected from the same coral colony or the same location, in some cases researchers may collect multiple samples from a single coral colony. Coral mucus samples are collected with a syringe without the needle attached or with swabs (Figure 10). Mucus samples are typically used for research purposes (e.g., disease assessment or coral-bacteria symbiont analysis).

Coral branches or portions of colonies (fragments; Figure 10) may be collected for disease and health research, as broodstock for coral nurseries, and for assessment of coral contaminants. The size of fragments collected from branching corals are generally small, ranging from a single polyp to approximately 2-10 cm (0.8-4 in), with occasional collection of larger fragments up to 30 cm (12 in). Fragments are collected using hand tools such as a syringe, shears, hammer and chisel, or pliers. Fragments taken from branching coral are generally collected from the outermost portion of the branch tip. Collected coral fragments also include dislodged small coral colonies, pieces broken from a colony as a result of natural events (e.g., storms) or accidental vessel groundings, or whole colonies that are "rescued" from areas where construction or other in-water activities would have destroyed them. Researchers may also use fragments of ESA-listed and non-ESA-listed corals from nursery-grown stocks.

Coral cores may be collected from large massive coral colonies to assess rates and patterns of reef accretion, the composition or nature of fossil assemblages, coral growth for species with annual banding patterns, and to generate a long-term record correlating environmental change with fossil records (Figure 11). Large cores are approximately 10-15 cm (4-6 in) in diameter and 0.55 m (1.6-16 ft)in length and small cores are approximately 2.5 cm (1 in) in diameter and 0.5-1.0 m (0.2-20 in) in length. Cores are collected using underwater hand-held hydraulic drills, pumps, and coring equipment (Figures 11 and 12). A common practice to minimize potential environmental impacts and reduce the potential for colony mortality is to fill holes left by coring with Portland cement, clay, marine epoxy, or similar materials allowing live tissue to grow over the part that was cored.

Figure 10. Examples of coral fragment collection by SCUBA diver (left) and mucus collection by a snorkeler (right) (Photo source: Johnston Applied Marine Science [left]; Mote Marine Laboratory [right])

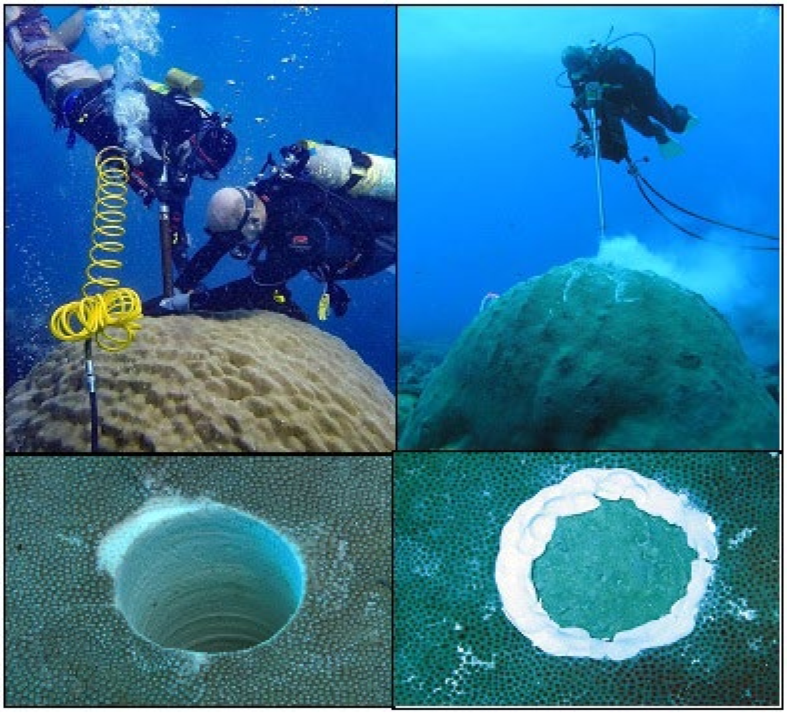

Figure 11. Top photos are examples of collecting larger coral cores; bottom photos are coral with removed core (left) and once core is filled (right) (Photo source: NOAA)

Figure 12. Examples of collecting small coral cores (Photo source: NOAA [left]; Johnston Applied Marine Science [right])

Table 2 provides an overview of the coral species and sizes and types of coral samples collected in Florida, Puerto Rico, and USVI over the period from 2018 to 2021 as part of CRCP-funded projects. The majority of these collections occurred in Florida at multiple reef sites targeting ESA-listed and non-listed corals in the collection of fragments and cores affecting up to 40 colonies per species per reef site. Projects in Puerto Rico over this period targeted acroporid corals in the collection of small fragments from up to 50 coral colonies. Projects in USVI targeted *Montastrea cavernosa* in 2019 collecting large fragments from approximately 30 corals in eight reef sites; *Acropora prolifera* in 2019 and 2020 collecting approximately 200 small fragments; and *Acropora palmata*, *Porites astreoides*, *Siderastrea siderea*, and *Orbicella faveolata* in 2021 collecting approximately 40 large fragments from each species.

Table 2: An overview of the coral species and types of fragments/cores collected in the U.S. Atlantic/Caribbean jurisdictions between 2018 and 2021 where FP = few polyps, < 1 cm^2 (< 0.4 in^2); S = small, 2.5 cm (1 in) fragment, 4 cm^2 (1.6 in^2) core; M = medium, 3-9 cm (1.2-3.5 in) fragment, 4-10 cm^2 (1.6-3.9 in^2) core; and L = large, 10-15 cm (4-6 in) fragment, 10 cm^2 (4 in^2) or greater core (NOAA CRCP 2021).

	Florida				Puerto Rico				USVI			
Species	**FP**	**S**	**M**	**L**	**FP**	**S**	**M**	**L**	**FP**	**S**	**M**	**L**
Acropora palmata	X	X	X	X*	--	X	--	--	--	--	--	X
A. cervicornis	X	X		X	--	X	--	--	--	--	--	X
Orbicella faveolata	X	X	X	X	--	--	--	--	--	--	--	--
O. franksi	X	--	X	--	--	--	--	--	--	--	--	--
O. annularis	X	--	X	--	--	--	--	--	--	--	--	--
Dendrogyra cylindrus	--	--		X*	--	--	--	--	--	--	--	--
Montastraea cavernosa	--	X	X	X	--	--	--	--	--	--	--	X
Pseudodiploria clivosa	--	--	X	--	--	--	--	--	--	--	--	--
Siderastrea siderea	--	--	X	X	--	--	--	--	--	--	--	X
Colpophyllia natans	--	X	--	X	--	--	--	--	--	--	--	--
A. prolifera	--	--	--		--	--	--	--	--	X	--	--
Diploria labyrinthiformis	--	--	X	X	--	--	--	--	--	--	--	--
Porites astreoides	--	--	--	X	--	--	--	--	--	--	--	X
Pseudodiploria strigosa	--	--	--	X	--	--	--	--	--	--	--	--
Meandrina meandrites	--	--	X	X	--	--	--	--	--	--	--	--
Dichocoenia stokesii	--	--	--	X	--	--	--	--	--	--	--	--

* these corals will also be collected in Bahamas – nursery and wild specimens as part of a project to enhance genotypic diversity of Florida *A. palmata* and *D. cylindrus.*

Table 3 provides an overview of the coral species and sizes and types of coral samples collected in CNMI and Guam over the period from 2018 to 2021 as part of CRCP-funded projects. CRCP-supported projects involving the collection of coral samples have been very limited in the Pacific with one project in CNMI in 2021 involving the collection of approximately 60 small fragments from each species and one in Guam in 2019 involving the collection of approximately eight small fragments from each species from four reef sites.

Table 3: An overview of coral species and types of fragments/cores collected in two of the U.S. Pacific jurisdictions between 2018 and 2021 where FP = few polyps, < 1 cm^2 (< 0.4 in^2); S = small, 2.5 cm (1 in) fragment, 4 cm^2 (1.6 in^2) core; M = medium, 3-9 cm (1.2-3.5 in) fragment, 4-10 cm^2 (1.6-3.9 in^2) core; and L = large, 10-15 cm (4-6 in) fragment, 10 cm^2 (4 in^2) core (NOAA CRCP 2021).

	CNMI				Guam			
Species	**FP**	**S**	**M**	**L**	**FP**	**S**	**M**	**L**
Acropora surculosa	--	X	--	--	--	X*	--	--
A. abrotenoides	--	X	--	--	--		--	--
Porites rus	--	--	--	--	--	X	--	--
P. cylindrica	--	--	--	--	--	X	--	--
Leptoria phrygia	--	X	--	--	--	X	--	--
Pocillopora eydouxi	--	--	--	--	--	X	--	--
A.globiceps	--	X	--	--	--	X*	--	--
Pocillopora meandrina	--	--	--	--	--	X	--	--
A. aspera	--	X	--	--	--		--	--
A. tenuis	--	X	--	--	--		--	--
Leptoria phrygia	--	--	--	--	--	X	--	--
Goniastrea spp.	--	X	--	--	--		--	--
*Fragments from these species would only be collected if found in collection areas surveyed - none have been found as of 2021.								

Coral gametes may be collected and grown to larval stages for genetic crossing or restoration and population-enhancement efforts, for laboratory research on early life stages of corals, or for cryopreservation. Coral colonies selected for gamete collection are typically about 10 m (33 ft) apart to try to obtain samples that are genetically diverse and to improve the likelihood of successful crosses because gametes from some coral clones will not fertilize. Colonies from which gametes are collected may be tagged. Prior to spawning events, a few polyps (about 1 cm^2 [0.4 in^2]) or small fragments (less than 4 cm [1.6 in]) may be collected from the targeted coral colonies and analyzed *in situ* or in a laboratory to see if the corals are sexually active. When collecting gametes from broadcast spawning corals, divers carefully place a nylon collection tent (Figure 13) over an entire small colony or a portion of the colony (i.e., single branch or multiple branches, and more than one net can be placed on a single colony). The tents may be temporarily secured to the seafloor using nails. The cone-shaped tent funnels and concentrates the egg/sperm bundles into removable collection tubes or jars located at the top of the net ranging from 50-100 ml (1.7 - 3.3 oz) to collect small spawn amounts to 250-1,000 ml [8-34 oz] to collect large amounts (Figure 14). The collector tubes/jars are removed/replaced when they are about 25% full or within 10-20 mins after spawning begins to avoid losing gametes due to reduced or declining water quality in the collector from the high concentration of gametes and lack of water flow. New collection tubes/jars can be added to the tent throughout the spawning event. Once removed from the tent, the tubes/jars are brought to the boat or shore for fertilization. (More information on gamete collection methods used in CRCP-supported projects can be found in Chapter 5: Rearing coral larvae for reef rehabilitation in the *Reef Rehabilitation Manual* (Guest et al. 2010).

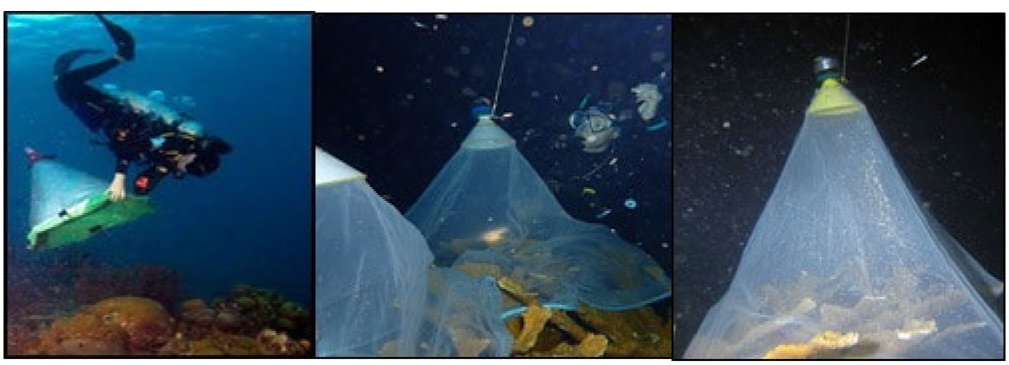

Figure 13. Examples of collecting gametes from coral (Photo source: NOAA [left]; NMFS Southeast Fisheries Science Center [middle and right])

Divers may use syringes to collect sperm and eggs released from gonochoric broadcast spawning corals. The needleless syringes used to collect sperm or eggs only contact the water surrounding the colonies and do not directly contact the coral. To collect gametes from brooding corals, researchers may “borrow” the whole coral colony from a reef (past work collected corals ranging in size from 10-20 cm [4-8 in] in diameter) by carefully hand chiseling the whole colony from the reef. The colony is then brought to a laboratory and placed in a tank for a few days while the planulae are released. The coral is then returned to the reef from which it was taken and reattached to hard substrate. The coral larvae produced in a laboratory from collected gametes may be released in the field after settlement, after reaching the planktonic stage, or used for research. Examples of coral species from which CRCP has supported the collection of gametes include non-listed and ESA-listed species such as *Acropora palmata*, *A. cervicornis*, *Orbicella faveolata*, *Diploria labyrinthiformis*, *Montipora capitata*, and *A. globiceps*.

Figure 14. Example of collected coral gametes in containers (Photo source: NMFS Southeast Fisheries Science Center [left]; Kelli O'Donnell [right])

Coral colonies are often measured (Figure 15) using hand-placed calipers, rulers, or flexible tapes, which briefly (less than 5 min) remain in contact with a portion of the coral colony. Diving or snorkeling associated with the collection of corals fragments, gametes, and measuring coral colonies and potential adverse effects of collecting coral colonies, tissue and other samples, and gametes will implement the required BMPs (Section 3.5.1) that include measures to avoid and minimize the adverse effects on ESA-listed corals, designated critical habitat and EFH, including to reduce the risk of transmitting coral diseases.

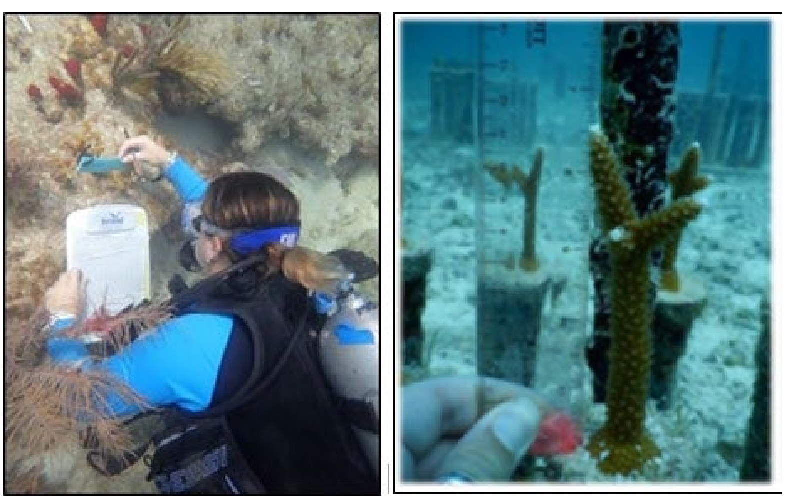

Figure 15. Measuring coral. Image on right is a nursery-grown coral (Photo source: Kelli O'Donnell)

In some instances, fish are collected using non-lethal sampling methods such as fin clips or collection of scales for genetic analysis from fish caught with traps, by hook-and-line, or by net, and released after sampling. Other non-stony coral invertebrate samples may also be collected.

Nets and traps for collection of fish and mobile invertebrates are usually placed in areas near reefs, but not on coral colonies. Hand collection may be used to collect slow-moving species, particularly mobile invertebrates. Hand collection includes the use of small hand-held nets, lobster snares, brushing off live rock or rubble, hand picking specimens from substrate, or suctioning of burrowed organisms. Traps may be baited and placed in mud or sand adjacent to coral reefs and mangroves, or in seagrass areas for up to 24 hrs. The substrate type is visually confirmed from the surface or by free divers prior to deployment of traps or other collection gear. Fish and invertebrate samples are also collected from specimens previously harvested by fishermen or bought from markets in order to characterize life history stage, fecundity, growth rates, and diet.

Some lethal and nonlethal collections of fish and motile invertebrates using hook-and-line, spearfishing, traps, or nets are undertaken (one to four projects per year based on information provided by the CRCP) to characterize life history stage, fecundity, growth rates, diet, to understand corallivore impacts on corals, or to assess contaminant exposure. In addition, Autonomous Reef Monitoring Structures (ARMS; Figure 16) or other structures, which are intended to mimic the structural complexity of coral reefs, may be deployed for a determined amount of time (months to years) to attract colonizing macroinvertebrates. The ARMS (https://origin-appspifsc.fisheries.noaa.gov/cred/survey_methods/arms/assembly.php) used by the CRCP were 36 cm x 46 cm x 20 cm (14 in x 18 in x 8 in) and contain nine layers measuring 23 cm x 23 cm (9 in x 9 in) each for colonization. The ARMS were made of non-caustic PVC type 1 plastic and consist of layers that alternate between an open surface and triangular-shaped colonization sites. The ARMS were moored to the seafloor as described for other moored instruments in Section 3.2.1.3. In Florida Keys National Marine Sanctuary (FKNMS) and FGBNMS, the NCRMP deployed ARMS, typically for up to three years prior to removal. NCRMP no longer deploys these structures but some are still in the water because of covid-related delays in removing them from the water.

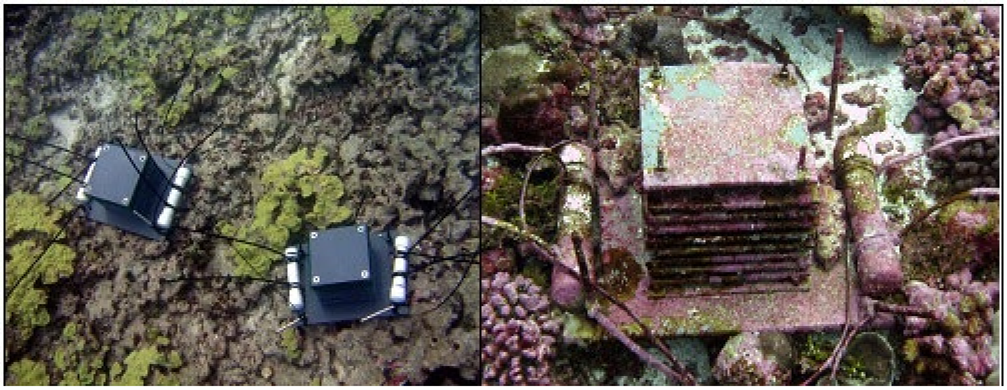

Figure 16. Examples of deployed Autonomous Reef Monitoring Structures, or ARMS: newly deployed (left); after two years (right) (Photo source: NMFS Pacific Islands Fishery Science Center)

Algae/seagrass may be collected during photo quadrat surveys or as single samples for species identification or contaminant/nutrient analysis. Samples collected for identification consist of individual plants, including blades, stipe, and holdfasts. Samples taken for contaminant/nutrient analysis typically collect single blades or blade segments from multiple plants within an area.

Any diving or snorkeling associated with in-water collection of fish and other non-stony coral invertebrate samples will implement the required BMPs (Section 3.5.1), including measures to minimize the potential for spread of coral disease and to avoid and minimize other effects on corals and other sessile species and on habitats, including designated critical habitat for ESA-listed corals and sea turtles and EFH.

3.2.2 **Coral Restoration and Interventions**

The CRCP uses a multi-prong approach to address the loss of coral reefs. This approach addresses local stressors such as invasive species and anchoring damage from vessel use in coral reef habitats. Simultaneously, the CRCP supports repopulating key reefs and conducting research and on-the-ground actions to prevent additional losses of corals and their habitat, and to develop innovative intervention techniques (e.g., stress hardening and assisted gene flow) for coral restoration to create resilient, genetically diverse, and reproductively viable populations of key coral species.

3.2.2.1 Coral Nurseries

Nurseries primarily grow corals for reef restoration and population enhancement. Nursery corals and fragments may also be used in research related to life history, restoration, and resilience. *In-situ* nurseries are generally installed in areas near coral reefs where environmental conditions are appropriate for rearing corals (e.g., good water quality, circulation, presence of herbivores). Each of the U.S. coral jurisdictions (American Samoa, CNMI, Guam, Hawaii, Florida, Puerto Rico, and the USVI) currently have *in-situ* coral nurseries managed by non-federal government partners. Federal agencies, including the Restoration Center in Puerto Rico, and the FKNMS in

Key West, also manage in-water coral nurseries. The nurseries in Florida, Puerto Rico, and USVI mainly grow ESA-listed corals such as *Acropora cervicorni*s, *A. palmata*, *Dendrogyra cylindrus*, *Orbicella annularis*, and *O. faveolata*. Pacific nurseries mainly grow non-ESA-listed corals, with the exception of the CNMI nursery that grows *A. globiceps*. Land-based/*ex-situ* facilities are also used for rearing corals. The CRCP has not historically supported land-based nurseries. However, the CRCP may provide support, such as funding for operations or expansions of stock, for land-based nurseries already in operation. Any expansion of stocks that include specimens from outside of the region will need to have a closed system and a plan to isolate foreign-sourced corals to ensure the new specimens are free of diseases, pathogens, or non-native species. If the CRCP supports the development of new land-based nurseries, there may be a need for ESA section 7 consultations if the nurseries were to include seawater intakes or outfalls in coastal areas that could pose threats to listed species such as entrainment or impingement in intakes or the introduction of toxins or disease vectors in water discharges from outfalls.

In-situ Coral Nursery Development/Expansion

In order to set up a new nursery, a site-specific nursery operational plan must be developed. The CRCP will work with external partners to identify options for nursery sites based on several selection factors: (1) avoiding impacts to existing benthic habitats including coral and seagrass; (2) areas with minimal predators; (3) appropriate water quality and substrate conditions for coral growth; and (4) logistics such as accessibility from land. Once a site is selected, the project lead will obtain all permits from applicable federal, state/territorial, and local permitting agencies. Nursery footprints generally range from less than 0.1 acre to two acres. To date, the CRCP has only supported the development/siting of new temporary (2-year) nurseries in Kaneohe Bay, Oahu, Hawaii in 2016. The footprints of these nurseries were 10 m x 10 m (32 ft x 32 ft), with the largest coral structures being 1.5 m x 1.5 m (5 ft x 5 ft; NMFS 2016). No ESA-listed corals were cultured in these nurseries, but they were located in monk seal critical habitat (in marine waters outside the ineligible area associated with the Marine Corps Base Hawaii that is not part of the critical habitat designation). In 2021, CRCP supported the expansion of additional nursery structures in Cocos Lagoon, Guam.

In-situ coral nurseries consist of floating/midwater nurseries or bottom-placed structures that hold coral colonies, fragments or cores. These structures can take a variety of forms including lines, trees, and tables for floating nurseries; and tables, blocks (including of PVC), wire cages, or A-frames secured to the bottom for bottom-placed nurseries. Most nursery sites in the U.S. Caribbean are less than one acre in size in terms of the total footprint of the nursery over the seafloor, but some, such as the floating underwater arrays and trees established in 2006 to provide corals for restoring the Margara grounding site of Guayanilla, Puerto Rico and the floating arrays established at Margarita Key, Cabo Rojo, Puerto Rico in 2013 have been larger at 1.25 and 1.46 acres, respectively. Nursery structures in Florida follow a similar pattern, although nurseries composed of trees and bottom-placed structures established in 2007 at three sites off Dade County, Florida were greater than one acre each.

Floating nurseries (Figure 17), such as lines and trees, have four main components: an anchor, floats, lines, and coral attachment devices. Only a very small subset of the benthic area within the nursery is directly impacted by the anchorage of the floating structures. Commonly used anchors include duckbill anchors, Helix ground anchors, rebar or stainless steel bars, anchor screws, heavy weights, mooring weights, or eyebolts cemented into hard bottom. Floats hold horizontal lines or frames taut. Tree-style structures have a PVC pipe or a fiberglass rod that runs up the center with branches (usually wooden, PVC, or fiberglass) coming off the center stem with floats to hold taut. Whenever possible, lines used in floating/midwater nurseries are encased with PVC pipe to provide rigidity to the structure and reduce slack line. The branches of tree-style nurseries may also support trays made of PVC and plastic mesh to hold microfragments or larger non-branching corals. Floating table-style structures have a flat surface typically made of PVC pipes or a plastic mesh that is floated vertically from the bottom. In some cases, during bleaching events, shade cloths can be deployed about 0.6 m (2 ft) above the coral table. The shade cloths are attached to the nursery structure, held taut with floats, and removed when the bleaching event ends. Corals are attached to the lines or branches using vinyl-coated wires, cable ties or monofilament fishing line, inserted into the braids of the line itself, or held in place with small pieces of hemp or rope. Floating structures directly impact the seafloor where the anchoring structures are located. Tree-style structures generally have one anchor, whereas other line or floating tables may have two or more anchors. The impact footprint of helix, screw, and duckbill anchors (Figure 18) on the seafloor depends on the diameter of the disk or diameter and length of the shank of the anchors. Diameters can range from 2.5 cm (1 in) to 20 cm (8 in). Mooring weights (Figure 17; A and B) have a greater footprint that varies based on the total weight and shape of the anchor. For example, a 100-kg (220-lb) weight could measure 56 cm x 33 cm x 6 cm (22 in x 13 in x. 3.5 in), and a 91-kg (200-lb) pyramid anchor could measure 61 cm x 36 cm x 36 cm (24 in x 14 in x 14 in).

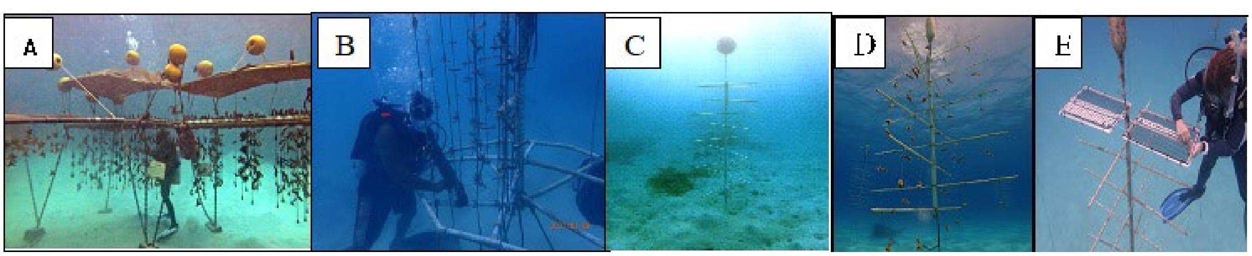

Figure 17. Examples of floating coral nursery structures found around Guam and Saipan: A. floating table structure (Guam) held in place with mooring weights; B. new chandelier structure (Guam); and C-E. floating tree structures (Guam and Saipan) (Photo source: A, B, and C University of Guam, Laurie Raymundo; D and E Johnston Applied Marine Science)

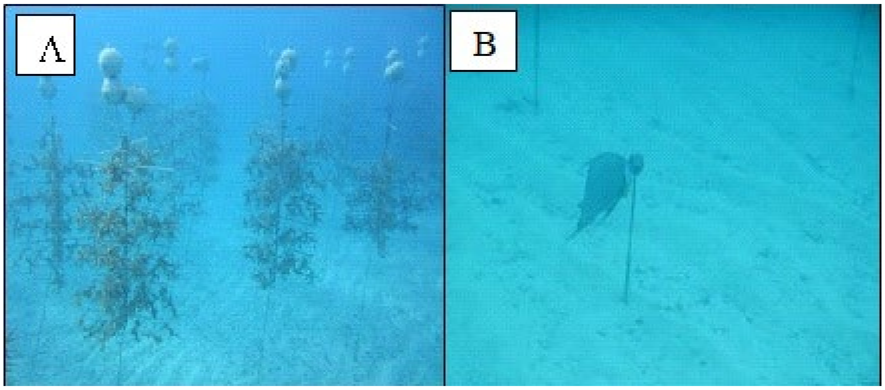

Figure 18. Examples of floating/midwater coral nurseries in Florida: A. Tree style nurseries; and B. short float marking a duckbill anchor used for a coral nursery tree (Photo source: Mote Marine Laboratory [left]; Kelli O'Donnell [right])

Bottom-placed structures (Figures 19, 20, and 21) include block or frame nurseries that are fixed to the bottom with cinder blocks, weights, or anchors, and do not include floats. This type of nursery has three main components: an anchor, a constructed unit, and a coral attachment device. For the block growout structures, cinder blocks (estimated footprint 30 cm x 20 cm x 40 cm [12 in x 8 in x 16 in]) may be used as the base of the construction unit and are anchored in place using rebar or steel bar. Pedestals (usually cut PVC pipes) are attached to the top of the cinder block using marine epoxy. Corals can be attached to the pedestal on the top of the cinder block via concrete disks, cones, or pyramids using plastic ties, wires, or marine epoxy. Individual block nurseries can be placed near each other within the nursery. Frame grow-out structures are made in a variety of shapes: tables, triangles, circles, or domes and are typically metal (stainless steel rebar with wire mesh) coated with marine epoxy, fiberglass to reduce fouling, or PVC pipes. The footprint of the bottom-placed coral grow-out structures varies based on the type of structure and how close the structures are placed together. Frame structures can vary in size. For example, dome structures can be 1 m to 1.5 m (3 ft to 5 ft) in diameter, A-frame structures can be 0.6 m wide x 1.2 m high (2 ft x 4 ft), and tables can range from small (1 m length x 1 m width x 1 m height [3 ft x 3 ft x 3 ft]) to large (8 m length x 8 m width x 1.5 m height [26 ft x 26 ft x 5 ft]). Novel biodegradable materials are also being tested and include bamboo with hemp ties, and hemp rope placed along the seabed and attached at the ends. Frames are anchored to the bottom using cinder blocks, weights, or rebar or steel bars and would have similar footprints as other structures. Corals are attached to the frames using wire or plastic ties.

Figure 19. Examples of benthic coral nurseries: block-style nursery where Acroporid corals are affixed on top of blocks to grow (left); A-frame nursery with Acroporid corals attached (right) (Photo source: Mote Marine Laboratory [left]; University of Miami [right])

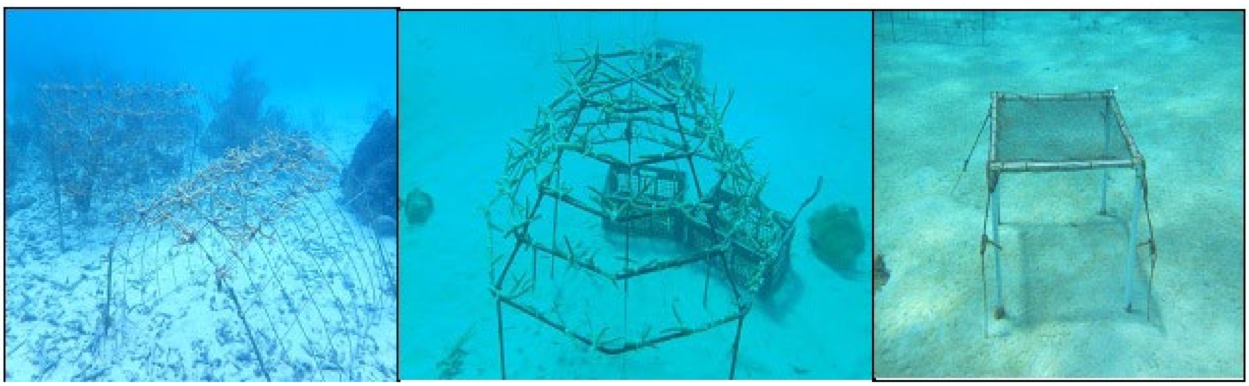

Figure 20. Examples of bottom nurseries in USVI (Photo source: The Nature Conservancy)

Figure 21. Examples of C-frames and spider frames in Guam (left) and a large table nursery in Hawaii (right) (Photo source: University of Guam, Laurie Raymundo [left and middle]; NOAA [right])

To support natural maintenance of corals, small structures made of multiple cinder blocks or similar size ceramic structures may be temporarily deployed within the nursery footprint to attract small fish or invertebrates to clean off the structures and corals within the nursery.

To rear newly settled corals, temporary floating mesocosms/pools (Figure 22) up to 2.4 m length x 3.7 m wide x 1.8 m depth (8 ft x 12 ft x 6 ft) may be deployed for several months within an existing coral nursery by using sand anchors or weighted anchors, or by attaching to existing structures near shore (e.g., docks).

Figure 22. Examples of floating pool nurseries: settlement devices inside floating pools (left); in-water view of the settling pool (right) (Photo source: Valerie Brown [left]; SECORE International [middle and right])

Corals grown in an *in-situ* nursery setting may be fragments of opportunity or collected from healthy colonies using the methods described in Section 3.2.1.5. Collected fragments are either transported underwater to nearby nurseries or placed in bins with seawater on a vessel or vehicle if they need to be transported some distance to nursery sites. The seawater is changed regularly, and the bins remain shaded during transit. Local transit times can vary between 10 mins to two hrs. However, the majority of transit times are 30 mins or less. Longer transport times may be three to four hrs such as when importing Bahamian coral genotypes to *ex-situ* nurseries in Florida. No coral mortality has been reported as a direct result of transporting corals. One CRCP-supported effort, which was an external grant in 2018 for a Guam nursery, reported four corals out of 486 died within three months, but there was no direct connection with transporting the corals and coral mortality.

Typically, coral collection occurs during the first year of establishment and operation of a nursery and no additional coral collection is needed to expand the nurseries in out-years because the nursery produces enough coral tissue *in situ* for both expansion by fragmenting and for outplanting. Some coral restoration practitioners may also share coral genotypes among different nurseries to increase propagation and reduce risk of things like bleaching and disease leading to the loss of genetically identical fragments. In some cases, additional collections are made to increase genetic diversity within a nursery or to house corals salvaged from groundings, natural disasters, or in-water construction projects.

Following a vessel grounding or other event that causes damage to coral habitats, temporary nurseries can be set up near the reef location where damage occurred for transplanting/outplanting of corals. Temporary nurseries may also be used to support restoration as part of habitat enhancement efforts. The temporary nurseries hold corals/fragments until they are transplanted back to the reef. This ensures corals never leave the water, which helps increase daily outplanting (restoration efforts), and minimizes the handling and transport time of the dislodged corals or fragments. Maintaining temporary nurseries allows corals to acclimate to the outplanting site's local microbiota and environmental condition (if corals are transported from a different site), or to remain acclimated to the site. These temporary nurseries are removed once the restoration activities are finished.

In-situ nurseries are not installed over sensitive habitat, any diving or snorkeling associated with installation and operation is done in accordance with the required BMPs (Section 3.5.1) that include measures to avoid and minimize the effects on corals and other sessile species and on habitats, including designated critical habitat for ESA-listed corals and sea turtles and EFH.

Nursery Maintenance

Regular maintenance of nurseries is needed to maintain the health of the corals and to ensure the in-water structures are stable. Typical nursery maintenance is done by divers (Figure 23) and includes the removal of fouling organisms (algae, tunicates, sponges, and hydroids) using wire or plastic brushes; the removal of corallivores (snails, worms, and damselfish) by hand (see *Invasive Species Removal/Nuisance Species Control* in Section 3.2.2.2); the repair of broken nursery components (lines, wires, and anchoring materials); the removal of diseased corals from the nursery or application of treatments such as administering a "break" or an antibiotic treatment (see *Coral Disease Control/Management* in Section 3.2.2.2); monitoring of coral health and growth (length, branch tips, width, condition, and mortality; Figure 24); and continued propagation (fragmentation) of corals to maintain nursery stock and to support transplanting/outplanting. The CRCP has supported and would likely continue to support nursery maintenance in all U.S. coral jurisdictions. Any diving or snorkeling associated with maintaining *in-situ* coral nurseries will implement the required BMPs (Section 3.5.1) that include measures to avoid and minimize the effects on corals and other sessile species and on habitats, including critical habitat for ESA-listed corals and sea turtles and EFH, and to minimize the spread of coral disease.

Figure 23. Coral nursery maintenance (Photo source: Kelli O'Donnell [left]; NOAA [middle and right])

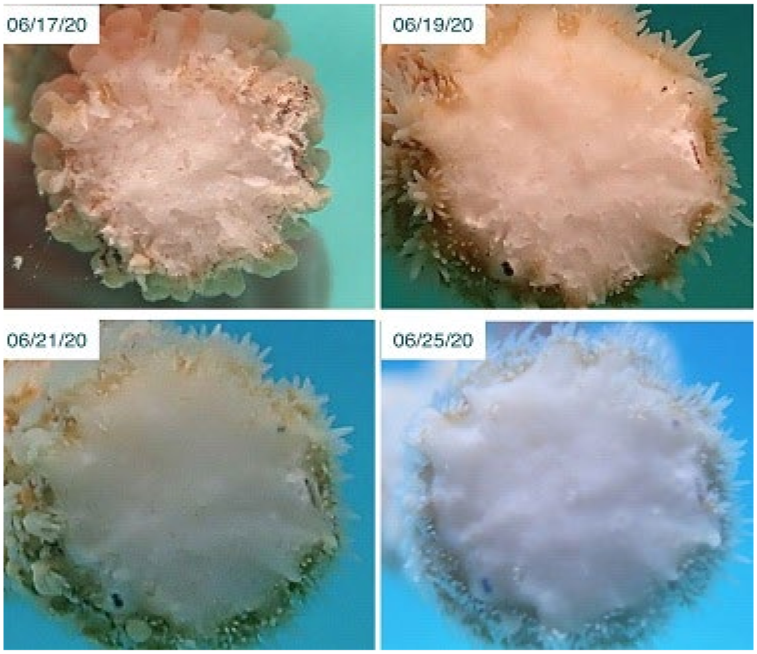

Figure 24. Example of monitoring coral wound healing from CNMI coral nursery (Photo source: Johnston Applied Marine Science)

Coral Transplantation/Outplanting

Coral transplantation involves stabilizing the substrate, reattaching fragments or colonies, and/or attaching nursery-raised corals to reef or other hard-bottom substrate. Generally, transplanted corals are attached either directly to hard substrates in reef areas or to a minimal base structure (e.g., a disk or pyramid made from concrete or limestone), which is then affixed to the seafloor. The outplanted corals may be placed near other living corals and/or near other transplanted corals, but far enough away to promote growth and reduce mortality and the density of outplanting varies by the species being outplanted.

As with transport to nurseries, colonies are either transported underwater to nearby outplanting sites or placed in bins with seawater on board a vessel or vehicle if they need to be transported a further distance (Figure 25). Reported transport times from nurseries to outplanting sites for CRCP-supported outplanting has ranged between 15-30 mins, but it is possible that some transport times may be up to an hour. There has been no reported fragment morality directly associated with transport, as stated previously in the section on coral nurseries above.

Before outplanting corals, the substrate may need to be cleaned of fouling organisms such as sponges, *Palythoa* spp. (encrusting anthozoan, an invertebrate that grows in thick mats), and algae, which can hinder attachment and overgrow the newly outplanted corals. *Palythoa* taken from an outplanting site will be bagged, removed from the water column, and disposed of at an appropriate land-based facility. Routine removal of *Palythoa* (by scraping and collection) is unlikely to have an impact on surrounding organisms as the toxin is not “released” by *Palythoa*.

To be cautious, divers conducting site maintenance will wear gloves to prevent accidental skin contact.

The placement, attachment, or stabilization of smaller coral fragments, individual coral colonies, or nursery-reared corals is typically done using marine epoxy, cement, concrete nails, other mechanical devices (e.g., plastic cable ties), hemp rope, or direct attachment to a rack or other stabilization structure that remains on-site and becomes overgrown by the transplanted corals (e.g., bamboo rack). Larger coral pieces or substrate may be attached or secured using cement, rebar, nails, marine epoxy, and/or limestone. Corals may also be outplanted using the technique of microskinning in which microfragments (very small-sized fragments) are attached to reef substrates or dead coral skeletons in an array that can then readily fuse together as the fragments grow.

Figure 25. Examples of transporting (left) and outplanting (right) nursery corals (Photo source: David Gross [left]; Mote Marine Laboratory [second from left]; NOAA [second from right, right])

The CRCP may fund new and innovative coral restoration techniques to increase outplanting efficiency, increase survivorship of outplanted corals, enhance natural coral recruitment, and/or increase the use of biodegradable materials. Activities may include the use of novel structures (e.g., bamboo, hemp rope, and natural limestone) to grow corals in nurseries and directly outplant them onto the reef on a pilot scale in a small area or portion of reef area (estimated between 1 m^2 to 20 m^2) or using a limited amount of corals (estimated between 12 and 150 corals/fragments). For example, one of the newer outplanting techniques uses hemp ropes containing nursery-grown corals that are nailed to the substrate. Corals are attached to the rope by looping it around the bases of large coral colonies, zip tying, or putting smaller corals into the twist of the rope. When ready for outplanting, the rope is laid across the substrate and nailed into place. The hemp rope biodegrades over time and the corals begin to grow and attach to the substrate. Other pilot testing to promote outplant success may occur, such as using dome-shaped structures to support multiple coral fragments.

Another method for propagating and outplanting corals involves the collection of coral gametes *in situ* followed by *ex situ* fertilization. Fertilized larvae can be released directly back into the reef areas from which gametes were collected, or be allowed to settle on ceramic plates or other structures such as small tetrapods or other designs (approximately 8-10 cm [about 3-4 in] in diameter), or small seed beads (about1-1.5 cm [about 0.4-0.6 in]; Figure 26) that mimic natural settlement structures. The density, shape, size, and ceramic material used to create the tetrapods and seed beads closely mimic pebbles, broken coral fragments, and other loose benthic materials found naturally in reef habitats. To enhance larval settlement, some nascent experimental methods may use "flypaper" (biofilms that have crustose coralline algae compounds to attract coral larvae) techniques or settlement tents (e.g., a two person-size tent kept over a reef area for 24-hrs that corals can settle on). Biofilms and settlement tents to attract coral larvae are placed in suitable restored substrate, thereby enhancing recruitment to a restoration site. Settlement plates and other structures that have larvae attached can be deployed on the reef using marine epoxy to attach the plate to non-living substrate. Alternatively, settled coral larvae may also be grown *in situ* or *ex situ* in nurseries for an extended period (e.g., 1-2 years) and then outplanted on reefs in order to increase the likelihood of survival.

Figure 26. Example of SECORE International ceramic settling devices and small larval seed beads deployed on the reef (Photo source: NOAA [top left]; Valerie Brown [top middle]; E. van der Steeg, Newcastle University [top right]; Johnston Applied Marine Science [bottom row])

Any diving or snorkeling associated with outplanting, relocating, and transplanting corals will implement the required BMPs (Section 3.5.1) that include measures to avoid and minimize the effects on corals and other sessile species and on habitats, including designated critical habitat for ESA-listed corals and sea turtles and EFH, and to reduce the risk of spreading coral diseases.

Large-Scale Restoration

Large-scale restoration activities to rebuild biological diversity and ecological function are expected to be supported by the CRCP. Mission: Iconic Reefs (Section 3.3) is an existing initiative with some CRCP support with the goal of implementing large-scale restoration activities at seven areas within the FKNMS. Other jurisdictions within the CRCP's action area may support similar large-scale efforts in the future. As with the Mission:Iconic Reefs initiative in Florida, these efforts may be supported, authorized or carried out by NOS (ONMS, NCCOS, and/or the CRCP) and/or NMFS (OHC Restoration Center). Because of the scale of these types of restoration efforts, project-specific reviews will be required for any new large-scale restoration initiative and tiered ESA and EFH consultations are likely to be needed.

3.2.2.2 Other Coral Ecosystem Interventions

Propagation and Outplanting of Herbivores

Various herbivores are known to contribute naturally to coral health and survival, and may be used to support coral outplanting or transplanting efforts. As of 2021, the most is known about propagation and outplanting of various sea urchin species. There are two methods for collecting urchins to rear in captivity. The first method involves the collection of adult urchins by hand to keep in an *ex-situ* facility to coax them to spawn and release gametes into containers in a laboratory. These gametes are mixed together to produce zygotes, which develop into larvae that are kept suspended until their settlement stage. Urchins that settle are reared in a laboratory nursery setting until they reach a suitable size for outplanting. The second method involves the collection of juvenile urchins from the seafloor, or newly settled urchins using turf settlement plates. For turf settlement plates or collectors, mooring lines are temporarily attached to concrete anchor blocks placed in a sand channel or unconsolidated sediment in a coral reef site for up to 6 months. Turf settlement plates are artificial turf squares ranging from 8 × 8 cm (3 x 3 in) to 14 x 14 cm (6 x 6 in). The plates are attached along a vertical mooring line held taut with a buoy. Past CRCP work deployed 10 lines containing 20 turf settlement plates for one week every month for six months. The plates were collected monthly and brought to a laboratory for analysis. Settled urchins are picked off the plates, moved to a nursery culture tank, and grown to a certain size until outplanted on the reef. Midwater collectors with similar turfs that attract urchin larvae may also be used by mooring the collectors in sandy bottoms in the same manner as for vertical coral nursery structures, although the urchin collectors are smaller in size.

Divers outplant urchins either by placing them directly on the reef or by placing them in temporary corrals or cages made of galvanized chicken wire, nylon, or plastic mesh (Figure 27) that is typically one-in or less in diameter. The containment structure is attached to the bottom of the corral so that it can be molded to the reef and fully enclose the corals. The cages/corrals are held in place using PVC or rebar (hammered into unconsolidated sediment) placed around a portion of the reef or isolated coral colonies for about one month for urchin acclimation and to help facilitate herbivory. Urchin outplanting may be done in conjunction with coral outplanting.

Figure 27. Examples of urchin corrals: Diadema outplanting cage (left); chicken wire mesh around coral (right) (Photo credit: NOAA [left]; Coastal Survey Solutions LLC [right])

Other herbivorous species such as the Caribbean king crab (*Maguimithrax spinosissimus*) and other crab species may be collected and transplanted to other nearby reefs within a jurisdiction. Divers collect crabs (10-50 individuals) at night from hard bottom or rocky areas near outplanting sites. Within 24-48 hrs after collection, divers release the collected crabs on algae-dominated reefs. Similar to transplanted urchins, cages or corral structures may be used to ensure transplanted crabs remain on the target reef. While not yet as advanced as *ex situ* urchin culture, laboratory-based crab propagation and in-water rearing of juveniles are underway in certain jurisdictions (e.g., Florida) and are expected to contribute large numbers of herbivorous crabs to support coral restoration efforts in the coming years. Future activities could include placement of small habitat structures for herbivores in reef areas with high algal cover.

Any diving or snorkeling associated with herbivore propagation and outplanting coral will implement the required BMPs (Section 3.5.1), which include measures to avoid and minimize the potential effects on corals and other sessile species and on habitats, including designated critical habitat for ESA-listed corals and sea turtles and EFH.

Invasive and Nuisance Species Removal Control

To help restore the condition of coral reef ecosystems, management efforts have been implemented to remove invasive species such algae (e.g., *Kappaphycus alvarezii* and *Gracilaria Salicornia* in Hawaii), seagrass (e.g., *Halophila stipulacea* in the U.S. Caribbean), and fish (e.g., lionfish in the Atlantic and Caribbean).

In Hawaii, invasive algae such as *Kappaphycus alvarezii* and *Gracilaria salicornia* may be controlled by outplanting native urchins, or removed by hand or by using a suction pump (e.g., trash pumps connected to underwater vacuum hoses to manually remove the bulk of the algae from the reef). Removed algae is transported to a boat for sorting and disposal on land or used as fertilizer. Red mangroves (*Rhizophora mangle*) are invasive in Hawaii (Olinger et al. 2017; Allen 1998) and efforts are underway to remove them from wetlands. In Puerto Rico and USVI, the invasive seagrass, *Halophila stipulacea*, may be removed by hand or by using a suction pump that transports the seagrass to a boat for sorting and disposal on land. In Florida, Puerto Rico, and

USVI, lionfish are removed by divers using hand nets, slurp guns, spears (Figure 28), or traps. Captured lionfish are used in research, disposed of on land, or if the appropriate licenses are held, sold to fish markets.

Figure 28. Examples of divers removing invasive lionfish using spears (Photo source: Alex Fogg [left]; FGBNMS/Schmahl [right])

Natural resource managers may also remove nuisance species to restore species' balance and to reduce coral morality. For example, Guam removes a cryptogenic *Chaetomorpha* macroalgae by hand. In American Samoa, CNMI, and Guam, crown-of-thorns starfish, *Acanthaster planci,* infestations on coral reefs are controlled manually by injecting ox bile and bile derivatives, acetic acid (vinegar), sodium bisulfite, or physical removal. Ox bile is a natural substance that kills the organism, but does not cause disease spread to corals and other organisms on the reef (Rivera-Posada et al. 2014; Grand et al. 2014). For this method, divers inject the ox bile near the central disk of each starfish using an ox bile injector, a 46 cm (18 in) metal tube that houses a syringe with a needle and contains ox bile. Acetic acid is injected on the central disk of each starfish using a similar injector. The sodium bisulfite method requires multiple injections on the central disk of each starfish. After a crown-of-thorns starfish is injected and dies, it is left on the reef. If injectors are not available, the starfish can be physically removed from the water and transferred to land for disposal. Strategic and repeated manual control has proven effective in reducing overall *A. planci* densities and in skewing the population size structure towards smaller, less damaging individuals, and has allowed for recovery of hard coral cover (Westcott et al. 2020). Divers can remove other corallivores, such as the gastropods, *Coralliophila abbreviata* and *Drupella* spp., fireworms, damselfish, and butterflyfish by hand or with a bar, pick, tongs, prong spear, or hand net. Removed specimens are either brought back to a laboratory for analysis or disposed of on land. Additionally, other nuisance species such as macroalgae, zoanthids (e.g., *Palythoa* sp.) and octocorals in the Atlantic/Caribbean, may be removed by hand to prepare sites for coral restoration activities.

Any diving or snorkeling associated with invasive species removal and nuisance species control will implement the required BMPs (Section 3.5.1), which include measures to avoid and minimize the effects on corals and other sessile species and on habitats, including designated critical habitat for ESA-listed corals and sea turtles and EFH, and to reduce the risk of spreading coral diseases.

Coral Disease Control

While the exact causes of many coral diseases are not known, researchers have used a variety of management strategies to try to control coral diseases. These strategies include surgical removal of diseased tissue or entire diseased colonies; removal of the area between the diseased tissue and the healthy tissue; application of topical barriers such as clay or marine epoxy putty next to or directly over the diseased tissue (Figure 29) or in the break line made between the healthy and unhealthy tissue; aspiration of the diseased tissue with large syringes or pumps to remove cyanobacteria or other microorganisms; or a combination of these activities. Such management strategies are applied only to diseased colonies, which may be ESA- or non-ESA-listed corals, and not broadly to the entire coral reef. The average number of colonies treated in a given area could be quite variable, based on the extent of the disease spread (within a colony and within a larger reef area) and the resources available to treat individual colonies or affected portions of colonies. The greatest number of colonies treated for SCTLD in 2020 in Florida was 12,082 colonies with a 1-cm (0.39-in) wide treatment line on each colony. Since treatments began, only 14% of corals treated for SCTLD in Florida were ESA-listed species (https://coral-disease-myfwc.hub.arcgis.com/).

In extreme situations, healthy corals may be removed from the water and cared for at *ex-situ* facilities until the disease event has subsided or ended, to preserve genetic diversity, provide broodstock for restoration work once a disease outbreak subsides, and ensure that highly susceptible species are not locally extirpated by disease.

Figure 29. An example of using epoxy to form a break between healthy and diseased tissue to prevent further spread of the disease (Photo source: NOAA)

In addition to the physical treatments mentioned above, diseased coral may also be treated *in situ* with antibiotics (Figure 30), powdered chlorine, or probiotics. For example, ampicillin and paromomycin are known to arrest white band disease in corals (Sweet et al. 2014). In severe disease outbreaks, diseased corals could be treated with a white petroleum mixture or similar non-toxic compound (e.g., marine epoxy, clay, shea butter) mixed with an antibiotic. For example to treat SCTLD in Florida, Puerto Rico, and USVI, managers apply the broad spectrum antibiotic, amoxicillin, mixed with a Core Rx Base 2b, which is an acetoxy silicone base (16:1, 8:1, or 4:1) weight ratio of base to antibiotic powder), to affected coral colonies. Additional treatments may occur if the initial application is ineffective (Neely et al. 2019; Neely 2020; Walker et al. 2020). Diseased corals may also be treated with chlorine powder (calcium hypochlorite at about 15 ml/50 ml [0.5 oz/1.7 oz]; Neely 2018a). The amount of the treatment mixture applied to individual corals depends on coral size. Larger infected colonies may require up to five grams of antibiotic to treat the disease. SCTLD antibiotic treatments are estimated to cover between 1% and 5% of the colony. Treatments are conducted along the lesion boundary, including one cm (0.4 in) of healthy tissue. USVI SCTLD protocols indicate that corals 30 cm (12 in) and larger with greater than 50% of living tissue are prioritized for antibiotic treatment (Meiling et al. 2020). This means treated corals in the USVI currently range from 30 cm (12 in) to 1.3 m (4.3 ft) with corals under 30 cm (12 in) rarely treated. The USVI tagged some of the treated corals for monitoring. These corals may be retreated up to six or seven times, with the average retreatment being 2.5 times; non-monitored corals are estimated to be retreated two times. In Florida, the average diameter of treated colonies has been 110 cm (43 in). Treated corals were monitored, failed treatments were retreated, and touch-ups were conducted to treat new lesions on previously treated corals (Neely 2020). The average initial application rate of base/antibiotic treatment was 17.8 ml (0.6 oz) and retreatments used 7.9 ml (0.3 oz). Treatments varied by coral size and coral morphology (Neely 2020).

Figure 30. Example of antibiotic treatment: Upper: left to right- initial treatment of lesion May 6, 2019; initial recovery May 15, 2019; recovered coral Jan. 31, 2020. Lower: Antibiotic treated corals (Photo source: Brian Walker, Nova Southeastern University GIS & Spatial Ecology Lab)

Probiotic methods currently being tested to treat SCTLD in Florida include colony bagging (Figure 31) and alginate paste. The alginate paste is made up of sodium alginate and other non-toxic compounds designed to have a working consistency similar to honey, but polymerizes into a gel when in contact with seawater. The probiotics are developed by extracting and amplifying specific bacteria isolated from local coral colonies. In a laboratory setting, the targeted probiotic bacteria are grown/amplified in growth medium to a specific density (about 6.2×10^{10} colony-forming unit [CFU]/ml) then centrifuged and concentrated. The 12.5 ml (0.42 oz) of concentrated probiotic bacteria are mixed with 500 g (17.6 oz) of paste, which fills about six 50 ml (about 0.2 x 1.7 oz) syringes and is applied along the lesions on diseased corals. For *in situ* colony bagging, diseased corals are covered with a weighted plastic bag, and concentrated probiotics are pumped into the bag using a 50 ml (1.7 oz) syringe connected to a tube with a stop valve. The concentrated bacteria are suspended in sterile seawater, loaded into syringes, and injected into the bag surrounding the diseased colony. The current application rate is about 3×10^{12} bacterial cells/bag at a concentration of about 1.8×10^{11} CFU/ml. Once injected, bags are left on corals for about two hours prior to removal. Tests are being conducted to determine the optimal frequency for retreating.

Current protocols that are used to help mitigate potential adverse effects of the application of probiotic treatments *in situ* include: (1) the probiotics used in a specific jurisdiction are from that jurisdiction, which eliminates the possibility of introducing invasive species; (2) for any bacteria that might be used in the field, the genomes are sequenced and checked for any obvious genes or gene clusters that would be related to virulence; and (3) research is being done to identify what antibacterial compounds the bacteria are producing to ensure it is not some general toxin that could pose a threat to other organisms. In the future, probiotics may be applied by grafting healthy, probiotic-fed corals to a diseased colony or lacing food with probiotics for natural consumption.

Figure 31. Diver treating a coral with probiotics (Photo source: Brian Walker, Nova Southeastern University GIS & Spatial Ecology Lab)

Future anticipated activities may include the administration of additional antibiotics or other drugs *in situ* to address the causal agents of the coral disease once the new antibiotic/drugs have been tested in research laboratories for effectiveness. As with physical treatments, chemical/biological treatment strategies are applied only to diseased colonies and not broadly to the entire coral reef. Diseased and healthy coral specimens will continue to be collected as described in Section 3.2.2.15 in order to support laboratory research on the causative agents of disease outbreaks and treatment options.

Any diving or snorkeling associated the treatment of coral diseases will implement the required BMPs (Section 3.5.1), which include measures to avoid and minimize the effects on corals and other sessile species and on habitats, including designated critical habitat for ESA-listed corals and sea turtles and EFH, and related to reducing the spread of coral disease.

Coral Genomics, Stress Hardening, and Survival Analysis

ESA-listed and non-ESA-listed coral samples may be analyzed in the laboratory for genotype sequencing that includes DNA isolations and data preparation using standard and routine procedures to help understand the genetic makeup of resilient corals. This information can be used to support selective or managed breeding of corals by mixing gametes from different populations or individuals that have certain traits (e.g., heat or disease resistance) and by hybridizing species to select for certain traits expressed by corals that would then be grown in nurseries and outplanted, as long as any required permits are obtained.

Studies can be conducted in the laboratory or *in situ* to assess how corals respond to warmer waters, bleaching, pollution, and coral disease to analyze why or how some corals appear to be more resistant or resilient to stressors than others. Additional studies may assess symbionts, develop methods to manipulate symbionts, and test symbiont-manipulated corals. *In situ* activities may involve temporarily transferring or transplanting corals from areas of high stress (e.g., pollution, high temperatures) to less stressed areas, and *vice versa*, to determine how well corals survive or maintain resistance to stressors, or transplanting healthy corals from areas with fewer stressors to areas with more stressors to see if the corals acclimate and remain acclimated to stressors. Coral fragments/cores may be exposed to stressors using a mobile laboratory on a vessel or on shore, or be taken to a laboratory for study. Once the fragments/cores are exposed to warmer temperatures or other stressors, the cores/fragments can be preserved for molecular and genetic analysis, or temporarily placed back on the reef to study responses. Generally, these types of studies are small-scale pilot studies (e.g., testing a limited number, approximately 12-150 coral fragments/cores). If the fragments/cores are placed back on the reef, they are usually attached to small gridded crates or other small structures that hold 12-50 coral fragments/cores temporarily placed in sandy/rubble areas near reef sites using the anchor methods described in 3.2.1.2 for moored instruments. Resilient and resistant corals identified through these types of studies may be grown in nurseries and outplanted, as long as any required permits are obtained.

Coral gametes collected from wild corals or nursery-reared corals may be cross-fertilized with each other to create new genotypes that have a higher likelihood of being resistant to stressors. Settled larvae from genetically different parents, or microfragments of different genets can grow and fuse together in order to enhance resilience to stressors. These crossed or fused corals can be placed back onto the reef or used in laboratory-based studies.

Foreign-sourced genotypes of native U.S. coral species may be outplanted as part of small pilot studies to assess their resilience to stressors (e.g., temperature or nutrients) in a natural setting over time or they may be used in larger scale coral reef restoration efforts to support population enhancement and species recovery. Colonies of genetically crossed or fused corals obtained from foreign sources are kept *ex situ* in a closed system for approximately one to two years in order to prevent the release of any invasive species and transfer of coral diseases. Fragments from foreign-sourced corals may also be directly outplanted after an extended period in quarantine and risk analysis has been completed. *Acropora palmata* and *Dendrogyra cylindrus* in Florida are the only two coral species that are currently being considered for genotypic enhancement using corals from the Bahamas and/or Mexico.

To help understand resistance to coral diseases, diseases can be transferred to healthy fragments by grafting (cable tying) a small piece of diseased tissue to the healthy tissues of coral colonies (Williams and Miller 2005; Vollmer and Kline 2008; Brandt et al. 2013). This can be done *in situ* or *ex situ*. *In situ* grafting of coral diseases is conducted using fragments either from nurseries or wild-collected corals that are kept on a separate nursery line/tree/table, or on a temporary moored structure. In *ex situ* situations, diseases can also be transferred using filtered homogenates (Kline and Vollmer 2011), or via other means such as through water exchange or direct tissue contact.

All diving or snorkeling associated with the other coral interventions described in this section will implement the required BMPs (Section 3.3.1), which include measures to avoid and minimize the effects on corals and other sessile species and on habitats, including designated critical habitat for ESA-listed corals and sea turtles and EFH, and the coral fragmentation collection BMPs to reduce impacts on individual coral colonies and habitat.

Potential Future Coral Intervention Activities

Future work to assist with the restoration of coral reefs may include outplanting of corals, possibly ESA-listed species or non-ESA-listed species, with modified symbionts, movement of additional coral species to non-native areas to enhance diversity (assisted migration), shading of corals/coral reefs, water cooling, and other methods to treat diseases. Presently, there is not enough information to describe the methods that would be used to conduct these activities. Therefore, should CRCP consider implementing small scale pilot studies or other projects using these types of interventions in the future, project-specific reviews would be required for each of the studies/projects and tiered ESA and EFH consultations may be required.

3.2.3 **Watershed Management and Restoration**

CRCP, working with the local jurisdictions, identifies priority watersheds in which to conduct watershed planning, management, and restoration activities targeting things like stormwater and erosion control. Within priority watersheds, activities may take place in the mid- and upper parts of the watershed or closer to the shoreline to address areas identified as land-based sources of pollutants. Most of CRCP's watershed restoration activities are conducted in areas ranging in size from under 0.04 km^2 (1 acre), or 0.8 km (0.5 mi), but some projects may be larger up to 24 km^2 (6,000 acres), or 16 km (10 mi). CRCP implements watershed management and restoration activities with the expectation that these activities will improve nearshore water quality in the long-term by reducing land-based pollutant transport. During the construction associated with some management and restoration measures, there may be temporary release of sediment or other short-term effects on nearshore resources. To reduce the chance of short-term adverse effects to nearshore marine resources, all of the watershed activities described in this section will include the required BMPs (Section 3.5.1).

3.2.3.1 Technical Support for Watershed Management Plans

The CRCP provides technical assistance toward the development and implementation of watershed management plans (WMPs) and/or conservation action plans (CAPs) in watersheds identified as priority areas by the jurisdictions. The primary purpose of a WMP or CAP is to outline a comprehensive set of actions and an overall management strategy for improving and protecting the watershed from nonpoint and point sources of pollution associated with changes in land use, and residential, commercial, industrial, and agricultural activities. A WMP or CAP identifies a set of key recommendations, specific partners, and next steps toward implementation of land-based pollution control strategies. WMP/CAP recommendations typically include BMPs and/or management and restoration activities that target reductions in transport and concentrations of sediment, nutrients, and other contaminants within watersheds. Examples include revegetation and stabilization of land, streambanks, and dirt-roads/trails; changes in stormwater and wastewater treatment practices; and improvements to site design practices. Implementation of BMPs and management activities are essential to maintaining hydrologic functions, including streamflow and groundwater recharge to limit land-based sources of pollution inputs and impacts to nearshore marine environments, particularly coral reef ecosystems.

The CRCP supports data collection for a WMP or CAP development. Terrestrial-based field assessments are conducted in a watershed to identify areas of concern that contribute to land-based sources of pollution. Areas of concern can include places where there is stormwater drainage, including unpaved roads, impervious surfaces, and conveyances; septic systems; point sources of pollution (including commercial, industrial, and municipal); and streams/ghuts (name for watercourses in USVI), detention areas, and wetlands. Activities involved in terrestrial-based field assessments include the collection of sediment and water samples, and walking through wetlands and along streams and shorelines to look for potential problem/erosion areas and ground truth remote sensing data, identify permanent and intermittent streams, and release tracer dyes to locate point-source pollution hotspots. Tracer dyes, such as fluorescein and rhodamine, are released at a known point and monitored for discharge at another known point. Tracer dyes are concentrated at the injection site and become diluted as they move through the system, which lowers the risk of effective exposure time for organisms in the waterbodies where tracers are released. Data generated from remote sensing are used to determine land use, land cover, benthic habitats, and turbidity. Additionally WMP or CAP data may include *in situ* monitoring of nearshore reefs. Nearshore reef *in situ* monitoring collects data on water quality, sedimentation rates, and assessments of benthic habitats, fish, and invertebrates using methods described in Section 3.2.1.

3.2.3.2 Erosion Control

Vegetative Plantings

Bare soil is stabilized through the establishment of vegetative cover (Figure 32). On highly erodible sites, grass seeds, mulch, fertilizer, and water can be combined and sprayed onto the hillside as hydroseed for quick and effective erosion control. While various plants can be used to revegetate bare soils, the CRCP uses native or non-weedy/noninvasive plants (e.g., vetiver grass) for this purpose. Plantings may also be used with existing or dormant crops as conservation cover (e.g., shade-grown coffee). When plantings necessitate fertilizer, efforts are taken to minimize potential leaching of nutrients to waterbodies by adhering to minimum application rates, understanding near-term climate predictions to prevent storm conveyance of nutrients, and assuring a sufficient buffer between fertilizer application points and any nearby waterbody.

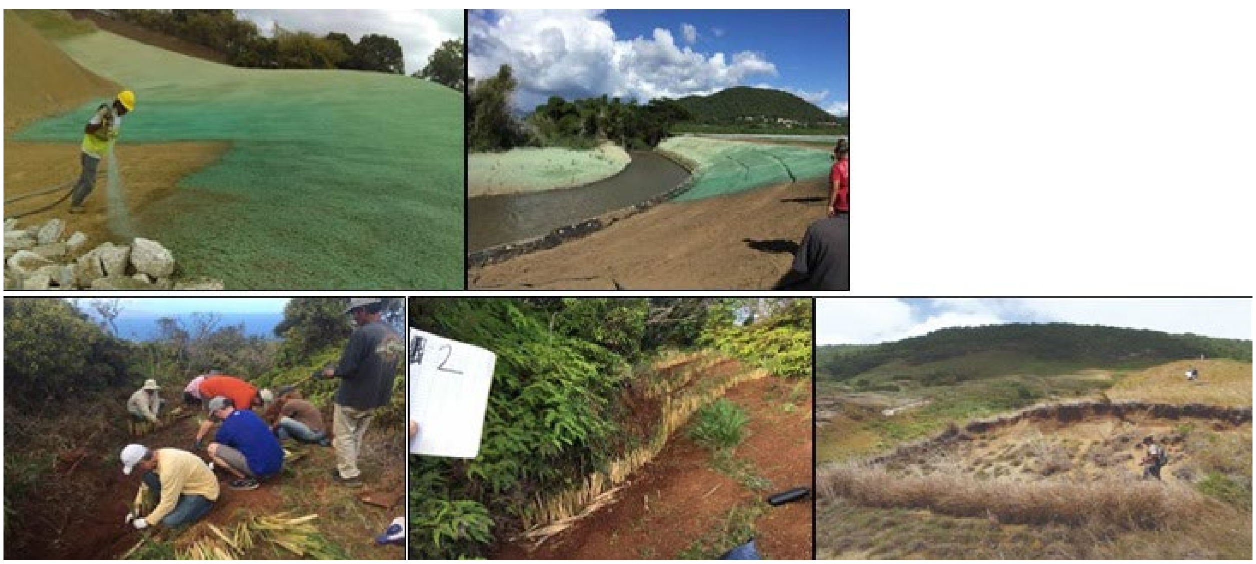

Figure 32. Upper: Hillside hydroseeding. Lower: Erosion control using vetiver grass (Photo source: Protectores de Cuencas [upper row]; West Maui Ridge to Reef [lower left and middle]; NOAA [lower right])

Unpaved Road/Trail Stabilization

Unpaved roads and trails can be significant sources of erosion and sedimentation. Two erosion-control measures used to direct runoff from unpaved roads before it can erode the roadway through the formation of gullies and channels are the construction of broad-based dips at the lowest point where the road grade curves, and water bars, which are small ditches constructed at low points (Figure 33). Designs incorporating these or similar elements allow runoff to be directed along various portions of the road to low points that are then sloped to the downstream side of the road, where a stabilized outlet receives the flow and directs it downstream. Additionally, roads can be paved (Figure 34) to prevent further erosion and sedimentation.

Figure 33. Dirt road stabilization in Puerto Rico (Photo source: Protectores de Cuencas)

Streambank or Ghut Stabilization

Streambank stabilization is defined as the stabilization of an eroding streambank using “soft” or “hard” engineering practices or a “hybrid” mixture of these two practices. “Soft” engineering practices include a nature-based approach using natural materials like coconut (coir) fiber mats, grasses, and various shrubs and trees to reduce slope erosion and stabilize slopes with planted vegetation with a root structure that will retain soil. “Hard” stabilization practices include the installation of turf reinforcement matting, riprap or other rock, and gabions to reduce velocities of storm flows and stabilize erosive streambanks. The use of “hard” engineering techniques is not considered a restoration or enhancement strategy, but may be necessary in certain locations where erosion threatens adjacent properties and the probability of success using soft engineering practices is low. Other sections along the channel banks can be treated with bioengineering and soft engineering practices, which can be expected to reduce bank erosion, increase site aesthetics, enhance in-stream habitat, and be less costly compared to construction of hardened structures.

Turf reinforcement mats are made of synthetic fabric and are used to line bare soil areas along channel banks to protect the channel bed and bank from erosion. These mats may also be used in areas with bare soils. They provide a long-term solution for erosion control and maintain intimate contact with the subgrade, resulting in rapid seedling emergence and minimal soil loss. Turf mats allow water to infiltrate into the substrate and provide for hydraulic connectivity to groundwater. Turf mats are made of non-biodegradable fabric to ensure long-term stabilization of soils.

Riprap is angular rock used for stabilizing steep slopes on which a healthy stand of vegetation cannot be established, or within channels that would otherwise be susceptible to erosion from rainfall and concentrated runoff. The size of the rock used is based on the expected shear stress induced by flowing water. Depending on the site conditions (e.g., water flow or velocity), rocks may be reinforced or held together with rebar and mortar or placed in wire baskets (gabions).

Non-reinforced riprap structures are usually anchored into the ground to increase their resistance to movement. A geotextile fabric is typically installed prior to riprap placement to prevent undermining of soils, and different sizes of rock are installed under and within the larger boulders to further stabilize the riprap.

Figure 34. Example of road stabilization, including retaining wall (right) in USVI (Photo source: Coral Bay Community Countil)

3.2.3.3 Protection of Ecologically Sensitive Vegetative Areas

Measures to reduce impacts to sensitive vegetated areas include the installation of treated wooden posts or other markers to identify sensitive areas and provide public access while limiting trampling and other effects to habitats (Figure 35). Treated posts or boulders can also be used to prevent vehicular access to sensitive habitats. Posts are generally installed by digging holes about a 0.46 m (1.5 ft) deep and securing the post with cement. Raised boardwalks may be built using treated wood anchored on piles to allow public access through sensitive habitats.

Figure 35. Examples of elevated boardwalks and delimitation of sensitive vegetation areas while allowing public access to beaches (Photo source: Protectores de Cuencas)

Fencing

Fencing is installed to prevent livestock (e.g., cattle or horses) or feral animals from accessing a stream or other sensitive area. The goal is to reduce erosion caused by trampling as well as abate nutrient or bacteria input.

3.2.3.4 Stormwater and Wastewater Management

Stormwater runoff is a significant source of sporadic, erosive flows leading to erosion and sediment transport downstream. Stormwater BMPs are designed to reduce the velocity of stormwater flows and trap and remove sediments and other contaminants that may be transported in the stormwater. There are several types of BMPs for these purposes for treating various size drainage areas. The implementation of these BMPs is site specific. BMPs include bioretention cells, baffle boxes, culvert repair or replacement, curb inlet grate filters, grass swales, and stormwater or sediment basins. Constructed wetlands may be installed to manage stormwater but are also used to treat wastewater.

Low-Impact Development

Low-impact development in watershed restoration refers to practices that use or mimic natural processes in order to protect water quality and associated aquatic habitat. Low-impact development strategies integrate the use of site planning and stormwater management to promote the infiltration and retention of stormwater and associated pollutants at their source (Figure 36). The overall goal of low-impact development is to maintain a site's pre-development hydrologic condition to the greatest degree practicable. The stormwater BMPs associated with low-impact development, subsequently referred to as low-impact development practices, utilize natural processes (e.g., infiltration, temporary detention, and groundwater recharge) to disperse stormwater throughout the site and retain stormwater volume and associated pollutants on-site, rather than conveying stormwater and associated pollutants directly to receiving waters. In general, low-impact development practices focus on reducing impervious cover (e.g., using pervious pavers or pervious concrete), retaining stormwater (e.g., cisterns or rain barrels), and/or slowing the velocity of stormwater runoff to allow for stormwater infiltration and retention of pollutants on-site (e.g., bioretention swales, vegetated buffers, green roofs, and infiltration wells/trenches).

Figure 36. Examples of low impact development practices and permeable parking areas that allow for filtration of rain/run off (Photo source: Protectores de Cuencas)

Bioretention Cell (Rain Garden)

A bioretention cell, or a rain garden (Figure 37), is a low-impact development measure placed along the flow path of runoff to reduce runoff volume and peak flow and to capture and treat stormwater containing pollutants in order to reduce pollutant loading to natural waterbodies. Bioretention cells help break up large impervious surfaces (e.g., shopping plazas, industrial areas, and roadways).

A bioretention cell is composed of a shallow depression excavated and backfilled with media used to promote infiltration and supporting plants that both physically trap and bioremediate pollutants (e.g., heavy metals and nutrients). This system detains the volume of stormwater runoff known as the “first flush,” which is the initial surface runoff over impervious or semi-impervious areas during a rain event. The “first flush” portion of rainfall typically contains the highest concentration of pollutants and is treated within the bioretention cell through natural chemical processes that include plant root uptake and soil retention. Bioretention cells have soft design features incorporating vegetative areas and can be installed alone or as part of a series of stormwater management measures.

Figure 37. Bioretention area installation (left) and a rain garden (right) constructed in West Maui (Photo source: West Maui Ridge to Reefs)

Baffle Box

A baffle box is a multi-chambered concrete box that contains a series of sediment settling chambers separated by baffles. The baffle box is tied into an existing stormwater drainage system, or at a drainage outfall, to decrease stormwater velocities to allow settling of sediment, suspended particles, and associated pollutants in the boxes. Baffle boxes can also be outfitted with trash screens to capture trash and debris, or can be outfitted with absorbent membranes to trap floating pollutants (e.g., hydrocarbons) to further minimize transport of contaminants to waterbodies.

Culvert Repair or Replacement

Undersized or collapsed culverts can impede natural flows and concentrate flows, which may increase flow velocity, flooding, and channel bank erosion. Standard culverts can be removed, repaired, or replaced with structures such as bottomless culverts to increase the area of flow and decrease the velocity of flow resulting in decreased channel bank erosion and sediment transport to downstream habitats.

Curb/Grate Inlet Basket

Curb or grate inlet baskets are manufactured frames that can be fitted with filters or fabric and placed in a curb opening to prevent trash, sediment, or debris from entering stormwater systems. Baskets trap items larger than sediment and can remove large quantities of hydrocarbons, including oils and grease, when fitted with an optional absorbent polymer.

Swale

A grass swale is a shallow excavation, constructed on a gradually sloped grade, lined with grass and constructed along a waterway or roadway. The vegetated conveyance channel slows stormwater flows, temporarily impounds a portion of the flow, filters a portion of the pollutants contained in stormwater flow, settles out sediment, encourages infiltration into the underlying soils, and reduces the potential for bank erosion by slowing the velocity of runoff velocity entering a channel. Grass swales can be installed when runoff needs to be conveyed to a natural drainage channel from another stormwater treatment structure or from a land area that has incorporated preventative treatment measures. Grass swales can be especially effective when constructed at grades approaching level because they slow water flow to the maximum extent possible while still maintaining a positive grade. Ponding may occur in swales, which will aid in additional settling and treatment of stormwater runoff.

Stormwater Ponds or Sediment Basins

Stormwater ponds or sediment basins (Figure 38) are stormwater drainage features designed to retain stormwater, reduce flow velocities, and retain sediment. The ponds or basins can be designed to store a permanent or intermittent pool of water, based on the design of the outlet. The outlets can be designed as a pipe or an overflow structure, or they can link into another stormwater BMP like a constructed wetland. The design of the pond or basin is site-specific and dependent on the intended purpose and the size of the drainage area.

Figure 38. An example of sediment pond construction in Puerto Rico (Photo source: Protectores de Cuencas)

Check Dams

Erosion from runoff forming small rills or gullies in the upper reaches of watersheds may be slowed with the use of check dams or fiber rolls. Check dams are small structures that slow the flow of water through small erosive features. Check dams and fiber rolls are often made of stone or other natural materials (e.g., wattles, dead branches, or coconut fiber). These are designed to slow the velocity of water and reduce runoff to downslope areas.

Fiber Mats and Rolls or Filter Socks

Bare soils may be stabilized with fiber mats made of natural materials like woven jute or coconut (coir) fiber mats (Figure 39). These mats are a good option for soils disturbed by wildfire or construction. The mats temporarily hold soil in place until vegetation can take root. They allow water to percolate and can provide a stable foundation for native plant growth, or be sown with seed. These mats can also be rolled and secured with short wooden stakes to create a barrier to slow overland flow on bare soils. In some cases, a filter sock filled with mulch, compost, or other filter material, can be used in a similar fashion.

Figure 39. Example of fiber in roll (foreground) in Guam (Photo source: Val Brown)

3.2.3.5 Constructed Wetland

A constructed wetland (Figure 40) is an artificial wetland that may be a marsh, mangrove area, or swamp created for pollutant retention and removal. The artificial wetlands can be constructed within coastal and upland areas. If the construction is sited within an existing wetland, authorization is required from the U.S. Army Corps of Engineers and other permits and authorizations may also be necessary depending on the jurisdiction and the type of project. Constructed wetlands have characteristics similar to natural wetlands and use the same natural processes (e.g., microbial activity) to remove pollutants from stormwater, wastewater, or sewage effluent, and also filter sediments. Constructed wetlands are engineered to manage stormwater flows resulting from storms with various levels of rainfall, incorporate structures such as outfall controls, and use plantings of native vegetative to stabilize the leading edge of the wetland. Constructed wetlands are ultimately designed to restore and maintain ecological function and may provide habitat for native and migratory wildlife.

Figure 40. Examples of wetland construction (left) and completion (right) (Photo source: West Maui Ridge to Reef [upper row]; Protectores de Cuencas [lower row])

3.2.3.6 Removal of Terrestrial Invasive or Nuisance Species

In some situations, invasive or nuisance species, such as bamboo (*Bambusa vulgaris*) on Guam, and feral goats and hogs, may impair watershed health and native habitat restoration. In such cases, invasive or nuisance species may be removed using appropriate methods (e.g., humane capture and relocation, trained herding animals, and culling of herds), as well as BMPs for stormwater control during removal activities and appropriate native vegetation for subsequent plantings. If used, pesticides are applied in mid and upper-watershed areas and would be limited to the minimum amount necessary to control the problem species. Projects that use herbicides generally have a treatment area less than an acre. For example, bamboo removal on Guam uses a cut stump method where bamboo stems are cut low to the ground and then spot treated with Roundup® (glyphosate), with additional retreatment on areas of new growth every few weeks. Glyphosate binds tightly to soil and has a low toxicity to fish and wildlife (Henderson et al. 2010). The application of Roundup® is considered resource intensive due to the personnel time required for application, monitoring, and reapplication and is not widely applied as part of projects on Guam. Past projects used Roundup® in areas of approximately 10 ft (3 m) by 20 ft (6 m) at a time. Other non-herbicide treatments to remove invasive plants may include pulling or digging up; grinding of tree stumps; or drilling holes, adding Epsom salt to holes, and covering with plastic.

3.2.4 **Reduction of Physical Impacts to Coral Reef Ecosystem**

The CRCP activities to reduce physical impacts to coral reef ecosystems as a result of human activities include the installation of buoys for mooring of recreational vessels and to serve as markers, and removal of debris from coastal and marine habitats.

3.2.4.1 Buoy Installation

For the installation of buoys and their anchor systems, a vessel is necessary to access the area and serve as a work platform. Two diving teams usually perform buoy installation. Each diving team consists of a pair of divers. Dive teams also assist in ensuring the vessel is anchored over the working site in an area and manner that does not result in adverse effects to marine habitat. A support team in charge of boating safety, equipment, and material handling is also present on the vessel. The installation of each anchoring system may take between 35 and 45 mins, depending on the depth and the type of substrate and system to be installed. If needed, hydraulic tools are lowered from the vessel to divers on the sea bottom. Lift bags may be used to ease and control both the descent and ascent of the tools as they are lowered from the vessel to avoid dragging them on the seafloor.

All diving or snorkeling associated with installing buoys will implement the required BMPs (Section 3.5.1) that include measures to avoid and minimize the effects on corals and other sessile species and on habitats, including designated critical habitat for ESA-listed corals and sea turtles and EFH.

Recreational Boat/Day Moorings

Anchor damage is a common disturbance to coral reefs and seagrass beds (Davis 1977; Jameson et al. 1999; Rogers et al. 1988), and permanent boat mooring systems are a widely accepted means to lessen the harmful effects of recreational boat anchoring and aid in coral ecosystem conservation (Halas 1985;1997; Rogers et al. 1988). All mooring buoy systems consist of the following three elements: an anchor on the sea bottom, a buoy floating on the water surface, and a line connecting the two (Figure 41). CRCP only funds projects for the installation of recreational mooring buoy and storm mooring buoys that use embedment anchors, which are embedded into either solid bedrock or soft substrate and held in place by the weight of the sand, rubble, or hard substrate. CRCP may also provide funding for maintenance of installed buoys. In 2018 and 2019, for example, CRCP provided funding to Florida for the installation of 208 recreational mooring buoys and subsequent maintenance.

Figure 41. A boater secures the buoy mooring line to anchor his vessel (Photo source: NOAA)

A common mooring buoy anchor system used in hard bottom habitat is the Halas system (Halas 1985;1997). The system consists of a stainless steel eye bolt cemented into a small drill hole measuring 5 cm diameter x 60.9 cm deep (2 in diameter x 24 in deep). The hole for the eyebolt is typically drilled in flat, solid, uncolonized bedrock using an underwater hydraulic drill. The hole is located away from branching coral formations that could catch or abrade the slack down line or damaged by its movement. Installation takes about 35 mins with 30 mins to drill the hole and approximately another five mins to set the steel rod with previously mixed hydraulic cement or marine epoxy. Installation of this anchor system does not suspend significant amounts of sediment or destroy living coral colonies.

A floating line is shackled to the eyebolt and extends to the surface. The line is passed through a polyethylene buoy to a pickup line. The pickup line floats and the surface and has a loop for a boater to tie a line from a vessel to attached to a boat and moor to the buoy. The Halas system eliminates the need for the heavy chain used for conventional mooring systems, which can often damage the surrounding sea bottom (Project AWARE & PADI International Resort Association 1996).

Embedment anchors suitable for vegetated and unvegetated soft bottoms include systems such as the Manta Ray® and the Helix anchors (Project AWARE & PADI International Resort Association 1996). The Manta Ray® anchor system consists of a utility anchor attached to an eight-foot anchor rod that is hammered under the soft bottom using a hydraulic underwater jackhammer and gad (Figure 42). The anchor is set using a load locker or by tying a line from the anchor to a workboat and driving the boat either forward or in reverse to apply pressure along the line and cause the anchor to open. A thimble eye at the upper end of the anchor rod is used for the attachment of the floating line, which extends to the surface through a buoy to a pick up line. Installation of a Manta Ray® System produces only minimal short-term impacts in the form of a small sediment plume during drilling. Installation time varies with sea bottom characteristics, but an anchor usually can be installed in less than 30 mins.

Figure 42. A diver installs a mooring buoy anchor system on the seafloor (Photo source: NOAA)

Screw-type mooring anchors such as the Helix system, which has a circular disk or disks (disk dimensions: 10-25.4 cm [4-10 in] on a shaft 1.9-3.2 cm [0.75-1.25 in] x 114-168 cm [45-66 in]), are installed in the seabed by screwing the shaft into the bottom by hand and divers may use a steel rod to help turn the anchor. The termination end or exposed end of the shaft has an eyebolt to which a floating line is attached, which extends to the surface through a polyethylene buoy to a pickup line.

Storm Moorings

Designated mooring fields with storm moorings are used to secure watercraft during storms. Mooring fields for storm moorings consist of open link mooring chain laid out in parallel rows and secured to the seabed with hydraulically installed helical embedment anchors. Installation of embedment anchors is done using the same methods described above. Individual mooring lines are attached to the ground chain between the installed helical embedment anchors, thereby spreading the load between the anchors. Marker buoys delineate where fore and aft secure shackle attachment points are connected to the ground chains in order for each boat to attach its individual down lines when mooring. The size of the storm mooring field is based on sizes of boats, chain length, and boat swing radius to allow sufficient room between boats and clear passageways for transiting boats. Storm mooring fields are typically located in sheltered coastal embayments.

Marker Buoys

Marker buoys are used to designate particular areas for use/nonuse by recreational boats and personal watercraft, swimmers, divers and snorkelers; to demarcate boundaries of preservation areas and designated use zones in protected areas; and to identify shallow seagrass and reef areas, among other things. Markers typically consist of a floating buoy or cylindrical floating pipe that may have an informational message and are secured in a fashion similar to that used for mooring buoys based on the substrate (Figure 43). Where possible, marker buoys generally use round shaft anchors or weighted anchors. Weighted anchors include anchors weighing 100-kg (220-lb) and measuring 56 cm x 33 cm x 6 cm (22 in x 13in x. 3.5 in) and a 91-kg (200-lb) pyramid anchor measuring 61 cm x 36 cm x 36 (24 in x 14 in x 14 in). Anchors for marker buoys are placed in sand to avoid the expense and complication of drilling in bedrock or hard bottom. Other types of markers may also be installed, such as the four range markers funded by CRCP in 2021 in Guam consisting of posts installed in a reef flat in water depths less than 1 m (3.3 ft) using drilling to a depth of 8 to 12.7 cm (3-5 in) and cementing of the anchor.

Figure 43. Examples of marker buoys: left - yellow marker buoys denote zones with special regulations in the FKNMS; right – informational spar buoys for Wildlife Management Areas and sites on the Shipwreck Trail in the FKNMS (Photo source: NOAA)

3.2.4.2 Debris Removal

As for buoy installation, in-water marine debris removal efforts may require the use of a vessel to access the work area and serve as a work platform. Dive teams assist in ensuring the vessel is anchored over the working site in an area and manner that does not impact marine habitat. A support team in charge of boating safety, equipment, and material handling will present on the vessel. Lift bags are used to ease and control the ascent of any large or heavy debris to avoid dragging items along the seafloor. Any diving or snorkeling associated with in-water marine debris removal will implement the required BMPs (Section 3.5.1) that include measures to avoid and minimize the effects on habitats, including EFH, corals and other sessile species.

Debris removal projects include coastal/beach cleanups and in-water removal of debris (e.g., plastics, glass, metal and rubber, and derelict fishing gear). The purpose of debris removal is to eliminate immediate physical, biological, or chemical threats to living coastal and marine resources and their habitats. SCUBA divers and snorkelers will be trained on how to safely remove debris and minimize interactions with ESA-listed species, their critical habitat and EFH. For in-water removal of debris that is caught or entangled on coral, SCUBA divers or snorkelers employ methods to reduce further negative impacts to coral (i.e., cutting nets and fishing lines instead of pulling on the objects and breaking coral).

3.2.5 **Outreach/Education, Data Analysis, and Program Operations**

3.2.5.1 Outreach and Education

Outreach and education activities include the installation of signs on land and in the water, and hands-on educational activities in the field, which may include in-water and watershed activities.

Signage

Informational and educational signs are placed in strategic locations with important conservation and preservation messages to educate the public. Land-based educational signs are placed near streams, in coastal areas at sites determined to be highly visible by the public. Signboards are firmly fastened to a metal post or wood pole, which is secured in concrete in the ground or driven with a hammer into soil. In-water educational signs (Figure 44) are installed in areas where they provide educational information or mark areas such as underwater educational trails. Underwater signs may consist of signs posted on stone markers installed on the seafloor that may or may not include a floating buoy for easy identification, or floating educational buoys with educational information. The stone markers are placed on the seafloor and are held in place using stainless steel pins. In-water signs are periodically cleaned by hand by divers using plastic brushes. Anchor systems for educational buoys are installed using the methods described in Section 3.2.4.1 above. Vessels and SCUBA divers are necessary for the installation and maintenance of in-water signage. Lift bags may be used to ease and control the descent/ascent of any large or heavy items such as stone markers. If work vessels anchor, the dive teams assist in ensuring the vessel is anchored in a way that minimizes effects to marine habitat.

Figure 44. A diver maintains an underwater stone marker trail sign at Buck Island National Monument, USVI (photo source: National Park Service)

Hands-on Educational Activities

Some outreach activities involve bringing stakeholders into the field to experience and learn about coral reef resources firsthand. These activities include training citizens to conduct biological assessments (e.g., fish and/or coral identification and measurements) or participate in on-the ground restoration activities. Training includes not only the techniques needed to conduct the work and minimize impacts to corals and habitats, but also considerations regarding health and safety precautions needed to conduct the various activities (Figure 45). In-water activities may involve diving/snorkeling from the shoreline or a boat, or kayaking along the coastline. Inexperienced snorkelers and swimmers are required to wear a flotation device. All divers participating in an activity must be certified for diving, have had proper training in diving, and be capable of exhibiting responsible dive practices (e.g., proper buoyancy). Land-based restoration activities may include walking in or near vegetated areas adjacent to the coastline and/or along beaches.

Figure 45. Example of an educational event in the Manell-Geus watershed in Guam: left - pre-snorkel orientation; right - snorkeling on reef (photo source: NOAA, Valerie Brown)

Additionally, all diving or snorkeling associated with hands-on outreach and education activities will implement the required BMPs (Section 3.5.1) that include measures to avoid and minimize the effects on corals and other sessile species and on habitats, including designated critical habitat for ESA-listed corals and sea turtles and EFH.

3.2.5.2 Data Analysis and Modeling

Computer-based analysis of data collected through mapping, monitoring, and research, or of data collected by other agencies or scientists is done as part of CRCP activities. The data can be used to create a variety of models to help improve management and guide the implementation of projects. While data analysis and modeling are part of the CRCP's action, this activity will have no effect on EFH and ESA resources and is not discussed further in this opinion.

3.2.5.3 Program and Interagency Coordination, Management, and Operations

The CRCP oversees U.S. coordination efforts through the USCRTF by serving as its co-chair and steering committee secretariat. The CRCP reviews plans, policies, and regulations related to coral reef conservation and management; supports meetings; manages CRCP data, including data sharing and public access[6]; implements and manages external funding opportunities; and supports program staff and travel to implement the program activities and coordination. The CRCP also provides support for international conferences such as the International Coral Reef Symposium. While program and interagency coordination and management is part of the CRCP's action, this activity will have no effect on EFH and ESA resources and is not discussed further in this opinion.

Vessel Operations

To support its mapping, monitoring, research, and restoration activities, the CRCP uses or supports the use of NOAA ships, charter boats, and small vessels. All vessels chartered by NOAA meet applicable international, federal, state, and local pollution control laws and

[6] See NOAA's policy: https://nosc.noaa.gov/EDMC/PD.all.php

regulations. Vessels are outfitted and operated in accordance with applicable U.S. Coast Guard (USCG), International Maritime Organization regulations, and all other required regulations.

Twice a year, the CRCP supports activities conducted using NOAA research vessels. Generally, the CRCP uses the *R/V Nancy Foster* in the U.S. Caribbean and one of the NOAA research vessels (size varies based on available vessel) in the U.S. Pacific Islands. The work on the *R/V Nancy Foster* (57 m [187 ft] in length) in the U.S. Caribbean supports yearly EFH mapping (i.e., echosounder mapping) and benthic assessments (ground truthing mapped areas with ROVs) in the waters around Puerto Rico and/or the USVI. Occasionally, the CRCP may support research, monitoring, and/or mapping activities off the coast of Florida and in the Gulf of Mexico on the *R/V Pisces* (63 m [208 ft] in length).

The NOAA research vessel (to be determined) in the Pacific supports the NCRMP, which rotates every three years among the American Samoa Reef Assessment and Monitoring Program, the Mariana Islands Coral Reef Monitoring Program, and the MHI Reef Assessment and Monitoring Program. The American Samoa and Mariana Islands cruises are typically two to three months long, generally from May to August, and start and end at port in Oahu, Hawaii. As part of the American Samoa cruise, the NOAA vessel stops near Palmyra, Kingman, Jarvis, Baker, and Howland Islands, and the Mariana Islands cruise stops at Wake Atoll and Johnston Atoll. The Hawaiian Islands monitoring cruises are completed in four legs usually taking place between June to August. Three legs are in the MHI and a fourth leg is in the NWHI. Typically, each leg of the Hawaiian cruises lasts about two to three weeks with the entire field season spanning about 12 weeks. For all of the Pacific Islands monitoring and assessment cruises, the NOAA vessels launch small (3-8 m [10-25 ft] long) soft hull boats so that teams of divers can conduct diver-based biological assessment activities, deploy instruments, and/or conduct instrument maintenance within shallow reef areas.

In all U.S. coral jurisdictions, the CRCP supports the use of small (3-8 m [10-25 ft] long), medium (charter vessels less than 24 m [80 ft] in length or less), and occasionally charter vessels larger than 27 m (88 ft) long by internal NOAA staff/contractors and external grantees/cooperative agreement staff/contractors. These vessels are used to conduct research activities, monitoring, coral restoration activities, activities to reduce physical impacts, and educational trips. The vast majority of the CRCP-supported work requiring the use of vessels between 2018 and 2021 employed small vessels, and the number of field days to conduct in-water project activities with vessels ranged from one day to 80 days/year. When on site, captains would 'live boat' (no anchoring, vessel is maintained on site by captain), use mooring buoys, or anchor in soft sediment or sand. When anchoring, the anchor site is usually verified visually prior to anchor deployment and/or the anchor is placed on the bottom by a diver.

The Atlantic/Caribbean NCRMP activities use one to six chartered vessels (about 20-24 m [65-80 ft] in length) from which teams of divers conduct the monitoring activities. In the USVI, the monitoring effort is usually conducted for two weeks in July for St. Thomas and St. John, and two weeks in August for St. Croix. In Puerto Rico, dive teams conduct monitoring activities on an ad-hoc basis, generally between July-December. In Florida, dive teams conduct monitoring activities by chartering five to six trips between May and December.

All vessels used during in-water activities described in the sections above will implement the required BMPs (Section 3.5.1) to minimize or avoid impacts of moving vessels on ESA-listed species and to reduce physical impacts of mooring vessels on habitat, including designated critical habitat for sea turtles and corals and EFH.

For the CRCP activities (monitoring and mapping) requiring the use of NOAA research vessels, this opinion evaluates the effects of vessel operation associated with CRCP activities at the project site and not while the ships are in transit. General operation and transits by NOAA research vessels are covered under separate completed and on-going consultations with NOAA Office of Ocean Exploration and Research, OAR, and NOS (OPR-2021-02543).

3.2.6 **CRCP Optional Best Management Practices**

CRCP has developed optional BMPs that may be implemented by those conducting CRCP-sponsored work. While these optional measures can serve to avoid and minimize effects to ESA-listed species, designated and proposed critical habitat, and EFH if CRCP projects implement some or all of these measures, they are not conservation measures that are part of the proposed action. Therefore, their effect cannot be evaluated in this opinion as conservation measures. Mandatory avoidance and minimization measures, referred to as required BMPs because the CRCP does require them to be implemented as part of all projects it authorizes, funds or carries out, are included as the PDCs for this programmatic opinion and are considered conservation measures that are part of the proposed action (see Section 3.5.1). The effects of these mandatory measures are evaluated in this opinion.

The optional BMPs include:

<u>Acoustics/Echosounder Restrictions:</u>

- Operate all active acoustic systems at or above 180 kHz when practicable.
- If echosounder frequencies less than 180 kHz must be employed, operate at the lowest possible power (to reduce source level) and ping rate (to reduce accumulated energy).
- Use directional echosounders with the smallest beam width practicable to concentrate noise directly under the vessel to the maximum extent practicable.
- Minimize the use of all active acoustic systems (e.g., turn off all non-navigational echosounders when not actively mapping)
- Power down or turn off a mapping echosounder if a marine mammal is observed closely approaching or within 100 m (328 ft) of the vessel.

SCUBA/Snorkel:

- The dive team lead will make sure that underwater conditions (e.g., visibility, current speeds) and weather are suitable for diving to ensure the safety of divers and their ability to avoid damaging sensitive underwater habitats.
- The point of entry and exit will be carefully selected to avoid damaging coral.
- During all in-water activities, participants in education programs and other activities should avoid stepping on/standing on corals, and kicking coral colonies while swimming.

Instruments Moored to the Seafloor:

- The installation and removal of in-water structures for research equipment should be performed by divers; all equipment must be removed to the extent practicable once the study is complete. Removal of in-water structures will comply with any permits that authorized their installation.
- Any lines associated with moored instruments should be taut to reduce the possibility of entanglement of protected species.

Coral Nursery:

As noted in the project description, project leads will need to obtain all permits, including verification of USACE permit requirements for development or expansion of in-water nurseries. This includes the USACE SAJ-112 Regional General Permit for many in-water nursery structures in the Southeast and Caribbean. This permit requires the implementation of many of these BMPs. New coral nursery sites require project-specific review and potentially tiered consultation. In SERO, project-specific review will only be required for proposed new coral nurseries that do not qualify for authorization under SAJ-112, which has undergone ESA section 7 consultation (SER-2014-15282; September 21, 2017), for as long as the regional general permit remains in effect, or those that cannot meet the minimization measures outlined in SAJ-112 if they are being authorized by another USACE permit.

- New coral nursery sites shall be selected in a way that minimizes potential adverse effects of the installation and operation of the site on ESA-listed coral colonies and their habitat. New nursery sites and modifications to existing coral nurseries will be preferentially located in areas of unconsolidated substrate (i.e., sand or coral rubble) with no seagrass, corals, sponges, or other sessile benthic organisms growing on substrate.
    - The siting and design of new nursery sites must be in keeping with oceanographic and physical characteristics of the site and should account for storm conditions in the area to prevent damage and loss of structural components that could become tangled in ESA-listed coral colonies and their habitat. Coral nurseries will not be placed in locations where the typical sea state is often rough and may result in frequent damage to or movement of the structures.

- The combined area of individual structures in a single coral nursery, regardless of configuration, will not occupy more than one acre of seafloor at a single site unless in uncolonized sand bottom. Staging and work areas (i.e., areas not occupied by a structure) for nursery construction, maintenance, and monitoring are not included in this size limit. New nurseries or modifications to existing nurseries that would require installation of structures in or shading of coral habitat, or that result in a combined footprint of individual structures that is larger than one acre, may require tiered consultation unless ESA section 7 consultations for the actions have already been conducted with the applicable federal permitting agency. Temporary of “popup” coral nursery structures may only be placed in coral habitat if ESA-listed species are avoided and the structures are monitored regularly to ensure they are meeting restoration goals without impacting sessile invertebrates, including corals.
- The installation of in-water structures will be performed by divers.
- A nursery maintenance and monitoring plan will be developed for each coral nursery or for a region and will include the applicable required BMPs (Section 3.5.1) such as those for divers and vessel operation, and a training plan for all personnel and volunteers who will be involved in the creation, operation, and/or maintenance of the nursery. The plan should include information regarding the schedule and methodology for removal of structures that are no longer needed, functional, or of a design that has become obsolete.
    - The removal of in-water structures will be performed by divers. Structures will be removed when no longer in use or when the condition of the structures is such that they are no longer functional due to age or storm damage, for example.
- Structures must be constructed in a manner that ensures the structures will not move or flip during storm events or due to human impacts such as anchor drag:
    - Stabilization of structures can be achieved with the use of weights and/or penetrating anchor systems such as Duckbill® or Helix® anchors or rebar driven to sufficient depth to prevent movement or lifting of the structures.
- Anchors for new, long-term coral nursery structures (e.g., trees in a coral nursery) will be installed only in uncolonized, unconsolidated bottoms. Anchors and associated tackle and any associated swing radius, if applicable, will not be within 15.2 m (50 ft) from hard bottom and coral reef habitats to avoid potential impacts from movement of structures or their components during regular wave and current movement. Anchors shall be inspected at least twice a year and following large storm events to ensure that anchors and the nursery structures they support are still in place and have not moved to areas containing ESA-listed corals or designated or proposed coral critical habitat where they could cause damage.
- Floating structures that use lines as part of the support system or for attaching corals must be constructed in a manner to eliminate or minimize the chances of entanglement of sea turtles and marine mammals:

  - Line nurseries must have, at a minimum, either horizontal or vertical components that are rigid (e.g., PVC pipe) to prevent the structures from collapsing and potentially causing entanglement of animals.
  - Vertical lines for anchoring structures to the seafloor must have sufficient tension created by buoys on the line to avoid slack.
  - Buoys should be tied to the rigid component of the structure with the minimum use of line such that less than 50 cm (20 in) of line is exposed between each buoy and the structure.
  - Line used to attach corals vertically to the nursery structures must be no longer than 20 cm (8 in).
  - Horizontal lines must be at least 20 cm (8 in) apart and must be kept taut and supported by a rigid frame structure (PVC or similar) in order to avoid slack in the horizontal lines.
  - The use of monofilament lines instead of steel cables to reduce the need to replace cables regularly is acceptable as long as the lines for floating structures are kept taut and follow the recommendations above for new floating structures to minimize entanglement of marine organisms.

Coral Restoration/Transplantation/Relocation:

- Unless part of a scientifically-vetted study with risks analyzed and appropriate approval such as an ESA consultation, if applicable, outplants/transplants must be from a genetically connected population (i.e., corals are not transplanted from genetically distinct populations).
- Restoration projects should ensure suitable site selection (e.g., not selecting a location where corals were not in existence) and follow-up monitoring (and, when applicable, include monitoring of the control sites where corals were collected from, a scientific hypothesis, and experimental design) to ensure that lessons learned from the project can be applied to future efforts, thereby mitigating their potential for causing significant adverse impacts.
- When relocating, avoid placing the transplanted corals and any required equipment (e.g., tools, sensors, weights, etc.) on live habitat-forming organisms such as corals or sponges.
- When transporting live coral either from a collection site to a nursery or a nursery to an outplanting site:
  - Corals should be handled as little as possible.
  - Coral colonies/fragments should not be in contact with each other to prevent additional harm to their structures and tissue.
  - If a bucket or container is used for transportation and transportation will be above water (such as on a vessel to get from the origin site to the transplant site), the

seawater should be routinely changed to avoid prolonged exposure to increased water temperatures.
    - Corals should be reattached the same day they are removed or stored at *in-situ* or *ex-situ* nurseries, or other appropriate temporary holding facilities, with appropriate conditions to promote health (e.g., water flow).

Coral Fragment Collection:

- Monitor, if possible, the parent coral colonies from which samples have been taken to track and record whether tissue regeneration across the lesions has occurred.

Reduce Impacts of Biological Sampling-Related Fishing Gear:

- Nets should be monitored at all times to ensure ESA-listed sea turtles and other nontarget species do not become entangled. If entanglement does occur, the animals will be freed immediately in accordance with any existing guidelines, including https://www.fisheries.noaa.gov/national/resources-fishing/fishing-tips-protect-seaturtles-and-marine-mammals.

Bottom Sediment Sample Collection:

- Minimize collecting bottom samples in seagrass designated as critical habitat under the ESA.
- For projects that may temporarily increase sedimentation:
    - Due to the high risk of sedimentation or suspended material, operations should be halted during peak stony coral mass spawning periods in the region where sampling will occur to the extent practicable. To allow for coral recruitment, sediment-generating activities should be limited for a three-week period after the primary spawning event as much as possible.
    - Avoid sediment-generating activities during known soft coral spawning periods if soft corals are observed at or near the site. Sediment-generating activities should be restricted for three weeks beginning one week after the full moon of each spawning period to protect the spawning season for soft corals if they are present to the extent practicable.

Buoy Installation:

- Buoys should be preferentially installed in uncolonized, unconsolidated bottom and avoid dead coral colonies of any ESA-listed coral species to the extent practicable.
- If the bottom tackle is longer than 3 m (10 ft), the installation site should include a circular buffer with a radius equal to the length of the tackle. Buoys should be preferentially installed at locations with no or low vertical relief and no live coral colonization within a 3 m (about 10 ft) of the estimated swing radius of anchor chain or

other tackle to avoid breakage or abrasion of sessile benthic organisms from the movement of buoy and tackle.

- All buoy mooring systems with ground tackle must have floats/subsurface buoys on the lines or anchor chains to prevent any tackle from dragging on the bottom. The float/subsurface buoy should be attached to the buoy chain above the chain attachment point to the bottom anchor in order to prevent the anchor chain from dragging on the seafloor should the chain become detached from the anchor.
- A helical screw anchor, duckbill anchor, or drill and epoxied pin anchor, depending on substrate type, should be used to minimize the footprint of the anchor in the marine bottom.
- The work vessel(s) should have an observer to ensure no marine mammals or sea turtles are in the area during buoy installation. If marine mammals or sea turtles are observed, operations will cease until the animals have left the area.
- GPS locations will be collected for the buoys once installation is complete. Monitoring of buoys should be done from the surface and using divers on an opportunistic basis, including following storms, to determine whether buoys moved and require reinstallation.

Watershed Restoration Activities:

- Avoid using products with large concentrations of pesticides.
- Avoid planting vegetation when a storm is approaching.

3.3 Mission: Iconic Reefs

NOAA (NOS ONMS, NMFS OHC, NOS NCCOS, and the CRCP), working with external partners including, but not limited to, the Florida Fish and Wildlife Conservation Commission, Florida Department of Environmental Protection, Coral Restoration Foundation™, Mote Marine Laboratory and Aquarium, The Florida Aquarium, The Nature Conservancy, Reef Renewal, and the National Marine Sanctuary Foundation, launched an initiative in 2019 to address the decline of Florida Keys coral reefs. Current stony coral cover in the Florida Keys is around 2%. Historically, the Florida Keys' reefs were characterized by coral cover of approximately 30-40%.

The Mission: Iconic Reefs initiative identified seven areas within the Florida Keys for large scale coral reef restoration. These areas are Carysfort Reef, Horseshoe Reef, Cheeca Rocks, Sombrero Reef, Newfound Harbor, Looe Key Reef, and Eastern Dry Rocks. The seven reef sites selected were narrowed from a larger list of 37 potential restoration sites evaluated based on characteristics such as likelihood of restoration success, biodiversity and habitat composition, connectivity to other habitat types, allowable and compatible human uses, and current enforcement and compliance activities. Sites were selected based on the best available site-specific information, with the understanding that global-scale stressors such as climate change could affect the suitability of some sites for future restoration. Mission: Iconic Reefs will be completed in two phases to ensure that multiple coral and other important reef species can be restored over time. Logistics for this large-scale restoration effort include planning, site preparation, coral restoration and addition of grazers, site maintenance, and monitoring.

The restoration of individual corals back to the Florida Keys coral reefs is the major component of this mission and the primary metric by which restoration requirements were generated. NOAA expects that about 5,000,000 stony coral fragments (diameter of approximately 5 to 20 cm per fragment) will be needed for this restoration effort (Table 4). This restoration effort will take place in two phases. In Phase 1, NOAA and partners will propagate elkhorn and staghorn corals sexually and asexually and rear them in nurseries for outplanting. Phase 1 will also consist of the propagation and outplanting of additional stony coral species (Table 5) and herbivores (Tables 4 and 6). Phase 2 restoration activities will include additional research and development, propagation, and outplanting of slower-growing stony coral species to restore diversity to the sites. All corals used in Phases 1 and 2 will be raised in either *in-situ* or *ex-situ* nurseries, or will be corals of opportunity[7]. Coral outplants will likely include *ex situ* propagated sexual recruits for which gametes are either collected *in situ* and brought to an *ex-situ* spawning facility or recruits from *ex situ* raised corals that spawned in captivity. Corals of opportunity will likely include broken or dislodged colonies. Additionally, corals collected from man-made objects such as markers, bridges, seawalls, and other in-water structures may be used. Table 5 provides an estimate of the number of coral fragments per species needed for each phase of the restoration.

Table 4. Projected number of coral fragments and grazers to be added to each reef site in Mission: Iconic Reefs Phase 1 (in grey; Phase 1: add rapid-growing corals; duration: 5-7 years and 10-year goal: about 15 percent cover) and Phase 2 (add slower-growing corals; duration: 10-12 years and 20-year goal: about 25 percent cover).

Region	Reef	Restorable area (square miles)	# of Coral fragments outplanted	# of Grazers added	# of Coral fragments outplanted	# of Grazers added
Upper Keys	Carysfort Reef	111,880	854,674	94,982	779,777	94,982
Upper Keys	Horseshoe Reef	10,477	129,416	5,696	182,817	5,696
Middle Keys	Cheeca Rocks	12,423	122,183	15,517	217,992	15,517
Middle Keys	Sombrero Reef	13,447	111,184	10,096	118,184	10,096
Middle Keys	Looe Key Reef	57,432	477,826	43,078	688,587	43,078

[7] Fragments of coral that have naturally been dislodged or unattached from the parent colony or substrate such as during strong wave action or storms or due to human activity such as vessel grounding or construction activities.

Lower Keys	Newfound Harbor	8,455	46,034	11,066	94375	11,066
Lower Keys	Eastern Dry Rocks	36,421	307,958	21,633	306,307	21,633
	Subtotal	250,535	2,049,275	202,068	2,455,911	202,068

Table 5. Stony coral fragments required for each Mission: Iconic Reefs restoration phase. Bold font denotes ESA-listed coral species.

Species	Phase 1	Phase 2	Total
Elkhorn Coral (*Acropora palmata*)	809,251	206,526	1,015,777
Star Coral*	425,291	149,786	575,076
Brain Coral**	507,316	891,524	1,398,840
Pillar Coral (*Dendrogyra cylindrus*)	296,755	499,784	796,539
Staghorn Coral (*Acropora cervicornis*)	17,660	21,468	39,129
Other Small Stony Coral***	0	686,823	696,823
Totals	2,056,274	2,455,911	4,512,184

*Star Coral includes the three ESA-listed star coral species (***Orbicella annularis*, *Orbicella faveolata*, and *Orbicella franksi***) and *Montastraea cavernosa*.

**Brain Coral includes *Pseudodiploria strigosa*, *Diploria labrynthiformis*, *Colpophyllia natans*, and *Pseudodiploria clivosa*.

***Other Small Stony Coral includes: *Agaricia agaricites* (lettuce coral), *Eusmilia fastigiata* (smooth flower coral), *Meandrina meandrites* (maze coral), ***Mycetophyllia ferox* (cactus coral)**, *Mycetophyllia lamarckiana (ridged cactus coral), Mycetophyllia aliciae (knobby cactus coral), Agaricia lamarcki* (whitestar sheet coral), *Helioceris cucullata* (sunray lettuce coral), *Porites astreoides* (mustard hill coral), *Porites porites* (clubtip Finger Coral), *Porites divaricata* (thin finger coral), *P. furcata* (branched finger coral), *Siderastrea siderea* (massive starlet coral), *Dichocoenia stokesi* (elliptical star coral), *Oculina diffusa* (ivory bush coral), *Mussa angulosa* (spiny flower coral), *Madracis auretenra* (yellow pencil coral), *Madacis decactis* (ten ray star coral), *Favia fragum* (golfball coral), *Solenastrea bournonii* (smooth star coral), *Stephanocoenia intersepta* (blushing star coral), and *Isophyllia spp.* (cactus coral).

Phase 1

The goal of Phase 1 is to initiate habitat recovery by outplanting relatively fast-growing coral species that are resistant to SCTLD to the seven reef sites. Prior to outplanting, divers conduct site preparation to remove nuisance and invasive species such as turf algae and *Palythoa* from the outplant area. These species compete with corals for space on the reef and prevent coral larvae from settling and growing. Removing nuisance and invasive species decreases the amount of energy that growing corals expend when competing for reef space. Removed *Palythoa* will be bagged and removed from the water column for disposal at an appropriate land-based facility. The toxins found in *Palythoa* also occur in cowfish, filefish, urchins, crabs, sponges, and other organisms found near *Palythoa*, and in predators that feed on *Palythoa*. It is thought that bacteria and dinoflagellates associated with *Palythoa* may produce the palytoxin associated with this anthozoan genus. Routine removal (by scraping and collection) is unlikely to have an impact on surrounding organisms as the toxin is not "released" by *Palythoa*. For safety, divers conducting site maintenance will wear gloves to prevent accidental skin contact.

Following site preparation, NOAA and partners will outplant a variety of coral species over the next 6-10 years. Elkhorn and staghorn corals will be outplanted first because they grow relatively quickly, are already in propagation in most coral nurseries, and are not susceptible to SCTLD. These acroporid corals will create habitat for other animals, and, within three to five years, they will reach reproductive maturity and be able to naturally reseed areas. As the acroporid corals become established, other coral species will be outplanted such as star, brain, and pillar corals, and a variety of small stony coral species. NOAA and partners will also outplant long-spined sea urchins (*Diadema antillarum*), Caribbean king crab (*Maguimithrax spinossisimus*), and other herbivorous crab species within the restored area (Table 6). The addition of grazers to the reef is necessary to help return the reef to a coral-dominated environment from an algae-dominated environment. The scale and scope of herbivore introductions at the restoration sites will be determined based on the status of the reef site, availability of the appropriate herbivores, and effectiveness of each in achieving restoration goals. The goal of Phase 1, Mission: Iconic Reefs is to increase coral cover to 15%, depending on the particular habitat zone.

Table 6. Other Mission: Iconic Reefs restoration plan components by phase, including herbivore introduction.

Activity	Phase 1	Phase 2	Total
Sea Urchins (# of Animals)	188,107	188,107	376,213
Caribbean King Crab (# of Animals)	13,962	13,962	27,923
Site Preparation (# of Days)	1,089	544	1,633
Monitoring (# of Days)	1,775	1,775	3,549

Phase 2

The goal of Phase 2 is to build on Phase 1 to create a healthy, restored, and vibrant reef community. Over approximately 12 years, volunteers and staff will continue to outplant elkhorn

(*Acropora palmata*), star (*Orbicella* spp. and *Montastrea cavernosa*), brain (*Pseudodiplora* spp., *Colpophyllia natans*, and *Diploria labyrinthiformis*), pillar (*Dendrogyra cylindrus*), and staghorn corals (*Acropora cervicornis*). They will also outplant other small stony corals like finger and brain coral species, helping to add diversity, function, and resiliency to the reef. All corals used in Phases 1 and 2 will be raised in either *in-situ* or *ex-situ* nurseries (including *ex situ* propagated sexual recruits- either gametes collected *in situ* and brought to an *ex-situ* spawning facility or recruits from *ex situ* raised coral that has spawned in captivity), or be corals of opportunity. By the end of Phase 2, NOAA hopes to increase coral cover to an average of 25%.

Maintenance and Monitoring

Site maintenance will include deployment of various teams at designated reef sites to assess restoration areas via roving surveys. Site maintenance teams will be regionally-focused (i.e., Upper, Middle, and Lower Keys), returning to the same sites at regular intervals. These teams will conduct minor interventions and maintenance at the sites such as removal of marine debris, removal of nuisance and invasive species, and reporting of dislodged coral outplants. The teams will be trained prior to any work being conducted and only team members who have a vetted level of experience and authorization from Mission: Iconic Reefs and the Florida Keys National Marine Sanctuary will be permitted to handle/reattach dislodged corals, remove certain nuisance and invasive species, or remove types of marine debris requiring special permission.

Mission: Iconic Reefs monitoring will include the collection of biological and oceanographic data. These monitoring data will help track successes and failures, and inform mid-course corrections and adaptive management, which is critical to the long-term success of any restoration effort. Biological monitoring teams will assess the restoration sites two to three times per year during the initial establishment phase, monitor annually during the outplanting years, and monitor post-disturbance (i.e., after major storms). Permanent plots will be established and performance will be tracked against the restoration targets. It is expected that 20% of each reef site and habitat type within a reef site be monitored comprehensively (e.g., camera arrays or recorded observations with temporary deployment of transect tapes or quadrats).

Mission: Iconic Reef monitoring sites will be delineated with tags and stainless steel stakes/pins/eyebolts that are inserted into unconsolidated substrate or by drilling into hard substrate and secured with cement/epoxy. All stakes/pins/other equipment deployed as part of Mission: Iconic Reefs will be removed at the end of a study in a manner such as not to cause additional damage, and any holes will be filled with epoxy/concrete to prevent erosion. If it is not possible to fully remove the stakes/pins, divers will cut them level with the substrate. Oceanographic sensors (e.g., temperature meters, pH meters, pressure sensors, and acoustic Doppler current profilers) will be deployed at each of the restoration sites for as long as funding allows, and will likely need periodic maintenance. To reduce the likelihood that instruments move during storms, they will be secured either by drilling into hard bottom and securing pin/stakes with epoxy/cement if needed, or by anchoring in unconsolidated sediment. All instruments will be secured in areas away from living resources and no drilling, anchoring or other attachment will occur on or adjacent to corals or other benthic organisms.

Any activities conducted as part of Mission: Iconic Reefs that are outside of the activities described herein will require project-specific review and may require tiered consultations.

3.4 Potential Stressors

Stressors are any physical, chemical, or biological agent, environmental condition, external stimulus or event that may induce an adverse response in either an ESA-listed species or its designated critical habitat (Schulte 2014). The proposed action consists of monitoring, mapping, intervention and restoration activities in watersheds and coastal and marine habitats. The major categories of stressors from CRCP and Mission: Iconic Reefs activities are:

- Vessel operation, including strikes, anchoring and accidental grounding, vessel discharges, and propeller wash;
- Sound from different sources (e.g., vessel noise, echosounders and other vessel navigational equipment, and sensors used during underwater investigations);
- Visual disturbance from divers, snorkelers, waders, and vessels in the water;
- Entanglement and entrapment (e.g., in gear used to collect biotic samples, in tackle associated with in-water structures such as buoys, towlines and cables of ROVs, and lines of other towed or anchored sensors/equipment);
- Sediment introduction or resuspension and transport from various activities (e.g., bottom sampling, anchor installation for in-water structures and equipment, watershed restoration involving earth movement in/near waterbodies);
- Habitat loss, damage, and alteration (e.g., in-water structure and equipment installation, operation and maintenance; shading from in-water structures; diver breakage and abrasion; placement of fish nets or traps);
- Injury or mortality from the use of nets and traps to sample fish and invertebrates, organism collection and transplantation, and trampling or breakage and abrasion during watershed assessments and in-water surveys and education and outreach activities; and
- Introduction of contaminants such as tracer dyes, antibiotics or probiotics, pesticides used in treatment of terrestrial vegetation, and lubricants from in-water instruments in coastal and marine waters.

Vessel operation and associated stressors apply across all activities that require vessel use. Diver/snorkeler operation and associated stressors apply to in-water activities, including biological monitoring and sample collection, installation of in-water equipment and structures, coral tagging, coral restoration and other interventions, buoy installation, in-water removal of marine debris, and in-water education and outreach events.

There are some additional stressors that were not considered fully in this opinion because details of these stressors and their potential effects are not currently available. These stressors are associated with activities such as novel coral restoration and recovery methods, and other activities that will require project-specific review and may require tiered consultation as described in Section 3.5.2.

3.5 Programmatic Consultation Requirements and Procedures

This section details the PDCs that are required for activities implemented by the CRCP and by NOAA partners as part of the Mission: Iconic Reefs initiative to avoid or minimize adverse effects on ESA-listed species, designated critical habitat and EFH. In the case of this opinion, the PDCs are equivalent to the CRCP's required BMPs, although some modifications have been made to these BMPs in coordination with NMFS to be more protective of ESA and EFH resources. As noted, PDCs, as up-front mandatory measures to avoid or minimize adverse effects likely to be caused by program activities, are part of the action for consultation; therefore, their effects are evaluated in this opinion. This section also describes the procedures for streamlined project-specific review and for tiered consultations. Finally, this section details the regular comprehensive review procedures for the program.

The following additional elements of programmatic consultations are covered in later sections of the Opinion:

- Description of the manner in which activities to be implemented under the programmatic consultation may affect listed species, critical habitat, and EFH, and evaluation of expected level of effects from covered activities (Sections 5 and 8).
- Process for the evaluation of the aggregate or net additive effects of all activities expected to be implemented under the programmatic consultation (Section 8).
- Procedures for tracking and monitoring projects and validating effects predictions, in addition to those contained in this section of the opinion related to periodic program review, are also found in the Incidental Take Statement, including its RPMs and associated terms and conditions (Section 11).

The proposed programmatic action includes specific activities that are (1) not likely to adversely affect ESA-listed species, their designated critical habitat, or EFH with implementation of applicable PDCs, and (2) are likely to adversely affect ESA-listed species, their designated critical habitat, and/or EFH, even with implementation of required PDCs. While some activities have ESA section 7 determinations made under this programmatic opinion, there are others that are likely to adversely affect ESA-listed species, their designated critical habitat, and/or EFH that will require project-specific review and may require tiered consultation because the effects of these activities cannot be fully determined at the time of writing of this opinion. Although some PDCs and RPMs appear similar, the implementing terms and conditions of the RPMs provide specific requirements that the action agency must follow in order to retain their incidental take authorization.

3.5.1 Project Design Criteria

The CRCP, in consultation with NMFS, has refined existing required BMPs for activities as part of their program and as part of the on-going coordination between the CRCP and NMFS OPR under this programmatic that serve as the PDCs for this programmatic. As stated previously, these do not include the optional BMPs described in Section 3.2.6.

PDCs, referred to as required BMPs, have been identified to limit potential adverse effects of CRCP activities to ESA-listed species, their designated critical habitat, and EFH. The required BMPs included in this opinion are those that the CRCP implements as conservation measures and were included in the BA for this consultation. These required BMPs, when applied to activities associated with the CRCP, including those that are part of Mission: Iconic Reefs supported by CRCP or other NOAA organizations, minimize the potential adverse effects to ESA-listed species, their designated critical habitat, and EFH.

The PDCs described below are required for use during all applicable activities to avoid or minimize potential adverse effects of in-water activities (i.e., monitoring, mapping, research, restoration, reduction of physical impacts, and outreach activities) and watershed restoration activities to ESA and EFH resources. As noted, these are largely synonymous with the CRCP's required BMPs for projects receiving program funding supplemented with additional requirements NMFS believes are necessary to avoid and minimize potential adverse effects of the action on ESA and EFH resources based on consultations involving vessel operations, in-water surveys and monitoring, in-water equipment use, and installation of buoys and other in-water structures. The term "required BMPs" is used in this opinion to refer to PDCs that, when applied to activities that may result in stressors that may affect ESA and EFH resources, minimize the negative effects of these stressors to these resources.

Required BMPs for Vessel Operations:

1. When using a boat or platform to conduct in-water work, at least one person will maintain a visual watch for mobile protected species to ensure none are sighted within the working area. If a listed species moves into the area of work, cessation of operation of any moving equipment within 15 m (50 ft) of animal will occur. Activities may resume once the species has departed the project area of its own volition.
2. Vessels must meet all U.S. Environmental Protection Agency (EPA) Vessel General Permit or other EPA requirements and USCG requirements for the control of pollution from air emissions, vessel discharges, and trash, and adhere to any more stringent site-specific regulations (e.g., No Discharge Zone within Florida Keys National Marine Sanctuary).
3. In order to avoid causing injury or death to marine mammals, sea turtles, or other marine species or habitats, the following measures will be taken when consistent with safe navigation:

    a. Vessel operators and crews shall maintain a vigilant watch for marine mammals and sea turtles to avoid striking sighted protected species.
    b. Vessels will maintain a safe operating speed consistent with the area through which it is transiting.
    c. When whales are sighted, maintain a distance of 100 yards (91 m [300 ft]) or greater between the whale and the vessel.
    d. When sea turtles or small cetaceans are sighted, attempt to maintain a distance of 50 yards (46 m [150 ft]) or greater between the animal and the vessel whenever possible.
    e. When small cetaceans are sighted while a vessel is underway (e.g., bow riding), attempt to remain parallel to the animal's course. Avoid excessive speed or abrupt changes in direction until the cetacean has left the area.
    f. Whales may surface in unpredictable locations or approach slowly moving vessels. When an animal is sighted in the vessel's path or in close proximity to a moving vessel and when safety permits, reduce speed and shift the engine to neutral. Do not engage the engines until the animals are clear of the area.
4. To reduce the risk of vessel impacts to coral reefs, colonized hard bottom, and seagrass areas, the vessel operator will carry and consult appropriate NOAA nautical charts, NOAA benthic habitat maps and aerial photographs, and/or use real-time data (e.g., GPS with nautical chart and onboard depth finder) to continuously observe and verify water depths and vessel location.
5. Vessel anchoring will be done in a way that minimizes effects to marine habitats.
    a. Vessel operators will use recreational mooring buoys or live boating (boat operator keeps engine on and uses dynamic positioning to keep boat on station without anchoring) when possible.
    b. If anchoring, operators will only use designated anchoring areas or will anchor in uncolonized bottom, i.e., mud or sand, whenever possible. If anchoring on an uncolonized bottom is not possible, vessels may be anchored on a vegetated bottom that consists of seagrass and/or algae (seaweed). Vessels should not anchor on hard bottom containing hard and/or soft coral, regardless of the percentage of coral cover present. The type of bottom present will be confirmed by divers, or from the vessel using a glass-bottom bucket or other appropriate means prior to anchoring. Divers may also be used to hand place anchors. Adherence to more stringent site-specific anchoring regulations (e.g., those within the Florida Keys National Marine Sanctuary) is required.
    c. If the vessel is anchored on vegetated bottom (seagrass/algae), the anchor will be removed from the seafloor in a manner that minimizes disturbance to the vegetation. For example, by attaching a secondary anchor line to the rear of any

plow-type anchor and pulling the anchor free from the seafloor before lifting to the surface.

Required BMPs for Moored Instruments

1. Moored instruments will be securely placed on/anchored into uncolonized hard bottom areas of rubble or sand whenever possible. If instrument deployment in coral habitats is a prerequisite of the project (i.e., critical to address the research question), such items shall be installed in such a manner as to not contact living ESA-listed coral colonies and the stability of the instruments will be checked periodically to ensure they have not moved.

Required BMPs for Remotely Operated Vehicles (ROV):

1. 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.
2. Stiffer line materials will be used for towing or operating all equipment and kept taut during operations to reduce the potential for entanglement of animals or in bottom features such as coral habitats.

Required BMPs for Divers/Snorkelers:

1. SCUBA divers/snorkelers involved in in-water activities will have proper training and be capable of responsible dive/snorkel practices (e.g., proper buoyancy) such that they minimize injury to organisms or unnecessary habitat impacts. It is the responsibility of NOAA or grantees/contractors to ensure that divers/snorkelers are trained to a level commensurate with the type and conditions of the diving activity being undertaken. The organization (if outside NOAA) must have the capacity (appropriate insurance, safety policies, etc.) to oversee all proposed diving/snorkeling activities.
2. To minimize disturbances (to animals and habitats), divers will use low-impact techniques, which typically include having no more than four divers per group in the water or spreading divers throughout a site and using appropriate dive equipment and tools.
3. Divers/snorkelers will not stand or rest on live corals or other slow-growing sessile benthic invertebrates. Bottom contact should only be in unconsolidated areas or non-living hardbottom. When contact with the seabed is necessary (e.g., mooring buoy anchoring installation, certain coral nursery maintenance activities), contact with living organisms shall be minimized to the greatest extent practicable.

Required BMPs for Laboratory Work:

1. Projects involving laboratory studies will follow the laboratory’s environmental compliance guidelines and ensure that chemicals are disposed of in a proper manner, and comply with the ethical treatment of animals.

2. Laboratory studies involving the use of live plants, animals, bacteria, and viruses will ensure proper steps are taken so that non-native species or pathogens are not introduced or spread as a result of the work.

Required BMPs for Invasive Species Control:

1. In areas where there is an identified risk of spreading invasive species or if particular activity can increase the chance of spreading invasive species, grantees/PIs will ensure invasive species are not introduced to non-native areas through means such as
    a. Cleaning instruments or tools according to scientific protocols to ensure no biofouling is present (e.g., scraping, treating surface with a mild bleach solution, storing removed species in a safe location to decompose, etc.);
    b. Rinsing dive gear in a disinfecting solution at the end of each day in the field;
    c. Sanitizing vessels and all gear at each departure from port;
    d. Disinfecting equipment and gear between use/sites; and
    e. Decontamination of clothing and soft gear to be taken ashore from a vessel by freezing materials for 48 hrs or by the use of new clothing or soft gear the next field day.

Required BMPs for Use of Fishing Gear:

1. Projects involving the use of traps, nets, or other types of fishing gear to sample fish populations will include measures to ensure the use of these gear types minimizes impacts to benthic habitats.

Required BMPs for Coral Collection:

1. The collection of coral fragments from naturally-occurring coral colonies for use in laboratory/research/restoration studies shall be done in compliance with local collection permit requirements.
2. Projects that remove cores from coral colonies will fill the core hole with clay, cement, or marine epoxy unless permits do not allow for filling cores.
3. When working with specimens with active diseases or in areas with active disease outbreaks, 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 in order to reduce the possible transmission of disease agents. All tools should be soaked before moving to new sites. Gear and tool decontamination should follow the ONMS protocol or the field manual by Woodley et al. (2008).

Required BMPs for Watershed Restoration Activities:

1. On-site Pollution Controls

   a. Properly confine, remove, and dispose of construction waste, including every type of debris, discharge water, concrete, cement, grout, debris and sediment from the washout facility, welding slag, petroleum product, or other hazardous materials generated, used, or stored on-site.
   b. All vehicles and other heavy equipment will be (a) operated in a safe manner; (b) stored, fueled, and maintained in a vehicle staging area set back from any natural waterbody or wetland; and (c) inspected daily for fluid leaks before leaving the vehicle staging area.
   c. Generators, cranes, and any other stationary equipment operated within 46 m (50 ft) of any natural waterway or wetland will be maintained as necessary to prevent leaks and spills from entering the water.
   d. Use procedures to contain and control a spill of any hazardous material generated, used or stored on-site, including notification of proper authorities if a spill occurs. Heavy equipment can also leak oil and fluids. Equipment is always refueled away from stream corridors, and operators are required to have a spill response plan in place in case of a leak.
2. Erosion Control
   a. Temporary erosion controls will be in place before any significant alteration of the action site and will be monitored during construction to ensure proper function. Any number of erosion control structures or approaches may be used including turbidity curtains, hay bales, and erosion mats, where appropriate. When possible, stream flow will be diverted from work areas to prevent excess turbidity.
   b. Vegetation and soil disturbance will be confined to the minimum area and minimum length of time necessary to complete the action, and to otherwise prevent or minimize erosion associated with the action.
   c. Reduce the potential for erosion and head cuts through the use of grade control structures or bank recontouring.
   d. Cease work under high flows or seasonal conditions that threaten to disturb turbidity reduction measures, except for efforts to avoid or minimize resource damage.
   e. Exposed areas will be mulched and seeded after ground-disturbing activities are complete.
   f. Any woody debris, mature native vegetation, topsoil, and native channel material displaced by construction will be stockpiled for use during site restoration. When construction is finished, all streambanks, soils, and vegetation will be cleaned up and restored as necessary to renew ecosystem processes that form and maintain productive fish habitats.
3. Methods to Reduce Soil Compaction

a. Existing access ways will be used whenever possible. Temporary access roads will not be built on slopes greater than 50% where grade, soil, or other features suggest a likelihood of excessive erosion or failure. Soil disturbance and compaction will be minimized within 46 m (150 ft) of a natural waterbody or wetland. All temporary access roads will be removed when the action is completed, the soil will be stabilized, and the site will be revegetated. Temporary roads in wet or flooded areas will be restored shortly after the work is complete.
b. Heavy equipment will be selected and operated in a manner that minimizes adverse effects to the environment (e.g., minimally-sized, low pressure tires, minimal hard turn paths for tracked vehicles, temporary mats or plates within wet areas or sensitive soils).
c. To the extent feasible, heavy equipment will work from the top of the bank, unless work from another location would result in less habitat disturbance.

4. Adequate Training of Volunteers
    a. Training will be provided to ensure minimal impact to the restoration site by volunteers. Volunteers shall be trained in the use of low-impact techniques for planting, equipment handling, and moving around the restoration site to avoid unnecessary impacts on native flora and fauna.

3.5.2 Project-Specific Review and Tiered Consultation Procedures

The CRCP or Mission: Iconic Reefs agencies will be responsible for determining whether the activities that are part of individual projects will be carried out at the scale and using the methods described in this opinion, fully meet the required BMPs applicable to the project, and are consistent with this opinion, including the effects analysis. If this is the case, project-specific submissions to NMFS are not needed. However, the CRCP and Mission: Iconic Reefs must track every activity that is carried out, funded, or otherwise authorized and compile this information as part of the required review under this programmatic consultation.

For activities that are not fully captured by this opinion or are identified in the list below, CRCP or Mission: Iconic Reefs agencies will submit project-specific reviews to NMFS, and NMFS will determine whether a tiered consultation is necessary. NMFS anticipates that tiered consultations may be required for the following activities either because of the uncertainty in estimating the extent of take of ESA-listed species as a result of the activity, because of the potential for changes in some of the methodologies used to conduct these activities as technology evolves, or because sufficient details of the activity were not available at the time this opinion was written to allow for a thorough analysis of the effects to ESA and/or EFH resources:

- *In situ* coral disease grafting projects;
- Installation of in-water structures or instruments using methods not described in this opinion, in areas where these structures have not been installed previously (see Section

7.2.4 that summarizes take based on location), or at larger scales than described in this opinion;

- Installation of moorings or markers using methods or anchor systems other than described in this opinion;
- Outplanting or other in-water work with corals, whether ESA-listed species or non-ESA-listed species, with genetically modified symbionts or with other genetic modification, including hybridization or other crossings that would result in the introduction of species not native to the region in which the work will occur;
- Movement of coral species to areas where the species does not currently or has not historically occurred to enhance diversity (assisted migration);
- *In situ* methods to reduce sea surface temperature such as water cooling and installation of shade cloths over coral habitats;
- Methods to treat diseases other than those described here or at larger scales than described in this opinion;
- Projects involving the use of fishing gear, including nets, traps, and hook-and-line where there is the potential for bycatch of Nassau grouper and/or ESA-listed DPSs of scalloped hammerhead shark;
- Any projects that may target ESA-listed species such as scalloped hammerhead shark or Nassau grouper using methods that involve direct interactions with the animals;
- Any projects that involve new (not already established) coral nurseries proposed within Hawaiian monk seal critical habitat or within the boundaries of other designated critical habitats in U.S. coral jurisdictions in locations containing the PBFs of the critical habitat; and
- Large-scale coral reef restoration projects other than as described in this opinion for Mission: Iconic Reefs or additional sites proposed for Mission: Iconic Reefs.

As specific projects or activities in the categories in the list above are planned for implementation, CRCP or the collaborating Mission: Iconic Reefs agencies must submita request for review to NMFS ESA Interagency Cooperation Division and Office of Habitat Conservation, and the applicable regional NMFS Protected Resources and Habitat Conservation Divisions in SERO and PIRO via email. Based on the information provided, NMFS will communicate its determination as to whether a tiered consultation is needed for a particular project or activity within 30 days of receipt of the request. In some cases, the information may reveal that the project does not fall within the scope of this programmatic opinion and will require a stand-alone consultation.

The email addresses for submission of project-specific information are as follows:

- OPR ESA Interagency Cooperation Division: lisamarie.carrubba@noaa.gov
- OHC: Habitat Protection Division: nmfs.hq.hc.efhconsult@noaa.gov
- SERO Protected Resources: nmfs.ser.esa.consultations@noaa.gov

- SERO Habitat Conservation: jocelyn.karazsia@noaa.gov
- PIRO: EFHESAconsult@noaa.gov

A standard form may be provided by the regions for email submissions or developed as part of programmatic coordination under this consultation. The subject line of the email request/submission should include a reference to "OPR-2019-01044, Programmatic Consultation on the CRCP and Mission: Iconic Reefs." The submission must include the following information:

1. Location: This should include the location where the activities are proposed.
2. BMPs met: Acknowledge whether or not all of the applicable required BMPs in this document will be met as part of the proposed project or activities. Identify whether there are some activities that require further analysis because they cannot meet the BMPs or can only partially meet them.
3. 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 or any new activities that would be associated with a particular project. This project-specific information must be detailed enough to enable NMFS to determine the potential effects to ESA or EFH resources in the action area and assess the risk to these resources because of the implementation of the project. The information must also be detailed enough to enable NMFS to determine whether additional protective measures for avoidance and minimization of the effects of a particular project or activity are required and whether a tiered consultation is needed.
4. Timeline: If there are timeline considerations to be aware of with CRCP or Mission: Iconic Reefs project approval status, information regarding any deadlines or other timing considerations should be included in the notification.

If a project-specific review has been conducted but a change is proposed to a particular project or activity, then a list of all projects or activities that will be affected by the change should be provided via email to OPR, OHC, and the applicable regional offices identifying the change (e.g., change of activities associated with a particular project, addition of a new project) as soon as the CRCP or Mission: Iconic Reefs agencies becomes aware of the change. Email notifications should follow the format described above and the submitter must receive a response from the NMFS office in the geography where the activity will occur prior to commencing any in-water work.

3.5.3 **Programmatic Review**

The CRCP, collaborating offices engaged in Mission: Iconic Reefs, and NMFS will conduct a regular programmatic reviews of the activities considered in this opinion six months after the end of each CRCP implementation planning period (i.e., the first programmatic review would be in

April 2024 after the FY21-23 implementation planning period ends). The submission will be to OPR, OHC, and the regions as described in Section 3.5.2 with a reference to "OPR-2019-01044, Programmatic Consultation on the CRCP and Mission: Iconic Reefs" in the subject line of the transmittal. This review will evaluate, among other things, whether the scope of projects 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 BMPs are being complied with and continue to be appropriate; and whether the project-specific review and tiered consultation procedures are being complied with and are effective.

To assist in the programmatic review, the CRCP and Mission: Iconic Reef partners will collaborate on the submission to NMFS of a comprehensive summary of:

- the activities conducted during each CRCP implementation planning period (or shorter time for the first programmatic review after completion of this opinion, if appropriate);
- information regarding the implementation of required BMPs and their efficacy, if known, in avoiding and minimizing impacts of the program on ESA-listed species and their designated critical habitat or EFH based on any issues identified by a project lead, vessel captain or other crew member, divers or other personnel engaged in in-water activities in implementing required BMPs;
- copies of any vessel logs, if available, detailing sightings of ESA-listed species in marine habitats, per the conservation recommendations in Section 12 of this opinion; and
- monitoring and reporting of take of ESA-listed species per the RPMs and implementing terms and conditions in the ITS, including quantification of the amount of habitat area impacted by the installation of in-water structures annually in each jurisdiction as a surrogate for incidental take of ESA-listed corals.

The summary of aggregate activities and associated effects during the CRCP implementation planning period will allow NMFS to review the information to determine whether the activities completed under the programmatic were within the scope of the opinion and any tiered 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 C.F.R. §402.02).

CRCP activities supporting the management, conservation, and restoration of tropical/subtropical coral reef ecosystems[8] are implemented throughout the U.S. coral jurisdictions (Figure 45). The

[8] The coral reef ecosystem includes colonized hard bottom habitats (e.g., spur-and-groove reefs, individual and aggregated patch reefs, and gorgonian-colonized pavement and bedrock); uncolonized hard bottom (e.g., reef rubble and uncolonized bedrock); mesophotic reefs (30–150 m, about 100–500 ft) that have a meaningful ecological connection between the mesophotic area and associated shallow-water coral reefs; submerged vegetation (e.g.,

U.S. has jurisdiction over an estimated 19,702 km^2 (12,242 square miles [mi^2]) of shallow-water coral reefs. Thus, the CRCP action area encompasses Southern Florida (i.e., the coastal areas within Martin, Palm Beach, Broward, Miami-Dade, and Monroe Counties), the Gulf of Mexico (i.e., FGBNMS and Dry Tortugas), Puerto Rico, the USVI, American Samoa, the CNMI, Guam, Hawaii (including the NWHI), and the U.S. Pacific Remote Island Area (i.e., the Pacific Remote Islands Marine National Monument [PRIMNM]).

The CRCP also supports capacity building such as information transfers and technical exchanges through workshops and training in other nations with coral ecosystem resources. Because these interactions do not include on-the-ground activities and thus do not cause effects to ESA-listed species, CRCP's International Priority Areas are not included in the action area for this consultation and international exchanges are not discussed as part of the proposed action (Section 3).

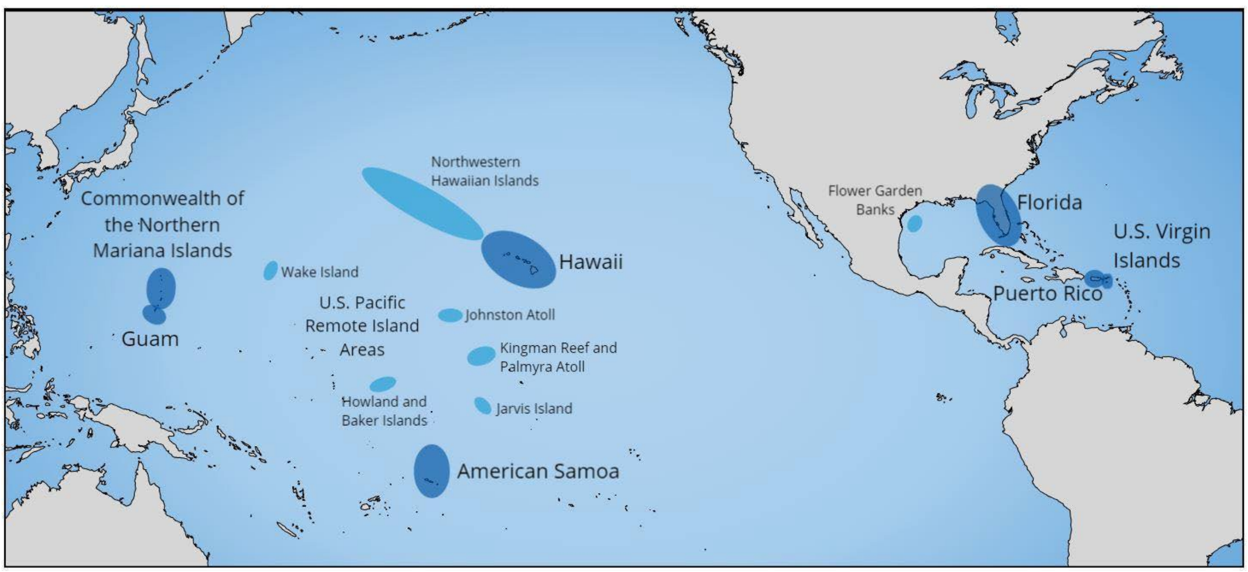

Figure 46. Map showing the location of the CRCP U.S. Coral reef areas. Light blue signifies the remote areas where CRCP supports periodic monitoring and assessment (NOAA CRCP 2020)

5 Species, Critical Habitat, and EFH Resources In The Action Area That May Be Affected

This section identifies the ESA-listed species and designated critical habitat that potentially occur within the action area (Table 8) that may be affected by the proposed CRCP and Mission Iconic Reef activities, as well as the EFH resources in the action area.

seagrass and macroalgae); mangroves and other emergent vegetation; and unconsolidated sediments (e.g., sand and mud).

Table 7. Threatened and Endangered Species and Critical Habitat in the Action Area That May Be Affected by the Proposed Action

Species	ESA Status	Recovery Plan	Critical Habitat	Jurisdiction
Blue whale (*Balaenoptera musculus*)	E – 35 FR 18319	07/1998	----	FL, GOMx, PR, VI, AS, CNMI, Guam, HI, PRIA
Fin whale (*Balaenoptera physalus*)	E – 35 FR 18319	75 FR 47538	----	FL, GOMx, PR, VI, AS, CNMI, Guam, HI, PRIA
Humpback whale (*Megaptera novaeangliae*), Western North Pacific DPS	E – 81 FR 62259	11/1991	not in action area	CNMI, Guam
Sei whale (*Balaenoptera borealis*)	E – 35 FR 18319	76 FR 43985	----	FL, GOMx, PR, VI, AS, CNMI, Guam, HI, PRIA
Sperm whale (*Physeter macrocephalus*)	E – 35 FR 18319	75 FR 81584	----	FL, GOMx, PR, VI, AS, CNMI, Guam, HI, PRIA
North Atlantic Right Whale (*Eubalaena glacialis*)	E – 73 FR 12024	70 FR 32293	not in action area	FL
North Pacific Right Whale (*Eubalaena japonica*)	E – 73 FR 12024	78 FR 34347	not in action area	HI
Rice's whale (*Balaenoptera riceii*) formerly known as Gulf of Mexico Bryde's whale	E – 84 FR 15446	----	----	FL, GOMx
False Killer Whale (*Pseudorca crassidens*), Main Hawaiian Islands Insular DPS	E – 77 FR 70915	Draft – 85 FR 65791	83 FR 35062	HI
Hawaiian Monk Seal (Neom*onachus schaunislandi*)	E – 41 FR 51611	72 FR 46966	80 FR 50925	HI
Nassau grouper (*Epinephelus striatus*)	T – 81 FR 42268	----	----	FL, PR, VI
Giant manta ray (*Mobila birostris*)	T – 83 FR 2916	----	----	FL, GOMx, PR, VI, AS, CNMI, Guam, HI, PRIA
Scalloped hammerhead shark (*Sphyrna lewini*), Central and Southwest Atlantic DPS	T – 79 FR 38214	----	----	FL, PR, VI
Scalloped hammerhead shark (*Sphyrna lewini*), Indo-West Pacific DPS	T – 79 FR 38214	----	----	AS, CNMI, Guam

Oceanic whitetip shark (*Carcharhinus longimanus*)	T – 83 FR 4153	----	----	FL, GOMx, PR, VI, AS, CNMI, Guam, HI, PRIA
Smalltooth sawfish (*Pristis pectinata*), U.S. populations	E – 68 FR 15674	74 FR 3566	74 FR 45353 – FL, GOMx	FL
Green sea turtle (*Chelonia mydas*), North Atlantic DPS	T – 81 FR 20057 (original listing 1978)	10/1991 – U.S. Atlantic	63 FR 46693 - PR	FL, GOMx, PR, VI
Green sea turtle (*Chelonia mydas*), South Atlantic DPS	T – 81 FR 20057	63 FR 28359	----	GOMx, PR, VI
Green sea turtle (*Chelonia mydas*), Central West Pacific DPS	E – 81 FR 20057	63 FR 28359	----	CNMI, Guam
Green sea turtle (*Chelonia mydas*), Central South Pacific DPS	E – 81 FR 20057	63 FR 28359	----	AS, PRIA
Green sea turtle (*Chelonia mydas*), Central North Pacific DPS	T – 81 FR 20057	63 FR 28359	----	HI, PRIA
Hawksbill sea turtle (*Eretmochelys imbricata*)	E – 35 FR 8491	12/1993	63 FR 46693 - PR	FL, GOMx, PR, VI, AS, CNMI, Guam, HI, PRIA
Leatherback sea turtle (*Dermochelys coriacea*)	E – 35 FR 8491, June 2, 1970	63 FR 28359	44 FR 17710 – USVI	FL, GOMx, PR, VI, AS, CNMI, Guam, HI
Loggerhead sea turtle (*Caretta caretta*), Northwest Atlantic DPS	T – 76 FR 58868, September 22, 2011 (original listing 1978)	63 FR 28359	79 FR 39855 – FL, GOMx	FL, GOMx, PR, VI
Loggerhead sea turtle (*Caretta caretta*), South Pacific DPS	E – 76 FR 58868, September 22, 2011	----	----	Samoa
Loggerhead sea turtle (*Caretta caretta*), North Pacific DPS	E – 76 FR 58868, September 22, 2011	----	----	CNMI, Guam, HI
Kemp's ridley sea turtle (*Lepidochelys kempii*)	E – 35 FR 18319, December 2, 1970	09/2011	----	FL, GOMx
Olive ridley sea turtle (*Lepidochelys olivacea*), all other populations (other than Mexico's breeding populations)	T – 43 FR 32800	----	----	FL, AS, CNMI, Guam, HI

Olive ridley sea turtle (*Lepidochelys olivacea*), Mexico's breeding populations)	E – 43 FR 32800	----	----	HI, PRIA
Elkhorn coral (*Acropora palmata*)	T – 71 FR 26852, May 9, 2006, and 79 FR 53852, September 10, 2014	80 FR 12146	73 FR 72210	FL, GOMx, PR, VI
Staghorn coral (*Acropora cervicornis*)	T – 71 FR 26852, May 9, 2006, and 79 FR 53852, September 10, 2014	80 FR 12146	73 FR 72210	FL, GOMx, PR, VI
Lobed star coral (*Orbicella annularis*)	T – 79 FR 53852, September 10, 2014	----	85 FR 76302 (Proposed)	FL, GOMx, PR, VI
Boulder star coral (*Orbicella franksi*)	T – 79 FR 53852, September 10, 2014	----	85 FR 76302 (Proposed)	FL, GOMx, PR, VI
Mountainous star coral (*Orbicella faveolata*)	T – 79 FR 53852, September 10, 2014	----	85 FR 76302 (Proposed)	FL, GOMx, PR, VI
Pillar coral (*Dendrogyra cylindrus*)	T – 79 FR 53852, September 10, 2014	----	85 FR 76302 (Proposed)	FL, PR, VI
Rough cactus coral (*Mycetophyllia ferox*)	T – 79 FR 53852, September 10, 2014	----	85 FR 76302 (Proposed)	FL, PR, VI
Acropora globiceps, Coral	T – 79 53852, September 10, 2014	----	85 FR 76262 (Proposed)	AS, CNMI, Guam, NWHI, PRIA
Acropora jacquelineae, Coral	T – 79 53852, September 10, 2014	----	85 FR 76262 (Proposed)	AS[9]
Acropora retusa, Coral	T – 79 53852, September 10, 2014	----	85 FR 76262 (Proposed)	AS, CNMI, Guam, PRIA

[9] One colony of this species was reported in 2008 on Tutuila, but the species has not been observed in more recent monitoring (Smith 2021a).

Acropora speciosa, Coral	T – 79 53852, September 10, 2014	----	85 FR 76262 (Proposed)	AS, PRIA
Euphyllia paradivisa, Coral	T – 79 53852, September 10, 2014	----	85 FR 76262 (Proposed)	AS
Isopora crateriformis, Coral	T – 79 53852, September 10, 2014	----	85 FR 76262 (Proposed)	AS
Seriatopora aculeata, Coral	T – 79 53852, September 10, 2014	----	85 FR 76262 (Proposed)	CNMI, Guam[10]
Chambered Nautilus (*Nautilus pompilius*)	T – 83 FR 48976	----	----	AS
T = threatened, E = endangered, FL = Florida, GOMx = Gulf of Mexico, PR = Puerto Rico, VI = Virgin Islands, AS = American Samoa, CNMI – Commonwealth of the Northern Mariana Islands, HI – Hawaii, PRIA – Pacific Remote Island Areas				

Essential Fish Habitat

The CRCP identified affected and potentially affected EFH designated by four fishery management councils and implemented by NMFS' Pacific Islands and Southeast Regional Offices. Those designations are subject to change through the councils' process as described by an amendment published in the Federal Register. At the time of this consultation, the information on the EFH designations in the CRCP EFH Assessment (NOAA CRCP 2021) reflects affected EFH. It will remain the obligation of the CRCP to be aware of changes to EFH designations where CRCP activities take place and the information in the EFH Assessment (NOAA CRCP 2021) should be updated annually (e.g., as part of an annual programmatic consultation review).

EFH resources in the action area include EFH under the Western Pacific Regional Fishery Management Council (WPRFMC), the Gulf of Mexico Fishery Management Council (Gulf Council), the South Atlantic Fishery Management Council (SAFMC), and the Caribbean Fishery Management Council (CFMC).

The WPRFMC has EFH designations for bottomfish and seamount groundfish, crustaceans, and pelagic and precious corals. The WPRFMC has designated EFH for these management unit species in American Samoa, Guam, and CNMI as all bottom habitat from the shoreline to a depth of 400 m (1,312 ft); and the water column from the shoreline to the Exclusive Economic Zone

[10] A colony of this species was recorded in Guam in 2008 and another in 2010, but no colonies were recorded in more recent surveys. Colonies of the species were observed in Saipan in 2011, but have not been observed in more recent monitoring (Smith 2021a).

(EEZ), and from the surface to 1,000 m (3,281 ft). The WPRFMC has designated EFH for Hawaii as all bottom habitat from the shoreline to a depth of 400 m (1,312 ft), and the outer reef slopes at depths between 400 and 700 m (1,312 to 2,297 ft); and the water column from the shoreline to the EEZ, and from the surface to 1,000 m (3,281 ft). CRCP identified EFH designated by the WPRFMC that is identified and described in the following fishery management plans[11] (FMPs) as EFH that may be adversely affected by the proposed action:

- Marianas Archipelago Fishery Ecosystem Plan;
- American Samoa Archipelago Fishery Ecosystem Plan;
- Hawaii Archipelago Fishery Ecosystem Plan;
- Pacific Remote Islands Areas Fishery Ecosystem Plan; and
- Pacific Pelagic Fishery Ecosystem Plan.

The Gulf Council has designated EFH and Habitat Areas of Particular Concern (HAPCs). CRCP identified EFH designated by the Gulf Council that is identified and described in the following FMPs[12] as EFH that may be adversely affected by the proposed action: Red Drum Fishery Management Plan (FMP), Reef Fish FMP, Coral and Coral Reefs FMP, Spiny Lobster FMP, Coastal Migratory Pelagic FMP, and Shrimp FMP.

CRCP identified EFH designated by the SAFMC that is identified and described in the following FMPs[13] as EFH that may be adversely affected by the proposed action: Spiny Lobster FMP, Shrimp FMP, Snapper-Grouper FMP, Coastal Migratory Pelagic FMP, and Coral, Coral Reefs, and Live/Hard Bottom Habitat FMP. The SAFMC has also designated HAPCs for the shrimp, snapper-grouper, spiny lobster, and coral FMPs and for specific species under the coastal migratory pelagic and snapper-grouper FMPs.

CRCP identified EFH designated by the CFMC that is identified and described in the following FMPs[14] as EFH that may be adversely affected by the proposed action: Reef Fish FMP, Coral and Reef-Associated Plants and Invertebrates FMP, Spiny Lobster FMP, and Queen Conch FMP. The CFMC has also designated HAPCs considered ecologically important habitats for coral in Puerto Rico and St. Croix; spawning habitats for reef fish in Puerto Rico, St. Croix, and St. Thomas; and ecologically important habitats for reef fish in Puerto Rico, St. Thomas, and St. Croix.

In addition, areas identified as EFH under the Secretarial Atlantic Highly Migratory Species FMP managed by NMFS Highly Migratory Species program are present in the action area.

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[11] http://www.fisherycouncils.org/western-pacific
[12] http://www.fisherycouncils.org/gulf-of-mexico
[13] http://www.fisherycouncils.org/south-atlantic
[14] http://www.fisherycouncils.org/caribbean

5.1 ESA-Listed Species and Designated Critical Habitat Not Likely to be Adversely Affected

In the case of the proposed action, ESA-listed species and designated critical habitat occur in waters that may be affected by the stressors resulting from the CRCP (Section 3.2) and Mission Iconic Reefs (Section 3.3) activities.

NMFS uses two criteria to identify the ESA-listed or designated critical habitat 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 action and ESA-listed species or designated critical habitat. The second criterion is the probability of a response given exposure. We applied these criteria to the ESA-listed species in Table 8 and we summarize our results below and in Section 7 of this opinion.

The probability of an effect on a species or designated critical habitat 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 listed species), but it is very unlikely to occur (NMFS and USFWS 1998).

For purposes of the effects analysis below, we use the term discountable with respect to effects when we have determined that the stressor is extremely unlikely to cause an effect to a species or designated critical habitat. Similarly, we use the term insignificant when we have determined that a stressor will cause an effect to a listed species or designated critical habitat but the effect will be so minor that the effect is undetectable, not measurable, or so minor that it cannot be meaningfully evaluated. While these criteria are relied on to support each insignificant or discountable conclusion, they are not repeated below.

5.1.1 ESA-Listed Marine Mammals

Fin, Blue and Sei Whales

Fin, blue and sei whales have a global distribution and may be found in the action area, as described below.

Fin whales are considered rare in Hawaiian waters, but occasional sightings have been reported in Hawaii's EEZ. Oleson et al. (2014) recorded fin whale song in Hawaii's EEZ from October through April and reported sightings have occurred in late summer/fall and spring with the most recent of two animals in 2017 (Carretta et al. 2021). In the U.S. Atlantic EEZ, it is likely that fin whales undergo migrations into Canadian waters, open ocean, and potentially subtropical or tropical regions (Hayes et al. 2021). Data from the Navy's Sound Surveillance System (SOSUS) have indicated fin whales to be largely distributed in the deep ocean (Hayes et al. 2021). Sei whales in the Pacific are distributed far out to sea and do not appear to be associated with coastal features. Sei whales in the U.S. Pacific EEZ include animals that have been sighted during summer/fall shipboard surveys in Hawaii's EEZ (Carretta et al. 2018). In the Atlantic, the general pattern of sei whale distribution is offshore but animals occasionally move to shallower nearshore waters in the northeastern U.S. (Hayes et al. 2021). The distribution of these animals in more southern waters is not known but they are likely rare. In the Pacific, some blue whales migrate to lower latitudes in the western and central Pacific in the winter, including Hawaii (Stafford et al. 2001). Other blue whales, those that feed off the coast of California, may be present in Hawaii's EEZ in summer (Carretta et al. 2018). Blue whales have also been sighted with fin whales in waters of Hawaii's EEZ (Carretta et al. 2018). In the Atlantic, the blue whale is considered an occasional visitor in U.S. Atlantic EEZ waters (Hayes et al. 2018). Blue whales have also been tracked acoustically through SOSUS in subtropical waters north of the West Indies and are thought to have a broad longitudinal distribution in tropical and warm temperature latitudes during the winter months (Hayes et al. 2020). Given the distribution of fin, sei, and blue whales in deep waters of the EEZ of U.S. jurisdictions in the Atlantic and Pacific, the low number of sightings of these animals in these areas, and the concentration of CRCP and Mission:Iconic Reefs activities in nearshore, shallower waters, we believe it is extremely unlikely that animals from these three species would be exposed to stressors associated with the proposed action and, thus, the effects of the proposed action on these species will be discountable. Therefore, we conclude that the proposed action may affect, but is unlikely to adversely affect fin, sei, and blue whales.

Sperm Whale

Sperm whales have a global distribution and may be found in the action area. The Hawaiian Islands marked the center of a major nineteenth century whaling ground for sperm whales and this species continues to be sighted throughout Hawaii's EEZ, as well as in nearshore waters of the MHI and NWHI (Carretta et al. 2021). Sperm whale sounds have been recorded year-round in these areas as well and summer/fall shipboard surveys in Hawaii's EEZ have reported sightings of 24 to 46 animals in 2002, 2010, and 2017 (Carretta et al. 2021). In the Atlantic, there is an offshore distribution of sperm whales off the southeast U.S. and large and small adults, calves and juveniles are reported in the southeast Caribbean (Hayes et al. 2020). Seasonal aerial surveys confirm that sperm whales are present in the northern Gulf of Mexico year-round though sightings indicate they are in deep waters of the Gulf (Hayes et al. 2021). Sperm whales were commercially hunted in the Caribbean Sea until the early 1900s and Puerto Rico was one of the areas where hunters targeted this species (Waring and et al. 2010). NOAA winter ship surveys in waters surrounding Puerto Rico and USVI indicate sperm whales are present in continental slope and oceanic waters. Sperm whales in the U.S. Caribbean are most common from late fall to early spring and are rare from April to September (Waring and et al. 2010). Unlike other large whale species considered in this opinion, sperm whales may be present close to shore on the shelf in the Hawaiian Islands and the U.S. Caribbean and may be present year-round in the Hawaiian Islands and throughout the fall, winter and spring in the U.S. Caribbean. Thus, sperm whales may be exposed to stressors associated with the proposed action, particularly stressors from vessel operation, operation of acoustic sensors, use of equipment with lines in the water, use of fishing gear, and the introduction of contaminants.

In terms of the potential for vessel strike, vessel operation will follow the required BMPs and given the size of sperm whales, it is likely that these animals would be sighted prior to any encounter with a vessel. In addition, no collisions with sperm whales have been reported during past CRCP activities. Therefore, we believe the effects of vessel strike on sperm whales will be discountable. In terms of acoustic sensors used during activities such as mapping, while the sounds produced by these sensors are within the hearing range of sperm whales, these activities are infrequent, particularly in the Pacific, and, because the sensors are deployed such that sounds are focused downward from the vessel or towed array, animals would have to remain within the cone of sound in order to be affected. Sperm whales are likely to swim away from a vessel and are not expected to remain within the ensonified area. Therefore, we believe the effects of sounds produced by acoustic sensors during activities associated with the proposed action on sperm whales will be discountable. In terms of the potential for entanglement associated with lines in the water from in-water structures and towed equipment, and the use of certain fishing gear, we believe the effects of this stressor on sperm whales are discountable for the following reasons: whales are likely to be sighted prior to any encounter with towed equipment or fishing gear occurring; whales are likely to swim away from vessels towing equipment or fishing gear; and in-water structures are typically placed in reef habitats with clearance in the water column between the structure and associated lines and the water surface. In addition, no entanglement of sperm whales or other marine mammals has been reported during past CRCP activities and the required BMPs associated with the use of equipment, fishing gear, and installation of in-water structures and equipment with lines in the water will be followed, further minimizing the potential for entanglement. Lines associated with towed equipment and in-water structures and instruments are kept taut and kept to the minimum length necessary depending on the structure or instrument and tackle system to reduce any possibility for entanglement. Therefore, we believe the effects of entanglement on sperm whales associated with the proposed action are discountable. In terms of the introduction of contaminants such as tracer dyes, treatments for diseased corals, or lubricants and other products used on in-water equipment, the volume of material that would enter the water column would be insignificant for a mobile animal as large as a sperm whale that is likely to be transiting through any areas where contaminants from CRCP activities enter the water. In addition, any contaminants are expected to be rapidly diluted to undetectable concentrations in the water column. Tracer dyes, lubricants, and other materials are not known to be toxic to sperm whales. Therefore, we believe the effects of the introduction of contaminants to the water column as a result of the proposed action on sperm whales will be insignificant. We conclude that the proposed action may affect, but is unlikely to adversely affect sperm whales.

Rice's Whale

Rice's (formerly Gulf of Mexico Bryde's) whale occurs almost exclusively in the northeastern Gulf of Mexico in the De Soto Canyon area along the continental shelf break between 100 and 400 m (328-1,312 ft) depth (Hayes et al. 2021). Historical whaling records from the 1800s suggest this whale may have been more common in U.S. waters of the north central and southern Gulf of Mexico (Hayes et al. 2021). All but one verified sightings of Rice's whale occur in a very restricted area of the Gulf of Mexico during surveys that uniformly sample the entire Gulf. The population size is estimated to be 51 animals. None of the Mission: Iconic Reefs activities occur where Rice's whales are present. There are deep water coral resources in De Soto Canyon so there may be a possibility for CRCP-sponsored activities in areas occupied by Rice's whale in the future but the CRCP is largely focused on nearshore, shallow water areas. Based on the distribution of this species versus the location of CRCP activities in the Gulf of Mexico, it is extremely unlikely that Rice's whales would be exposed to stressors associated with the proposed action. Therefore, we believe the effects of the proposed action on Rice's whale are extremely unlikely to occur and thus discountable. We conclude that the proposed action may affect, but is unlikely to adversely affect Rice's whale.

North Atlantic Right Whale

North Atlantic right whales are found along the east coast of the U.S., including in waters in the northern part of Florida's coral reef ecosystem though there are some rare sightings in the Gulf of Mexico representing individuals outside the primary calving and wintering ground in the southeastern U.S. (Hayes et al. 2021). The majority of right whales are found within 90 km of the shoreline based on surveys conducted from 1996 to 2018 (Hayes et al. 2020). Right whales aggregate in the winter in the southeastern U.S. including Florida, but the main calving grounds that are part of the designated critical habitat for right whales extend to Brevard County, Florida, which is outside the action area for this consultation. Because rare sightings of right whales in the Florida portion of the Gulf of Mexico have been reported and the tendency of the animals to be closer to shore than many other whale species, there is a possibility that right whales could be exposed to stressors associated with the proposed action. However, given the main distribution of this species being outside the action area, we believe the effects of the proposed action are discountable as exposure is extremely unlikely to occur. We conclude that the proposed action may affect, but is unlikely to adversely affect North Atlantic right whale.

North Pacific Right Whale

North Pacific right whales generally occur in more northerly, higher latitude areas during the summer and temperate areas during the winter, but have been reported as far south as Hawaii. A right whale was sighted in March and April 1979 off Hawaii (Muto et al. 2021). A right whale was also sighted off Maui in April 1996 and identified 119 days later in the Bering Sea (Kennedy et al. 2012), which is the only low- to high-latitude match of an identified individual right whale in the eastern North Pacific (Muto et al. 2021). Given the lack of recent sightings of this species and the main distribution of North Pacific right whale further north, outside the Pacific Ocean portion of the action area, we believe the effects of the proposed action are discountable as exposure is extremely unlikely to occur. We conclude that the proposed action may affect, but is unlikely to adversely affect North Pacific right whale.

Western North Pacific DPS Humpback Whale

The Western North Pacific DPS humpback whale consists of winter/spring populations off Asia that migrate to Russia and the Bering Sea, including around the Aleutian Islands (Muto et al. 2021). CNMI and Guam are considered part of the wintering area of the Western North Pacific DPS humpback whale. Humpback whale songs were infrequently detected at Tinian from June to October (DoN 2019). The presence of newborn calves and competitive groups of whales documented during small boat surveys confirm the Mariana Islands as a breeding location for Western North Pacific DPS humpback whales. Researchers now believe that the Mariana Islands are not only used as a breeding area but as a winter calving area for humpback whales because individual females have been recorded returning to the islands. Navy aerial monitoring surveys at FDM conducted monthly from 1997-2009 and irregularly thereafter documented the occasional presence of humpback whales, including mother-calf pairs and other adult individuals (DoN 2019). Small boat surveys in 2010 and 2014 off Guam, Saipan, Tinian, Aguijan, and Rota did not encounter humpback whales (Hill et al. 2014) but whales were documented at Chalan Kanoa Reef off Saipan Hill from February 26 to March 8, 2015 (Hill et al. 2016). Humpback whales were seen again off Saipan during Navy-funded surveys in January through March of 2016, 2017, and 2018 (Hill et al. 2017; Hill et al. 2018; Hill et al. 2020a; Hill et al. 2020b). Ecological Acoustic Recorder data collected off Pagan and Maug from April 2009 to October 2010 indicate that humpback whales may occur around other islands of the archipelago (Munger et al. 2012). Thus, adults and calves may be exposed to stressors associated with the proposed action in the area of CNMI and Guam, particularly stressors from vessel operation, operation of acoustic sensors, use of equipment with lines in the water, use of fishing gear, and the introduction of contaminants.

In terms of the potential for vessel strike, vessel operation will follow the required BMPs and given the size of Western North Pacific DPS humpback whales, it is likely that these animals would be sighted prior to any encounter with a vessel. In addition, no collisions with Western North Pacific DPS humpback whales have been reported during past CRCP activities and CRCP operations involving vessels in Guam and CNMI are infrequent. Therefore, we believe the effects of vessel strike on Western North Pacific DPS humpback whales will be discountable. In terms of acoustic sensors used during activities such as mapping, while the sounds produced by these sensors are within the hearing range of Western North Pacific DPS humpback whales, these activities are infrequent, particularly in the Pacific, and, because the sensors are deployed such that sounds are focused downward from the vessel or towed array, animals would have to remain within the cone of sound in order to be affected. Western North Pacific DPS humpback whales are likely to swim away from a vessel and are not expected to remain within the ensonified area. Therefore, we believe the effects of sounds produced by acoustic sensors during activities associated with the proposed action on Western North Pacific DPS humpback whales will be discountable. In terms of the potential for entanglement associated with lines in the water from in-water structures and towed equipment, and the use of certain fishing gear, we believe the effects of this stressor on Western North Pacific DPS humpback whales are discountable for the following reasons: whales are likely to be sighted prior to any encounter with towed equipment or fishing gear occurring and these types of activities are infrequent in this portion of the action area; whales are likely to swim away from vessels towing equipment or fishing gear; and in-water structures are typically placed in reef habitats with clearance in the water column between the structure and associated lines and the water surface. In addition, no entanglement of Western North Pacific DPS humpback whales or other marine mammals has been reported during past CRCP activities and the required BMPs associated with the use of equipment, fishing gear, and installation of in-water structures and equipment with lines in the water will be followed, further minimizing the potential for entanglement. Lines associated with towed equipment and in-water structures and instruments are kept taut and kept to the minimum length necessary depending on the structure or instrument and tackle system to reduce any possibility for entanglement. Therefore, we believe the effects of entanglement on Western North Pacific DPS humpback whales associated with the proposed action are discountable. In terms of the introduction of contaminants such as tracer dyes, treatments for diseased corals (which is currently not being done in the U.S. Pacific), or lubricants and other products used on in-water equipment, the volume of material that would enter the water column would be insignificant for a mobile animal as large as a Western North Pacific DPS humpback whale that is likely to be transiting through any areas where contaminants from CRCP activities enter the water. In addition, any contaminants are expected to be rapidly diluted to undetectable concentrations in the water column. Tracer dyes, lubricants, and other materials are not known to be toxic to Western North

Pacific DPS humpback whales. Therefore, we believe the effects of the introduction of contaminants to the water column as a result of the proposed action on Western North Pacific DPS humpback whales will be insignificant. We conclude that the proposed action may affect, but is unlikely to adversely affect humpback whales.

Main Hawaiian Islands Insular False Killer Whale and Designated Critical Habitat

The Main Hawaiian Islands Insular False Killer Whale (MHI IFKW) occurs in nearshore waters of the MHI and is genetically distinct from false killer whales in the Northwest Hawaiian Islands and other U.S. Pacific jurisdictions (Carretta et al. 2021). The MHI IFKW inhabits waters up to 72 km around the MHI (2020 stock assessment). Thus, MHI IFKW may be exposed to stressors associated with the proposed action, particularly stressors from vessel operation, operation of acoustic sensors, use of equipment with lines in the water, use of fishing gear, and the introduction of contaminants.

In terms of the potential for vessel strike, vessel operation will follow the required BMPs. In addition, no collisions with MHI IFKW have been reported during past CRCP activities, although these animals have been sighted from NOAA ships (Carretta et al. 2021). These animals are highly maneuverable and can change direction rapidly to avoid vessels. Therefore, we believe the effects of vessel strikes on MHI IFKW will be discountable. In terms of acoustic sensors used during activities such as mapping, while the sounds produced by these sensors are within the hearing range of MHI IFKW, these activities are infrequent in the Pacific, and, because the sensors are deployed such that sounds are focused downward from the vessel or towed array, animals would have to remain within the cone of sound in order to be affected. MHI IFKW are not expected to remain within the ensonified area, but, if they did, they could be exposed to sounds within their hearing range for a short time while the vessel moves past the animals. However, given the infrequent nature of these types of activities in the Pacific, as well as the size of the water area where surveys would occur, the likelihood of encounter is expected to be low. Therefore, we believe the effects of sounds produced by acoustic sensors during activities associated with the proposed action on MHI IFKW will be discountable. In terms of the potential for entanglement associated with lines in the water from in-water structures and towed equipment, and the use of certain fishing gear, we believe the effects of this stressor on MHI IFKW are discountable because whales are likely to be sighted prior to any encounter with towed equipment or fishing gear occurring, whales are likely to swim away from vessels towing equipment or fishing gear, and in-water structures are typically placed in reef habitats with clearance in the water column between the structure and associated lines and the water surface. In addition, no entanglement of MHI IFKW or other marine mammals has been reported during past CRCP activities and the required BMPs associated with the use of equipment, fishing gear, and installation of in-water structures and equipment with lines in the water will be followed, further minimizing the potential for entanglement. Lines associated with towed equipment and in-water structures and instruments are kept taut and kept to the minimum length necessary depending on the structure or instrument and tackle system to reduce any possibility for entanglement. Therefore, we believe the effects of entanglement on MHI IFKW associated with the proposed action are discountable. In terms of the introduction of contaminants such as tracer dyes, treatments for diseased corals, or lubricants and other products used on in-water equipment, the volume of material that would enter the water column would be insignificant for a mobile animal like the MHI IFKW that is likely to be transiting through any areas where contaminants from CRCP activities enter the water. It is also important to note that SCTLD and associated disease treatment occurs only in the Atlantic/Caribbean. In addition, any contaminants are expected to be rapidly diluted to undetectable concentrations in the water column. Tracer dyes, lubricants, and other materials are not known to be toxic to MHI IFKW. Therefore, we believe the effects of the introduction of contaminants to the water column as a result of the proposed action on MHI IFKW will be insignificant. We conclude that the proposed action may affect, but is unlikely to adversely affect MHI IFKW.

Critical habitat was designated for the MHI IFKW in 2018 and includes waters from the 45 m depth contour to the 3,200 m depth contour around the MHI. The designated critical habitat includes one PBF essential for conservation of the species, with the following four characteristics:

- Adequate space for movement and use within shelf and slope habitat;
- Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth;
- Waters free of pollutants of a type and amount harmful to MHI IFKWs; and
- Sound levels that would not significantly impair false killer whales' use or occupancy.

The final rule to designate critical habitat identified several activities that may threaten the PBF essential to conservation such that species management considerations or protections may be required. Major categories of activities included in the final rule were (1) in-water construction (including dredging); (2) energy development (including renewable energy projects); (3) activities that affect water quality; (4) aquaculture/mariculture; (5) fisheries; (6) environmental restoration and response activities (including responses to oil spills and vessel groundings, and marine debris cleanup activities); and (7) some military readiness activities.

Some CRCP activities, particularly marine debris cleanup and watershed activities (that may have short-term negative effects on water quality), fall within the list of activities that may threaten the function of MHI IFKW critical habitat. However, CRCP activities are typically small in scale and are largely conducted in waters shallower than 45 m (148 ft), and designated critical habitat begins at this depth contour. While watershed activities may have adverse effects on water quality during construction of stormwater management and soil stabilization controls, the effects will be short-term and there will be a long-term improvement in water quality as a result of these activities. Therefore, the effects of CRCP activities on MHI IFKW designated critical habitat will be insignificant. We conclude that the proposed action may affect, but is unlikely to adversely affect MHI IFKW designated critical habitat.

Hawaiian Monk Seal and Designated Critical Habitat

The Hawaiian monk seal is distributed throughout the NWHI with subpopulations at French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Atoll, Kure Atoll, and Necker and Nihoa Islands. Hawaiian monk seals also occur throughout the MHI. There are six main breeding subpopulations in the NWHI on Kure Atoll, Midway Islands, Pearl and Hermes Reef, Lisianski Island, Laysan Island, and French Frigate Shoals. Hawaiian monk seals are mostly solitary and do not live in colonies. Monk seals haul out on beaches and shorelines composed of sand, rubble and volcanic rock. Monk seals are generalist feeders and diet studies indicate that they forage on or near the seafloor and target prey species that hide in the sand or under rocks including eels, crustaceans and octopi. They use waters surrounding atolls and islands and areas further offshore on reefs and submerged banks, including foraging in deep and shallow coral areas. The majority of the Hawaiian monk seal population is found in the NWHI (approximately 1,100 individuals) with only about 300 individuals living in the MHI. CRCP activities in the NWHI are largely confined to in-water biological surveys so Hawaiian monk seals in these areas would mainly be exposed to stressors associated with vessel operations and visual disturbance due to the presence of divers in the water. In the MHI, the range of activities described in Section 3.2 may occur, meaning the small population of Hawaiian monk seals in these islands may be exposed to the full range of stressors associated with CRCP activities.

In terms of the potential for vessel strike, vessel operation will follow the required BMPs. In addition, no collisions with Hawaiian monk seals have been reported during past CRCP activities. These animals are highly maneuverable and can change direction rapidly to avoid vessels. In NWHI, vessel operations associated with CRCP activities are infrequent, largely associated with triannual NCRMP activities. In the MHI, vessel operations associated with CRCP activities may occur more frequently as vessels are used for more than triannual NCRP surveys but do not contribute in any measurable way to the marine vessel traffic around the islands. Therefore, we believe the effects of vessel strike on Hawaiian monk seals will be discountable. In terms of acoustic sensors used during activities such as mapping, while the sounds produced by these sensors are within the hearing range of Hawaiian monk seals, these activities are infrequent in the Pacific, and, because the sensors are deployed such that sounds are focused downward from the vessel or towed array, animals would have to remain within the cone of sound in order to be affected. Seals are not skittish and so could remain within the ensonified area, but, given the infrequent nature of these activities in the Pacific and the short period of time during which animals would be exposed, as well as the size of the in-water area where these activities could occur, the likelihood of exposure is expected to be low. Therefore, we believe the effects of sounds produced by acoustic sensors during activities associated with the proposed action on Hawaiian monk seals will be discountable.

In terms of the potential for entanglement associated with lines in the water from in-water structures and towed equipment, we believe the effects of this stressor on Hawaiian monk seals are discountable because seals are likely to be sighted prior to any encounter with towed equipment occurring, seals are likely to swim away from vessels towing equipment, and in-water structures are typically placed in reef habitats with clearance in the water column between the structure and associated lines and the water surface. Lines associated with towed equipment and in-water structures and instruments are kept taut and kept to the minimum length necessary depending on the structure or instrument and tackle system to reduce any possibility for entanglement. In terms of fishing gear, entanglement in fishing gear is considered a significant threat to Hawaiian monk seals. In the NWHI, seals have been entangled in gear that apparently drifts into the area from other places. Hooking of seals often occurs in the MHI largely due to shoreline fishing. Any fishing gear used during CRCP activities will be done in compliance with the required BMPs (Section 3.5.1), and gear that has been documented as leading to seal entanglement are different types of nets, which are not used frequently in CRCP activities, and hooking associated with shoreline fishing rather than fishing from vessels. Fishing gear used during CRCP activities will be tended, meaning there is little possibility of the gear becoming marine debris, which is a common source of entanglement for Hawaiian monk seals (Carretta et al. 2021). In addition, no entanglement of Hawaiian monk seal or other marine mammals has been reported during past CRCP activities and the required BMPs associated with the use of equipment, fishing gear, and installation of in-water structures and equipment with lines in the water will be followed, further minimizing the potential for entanglement. Therefore, we believe the effects of entanglement on Hawaiian monk seals associated with the proposed action are discountable.

In the MHI, Hawaiian monk seals of various life stages could experience visual disturbance due to the presence of vessels and divers and snorkelers in the water, and people and equipment on shorelines. In the NWHI, CRCP activities take place in the water only and are infrequent, with NCRMP surveys conducted on a triennial basis. In the MHI, both in-water and land-based CRCP activities may occur throughout the year, including in-water surveys and watershed activities. Visual disturbance of animals that might be encountered during in-water activities would be short-term as activities such as monitoring, instrument installation and operation, and vessel operations are conducted over short periods. All activities will follow the required BMPs (Section 3.5.1), including the training of volunteers and others participating in watershed activities on the importance of minimizing disturbance of native fauna. Thus, any visual disturbance of animals would be temporary and not likely to result in measurable changes in behavior. Therefore, the effects of visual disturbance as a result of the proposed action will be insignificant.

In terms of the introduction of contaminants such as tracer dyes, treatments for diseased corals, or lubricants and other products used on in-water equipment, the volume of material that would enter the water column would be insignificant for a mobile animal like the Hawaiian monk seal that is likely to be transiting through any areas where contaminants from CRCP activities enter the water. It is also important to note that SCTLD and associated disease treatment occurs only in the Atlantic/Caribbean. In addition, any contaminants are expected to be rapidly diluted to undetectable concentrations in the water column. Tracer dyes, lubricants, and other materials are not known to be toxic to monk seals. Contaminants such as sediment may also be introduced to areas used by monk seals from watershed activities. However, any plumes would be minimal due to implementation of the required BMPs and short-term, and the overall water quality downstream of watershed activities associated with stormwater management and erosion control is expected to improve in the long-term. Therefore, we believe the effects of the introduction of contaminants to the water column as a result of the proposed action on Hawaiian monk seals will be insignificant. We conclude that the proposed action may affect, but is unlikely to adversely affect Hawaiian monk seals.

Hawaiian monk seal critical habitat was originally designated in 1986 and extended in 1988. It includes all beach areas, sand spits, and islets (including all beach crest vegetation to its deepest extent inland), lagoon waters, and inner reef waters. The earlier designation included ocean waters out to a depth of 20 fathoms (37 m) around the NWHI breeding atolls and islands, but this was revised in 2015. The revised designation extended the boundary of critical habitat in the NWHI out to the 200 m depth contour (including Kure Atoll, Midway Islands, Pearl and Hermes Reef, Lisianski Island, Laysan Island, Maro Reef, Gardner Pinnacles, French Frigate Shoals, Necker Island, and Nihoa Island). It also designated six new areas in the MHI (i.e., terrestrial and marine habitat from 5 m inland from the shoreline extending seaward to the 200 m depth contour around Kaula, Niihau, Kauai, Oahu, Maui Nui, and Hawaii).

The PBFs of designated critical habitat for monk seals essential for the conservation of the species include the following:

- Terrestrial areas and adjacent shallow, sheltered aquatic areas with characteristics preferred by monk seals for pupping and nursing;
- Marine areas from 0 to 200 m deep that support adequate prey quality and quantity for juvenile and adult monk seal foraging; and
- Significant areas used by monk seals for hauling out, resting, or molting.

As stated previously, CRCP activities in the NWHI only occur in the water. Thus, CRCP activities in the NWHI may affect marine areas that contain the PBFs of monk seal designated critical habitat. CRCP activities in the MHI could take place in or lead to short-term effects to terrestrial areas and adjacent sheltered aquatic areas where monk seals may pup if these areas are associated with watersheds where construction of stormwater management or erosion control measures take place. These activities could lead to temporary effects to water quality during construction, though these are expected to be minimal due to the implementation of the required

BMPs to minimize sediment and other contaminant transport downstream during construction activities. None of the CRCP activities would result in a reduction in prey quality and quantity. If biological sampling such as that using fishing gear occurs in areas of monk seal critical habitat, the sampling would be of limited scope with few gear types typically deployed from a single vessel over a short period and would not be expected to catch quantities of prey species that would lead to a measurable decline in prey availability. Similarly, any contaminant transport to nearshore waters during construction in watersheds would be temporary and is not expected to reduce the amount of prey available to monk seals. No effects to important haul out, resting or molting areas are expected as a result of CRCP activities. Therefore, any effects to monk seal critical habitat as a result of CRCP activities will be insignificant. We conclude that the proposed action may affect, but is unlikely to adversely affect Hawaiian monk seal designated critical habitat.

5.1.2 Giant Manta Ray, Oceanic Whitetip Shark, Smalltooth Sawfish and Smalltooth Sawfish Designated Critical Habitat

Giant manta rays are found worldwide in tropical, subtropical and temperate waters and are commonly found offshore in oceanic waters and in productive coastal areas. The species has also been observed in estuarine waters, oceanic inlets and in bays and intercoastal waterways (Miller and Klimovic 2017). Of the U.S. coral jurisdictions, sightings of the giant manta ray are more regular in Kona, Hawaii (Miller and Klimovich 2017), though the animal has also been reported in St. Thomas, USVI and San Juan, Puerto Rico. FGBNMS in the Gulf of Mexico has been found to have a population of giant manta rays and serve as juvenile habitat for the species and schools of manta rays were observed during aerial surveys off St. Augustine, Florida from 2009-2012 (Miller and Klimovic 2017). The main threats to the species are targeted fishing and bycatch.

The oceanic whitetip shark is usually found offshore in the open ocean, along the continental shelf, or around oceanic islands in waters from the surface to at least 200 m (656 ft) in depth. 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 Northwest and Central Atlantic, Gulf of Mexico and U.S. Caribbean, and Eastern, Central and West Pacific (Young et al. 2017). The primary threat to this species is bycatch in fisheries and abundance declines due largely to this threat have been estimated as 88% in the Gulf of Mexico and 80 to 95% across the Pacific Ocean since the mid-1990s. Oceanic whitetip are considered surface-dwelling sharks, which is largely the reason for high encounter rates and mortality in fisheries.

In most coral jurisdictions, giant manta rays and oceanic whitetip sharks are unlikely to be exposed to stressors associated with CRCP activities because they are more common in oceanic waters. If they were exposed to any stressors, such as during vessel operation, the effects would be short-term and infrequent. The exception is the population of giant manta rays in FGBNMS, which are present year-round. These animals could be exposed to stressors from vessel operation, sound-producing activities, visual disturbance, entanglement, and sediment resuspension. Giant manta rays are often at or near the water surface, though the size of the animals mean that individuals can be sighted from vessels. There have been no reported interactions between vessels and giant manta rays during CRCP activities. Thus, the effects of vessel operations on giant manta ray will be discountable. CRCP activities in FGBNMS have been associated mainly with NCRMP monitoring in FGBNMS, including the installation of ARM structures. The installation and removal of ARM and similar structures can cause temporary sediment plumes when the structures are placed on the seafloor or removed at the end of deployment. Visual disturbance from vessels and divers or snorkelers would be temporary during installation and removal of equipment, in-water surveys, and biological sampling. The effects of temporary sediment plumes and visual disturbance on giant manta ray will be insignificant. Giant manta rays could be entangled in lines associated with towed equipment, equipment installed on the seafloor, and fishing gear. However, implementation of the required BMPs will minimize the potential for interactions between these animals and any in-water or towed equipment or fishing gear. The effects of entanglement on giant manta rays will be discountable. In terms of the introduction of contaminants such as tracer dyes, treatments for diseased corals, or lubricants and other products used on in-water equipment, the volume of material that would enter the water column would be insignificant for a mobile animal like the giant manta ray that is likely to be transiting through any areas where contaminants from CRCP activities enter the water because the volume of contaminant will be too small to measure in the marine environments they enter. In addition, any contaminants are expected to be rapidly diluted to undetectable concentrations in the water column. Tracer dyes, lubricants, and other materials are not known to be toxic to giant manta rays. Watershed activities may involve the use of pesticides. Specifically, the use of glyphosate products is noted in the description of the action associated with spot treatment of bamboo as part of watershed activities on Guam (Section 3.2.3.6). In a recent request for consultation from EPA, the agency determined that "approximately 93% of all species and 96% of all critical habitats were given a likely to adversely affect determination and these species were distributed across all taxa" (EPA 2021) due to the toxicity of additives in many glyphosate products to fish. Species for which this effects determination was made included giant manta and smalltooth sawfish. Despite the potential toxicity of some pesticide products that may be used in spot applications to treat invasive or nuisance species of vegetation to giant manta ray, the limited use of these products (only used on Guam at this time) and the location where spot applications occur versus the size of the in-water area and patchy distribution of giant manta ray means exposure to any runoff of these chemicals would be rare. The required BMPs related to stormwater management also make it unlikely pesticides with toxicity to aquatic organisms would enter waterbodies in concentrations that would affect marine species such as giant manta ray. Therefore, we believe the effects of the introduction of contaminants into the water column as a result of the proposed action on giant manta ray will be insignificant.

Most fish species can hear sounds between 50 and 1,000 Hz with most ESA-listed fish studied (largely salmonids and sturgeon) having a hearing range below 400 Hz, so fish without hearing specialization (including elasmobranchs) are not expected to detect signals emitted by navigational and survey equipment that may be used during CRCP activities. Thus, the effects to giant manta ray from sounds produced by vessel operation and navigational equipment and sensors used during underwater investigations will be insignificant. We conclude that the proposed action may affect, but is unlikely to adversely affect giant manta ray and oceanic whitetip sharks.

In the U.S. smalltooth sawfish are most often found off the southwest coast of Florida from around Charlotte Harbor through the Everglades and Florida Keys, and the U.S. population of the species has been designated as threatened. The non-U.S. population of smalltooth sawfish is found in other countries in the Atlantic Ocean, particularly the Bahamas, though they may also be found off the coasts of Honduras, Belize, Cuba, and Guinea Bissau. Smalltooth sawfish use a variety of coastal habitats with juveniles preferring estuaries and shallow portions of bays, lagoons and rivers where they remain for their first two years. Juveniles have an affinity for warmer water less than 0.9 m (3 ft) deep. Once the fish reach approximately 2.1 m (7 ft) in length, they begin moving out of shallow estuaries into other coastal habitats. Older juveniles and adults can be found in estuaries, off beaches, and along deep water reefs.

Smalltooth sawfish could be exposed to stressors from in-water CRCP and Mission: Iconic Reefs and CRCP watershed activities in South Florida, including the Florida Keys year-round. In terms of the potential for vessel strike, juvenile smalltooth sawfish have been killed and injured by vessel operation because of their preference for very shallow estuarine waters where there may be limited opportunity for fish to avoid vessel propellers. However, vessel operation during CRCP and Mission: Iconic Reefs activities will follow the required BMPs and little CRCP (and no Mission: Iconic Reefs) in-water work is conducted in extremely shallow estuarine areas where these fish are likely to be present. Therefore, we believe the effects of vessel strike on smalltooth sawfish will be discountable. In terms of acoustic sensors used during activities such as mapping and noise from vessel operation and navigational equipment, the sounds produced are likely to be outside the hearing range of smalltooth sawfish. Therefore, we believe the effects of sounds produced by acoustic sensors, vessels, and navigational equipment during activities associated with the proposed action on smalltooth sawfish, if they are within the hearing range of the species, will be insignificant. Sounds outside the hearing range of the species will not affect smalltooth sawfish.

In terms of the potential for entanglement associated with lines in the water from in-water structures and towed equipment, we believe the effects of this stressor on smalltooth sawfish are discountable because the fish are likely to swim away from vessels towing equipment and in-water structures are typically placed in reef habitats rather than in areas where juvenile and adult sawfish are more likely to be concentrated. Lines associated with towed equipment and in-water structures and instruments are kept taut and kept to the minimum length necessary depending on the structure or instrument and tackle system to reduce any possibility for entanglement. In terms of fishing gear, entanglement in fishing gear is considered a threat to smalltooth sawfish. Biological sampling using fishing gear is uncommon in shallow waters where juvenile sawfish in particular are more frequent. When this type of sampling does occur, nets may be used. Tents are also used to collect coral gametes, but these are constantly monitored by divers in order to collect samples as gametes are released. No entanglement of smalltooth sawfish has been reported during past CRCP activities and the required BMPs associated with the use of equipment, fishing gear, and installation of in-water structures and equipment with lines in the water will be followed, further minimizing the potential for entanglement. Adult smalltooth sawfish could be present in areas where equipment, line nurseries for corals, or towed equipment may be used during CRCP activities. The design and requirements for lines and tackle associated with in-water equipment and structures will minimize the potential for entanglement of sawfish in nearshore waters. These fish tend to be on or near the bottom and have never been reported as entangled in any structures or equipment used as part of CRCP activities. Therefore, we believe the effects of entanglement on smalltooth sawfish associated with the proposed action are discountable.

Smalltooth sawfish juveniles and adults could experience visual disturbance due to the presence of vessels and divers and snorkelers in the water. In South Florida, both in-water and land-based CRCP activities may occur throughout the year, including in-water surveys and watershed activities, as could in-water Mission: Iconic Reefs activities. Visual disturbance of animals that might be encountered during in-water activities would be short-term as activities such as monitoring, instrument installation and operation, and vessel operations during CRCP activities and coral restoration and associated vessel operations associated with Mission: Iconic Reefs activities are conducted over short periods. All activities will follow the required BMPs (Section 3.5.1), including the training of volunteers and others participating in watershed activities on the importance of minimizing disturbance of native fauna. Thus, any visual disturbance of animals would be temporary and not likely to result in measurable changes in behavior. Therefore, the effects of visual disturbance to smalltooth sawfish as a result of the proposed action will be insignificant.

In terms of the introduction of contaminants such as tracer dyes, treatments for diseased corals, or lubricants and other products used on in-water equipment, the volume of material that would enter the water column would be insignificant and uncommon in the shallow water areas where younger juvenile sawfish may be concentrated. Any contaminants are expected to be rapidly diluted to undetectable concentrations in the water column. Tracer dyes, lubricants, and other materials are not known to be toxic to smalltooth sawfish. Watershed activities may involve the use of pesticides. Specifically, the use of glyphosate products is noted in the description of the action associated with spot treatment of bamboo as part of watershed activities on Guam (Section 3.2.3.6). In a recent request for consultation from EPA, the agency determined that "approximately 93% of all species and 96% of all critical habitats were given a likely to adversely affect determination and these species were distributed across all taxa" (EPA 2021) due to the toxicity of additives in many glyphosate products to fish. Species for which this effects determination was made included giant manta and smalltooth sawfish. However, despite the potential toxicity of some pesticide products that may be used in spot applications to treat invasive or nuisance species of vegetation to smalltooth sawfish, the use of these products on Guam would not result in exposure of smalltooth sawfish. Contaminants such as sediment may also be introduced to areas used by smalltooth sawfish from watershed activities. However, any plumes would be short-term and minimal due to implementation of the required BMPs, and the overall water quality downstream of watershed activities associated with stormwater management and erosion control is expected to improve in the long-term. Therefore, we believe the effects of the introduction of contaminants to the water column as a result of the proposed action on smalltooth sawfish will be insignificant because exposure is unlikely and any exposure that does occur would be to contaminants at concentrations that would not be detectable. We conclude that the proposed action may affect, but is unlikely to adversely affect smalltooth sawfish.

Critical habitat was designated for smalltooth sawfish in 2009. Designated critical habitat includes two units along the southwest coast of peninsular Florida. The Ten Thousand Islands, Everglades Unit, which is the southern unit, is within the action area for CRCP activities. The PBFs essential for the conservation of the U.S. DPS of smalltooth sawfish, which provide nursery area functions are: red mangroves and shallow euryhaline habitats characterized by water depths between the Mean High Water line and 0.9 m (3 ft) measures at Mean Lower Low Water.

CRCP activities in the could take place in or lead to short-term effects to mangrove wetlands and other nearshore habitats where juvenile smalltooth sawfish are present if these areas are associated with watersheds where construction of stormwater management or erosion control measures take place. These activities could lead to temporary effects to water quality during construction, though these are expected to be minimal due to the implementation of the required BMPs to minimize sediment and other contaminant transport downstream during construction activities. Therefore, any effects to smalltooth sawfish critical habitat as a result of CRCP activities will be insignificant. We conclude that the proposed action may affect, but is unlikely to adversely affect smalltooth sawfish designated critical habitat.

5.1.3 Chambered Nautilus

The chambered nautilus is found in tropical coastal reef deepwater habitats of the Indo-Pacific. The chambered nautilus has a patchy distribution and is considered to be an extreme habitat specialist that cannot tolerate temperatures above approximately 25ºC or depths exceeding 750-800 m (2,460-2,625 ft). It is found in association with steep-sloped forereefs and associated sandy, silty, or muddy-bottomed substrates. In U.S. waters, population density estimates of individuals per km^2 are available for American Samoa where density is estimated as 0.16 per km^2 (Miller 2018). The chambered nautilus is known to occur in ten countries and only three of these, including American Samoa, have regulations protecting the animals from harvest, which is the greatest threat to the species (Miller 2018).

CRCP activities in American Samoa include NCRMP monitoring conducted on a triennial basis that includes the use of vessels and the deployment of temperature loggers that are cable-tied to non-living hard substrate. The species are benthic-dwelling fore-reef and opportunistic scavengers that do not swim in the open water column but instead live in close association with reef slopes and bottom substrate and rest by attaching to the substrate with their tentacles (Miller 2018). Therefore, vessel operation is not expected to pose any threat to this species. Similarly, given the characteristics of these animals, towed equipment that might be used during monitoring is not expected to pose a threat to the species. Chambered nautilus could be disturbed by divers working near the bottom where these animals are present in American Samoa during surveys or deployment of temperature loggers. Any visual disturbance is expected to be temporary and, given the rarity of these animals, not likely to occur with any frequency during the short time over which NCRMP surveys take place. If brief visual disturbance did occur, the response of exposed animals is expected to be minor and short-term and thus insignificant. The deployment of temperature loggers is not expected to result in sediment plumes or any discharges of lubricants or other chemicals and there is currently no disease treatment occurring in the Pacific. Biological sampling in the form of organism collection could be a stressor depending on the type of fishing gear used but, because nets would not be deployed in coral areas during sampling associated with CRCP activities, the potential for capture of chambered nautilus would be extremely unlikely to occur and thus discountable. We conclude that activities associated with the proposed action in American Samoa may affect, but are unlikely to adversely affect chambered nautilus.

5.1.4 ESA-Listed Sea Turtles and Designated Critical Habitat for Loggerhead, Green, Leatherback, and Hawksbill Sea Turtles

Kemp's ridley sea turtles can be found in the Gulf of Mexico, but can also be found in Florida and along the east coast of the U.S., though the species has always been most common in the Gulf with most nesting occurring in the state of Tamaulipas, Mexico. Later stage juveniles migrate to nearshore areas in the Gulf of Mexico or northwestern Atlantic Ocean. Adult males migrate annually between feeding and breeding grounds while others remain in feeding grounds or near nesting beaches as residents. Adult females may reside in certain foraging grounds for months and return to these areas in subsequent years, but tend to migrate between foraging and nesting areas. Adults and juveniles prefer nearshore coastal habitats with muddy or sandy bottoms where their preferred prey is crabs. Because of the rarity of these turtles in areas where CRCP activities take place and their preference for coastal habitats in the Gulf of Mexico that are usually not associated with the coral reef ecosystem, we believe the chance of exposure of this species to stressors associated with the proposed action is extremely unlikely and effects are discountable. Therefore, we conclude the proposed action may affect, but is not likely to adversely affect Kemp's ridley sea turtles.

Olive ridley sea turtles from populations other than Mexico's breeding populations can be found in Florida, American Samoa, CNMI, Guam, and Hawaii. Olive ridley sea turtles from Mexico's breeding population can be found in Hawaii and PRIA. Olive ridleys do not nest in the U.S. and can be found in nearshore habitats largely during the breeding and nesting season because the species is mainly pelagic. However, olive ridleys are known to inhabit coastal areas, particularly along the coasts of West Africa and South America and may be from both of the listed populations of this species. Olive ridleys have been caught in the Hawaii-based pelagic longline fishery (Work and Balazs 2010). Because of the rarity of these turtles in areas where CRCP activities take place and their preference for pelagic waters, we believe the chance of exposure of this species to stressors associated with the proposed action is extremely unlikely and effects are discountable. Therefore, we conclude the proposed action may affect, but is not likely to adversely affect olive ridley sea turtles.

Leatherback sea turtles can be found in the Atlantic and Pacific, although these sea turtles are pelagic and are only found in nearshore waters during their nesting season, the timing of which differs depending on the geographic location. Pacific leatherback turtle populations are most at-risk for extinction as evidenced by declines in nesting, but no significant nesting areas are present in U.S. jurisdictions. In the Atlantic, one of the main nesting areas in the continental U.S. is on the Atlantic coast of Florida and the numbers of nests has been declining. Leatherbacks nest in the U.S. Caribbean as well, particularly in Puerto Rico and St. Croix. Because these turtles are largely pelagic and not associated with the coral reef ecosystem, we believe the chance of exposure of this species to stressors associated with the proposed action is extremely unlikely and effects are discountable. Therefore, we conclude the proposed action may affect, but is not likely to adversely affect leatherback sea turtles.

Loggerhead sea turtles from the Northwest Atlantic DPS may be found in Florida and the Gulf of Mexico and occasionally in Puerto Rico and USVI. In the Pacific, loggerhead sea turtles from the South Pacific DPS can be found in Samoa and from the North Pacific DPS in CNMI, Guam, and Hawaii. In the Atlantic, South Florida is one of the most important nesting sites in the world with over 10,000 females nesting annually. In the Pacific, there are no important nesting sites for this species in U.S. jurisdictions. Juveniles migrate to nearshore coastal areas where they forage and grow to adulthood for several years before beginning to migrate to nesting beaches. Northwest Atlantic loggerheads inhabit continental shelf waters south through Florida and in the

Gulf of Mexico as juveniles, including estuarine habitats. Adult loggerheads in the Northwest Atlantic rarely use shallow estuarine habitats. However, the shallow waters of Florida Bay do provide year-round foraging areas for large numbers of adult loggerhead sea turtles (Conant et al. 2009). Shelf waters along the west Florida coast have been identified as resident areas for adult female loggerheads that nest in Florida (Conant et al. 2009). In the Pacific, loggerheads become residents near nesting beaches as adults once migrating from juvenile nursery areas, but none of these areas appear to be in U.S. waters. Juvenile and adult sea turtles in coastal waters are largely bottom feeders that eat mollusks and crabs. Loggerhead sea turtles are rare in waters of the U.S. Caribbean based on strandings data from Puerto Rico and USVI from the 1990s and 2000s. Two nesting females were reported on Buck Island, St. Croix, in the early 2000s, but nesting by this species has not been reported for several years. Similarly, nesting by a few females was reported from the east coast of Puerto Rico and Culebra in the early 2000s but nests of the species have not been recorded since then. Based on information regarding geographic areas where loggerhead sea turtles concentrate, juvenile and adult loggerheads from the Northwest Atlantic DPS in Florida and the Gulf of Mexico are those that are most likely to be exposed to stressors associated with CRCP and Mission: Iconic Reefs activities.

Green sea turtles from the North and South Atlantic DPSs can be found in the Gulf of Mexico, Puerto Rico, and the USVI, and turtles from the North Atlantic DPS can also be found in Florida. Green sea turtles from the Central West Pacific DPS can be found in CNMI and Guam, from the Central South Pacific DPS in American Samoa and PRIA, and from the Central North Pacific DPS in Hawaii and PRIA. In each U.S. coral jurisdiction, adult and juvenile green sea turtles are the life stages of this species most likely to be exposed to stressors associated with CRCP activities because both resident and transient juveniles and adults may be present in nearshore waters in habitats associated with the coral reef ecosystem where they find refuge and foraging habitat. Green sea turtles from different DPSs nest in the Hawaiian Islands, Guam, CNMI, American Samoa, Puerto Rico, USVI, and Florida, but few CRCP activities take place on nesting beaches, particularly in the Pacific, and hatchling sea turtles move rapidly to pelagic waters once they emerge from their nests, meaning the likelihood of exposure to stressors from CRCP activities is low for sea turtles nests and hatchlings.

Hawksbill sea turtles can be found in U.S. coral jurisdictions in the Atlantic and Pacific. As for green sea turtles, juvenile and adult hawksbills are the life stages that are most likely to be exposed to stressors associated with CRCP activities because these life stages may be resident or transient and use habitats associated with the coral reef ecosystem for refuge and foraging. Hawaiian hawksbills migrate shorter distances than hawksbills from other populations and stay within the island chain. There are no significant nesting areas of hawksbills in the U.S. Pacific jurisdictions, but small numbers of hawksbills nest on the south coast of the island of Hawaii and the east coast of the island of Molokai. This is one of the smallest nesting populations of hawksbills in the world, but the largest in the Central North Pacific Ocean. In the Atlantic, Mona Island, Puerto Rico, as well as Sandy Point, St. Croix, host large numbers of nesting hawksbills each year, as well as smaller numbers of nests on other beaches around the islands. Nesting also occurs sporadically on the southeast coast of Florida and in the Florida Keys. Therefore, the likelihood of exposure to stressors from CRCP activities is low for hawksbill nests and hatchlings in the Atlantic and in Hawaii.

As noted above, juvenile and adult loggerheads from the Northwest Atlantic DPS in Florida and the Gulf of Mexico are those that are most likely to be exposed to stressors associated with CRCP and Mission: Iconic Reefs activities. Similarly, juvenile and adult green sea turtles from the North and South Atlantic DPSs in the Gulf of Mexico, Puerto Rico, and the USVI, from the Central West Pacific DPS in CNMI and Guam, from the Central South Pacific DPS in American Samoa and PRIA, and from the Central North Pacific DPS in Hawaii and PRIA are those that are most likely to be exposed to stressors associated with CRCP activities. In addition, juvenile and adult green sea turtles from the North Atlantic DPS in Florida are likely to be exposed to stressors associated with CRCP and Mission: Iconic Reefs activities. Juvenile and adult hawksbill sea turtles are likely to be exposed to CRCP activities particularly around Hawaii in the Pacific and in all the U.S. Atlantic and Caribbean coral jurisdictions. Juvenile and adult sea turtles of these species and DPSs could be exposed to stressors from vessel operation, sound, entanglement, contaminants, bycatch, and habitat loss or alteration. Vessel strike is a serious threat to all sea turtle species. However, vessel operation during CRCP and Mission: Iconic Reefs activities will follow the required BMPs and there are no reports of vessel strikes of sea turtles during CRCP or Mission: Iconic Reefs activities as of 2021. Therefore, we believe the effects of vessel strike on Northwest Atlantic DPS loggerhead sea turtles; North and South Atlantic, Central West, North, and South Pacific DPSs green sea turtles; and hawksbill sea turtles will be discountable. In terms of acoustic sensors used during activities such as mapping and noise from vessel operation and navigational equipment, even if the sounds produced are within the hearing range of sea turtles, the animals would have to be very close to the vessel in order for the sound to have any effect because the sensors are deployed such that sounds are focused downward from the vessel or towed array, animals would have to remain within the cone of sound in order to be affected. Sea turtles are likely to swim away from a vessel and are not expected to remain within the ensonified area. Therefore, while we believe exposure could occur, we believe the effects of sounds produced by acoustic sensors, vessels, and navigational equipment during activities associated with the proposed action on loggerhead, green, and hawksbill sea turtles will be so small that they cannot be meaningfully measured, detected or evaluated and are thus insignificant.

In terms of the potential for entanglement associated with lines in the water from in-water structures and towed equipment, we believe the effects of this stressor on loggerhead (Northwest Atlantic DPS), hawksbill and green sea turtles are discountable because lines associated with towed equipment and in-water structures and instruments are kept taut and kept to the minimum length necessary depending on the structure or instrument and tackle system to reduce any possibility for entanglement. There was a reported entanglement of a green sea turtle in a coral nursery structure in Florida approximately 10 years ago and, following the incident, the structure was observed and NMFS developed recommendations for coral nursery structure to avoid this occurring in the future. Many of these recommendations are the same as the required BMPs (Section 3.5.1) and there have been no entanglements of sea turtles in coral nursery structures since the changes in design were recommended. In terms of fishing gear, entanglement in fishing gear is considered a threat to sea turtles with bycatch being one of the greatest threats to all sea turtle species. Biological sampling using fishing gear as part of CRCP activities is uncommon. Tents are used to collect coral gametes, but these are constantly monitored by divers in order to collect samples as gametes are released and entanglement of sea turtles in these structures would only occur if tents were to come loose and become debris in the water column or on the seafloor. This is not likely given the full-time monitoring of the tents by divers. No entanglement of sea turtles has been reported during past CRCP activities and the required BMPs associated with the use of equipment, fishing gear, and installation of in-water structures and equipment with lines in the water will be followed, further minimizing the potential for entanglement. Therefore, we believe the effects of entanglement on loggerhead, green, and hawksbill sea turtles associated with the proposed action are discountable.

Juvenile and adult loggerhead (Northwest Atlantic DPS), green, and hawksbill sea turtles could experience visual disturbance due to the presence of vessels and divers and snorkelers in the water. Visual disturbance of animals that might be encountered during in-water activities would be short-term as activities such as monitoring, instrument installation and operation, and vessel operations during CRCP activities and coral restoration and associated vessel operations associated with Mission: Iconic Reefs activities (that could affect Northwest Atlantic DPS loggerhead, North Atlantic DPS green, and hawksbill sea turtles) are conducted over short periods. All activities will follow the required BMPs (Section 3.5.1), including the training of volunteers and others participating in watershed activities on the importance of minimizing disturbance of native fauna. Thus, any visual disturbance of animals would be temporary and not likely to result in measurable changes in behavior. Therefore, the effects of visual disturbance to Northwest Atlantic DPS loggerhead, green and hawksbill sea turtles as a result of the proposed action will be insignificant.

In terms of the introduction of contaminants such as tracer dyes, treatments for diseased corals, or lubricants and other products used on in-water equipment, the volume of material that would enter the water column would be insignificant in the nearshore habitats where juvenile and adult loggerhead, green and hawksbill sea turtles may be present. Any contaminants are expected to be rapidly diluted to undetectable concentrations in the water column. Tracer dyes, lubricants, and other materials are not known to be toxic to sea turtles. Treatment of diseased corals currently occurs only in the Atlantic and Caribbean U.S. coral jurisdictions due to SCTLD. Contaminants such as sediment may also be introduced to areas used by juvenile and adult loggerhead, green and hawksbill sea turtles from watershed activities. However, any plumes would be minimal due to implementation of the required BMPs and short-term, and the overall water quality downstream of watershed activities associated with stormwater management and erosion control is expected to improve in the long-term. Therefore, we believe that any exposure to contaminants in the water column as a result of the proposed action on Northwest Atlantic DPS loggerhead, green and hawksbill sea turtles will result in effects that are so small they cannot be meaningfully evaluated and thus insignificant. We conclude that the proposed action may affect, but is unlikely to adversely affect these sea turtle species.

Critical habitat is designated for the Northwest Atlantic DPS of loggerhead sea turtle off the east coast of the U.S. and in the Gulf of Mexico. Within the action area, the LOGG-N-19 (Southern Florida Constricted Migratory Corridor; Southern Florida Concentrated Breeding Area; and Six Nearshore Reproductive Areas: Martin County/Palm Beach County line to Hillsboro Inlet, Palm Beach and Broward Counties, Florida; Long Key, Bahia Honda Key, Woman Key, Boca Grande Key, and Marquesas Keys, Monroe County, Florida) unit contains nearshore reproductive habitat, constricted migratory habitat, and breeding habitat and the LOGG-N-20 (Dry Tortugas, Monroe County, Florida) unit contains nearshore reproductive habitat only where loggerhead sea turtle nesting has been document on six islands in the Dry Tortugas. The LOGG-S-1 (Atlantic Ocean Sargassum) unit contains *Sargassum* habitat in the Gulf of Mexico and Atlantic and the LOGG-S-2 (Gulf of Mexico Sargassum) unit contains *Sargassum* habitat only. The PBF of loggerhead designated critical habitat for nearshore reproductive habitat is a portion of nearshore waters adjacent to nesting beaches used by hatchlings to egress open-water environment and by nesting females to transit between beach and open water during the nesting season. This means that waters are sufficiently free of obstructions or artificial lighting to allow transit through the surf zone and outward toward open water and waters have minimal manmade structures that could promote predators, disrupt wave patterns necessary for orientation, and/or create excessive longshore currents. The PBF of concentrated breeding habitat is those sites with high densities of male and female adults during the breeding season near the primary Florida migratory corridor and Florida nesting grounds. The PBF of constricted migratory habitat is high use migratory corridors that are limited in width by land on one side and the edge of the continental shelf and Gulf Stream on the other thereby concentrating migratory pathways with passage conditions to allow for migration to and from nesting, breeding, and/or foraging areas. The PBF of *Sargassum* habitat is developmental and foraging habitat for young loggerheads where surface waters form accumulations of floating material, especially *Sargassum* in convergence zones, surface-water downwelling areas, the margins of major boundary currents (Gulf Stream), and other locations where there are concentrated components of the *Sargassum* community in water temperatures suitable for optimal growth of *Sargassum* and inhabitance of loggerheads, *Sargassum* concentrations that support adequate prey abundance and cover, available prey and other material including, but not limited to, plants and cyanobacteria and animals native to the *Sargassum* community such as hydroids and copepods, and sufficient water depth and proximity to available currents to ensure offshore transport (out of the surf zone) and foraging and cover requirements by *Sargassum* for post-hatchling loggerheads (i.e., greater than 10 m depth). None of the stressors associated with CRCP and Mission: Iconic Reefs activities are expected to affect the PBFs of Northwest Atlantic DPS loggerheads as the stressors will not affect the ability of various life stages to access and exit nesting beaches, access migratory corridors, or interfere with *Sargassum* habitat from the Gulf to the east coast of the U.S. Stressors associated with vessel operations could temporarily block small areas as vessels transit through but this effect would be ephemeral and thus insignificant. Therefore, we conclude the proposed action may affect, but is not likely to adversely affect this designated critical habitat.

Critical habitat was designated for green sea turtles prior to the designation of DPSs and now pertains to the North Atlantic DPS. Critical habitat includes waters extending seaward 3 nautical miles (nm; 5.6 km) from the mean high water line of Culebra Island, Puerto Rico and includes Culebra's outlying keys, including Cayo Norte, Cayo Ballena, Cayos Geniquí, Isla Culebrita, Arrecife Culebrita, Cayo de Luís Peña, Las Hermanans, El Mono, Cayo Lobo, Cayo Lobito, Cayo Botijuela, Alcarraza, Los Gemelos, and Piedra Steven. When the critical habitat was designated in 1998, PBFs were not described for the habitat, but a description of the importance of the seagrass beds and coral reefs around the Culebra archipelago was included in the preamble to the designation. Seagrass beds are the principal dietary component of juvenile and adult green sea turtles and the seagrass beds around Culebra support populations of juvenile and subadult green sea turtles, as well as some resident adults. The coral reefs in waters around Culebra provide shelter during interforaging periods. Several CRCP activities may be conducted in and around Culebra, including NCRMP monitoring, biological sampling, the establishment and maintenance of coral nurseries and outplanting of corals, coral disease treatment, and watershed activities, based on information regarding past CRCP projects. Therefore, green sea turtle critical habitat around Culebra could be exposed to stressors from vessel operation (accidental grounding, anchoring, discharges, propeller wash), contaminants including sediment and compounds used to treat diseased corals, and habitat loss or damage associated with the installation of in-water structures. Vessels will operate according to USCG requirements and following the required BMPs and there have not been accidental groundings or other effects of vessel operations reported as part of CRCP activities around Culebra so the effects of vessel operation are unlikely to occur and thus discountable. The installation of in-water structures, including coral nurseries, in Culebra will be done in accordance with the required BMPs and past and existing nursery structures, which have been the most common in-water structures installed and maintained with CRCP support, have been located near colonized hard bottom, reef and seagrass areas in sand bottom. Several watershed activities have been conducted in Culebra that may have resulted in short-term sediment plumes in nearshore waters but are meant to manage and treat stormwater, as well as prevent motor vehicle transit on beaches. The long-term effects of these project should improve nearshore water quality. Similarly, treatment of diseased corals is not expected to result in adverse effects to seagrass and corals that are part of green sea turtle critical habitat. On the contrary, coral disease treatment is meant to improve the quality of habitat. Therefore, we believe the effects of stressors associated with the installation of in-water structures, watershed activities, and coral disease treatment as part of the proposed action on green sea turtle critical habitat around Culebra will be insignificant. We conclude that the effects of the proposed action may affect, but are not likely to adversely affect this designated critical habitat.

Critical habitat was designated for leatherback sea turtles off Sandy Point, St. Croix, USVI in 1979. This critical habitat includes water adjacent to Sandy Point Beach up to and including the waters from the hundred fathom curve shoreward to the level of mean high tide. When the critical habitat was designated, no PBFs were identified, but the preamble to the designation indicated that the area designated as critical habitat is used by the leatherback for courting and mating activities and provides access to and from an important nesting beach. Sandy Point is within the USFWS Sandy Point National Wildlife Refuge. CRCP activities are unlikely to take place in waters designated as critical habitat for leatherback sea turtles but if they do, the stressors associated with the activities will be unlikely to interfere with courting and mating of leatherback sea turtles or interfere with access to and from the nesting beach, other than on a short-term basis if vessels are transiting through the area. Therefore, we believe the effects of stressors associated with the proposed action on leatherback sea turtle critical habitat around Sandy Point, St. Croix will be insignificant and thus may affect, but are not likely to adversely affect this designated critical habitat.

Critical habitat has been designated for hawksbill sea turtles around Mona and Monito Islands, Puerto Rico. Critical habitat includes waters extending seaward 3 nm (5.6 km) from the mean high water line of Mona and Monito Islands. When the critical habitat was designated in 1998, PBFs were not described for the habitat, but a description of the importance of the coral reefs of Mona and Monito Islands in supporting a considerable density of juvenile, subadult, and adult hawksbill sea turtles was included in the preamble to the designation. Because Mona and Monito Islands are managed by the Puerto Rico Department of Natural and Environmental Resources (PRDNER) as a natural reserve, as well as areas where fishing is restricted, and because these islands are a considerable distance from the main island of Puerto Rico, they are not developed. The CRCP activities that have occurred in the area have been part of biological monitoring and coral restoration projects. Therefore, hawksbill sea turtle critical habitat could be exposed to stressors from vessel operation, compounds used to treat diseased corals, and effects to habitat from coral nurseries and outplanting. Vessels will operate according to USCG requirements and following the required BMPs and there have not been accidental groundings or other effects of vessel operations reported as part of CRCP activities around Mona and Monito. Therefore, the effects of stressors associated with vessel operation are extremely unlikely to occur and thus discountable. The installation of in-water structures, including coral nurseries, is not likely to be common around Mona and Monito given the distance of the islands from the main island of Puerto Rico but, if it occurs, will be done in accordance with the required BMPs. These structures may be located near colonized hard bottom, reef and seagrass areas in sand bottom, but are not expected to alter the structure and function of critical habitat. Similarly, treatment of diseased corals is not expected to result in adverse effects to seagrass and corals that are used by juvenile and subadult hawksbills and are within the area of designated critical habitat. On the contrary, coral disease treatment is meant to improve the quality of habitat. Therefore, we believe the effects of stressors associated with the installation of in-water structures, watershed activities, and coral disease treatment as part of the proposed action on hawksbill sea turtle critical habitat around Mona and Monito will be insignificant. We conclude the effects of the proposed action may affect, but are not likely to adversely affect this designated critical habitat.

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

This Opinion examines the status of Nassau grouper; scalloped hammerhead shark (Central and Southwest Atlantic DPS and Indo-West Pacific DPS); elkhorn coral, staghorn coral, rough cactus coral, pillar coral, lobed star coral, mountainous star coral, and boulder star coral, and *Acropora globiceps*, *A. jacquelineae*, *A. retusa*, *A. speciosa*, *Euphyllia paradivisa*, *Isopora crateriformis*, and *Seriatopora aculeata* corals; and designated critical habitat for elkhorn and staghorn coral (Florida, Puerto Rico, St. Thomas/St. John, and St. Croix units); and proposed critical habitat for lobed star, boulder star, mountainous star, pillar, rough cactus, *Acropora globiceps*, *A. jacquelineae*, *A. retusa*, *A. speciosa*, *Euphyllia paradivisa*, *Isopora crateriformis*, and *Seriatopora aculeata* corals that may be adversely 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 in the action area that may be adversely affected. The status is determined by the level of risk that the ESA-listed species and designated critical habitat face based on parameters considered in documents such as recovery plans, status reviews, listing decisions, and critical habitat designations. 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 C.F.R. §402.02 and examines the condition and current function of designated or proposed critical habitat, including the essential PBFs that contribute to that conservation value of the critical habitat that is part of the determination of destruction and adverse modification. More detailed information on the status and trends of these ESA-listed species and designated and proposed critical habitats 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/species-directory/threatened-endangered.

5.2.1 **Nassau Grouper**

NMFS listed the Nassau grouper as threatened under the ESA in 2016 (81 FR 42268, June 29, 2016).

Species Description and Life History

The Nassau grouper, *Epinephelus striatus*, is a long-lived, moderate-sized serranid fish, living 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% 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 mm (0.39 in)/month total length (TL) for small juveniles, and 8.4-11.7 mm (0.33-0.46 in)/month TL for larger juveniles (Beets and Hixon 1994; Eggleston 1995). 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 between 40 and 45 cm (15.7 and 17.7 in) 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 spawn once a year in large aggregations. 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 m (66 and 108 ft). 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 water temperatures between 25 and 26°C. Spawning aggregation sites are located near significant geomorphological features, such as reef projections (as close as 50 m [164 ft] from shore) and close to a drop-off into deep water over a wide depth range (6-60 m [20-197 ft]). 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 mins of sunset over the course of several days. There have been about 50 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, and the USVI.

Fertilized eggs are transported offshore by ocean currents. Thirty-five to 40 days after hatching, larvae recruit from the oceanic environment to demersal habitats (at a size of about 32 mm [1.26 in] 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 40 individuals. When not spawning, adults are most commonly found in waters less than 100 m (328 ft) deep. Nassau grouper diet changes with age. Juveniles eat plankton, pteropods, amphipods, and copepods. Adults are unspecialized piscivores and are bottom-dwelling ambush suction predators (NMFS 2013).

Population Dynamics

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.

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

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).

The Nassau grouper's confirmed distribution currently includes "Bermuda and Florida (USA), throughout the Bahamas and Caribbean Sea" (e.g., Heemstra 1993). 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 (*E. 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 FGBNMS, which is located in the northwest Gulf of Mexico approximately 180 km (111.8 mi) 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. The Biological Report (Hill and Sadovy de Mitcheson 2013) provides a detailed description of the distribution, summarized in Figure 47.

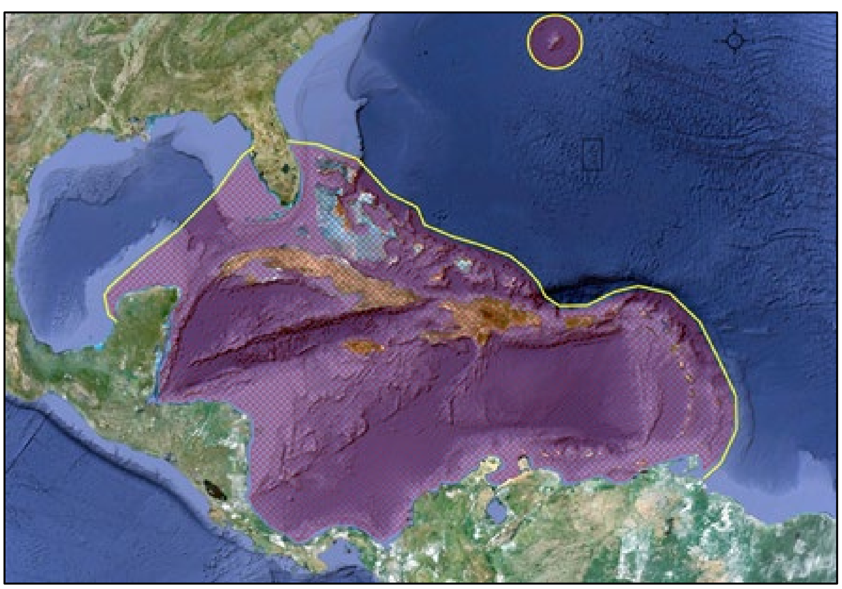

Figure 47. Range of Nassau grouper (*Epinephelus striatus*)

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 overfishing and was a cause of its decline. At some sites (e.g., Belize), spawning aggregations have decreased by over 80% 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.

Critical Habitat

No critical habitat has been designated for the Nassau grouper.

Recovery Goals

NMFS has prepared a recovery outline for the 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. 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 subadult 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.

5.2.2 **Scalloped Hammerhead Shark**

The scalloped hammerhead shark is a highly mobile, circumglobal species occurring in coastal warm temperate and tropical seas (Figure 48). The Ecological Review Team convened to assess whether to list the species under the ESA determined there are six DPSs for the species and four were listed in 2014, two as endangered (Eastern Pacific and Eastern Atlantic DPSs) and two as threatened (Central and Southwest Atlantic and Indo-West Pacific DPSs). The two threatened DPSs are within the action area of the proposed action.

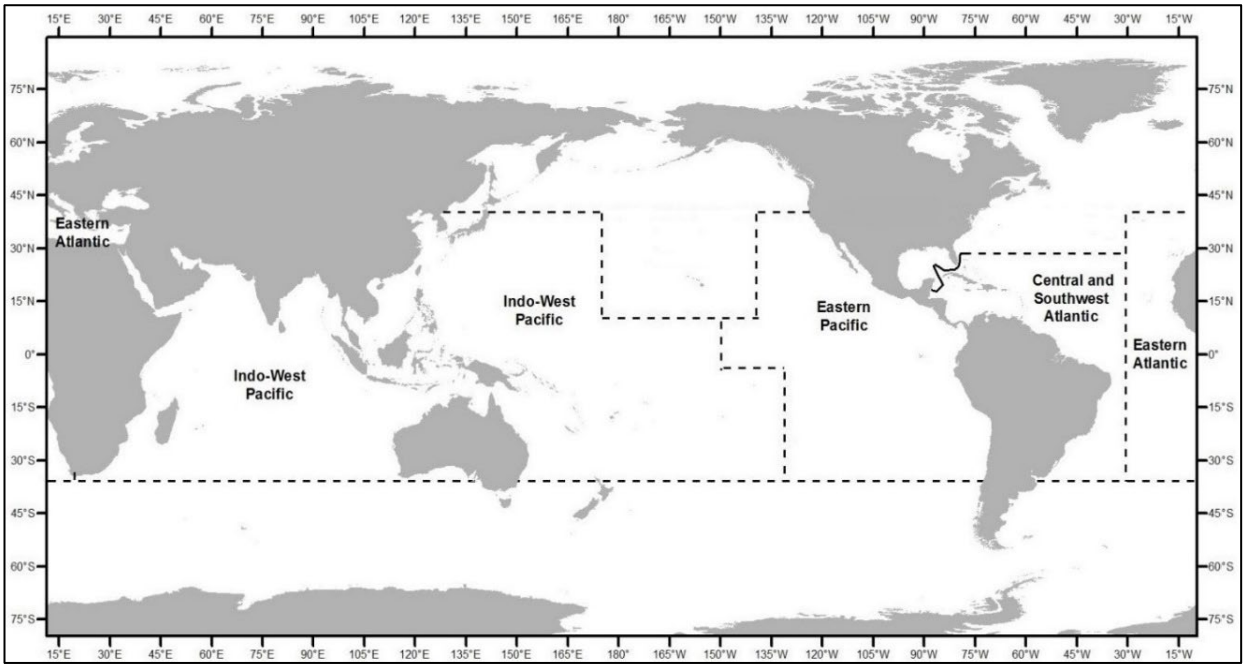

Figure 48. Distribution map of the scalloped hammerhead shark

Species Description and Life History

The scalloped hammerhead shark occurs over continental shelves, as well as adjacent deep waters, but is seldom found in waters below 22ºC. It ranges from the surface to depths up to 512 m (1,680 ft) with occasional dives to deeper waters and has been documented entering enclosed bays and estuaries (Miller et al. 2014). These sharks are highly mobile and partly migratory. Juveniles and adults occur as solitary individuals, in pairs or in schools. Neonate and juvenile aggregations are more common in nearshore nursery habitats, such as Kāne'ohe Bay in Oahu, Hawaii and inner Apra Harbor, Guam (Miller et al. 2014). Coral Bay, St. John, and Magens Bay, St. Thomas provide nursery habitat for scalloped hammerhead sharks in the U.S. Caribbean (DeAngelis et al. 2008). Data from the Pacific indicate that juvenile scalloped hammerheads prefer to aggregate in deeper water during the day and areas of high hammerhead abundance correspond to locations of greater turbidity, higher sedimentation and nutrient flow, and areas where the current is strongest (Duncan et al. 2006; Bessudo et al. 2011). Scalloped hammerhead sharks are high trophic level predators and opportunistic feeders with a diet that includes a wide variety of bony fishes, cephalopods, crustaceans, and rays.

Scalloped hammerhead sharks give birth to live young with a gestation period of 9-12 months, which may be followed by a one-year resting period (Miller et al. 2014). Males mature at small sizes between 140-198 cm TL compared to females at 200-250 cm TL. Females mature at 13.2 years and males at 8.9 years (Drew et al. 2015) and females live up to 35 years (Rigby et al. 2019). Females move inshore to birth with litter sizes between 12 and 41 live pups and a generation length of 24.1 years (Rigby et al. 2019). While maturity, age, and growth estimates appear to vary by region, it is unclear whether these differences are biological or a result of differences in band interpretations in aging methodology approaches because band formation was assumed to occur bi-annually in studies conducted in the eastern and western Pacific and annually in the Atlantic. Based on information from other shark species, it is likely that the scalloped hammerhead shark undergoes annual band formation. Rigby et al. (2018) summarized the literature on age and growth from various populations and determined that scalloped hammerheads reach a maximum size of 370-420 cm (146-165 in) TL.

Population Dynamics

Current effective population sizes for the scalloped hammerhead shark are considered qualitative indicators rather than precise estimates given their reliance on mutation rates and generation times (Duncan et al. 2006). Calculations of the effective female population size for the major ocean basins by Duncan et al. (2006), have been converted into total (male and female) effective population size by multiplying by two. Results varied greatly within and between ocean basins with the global estimated effective population size being 240,000 using a generation time of 5.7 years and 94,000 using a generation time of 16.7 years. For Hawaii, the effective population size was calculated as 3,200 using a 5.7 year generation time and 1,199 using a 16.7 year generation time. For the east coast of the U.S., the effective population size was calculated as 36,000,000 using a 5.7 year generation time and 12,000,000 using a 16.7 year generation time. In terms of mean population sizes, Duncan Seraphin and Holland (2006) estimated mean population sizes in Hawaii during peak densities (i.e., summer season) to range from 2,300 to 7,700 sharks born per year. Hayes et al. (2009) estimated a population size of 25,000 to 28,000 in 2005 for the northwestern Atlantic and Gulf of Mexico scalloped hammerhead stock.

In the western Atlantic, scalloped hammerhead sharks appear to grow more slowly than in the eastern and western Pacific. In the northwest Atlantic and Gulf of Mexico, maximum size observed was 313 cm (123 in) TL for a female and 304 cm (120 in) TL for a male, corresponding to an age of 30.5 years. Data from these areas indicate a growth constant of 0.13 per year for males and 0.09 for females (Piercy et al. 2007). In the western Pacific, Chen et al. (1990) report the growth constant as 0.22 with observed maximum sizes of 331 cm (130 in) TL for a female and 31 cm (12 in) TL for a male corresponding to ages of 14 and 10.6 years, respectively.

There is no evidence of shared haplotypes between the Atlantic Ocean and the Indian or Pacific Oceans, but some haplotypes from the Indo-Pacific are very closely related to the Atlantic with a sequence divergence of 0.18% (Duncan et al. 2006). Duncan et al. (2006) and Chapman et al. (2009) concluded that oceanic dispersal by females is rare. On the other hand, males may participate in ocean migrations, although the frequency of these may be very low considering the discovery of genetically isolated populations in the Gulf of Mexico and Eastern Tropical Pacific (Daly-Engel et al. 2012).

In the western Atlantic Ocean, the scalloped hammerhead range extends from the northeast coast of the United States from New Jersey to Florida to Brazil, including the Gulf of Mexico and the Caribbean Sea. In the eastern Pacific Ocean, distribution includes waters off Hawaii. Rooker et al. (2019) found that scalloped hammerheads displayed prolonged periods of residency in the northern Gulf of Mexico with limited displacement to Mexico and none to Cuba based on an assessment of electronically tagged animals from 2012 to 2016, although scalloped hammerheads in the northern Gulf are not from an ESA-listed DPS (Conant and Miller 2020). Chin et al. (2017) determined that scalloped hammerheads occurring across northern Australia, Indonesia, and Papua New Guinea moved across all areas based on genetic and tagging data and expert elicitation.

Status

Scalloped hammerhead sharks are both targeted fishery species and taken as bycatch in many global fisheries. There is a lack of information on fisheries prior to the 1970s and catch is likely underreported due to many of the catch records not accounting for discards, reflecting dressed weights instead of live weights, or differentiating between hammerhead species. In some nursery areas, neonate and juvenile sharks are targeted and fishing pressure has also increased on known aggregations of adult sharks in “hot spots” such as off Cocos Island, Galapagos Islands, and Malpelo Islands that are protected areas but have poor enforcement (Miller et al. 2014). The species is also caught in the shark finning trade.

Data from multiple sources indicate that the Atlantic population of scalloped hammerhead shark has experienced severe declines over the past few decades. It is likely that scalloped hammerheads in the Northwest Atlantic and Gulf of Mexico were overfished beginning in the early 1980s and experienced periodic overfishing from 1983-2005 (Jiao et al. 2011). Baum et al. (2003) calculated that the northwest Atlantic population of scalloped hammerhead sharks has declined 89% since 1986, but the study is controversial due to the use of only pelagic longline logbook data (Miller et al. 2014). In a recent stock assessment, Hayes et al. (2009) concluded that the northwestern Atlantic and Gulf of Mexico stock has been depleted by approximately 83% since 1981, but this stock is likely rebuilding based on fishery management allowing for a decreased total allowable catch. Similar data are not available for the U.S Pacific but catch data from Mexico, Costa Rica, Columbia, Ecuador, and South Africa indicate that catch of this species in fisheries, many of which target them, have declined significantly. In addition, estimates from Australia indicate hammerhead abundance has declined between 58-85% (Heupel and McAuley 2007; CITES 2010).

The five-year review conducted for ESA-listed scalloped hammerhead sharks indicated that new information demonstrated these animals are exposed to pollutants and contaminants based on studies of animals from the Indo-West Pacific and Central and Southwest Atlantic DPSs (Conant and Miller 2020).

Critical Habitat

NMFS determined that no marine areas within the jurisdiction of the U.S. meet the definition of critical habitat for the Central and Southwest Atlantic, Indo-West Pacific or Eastern Pacific DPSs in 2015.

Recovery Goals

There is no recovery plan for any of the DPSs of scalloped hammerhead shark.

5.2.3 **Status of ESA-Listed Corals**

5.2.3.1 General Threats Faced by ESA-Listed Corals

Corals face numerous natural and anthropogenic 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 the continued growth of the human population and associated changes in greenhouse gas (GHG) emissions, water quality, and extractive use of coastal and marine resources, which are discussed further in Section 7.

Ocean Warming

As a result of rising atmospheric GHGs, global surface air temperatures have warmed and the rate of warming has increased. The global trend in average temperature is reflected in long-term trends in sea surface temperature. Ocean warming is one of the most important threats posing extinction risks to the listed coral species, but individual susceptibility varies among species. The primary observable coral response to ocean warming is bleaching of adult coral colonies, wherein corals expel their symbiotic algae in response to stress. For many corals, an episodic increase of only 1°C–2°C above the normal local seasonal maximum ocean temperature can induce bleaching. Corals can withstand mild to moderate bleaching; however, severe, repeated, and/or prolonged bleaching can lead to colony death. Coral bleaching patterns are complex, with several species exhibiting seasonal cycles in symbiotic algae density. Thermal stress has led to bleaching and mass mortality in many coral species during the past 25 years. Mass bleaching events, including at a regional and even global scale, are becoming more common as oceans continue to warm.

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

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

Diseases

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

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

Monitoring surveys conducted from 2002 to 2006 in the American Samoa archipelago reported total coral disease prevalence rates per island ranging from 0.04% on Swains Island to 0.5% on Tutuila (Brainard 2008). Monitoring surveys conducted from 2003 to 2007 in the Mariana Islands reported total coral disease prevalence rates per island ranging from 0.1% on Rota Island to 1.4% on Guam (Brainard 2012). These studies give us a general idea of coral disease prevalence rates across the region, but do not provide trend information that might indicate temporal patterns.

Effects of Reef Fishing

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

In the Caribbean, parrotfishes can graze at rates of more than 150,000 bites per square meter (m^2) per day (Carpenter 1986), and thereby remove up to 90-100% of the daily primary production (e.g., algae; Hatcher 1997). With substantial populations of herbivorous fishes, as long as the cover of living coral is high and resistant to mortality from environmental changes, it is very unlikely that the algae will take over and dominate the substrate. However, if herbivorous fish populations, particularly large-bodied parrotfish, are heavily fished and a major mortality of coral colonies occurs, then algae can grow rapidly and prevent the recovery of the coral population. The ecosystem can then collapse into an alternative stable state, a persistent phase shift in which algae replace corals as the dominant reef species. Although algae can have negative effects on adult coral colonies (e.g., overgrowth, bleaching from toxic compounds), the ecosystem-level effects of algae are primarily from inhibited coral recruitment. Filamentous algae can prevent the colonization of the substrate by planula larvae by creating sediment traps that obstruct access to a hard substrate for attachment. Additionally, macroalgae can block successful colonization of the bottom by corals because the macroalgae takes up the available space and causes shading, abrasion, chemical poisoning, and infection with bacterial disease. Trophic effects of fishing are a medium importance threat to the extinction risk for listed corals.

Fishing activities also lead to derelict gear that leads to significant habitat degradation. As an example of how much derelict fishing gear can affect coral reefs, Dameron et al. (2007) estimated that at least 52 metric tons of derelict fishing gear annually become entangled in reefs of the NWHI from fisheries thousands of kilometers away. In addition to derelict gear, actively fished gear can damage corals and their habitat depending on the type of gear and where it is deployed.

Land-Based Sources of Pollution

Human activities in coastal and inland watersheds introduce sediment, nutrients, chemicals, and other pollutants 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. Agricultural runoff leads to discharges of nutrients from fertilizers and chemicals from pesticide use. Elevated sediment levels are generated by poor land use practices, including during coastal and nearshore construction. Industry is also a source of chemical contaminants through air emissions and water discharges.

Delivery of terrestrial sediment to areas containing corals results in sediment stress in these animals. 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. Corals with large calices (skeletal component that holds the polyp) tend to be better at actively rejecting sediment. When corals actively remove sediment there is a significant energy cost, meaning respiration increases, photosynthetic efficiency decreases, and the photosynthesis to respiration ratio decreases. Some coral species can tolerate complete burial for several days. Corals that cannot remove sediment will be smothered and die. Sediment can also cause sublethal effects such as reductions in tissue thickness, polyp swelling, zooxanthellae loss, and excess mucus production. In addition, suspended sediment can reduce the amount of light in the water column, making less energy available for coral photosynthesis and growth. Sedimentation also impedes fertilization of spawned gametes and reduces larval settlement and survival of recruits and juveniles. Sediment stress and turbidity can also induce coral bleaching.

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. Elevated nutrient levels have been shown to inhibit gamete development, induce a shift toward more male gametes, reduce fertilization success, and reduce larval settlement. Settlement and growth of recruits may also be affected by elevated nutrient levels. In areas where the populations of herbivores have been depleted, higher nutrient levels lead to increased growth of algae that may overgrow reef substrates.

Toxins and bioactive contaminants may also be delivered to areas containing coral habitats via point and non-point sources. Records of heavy metals in skeletal material are useful for evaluating the effects of long-term chronic exposures to things like contaminated sediments and runoff. Skeletal heavy metals were correlated with reduced coral growth rates near areas with coastal development in Jordan (Al-Rousan et al. 2007), rum refineries in Barbados (Runnalls and Coleman 2003), and effects of agriculture and development in marine reserves along the Mesoamerican Reef (Carilli et al. 2010), although heavy metals are most heavily concentrated in zooxanthellae (Reichelt-Brushett and McOrist 2003). Responses to metal concentrations in corals can be species-specific. For example, *Acropora cervicornis* and *Orbicella faveolata* accumulated copper in their tissues when exposed to the metal while *Pocillopora damicornis* did not, but *Acropora cervicornis* and *Pocillopora damicornis* showed reduced photosynthesis and growth while *Orbicella faveolata* did not (Bielmyer et al. 2010). Exposure to pesticides can inhibit coral reproduction, including fertilization, settlement and metamorphosis (Markey et al. 2007). Similarly, other endocrine disruptors, including steroidal estrogens, have been shown to reduce coral growth and fecundity, and increase tissue thickness (Tarrant et al. 2004). The general effects of contaminants on coral communities are reductions in coral growth, coral cover, and species richness, and a shift in community composition to more tolerant species (Brainard et al. 2011).

5.2.3.2 Elkhorn Coral (*Acropora palmata*), Staghorn Coral (*Acropora cervicornis*), and Designated Critical Habitat

Elkhorn and staghorn coral were listed as threatened under the ESA in 2006, and this listing was reaffirmed in 2014.

Species Description and Life History

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 cm (20 in) wide and range in thickness from about 4-5 cm (1.5-2 in). Individual colonies can grow to at least 2 m (6.5 ft) in height and 4 m (13 ft) 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 cm (0.1-2 in; Lirman et al. 2010a), and linear branch growth rates have been reported to range between 3-11.5 cm (1.2-4.5 in) per year

(*Acropora* Biological Review Team 2005). The species can exist as isolated branches, individual colonies up to about 1.5 m (5 ft) 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 49). 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.

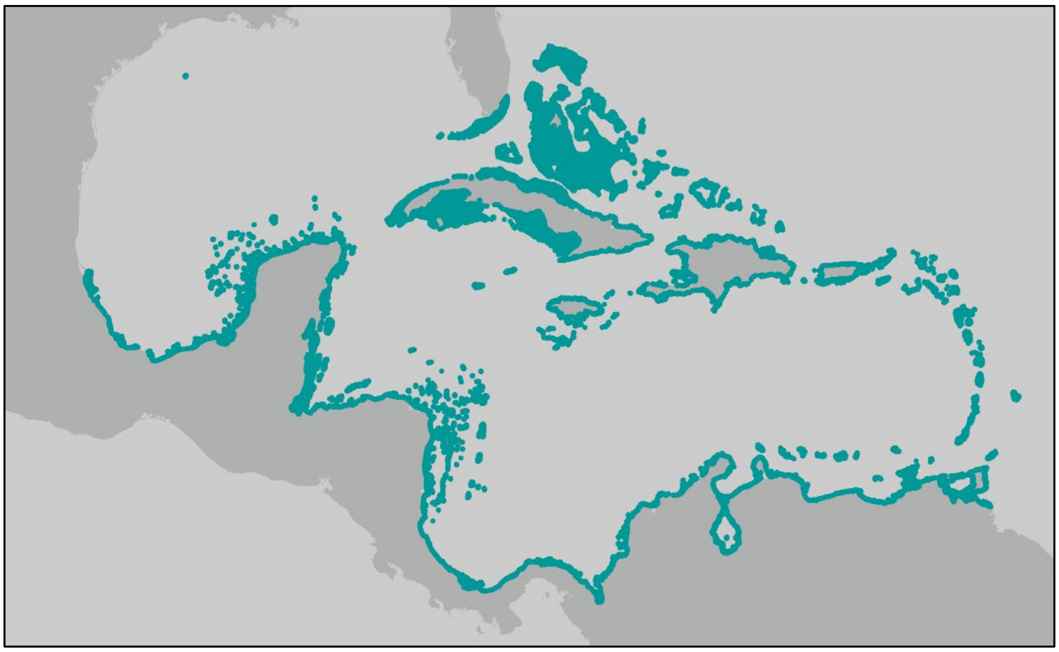

Figure 49. Map showing range of elkhorn and staghorn corals

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

Elkhorn and staghorn coral, like most stony corals, employ both sexual and asexual reproductive strategies to propagate. Sexual reproduction in corals includes gametogenesis, the process in which cells undergo meiosis to form gametes within the polyps. Because elkhorn and staghorn coral are hermaphroditic, each polyp contains both sperm and egg cells that are released together in a "bundle" causing the coral gametes to develop externally from the parent colony.

Elkhorn

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 2-month period) has been reported from the Florida Keys Fogarty et al. (2012). The estimated size at sexual maturity is approximately 1,600 cm^2 (250 in^2), and growing edges and encrusting base areas are not fertile (Soong and Lang 1992). Larger colonies have higher fecundity per unit area, as do the upper branch surfaces (Soong and Lang 1992). Although self-fertilization is possible, elkhorn coral is largely self-incompatible (Baums et al. 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 m (0.32-328 ft), but fragments usually travel less than 30 m (98 ft; 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 4-11 cm (1.6-4.3 in) per year. Branches are up to approximately 50 cm (20 in) wide and range in thickness of about 4-5 cm (1.6-2 in). Individual colonies can grow to at least 2 m (6.6 ft) in height and 4 m (13 ft) 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 6 in (17 cm; (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. 2010).

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

Population Dynamics

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

Elkhorn

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 m^2). The eastern Caribbean populations are characterized by denser (0.30 ± 0.21 colonies per m^2), 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.

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.

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% 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% 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).

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 m in depth. Historically, elkhorn coral inhabited most waters of the Caribbean between one to five m 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 14 (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.

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% of the sites surveyed between 1999 and 2017. Average density ranged from 0.001 to 0.12 colonies per m^2 (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 7% of surveyed reefs, and average density ranged from 0.001 to 0.01 colonies per m^2 (NOAA, unpublished data). Maximum elkhorn coral density at ten sites in St. John, USVI was 0.18 colonies per m^2 (Muller et al. 2014). In Puerto Rico, average density ranged from 0.002 to 0.09 colonies per m^2 in surveys conducted between 2008 and 2018, and elkhorn coal was observed on one to 27% of surveyed sites (NOAA, unpublished data). Density estimates from sites in Cuba range from 0.14 colonies per m^2 (Alcolado et al. 2010) to 0.18 colonies per m^2 (González-Díaz et al. 2010).

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% of elkhorn corals were impacted (NOAA 2018). 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.

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.

Staghorn

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 km (310.7 mi) 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 km (1.2 mi), 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 *A. prolifera* with staghorn coral (Garcia Reyes and Schizas 2010; Vollmer and Palumbi 2007). Populations in Florida and Honduras are genetically distinct from each other and other populations in the 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).

Staghorn coral is distributed throughout the Caribbean Sea, in the southwestern Gulf of Mexico, and in the western Atlantic Ocean. The fossil record indicates that during the Holocene epoch, staghorn coral was present as far north as Palm Beach County in southeast Florida (Lighty et al. 1978), which is also the northern extent of its current distribution (Goldberg 1973).Staghorn coral commonly occurs in water ranging from five to 20 m (16 to 65.6 ft) in depth, though it occurs in depths of 16-30 m (52-98 ft) at the northern extent of its range, and has been rarely found to 60 m (196.8 ft) in depth.

Staghorn coral naturally occurs on spur and groove, bank reef, patch reef, and transitional reef habitats, as well as on limestone ridges, terraces, and hard bottom habitats (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 m (16-65.6 ft) in depth; though it has rarely been found to approximately 60 m (196.8 ft; Davis 1982; Jaap 1984; Jaap et al. 1989; Schuhmacher and Zibrowius 1985; Wheaton and Jaap 1988). At the northern extent of its range, it grows in deeper water, 16-30 m (52-98 ft; Goldberg 1973). Historically, staghorn coral was one of the primary constructors of mid-depth 10-15 m (32.8-49 ft) 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 m [16-72 ft]; Miller et al. 2008). There is no evidence of range constriction, though loss of staghorn coral at the reef level has occurred (Acropora Biological Review Team 2005).

Precht and Aronson (2004) suggest that coincident with climate warming, staghorn coral 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 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% 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% or more (Colella et al. 2012; Lundgren and Hillis-Starr 2008; Muller et al. 2008; Rogers and Muller 2012; Williams et al. 2008a). 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% in 1995 to 10.5% in 2004 (Idjadi et al. 2006).

Riegl et al. (2009) monitored staghorn coral in photo plots on the fringing reef near Roatan, Honduras from 1996 to 2005. Staghorn coral cover declined from 0.42% in 1996 to 0.14% in 1999 after the Caribbean bleaching event in 1998 and mortality from run-off associated with a Category 5 hurricane. Staghorn coral cover further declined to 0.09% in 2005. Staghorn coral colony frequency decreased 71% between 1997 and 1999. In sharp contrast, offshore bank reefs near Roatan had dense thickets of staghorn coral with 31% cover in photo-quadrats in 2005 and appeared to survive the 1998 bleaching event and hurricane, most likely due to bathymetric separation from land and greater flushing. Modeling showed that under undisturbed conditions, retention of the dense staghorn coral stands on the banks off Roatan is likely with a possible increased shift towards dominance by other coral species. However, the authors note that because their data and the literature seem to point to extrinsic factors as driving the decline of staghorn coral, it is unclear what the future may hold for this dense population (Riegl et al. 2009).

While cover of staghorn coral increased from 0.6% in 1995 to 10.5% in 2004 (Idjadi et al. 2006) and 44% in 2005 on a Jamaican reef, it collapsed after the 2005 bleaching event and subsequent disease to less than 0.5% in 2006 (Quinn and Kojis 2008). A cold water die-off across the lower to upper Florida Keys in January 2010 resulted in the complete mortality of all staghorn coral colonies at 45 of the 74 reefs surveyed (61 %; Schopmeyer et al. 2012). Walker et al. (2012) report increasing size of 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% highlighting the dynamic nature of staghorn coral distribution via fragmentation and re-attachment.

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

Staghorn coral was observed in 21 out of 301 stations between 2011 and 2013 in stratified random surveys designed to detect *Acropora* colonies along the south, southeast, southwest, and west coasts of Puerto Rico (García-Sais et al. 2013). Staghorn coral was also observed at 16 sites outside of the surveyed area. The largest colony was 60 cm (23.6 in) and density ranged from one to ten colonies per 15 m^2 (García-Sais et al. 2013).

A report on the status and trends of Caribbean corals over the last century indicates that cover of staghorn coral has remained relatively stable (though much reduced) throughout the region since the large mortality events of the 1970s and 1980s. The frequency of reefs at which staghorn coral was described as the dominant coral has remained stable. The number of reefs with staghorn coral present declined during the 1980s (from approximately 50 to 30% of reefs), remained relatively stable at 30% through the 1990s, and decreased to approximately 20% of the reefs in 2000-2004 and approximately 10% in 2005-2011 (Jackson et al. 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% of staghorn coral colonies were impacted (NOAA 2018). 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.

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.

Status

Elkhorn

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. 2013b). 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. 2013b).

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 hurrricanes do not increase; Vardi 2011). In contrast, the studied populations in Jamaica were projected to increase in abundance, and studied populations in Navassa were projected to remain stable. Studied populations in the British Virgin Islands were predicted to decrease slightly from their initial very low levels. Studied populations in Florida, Curaçao, and Puerto Rico were predicted to decline to zero by 2100. Because the study period did not include physical damage (storms), the population simulations in Jamaica, Navassa, and the British Virgin Islands may have contributed to the differing projected trends at sites in these locations.

A report on the status and trends of Caribbean corals over the last century indicates that cover of elkhorn coral has remained relatively stable at approximately 1% throughout the region since the large mortality events of the 1970s and 1980s. The report also indicates that the number of reefs with elkhorn coral present steadily declined from the 1980s to 2000-2004, then remained stable between 2000-2004 and 2005-2011. Elkhorn coral was present at about 20% of reefs surveyed in both the 5-year period of 2000-2004 and the 7-year period of 2005-2011. Elkhorn coral was dominant on approximately 5 to 10% of hundreds of reef sites surveyed throughout the Caribbean during the 4 periods of 1990-1994, 1995-1999, 2000-2004, and 2005-2011 (Jackson et al. 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 m in depth, though it occurs in depths of 16-30 m (52-98 ft) at the northern extent of its range and has been rarely found to 60 m (196.8 ft) 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 m in order to support successful larval settlement, recruitment, and reattachment of fragments. "Substrate of suitable quality and availability" means consolidated hard bottom or dead coral skeletons free from fleshy macroalgae or turf algae and sediment cover. Areas containing this feature have been identified in four locations within the jurisdiction of the United States (Figure 50): the Florida area, which comprises approximately 3,442 km^2 (1,329 mi^2) of marine habitat; the Puerto Rico area, which comprises approximately 3,582 km^2 (1,383 mi^2) of marine habitat; the St. John/St. Thomas area, which comprises approximately 313 km^2 (121 mi^2) of marine habitat; and the St. Croix area, which comprises approximately 326 km^2 (126 mi^2) of marine habitat. The total area covered by the designation is thus approximately 7,664 km^2 (2,959 mi^2).

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 aids-to-navigation (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 run-off, coastal and maritime construction, land development, wastewater and sewage outflow discharges, point and non-point source pollutant discharges, fishing, placement of large vessel anchorages, and installation of submerged pipelines or cables. The impacts from these activities, combined with those from natural factors (i.e., major storm events), significantly affect the quality and quantity of available substrate for these threatened species to successfully sexually and asexually reproduce.

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

While algae, including crustose coralline algae and fleshy macroalgae, are natural components of healthy reef ecosystems, 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 (Rogers et al. 1984; Hughes 1985; Connell et al. 1997; Edmunds et al. 2004; Birrell et al. 2005; Vermeij 2006). In addition to preempting space for coral larval settlement, many fleshy macroalgae produce secondary metabolites with generalized toxicity, which also may inhibit settlement of coral larvae (Kuffner and Paul 2004). The rate of sediment input from natural and anthropogenic sources can affect reef distribution, structure, growth, and recruitment. Sediments can accumulate on dead and living corals and exposed hard bottom, thus reducing the available substrate for larval settlement and fragment attachment.

In addition to the amount of sedimentation, the source of sediments can affect coral growth. In a study of 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.

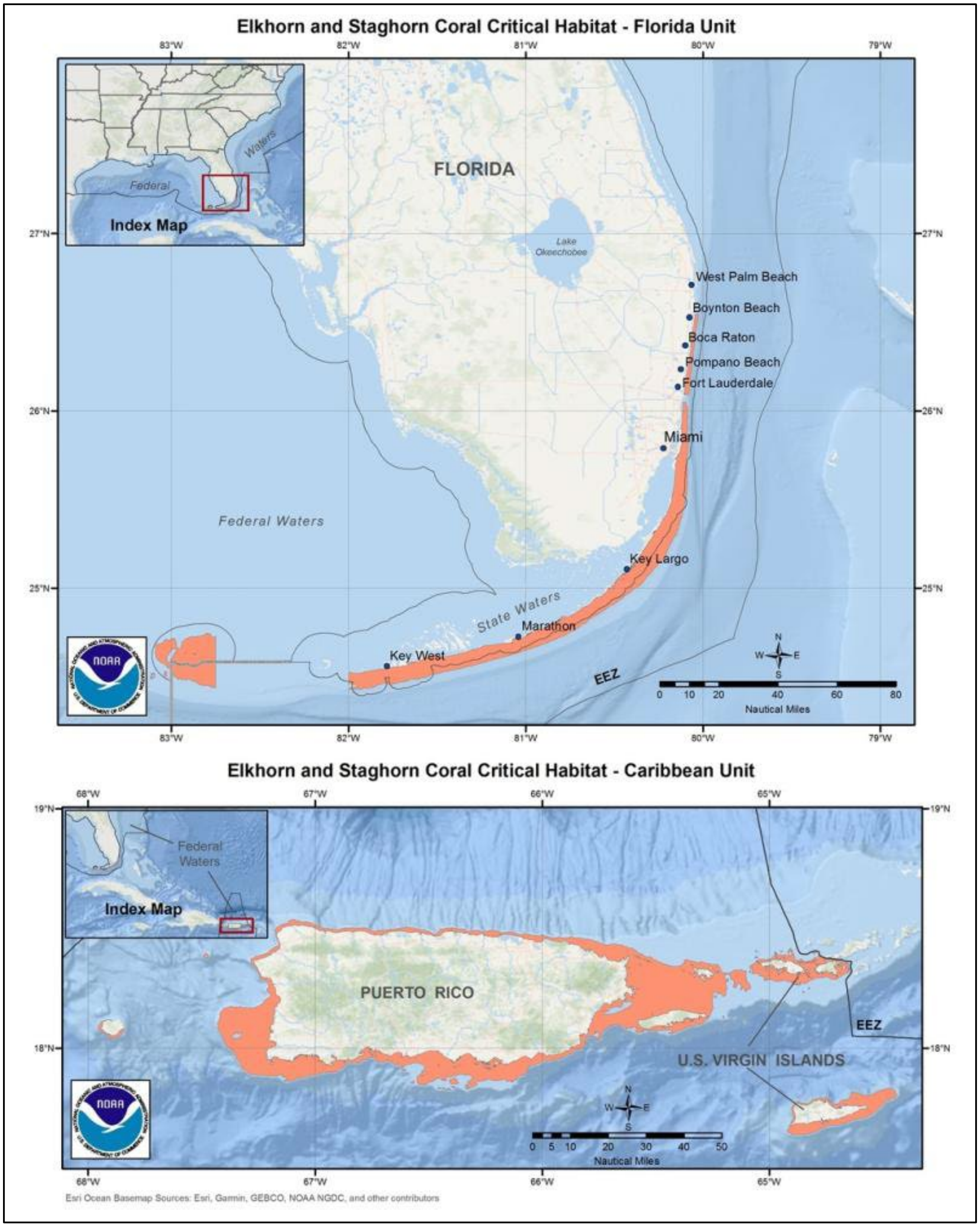

Figure 50. Florida, Puerto Rico, and Two USVI Critical Habitat Units for Elkhorn and Staghorn Corals

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% 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% 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 (Weil et al. 2009; Hernández-Pacheco et al. 2011; Bruckner and Hill 2009; Croquer and Weil 2009; Bastidas et al. 2012). 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 2015a) contains complete downlisting/delisting criteria for each of the 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.

5.2.3.3 Pillar Coral (*Dendrogyra cylindrus*)

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

Species Description and Life History

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

Pillar coral is present in the western Atlantic Ocean and throughout the greater Caribbean Sea, though absent from the southwest Gulf of Mexico (Tunnell Jr. 1988; Figure 10).

Figure 51. Range map for pillar coral (from Aronson et al. 2008a)

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 1-25 m (3.3-82 ft), but it is most common in water between approximately 5 to 15 m (16 to 49 ft) deep (Acosta and Acevedo 2006; Cairns 1982; Goreau and Wells 1967).

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

Pillar coral is a gonochoric broadcast spawning 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.

Benthic cover is generally less than 1% in monitoring studies. Mean density of pillar coral was approximately 0.5 colonies per ten m^2 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 km^2 for an overall density of approximately 450 colonies per mi^2.

Information on pillar coral is most extensive for Florida. Pillar coral ranked as the least abundant to third least abundant coral species in stratified random surveys of the Florida Keys between 2005 and 2009 and was not encountered in surveys in 2012 (Miller et al. 2013b). Pillar coral was seen only on the ridge complex and mid-channel reefs at densities of approximately 1 and 0.1 colonies per 10 m^2 (approximately 100 ft^2), respectively, between 2005 and 2010 in surveys from West Palm Beach to the Dry Tortugas (Burman et al. 2012). In surveys conducted between 1999 and 2016 from Palm Beach to the Dry Tortugas, pillar coral was present at 2% of sites surveyed and ranged in density from 0 to 0.4 colonies per m^2 with an average density of 0.004 colonies per 10 m^2 (approximately 100 ft^2; NCRMP). In 2014, there were 714 known colonies of pillar coral along the Florida reef tract from southeast Florida to the Dry Tortugas. By 2017, many of these colonies had suffered tissue loss, particularly in the northern portion of the reef tract, and over half (57%) suffered complete mortality due to disease, most likely associated with multiple years of warmer than normal temperatures (Lewis et al. 2017). Pillar coral is particularly susceptible to SCTLD, which was first reported in Florida in 2014 and then in the U.S. Caribbean in 2019.

Density of pillar corals in the Caribbean is low and on average less than 0.1 colonies per 10 m^2. The average number of pillar coral colonies in remote reefs off southwest Cuba was 0.013 ± 0.045 colonies per 10 m (approximately 32 ft) transect, and the species ranked sixth rarest out of 38 coral species (Alcolado et al. 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 km^2 (0.6 mi^2) for an overall density of approximately 0.000017 colonies per 10 m^2 (approximately 100 ft^2;

Acosta and Acevedo 2006). In Puerto Rico, density of pillar coral ranged from 0.003 to 0.01 colonies per m^2 with an average density of 0.03 colonies per m^2; it occurred in one to 18% of the sites surveyed between 2008 and 2018 (NCRMP). In the USVI, average density of pillar coral ranged between 0.0003 and 0.005 colonies per m^2 (approximately 100 ft^2); it occurred in one to 6% of the sites surveyed between 2002 and 2017 (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% of pillar corals were impacted (NOAA 2018). 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 1% in monitoring studies. Pillar coral's average cover was 0.002% on patch reefs and 0.303% in shallow offshore reefs in annual surveys of 37 sites in the Florida Keys between 1996 and 2003 (Somerfield et al. 2008). In surveys conducted in Florida between 1996 and 2016, cover of pillar coral ranged from 0 to 0.5% with an average of 0.0002% (NOAA NCRMP). In Puerto Rico, cover of pillar coral ranged between 0 and 4% with an average of 0.02% in surveys conducted between 2001 and 2016 (NOAA NCRMP). In Dominica, pillar coral comprised less than 0.9 percent cover and was present at 13.3% of 31 surveyed sites (Steiner 2003). Pillar coral was observed on 1 of 7 fringing reefs surveyed off Barbados, and cover was 2.7 ± 1.4% (Tomascik and Sander 1987).

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

Pillar coral is currently uncommon to rare throughout Florida and the Caribbean. Low abundance and infrequent encounter rate in monitoring programs result in small sample sizes. The low coral cover of this species renders monitoring data difficult to extrapolate to realize trends. The studies that report pillar coral population trends indicate some decline with severe declines in Florida. 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, but there is little evidence of population declines thus far. 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 twenty-five m, 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 5.2.4 for more information.

Recovery Goals

No final recovery plans currently exist for pillar coral; however, a recovery outline was published in 2014. 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 overfishing).
- 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.

5.2.3.4 Rough Cactus Coral (*Mycetophyllia ferox*)

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

Species Description and 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 occurs in the western Atlantic Ocean and throughout the wider Caribbean Sea (Figure 52).

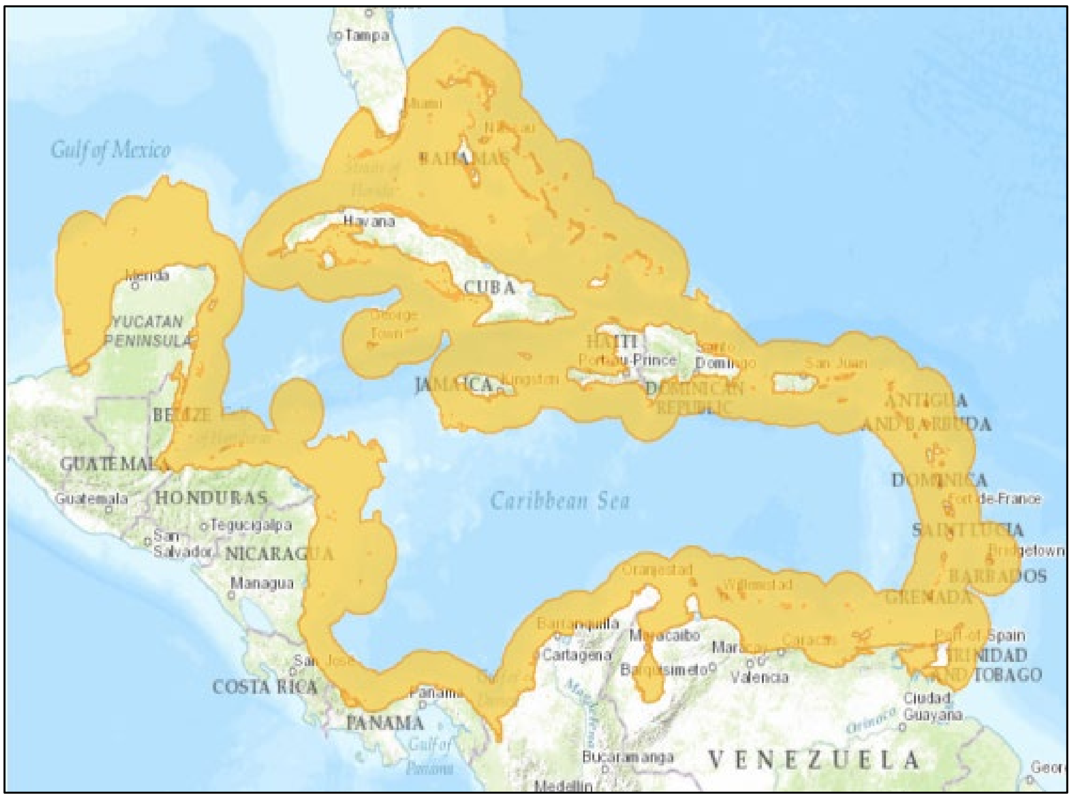

Figure 52. Range map for rough cactus coral (from Aronson et al. 2008e)

According to the International Union for Conservation of Nature (IUCN) Species Account and the Convention on International Trade in Endangered Species database, rough cactus coral occurs throughout the U.S. waters of the western Atlantic but has not been reported from FGBNMS (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 National Wildlife Refuge; Biscayne National Park; Buck Island Reef National Monument. It inhabits reef environments in water depths of five to ninety m, including shallow and mesophotic habitats (e.g., > 30 m).

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

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 2% of sites where they occurred (NOAA, unpublished data). Rough cactus corals were present at 8% of sites surveyed in Puerto Rico in 2008, but in surveys conducted between 2010 and 2018, they were found at one to 4% 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% 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 1% 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 m^2 (100 ft^2) 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.

The effects of SCTLD have been severe, causing mortality of millions of coral colonies across several species, including *Mycetophyllia* species, since it was first reported in Florida in 2014. At study sites in southeast Florida, prevalence of disease was recorded in 67% of all coral colonies and 81% of colonies of those species susceptible to the disease (Precht et al. 2016). No species-specific information is available for the effects of disease on rough cactus coral, but in a survey of 134 sites conducted between October 2017 and April 2018, 9% of *Mycetophyllia* species were affected (Neely 2018b). This disease prevalence is a snapshot in time and does not represent the total proportion of *Mycetophyllia* species affected by the disease outbreak.

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% in 2007, accounting for 0.02% 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% of the colonized bottom and 0.07% 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 8% of 784 surveyed sites and was the 36th most commonly observed out of 46 coral species; other *Mycetophyllia* species were seen more commonly (Afzal et al. 2001). In surveys of remote southwest reefs of Cuba, rough cactus coral was observed at one of 38 reef-front sites, where average abundance was 0.004 colonies per approximately 10 m^2 (108 ft^2); 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% (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 m^2 (100 ft^2) and cover of less than 0.1%. Low encounter rate and percent cover coupled with the tendency to include *Mycetophyllia* spp. at the genus level make it difficult to discern population trends of rough cactus coral from monitoring data. However, reported losses of rough cactus coral from monitoring stations in the Florida Keys and Dry Tortugas (63-80% loss) 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 5 to 90 m (16 to 295 ft) 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 5.2.4 for more information.

Recovery Goals

No final recovery plan currently exists for rough cactus coral, however a recovery outline was developed in 2014 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 (see Pillar Coral, above) with short and long-term goals.

5.2.3.5 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).

Species Description and Life History

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 because 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.

Lobed, mountainous, and boulder star corals occur in the western Atlantic and greater Caribbean as well as FGBNMS. Lobed and mountainous star coral may be absent from Bermuda (Figure 53).

The star coral species complex has growth rates ranging from 0.02-0.5 in (0.06-1.2 cm) per year and averaging approximately 1 cm (0.3 in) in linear growth per year. The reported growth rate of lobed star coral is 0.4 to 1.2 cm (0.16 to 0.47 in) per year (Cruz-Piñón et al. 2003; Tomascik 1990). They grow slower in deep and murky waters.

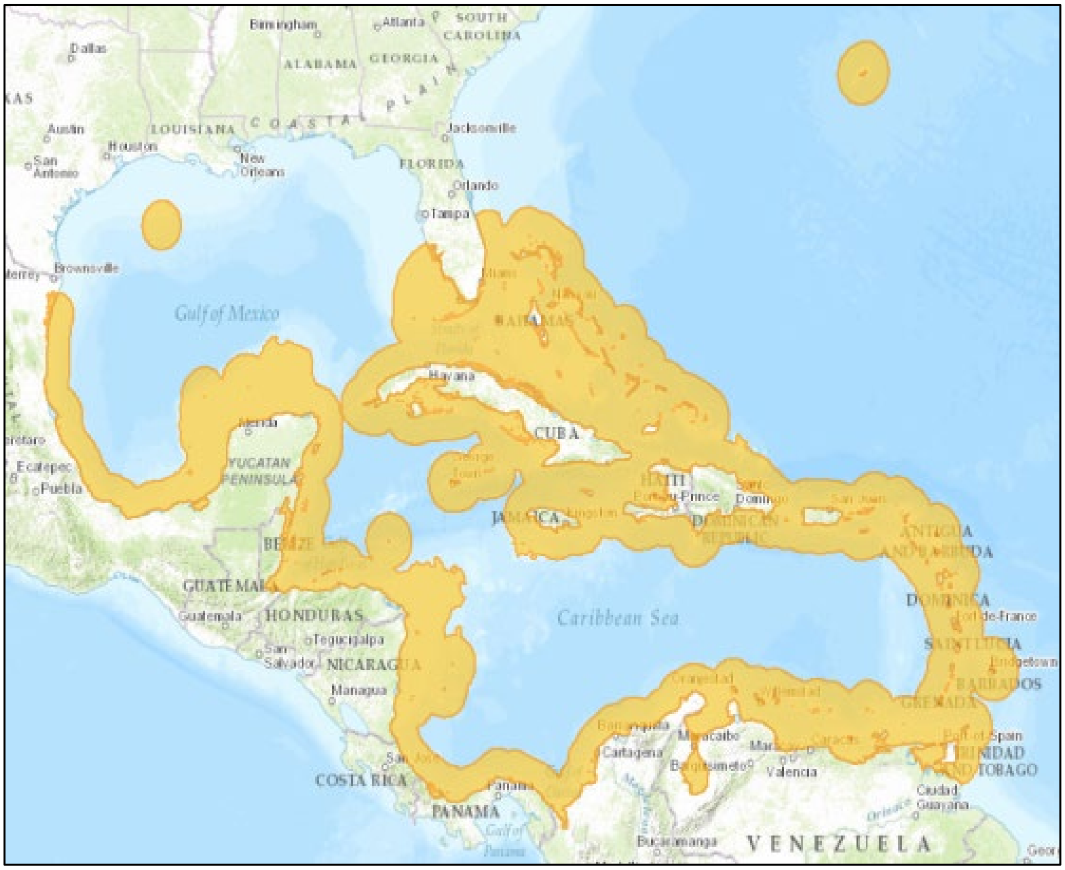

Figure 53. Range map for lobed, mountainous, and boulder star corals. Note that only boulder star corals are reported in the Bahamas (from Aronson et al. 2008b;c;d)

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

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

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

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. The reported growth rate of lobed star coral is 0.4 to 1.2 cm (0.16 to 0.47 in) per year (Cruz-Piñón et al. 2003; Tomascik 1990).

Lobed star coral is reported from most reef environments within the Caribbean (except for Bermuda) in depths of approximately 0.5-20 m (1.5-66 ft). The star coral species complex is a common, often dominant component of Caribbean mesophotic (e.g., >30 m [100 ft]) reefs, suggesting the potential for deep refuge across a broader depth range, but lobed star coral is generally described with a shallower distribution.

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

Mountainous Star Coral

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

Mountainous star coral occurs in the western Atlantic and throughout the Caribbean, including Bahamas, FGBNMS, 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 m (33-66 ft) in fore-reef environments. The depth range of mountainous star coral has been reported as approximately 0.5-40 m (1.5-132 ft), though the species complex has been reported to depths of 90 m (295 ft), indicating mountainous star coral's depth distribution is likely deeper than 40 m (132 ft). Star coral species are a common, often dominant component of Caribbean mesophotic reefs (e.g., 30 m [> 100 ft]), suggesting the potential for deep refugia for mountainous star coral.

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

Boulder Star Coral

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

Boulder star coral is distributed in the western Atlantic Ocean and throughout the Caribbean Sea including in the Bahamas, Bermuda, and FGBNMS. 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 5-50 m (16-165 ft), with the species complex reported to 90 m (250 ft). *Orbicella* species are a common, often dominant, component of Caribbean mesophotic reefs (e.g., 30 m [>100 ft]), suggesting the potential for deep refugia for boulder star coral.

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

Population Dynamics

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

<u>Lobed Star Coral</u>

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 cm (36 in) size class in 2012 compared to 2005 and 2009. Partial colony mortality was lowest at less than 10 cm (4 in; as low as approximately 5%) and up to approximately 70% in the larger size classes. In the Dry Tortugas, Florida, abundance of lobed star coral ranked 41 out of 43 in 2006 and 31 out of 40 in 2008. The extrapolated population estimate was 0.5 million ± 0.3 million (SE) colonies in 2008. Differences in population estimates between years may be attributed to sampling effort rather than population trends (Miller et al. 2013b).

Colony density varies by habitat and location, and ranges from less than 0.1 to greater than 1 colony per approximately 10 m^2 (100 ft^2). Benthic surveys along the Florida Reef Tract between 1999 and 2017 recorded an average density of 0.01 to 0.09 colonies per m^2, and lobed star coral was observed at 4% to 16% of surveyed sites (NOAA NCRMP). Average density of lobed star corals in Puerto Rico ranged from 0.01 to 0.08 colonies per m^2 in surveys conducted between 2008 and 2018 and was observed at 9% to 63% of surveyed sites (NOAA NCRMP). In the USVI, average density ranged from 0.03 to 0.21 colonies per m^2 in benthic surveys conducted between 2002 and 2017, and lobed star coral was observed at 25% to 54% of surveyed sites (NOAA NCRMP). In the Flower Garden Banks, limited surveys detected lobed star corals at none to 24% of surveyed sites, and density was recorded as 0.1 colonies per m^2 in 2010 and 0.01 colonies per m^2 in 2013 (NOAA NCRMP). Off southwest Cuba on remote reefs, average lobed star coral density was 0.31 colonies per approximately 10 m^2 (108 ft^2) at 38 reef-crest sites and 1.58 colonies per approximately 10 m^2 (108 ft^2) at 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 cm (40 in;(Alcolado et al. 2010).

Recent events have greatly impacted coral populations in Florida and the U.S. Caribbean. An unprecedented, multi-year disease event, which began in 2014, swept through Florida and caused massive mortality from St. Lucie Inlet in Martin County to Looe Key in the lower Florida Keys. The effects of this widespread disease have been severe, causing mortality of millions of coral colonies across several species. At study sites in southeast Florida, prevalence of disease was recorded at 67% of all coral colonies and 81% of colonies of those species susceptible to the disease (Precht et al. 2016). Lobed star coral was one of the species in surveys that showed the highest prevalence of disease, and populations were reduced to < 25% of the initial population size (Precht et al. 2016).

Hurricanes Irma and Maria caused substantial damage in Florida, Puerto Rico, and the US Virgin Islands in 2017. Hurricane impacts included large, overturned and dislodged coral heads and extensive burial and breakage. At 153 survey locations in Puerto Rico, approximately 43-44% of lobed star corals were impacted by hurricanes Irma and Maria in 2017 (NOAA 2018). In Florida, approximately 80% 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 marine protected area (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% in permanent monitoring stations in the Florida Keys (Waddell and Clarke 2008). Cover of lobed star coral declined 71% in permanent monitoring stations between 1996 and 1998 on a reef in the upper Florida Keys (Porter et al. 2001).

Mountainous Star Coral

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 3 regions (Baums et al. 2010). Of 10 mountainous star coral colonies observed to spawn at a site off Bocas del Toro, Panama, there were only three genotypes (Levitan et al. 2011) potentially indicating 30% clonality.

A multi-year disease event, which began in 2014, has had severe effects, causing mortality of millions of coral colonies across several species, including mountainous star coral. At 153 survey locations in Puerto Rico, approximately 12-14% of mountainous star corals were impacted by hurricanes Irma and Maria in 2017 (NOAA 2018). In Florida, approximately 24% of mountainous star corals surveyed at 57 sites were impacted (Florida Fish and Wildlife Conservation Commission, unpublished data).

Benthic surveys along the Florida Reef Tract between 1999 and 2017 have shown a decrease of mountainous star coral (NOAA, unpublished data). In 1999, mountainous star coral was present at 62% of surveyed sites and had an average density of 0.62 colonies per m^2. Presence and density decreased substantially after 2005, and in 2017, mountainous star coral was present at 30% of sites and had an average density of 0.09 colonies per m^2.

Benthic survey data for the U.S. Caribbean show less variability in the density of mountainous star coral. In Puerto Rico, average density was between 0.1 and 0.2 colonies per m^2 between 2008 and 2016 (NOAA, unpublished data). In 2018, average density was recorded as 0.01 colonies per m^2, the lowest recorded for all survey years. In the USVI, density ranged from 0.01 to 0.2 colonies per m^2 between 2002 and 2017 with no obvious trends among years.

In the Flower Garden Banks, limited benthic surveys show density of mountainous star coral remained relatively stable between 2010 and 2015 (NOAA, unpublished data). Average density was recorded as 0.09 colonies per m^2 in 2010, 0.19 colonies per m^2 in 2013, and 0.21 colonies per m^2 in 2015. These may represent an increasing trend as the presence of mountainous star coral also increased during this same period. It was present at 35% of sites in 2010 and increased to 68% of sites in 2013 and 77% of sites in 2015.

Limited data are available for other areas of the Caribbean. On remote reefs off southwest Cuba, average density of mountainous star coral was 0.12 colonies per 10 m^2 (108 ft^2) at 38 reef-crest sites and 1.26 colonies per 10 m^2 (108 ft^2) at 30 reef-front sites (Alcolado et al. 2010). In a survey of 31 sites in Dominica between 1999 and 2002, mountainous star coral was present at 80% of the sites at 1-10% cover (Steiner 2003).

Boulder Star Coral

Reported density is variable by location and habitat and is reported to range from 0.002 to 10.5 colonies per approximately 108 ft^2 (10 m^2). Benthic surveys conducted in Florida between 1999 and 2017 recorded an average density of 0.01 to 0.36 colonies per m^2 and boulder star coral was observed at five to 45% of surveyed sites (NOAA, unpublished data). In Puerto Rico, boulder star coral was observed at three to 50% of sites, and average density ranged from 0.002 to 0.13 colonies per m^2 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 m^2 in 19 to 69% of sites surveyed between 1999 and 2018 (NOAA, unpublished data). Limited surveys in FGBNMS reported a relatively stable density of 0.91 to 1.05 colonies per m^2 between 2010 and 2015, and boulder star coral was present at 90 to 100% of surveyed sites (NOAA NCRMP). In a survey of 31 sites in Dominica between 1999 and 2002, boulder star coral was present in 7% of the sites at less than one percent cover (Steiner 2003). On remote reefs off southwest Cuba, colony density was 0.08 colonies per about100 ft^2 (10 m^2) at 38 reef-crest sites and 1.05 colonies per about 10 m^2 (100 ft^2) 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 cm [20 in]) 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, 4% of all corals at six sites surveyed off Mona Island were boulder star coral colonies, and approximately 5% were boulder star corals in 2008; at Desecheo Island, about 2% of all coral colonies were boulder star coral in both 2000 and 2008 (Bruckner and Hill 2009).

Recent events have greatly impacted boulder star coral populations in Florida and the U.S. Caribbean. The multi-year SCTLD event, which began in 2014, swept through Florida and caused massive mortality from St. Lucie Inlet in Martin County to Looe Key in the lower Florida Keys. The effects of this widespread disease have been severe, causing mortality of millions of coral colonies across several species, including boulder star coral. At study sites in southeast Florida, prevalence of disease was recorded at 67% of all coral colonies and 81% of colonies of those species susceptible to the disease (Precht et al. 2016).

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% of boulder star corals were impacted by hurricanes Irma and Maria in 2017 (NOAA 2018). 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 cm (0.02-0.47 in) per year and averaging approximately one-cm 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% 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 5 m (3.28 ft), colonies spawned more synchronously than farther spaced colonies, regardless of genotype. At distances greater than 5 m (3.28 ft), 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% and 90% 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% and 57% 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 cm size class in 2012 compared to 2005 and 2009. Partial colony mortality was lowest at less than ten cm (as low as approximately 5%) and up to approximately 70% in the larger size classes. In the Dry Tortugas, Florida, abundance of lobed star coral ranked 41 out of 43 in 2006 and 31 out of 40 in 2008. The extrapolated population estimate was 0.5 million ± 0.3 million (SE) colonies in 2008. Differences in population estimates between years may be attributed to sampling effort rather than population trends (Miller et al. 2013b).

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% in permanent monitoring stations in the Florida Keys (Waddell and Clarke 2008). Cover of lobed star coral declined 71% in permanent monitoring stations between 1996 and 1998 on a reef in the upper Florida Keys (Porter et al. 2001).

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

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 its vulnerability to extinction. Despite high declines, the species is still common and remains one of the most abundant species on Caribbean reefs. Its life history characteristics of large colony size and long life span have enabled it to remain relatively persistent despite slow growth and low recruitment rates, thus moderating vulnerability to extinction. 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 m (1.6-65.6 ft) 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 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% and 48% at Mona and Desecheo Islands, respectively (Bruckner and Hill 2009). In 1998, 27% of all corals at 6 sites surveyed off Mona Island were mountainous star coral colonies, but this statistic decreased to approximately 11% in 2008 (Bruckner and Hill 2009). At Desecheo Island, 12% of all coral colonies were mountainous star coral in 2000, compared to 7% in 2008.

In a survey of 185 sites in 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%. The total live area occupied by mountainous star coral declined by a mean of 65%, and mean colony size declined from 4005 cm^2 to 1413 cm^2 (43 ft^2 to 15 ft^2). At the same time, there was a 168% increase in small tissue remnants less than 500 cm^2 (5 ft^2), while the proportion of completely live large (1,500- 30,000 cm^2 [1.6 ft^2 to 32 ft^2]) 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).

Overall, it appears that populations of mountainous star coral have been decreasing. Population decline has occurred over the past few decades with a 65% loss in mountainous star coral cover across five countries. Losses of mountainous star coral from Mona and Descheo Islands, Puerto Rico include a 36-48% reduction in abundance and a decrease of 42-59% in its relative abundance (i.e., proportion relative to all coral colonies). High partial mortality of colonies has led to smaller colony sizes and a decrease of larger colonies in some locations such as The Bahamas, Bonaire, Puerto Rico, Cayman Islands, and St. Kitts and Nevis. 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.

Boulder Star Coral

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 cm (4-8 in) and approximately 20-30 cm (8-12 in). Partial colony mortality ranged from zero to approximately 73% and was generally higher in larger colonies (Miller et al. 2013b).

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 cm (8-12 in) 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 90 cm (35 in). Partial colony mortality ranged from approximately 10-55%. Two years later (2008), no size class was found to dominate, and the proportion of colonies in the medium-to-large size classes (approximately 61-91 cm [24-36 in]) appeared to be less than in 2006. The number of colonies in the largest size class of greater than 90 cm (35 in) remained consistent. Partial colony mortality ranged from approximately 15-75% (Miller et al. 2013b).

In 2003, on the East Flower Garden Bank of FGBNMS, boulder star coral comprised 46% of the 76.5 percent coral cover on reefs approximately 32-40 m (105-131 ft) in depth. Partial coral mortality due to bleaching, disease and predation was rare in survey stations (Precht et al. 2005).

In a survey of 31 sites in Dominica between 1999 and 2002, boulder star coral was present in 7% of the sites at less than 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 m^2 (100 ft^2). In surveys of 1,176 sites in southeast Florida, the Dry Tortugas, and the Florida Keys between 2005 and 2010, density of boulder star coral ranged between 0.04 and 0.47 colonies per about 10 m^2 (100 ft^2) and was highest on the offshore patch reef and fore-reef habitats (Burman et al. 2012). In south Florida, density was highest in areas south of Miami at 0.44 colonies per about 10 m^2 (100 ft^2) compared to 0.02 colonies per about 10 m^2 (100 ft^2) in Palm Beach and Broward Counties (Burman et al. 2012). Along the Florida reef tract from Martin County to the lower Florida Keys, density of boulder star coral was about 0.9 colonies per about 10 m^2 (100 ft^2; Wagner et al. 2010). On remote reefs off southwest Cuba, colony density was 0.083 ± 0.17 (SD) per about 10 m^2 (100 ft^2) transect on 38 reef-crest sites and 1.05 ± 1.02 colonies per about 10 m^2 (100 ft^2) 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 1 (i.e., less than about 50 cm [20 in]) 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, 4% of all corals at six sites surveyed off Mona Island were boulder star coral colonies and approximately 5% in 2008; at Desecheo Island, about 2% of all coral colonies were boulder star coral in both 2000 and 2008 (Bruckner and Hill 2009).

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 FGBNMS 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%. Overall, the total live area occupied by boulder star coral declined by a mean of 38%, and mean colony size declined from 1356 cm^2 to 845 cm^2 (210 in^2 to 131 in^2). At the same time, there was a 137% increase in small tissue remnants, along with a decline in the proportion of large (1,500 to 30,000 cm^2 [232.5 to 4,650 in^2]), completely alive colonies. Mortality was attributed primarily to outbreaks of white plague and yellow band disease, which emerged as corals began recovering from mass bleaching events. This was followed by increased predation and removal of live tissue by damselfish to cultivate algal lawns (Bruckner 2012).

Overall, abundance of boulder star coral appears stable in some locations and has declined in others. Although boulder star coral remains common, the buffering capacity of its 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 anticipate that population abundance is likely to decrease in the future with increasing threats.

Critical Habitat

Critical habitat has been proposed for lobed star, mountainous star, and boulder star coral. See Section 5.2.4 for more information.

Recovery Goals

No final recovery plan currently exists for lobed star, mountainous star or boulder star coral; however, a recovery outline was developed in 2014 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 (see Pillar Coral section) with short and long-term goals.

5.2.3.6 *Acropora globiceps*

Acropora globiceps was listed as threatened on September 10, 2014 (79 FR 53852).

Species Description and Life History

Acropora globiceps is distributed from the oceanic west Pacific to the central Pacific as far east as the Pitcairn Islands (Figure 54).

Colonies of *Acropora globiceps* are typically about a foot in diameter or less, but can reach approximately 1 m (3.28 ft) in diameter. Colonies are round, with finger-like branches growing upward. Branches are uniform in size and shape, roughly finger length, diameter, and shape, with almost no side branches. Branch tips are rounded. The axial corallite is small and short. Radial corallites (i.e., corallites on the sides of branches) are uniform and fairly small, and often some are in rows. Branches are usually close together and can have a narrow, uniform crack between them, though not always. Length of branches, how close they are together, and the degree of branch tapering varies some between colonies, but usually not within colonies. Colony color is typically cream to brown, and sometimes fluorescent green in some locations. As explained above, this species is similar to some other *Acropora* species. However, *Acropora globiceps* has distinctive characteristics and can be reliably identified in the field, as noted above and in more detail in Fenner and Burdick (2016) and Fenner (2020a).

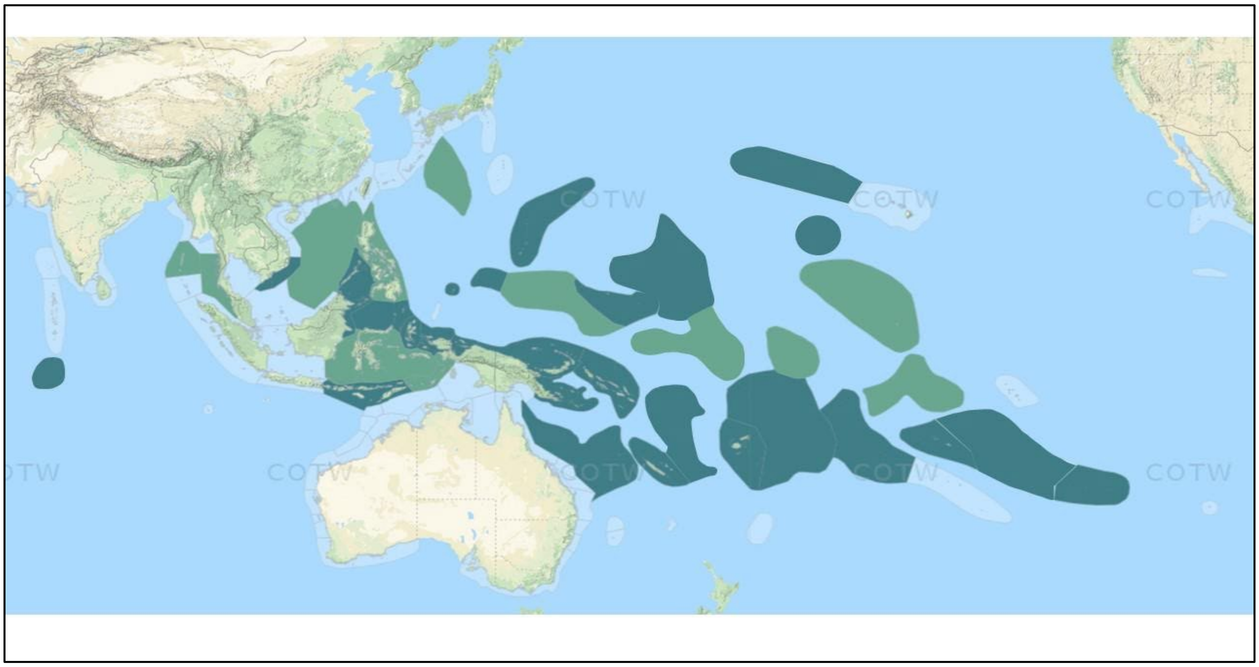

Figure 54. Range of *Acropora globiceps*, modified from the map in Veron et al. (2016), based on sources cited in the text. Dark green indicates ecoregions with confirmed observations of *Acropora globiceps* by recognized experts, and light green indicates ecoregions where it is strongly predicted to occur by recognized experts.

Like other *Acropora* species, *Acropora globiceps* reproduces by broadcast spawning, whereby colonies release large numbers of eggs and sperm into the water. Colonies are hermaphroditic, in that each colony produces both eggs and sperm. Larvae settle on suitable substrates such as rock or dead coral and grow into colonies. Skeletal growth of colonies is relatively rapid compared to other reef-building corals. Prolific reproduction, rapid skeletal growth, and branching colony morphology help *Acropora globiceps* successfully compete for space. However, resilience to disturbance is low, and populations that are frequently disturbed by warming-induced bleaching, storms, and other threats have high levels of mortality, rapid turnover, and high proportions of small colonies (Adjeroud et al. 2015; Darling et al. 2012; Kayal et al. 2015).

Many *Acropora* have branching morphologies, making them potentially susceptible to fragmentation. Fragment survival can increase coral abundance in the short-term but does not contribute new genotypes (or evolutionary opportunities) to the population.

Population Dynamics

DeVantier and Turak (2017) characterized relative abundances of each reef-building coral species present at a total of 3,075 sites distributed throughout 31 Indo-Pacific ecoregions from the Red Sea to the Great Barrier Reef. The sites were surveyed from 1994 to 2016, and included all main reef types, including fringing, patch, platform and barrier reefs, atolls, and non-reefal coral communities. Non-reefal areas are those where environmental conditions prevent reef formation by reef-building corals, but some reef-building coral species are present (Perry and Larcombe 2003). Surveys were generally conducted between the surface and approximately 40 m (131 ft) in depth, although some extended to 40 – 50 m (131-164 ft; DeVantier and Turak 2017). The relative abundance of each species in each ecoregion was quantified on a scale of 1 to 5, where 1 = rare, 2 = uncommon, 3 = common, 4 = abundant, and 5 = dominant, then the mean relative abundance of each species was calculated for all of the ecoregions where it was reported. Of the 31 surveyed ecoregions, *Acropora globiceps* was reported from 13 ecoregions, and its mean relative abundance was 1.95 (DeVantier and Turak 2017).

In addition to the 13 ecoregions where the relative abundance of *Acropora globiceps* was estimated by DeVantier and Turak (2017), their rating method has been used to estimate relative abundances of reef-building corals in portions of several other ecoregions in the central Pacific. The relative abundances of *Acropora globiceps* in these surveys ranged from 1.3 (Saipan) to 2.5 (Wallis), and included scores of 1.8 (American Samoa), 1.5 (Tonga), 1.5 (Fiji), 2.1 (New Caledonia), and 1.7 (Marshall Islands; Fenner 2020b). Based on the results of DeVantier and Turak (2017) and Fenner (2020b), the overall relative abundance of *Acropora globiceps* is uncommon, but ranges from rare to common, depending on the location.

Based on *Acropora globiceps'* distribution and relative abundance, NMFS (2014a) estimated the absolute abundance of *Acropora globiceps* to be at least tens of millions of colonies. Dietzel et al. (2021) estimated its absolute abundance at 654 million colonies.

In the 2014 listing rule, NMFS determined that, within U.S. waters, *Acropora globiceps* occured in Guam (a single island), the CNMI (an archipelago of 15 islands), American Samoa (an archipelago of 7 islands), PRIA (an administrative grouping of seven islands, atolls, and reefs widely distributed across the central Pacific), and the NWHI. As described in more detail below, Smith (2021a) has updated the information regarding the distribution of this species based on more recent surveys.

Guam: *Acropora globiceps* is widely distributed on the reef slopes around Guam. The U.S. Department of Defense reported the species from 24 sites around Guam (Figure 4-14; Department of Defense 2019).

CNMI: *Acropora globiceps* has been recorded throughout southern CNMI, including on Saipan as recently as 2021 (Smith 2021a). Various expert data records indicate that the species is present on Rota as recently as 2019, and the species has been recorded on Aguijan and Tinian as recently as 2021 and 2017, respectively (Smith 2021b). The islands of northern CNMI are uninhabited and rarely surveyed. However, Smith (2021a) reports *Acropora globiceps* from Pagan and Maug, and possibly Anatahan. Burdick (2021) reported a colony on Alamagan in 2017 and two colonies on Urracas (Farallón de Pájaros) in 2017, but PIFSC did not find any colonies of this species when they surveyed the islands the same year (Smith 2021b). *Acropora globiceps* has been reported from FDM (Carilli et al. 2020), an islet between CNMI's southern and northern islands.

American Samoa: *Acropora globiceps* has been reported in monitoring within the National Park of American Samoa Tutuila Unit from 2007 and 2019, on Ofu and Olosega Islands as recently as 2019, on Ta'u between 2005 and 2016, although monitoring by the PIFSC in 2015 and 2018 did not find the species on Ta'u, and Rose Atoll as recently as 2017 (Smith 2021b). Swains Island is the most isolated island of American Samoa. It has occasionally been surveyed for corals, but *Acropora globiceps* has not been recorded there (Fenner 2020a;b; Montgomery et al. 2019).

PRIA: Portions of each of the seven islands, atolls, and reefs of PRIA have been surveyed over the past several years. Williams et al. (2008b) and Kenyon et al. (2011) reported *Acropora globiceps* on Palmyra Atoll. Kenyon et al. (2011) reported it from Kingman Reef, but NMFS (2021) noted that the photo evidence appears to show a different species than *Acropora globiceps*. The species has been reported from Johnston Atoll in 2006 and 2014 (Smith 2021b). A detailed Wake Atoll coral reef survey in 2016 recorded various colonies of this species (Foster et al. 2017). The species has not been reported on Baker Island, Howland Island, or Jarvis Island.

NWHI: *Acropora humilis* has been recorded in the NWHI multiple times over the last several decades, although only at French Frigate Shoals. Review of photos from French Frigate Shoals taken in 2014 and 2017 indicate that these colonies are actually *Acropora globiceps*. The species was photographed at Maro Reef between 2004 and 2006 and at Gardner Pinnacles in 2000, but no more recent evidence is available (Smith 2021a).

Status

Detecting changes in abundance over time of rare or uncommon Indo-Pacific reef-building coral species such as *Acropora globiceps* is complicated by many factors, and time-series abundance data is not available for this species. However, overall mean coral cover (i.e., percentage of live cover of all reef-building coral species combined) has declined across much of the Indo-Pacific since the 1970s, and likely many decades before then in some locations (NMFS 2020b;2014a). Furthermore, from 2014 to 2017, an unprecedented series of bleaching events impacted most of the Indo-Pacific's coral reefs (Eakin et al. 2019), further reducing overall mean coral cover, especially of relatively sensitive species such as many *Acropora* species including *Acropora globiceps*. For example, between 2013 and 2017 on Guam, reduction in mean *Acropora* cover was much higher than the reduction in overall mean coral cover, and mortality of *Acropora globiceps* colonies from bleaching was higher than overall coral mortality from bleaching (Raymundo et al. 2019). Based on these general trends, it is likely that *Acropora globiceps*' abundance has been in decline for decades, and that the rate of its decline has accelerated in recent years.

Critical Habitat

Critical habitat has been proposed for *Acropora globiceps*. See Section 5.2.5 for more information.

Recovery Goals

No final recovery plans currently exist for *Acropora globiceps*; however, a recovery outline was published in 2015. The following short and long-term recovery goals are listed in the document:

Short-Term Goals:

- Through research, improve understanding of population distribution, abundance, trends, and structure through monitoring and modeling.
- Reduce locally-manageable stress and mortality sources for coral reefs (e.g., acute sedimentation, nutrients, contaminants, and overfishing on coral reefs).
- Improve understanding of genetic and environmental factors that lead to variability of bleaching response and disease susceptibility.

Long-Term Goals:

- Develop and implement U.S. and international measures to reduce atmospheric carbon dioxide concentrations to curb waning (and its effect on coral disease) and acidification impacts.
- Implement ecosystem-level actions to improve habitat quality and restore keystone species and functional processes to maintain adult colonies and promote successful natural recruitment.

5.2.3.7 *Acropora jacquelineae*

Acropora jacquelineae was listed as threatened on September 10, 2014 (79 FR 53852).

Species Description and Life History

Acropora jacquelineae has been either confirmed or strongly predicted in 19 ecoregions from central Indonesia to Tonga by Veron's group (Veron et al. 2016). Thus, we consider *Acropora jacquelineae*'s geographic range to consist of the 19 ecoregions shown in Figure 55 below. *Acropora jacquelineae* is found on walls, ledges, and reef slopes from approximately 10 to 50 m in depth (Brainard et al. 2011; Turak and DeVantier 2019).

Acropora jacquelineae was described by Wallace (1994), with additional taxonomic details provided in more recent publications (Wallace 1999; Wallace et al. 2012). Colonies are flat-topped and usually small, with long, very thin tubular corallites projecting upwards at various angles from branchlets. There are very few radial corallites in all but the edge of the colony (Fenner 2020a; Wallace 1999; Wallace et al. 2012). Colonies are uniform grey-brown or pinkish in color (Veron et al. 2016). This species is virtually indistinguishable underwater from *Acropora speciosa*. The principle difference between these two can only be seen in skeleton under the microscope, whereby *Acropora globiceps* has rows of tiny spines on the outer surface of the corallites, while *Acropora speciosa* has a dense, evenly-spaced arrangement of spines that are not in rows (Fenner 2020a; Fenner and Burdick 2016). The diameters of the tubular corallites are virtually identical in the two species (Wallace 1999).

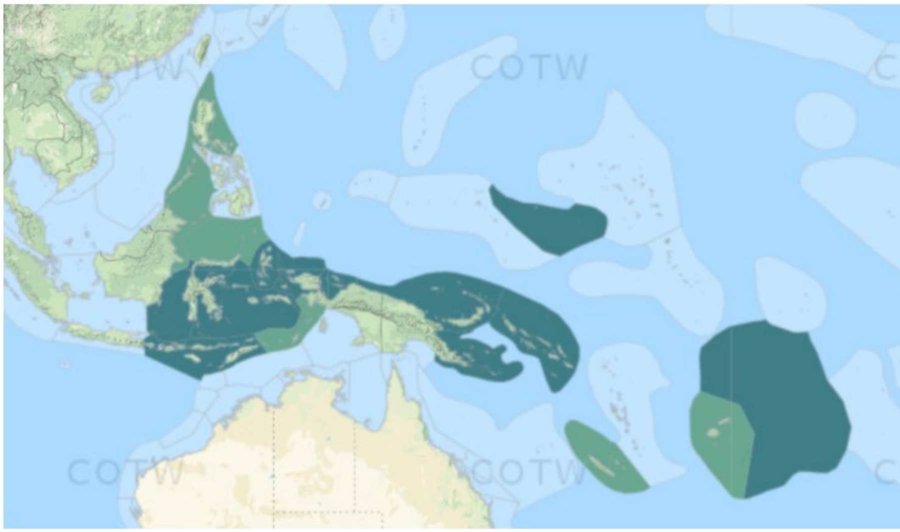

Figure 55. Range of *Acropora jacquelineae* (Veron et al. 2016)

Population dynamics

As discussed for *Acropora globiceps*, DeVantier and Turak (2017) characterized relative abundances of each reef-building coral species present at a total of 3,075 sites distributed throughout 31 Indo-Pacific ecoregions from the Red Sea to the GBR. Of the 31 surveyed ecoregions, *Acropora jacquelineae* was present within eight ecoregions, and its mean relative abundance in the eight ecoregions was 1.43 (DeVantier and Turak 2017, Table S2), which is between rare and uncommon on DeVantier and Turak's abundance scale.

In a study of reef corals in the upper mesophotic zone of the Coral Triangle and adjacent areas, *Acropora jacquelineae* was reported as one of the most common corals at that depth in the Solomon Islands (Turak and DeVantier 2019). In contrast, on Tutuila in American Samoa, hundreds of surveys at <30 m (98 ft) in depth have found only two colonies of *Acropora jacquelineae* (Fenner 2020b), and a survey of the upper mesophotic zone and deeper areas did not find any *Acropora jacquelineae* (Fenner 2020a;b; Montgomery et al. 2019). Thus, we consider the overall relative abundance of *Acropora jacquelineae* to be rare to uncommon.

Based on information from Richards et al. (2008); and Richards et al. (2019), *Acropora jacquelineae* had a population estimate of 31,599,000 colonies, and an effective population size of 3,476,000 colonies.

Within U.S. waters, *Acropora jacquelineae* was reported from Tutuila by (Fenner 2020a) in 2008 and another by Hughes (2011), although the 2011 report did not have photographic evidence or information regarding date and location, but more recent reports indicate there are no populations of this species on any of the U.S. Pacific Islands (Smith 2021b). Fenner (2021 personal communication from Doug Fenner reported in Smith 2021b) indicated the colony reported in 2008 could have been destroyed by the 2009 tsunami.

Status

Detecting changes in abundance over time of rare or uncommon Indo-Pacific reef-building coral species such as *Acropora jacquelineae* is complicated by many factors, and we do not have time-series abundance data for this species. However, overall mean coral cover (i.e., percentage of live cover of all reef-building coral species combined) has declined across much of the Indo-Pacific since the 1970s, and likely many decades before then in some locations (NMFS 2014a;2020b). Furthermore, from 2014 to 2017, an unprecedented series of bleaching events impacted most of the Indo-Pacific's coral reefs (Eakin et al. 2019), further reducing overall mean coral cover, especially of relatively sensitive species such as many *Acropora* species. Based on these general trends, it is likely that *Acropora jacquelineae*'s abundance has been in decline for decades, and that the rate of its decline has accelerated in recent years.

Critical Habitat

Critical habitat has been proposed for *Acropora jacquelineae*.

Recovery Goals

No final recovery plan currently exists for *Acropora jacquelineae*, however a recovery outline was developed in 2015 to serve as interim guidance to direct recovery efforts, including recovery planning, until a final recovery plan is developed and approved for the 15 Indo-Pacific coral species listed in September 2014. The recovery goals are the same for all species (see *Acropora globiceps* section) with short and long-term goals.

5.2.3.8 *Acropora retusa*

Acropora retusa was listed as threatened on September 10, 2014 (79 FR 53852).

Species description and Life History

Acropora retusa is either confirmed or strongly predicted from South Africa to French Polynesia (Veron et al. 2016). In addition, *Acropora retusa* has been confirmed in the Chagos Archipelago (Smith 2021a; Figure 20).

Figure 56. Range of *Acropora retusa*, modified from the map in Veron et al. (2016)

Colonies of *Acropora retusa* are flat plates with short, thick finger-like branches. Branches look spiky because radial corallites are variable in length, giving the species rougher-looking branches than other digitate *Acropora* species. Colonies are typically brown or green in color. Corallites are tubular and thick walled. Similar *Acropora* species and key differences are described in Fenner and Burdick (2016) and Fenner (2020a).

Like other *Acropora* species, *Acropora retusa* reproduces by broadcast spawning, whereby colonies release large numbers of eggs and sperm into the water. Colonies are hermaphroditic, in that each colony produces both eggs and sperm. Larvae settle on suitable substrates such as rock or dead coral and grow into colonies. Skeletal growth of colonies is relatively rapid compared to other reef-building corals. Prolific reproduction, rapid skeletal growth, and branching colony morphology help *Acropora retusa* successfully compete for space, but susceptibility to threats such as warming-induced bleaching is high (NMFS 2014a).

Acropora retusa most commonly occurs on upper reef slopes in less than 5 m in depth. It is also sometimes found on reef flats and in backreef pools, and has been recorded as deep as 10 m on Tutuila, American Samoa (2015 personal communication from Doug Fenner reported in Smith 2021a).

Population Dynamics

DeVantier and Turak (2017) characterized relative abundances of each reef-building coral species present at a total of 3,075 sites distributed throughout 31 Indo-Pacific ecoregions from the Red Sea to the Great Barrier Reef. Of the 31 surveyed ecoregions, *Acropora retusa* was present within five ecoregions, and its mean relative abundance in the five ecoregions was 1.21 (DeVantier and Turak 2017, Table S2). However, in French Polynesia (outside the area surveyed by DeVantier and Turak (2017)), *Acropora retusa* is one of the most common reef coral species (Lantz et al. 2017), making up one-third of all adult *Acropora* colonies in some locations (Lenihan et al. 2011). Thus, we consider the overall relative abundance of *Acropora retusa* to be rare to common, depending on the location.

Based on *Acropora retusa*'s distribution and relative abundance, NMFS (2014a) estimated the absolute abundance of *Acropora retusa* to be at least millions of colonies. Dietzel et al. (2021) estimated its absolute abundance at 540 million colonies.

Within U.S. waters, *Acropora retusa* occurs in American Samoa, and has been reported in Guam and PRIA, as described in more detail below.

Guam: Wallace et al. (2012) reported a sample of *Acropora retusa* from Guam in the Museum of Tropical Queensland collection. David Burdick has recorded the species from at least one reef slope site in Guam (2015 personal communication reported in Smith 2021a), although there is not a clear distinction between this species and *Acropora cophodactyla*, meaning species misidentification is possible. The U.S. Department of Defense reported the species from two sites on Guam (Department of Defense 2019).

CNMI: The U.S. Department of Defense reported the species from one site on Tinian (Department of Defense 2019). Fenner (2020b) reported it from Rota and Tinian, although the photo was identified as being *Acropora retusa* or *Acropora cophodactyla*, meaning species misidentification is possible (Smith 2021b).

American Samoa: *Acropora retusa* has been found on Tutuila (Brainard et al. 2011), including at Fagasa Bay, Fagafue Bay, Gataivai, Aoa and Asili on upper reef slopes. Surveys by PIFSC as recently as 2020 report the species on Tutuila. Fenner (2020) recorded the species on Ofu and Olosega and PIFSC recorded a colony of this species as recently as 2018 (NMFS 2021). Kenyon et al. (2011) recorded the species on Ta'u, although PIFSC did not observe the species during surveys of the island in 2015 or 2018. Kenyon et al. (2011) reported finding *Acropora retusa* on Rose Atoll and PIFSC found the species during surveys in 2018 (Smith 2021b). The species has not been reported from Swains Island.

PRIA: Kenyon et al. (2011) reported *Acropora retusa* from Johnston Atoll, Howland Island, and Kingman Reef. Doug Fenner reported it from Wake Atoll (2017 personal communication reported in Smith 2021a), and Vargas-Ángel et al. (2019) reported it from Jarvis Island.

Status

Acropora retusa is highly susceptible to ocean warming, disease, ocean acidification, trophic effects of fishing, predation, and nutrients. These threats are expected to continue and increase into the future. In addition, existing regulatory mechanisms addressing global threats that contribute to extinction risk for this species are inadequate. *Acropora retusa* is restricted to shallow habitat (0 – 5 m [0-16 ft]), where many global and local threats may be more severe, especially near populated areas. Shallow reef areas are often subjected to highly variable environmental conditions, extremes, high irradiance, and simultaneous effects from multiple stressors, both local and global in nature. A limited depth range also reduces the absolute area in which the species may occur throughout its geographic range, and indicates that a large proportion of the population is likely to be exposed to threats that are worse in shallow habitats, such as simultaneously elevated irradiance and seawater temperatures, as well as localized impacts. *Acropora retusa*'s abundance is considered rare overall.

Overall mean coral cover (i.e., percentage live cover of all reef-building coral species combined) has declined across much of the Indo-Pacific since the 1970s, and likely many decades before then in some locations (NMFS 2014a;2020b). Furthermore, from 2014 to 2017, an unprecedented series of bleaching events impacted most of the Indo-Pacific's coral reefs (Eakin et al. 2019), further reducing overall mean coral cover, especially of relatively sensitive species such as many *Acropora* species. Based on these general trends, it is likely that *Acropora retusa*'s abundance has been in decline for decades, and that the rate of its decline has accelerated in recent years.

This level of abundance, combined with its restricted depth distribution where impacts are more severe, leaves the species vulnerable to becoming of such low abundance within the foreseeable future that it may be at risk from dispensatory processes, environmental stochasticity, or catastrophic events. The combination of these characteristics and future projections of threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range.

Critical Habitat

Critical habitat has been proposed for *Acropora retusa*. See Section 5.2.5 for more information.

Recovery Goals

No final recovery plan currently exists for *Acropora retusa*; however, a recovery outline was developed in 2015 to serve as interim guidance to direct recovery efforts, including recovery planning, until a final recovery plan is developed and approved for the 15 Indo-Pacific coral species listed in September 2014. The recovery goals are the same for all species.

5.2.3.9 *Acropora speciosa*

Acropora speciosa was listed as threatened on September 10, 2014 (79 FR 53852).

Species Description and Life History

Acropora speciosa has been either confirmed or strongly predicted in the western Indian Ocean to French Polynesia (Veron et al. 2016). In addition, *Acropora speciosa* has been confirmed in the Chagos Archipelago (Smith 2021a), Pohnpei State of the Federated States of Micronesia (Turak 2005), the Mariana Islands, and American Samoa, and strongly predicted to occur in Yap State of FSM, Kiribati Central, and the Cook Islands (2020 personal communication from Doug Fenner reported in Smith 2021a) .

Figure 57. Range of *Acropora speciosa*, modified from the map in Veron et al. (2016)

Acropora speciosa most commonly occurs on lower reef slopes. It is found between 12 m (39 ft) and at least 40 m (131 ft) of depth. Fenner (2020a) reports that it is usually found deeper than 18 m (59 ft), and apparently is more common below 30 m (98 ft). Montgomery et al. (2019) reported it from 46 m (151 ft)on Tutuila.

Acropora speciosa forms flat-topped colonies with small branches that have long smooth tips. Colonies are usually uniform grey-brown or pinkish in color, and 30 cm (11.8 in) or less in diameter. *Acropora speciosa* is very difficult to distinguish from *Acropora globiceps* in the water, but can be distinguished under the microscope based on skeletal characteristics (Fenner 2020a; Fenner and Burdick 2016).

Like other *Acropora* species, *Acropora speciosa* reproduces by broadcast spawning, whereby colonies release large numbers of eggs and sperm into the water. Colonies are hermaphroditic, in that each colony produces both eggs and sperm. Larvae settle on suitable substrates such as rock or dead coral and grow into colonies (NMFS 2014a).

Population dynamics

Relative abundance refers to how common *Acropora speciosa* is relative to other reef-building corals. DeVantier and Turak (2017) characterized relative abundances of each reef-building coral species present at a total of 3,075 sites distributed throughout 31 Indo-Pacific ecoregions from the Red Sea to the Great Barrier Reef). Of the 31 surveyed ecoregions, *Acropora speciosa* was present within 17 ecoregions, and its mean relative abundance in the 17 ecoregions was 1.58 (DeVantier and Turak 2017, Table S2), which is between rare and uncommon on DeVantier and Turak's abundance scale.

In addition to the 17 ecoregions where the relative abundance of *Acropora speciosa* was estimated by DeVantier and Turak (2017), their rating method has been used to estimate relative abundances of reef-building corals in portions of several other ecoregions in the central Pacific.

The relative abundances of *Acropora speciosa* in these surveys was 1.0 (Tonga), 2.0 (Fiji), and 2.1 – 2.5 (New Caledonia; Fenner 2020b). Based on the results of DeVantier and Turak (2017) and Fenner (2020b), we consider the overall relative abundance of *Acropora speciosa* to be rare to uncommon.

Based on information from Richards et al. (2008); and Richards et al. (2019), *Acropora speciosa* had a population estimate of 10,942,000 colonies, and an effective population size of 1,204,000 colonies (NMFS 2014a). Dietzel et al. (2021) estimated its absolute abundance at 19.2 million colonies.

Within U.S. waters, *A. speciosa* occurs on American Samoa and has been reported in PRIA, as described in more detail below.

American Samoa: *Acropora speciosa* occurs on Tutuila, but has not been reported from any of the other islands of the archipelago (Fenner 2020a; Montgomery et al. 2019).

PRIA: Kenyon et al. (2011) reported *Acropora speciosa* from Kingman Reef, although surveys by the PIFSC in 2015 and 2018 did not report observations of this species. It has not been reported from elsewhere within PRIA.

Status

Detecting changes in abundance over time of rare or uncommon Indo-Pacific reef-building coral species such as *Acropora speciosa* is complicated by many factors, and we do not yet have time-series abundance data for this species. However, overall mean coral cover (i.e., percentage live cover of all reef-building coral species combined) has declined across much of the Indo-Pacific since the 1970s, and likely many decades before then in some locations (NMFS 2014a;2020b). Furthermore, from 2014 to 2017, an unprecedented series of bleaching events impacted most of the Indo-Pacific's coral reefs (Eakin et al. 2019), further reducing overall mean coral cover, especially of relatively sensitive species such as many *Acropora* species. Based on these general trends, it is likely that *Acropora speciosa*'s abundance has been in decline for decades, and that the rate of its decline has accelerated in recent years.

Critical Habitat

Critical habitat has been proposed for *Acropora speciosa*. See Section 5.2.5 for more information.

Recovery Goals

No final recovery plan currently exists for *Acropora speciosa*, however a recovery outline was developed in 2015 to serve as interim guidance to direct recovery efforts, including recovery planning, until a final recovery plan is developed and approved for the 15 Indo-Pacific coral species listed in September 2014. The recovery goals are the same for all species.

5.2.3.10 *Euphyllia paradivisa*

Euphyllia paradivisa was listed as threatened on September 10, 2014 (79 FR 53852).

Species Description and Life History

Euphyllia paradivisa has been confirmed or strongly predicted in 18 ecoregions from Socotra (Indian Ocean) to Samoa (Veron et al. 2016). In addition, the species has been confirmed in the northern Red Sea (Eyal et al. 2016), Okinawa (Eyal et al. 2016), and Fiji (personal communication from Doug Fenner reported in Smith 2021a), and is strongly predicted in the southern Red Sea, the Gulf of Aden, the southern Ryukyu Islands, Taiwan, the Solomon Islands, and Vanuatu. Thus, we consider *Euphyllia paradivisa*'s geographic range to consist of at least the 27 ecoregions shown in Figure 58.

Euphyllia paradivisa occurs in environments protected from wave action across a broad depth range, especially in low light habitats, such as turbid areas (Fenner 2020a) and mesophotic depths (Eyal et al. 2016). The species also sometimes occurs on shallow reefs in clear water (Turak and DeVantier 2019). Colonies of *Euphyllia paradivisa* have been reported from a variety of substrates, including fine sediment (Fenner 2020a), sand (Fenner 2001), rubble (Sinniger and Harii 2018), and rock (Loya et al. 2016; Montgomery et al. 2019). Its confirmed depth range is from 6 m (19.7 ft; Turak and DeVantier 2019) to 75 m (246 ft; Muir et al. 2018). At one study site in the northern Red Sea, it was much more common between 30 and 50 m (98 and 164 ft) than <30 m (<98 ft; Eyal et al. 2016). Colonies consist of branching, separate corallites. Polyps have branching tentacles, an important characteristic for distinguishing it from other *Euphyllia* species. Color is typically pale greenish-grey with lighter tentacle tips (Fenner 2020a; Fenner and Burdick 2016; Veron et al. 2016).

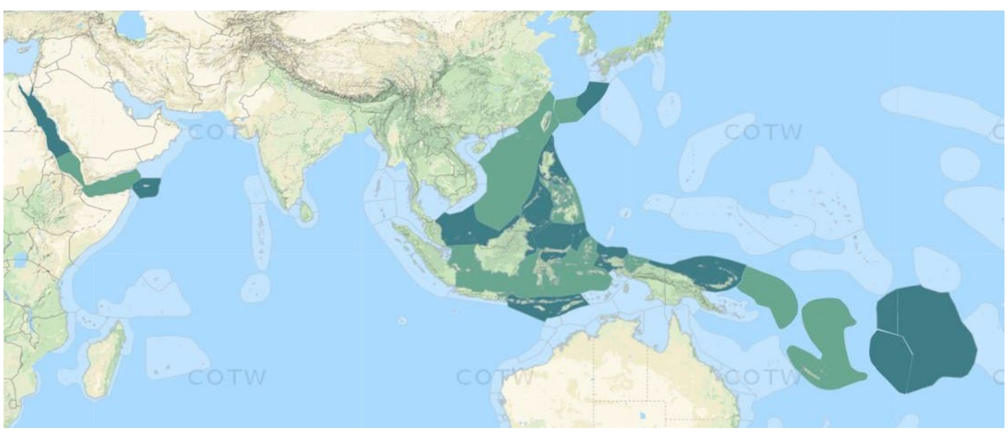

Figure 58. Range of *Euphyllia paradivisa*, modified from the map in Veron et al. (2016), based on sources cited in the text.

While the reproductive life history of *Euphyllia paradivisa* is still unknown, it most likely reproduces by broadcast spawning, whereby colonies release large numbers of eggs and sperm into the water, like other species in the genus (Luzon et al. 2017). Colonies are gonochoric, in that separate colonies produce eggs and sperm. Like all *Euphyllia* species, *Euphyllia paradivisa* has large polyps with tentacles that can be extended 10 – 20 cm (3.9-7.9 in; Eyal et al. 2016). Like other *Euphyllia* species, *Euphyllia paradivisa* typically occurs in habitats with high sedimentation, high turbidity, and low light, although it is not limited to such habitats (see Depth section below). In the upper mesophotic zone (30 – 50 m [98-164 ft] depth) in some parts of the Red Sea, *Euphyllia paradivisa* is the dominant reef-building coral species (Loya et al. 2016; Eyal et al. 2016; Eyal et al. 2019).

Population dynamics

DeVantier and Turak (2017) characterized relative abundances of each reef-building coral species present at a total of 3,075 sites distributed throughout 31 Indo-Pacific ecoregions from the Red Sea to the Great Barrier Reef. Of the 31 surveyed ecoregions, *Euphyllia paradivisa* was reported from four ecoregions, and its mean relative abundance was 1.44 (DeVantier and Turak 2017, Table S2), which is between rare and uncommon on DeVantier and Turak's abundance scale. However, as explained below, in some areas *Euphyllia paradivisa* is most abundant at 40 to 50 m in depth, deeper than most of DeVantier and Turak (2017) surveys.

In 2014 when *Euphyllia paradivisa* was listed under the ESA, it was not known to occur in the Red Sea (NMFS 2014a), nor was it found at any of the Red Sea sites reported by DeVantier and Turak (2017). However, recent mesophotic research has shown that *Euphyllia paradivisa* is the most common reef coral species in the upper mesophotic zone in the northern Red Sea (Loya et al. 2016; Eyal et al. 2016; Eyal et al. 2019). For example, surveys conducted along a depth gradient from 5 to 150 m (16 to 492 ft) in depth in the Gulf of Eilat in the northern Red Sea reported that while *Euphyllia paradivisa* was absent from <30 m (<98 ft) depth, it was abundant from 36 to 72 m (118 to 236 ft) where it dominated the reef coral community. At some sites between 40 and 50 m (131 and 164 ft), it made up 73% of all live coral cover (Eyal et al. 2016).

Elsewhere in the Indo-Pacific, *Euphyllia paradivisa* has been reported in low abundances from both shallow and mesophotic depths. At 287 sites surveyed from approximately five to ten m to 35 – 50 m (114.8-164 ft) of depth in the Coral Triangle and adjacent areas, *Euphyllia paradivisa* was found at two sites, one at 6 m (19.7 ft) and one at >30 m (>98 ft; Turak and DeVantier 2019). Single colonies of *Euphyllia paradivisa* have been reported from <30 m (<98 ft) in American Samoa and Fiji (personal communication from Doug Fenner reported in Smith 2021a). Montgomery et al. (2019) reported a group of *Euphyllia paradivisa* colonies from 49 m (160.8 ft) in American Samoa. Waheed and Hoeksema (2014) reported *Euphyllia paradivisa* from three out of 31 sites (two sites >30 m [98 ft], one site <30 m) surveyed in Malaysia, and that it was among the least common species in the survey. The species has also been reported at 45 – 53 m (147.6-173.9 ft; Eyal et al. 2016) and 55 m (180 ft; Sinniger and Harii 2018) in Okinawa, Japan, although abundance was not mentioned. Thus, we consider the overall relative abundance of *Euphyllia paradivisa* to range from rare to common, depending on the location.

Euphyllia species including *Euphyllia paradivisa* are relatively sediment-tolerant compared to other reef corals (Morgan et al. 2016; Rachello-Dolmen and Cleary 2007), often occurring on shallow, inshore reefs where turbidity and sediment are naturally high (Morgan et al. 2017; DeVantier and Turak 2017), but such turbid sites may not be included in coral reef surveys. For example, in American Samoa, shallow coral reef surveys were conducted for decades without finding *Euphyllia paradivisa*, but the species was observed in turbid water in a bay below the depth of the surveys (personal communication from Doug Fenner reported in Smith 2021a). On the Great Barrier Reef, fisheries managers working with the coral collection industry report *Euphyllia paradivisa* at "high densities" in "turbid inshore northern waters" (Roelofs 2018), but *Euphyllia paradivisa* is not reported from the Great Barrier Reef in the scientific literature. This may be due to species identification uncertainty by coral collectors, lack of scientific surveys on turbid reefs, or some combination thereof. Regardless, turbid reef species such as *Euphyllia paradivisa* may be under-represented in scientific coral survey results.

Based on *Euphyllia paradivisa*'s distribution and relative abundance, NMFS (2014a) estimated the absolute abundance of *Euphyllia paradivisa* to be at least tens of millions of colonies. However, that estimate was based on the assumptions that *Euphyllia paradivisa*'s distribution was smaller, and its abundance lower, than shown by the recent information cited above.

Within U.S. waters, *Euphyllia paradivisa* occurs on American Samoa, as described in more detail below.

American Samoa: *Euphyllia paradivisa* occurs on Tutuila, including photo records from 2021 (Smith 2021b).

Status

Detecting changes in abundance over time of rare or uncommon Indo-Pacific reef-building coral species such as *Euphyllia paradivisa* is complicated by many factors, and we do not have time-series abundance data for this species. However, overall mean coral cover (i.e., % live cover of all reef-building coral species combined) has declined across much of the Indo-Pacific since the 1970s, and likely many decades before then in some locations (NMFS 2014a;2020b). In 2014, the available information at that time supported the assumption that these trends applied to *Euphyllia paradivisa*. In the upcoming 5-year review (Smith 2021a), we will evaluate the current status of the species based on the recent information described above, and any other new information that becomes available.

Critical Habitat

Critical habitat has been proposed for *Euphyllia paradivisa*. See Section 5.2.5 for more information.

Recovery Goals

No final recovery plan currently exists for *Euphyllia paradivisa*, however a recovery outline was developed in 2015 to serve as interim guidance to direct recovery efforts, including recovery planning, until a final recovery plan is developed and approved for the 15 Indo-Pacific coral species listed in September 2014. The recovery goals are the same for all.

5.2.3.11 *Isopora crateriformis*

Isopora crateriformis was listed as threatened on September 10, 2014 (79 FR 53852).

Species Description and Life History

Isopora remained a subgenus of *Acropora* until Wallace et al. (2007) presented clear evidence that *Isopora* is a separate, valid genus. Since that time, *Isopora* has been treated as a genus, including *Isopora crateriformis* (Veron et al. 2016; Wallace et al. 2012), which is accepted by the World Register of Marine Species (Hoeksma and Cairns 2021).

Isopora crateriformis most commonly occurs in habitats with strong wave action, such as upper reef slopes and reef flats near the reef crest. It may occur on lower reef slopes or backreef pools with strong wave action, but is absent from habitats protected from wave action such as lagoons and harbors. The species is most common in depths of approximately 5 m (16 ft), but extends to at least 12 m (39 ft) depths Fenner (2020a). *Isopora crateriformis* has been either confirmed or strongly predicted in 30 ecoregions from the Coral Triangle to Tonga (Figure 59).

Isopora crateriformis forms flattened, solid, encrusting plates, usually with ripples on the surface. Most colonies are tan, but a few have tiny green spots which are the retracted polyps. Colonies are usually up to about 40 cm (15.7 in) in diameter but can be over 1 m (3.28 ft) in diameter. Corallites are 1-2 mm (0.04-0.08 in) in diameter, rounded projecting tubes, larger on the ridges and smaller between. When a colony occurs on a slope, the lower edge is often lifted as a plate (Veron and Stafford-Smith 2000; Fenner and Burdick 2016). This species is similar to some other *Isopora* species, but *Isopora crateriformis* has distinctive characteristics that can usually be reliably identified in the field. However, it is not distinguishable from juvenile, unbranched *I. cuneata*, as described in Fenner and Burdick (2016).

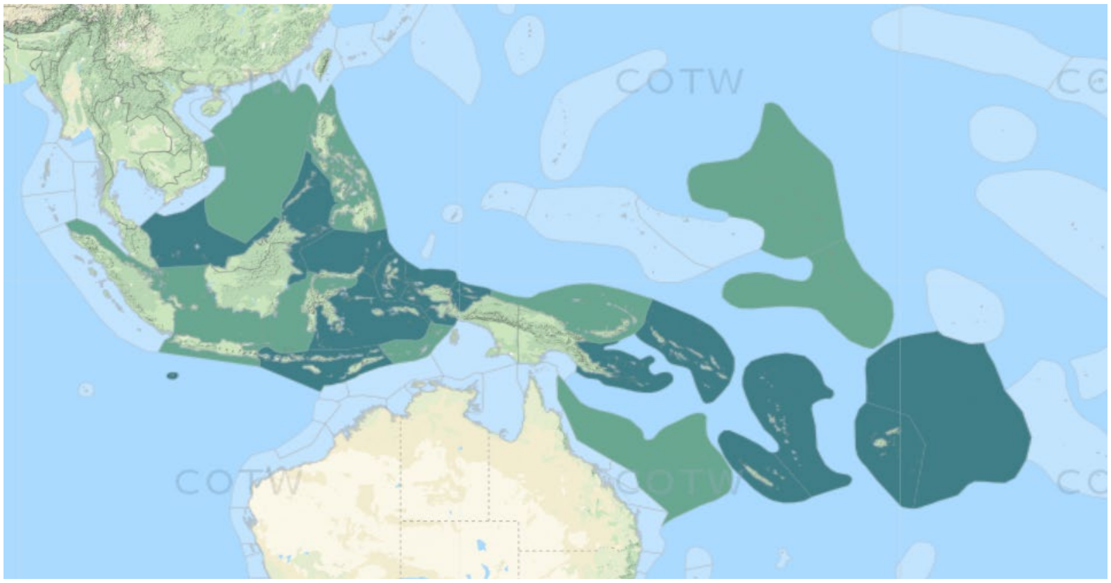

Figure 59. Range of *Isopora crateriformis* (Veron et al. 2016)

Population dynamics

DeVantier and Turak (2017) characterized relative abundances of each reef-building coral species present at a total of 3,075 sites distributed throughout 31 Indo-Pacific ecoregions from the Red Sea to the Great Barrier Reef. Of the 31 surveyed ecoregions, *Isopora crateriformis* was present in five ecoregions, and its mean relative abundance in the five ecoregions was 1.40 (DeVantier and Turak 2017, Table S2), which is between rare and uncommon on DeVantier and Turak's abundance scale.

In addition to the five ecoregions where the relative abundance of *Isopora crateriformis* was estimated by DeVantier and Turak (2017), their rating method has been used to estimate relative abundances of reef-building corals in portions of several other ecoregions in the central Pacific. The relative abundances of *Isopora crateriformis* in these surveys was 1.5-1.6 (Fiji), 1.6-1.8 (American Samoa), 1.6-2.0 (New Caledonia), and 1.9 (Wallis; Fenner 2020b), all of which fall between the rare and uncommon categories. However, the species can be common or even dominant in some locations: Wallace (1999) and the Corals of the World website (Veron et al. 2016) note that *Isopora crateriformis* is common in parts of Indonesia. In addition, Fenner (2020a) and Fenner (2020b) note that the species is dominant on some upper reef slopes on the southwest side of Tutuila, but this is unusual. Based on the information summarized above, we consider the relative abundance of *Isopora crateriformis* to be rare to common, depending on the location.

Based on *Isopora crateriformis*'s distribution and relative abundance, NMFS (2014a) estimated the absolute abundance of *Isopora crateriformis* to be at least millions of colonies. Dietzel et al. (2021) estimated its absolute abundance at 69.6 million colonies.

Within U.S. waters, *Isopora crateriformis* occurs on American Samoa, as described in more detail below.

American Samoa: *Isopora crateriformis* is the most common ESA-listed coral species on Tutila with the most recent observations of the species dating to 2020 (Smith 2021b). The species has also been recorded on Ofu-Olosega with the most recent observations of the species dating to 2019 (Smith 2021a). The species has also been observed on Ta'u with the most recent observations from the PIFSC in 2018 (Smith 2021b).

Status

Surveys of reef-building corals were conducted at Fagatele Bay, American Samoa, in 1985, 1995, 2002, and 2018. The only ESA-listed coral species to be detected in more than one of the surveys was *Isopora crateriformis*, which showed steadily declining relative abundances of 1.8% of all colonies surveyed in 1985, 1.2% in 1995, 1.1% in 2002, and 0.4% in 2018 (Birkeland 2021). In addition, overall mean coral cover (i.e., percentage live cover of all reef-building coral species combined) has declined across much of the Indo-Pacific since the 1970s, and likely many decades before then in some locations (NMFS 2014a;2020b). Furthermore, from 2014 to 2017, an unprecedented series of bleaching events impacted most of the Indo-Pacific's coral reefs (Eakin et al. 2019), further reducing overall mean coral cover, especially of relatively sensitive species such as many *Isopora* species. For example, between 2013 and 2017 on Guam, the five coral genera with the highest percentage of full-colony bleaching-associated mortality included *Isopora* (Raymundo et al. 2019). Based on this information, it is likely that *I. crateriformis*'s abundance has been in decline for decades, and that the rate of its decline has accelerated in recent years.

Critical Habitat

Critical habitat has been proposed for *Isopora crateriformis*. See Section 5.2.5 for more information.

Recovery Goals

No final recovery plan currently exists for *Isopora crateriformis*, however a recovery outline was developed in 2015 to serve as interim guidance to direct recovery efforts, including recovery planning, until a final recovery plan is developed and approved for the 15 Indo-Pacific coral species listed in September 2014. The recovery goals are the same for all species.

5.2.3.12 *Seriatopora aculeata*

Seriatopora aculeata was listed as threatened on September 10, 2014 (79 FR 53852).

Species Description and Life History

Seriatopora aculeata has been either confirmed or strongly predicted in 27 ecoregions from the Coral Triangle to Micronesia and New Caledonia (Veron et al. 2016). In addition, *Seriatopora* *aculeata* has been confirmed in Independent Samoa (Fenner and Burdick 2016), Wallis and Futuna, Fiji (personal communication from Doug Fenner reported in Smith 2021a), and the Chagos Archipelago (Corals of Chagos https://chagosinformationportal.org/corals accessed Sep-2020), and is strongly predicted to occur in western Kiribati. Thus, we consider *Seriatopora aculeata*'s geographic range to consist of the 31 ecoregions shown in Figure 60.

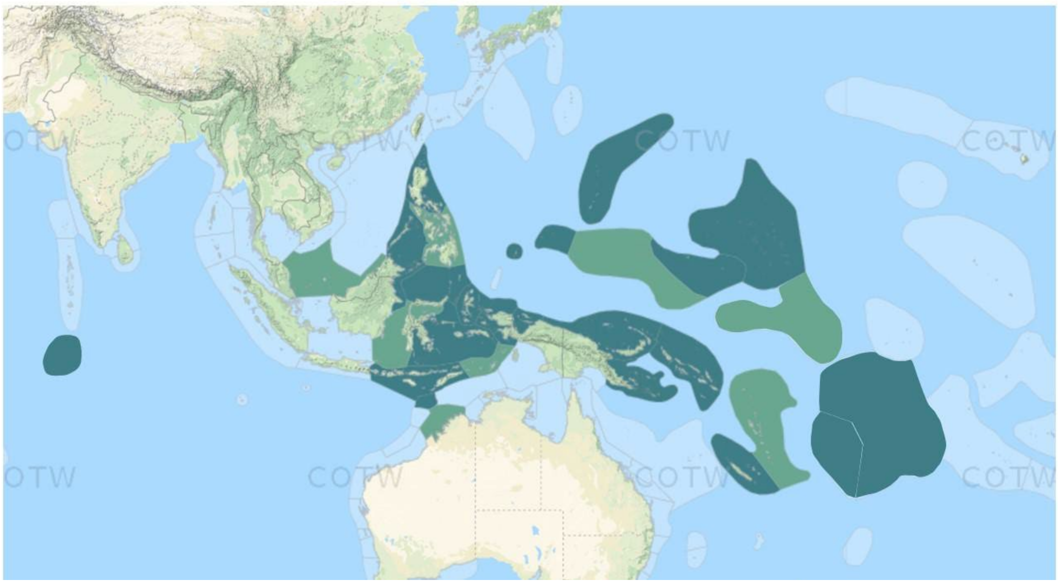

Figure 60. Range of *Seriatopora aculeata*, modified from the map in Veron et al. (2016)

Seriatopora aculeata occurs in a broad range of habitats on the reef slope and back-reef, including but not limited to upper reef slopes, mid-slope terraces, lower reef slopes, reef fats, and lagoons in a depth range of 3 to 40 m (9.8 to 131 ft). Colonies are made up of pencil-diameter branches, which are usually short and always taper sharply at the end to a relatively sharp tip. The corallites on the sides of the branches, and irregularly spaced. Tentacles are commonly extended during the daytime. Colonies are yellow, pink or tan in color (Veron et al. 2016; Fenner and Burdick 2016).

Population dynamics

DeVantier and Turak (2017) characterized relative abundances of each reef-building coral species present at a total of 3,075 sites distributed throughout 31 Indo-Pacific ecoregions from the Red Sea to the Great Barrier Reef. Of the 31 surveyed ecoregions, *Seriatopora aculeata* was reported from 17 ecoregions, and its mean relative abundance was 1.70 (DeVantier and Turak 2017, Table S2).

In addition to the 17 ecoregions where the relative abundance of *Seriatopora aculeata* was estimated by DeVantier and Turak (2017), their rating method has been used to estimate relative abundances of reef-building corals in portions of several other ecoregions in the central Pacific. The relative abundances of *Seriatopora aculeata* in these surveys was 1.5 (Fiji) (New Caledonia) and 1.0 (Marshall Islands; Fenner 2020b). Based on the results of DeVantier and Turak (2017) and Fenner (2020b), we consider the overall relative abundance of *Seriatopora aculeata* to be uncommon.

Based on *Seriatopora aculeata'*s distribution and relative abundance, NMFS (2014a) estimated the absolute abundance of *Seriatopora aculeata* to be at least millions of colonies.

Within U.S. waters, *Seriatopora aculeata* was reported from Guam by Burdick (2021) in 2008 and 2010. Dives by Burdick and others since 2010 have not found the species potentially due to the sharp decline in coral cover around Guam due to severe bleaching between 2013 and 2017, indicating the species may have been extirpated from Guam (Maynard et al. 2015; Maynard et al. 2017; Raymundo et al. 2019; Burdick 2021). Similarly, the species was reported by Houk (2020) on Saipan in 2011 but has not been observed since during multiple surveys and, due to recent declines in overall coral cover, the species may have been extirpated from CNMI (Smith 2021b).

Status

Detecting changes in abundance over time of rare or uncommon Indo-Pacific reef-building coral species such as *Seriatopora aculeata* is complicated by many factors, and we do not yet have time-series abundance data for this species. However, overall mean coral cover (i.e., % live cover of all reef-building coral species combined) has declined across much of the Indo-Pacific since the 1970s, and likely many decades before then in some locations (NMFS 2014a;2020b). Furthermore, from 2014 to 2017, an unprecedented series of bleaching events impacted most of the Indo-Pacific's coral reefs (Eakin et al. 2019), further reducing overall mean coral cover, especially of relatively sensitive species such as many *Seriatopora* species including *Seriatopora aculeata*.

Critical Habitat

Critical habitat has been proposed for *Seriatopora aculeata*. See Section 5.2.5 for more information.

Recovery Goals

No final recovery plan currently exists for *Seriatopora aculeata*, however a recovery outline was developed in 2015 to serve as interim guidance to direct recovery efforts, including recovery planning, until a final recovery plan is developed and approved for the 15 Indo-Pacific coral species listed in September 2014. The recovery goals are the same for all species.

5.2.4 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 km^2 (4,373.3 square nautical miles [nm^2]) of marine habitat. The proposed critical habitat boundaries are described in Table 8, 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 C.F.R. 80), the boundary between the SAFMC and Gulf Council (50 C.F.R. 600.105), the FKNMS boundary (15 C.F.R. Part 922 Subpart P, Appendix I), and the Caribbean Islands Management Area (50 C.F.R. 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 m (1.6-295 ft) 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 m (50 yards) adjacent to the base for a total of approximately 800 in-water 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 8. 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 (m)
Lobed Star Coral (*Orbicella annularis*)	OANN-1	Florida	Lake Worth Inlet, Palm Beach County to Government Cut, Miami-Dade County	2 to 20
Lobed Star Coral (*Orbicella annularis*)	OANN-1	Florida	Government Cut, Miami-Dade County to Dry Tortugas, Monroe County	0.5 to 20
Lobed Star Coral (*Orbicella annularis*)	OANN-2	Puerto Rico	All Islands	0.5 to 20
Lobed Star Coral (*Orbicella annularis*)	OANN-3	U.S. Virgin Islands (USVI)	All Islands of St. Thomas and St. John	0.5 to 20
Lobed Star Coral (*Orbicella annularis*)	OANN-4	USVI	All Islands of St. Croix	0.5 to 20
Lobed Star Coral (*Orbicella annularis*)	OANN-5	Navassa	Navassa Island	05 to 20
Lobed Star Coral (*Orbicella annularis*)	OANN-6	Flower Garden Banks (FGB)	East FGB and West FGB	17 to 90
Mountainous Star Coral (*Orbicella faveolata*)	OFAV-1	Florida	St. Lucie Inlet, Martin County to Government Cut, Miami-Dade County	2 to 90

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

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

m=meter, 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 5.2.3.2) 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.

5.2.5 Status of Proposed Indo-Pacific Coral Critical Habitat

Reef-building corals, including the seven listed Indo-Pacific species that can be found in U.S. waters in the action area, have specific habitat requirements including hard substrate, narrow mean temperature range, adequate light, and adequate water flow, among others. These habitat requirements are most commonly found in shallow tropical and subtropical coral reef ecosystems, but can also be found in non-reef and mesophotic areas (NMFS 2019c). Since the publication of the final listing rule in 2014, new information has become available regarding locations where different listed coral species are found in U.S. waters and their depth distributions. Therefore, in the proposed critical habitat rule published in November 2020, NMFS considers the rangewide depth distributions to be: 0-20 m (0-66 ft) for *Acropora globiceps*; 10-35 m (33-115 ft) for *Acropora jacquelineae*; 0-10 m (0-33 ft) for *Acropora retusa*; 12-40 m (39-131 ft) for *Acropora speciosa*; 2-40 m (6.5-131 ft) for *Euphyllia paradivisa*; 0-12 m (0-39 ft) for *Isopora crateriformis*; and 3-40 m (10-131 ft) for *Seriatopora aculeata*. Based on these depth distributions, in 2020, NMFS determined there are 19 specific occupied areas containing PBFs essential to the conservation of these corals in U.S. waters in the Indo-Pacific region. Of these, 17 were proposed to be designated as critical habitat for the seven coral species, although the most recent information from surveys indicates that two of these species may no longer occur in U.S. waters (Smith 2021b). Two of the specific occupied areas were excluded because they are within INRMPs for military areas, as explained further below.

American Samoa, CNMI, and RIA each include islands where no listed coral species have been confirmed (e.g., Swains Island in American Samoa, several islands in northern CNMI, Baker Island in PRIA). These locations were not included in the proposed critical habitat because it is not known whether these locations are within the range of the seven coral species. Thus, the proposed critical habitat for the seven coral species in the 17 units includes the areas in American Samoa (Tutuila and Offshore Banks, Ofu and Olosega, Ta'u, and Rose Atoll), Guam and CNMI (Guam and Offshore Banks, Rota, Aguijian, Tinian and Tatsumi Reef, Saipan and Garapan Bank, FDM, Anatahan, Pagan, Maug Islands and Supply Reef), and PRIA (Howland Island, Palmyra Atoll, Kingman Reef, Johnston Atoll, Wake Atoll, and Jarvis Island) in depths of 0-40 m (0-131 ft), 0-20 m (0-66 ft), and 0-10 m (0-33 ft) depending on which listed species are present in each location and the depth range of those species. The proposed designated critical habitat area contains approximately 600 km^2 (174.9 nm^2) of marine habitat.

The PBFs identified as essential to the conservation of each species are reproductive, recruitment, growth, and maturation habitat. Sites that support the normal function of all life stages of the corals are natural, consolidated hard substrate or dead coral skeleton free of algae and sediment at the appropriate scale at the point of larval settlement of 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 of the conservation of the species (85 FR 76262):

1. Substrate with presence of crevices and holes that provide cryptic habitat, the presence of microbial biofilms, or 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 waters 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.

The Navy's Joint Region Marianas INRMP and the Air Force's Wake Island Air Field, Wake Atoll, Kokee Air Force Station, Kuia, Hawaii, and Mt. Kaala Air Force Station, Oahu, Hawaii (Wake INRMP) includes marine areas around Guam, Tinian, FDM, and Wake that are excluded from the proposed critical habitat designation. The INRMPs for these areas were determined by NMFS to provide a benefit to the ESA-listed coral species found within the in-water area of the base.

In addition to the excepted areas subject to the 2017 Wake Island and 2019 Joint Region Marianas INRMP (see paragraph (d) of 85 FR 76286 for more detailed information), proposed critical habitat does not include areas where the essential feature does not occur and the following particular locations:

1. Pursuant to ESA section 3(5)(A)(i)(I), all managed areas that may contain natural hard substrate but do not provide the quality of substrate essential for the conservation of threatened corals. Managed areas that do not provide the quality of substrate essential for the conservation of the seven Indo-Pacific corals are defined as particular areas whose consistently disturbed nature renders them poor habitat for coral growth and survival over time. These managed areas include specific areas where the substrate has been disturbed by planned management authorized by local, territorial, state, or Federal governmental entities at the time of critical habitat designation, and will continue to be periodically disturbed by such management. Examples include, but are not necessarily limited to, dredged navigation channels, shipping basins, vessel berths, and active anchorages; and
2. Pursuant to ESA section 3(5)(A)(i), artificial substrates including but not limited to: Fixed and floating structures, such as ATONs, seawalls, wharves, boat ramps, fishpond walls, pipes, submarine cables, wrecks, mooring balls, docks, aquaculture cages.

As discussed in other sections of this opinion, the percentage of live cover of all reef-building coral species combined has declined across much of the Indo-Pacific since the 1970s, and likely many decades before then in some locations (NMFS 2014a;2020b). Furthermore, from 2014 to

2017, an unprecedented series of bleaching events impacted most of the Indo-Pacific's coral reefs (Eakin et al. 2019), further reducing overall habitats with high mean coral cover, especially of relatively sensitive species. While coral bleaching patterns are complex, there is general agreement that thermal stress has led to accelerated bleaching and mass mortality during the past several decades. During the years 1983, 1987, 1995, 1996, 1998, 2002, 2004, 2005, 2014, 2015, 2016, and 2017 widespread warming-induced coral bleaching and mortality was documented in many Indo-Pacific reef coral communities (Jokiel and Brown 2004; Brainard et al. 2011; Hughes et al. 2017). The series of coral bleachings in 2014-2017 are considered a single three-year event by NOAA's Coral Reef Watch (Eakin et al. 2019). It was the longest, most widespread, and likely the most damaging coral bleaching event on record. It affected more coral reefs than any previous global bleaching event, and was worse in some locales than ever recorded before (e.g., Great Barrier Reef). Heat stress during this event also caused mass bleaching in several reefs where bleaching had never been recorded before, such as in the uninhabited atolls of the central Pacific (Eakin et al. 2019).

In addition to bleaching, impacts from ocean acidification are causing numerous adverse effects to coral habitat in the Pacific. Ocean acidification reduces the aragonite saturation state (Ω_{arg}) in seawater by lowering the supersaturation of carbonate minerals including aragonite, which requires marine calcifiers like reef-building corals to expend more energy to calcify their skeletons. The effects of the lower Ω_{arg} projected for Indo-Pacific coral reef waters on coral calcification and growth, reef erosion, and coral reproduction have been extensively studied via laboratory experiments, modeling efforts, and at field sites with naturally low Ω_{arg} representative of projected conditions. The ocean acidification projected for the foreseeable future is expected to result in erosion outpacing accretion on many Indo-Pacific reefs, just as it has already done on eastern Pacific reefs (Brainard et al. 2011). An analysis of 22 coral reef sites, including 19 in the Indo-Pacific, and the resulting model projected that 17 of the 19 sites would fall below Ωarg levels of 2.92 by 2100, the threshold below which dissolution of reef sediments would exceed accumulation of reef sediments, thus demonstrating that reef erosion is outpacing reef accretion (Eyre et al. 2018). Field studies at Indo-Pacific sites with naturally acidic seawater show that reef erosion exceeds reef accretion at a pH of approximately 7.8 (Enochs et al. 2016), and that very high rates of reef erosion characterize such sites (Barkley Hannah et al. 2015). In addition to effects on coral calcification and reef erosion, the ocean acidification projected for the foreseeable future is also expected to lower the fertilization, settlement, and recruitment of some Indo-Pacific reef-building corals (Brainard et al. 2011).

Because of the above effects of projected ocean acidification on coral calcification, reef erosion, and coral reproduction, Indo-Pacific reef-building coral communities are expected to experience reductions in complexity and resilience, loss of reef corals, increases in macroalgae, simplification, and overall degradation. For example, within Indo-Pacific communities where naturally acidic seawater roughly approximates pH levels projected by 2100 (8.1 to 7.8), there is lower reef coral diversity, recruitment, and abundances than in other Indo-Pacific reef coral communities, suggesting that projected ocean acidification in the foreseeable future will reduce the complexity and resilience of these communities (Fabricius et al. 2011) by affecting coral colonies and their calcium carbonate substrate.

Since the 2014 listing of *Acropora jacquelineae, Acropora retusa, Acropora speciosa, Euphyllia paradivisa, Isopora crateriformis, and Seriatopora aculeata*, the threats to these species and their habitat have worsened, especially the most important threat to the listed species, global warming. All threats are projected to further worsen, based on current information (Smith 2021a). Recovery of the 15 species is not possible unless the worsening trends are at least stabilized, especially for the two most important threats, ocean warming and ocean acidification, both of which are caused by global climate change (Smith 2021a). In order for adverse impacts on Pacific coral habitat to subside, a viable recovery strategy must be based on controlling global climate change.

There are several protected areas within the proposed critical habitat designation where habitat conditions are better because of the lack of human activities, although these areas are still subject to stressors associated with climate change and ocean acidification. Howland and Jarvis Islands were designated as a National Wildlife Refuge in 1974 and expanded to include submerged lands out to 12 nautical miles in 2009. In 2009, the islands were also included in the designation of the Pacific Remote Islands Marine National Monument. USFWS and NOAA conduct occasional ship-based research and monitoring every three years but there are no structures or other activities requiring special management in this area. Similarly, Kingman Reef in the Pacific Remote Islands Marine National Monument (designated in 2009) is visited every three years to conduct surveys of the reef area and on rare occasions a research vessel may visit the area to conduct other studies of the marine environment. Rose Atoll is a National Wildlife Refuge and was designated as a Marine National Monument in 2009. Rose Atoll is visited approximately three times per year for inventory and monitoring, and sea turtle and other research. Maug Island in the northern CNMI is included in the area of the Marianas Trench Marine National Monument established in 2009. Fishing and diving, as well as research cruises, occur infrequently at Maug.

Pala Lagoon and Pago Pago Harbor, Tutuila Island were excluded from the proposed coral critical habitat because of the amount of artificial substrate associated with the construction and management of shoreline protection and beach erosion control structures, small boat harbors and other channels, turning basins and berthing areas. Similarly, the Ofu Small Boat Harbor; Ta'u Small Boat Harbor and Faleasao Small Boat Harbor; Rota Harbor; Tinian Harbor; CNMI Ports Authority harbors, basins, and navigation channels; breakwaters; areas around Apra Harbor (outside the Naval area discussed previously); ATONs; small boat ramps; shoreline protection and erosion control structures, and other artificial structures are not included in the proposed designation due to the alteration of habitat in this area associated with the construction and management of artificial structures.

6 Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated 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 C.F.R. §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 Nassau grouper; scalloped hammerhead shark (Central and Southwest Atlantic and Indo-West Pacific DPSs); *Acropora globiceps*, *A. jacquelineae*, *A.retusa*, *A. speciosa*, boulder star coral, elkhorn coral, *Euphyllia paradivisa*, *Isopora crateriformis*, lobed star coral, mountainous star coral, pillar coral, rough cactus coral, *Seriatopora aculeata*, and staghorn coral; designated critical habitat for elkhorn and staghorn coral; and proposed critical habitat for Atlantic/Caribbean and Indo-Pacific corals in the action area. The following information summarizes 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 critical habitat that are likely to be adversely affected by the proposed action.

6.1 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. 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 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).

This section provides some examples of impacts to ESA-listed species and their habitats that have occurred or may occur as the result of climate change. We address climate change as it has affected and continues to affect ESA-listed species and their habitat, and we look to the foreseeable future to consider effects that we anticipate will occur as a result of ongoing activities. While the consideration of future impacts may also be suited to our cumulative effects analysis (Section 8), it is discussed here to provide a comprehensive analysis of the effects of climate change in one location in the document. Although it is difficult to accurately predict the consequences of climate change to a particular species or habitat, a range of consequences are expected that are likely to change the status of the species and the condition of their habitats both within and outside of the action area.

The main concerns regarding impacts of global climate change on coral reefs and other calcium carbonate habitats generally, and on ESA-listed corals 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 (GHG) in the atmosphere since the Industrial Revolution, ocean acidification has already occurred throughout the world's oceans and is predicted to increase considerably through the 21st century (IPCC 2022;2014).

Climate change has the potential to impact species abundance, geographic distribution, migration patterns, and susceptibility to disease and contaminants, as well as the timing of seasonal activities and community composition and structure (Learmonth et al. 2006; MacLeod 2009; Robinson et al. 2008; Kintisch and Buckheit 2006; McMahon and Hays 2006; Evans and Bjørge 2013; IPCC 2014). Though predicting the precise consequences of climate change on highly mobile marine species is difficult (Simmonds and Eliott 2009), recent research has indicated a range of consequences already occurring. For example, in sea turtles, sex is determined by the ambient sand temperature (during the middle third of incubation) with female offspring produced at higher temperatures and males at lower temperatures within a thermal tolerance range of 25 to 35°C (Ackerman 1997). These impacts will be exacerbated by sea level rise. The loss of habitat because of climate change could be accelerated due to a combination of other environmental and oceanographic changes such as an increase in the frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion (Antonelis et al. 2006; Baker et al. 2006).

In order to evaluate the implications of different climate outcomes and associated impacts throughout the 21st century, many factors have to be considered with GHG emissions and the potential variability in emissions serving as a key variable. Developments in technology, changes in energy generation and land use, global and regional economic circumstances, and population growth must also be considered.

6.1.1 **Oceanic Temperature Regimes**

A set of four scenarios were developed by the Intergovernmental Panel on Climate Change (IPCC) for its third and fourth assessment report to ensure that starting conditions, historical data, and projections were employed consistently across the various branches of climate science. The scenarios are referred to as representative concentration pathways (RCPs), which capture a range of potential GHG emissions pathways and associated atmospheric concentration levels from 2007 through 2100 using the Coupled Model Intercomparison Project (CMIP) five (IPCC 2014). The RCP scenarios drove climate model projections for temperature, precipitation, sea level, and other variables: RCP2.6 is a stringent mitigation scenario; RCP2.5 and RCP6.0 are intermediate scenarios; and RCP8.5 is a scenario with no mitigation or reduction in the use of fossil fuels. IPCC future global climate predictions (2014 and 2018) and national and regional climate predictions included in the Fourth National Climate Assessment for U.S. states and territories (USGCRP 2018) use the RCP scenarios. CMIP6 was used in the sixth IPCC assessment report (IPCC 2022), which has a starting point of 2014 and uses five scenarios, called shared socioeconomic pathways (SSPs). SSPs look at five different ways in which the world might evolve in the absence of climate policy under different emission scenarios and how different levels of climate change mitigation could be achieved when the mitigation targets are combined with the SSPs.

The increase of global mean surface temperature change by 2100 is projected to be 0.3 to 1.7°C under RCP2.6, 1.1 to 2.6°C under RCP4.5, 1.4 to 3.1°C under RCP6.0, and 2.6 to 4.8°C under RCP8.5 with the Arctic region warming more rapidly than the global mean under all scenarios (IPCC 2014). The Paris Agreement aims to limit the future rise in global average temperature to 2°C, but the observed acceleration in carbon emissions over the last 15 to 20 years, even with a lower trend in 2016, has been consistent with higher future scenarios such as RCP8.5 (Hayhoe et al. 2018). The results of runs of CMIP6 indicate that projections of warming are around 0.4ºC greater than under CMIP5. The CMIP6 climate models also predict greater end-of-the-century ocean warming because of greater climate sensitivity than in CMIP5 (IPCC 2022).

The globally-averaged combined land and ocean surface temperature data, as calculated by a linear trend, show a warming of approximately 1.0°C from 1901 through 2016 (Hayhoe et al. 2018). The IPCC Special Report on the Impacts of Global Warming (IPCC 2021) projects that human-induced global average warming is likely to reach 1.5 °C between 2030 and 2052 at the current rate of anthropogenic GHG emissions. Warming greater than the global average has already been experienced in many regions and seasons, with most land regions experiencing greater warming than over the ocean (Allen et al. 2018). Annual average temperatures have increased by 1.8°C across the contiguous U.S. since the beginning of the 20th century with Alaska warming faster than any other state and twice as fast as the global average since the mid-20th century (Jay et al. 2018). Global warming has led to more frequent heatwaves in most land regions and an increase in the frequency and duration of marine heatwaves (Hoegh-Guldberg et al. 2018). Average global warming up to 1.5°C as compared to pre-industrial levels is expected to lead to regional changes in extreme temperatures, and increases in the frequency and intensity of precipitation and drought (Hoegh-Guldberg et al. 2018).

The Atlantic Ocean appears to be warming faster than all other ocean basins except perhaps the southern oceans (Cheng et al. 2017). In the western North Atlantic Ocean, surface temperatures have been unusually warm in recent years (Blunden and Arndt 2017). A study by Polyakov et al. (2010) suggests that the North Atlantic Ocean overall has been experiencing a general warming trend over the last 80 years of 0.031±0.0006 °C per decade in the upper 2,000 m (6,561.7 ft) of the ocean. Additional consequences of climate change include increased ocean stratification, decreased sea-ice extent, altered patterns of ocean circulation, and decreased ocean oxygen levels (Doney et al. 2012). Since the early 1980s, the annual minimum sea ice extent (observed in September each year) in the Arctic Ocean has decreased at a rate of 11 to 16% per decade (Jay et al. 2018). Further, ocean acidity has increased by 26% since the beginning of the industrial era (IPCC 2014) and this rise has been linked to climate change. Climate change is also expected to increase the frequency of extreme weather and climate events including, but not limited to, cyclones, tropical storms, heat waves, and droughts.

Oceanographic conditions in the Pacific Ocean can be altered due to periodic shifts in atmospheric patterns caused by the Southern oscillation in the Pacific Ocean, which leads to El Niño and La Niña events, and the Pacific decadal oscillation. These climatic events can alter habitat conditions and prey distribution for ESA-listed species in the Pacific action area (Beamish 1993; Mantua et al. 1997; Hare and Mantua 2001; Benson and Trites 2002; Stabeno et al. 2004; Mundy 2005; Mundy and Cooney 2005).

The Pacific decadal oscillation is the leading mode of variability in the North Pacific and operates over longer periods than either El Niño or La Niña/Southern Oscillation events. It is capable of altering sea surface temperature, surface winds, and sea level pressure (Mantua and Hare 2002; Stabeno et al. 2004). During positive Pacific decadal oscillations, the northeastern Pacific Ocean experiences above average sea surface temperatures while the central and western Pacific Ocean undergoes below-normal sea surface temperatures (Royer 2005). Warm Pacific decadal oscillation regimes, as occurs in El Niño events, tends to decrease productivity along the U.S. west coast, as upwelling typically diminishes (Hare et al. 1999; Childers et al. 2005). Sampling of oceanographic conditions just south of Seward, Alaska has revealed anomalously cold conditions in the Gulf of Alaska from 2006 through 2009, suggesting a shift to a colder Pacific decadal oscillation phase.

Changes in the marine ecosystem caused by global climate change (e.g., ocean acidification, salinity, oceanic currents, dissolved oxygen 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 ESA-listed species including fish. 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). Hazen et al. (2012) examined top predator distribution and diversity in the Pacific Ocean in light of rising sea surface temperatures using a database of electronic tags and output from a global climate model. They predicted up to a 35% change in core habitat area for some key marine predators in the Pacific Ocean, with some species predicted to experience gains in available core habitat and some predicted to experience losses.

Because habitat for many shark species is comprised of open ocean environments occurring over broad geographic ranges, large-scale impacts such as global climate change that affect ocean temperatures, currents, and potentially food chain dynamics, may impact these species. Chin et al. (2010) conducted an integrated risk assessment to assess the vulnerability of several shark and ray species on the Great Barrier Reef to the effects of climate change. Scalloped hammerheads were ranked as having a low overall vulnerability to climate change, with low vulnerability to each of the assessed climate change factors (i.e., water and air temperature, ocean acidification, freshwater input, ocean circulation, sea level rise, severe weather, light, and ultraviolet radiation). In another study on potential effects of climate change to sharks, Hazen et al. (2012) used data derived from an electronic tagging project and output from a climate change model to predict shifts in habitat and diversity in top marine predators in the Pacific out to the year 2100. Results of the study showed significant differences in habitat change among species groups but sharks as a whole had the greatest risk of pelagic habitat loss. Marine populations that are already at risk due to other threats are particularly vulnerable to the direct and indirect effects of climate change. Several ESA-listed species and habitats considered in this opinion have likely already been impacted by this threat through the pathways described above.

Global climate change may affect Nassau grouper in Florida and the Caribbean. 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), 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.

6.1.2 Ocean Acidification and Coral Bleaching

Aspects of climate change that influence water quality include decreasing ocean pH (i.e., more acidic), increasing water temperatures, and increasing storm activity. Changes in pH outside the normal range can make it difficult for marine organisms with shells to maintain their shells (Fabry et al. 2008). Many of those creatures are at the base of the marine food chain, such as phytoplankton, so changes may reverberate through the ecosystem. Rising water temperatures combined with decreasing ocean pH can be detrimental to coastal ecosystems, particularly to corals and the communities that depend on them (Anthony et al. 2008). For example, in waters warmer than normal, coral colonies appear to turn white ("bleaching") because they expel symbiotic microbes (zooxanthellae) that give them some of their colors. These microbes are important for coral survival because they provide the coral with food and oxygen, while the coral provides shelter, nutrients, and carbon dioxide.

Coral bleaching can occur as a stress response to changes in light availability, nutrients, toxicants, or pathogens (NOAA 2017). Bleaching events have increased in frequency in recent decades, and coral bleaching on a global scale has been on the rise for decades (Donner and Carilli 2019).

According to Raymundo et al. (2019), recent analyses have suggested that more than 50% of the corals in Guam died between 2013 and 2014 during a coral bleaching event of which, about 85% in total had bleached. That event, combined with the strong associations between sea surface temperature increases and coral bleaching events throughout the Pacific (Griesser and Spillman 2016), suggests that it is highly likely sea surface temperature increases are at least partially to blame for coral bleaching events in the Mariana Islands. Raymundo et al. (2019) provide further discussion of the impacts of increased sea surface temperatures on local *Acropora* spp. corals around Guam. Elevated sea surface temperatures induced severe island-wide bleaching in 2013, 2014, 2016, and 2017. This coupled with an El Nino Southern Oscillation event triggered extreme low tides in 2014 that extended into 2015 and caused additional coral mortalities. These events have resulted in a loss of approximately 36% live *Acropora* spp. coral coverage (as of 2017) around Guam. Their data suggest that some coral species are at high risk of extirpation in these waters and that increasing bleaching events raise concerns that coral recovery may not keep pace with mortality. Furthermore, (Van Hooidonk et al. 2016) previously predicted that severe bleaching events around the Mariana Islands could begin as early as 2020, but events documented by Raymundo et al. (2019) suggest that Guam's shallow-water corals may not be able to adapt and keep pace with rapidly warming ocean temperatures.

The distance from human population centers, cooler waters, and greater depth has shielded reefs of FGBNMS from human impacts. In the past decade, FGBNMS has had bleaching events without significant mortality. However, climate change impacting coral bleaching and disease spread have been major management concerns. During 2016, water temperatures in both the East and West Flower Garden Banks were above 30°C (86°F) for an extended period of time, and corals within these banks showed signs of bleaching and paling stress (Johnston et al. 2019).

Specific biological stressors for the coral reefs of the USVI include the mass mortality of *Acropora* species and other reef-building corals due to disease and several coral bleaching events in the early 1980s. For example in 2005, a bleaching event coincided with a 2,530% increase in disease lesions, a 770% increase in denuded skeletons, and a loss of 51.5% live coral cover in the USVI (Miller et al. 2006). More recently, SCTLD has spread throughout the Caribbean, and was first sighted in St. Thomas in 2019 (NOAA and UMCES 2020).

Diseases, such as white plague-II, yellow band disease, white band, black band, white pox, red band, Caribbean ciliate infection, dark spots disease, fungal aspergillosis, and tumors, are especially prevalent during times of stress (e.g., increased sea surface temperatures and bleaching).

Papahanaumokuakea Marine National Monument is in the NWHI. Corals in this region have experienced temperature stress and ocean acidification, impairing reef material growth. However, due distance from human populations, they have been mainly shielded from human impacts (NOAA and UMCES 2018).

In 2005, the USVI suffered a major coral bleaching event, followed by a disease outbreak where USVI lost nearly half of its corals in an extensive die off. Major bleaching occurred again in both 2010 and 2019. The most severe disease outbreak ever recorded has spread throughout most of the Florida reef tract and has been ongoing since 2014 (Walton et al. 2018). Extreme cold events have also been demonstrated to cause mass mortality of corals in the Florida Keys, USA (Lirman et al. 2011).

Throughout the entire action area, severe hurricanes such as those during the 2017 Atlantic 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 in-water habitat for the Nassau grouper and ESA-listed corals.

6.2 Fisheries

Fisheries constitute an important and widespread use of the ocean resources throughout the CRCP action area in Federal, State and Territorial waters. Fisheries can adversely affect ESA-listed Nassau grouper, scalloped hammerhead sharks, corals, and designated and proposed coral critical habitat. Direct effects of fisheries interactions with ESA-listed species include entanglement and entrapment which can lead to fitness consequences or mortality as a result of injury or drowning. Indirect effects include reduced prey availability and destruction of habitat. Use of mobile fishing gear, such as bottom trawls, disturbs the seafloor and reduces structural complexity. Indirect impacts of trawls include increased turbidity, alteration of surface sediment, removal of prey (leading to declines in predator abundance), removal of predators, ghost fishing (i.e., lost fishing gear continuing to ensnare fish and other marine animals), smothering of sessile organisms, and generation of marine debris. Lost gill nets, purse seines, and long-lines may foul and disrupt bottom habitats and have the potential to entangle sea turtles.

Scalloped hammerhead sharks are both targeted and taken as bycatch in many global fisheries (e.g., bottom and pelagic longlines, coastal gillnet fisheries, artisanal fisheries). This species is highly desired for the shark fin trade because of its fin size and high fin ray count. In the U.S., scalloped hammerhead sharks are mainly caught as bycatch in longline and coastal gillnet fisheries and are known to suffer high post-release mortality rates. Many of the scalloped hammerhead sharks captured in U.S. fisheries are not from an ESA-listed DPS since the only non-foreign listed DPSs are the Central and Southwest Atlantic, Eastern Pacific, and Indo-West Pacific.

The NMFS Pelagic Observer Program reported 100 scalloped hammerhead sharks bycaught in the U.S. Atlantic pelagic longline fishery in 2015, including 51 released dead (NMFS 2015b). Another 126 unidentified hammerhead sharks were also reported captured in this fishery, presumably some of which were scalloped hammerheads. In 2014, 138 scalloped hammerheads were caught during observed bottom longline trips in the sandbar shark research fishery in the Gulf of Mexico and Southern Atlantic (NMFS 2015b). In 2015, seven scalloped hammerheads were caught (five of which were released dead) during observed Southeast sink gillnet trips targeting Atlantic sharpnose, blacknose, and other shark species (NMFS 2015b). Data from the Marine Recreational Information Program (MRIP) from Puerto Rico from 2001 – 2016 show 797 scalloped hammerhead sharks were landed by recreational charter boats using vertical line gear within Puerto Rico's territorial waters, which extend to 9 nm from shore. The greatest number of scalloped hammerhead sharks, 516, were captured in 2003. The other landings were from 2004 (44), 2006 (30), 2012 (98), and 2016 (109). Landed sharks ranged in length from 600 – 800 mm, meaning they were likely neonates or juveniles as maturity is reached when males are approximately 1,219 mm and females are 1,981 mm. At least some of the sharks may have been misidentified and others were included in a general hammerhead shark category and could be species other than scalloped hammerhead, but the numbers indicate that the species is captured in Puerto Rico. Adult sharks tend to be more common in offshore waters while neonates and juveniles are more common in nearshore waters in areas where they occur. There are limited data from the U.S. Caribbean indicating that two bays, one in St. Thomas and one in St. John, USVI serve as nursery habitat for neonate scalloped hammerhead sharks (DeAngelis 2006).

In the Pacific, shark bycatch occurs primarily in the Hawaii-based pelagic longline fishery. An observer program has been in place since 1995 with targeted coverage of 25% in the deep-set sector and 100% in the shallow-set sector. Observer data from 1995-2006 indicated a very low catch of scalloped hammerhead sharks in this fishery (56 individuals on 26,507 sets total, both fishery sectors combined) (Miller et al. 2013a). Scalloped hammerheads are also occasionally caught in U.S. recreational fisheries, although recreational catch estimates are often unreliable due to the rare event nature of capture and species identification issues.

Nassau grouper were an important component of the fishery and were targeted in federal, Territorial 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.

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) in USVI and Puerto Rico, respectively, 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. Similarly, the predominant fishing gear types used in the Pacific (hook-and-line, longline, troll, traps) may affect habitat and coral colonies, particularly due to anchoring of fishing vessels and the use of heavy weights and entanglement in lines during hook-and-line fishing. The WPRFMC determined that, while these effects may occur, there are few fishing-related impacts to habitat and listed corals (WPRFMC 2009).

NMFS consults with the appropriate regional fishery management councils and internally for highly migratory species fisheries under section 7 of the ESA, including the CFMC for the Coral, Queen Conch, Reef Fish, and Spiny Lobster FMPs; with the SAFMC for the southeast shrimp trawl fishery, spiny lobster fishery, and the South Atlantic snapper-grouper complex fishery; for the U.S. Atlantic pelagic longline fishery comprised of five distinct fishing sectors: Gulf of Mexico yellowfin tuna fishery, southern Atlantic swordfish fishery, Mid-Atlantic and New England swordfish and tuna fishery, U.S. Atlantic Distant Water swordfish fishery, and the Caribbean tuna and swordfish fishery; for the Consolidated Highly Migratory Species FMP; for the FMP for coastal migratory pelagics in the Atlantic and Gulf of Mexico; with the Gulf Council on reef fish fishery, stone crab fishery, and spiny lobster fishery in the Gulf of Mexico; for Hawaii longline fisheries; and for the American Samoa longline fishery.

The U.S. commercial purse seine fishery (Western and Central Pacific Ocean: WCPO) operating in the western and central Pacific is managed under the authority of the South Pacific Tuna Treaty Act of 1988 (16 U.S.C. Chapter 16C). The treaty area, where U.S. and other treaty member nations fish, extends from Palau eastward to the Line Islands of Kiribati (approximately 15°N to 15°S and 125°E to 140°W) and includes some of the world’s most productive tuna fishing grounds (NMFS 2006). There is the potential for bycatch mortality or serious injury to scalloped hammerhead sharks.

6.3 Aquaculture

A variety of designs are used for open-ocean aquaculture. In the U.S., submersible cages are the model used for offshore finfish production (Naylor 2006). These cages are anchored to the ocean floor but can be moved within the water column; they are tethered to buoys that contain an equipment room and feeding mechanism; and they can be large enough to hold hundreds of thousands of fish in a single cage. One of the negative effects attributed to finfish culture is enrichment of the water column with dissolved nutrients, resulting from the decomposition of uneaten feed, and from metabolic wastes produced by the fish (Langan 2004). There is growing interest in marine aquaculture systems which combine fed aquaculture species (e.g., finfish), with inorganic extractive aquaculture species (e.g. seaweeds) and organic extractive species (e.g., suspension- and deposit-feeders) cultivated in proximity to mitigate these negative effects. Another type of offshore aquaculture system that is expected to grow is longline mussel aquaculture. At a typical commercial mussel farm, multiple backbone lines are arrayed in parallel rows submerged 5 to 20 m below the surface using a system of anchors and buoys (Price et al. 2016). The longlines may be 150 – 300 m in length. Submerged floats keep the vertical lines running up from the anchors and the horizontal longlines properly oriented in the water column and prevent the lines from becoming entangled with each other. In many parts of the world, a single farm may include several hundred longlines covering hundreds of acres. Currently in the United States, farms are typically being permitted at smaller scales (less than 100 acres), though it is anticipated that scaling up will follow once the domestic industry expands in the near future (Price et al. 2016).

Aquaculture has the potential to impact protected species via entanglement and/or other interaction with aquaculture gear (i.e., buoys, nets, and lines), introduction or transfer of pathogens, increased vessel traffic and noise, impacts to habitat and benthic organisms, and water quality (Price et al. 2017; Lloyd 2003; Clement 2013; Price and Morris 2013). Current data suggest that interactions and entanglements of ESA-listed species in aquaculture gear are rare (Price et al. 2017), but a net pen farm in Hawaii has caused Hawaiian monk seals to significantly alter their behavior and even become entrapped in the gear. A former net pen in Culebra, Puerto Rico, served as a fish attracting device (FAD), including for shark species that were then targeted by fishers. Some aquaculture gear, such as that used in longline mussel farming, is similar to gear used in commercial fisheries, so some aquaculture operations may have effects similar to those of fisheries such as bycatch and entanglement for species such as Nassau grouper and scalloped hammerhead sharks. If aquaculture operations are not properly sited, they may also have effects on benthic habitats, including those containing ESA-listed corals due to stressors such as releases of nutrients and other contaminants from feed and from fish waste that is concentrated in the cages and then may be transported by ocean currents and waves.

The governments of American Samoa, Guam, and CNMI are actively promoting aquaculture as an emerging industry in their coastal waters. The development of the Guam Aquaculture Development Plan in 2010 has led to Asian investors in particular expressing interest in shrimp broodstock production in Guam (Wyban 2022). Lack of investor capacity has impeded attempts to further develop viable aquaculture operations in CNMI, which have been mainly limited to tilapia and marine shrimp culture, but the Northern Marianas College has prepared a plan to strengthen the development of aquaculture in CNMI (Northern Marianas College 2011).

Marine aquaculture is expected to expand in the U. S. EEZ due to increased demand for domestically grown seafood, coupled with improved technological capacity to farm in the open ocean. NMFS is preparing a PEIS in coordination with the WPRFMC that is intended to support offshore aquaculture development in the U.S. Pacific Islands Region, which could lead to increased offshore aquaculture activity, though most is expected to occur in waters greater than 50 m (164 ft) deep.

Executive Order 13921, Promoting American Seafood Competitiveness and Economic Growth, of May 2020 required, among other things, that the Secretary of Commerce establish Aquaculture Opportunity Areas (AOA) beginning with the identification of two geographic areas one year after issuance of the order and continuing with the identification of two additional areas every four years thereafter. In 2021, one of the areas recommended for establishment of an AOA is the Gulf of Mexico. In addition to potential effects to benthic habitats and corals, and due to the potential for these structures to serve as FADS, escapees from finfish farms could affect native populations of fish and other organisms depending on their life history characteristics.

6.4 Marine Debris

Marine debris can be introduced into the marine environment by its improper disposal, accidental loss, or natural disasters (Watters et al. 2010), and can include plastics, glass, derelict fishing gear, derelict vessels, or military expendable materials. Globally, 6.4 million tons of fishing gear is lost in the oceans every year (Wilcox et al. 2015). Marine debris can scour, break, smother, and otherwise damage important marine habitat, such as coral reefs. Examples of various marine debris from recent surveys in the Florida Keys by Renchen et al. (2021) are shown in Figure 61. Many of these habitats serve as the basis of marine ecosystems and are critical to the survival of many other species. 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. Marine debris affects marine habitats and marine life worldwide, primarily by entangling or choking individuals that encounter it. Entanglement in marine debris can lead to injury, infection, reduced mobility, increased susceptibility to predation, decreased feeding ability, fitness consequences, as well as mortality through drowning for air breathing marine species. Ingestion of marine debris may be a growing threat, particularly in the southwest Atlantic, with studies indicating mortality rates even higher than those associated with bycatch (Guebert-Bartholo et al. 2011). Marine debris ingestion can lead to intestinal blockage, which can impact feeding ability and lead to death. Information 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 listed species.

Abandoned or lost fishing gear can also affect ESA-listed corals and their habitat, as well as the quality of refuge, spawning, and foraging habitat for Nassau grouper and foraging habitat for scalloped hammerhead sharks as abandoned gear can lead to abrasion and breakage in hard bottom and coral reef habitats. Abandoned gear also has shading impacts on seagrass and macroalgae if the gear is large enough, such as traps and nets.

Lost fishing nets and line can cause severe harm to coral reefs through breakage and tissue abrasion. In a recent study conducted on coral reefs around Koh Tao, Gulf of Thailand, the researchers found that corals (specifically branching varieties, e.g. *Acropora spp.*) underneath gear showed most damage, which predominantly consisted of tissue loss (Ballestero et al. 2018). Branching corals were the most commonly found growth form in close proximity to the lost gear in this study. Branching corals can easily become entangled in lines, nets, and ropes, which was observed in the 2018 study and in previous ones (Schleyer and Tomalin 2000; Yoshikawa and Asoh 2004; Chiappone et al. 2005; Sheehan et al. 2017; Sheridan et al. 2003). Damage caused by lost fishing gear may contribute to coral mortality, especially in conjunction with severe storm events. However, quantitative data on damage to corals by lost fishing gear is lacking.

Derelict nets, ropes, line, traps, or other fishing gear, packing bands, rubber bands, balloon string, six-pack rings, and a variety of marine debris can wrap around marine life. Lost traps can continue to fish and trap animals with no escape. Entanglement and entrapment can lead to injury, illness, suffocation, starvation, and even death.

Lost fishing gear is also a threat to benthic organisms and their habitat. Hard corals, like the kind that form reefs, can become entangled in abandoned or lost fishing nets. As floating nets become snagged on branches, it can break or scratch the coral, which can leave big scars on the reef. Other types of fishing gear can cause damage too. In a 2009 study, lobster traps were placed on reef sites off the coast of Florida to see how much damage was caused by trap movement. Due to sustained winds, the movement of the trap caused the delicate coral to be scarred, fragmented, and dislodged.

In a recent study of marine debris occurring in MPAs in the Florida Keys, Renchen et al. (2021) observed 48 pieces of debris interacting with hard and soft corals. Of these 48 interactions, 60.4% were trap debris (mainly rope) belonging to the spiny lobster (93.3%) or stone crab fisheries (0.7%); 29.2% were with non-trap fishing debris composed mainly of monofilament fishing line and fishing tackle; and 10.4% were with non-fishing debris. More than half of the debris interactions (58.3%) were with ESA-listed corals (*A. cervicornis*, *Orbicella annularis*, *O. faveolata*, and *O. franksi* (Renchen et al. 2021).

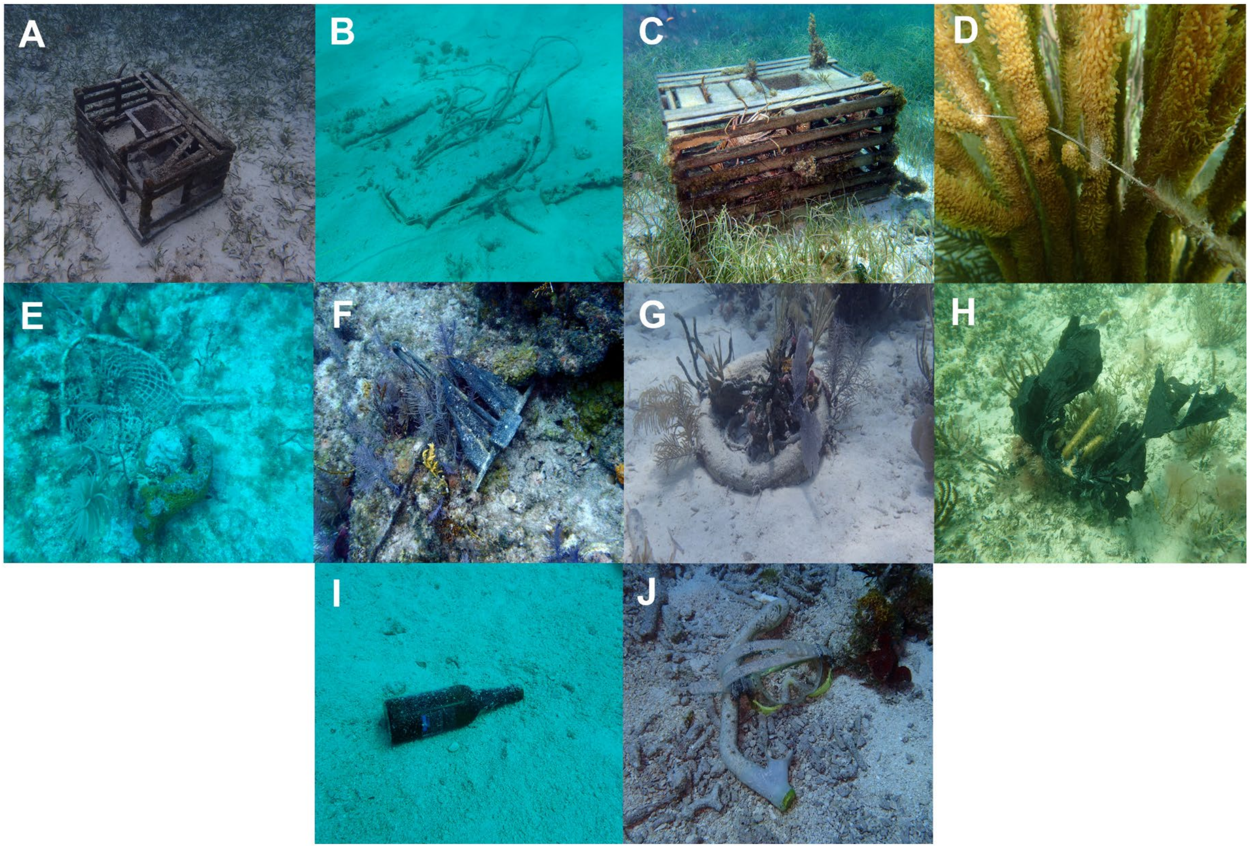

Figure 61. Examples of debris observed by debris category. A) Lobster trap frame parts including wood slats, and plastic trap throat, B) lobster trap rope and concrete ballast, C) intact lobster trap, D) monofilament (non-trap fishing), E) lobster hand net (non-trap fishing, other), F) boat anchor (non-fishing, metal), G) rubber tire (non-fishing, other), H) plastic bag (non-fishing, plastic), I) bottle (non-fishing, glass) and J) snorkel gear (non-fishing) (Renchen et al. 2021)

Richardson et al. (2016) reported that from 2003-2015 fisheries observer data for the western and central Pacific Ocean recorded over 10,000 incidents of pollution related to purse-seine and longline fisheries vessels. The largest percentage (37%) of the purse-seine incidents were related to plastics waste, 16% as oil spillage or leakage, 15% as metals, 13% as abandoned, dumped, or lost fishing gear, nine percent as waste oil, 8% as garbage, and 2% as chemicals. The incidents in the Guam and Northern Mariana Islands area (n=25) constituted less than 1% of the overall incidents reported. Data reported from this study are tentative and may be more extensive than thought.

Many animals, such as sea turtles, seabirds, and marine mammals have been known to ingest marine debris. The debris item may be mistaken for food and ingested, an animal's natural food (e.g. fish eggs) may be attached to the debris, or the debris item may have been ingested accidentally with other food. Debris ingestion may lead to loss of nutrition, internal injury, intestinal blockage, starvation, and even death.

Law et al. (2010) 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% of 6,136 surface plankton net tows collected small, buoyant plastic pieces. 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. 2010). Additionally, plastic waste in the ocean chemically attracts hydrocarbon pollutants such as polychlorinated biphenyls (or PCBs) and Dichlorodiphenyltrichloroethane (or DDT). Fish and other animals can mistakenly consume these wastes containing elevated levels of toxins instead of their prey. In the North Pacific Subtropical Gyre, it is estimated that the fishes in this area are ingesting 12,000 to 24,000 U.S. tons (10,886,216 to 21,772,433 kg) of plastic debris a year (Davison and Asch 2011).

Plastic debris is the most dominant type of marine debris in the Western Pacific, which includes Hawaii, American Samoa, Guam and the Northern Mariana Islands. A plastic bag was found as deep as 10,898 m in the Mariana Trench, showing that marine debris also has implications for deep-sea ecosystems (Jamieson et al. 2019). Another study found the presence of ingested microplastics in amphipod populations living in six deep ocean trenches, including the Mariana Trench (Chiba et al. 2018). This discovery is the deepest record of microplastic ingestion.

Recently, Germanov et al. (2019) evaluated the contribution of microplastics to the diet of filter-feeding megafauna (manta rays and whale sharks) at three coastal locations in Indonesia. Their data show that plastic abundance ranged from 0.04-0.09 pieces per m^2 (based on trawls) and 210-40,844 pieces per km^2 (visual surveys;(visual surveys; Germanov et al. 2019). Germanov et al. (2019) calculated the theoretical plastic ingestion rates using estimated filtration volumes of manta rays and whale sharks and the mean plastic abundance in their feeding grounds. Their estimates ranged from approximately 25-63 pieces per hour for manta rays, and approximately 137 pieces per hour for whale sharks.

There have also been reports of microplastic ingestion by scleractinian corals in waters of Australia's Great Barrier Reef and experimental feeding of corals indicated corals mistake microplastics for prey, consuming them at rates similar to their consumption of plankton and *Artemia* nauplii and leading to potential health impairments as the microplastic was found wrapped in mesenterial tissue in the gut cavity (Hall et al. 2015). Similarly, in an experiment using *Montipora capitata* and *Pocillopora damicornis* exposed to a temperature of 30ºC and then fed microplastics, *Artemia* nauplii, or both, both species significantly reduced feeding on *Artemia* but no significant decrease in ingestion of microplastics was observed (Axworthy and Padilla-Gamiño 2019). *P. damicornis* only ingested microplastics when *Artemia* were present, indicating microplastics may be incidentally ingested or mistaken for this prey species. Hankins et al. (2018) found that *Montastraea cavernosa* and *Orbicella faveolata* actively ingested microbeads ranging in size from 425 μm to 2.8 mm but did not ingest beads ranging in size from 212 to 250 μm. They also found that the majority of the beads were expelled within 48 hrs with no apparent effects to coral calcification from ingestion and egestion. The results of the different studies indicate there may be variability in the risk of microplastic ingestion among coral species and, therefore, varying effects.

6.5 Invasive and Predatory Species

The introduction of invasive species is considered one of primary threats to at-risk species (Wilcove and Chen 1998; Anttila et al. 1998; Pimentel et al. 2004). Clavero and Garcia-Bertro Clavero and Garcıa-Berthou (2005) found that invasive species were a contributing cause to over half of the extinct species in the IUCN database; invasive species were the only cited cause in 20% of those cases. Invasive species consistently rank as one of the top threats to the world's oceans (Wambiji et al. 2007; Terdalkar et al. 2005; Raaymakers and Hilliard 2002; Raaymakers 2003; Pughiuc 2010). Sources of invasive species can occur via vessels (ballast, biofouling, and anchor wells), recreational vessels, aquaculture, aquarium trade, and plastic marine debris. Anchors that disturb sediment could spread seeds of invasive seagrass (e.g., *Halophila stipulacea* in the Caribbean).

When non-native animals and plants are introduced into habitats where they do not naturally occur, they can have significant impacts on ecosystems and native fauna and flora. Non-native species can reduce native species abundance and distribution, and reduce local biodiversity by out-competing native species for food and habitat. They may also displace food items preferred by native predators, disrupting the natural food web. Invasive plants can cause widespread habitat alteration, including native plant displacement, changes in benthic and pelagic animal communities, altered sediment deposition, altered sediment characteristics, and shifts in chemical processes such as nutrient cycling (Wigand et al. 1997; Grout et al. 1997; Ruiz et al. 1999).

Introduced seaweeds alter habitat by colonizing previously unvegetated areas, while algae form extensive mats that exclude most native taxa, dramatically reducing habitat complexity and the ecosystem services provided by it (Wallentinus and Nyberg 2007). Invasive algal species (e.g., *Avrainvillea amadelpha* and *Kappaphycus/Eucheuma* spp. in Hawaii) can spread through ballast water discharge, hull fouling, aquaculture, instrument/trap deployment, and SCUBA activities, including in-water research and invasive species removal. Similarly, the invasive seagrass, *Halophila stipulacea*, in the Caribbean is thought to spread through transport of anchor wells in vessels that transit across the Atlantic and anchor in various areas around the Caribbean. This seagrass is thought to out-compete native seagrass species (Steiner and Willette 2015; Williams et al. 2019) and has been observed growing over corals in waters as deep as 24 m (80 ft) in St. John.

Invasive algae can alter native habitats through a variety of impacts including trapping sediment, reducing the number of suspended particles that reach the benthos for benthic suspension and deposit feeders, reducing light availability, and adverse impacts to foraging for a variety of animals (Sanchez et al. 2005; Levi and Francour 2004; Britton-Simmons 2004; Gribsholt and Kristensen 2002). Pathogens and species with toxic effects not only have direct effects on listed species, but also may affect essential critical habitat features or indirectly affect the species through ecosystem-mediated impacts.

There are a total of 333 non-native species, and another 130 cryptogenic species (i.e., unknown origin), documented as part of the marine and estuarine biota of the six largest Hawaiian islands from Kauai to Hawaii (Carlton and Eldredge 2015). The greatest proportion of non-native and cryptogenic species are found in the majors harbors of Oahu, which receive the large majority of all vessel traffic in the Hawaiian Islands (Coles and Eldredge 2002). Approximately 20% of the benthic algae, fish, and macroinvertebrate species found these harbors are either non-native or cryptogenic. Algal species have become nuisance invaders of many Hawaiian reefs (Smith et al. 2002). With the exception of Kaneohe Bay, the largest embayment in Hawaii with a history of urban impact, few nonindigenous fish or invertebrates have been detected on Hawaiian reefs (Coles and Eldredge 2002).

In August of 2019, researchers diving at the Pearl and Hermes Atoll (Manawai) in Papahanaumokuakea Marine National Monument, found a cryptogenic species of fast growing algae, later identified as *Chondria tumulosa*. This algae was seen spreading over several 100 m and observed smothering corals (Sherwood et al. 2020). Nearly a year later, after extensive molecular and morphological analyses, researchers have determined that this mat-forming alga was an undescribed species whose origin is unknown.

Coles and Eldredge (2002) reviewed scientific literature for information regarding the occurrence and impacts of nonindigenous species from harbors, embayments, and coral reef surveys in the tropical Pacific. Coles and Eldredge (2002) found, for U.S. waters of Apra Harbor, Guam, and Pearl Harbor and other harbors in Oahu, Hawaii, that low percentages of nonnative species or species that could not be confirmed to be native were present with larger numbers in the most-used harbor areas. They found Inner Apra Harbor, which is dedicated to military use, had 27 nonindigenous species and 29 cryptogenic species, making up 6.7% of the total species in the harbor. In outer Apra Harbor and island-wide, nonindigenous and cryptogenic species made up only 1.7% of the total species. In Hawaii, the nonindigenous and cryptogenic species in Pearl Harbor comprised 23% of the total number of species and 17% in harbors on the south and west shores of Oahu, while Midway and Kahoolawe had only 1.5 and 1%, respectively. However, with the exception of some invasive algae in Hawaii, discussed above, results of studies indicate that the nonindigenous and cryptogenic species in tropical areas are relatively rare on coral reefs and do not appear to cause substantial negative effects (Coles and Eldredge 2002).

Invasive species, namely lionfish (Johnston et al. 2013) and orange cup coral (*Tubastrea coccinea*;(Precht et al. 2014), have impacted coral health through overwhelming native fish and invertebrate populations and displacing coral species in the Atlantic, Caribbean, and the Gulf of Mexico. Lionfish (*Pterois volitans* and *P. miles*) are one of the most ecologically damaging marine invasions in recent times. They are native to the Indo-Pacific oceans and were introduced along the southern U.S. coast through the aquarium trade (Hare and Whitfield 2003; Ruiz-Carus et al. 2006; Morris et al. 2011). Lionfish have no natural predators outside of their home range. Researchers have discovered that a single lionfish residing on a coral reef can reduce recruitment of native reef fish by 79% (Albins and Hixon 2008) and are cable of decimating native juvenile/adult reef fishes – potential prey normally consumed by snappers, groupers, and other commercially important native species. The potential for lionfish to feed on ESA-listed Nassau grouper is not inconceivable. As lionfish populations grow, they put additional stress on coral reefs. For example, lionfish eat herbivores, and herbivores eat algae from coral reefs. Without herbivores, algal growth goes unchecked, which can be detrimental to the health of coral reefs.

Corallivores are present throughout the action area. These animals are usually present in small numbers but their populations may increase to levels that result in widespread damage to corals and their habitat, and affect species that depend on a healthy coral reef ecosystem. The crown of thorns starfish (*Acanthaster planci*) is a corallivore found throughout the Indo-Pacific. A single starfish can consume approximately 6-10 m^2 (64.6-108 ft^2) of living reef per year. However, the starfish is usually present in low densities due to natural predators but under certain conditions, the population of this animal increases dramatically, leading to extensive damage to corals and their habitat. The National Park of American Samoa experienced an outbreak of this animal in 2014 and managers worked to cull and remove the starfish to protect corals, eliminating thousands of starfish from reef areas where they were consuming corals, including listed species. Outbreaks of this starfish appear to be increasing in frequency over the last several decades. It is thought that nutrient enrichment from land-based sources of pollution lead to outbreaks because elevated nutrient levels cause phytoplankton blooms. Phytoplankton are the food source for starfish larvae so the availability of phytoplankton affects the growth and population size of the starfish. Other scientists believe that outbreaks are linked to the timing of El Niño events or removal of natural predators due to things like fishing.

6.6 Anthropogenic Sound

The ESA-listed species that occur in the action area are regularly exposed to multiple sources of anthropogenic sounds. Anthropogenic sound is generated by commercial and recreational vessels, aircraft, sonar, ocean research activities, dredging, construction, offshore mineral exploration, military testing and training activities, seismic surveys, and other human activities. These activities occur within the action area to varying degrees throughout the year. ESA-listed species have the potential to be impacted by increased levels of both background sound and high intensity, short-term sounds. Sources of anthropogenic noise are becoming both more pervasive and more powerful, increasing both oceanic background sound levels and peak intensity levels (Hildebrand 2004).

Sounds are often considered to fall into one of two general types, impulsive and non-impulsive, which differ in the potential to cause physical effects to animals (see Southall et al. 2007 for in-depth discussion). Impulsive sound sources produce brief, broadband signals that are atonal transients and occur as isolated events or repeated in some succession. They are characterized by a relatively rapid rise from ambient pressure to a maximal pressure value followed by a rapid decay period that may include a period of diminishing, oscillating maximal and minimal pressures, and generally have an increased capacity to induce physical injury. Non-impulsive sounds can be tonal, narrowband, or broadband, brief or prolonged, and may be either continuous or non-continuous. Some can be transient signals of short duration but without the essential properties of pulses (e.g., rapid rise time). The duration of non-impulsive sounds, as received at a distance, can be greatly extended in a highly reverberant environment.

Anthropogenic sound within the marine environment is recognized as a potential stressor that can harm marine animals and significantly interfere with their normal activities (NRC 2005). The fish species considered in this opinion may be impacted by anthropogenic sound in various ways. For fishes, the effects of anthropogenic sound have been well documented. However, due to the sheer diversity and numbers of fish, much remains unknown about fishes' abilities to detect and respond to sound. Sensitivity to sound also varies among fishes, and many fish species have developed sensory mechanisms that enable them to detect, localize, and interpret sounds in their environment. When considering the effects of anthropogenic sound on fishes, it is those sound sources that have the potential to cause physical injury and mortality to the individual or disrupt essential behavioral patterns; and whether or not these effects pose a risk to the population of a particular species that are a great concern. These would be acute or limited in duration sound exposures such as those sounds generated during construction activities, use of explosives, and seismic surveys. Chronic and continuous sound sources such as those produced from vessels or alternative energy sources are also a concern, especially if they could result in fitness consequences and decrease survival and recovery of fishes. Thus, understanding of how fishes detect and respond to sound needs to be tied to ecologically relevant factors such as fish physiology and specific life stage needs, in conjunction with spatial patterns and distribution within the habitats they occupy.

6.6.1 **Vessel Noise**

Much of the increase in sound in the ocean environment over the past several decades is due to increased shipping, as vessels become more numerous and of larger tonnage (Mckenna et al. 2012; Hildebrand 2009b; NRC 2003). Shipping constitutes a major source of low-frequency sound in the ocean (Hildebrand 2004), particularly in the Northern Hemisphere where the majority of vessel traffic occurs. The northeastern U.S. hosts some of the busiest commercial shipping lanes in the world, including those leading into Boston, Providence, Newark, and New York. While commercial shipping vessels contribute a large portion of oceanic anthropogenic noise, other sources of maritime traffic can be present in large numbers and impact the marine environment. These include recreational boats, whale-watching boats, research vessels, and ships associated with oil and gas activities. Individual vessels produce unique acoustic signatures, although these signatures may change with vessel speed, vessel load, and activities that may be taking place on the vessel. Sound levels are typically higher for the larger and faster vessels. Peak spectral levels for individual commercial vessels are in the frequency band of ten to 50 Hz and range from 195 dB re: μPa^2-s at one m for fast-moving (greater than 20 knots) supertankers to 140 dB re: μPa^2-s at one m for smaller vessels (NRC 2003). Although large vessels emit predominantly low frequency sound, studies report broadband sound from large cargo vessels above two kHz, which may interfere with important biological functions of cetaceans (Holt 2008). At frequencies below 300 Hz, ambient sound levels are elevated by 15 to 20 dB when exposed to sounds from vessels at a distance (McKenna et al. 2013).

6.6.2 Surveillance Towed Array Sensor System Low Frequency Active Sonar

The Navy operates up to four Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar vessels in the Mariana Islands Testing and Training Area (MITT). Based on Navy national security and operational requirements, training and testing with these sonar systems may occur western and central North Pacific (including the Pacific portion of the CRCP action area) and eastern Indian Oceans. During training and testing with SURTASS LFA sonar, the Navy employs a three-part mitigation and monitoring protocol to avoid or minimize the risk of injury to protected species: 1) visual monitoring for protected species during daylight hours, 2) passive (low-frequency) SURTASS to listen for sounds generated by marine mammals as an indicator of their presence, and 3) high frequency active sonar to detect potentially affected protected species. If protected species are detected within the mitigation zone while LFA sonar is active, sonar is suspended or delayed.

Additional SURTASS LFA sonar mitigation applies to coastal waters within 12 NM (22 km) of emergent land (which includes Saipan). This coastal standoff zone encompasses the Chalan-Kanoa Reef and Marpi Reef geographic mitigation areas established for the MITT proposed action. The SURTASS coastal waters mitigation states that no LFA sonar shall be operated during training and testing such that the SURTASS LFA sonar sound field exceeds 180 dB (re: 1µPa [rms]) within these areas to be protective of marine species, including ESA-listed species.

6.6.3 Pile Driving and Construction Sound

Industrial activities and construction both in the ocean and along the shoreline can contribute to underwater noise. Pile driving is commonly used for the construction of foundations for a large number of structures including bridges, buildings, retaining walls, harbor facilities, offshore wind turbines, and offshore structures for the oil and gas industry. Impact hammer pile driving during construction activities is of particular concern because it generates noise with a very high source level. During pile installation, noise is produced when the energy from construction equipment is transferred to the pile and released as pressure waves into the surrounding water and sediments. The impulsive sounds generated by impact pile driving are characterized by a relatively rapid rise time to a maximal pressure value followed by a decay period that may include a period of diminishing, oscillating maximal and minimal pressures (Illingworth and

Rodkin Inc. 2001; Illingworth and Rodkin 2007; Reyff 2012). The amount of noise produced by pile driving depends on a variety of factors, including the type and size of the impact hammer, size of the pile, the properties of the sea floor, and the depth of the water. The predominant energy in pile impact impulses is at frequencies below approximately 2000 Hz, with the majority of the sound energy associated with pile driving is in the low frequency range, less than 1,000 Hz (Laughlin 2006; Reyff 2009; Reyff 2012; Illingworth and Rodkin Inc. 2001;2004; NMFS 2018a). Pressure levels from 190-220 dB re: one µPa root mean square (rms) were reported for piles of different sizes in a number of studies (NMFS 2018a). The majority of the sound energy associated with pile driving is in the low frequency range (<1,000 Hz; Illingworth and Rodkin Inc. 2001;2004; Reyff 2003). Impact pile driving occurs over small spatial and temporal scales and produces high-intensity, low-frequency, impulsive sounds with high peak pressures that can be detected by mammals, sea turtles and other marine species such as fish (Dow Piniak et al. 2012). Injury to the inner ear of fishes is caused by pressure damage to hair cells in the inner ear, ear canals, or eardrums. Barotrauma can also result in fishes and result in both lethal and non-lethal physical injuries. Vibratory pile driving produces a continuous sound with peak pressures lower than those observed in impulses generated by impact pile driving (Popper et al. 2014).

6.7 Vessel Operation and Traffic

There are several types of vessels traffic sources that operate in the CRCP action area and can cause adverse effects to the ESA-listed species and habitats in those areas. These include federal vessels (e.g., NOAA, EPA, Navy, USCG), as well as recreational and commercial vessels such as personal watercraft, cruise ships, and ferries.

Through the section 7 process, where applicable, NMFS will establish conservation measures for federal agency vessel operations to avoid or minimize adverse effects to 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 ESA-listed species in the action area.

Commercial, recreational, and research vessel traffic can have adverse effects on ESA-listed corals and their habitat via accidental groundings, propeller scarring, and propeller wash. Similarly, commercial and recreational vessel traffic in the CRCP action area is also associated with commercial and private diving activities. Anchoring of these vessels at reef sites can lead to impacts to corals and habitat used by Nassau grouper, scalloped hammerhead sharks, and corals, in addition to the potential for vessel strikes of scalloped hammerhead sharks, which are commonly found at or near the water surface.

NOAA, including NOS and other line offices, conduct coral reef monitoring, benthic surveys, sediment sampling and other scientific surveys in the CRCP 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 and USVI.

NMFS PIFSC conducts American Samoa Rapid Assessment and Monitoring Program cruises every three years in the area. These surveys are covered by recurring informal section 7 consultations for this program. The U.S. Navy funds coral surveys of Guam and CNMI every five years. EPA conducts coral surveys at different locations around Puerto Rico and USVI, sometimes 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 and for marine events in the rest of District 7 (that includes all of Florida) in 2018.

Portions of the Action Area are heavily traveled by commercial, recreational, and government marine vessels, with several commercial ports occurring in or near the Action Area. In the western Pacific Ocean, four waterways used by commercial vessels link Guam and the CNMI with major ports to both the east and west. Guam contains one commercial port located within Apra Harbor. The Port of Guam is the largest U.S. deepwater port in the Western Pacific and handles approximately 1,814,369,480 kg (two million tons) of cargo a year (Port Authority of Guam 2011). The U.S. provides some 60% of Guam's imported goods, with the balance of Guam's trade coming from the Asian and Pacific markets of Japan, Taiwan, the Philippines, Hong Kong, and—to a lesser extent—Australia, New Zealand, and the islands of Micronesia (Port Authority of Guam 2011). Apra Harbor also provides economical transshipment services from Hawaii, and East Asia to the entire western Pacific. Most shipping lanes are located close to the coast but those that are trans-oceanic start and end to the northwest of Guam.

There are three ports within the CNMI. The Port of Rota, or Rota West Harbor, is located on the southwestern tip of the island and is classified by World Port Source (http://www.worldportsource.com/) as a very small port that is mainly used for ferry boats. The Port of Tinian is described by the World Port Source as a small port offering excellent shelter, which allows relatively large vessels to dock there. The Port of Saipan is the largest and most advanced of the three ports, but is nevertheless described as a small seaport with poor shelter by the World Port Source. A number of facilities and services are available at the Port of Saipan, which transferred over 338,000 tons of cargo in 2009 (Commonwealth Ports Authority 2005;2010).

Major commercial shipping vessels use the shipping lanes for shipping goods between Hawaii, the continental U.S., and Asia. There are no direct routes between Guam and the U.S.; stops are made in Asia, and usually Japan or Korea, before continuing on to either Hawaii or the continental U.S. The total number of vessels transiting through the Port of Guam has steadily decreased from 2,924 in 1995 to 1,022 in 2008 (DoN 2010). The Port Authority of Guam estimates 635 total vessel calls, not counting naval ships, in 2013. The decrease is most pronounced in the number of barges and fishing vessels that transit through the port; however, the number of container ships has increased from a low of 103 in 2003 to a high of 165 in 2008.

6.8 Military Activities

The U.S. Navy conducts testing and training testing activities as part of their military readiness activities – worldwide. These Navy action areas include the Hawaiian and Southern California Range Complexes (HSTT), MITT and the Atlantic Forces Testing and Training area (AFTT) which includes the Gulf of Mexico Range Complex, Florida, and the U.S. Atlantic coast. During training, existing and established weapon systems and tactics are used in realistic situations to simulate and prepare for combat. Activities include routine gunnery, missile, surface fire support, amphibious assault and landing, bombing, sinking, torpedo, tracking, and mine exercises. Testing activities are conducted for different purposes and include at-sea research, development, evaluation, and experimentation. The Navy performs testing activities to ensure that its military forces have the latest technologies and techniques available to them. NMFS and the Navy have completed several formal section 7 consultations regarding the Navy's military readiness activities that overlap with the current CRCP action area. The majority of the training and testing activities the Navy conducts in the action area are similar, if not identical, to activities that have been occurring in the same locations for decades and are covered under several range-specific biological opinions (NMFS 2018c;2020a;2018b) and are expected to continue into the future.

The Navy activities include numerous vessels (of various sizes) and aircraft moving continuously to/from and throughout these action areas. As part of the section 7 consultation process NMFS and the Navy conduct vessel strike analyses based on the Navy's proposed actions and the most recent ESA-listed species abundance information. These analyses result in the estimation of potential effects to ESA-listed fish and corals that are expected to occur annually for the foreseeable future in all three Navy action areas (NMFS 2018c;2020a;2018b).

In addition to training and testing activities, the Navy has consulted with NMFS for on-going activities in portions of the action area including the cleanup of former Naval stations on the main island of Puerto Rico (Ceiba) and on the island of Vieques. The U.S. Army Corps of Engineers (USACE), which is the agency responsible for the cleanup of areas designated as Formerly Used Defense Sites (FUDS) is currently consulting with NMFS for cleanup activities in and around Desecheo Island and Culebra Island and its associated islands and cays.

The Navy is conducting removal activities on terrestrial and in underwater portions of the eastern portion of Vieques Island, the western portion of the island that was also used for some training activities and munitions disposal sites, and offshore anchorage areas. A programmatic section 7 consultation was completed in 2020 for activities associated with the removal of underwater ordnance (UXO). Some coral areas were used as targets, in addition to being affected by skips and misses during live fire exercises. During some UXO removal activities, ESA-listed and other corals are transplanted to other reef areas or to coral arks that serve as coral nurseries for later outplanting. As part of their work around Vieques, the Navy is also using ARM structures (that are described in Section 3). The consultation concluded that there could be adverse effects to Nassau grouper as a result of bycatch during biological sampling associated with testing organisms for contaminant load and to ESA-listed corals and their habitat due to underwater cleanup activities.

The Navy is working to implement the deployment of two Coral Reef Ark structures as part of a demonstration project in UXO 16, west of the former Naval Ammunition Support Detachment in Vieques. The project objective is to demonstrate an improved alternative method for coral reef mitigation that can be required at Department of Defense sites. The traditional mitigation approach, typically associated with in-water construction work, is to translocate individual adult corals to new locations, which can be expensive and have low success rates. The Coral Reef Ark project in Vieques focuses on translocating a larger proportion of reef diversity and providing new habitat with improved physical conditions to encourage growth of mini-reefs in locations that would then produce larvae and help recolonize areas affected by UXO removal (or by training and testing activities, if applicable, in other jurisdictions).

The programmatic consultation requested by the USACE for the FUDS around Culebra and Desecheo includes activities similar to those being conducted by the Navy with the exception of the coral arks and use of ARM structures, though some restoration of seagrass and coral habitats may occur in the future depending on the extent of the potential effects of underwater cleanup activities on these habitats.

The AFTT consultation concluded that, because Nassau grouper may occur in the southern portion of the Jacksonville Range Complex and in the Key West and Gulf of Mexico Range Complexes, they could be exposed to stressors associated with Navy training and testing with the use of explosives in the Key West and Gulf Range Complexes being the most likely stressor to affect the species. However, because Nassau grouper tend to be located in habitats associated with the coral reef ecosystem, which are protected from exposure to the effects of explosive use through mitigation measures the Navy implements to prevent explosive discharges in areas with mapped coral reefs and no large explosives are detonated near FGBNMS, NMFS determined the effects of AFTT activities were not likely to adversely affect Nassau grouper. On the other hand, NMFS determined the use of explosives were likely to adversely affect scalloped hammerhead sharks. NMFS also determined that military expended materials, and wires and cables and biodegradable polymers (that present an entanglement risk) were likely to adversely affect ESA-listed corals and elkhorn and staghorn coral critical habitat, but the action is not likely to result in jeopardy to any of these species or destruction and adverse modification of elkhorn and staghorn coral critical habitat.

Pacific Islands

The island of Farallon De Medinilla (FDM, northern CNMI) has been used as a target area since 1971 by the Navy. Between 1997 and 2012, there were 14 underwater scientific survey investigations around the island providing a long term look at potential impacts on the marine life from Navy training and testing involving the use of munitions (Smith and Marx Jr. 2016) Marine life assessed during these surveys included algae, corals, benthic invertebrates, sharks, rays, and bony fishes, and sea turtles. The investigators found no evidence over the 16-year period of the survey that the condition of the biological resources had been adversely impacted to a significant degree by the training activities (Smith and Marx Jr. 2016). Furthermore, they found that the health, abundance, and biomass of fishes, corals and other marine resources were comparable to or superior to those in similar habitats at other locations within the Mariana Archipelago.

ESA-listed *A. globiceps* colonies are known to occur in the nearshore areas around FDM in habitats with live coral cover and at depths between 15 and 25 m (49 and 82 ft; i.e., the depth range where the species was observed during recent coral reef surveys). The Navy has taken measures to avoid these locations and there is a potential for these colonies to be impacted by future Navy actions. Due to the lack of quantifiable data on the abundance and distribution of ESA-listed corals in the action area, it was not practical or possible to express the amount or extent of anticipated take of *A. globiceps*, or to monitor take-related impacts in terms of individuals of this species. The Navy continues to monitor the coral colonies around FDM through funding coral surveys every five years (NMFS 2020a).

The MITT consultation concluded that, because *Acropora retusa* and *Seriatopora aculeata* have only been documented in a few locations within the MITT action area, and these locations are not areas where Navy activities that could affect this species of coral (e.g., FDM or Apra Harbor) typically occur, the action was not likely to adversely affect these species. NMFS concluded that the Indo-West Pacific DPS scalloped hammerhead sharks and *Acropora globiceps* were likely to be adversely affected, but not jeopardized, by the Navy's activities in the MITT action area because of the use of explosives. The HSTT consultation, which includes the Hawaii Range Complex, concluded that the Eastern Pacific DPS scalloped hammerhead shark was likely to be adversely affected, but not jeopardized, by the Navy's activities because of the use of explosives but this DPS is not present in the action area and the action area for the HSTT consultation did not include the range of the Indo-West Pacific DPS considered in this consultation. However, multiple DPSs of scalloped hammerhead shark may be affected by military activities, particularly the use of explosives during training and testing activities, including in the action area.

6.9 Research and Monitoring 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. Prior to issuance of any section 10 permit, the proposal is reviewed for compliance with section 7 and a consultation is conducted between OPR divisions because NMFS is the action agency as the federal agency authorizing the action. In addition, section 6 of the ESA allows NMFS to enter into cooperative agreements with states and territories to assist in recovery actions for listed species, including conducting research on listed species. Numerous research activities are ongoing with the action area. Both the NMFS SEFSC and PIFSC hold permits from NMFS OPR for conducting research on all ESA-listed coral species in the Atlantic Ocean, Pacific Ocean, Gulf of Mexico, and the Caribbean Sea. NMFS also issues authorization under the MMPA for research activities targeting listed and non-listed cetaceans. Some of these research projects result in effects to other ESA-listed species, requiring section 7 consultations.

Other research activities that do not require a NMFS ESA permit, but may require an ESA section 7 consultation are also ongoing in the action area, though many may require state and territorial authorization. In addition, NOAA and the Department of the Interior conduct and issue permits for research and monitoring activities in the action area. USFWS and the National Park Service manage protected areas in various locations in the Atlantic/Caribbean and Pacific and NOAA manages national marine sanctuaries and marine national monuments in the Atlantic, Gulf of Mexico, and Pacific, including FKNMS, FGBNMS, Papahanaumokuakea Marine National Monutment, Hawaiian Islands Humpback Whale National Marine Sanctuary, and National Marine Sanctuary of American Samoa. Many activities in these protected areas require permits from the managing agency and the agencies themselves conduct research and monitoring as part of their management activities.

Atlantic/Caribbean Region

Two ESA-listed coral, elkhorn and staghorn corals, have “take” prohibitions due to the promulgation of a 4(d) rule. For elkhorn and staghorn coral, the 4(d) rule enables permits issued by the Commonwealth (Puerto Rico) or Territory (USVI) to be used in lieu of section 10 permits issued by NMFS for activities meant to promote scientific research, enhancement, and recovery of these two coral species.

The Commonwealth and Territorial agencies have coral monitoring sites around Puerto Rico and USVI that have been funded in part by the CRCP and through an ESA section 6 grant in the case of the PRDNER. CRCP has also funded survey work by NCCOS to evaluate benthic habitats and fish in areas around Puerto Rico and the USVI. In addition, the NCRMP randomly selects sites to survey in Puerto Rico and USVI, alternating between jurisdictions each year. Survey work by the states and territories, NCCOS, and under the NCRMP is as described in Section 3.

There has been and continues to be, research on Nassau grouper spawning aggregation sites in waters of the USVI, particularly Grammanik Bank, and Puerto Rico, particularly on the west coast of the main island and at Mona Island. Most of the research is done using visual censuses and/or passive acoustic monitoring rather than capturing animals. When fish are captured, they are captured live and returned to the water to limit any mortality from fishery-independent research activities.

There are also research activities such as seismic surveys conducted by the National Science Foundation, often in partnership with academic institutions and with the U.S. Geological Survey. These surveys require MMPA authorization and ESA section 7 consultations. In its effects analyses for these consultations, NMFS has concluded that the surveys may affect, but are not likely to adversely affect ESA-listed species considered in this opinion.

Pacific Region

NOAA and the Department of the Interior conduct scientific research and issue permits for various research and monitoring activities in the coastal waters of American Samoa, Guam, CNMI, NWHI, and the PRIA. Scientific research and monitoring activities include the installation of scientific instrumentation, ship-based surveys, and in-water surveys, including those associated with existing CRCP activities. Many of the USFWS and NOAA activities associated with protected areas occur every three years but some occur approximately three times per year such as at Rose Atoll.

As of October 2019, scientific research and monitoring activities in Guam and CNMI included 21 permits in the Pacific Ocean authorizing research on one or more ESA-listed species. Most of this research and monitoring took place or is taking place in Guam. There is also research and monitoring in American Samoa, particularly at Palmyra Atoll, which is technically uninhabited with no permanent residents but a year-round human presence due to the active research station there that houses seasonal researchers, refuge staff, and facility maintenance staff.

The Navy funds numerous scientific research projects within all of their operational areas at various levels within the Department of the Navy. Their funding serves to advance their environmental stewardship goals and to support impact analyses to environmental resources related to Navy operations and training. Within MITT, the Navy has funded numerous research projects over the last two decades. As part of their formal section 7 Consultation with NMFS, the Navy continues to fund research on coral reefs in the area. These coral surveys are conducted every five years and are focused on locating ESA-listed corals in the waters around Guam and FDM specifically (NMFS 2020a). Additionally, the Navy provides funding for NMFS PIFSC to conduct annual sea turtle tagging in the nearshore waters of Guam and CNMI.

In 2019, NMFS Habitat Conservation Division consulted with NMFS PIRO Protected Resources Division for the effects of building and operating a coral nursery for growing and reproducing coral colonies, including ESA-listed *A. globiceps* colonies, in Saipan Lagoon. In that opinion, it was determined that the action would result in at least 30, and up to 300, parent colonies on reef slopes throughout Saipan being wounded due to fragments being broken off to supply the nursery (NMFS 2019b).

Recently, the NMFS Office of Habitat and Conservation, NOAA CRCP, and NMFS PIRO completed a formal section 7 consultation for a three-year coral gamete collection and restoration research project in Saipan, CNMI. The project involves three main types of activities that have the potential to impact ESA-listed resources: 1) coral fragment and gamete collection from coral colonies located at reefs around Saipan; 2) deployment of settling pools in Saipan Lagoon; and 3) outplanting of settlement units at various reef test sites around Saipan (NMFS 2021).

6.10 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 ESA-listed Nassau grouper, sea turtles, and corals, in the action area. Sources of pollutants in the action area include atmospheric loading of pollutants, stormwater runoff from residential, commercial, and urban areas into waterbodies and associated transport of contaminants in runoff, point source discharges, and in-water activities such as vessel operation and construction. Fueling facilities at marinas sometimes discharge oil, gas, and sewage into sensitive coastal habitats. Although these contaminant concentrations are less likely to affect scalloped hammerhead shark, which may be in areas near marinas as neonates and juveniles if the area serves as nursery habitat, juvenile Nassau grouper, ESA-listed corals and their habitat are often in areas that may be affected by marine operations. Regardless of location, land-based pollutant runoff, marina and dock construction and operation, dredging, increased underwater noise, and boat traffic can degrade marine habitats used by Nassau grouper, scalloped hammerhead sharks, ESA-listed corals, and designated and proposed coral critical habitat.

Limited data are available for ESA-listed corals related to exposure and toxicity thresholds for things like heavy metals. Exposure data that are available, such as from studies using mountainous star coral indicate that chronic exposure to certain concentrations of copper result in effects to embryo development (Bielmyer et al. 2010). Toxicity data are not available for scalloped hammerhead sharks or Nassau grouper, but there have been studies using saltwater and estuarine fish species to determine the toxicity of and response to certain metals. Based on the results of these studies, NMFS concluded that chronic exposure to copper could lead to developmental effects to Nassau grouper and potential behavioral aberrations in juveniles (NMFS 2019a). Contaminants such as heavy metals could reach nearshore waters from coastal development, affecting Nassau grouper, scalloped hammerhead sharks, and ESA-listed corals.

Dredging, filling, and explosive clearing can cause numerous harmful effects to ESA-listed species from the suspension of sediments and the removal of substrate. While suspension of sediments from dredge and fill operations may be temporary, the effects may have longer impacts to ESA-listed corals depending on the flushing potential of the area to clear away the sediment from the corals.

Apra Harbor is a natural deep-water harbor, which has been heavily modified, particularly since World War II. Much of the harbor's current topography and bathymetry is man-made as a result of work begun by the U.S. Government in 1943. Extensive dredging and fill projects resulted in the creation of Inner Apra Harbor and its channel as well as the creation of Dry Dock Peninsula, Polaris Point, and the manmade northeastern and southeastern shorelines and the Glass Breakwater, which extends from Cabras Island, out and across Luminau Reef to provide increased protection for the harbor. Other impacts include the knolls (hard bottom sites that protrude at least 7.6 m (25 ft) above the harbor bottom) that were explosively cleared during WWII because they were considered navigational hazards. Some of the shallower knolls have been used as anchorage sites since WWII, and some are still used by military and commercial vessels. The Guam and CNMI military relocation involves additional dredging in Inner Apra Harbor (Joint Guam Program Office 2010). Maintenance dredging within Apra Harbor is performed as necessary to maintain navigable depths (DoN 2019). In addition to Apra Harbor, Guam, the other large, active harbor in the Pacific that is periodically dredged for maintenance is Pago Pago Harbor, Tutuila. There is also a dredged channel off Saipan in the offshore anchorages and some dredged areas in marinas in Tinian and Rota.

There are 12 harbors with navigation channels that are maintained by the USACE in the Atlantic/Caribbean that are periodically dredged or expanded. These harbors include Palm Beach Harbor (Lake Worth Inlet, Port Everglades, Miami Harbor, and Key West Harbor in Florida; San Juan Harbor and Ponce Harbor in Puerto Rico (with four other harbors that have not been actively maintained for decades), Charlotte Amalie, St. Thomas (but recent dredging projects have been funded and conducted by local entities with USACE permits), and Christiansted Harbor, St. Croix (but no active maintenance in 25 years). Local port authorities in Florida, Puerto Rico and USVI also manage periodic dredging in non-federal harbors and channels.

Beach nourishment projects are common in Florida and have resulted in turbidity, as well as direct effects to hard bottom and other habitats that may be used by listed species considered in this opinion. Some of these projects result in beach nourishment as frequently as annually while others may not result in re-nourishment. Depending on the frequency of re-nourishment, there may be chronic effects from turbidity and changes to benthic habitat in areas where these projects occur.

Water pollution can inflict additional stress on corals (Hughes and Connell 1999). Several studies suggest a direct link between declining water quality from increased runoff, sedimentation and pollutants, which can be a byproduct of coastal development or other human activity, and coral reef health and bleaching (Ennis et al. 2016; Nelson et al. 2016; Gailani et al. 2016). For example, toxicants such as oxybenzone, zinc and titanium oxide found in sunscreens and personal beauty products have been shown to induce severe and rapid coral bleaching due to the alteration of the symbiosis between coral and zooxanthellae (Downs et al. 2016; Corinaldesi et al. 2018) and the concentrations of these contaminants in nearshore waters increases with increased tourism development, as well as increased vessel operation and wastewater discharges associated with coastal development.

Land-based sources of pollution play a major role in the overall declined health of habitat throughout coral reefs in the Pacific. Land-based sources of pollution on coral reefs include sediment, nutrients, and contaminants. Since the seven Indo-Pacific coral species considered in this opinion were listed in 2014, contaminant transport to nearshore waters has continued to increase as the human population and industrialization grows within much of the ranges of the seven ESA-listed Indo-Pacific coral species. Subsequently, exposures and vulnerabilities of the species to land-based sources of pollution continue to increase. For example, Guam is experiencing higher rates of development which is impacting surrounding coral reef habitat due to sewage pollution. Average coral cover on Guam in the 1960s was roughly 50% (Randall 1971 as cited in Redding et al. 2013), but it had declined by approximately 26.1% by 2005 (Burdick et al. 2008). Due to repeated crown-of-thorns outbreaks on forereefs, most of Guam's residual coral communities are limited to reef flat zones, where they are most susceptible to land-based influences. Guam's wastewater is subject only to primary- or secondary-treatment (i.e., no nutrient removal) and thus, the nitrogen pool in coastal waters is dominated by sewage-derived nitrogen (Redding et al. 2013), which can lead to fertilization of nearshore waters, promoting the growth of algae that can outcompete corals for substrate.

6.11 Natural Disturbance

Hurricanes and large coastal storms can significantly alter habitats used by ESA-listed Nassau grouper and corals in particular, but these habitats are also used by scalloped hammerhead sharks, particularly neonates and juveniles, as foraging habitat. The movement of Nassau grouper and scalloped hammerhead sharks can be affected by oceanographic conditions caused by large storms and potentially shift locations of prey species. 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 coral asexual reproductive events, particularly for branching coral species, if the fragments encountered suitable substrate, attached, and grew into new colonies. However, 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).

Major hurricanes have caused significant losses in coral cover and changes in the physical structure of many reefs in the action area, 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 Nassau grouper as juveniles use shallow nearshore habitats as nursery areas and adults use deeper coral habitats for refuge and foraging, and scalloped hammerhead sharks that use these sites for foraging and, in some cases, as nursery areas.

In September 2017, Hurricanes Irma and Maria hit the USVI and Puerto Rico, causing catastrophic damage to coral reef habitat with an estimated 11% of Puerto Rico's reefs experiencing damage. Corals were broken and dislodged by intense wave energy and terrestrial debris that landed in the water. Shallow nearshore reefs received the most damage. After the hurricanes, limited emergency restoration was conducted at select sites. Approximately 2,500 loose coral fragments were stabilized across USVI (Blondeau et al. 2020) and 16,000 coral fragments acros 63 sites in Puerto Rico (Viehman et al. 2020). However, this represents only a fraction compared to the number of fragments lost given that damage assessments along transects in various locations around Puerto Rico post-hurricanes showed approximately 40% of acroporid coral colonies, 75% of pillar coral colonies, and 10% of colonies from the star coral complex were damaged (Viehman et al. 2020).

In Puerto Rico, 2018 coral reef surveys after Hurricanes Irma and Maria showed that 11% (2,958 of 27,410) of corals in transect surveys had coral damage where the colony was broken, overturned, upside down or loose (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, and West regions. Medium-sized coral colonies (20 - 50 cm [7.9-19.7 in]) had the largest number of damaged colonies, although large (50 - 100 cm [19.7-39.4 in]) and extra-large (100 - 150 cm [39.4-59 in]) corals had the greatest proportion of damage to colonies (15%(Viehman et al. 2020). Damaged colonies may be more susceptible to bleaching, disease, boring organisms and algae overgrowth; therefore it is essential that restoration efforts be applied to recover the capacity of these nearshore shallow water reefs systems to provide effective protection to coastal infrastructure.

6.12 Synthesis of Baseline Impacts

Collectively, the stressors described above have had, and are likely to continue to have, lasting impacts on Nassau grouper, scalloped hammerhead shark (Central and Southwest Atlantic and Indo-West Pacific DPSs), ESA-listed corals, and designated and proposed coral critical habitat within the action area. Some of these stressors, such as fisheries and entanglement in marine debris, may result in mortality or serious injury to individual fish or breakage and abrasion of corals, whereas others result in more indirect (e.g., water quality degradation from coastal development) or minor (e.g., research permits involving observation of marine mammals that could temporarily disturb ESA-listed fish) effects. Climate change-related effects and changes in ocean chemistry that are exacerbated by climate change, specifically ocean acidification, have had significant impacts on listed species. In the case of corals, these threats led to the listing of various Atlantic/Caribbean and Indo-Pacific species under the ESA.

We consider the best indicator of the environmental baseline on ESA-listed resources to be the status and trends of those species and their designated critical habitat. As noted in Section 5.2, some of the species considered in this consultation appear to have stable populations, others are declining, and for others such as Indo-Pacific corals, 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 and critical habitat for which NMFS has found the action is likely to cause adverse effects is discussed in Section 5.2 of this opinion.

7 Effects of the Action

"Effects of the action" has been recently revised to mean 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 (50 C.F.R. §402.02). Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 C.F.R. §402.17). This means we identify stressors associated with the proposed action and evaluate the response of ESA-listed species and designated and proposed critical habitat to exposure to the stressors.

7.1 Stressors Not Likely to Adversely Affect ESA-Listed Corals, Nassau Grouper, Scalloped Hammerhead Shark, and Designated and Proposed Critical Habitat for ESA-Listed Corals

We have determined that ESA-listed Atlantic/Caribbean and Indo-Pacific coral species, elkhorn and staghorn coral critical habitat, and proposed critical habitat for five Atlantic/Caribbean and seven Indo-Pacific coral species; Nassau grouper, and the Central and Southwest Atlantic and Indo-West Pacific DPSs of scalloped hammerhead shark may be adversely affected by the proposed action. However, the effects of some of the stressors resulting from the proposed action will be discountable or insignificant for some or all of these species and designated and proposed critical habitats and therefore not likely to result in adverse effects. Insignificant or discountable effects are discussed below.

7.1.1 Vessel Operation and Equipment Collisions

Vessel operations associated with the activities that are part of the proposed action could lead to collisions with mobile (free-swimming) ESA-listed species, specifically Nassau grouper and scalloped hammerhead sharks. However, there are no reports of vessel collisions with mobile ESA-listed species as a result of past CRCP activities. The majority of activities are expected to occur in nearshore waters along coastlines and within embayments. Scalloped hammerhead sharks tend to be found at or near the water surface where they may be observed by vessel crew members engaged in removal activities. These animals are expected to move away from these activities in response to the associated visual and noise stimuli. Vessel collisions with Nassau grouper are not expected to occur because these fish do not need to surface to breathe, and larger individuals prefer to be in deeper water. The CRCP applies required BMPs to vessel operation (Section 3.5.1) to keep a vigilant watch to prevent collisions with protected species. Collisions with ROVs, remote sensing and other towed equipment are also possible, but extremely unlikely for mobile species and have not been reported during past CRCP activities. Therefore, we believe that the effects of collisions associated with CRCP activities and the use of vessels, ROVs and towed equipment to Nassau grouper and scalloped hammerhead shark will be discountable.

Vessel anchoring, accidental grounding and propeller wash and scarring could affect in-water habitats used by ESA-listed species, including seagrass beds and coral habitats, and ESA-listed coral colonies. There have been no reported groundings by vessels associated with CRCP projects in the last decade. Vessel anchoring 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 ESA-listed corals and their designated or proposed critical habitat. The required vessel operation BMPs encourage vessel operators' safe navigation, including in shallow water areas, thus minimizing potential impacts to benthic habitats. The use of nautical charts and depth finders for navigation minimize the potential for accidental groundings and propeller wash and scarring, including in habitats occupied by listed corals. Therefore, we believe the effects of accidental grounding of vessels, propeller wash and scarring to ESA-listed corals and their designated and proposed critical habitat as a result of the proposed CRCP and Mission: Iconic Reefs action will be discountable. In terms of Nassau grouper and scalloped hammerhead shark, even if these effects were to occur, the amount of habitat available to these animals would offset any effects of accidental groundings, propeller wash and scarring, thus we would consider them to be insignificant.

Anchor damage to ESA-listed corals and their habitat will be minimized by implementation of the required BMPs that mandate the preferential use of recreational moorings or live boating and the use of divers to secure and remove the anchor when buoys or live boating are not an option.

For vessel anchoring, divers check areas where vessels will anchor to verify that no ESA-listed corals are present and to target unconsolidated habitat. We believe the effects of vessel anchoring to ESA-listed corals and their designated and proposed critical habitat will be insignificant due to the required BMPs employed by the CRCP and Mission: Iconic Reefs to avoid anchoring to minimize potential impacts to habitats from vessel operations and the extent of coral habitats within the action area. We believe the effects of vessel anchoring on ESA-listed corals will be discountable due to the BMPs minimizing potential impacts to coral species by requiring avoidance of ESA-listed coral colonies when anchoring. We believe the effects of anchoring to Nassau grouper and scalloped hammerhead shark will be insignificant because effects would be to the habitat of these mobile species and there are large areas of habitat available within the action area.

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. Vessel motors often discharge a small amount of petroleum products during normal operation as well. Some of the vessels used by the CRCP and its grantees/contractors as part of the proposed action may have toilets, kitchens, showers, or other sources of discharges. However, the majority of vessels used to conduct the activities that are part of the proposed action are small vessels such as zodiacs with only a center console. There are regulations (under the authority of EPA and USCG) governing the location where vessels can discharge, such as for sanitary wastewater, and requiring controls for some discharges that contain contaminants to minimize their release into marine waters. National Marine Sanctuary Act regulations also prohibit and restrict vessel discharges (depending on the type of discharge) in national marine sanctuaries and discharges in the Papahanaumokuakea Marine National Monument are regulated by USFWS and NOAA.

Vessels also generate marine debris such as trash that falls into the water. Because divers are used in the majority of activities that are part of the proposed action, any 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. Most work does not involve overnight stays on the water and some work is done from the shoreline, so trash generation is minimal. For larger vessels, trash control is part of shipboard requirements and regulations governing operations. Therefore, we believe the effects of discharges and marine debris associated with vessel operations to Nassau grouper, scalloped hammerhead sharks, and ESA-listed corals and their designated and proposed critical habitat will be insignificant.

Based on the above, we believe vessel operations may affect, but are not likely to adversely affect Nassau grouper, scalloped hammerhead shark, ESA-listed corals, and designated and proposed coral critical habitat. Collisions with ROVs and towed equipment may affect, but are not likely to adversely affect Nassau grouper and scalloped hammerhead sharks.

Activities involving the use of ROVs and towed equipment could result in collisions with the marine bottom in an area containing ESA-listed coral colonies and/or designated and proposed coral critical habitat. The effects of these potential collisions are discussed in Section 7.2.

7.1.2 **Sound**

Sound from different sources, including vessel noise, echosounders and other vessel navigational equipment, sensors used during activities such as mapping, and in-water equipment used to install structures and collect cores may affect Nassau grouper and scalloped hammerhead shark in the action area.

Vessel Noise

Underwater sound from vessels is generally at relatively low frequencies, usually between 5 and 500 Hz (Hildebrand 2009a; NRC 2003; Urick 1983; Wenz 1962; Southall et al. 2017). Low frequency ship 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 include recreational vessel, small commercial fishing vessels, vessels for tourism and scientific research, and some larger vessels such as cargo ships that may transit longer distances. These vessels produce varying noise levels and frequency ranges. Commercial ships radiate noise underwater with peak spectral power at 20–200 Hz (Ross 1976). The dominant noise source is usually propeller cavitation, which has peak power near 50–150 Hz (at blade rates and their harmonics), but also radiates broadband power at higher frequencies, at least up to 100,000 Hz (Arveson and Vendittis 2000; Gray and Greeley 1980; Ross 1976). Propeller singing is caused by blades resonating at vortex shedding frequencies and emits strong tones between 100 and 1,000 Hz, propulsion noise is caused by shafts, gears, engines, and other machinery and has peak power below 50 Hz (Richardson et al. 1995). Overall, larger vessels generate more noise at low frequencies (<1,000 Hz) because of their relatively high power, deep draft, and slower-turning engines (<250 rotations per minute) and propellers (Richardson et al. 1995). While the majority of vessels used during CRCP and Mission: Iconic Reefs activities will be smaller vessels that generate less noise, NOAA ships with lengths up to approximately 63 m (208 ft) are used for some mapping and monitoring activities.

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;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;2005).

Given that the range of best hearing appears to be between 300 to 1000 Hz for fishes (including elasmobranchs, although limited information is available for groupers), the frequency range for operation of small vessels is outside the hearing range of Nassau grouper and scalloped hammerhead sharks so noise from operation of small vessels is not expected to affect these animals. Based on available information and other consultations, we conclude that Nassau grouper and scalloped hammerhead sharks in the action area are likely to either not react or to exhibit avoidance behavior in response to vessel noise and movement. Most avoidance responses would consist of movements away from vessels. Most of the temporary changes in behavior would 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 would likely need to be sustained for a significant duration or extent, which is not expected for activities that are part of this consultation. Thus, we do not expect Nassau grouper and scalloped hammerhead shark to respond to vessel noise or to respond measurably to vessel transit 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

Echosounders and side-scan sonar may be used by vessels to aid in navigation or during mapping activities. An echosounder measures the round trip time it takes for a pulse of sound to travel from the source at the vessel to the sea bottom and return. When mounted to the vessel, it is called a fathometer. Typical low frequency equipment operates at 12 kHz and high frequency equipment at 200 kHz. The major difference between various types of echosounders is the frequency. 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 would produce a wider beam. Lower frequencies penetrate deeper into the water, but have less resolution at depth. The Kongsberg/Simrad EK60 split-beam echosounder has been used in

Puerto Rico in acoustic surveys to look for spawning aggregations. When in use, the power is set to the lowest possible level, nominally 200 dB re: 1 PA, with a duty cycle of less than 10 Hz. The beam is maintained at less than a 12-degree angle, which focuses the sound downward, with a small beam width. For CRCP echosounder activities, multibeam vessel-based systems are typically used, as well as portable sonar-based mapping systems. The vessel-based system frequencies are between 65-120 kHz with effective operational depths of 100-2,000 m (328-6,562 ft). The echosounders on NOAA vessels are downward-oriented from the hull and spread up to 140 degrees across the ship width and 1-3 degrees along the track. Power is set to the lowest possible level (approximately 190-210 dB re: 1 µPA) with a duty cycle or "ping rate" also set to the lowest possible level of 10-30 Hz. The portable systems operate at selectable narrow band frequencies from 200-400 kHz with a downward transducer orientation with a typical swath set to 130 degrees during survey operations. CRCP-supported echosounder mapping takes place in depths below 200 m (656 ft). The power is set to the lowest possible level, nominally 200 dB re: 1 PA, with a duty cycle of less than 10 Hz. The sound is focused downward, with a small beam width, which means the potential area where an impact due to equipment noise would be extremely small.

Most fish species can hear sounds between 50 and 1,000 Hz with most ESA-listed fish studied (largely salmonids and sturgeon) having a hearing range below 400 Hz, so fish without hearing specialization (such as scalloped hammerhead sharks and Nassau grouper) are not expected to detect signals emitted by navigational and survey equipment. Therefore, we believe the effects of sound from navigation and survey equipment operated as described in Section 3 will be insignificant and not likely to adversely affect Nassau grouper and scalloped hammerhead sharks.

Coring equipment could be used to collect coral tissue samples. Hand-held hydraulic or pneumatic drills may be used to collect cores. Due to the small size of these drills, noise produced by coring is not comparable to hydraulic dredges used in underwater construction for which source levels of 164.2 to 179.2 dB re: 1 µPa at 1 m rms are reported for sound pressure levels examined at frequency bands of 50-1000 Hz and 100-400 Hz (Reine et al. 2014). Coral coring is done quickly and the sound produced is not expected to result in levels above those produced by other equipment discussed in this section or to be significantly above ambient noise levels recorded in reef environments. For example, snapping shrimp generate sounds with the most energy at frequencies of 2-5 kHz and individual snaps can have peak-to-peak pressure source levels up to 189 dB at 1 m (Au and Banks 1998). The CRCP projects using coring are limited to a small number of projects and a small number of coral colonies sampled per project (about three projects in the last four years involved coring with 40-80 samples per project). We believe the effects to Nassau grouper and scalloped hammerhead sharks from the noise associated with coral coring will be insignificant and thus not likely to adversely affect these animals. Coral coring will adversely affect ESA-listed corals and, because coral (both ESA-listed and non-listed species) is a key component of coral habitat, may also adversely affect designated and proposed coral critical habitat. These effects are discussed further in Section 7.2.

The installation of in-water structures such as buoys, floating barriers, and associated anchor systems, will also result in temporary impacts associated with noise generated by coring and drilling equipment used to bore holes in hard substrate to install anchor pins and jacks used to install Manta Ray® anchors in sand and other bottom substrates. Manta Ray® and the Helix anchors are typically installed using a hydraulic jack. Anchor pins are installed using a hydraulic drill or corer with a diameter up to 10-cm (4-in). The equipment used to install anchor pins may be the same as that used to collect coral cores, and the noise generated during installation of anchor pins is expected to be similar. 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. Thus, none of the sound produced by the installation of 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 Nassau grouper and scalloped hammerhead sharks. We believe the effects to Nassau grouper and scalloped hammerhead sharks 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.

If new equipment for remote sensing or other activities associated with the proposed action is proposed in the future that will operate at different frequencies and have different source levels, the potential effects of the use of this equipment on ESA-listed species would have to be analyzed as part of project-specific reviews and possible tiered consultations as described in Section 3.5.2 and could require reinitiation of consultation or a separate consultation depending on the potential effects of the equipment on ESA-listed species.

7.1.3 **Visual Disturbance**

Visual disturbance to Nassau grouper and scalloped hammerhead shark resulting from the presence of vessels and/or divers and snorkelers in the water could occur as a result of the proposed action. Visual disturbance of animals that might be encountered during in-water activities would be short-term as activities such as monitoring, instrument installation and operation, and vessel operations are conducted over short periods. In addition, the rarity of Nassau grouper and scalloped hammerhead shark makes the likelihood for encountering these animals during in-water work low. Thus, any visual disturbance of animals would be temporary and not likely to result in measurable changes in behavior. Therefore, the effects of visual disturbance as a result of the proposed action on Nassau grouper and scalloped hammerhead shark will be insignificant and thus not likely to adversely affect these animals.

7.1.4 Entanglement and Entrapment

In terms of the potential for entanglement associated with lines in the water from in-water structures and towed equipment, we believe the effects of this stressor on Nassau grouper and scalloped hammerhead shark are discountable because lines associated with towed equipment and in-water structures and instruments are kept taut and kept to the minimum length necessary depending on the structure or instrument and tackle system to reduce any possibility for entanglement. There have not been reported entanglements of these species in coral nursery structures. Tents are used to collect coral gametes, but these are constantly monitored by divers in order to collect samples as gametes are released and entanglement of ESA-listed fish in these structures would only occur if tents were to come loose and become debris in the water column or on the seafloor. This is not likely given the full-time monitoring of the tents by divers. No entanglement of Nassau grouper or scalloped hammerhead shark has been reported during past CRCP activities and the required BMPs associated with the use of equipment and installation of in-water structures and equipment with lines in the water will be followed, further minimizing the potential for entanglement. Therefore, we believe the effects of entanglement in lines in the water, other than from fishing gear, on Nassau grouper and scalloped hammerhead shark associated with the proposed action are discountable.

In terms of fishing gear, entanglement in fishing gear or bycatch is considered a significant threat to scalloped hammerhead sharks. Nassau grouper could also be entangled or entrapped or be bycatch in gear used to conduct biological sampling. Biological sampling using fishing gear as part of CRCP activities is uncommon, but does occur in areas where these species may be present. Therefore, the use of fishing gear may adversely affect Nassau grouper and scalloped hammerhead shark and these effects are discussed further in Section 7.2. In addition, CRCP could fund projects to conduct activities such as tagging of these species or could decide to tag animals caught incidentally in fishing gear while using these gear to conduct biological sampling. If tagging is proposed in the future, projects involving tagging would require project-specific review and likely tiered consultations to fully consider the effects of this activity and determine whether additional BMPs or an amended ITS will be required.

7.1.5 Sediment Resuspension and Transport

Many of the activities associated with the proposed action have the potential to disturb the bottom, including removal of invasive/nuisance species from the marine bottom, sediment sampling, installation of in-water structures, diving operations, coral transplantation/outplanting, use of fish traps, and associated vessel anchoring during operations. Bottom disturbance is expected to cause sediment resuspension and transport. However, because the required BMPs emphasize the preferential use of unconsolidated bottom (particularly sand) for the installation of in-water structures and their anchors, use of bottom-tended fishing gear, and vessel anchoring, in 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 lead to sand resettling to the bottom quickly after a disturbance. Similarly, disturbance in coral habitats will not generate large amounts of sediment because coral habitats, unless subject to high concentrations of land-based sediment transport, are not characterized by high sediment content. BMPs for watershed projects minimize land-based pollutant transport, including sediment transport. BMPs for vessel anchoring and diving activities include measures that minimize sediment resuspension associated with projects. Sediment cores associated with sediment sampling are often done by hand in uncolonized bottom substrate and are not expected to lead to measurable sediment resuspension. Any sediment resuspension and transport from CRCP activities are expected to be minimal and temporary. Therefore, we believe the effects to Nassau grouper, scalloped hammerhead shark, ESA-listed corals, and proposed and final coral critical habitat due to sediment resuspension and transport will be insignificant and thus not likely to result in adverse effects to these species or habitats.

7.1.6 **Habitat Loss, Damage, or Alteration**

Habitat used by Nassau grouper, including nearshore juvenile nursery habitat, and habitat used by adults for refuge, foraging and spawning; by neonate and juvenile scalloped hammerhead shark, particularly nearshore habitat, and habitat used by adults for foraging; and designated and proposed coral critical habitat could be lost, damaged, or altered by some of the activities conducted by the CRCP and Mission: Iconic Reefs. Specifically, the installation of in-water structures and their anchors, anchoring of vessels, biological sampling using fishing gear, organism collection from reef substrate, and diving and snorkeling operations can all result in effects to habitats associated with the coral reef ecosystem, including seagrass beds, mangroves, and coral reefs. Anchoring of vessels and the installation of anchor systems and in-water structures and equipment will be done in accordance with the required BMPs, including installation the majority of them in unconsolidated bottom and the use of divers or snorkelers to install structures and equipment, but, because unconsolidated bottom may include seagrass habitat, there may be a small portion of seagrass lost due to sharing or direct effects of installation. Biological sampling using fishing gear is rare and BMPs require that traps not be placed in areas containing corals. The soak time for traps is short and studies on the use of fish traps have found that traps have to be left in areas such as seagrass beds for six weeks before effects to the habitat are observed (Uhrin et al. 2005). Other biological sampling, such as collection of coral fragments and coring have an extremely small footprint. Divers and snorkelers can also cause damage to habitats, particularly coral habitats, if they do not control their buoyancy, maintain their gear close to their bodies, or stand on corals. Implementation of the required BMPs during activities involving divers and snorkelers are expected to minimize the potential for effects to habitat. In addition, most activities using divers and snorkelers involve only a small number of people in the water at any given time so damage from divers or gear causing breakage or abrasion of substrate will be minimal. As discussed previously, the amount of habitat available to Nassau grouper and scalloped hammerhead shark compared to the footprint of impacts from these activities means the effects of any habitat loss, damage, or alteration to Nassau grouper and scalloped hammerhead shark will be insignificant.

Habitat loss or damage to ESA-listed corals and designated and proposed coral critical habitat associated with the installation of anchor systems, including anchor pins, in hard substrate and biological sampling activities, including organism collection, is likely to adversely affect these resources and is discussed further in Section 7.2.

7.1.7 **Introduction of Contaminants**

Watershed activities could result in the transport of sediment and other contaminants to areas containing ESA-listed corals and designated and proposed coral critical habitat and habitat utilized by juvenile Nassau grouper and neonate and juvenile scalloped hammerhead shark (particularly nearshore nursery areas) due to construction of stormwater management or erosion control measures. Earth movement activities in or near waterbodies may result in pulses of land-based contaminants to nearshore waters, especially during storms. Activities could lead to temporary effects to water quality during construction, though these are expected to be minimal due to the implementation of the required BMPs to minimize sediment and other contaminant transport downstream during construction activities. In addition, any contaminant transport associated with watershed activities would be short-term, whereas the watershed activities to manage stormwater and erosion are expected to have long-term benefits to the coral reef ecosystem. Therefore, we believe the effects of watershed activities on Nassau grouper, scalloped hammerhead sharks, ESA-listed corals and designated and proposed coral critical habitat will be insignificant and thus not likely to adversely affect these species and habitats.

Studies suggest that tracer dyes, which may be used during some CRCP watershed activities to look for pollutant sources, have a lethal dose at which 50% of individuals exposed to the dye may die (LC50) at concentrations much higher than expected exposure levels (Field et al. 1995; Field 2005). In addition, because these dyes are typically used in watersheds, concentrations will be further diluted by the time the dyes reach nearshore waters where Nassau grouper, scalloped hammerhead sharks, or ESA-listed corals are located. Similarly, lubricants and other products used on in-water instruments installed and operated as part of CRCP activities are used in very small amounts and any concentrations in the water column would be quickly diluted. Therefore, we believe the effects of exposure to tracer dyes and lubricants and similar products will be insignificant thus these are not likely to adversely affect Nassau grouper, scalloped hammerhead shark, and ESA-listed corals.

Antibiotics in the marine environment are present in high concentrations in some areas from agricultural runoff or domestic effluent streams and may be causing antibiotic resistant bacteria in the wild (MacAfee 2017). Samples collected from the Miami-Dade North District Wastewater Treatment Facility has a reclaimed distribution line that is used to irrigate the Florida International University Biscayne Bay Campus. Samples were collected from reclaimed water used in irrigation, as well as from the Miami River and drinking water to test for the presence of antibiotics. Erythromycin was detected in more than 85% of samples from all water sources and reclaimed waters frequently had concentrations of nalidixic acid, clarithromycin, azithromycin, trimethoprim, and sulfamethoxazole (Panditi et al. 2013). The marine environment was found to host a diversity of genes that confer antibiotic resistance and 44% of these genes were found in abundant marine taxa such as *Pelagibacter* and *Vibrio* (Hatosy et al. 2015; Marti et al. 2013). Use of antimicrobials such as quinolones, tetracyclines, and b-lactamases in aquaculture is also a source of contaminants in marine waters. Cabello et al. (2013) found genetic elements and resistance determinants that were shared between aquatic bacteria, fish pathogens, and human pathogens with origins in aquatic bacteria. A study of the toxicity of ibuprofen and amoxicillin to rotifers (*Brachionus calyciflorus* and *Brachionus havanaensis*) found amoxicillin had more adverse effects to both species at three sublethal concentrations of 200, 100, and 50 µg/L. Survivorship and reproduction-related variables were negatively affected in both species with increasing concentrations of ibuprofen and amoxicillin (González-Pérez et al. 2016). Amoxiccilin was also found to have marked toxicity to the cyanobacteria, *Synechococcus leopolensis*, while not showing toxicity to the green algae, *Pseudokirchneriella subcapitata* and *Closterium ehrenbergii*, or the diatom, *Cyclotella meneghiniana* (Andreozzi et al. 2004). Sircar (2014) investigated how changes in oceanic pH may affect the toxicity of antibiotics being released into the ocean from anthropogenic sources using amoxicillin and ciprofloxacin at pH levels of 8.1 and 7.7. Amoxicillin was found to be more toxic at low pH while ciprofloxacin was more toxic at high pH. Thus ocean acidification may influence the toxicity of antibiotics to marine organisms.

The use of antibiotics and probiotics to treat coral diseases are relatively new methods that are being implemented in places where coral disease is decimating reef areas, such as SCTLD in Florida and the Caribbean. There is some uncertainty regarding the potential environmental effects from leach rates of antibiotics from the adhesive substance used to treat corals in the field. The amount of antibiotics or probiotics used in treating coral diseases as part of CRCP activities is likely a minimal contribution to what is in the environment from anthropogenic sources, particularly at the small scale at which these activities are undertaken (a maximum of 150 coral colonies in a single site in 2021). The information from studies of the toxicity of antibiotics indicates that, while amoxicillin does not appear to be toxic to algae, meaning zooxanthellae are not likely to be affected by its use, it is toxic to rotifers, which are similar to corals. Therefore, while the toxicity to bacteria may help in controlling the spread of diseases such as SCTLD, there could be long-term effects to corals from treatment. At this time and due to the poor condition of corals following disease outbreaks and treatment, there is little information to determine whether the treatment is successful at managing disease outbreaks but leads to effects to coral colonies such as decreased reproductive capacity. Given the small treatment area and small numbers of corals being treated at one time, in addition to the fact that treatment is occurring on coral colonies that are likely to suffer full mortality from diseases such as SCTLD, the effects of the use of antibiotics to Nassau grouper and scalloped hammerhead sharks are likely to be insignificant and thus not likely to adversely affect these species. However, if the use of antibiotics is scaled up as part of future CRCP or Mission: Iconic Reefs activities, project-specific review and potential tiered consultation may be necessary to further analyze the concentrations of antibiotics that could be present in the water column at sites where treatment occurs as greater concentrations could affect ESA-listed Nassau grouper and scalloped hammerhead sharks, particularly if they were used frequently in the same areas potentially leading to the development of antibiotic resistance in local bacterial populations.

Antibiotics are mixed into various compounds for application to diseased corals and the amount and type of these compounds varies. Shea butter was used initially but was found to be removed quickly due to water movement, meaning the antibiotic did not remain on treated corals for long. Alternatives using petrolatum mixed with other compounds such as mineral oil and carboxymethylcellulose have been tested, as well as the use of dental paste, modeling clay, and other formulas. Probiotic cultures are created using frozen bacterial strains that are reconstituted and grown in a media containing tryptone, yeast extract and filtered seawater and the mix is applied via syringe directly to affected corals. Probiotics and compounds used as media for applying antibiotics are not expected to be toxic to ESA-listed species, thus the effects of their release into the water column will be insignificant and thus not likely to adversely affect Nassau grouper, scalloped hammerhead shark, or ESA-listed corals.

Disease treatment is likely to adversely affect ESA-listed corals because of the physical contact with these corals required as part of the methodology, including the removal of portions of the colony in some cases. These effects will be discussed further in Section 7.2.

7.2 Exposure and Response Analyses

In Section 7.1, we described the stressors resulting from the action and determined that habitat loss, damage, and alteration is likely to adversely affect ESA-listed corals and their designated and proposed critical habitat; biological sampling using traps and nets is likely to adversely affect Nassau grouper and scalloped hammerhead sharks; the use of in-water equipment is likely to adversely affect ESA-listed corals; and organism collection and transport and disease treatment is likely to adversely affect ESA-listed corals.

In the following section, we consider the exposures that could cause an effect on ESA-listed species that are likely to co-occur with the effects of the stressors identified in the previous paragraph on the environment in space and time, and identify the nature of that co-occurrence. We consider the frequency and intensity of exposures that could cause an effect on 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 ESA-listed species to exposures and the potential reduction in fitness associated with these responses.

As discussed previously, stressors associated with novel techniques such as *in situ* coral grafting, in-water work with corals with genetically modified symbionts or other genetic modification, assisted migration of corals, and *in situ* methods to reduce sea surface temperature such as water cooling and installation of shade cloths may result in adverse effects to ESA-listed species and their habitats considered in this opinion, but there is not enough information to conduct a thorough effects analysis at this time. The use of any of these techniques, and other changes to activities as described in Section 3.5.2 will require project-specific review and may require tiered consultations. If a tiered consultation is required, it will be used to determine whether the effects of the activities described in Section 3.5.2 on Nassau grouper, scalloped hammerhead sharks (Indo-West Pacific and Central and Southwest Atlantic DPSs), ESA-listed corals, elkhorn and staghorn coral critical habitat, and proposed coral habitat for other ESA-listed corals considered in this opinion will differ from the effects analyzed in this opinion, whether additional BMPs are needed, and whether the ITS needs modification to address additional incidental take.

7.2.1 **Exposure to Stressors**

Nassau grouper were once common in the Caribbean but overfishing led to the dramatic decline in the population of this species. Grammanik Bank, a mesophotic reef (30-40 m [98-131 ft]) on the shelf edge of St. Thomas, once hosted large aggregations of the species and small numbers of Nassau grouper still use the area to spawn, often in multi-species aggregations. Spawning Nassau grouper have also been reported in other historic spawning aggregation sites in Puerto Rico and USVI, as well as in novel aggregation sites in low numbers since 2010 (NMFS 2013). Historic spawning aggregation sites are not known for Florida. Nassau grouper were rarely observed during in-water surveys in Puerto Rico in coral reefs, seagrass beds, and colonized hard bottom (Department of the Navy 1979;1986; GMI 2003; García-Sais et al. 2001; García-Sais et al. 2004) and only one Nassau grouper was seen during a few hundred reef fish surveys conducted by NCCOS around St. Croix (NOAA CRCP 2020). Nassau grouper have been caught in the Florida Keys, though not during CRCP activities. Seagrass and coral habitats in nearshore waters provide nursery habitat for juvenile Nassau grouper while adults use reef habitats, usually in deeper waters. Thus, it is likely that juvenile and adult Nassau grouper may be present in the action area in low numbers during activities associated with the proposed action.

The Cooperative Atlantic States Shark Pupping and Nursery Survey and the Cooperative Gulf of Mexico States Shark Pupping and Nursery Survey indicate the importance of estuarine, nearshore and coastal waters in the action area, specifically along the Atlantic coast of Florida and the Florida Panhandle in the action area in supporting various life stages of scalloped hammerhead shark from the Central and Southwest Atlantic DPS. In particular, juveniles (61-179 cm [24-70 in] TL) and adults (≥180 cm [71 in] TL) were found to use coastal areas, including the Florida Keys (Miller et al. 2014). Coral Bay, St. John, and Magens Bay, St. Thomas, that contain seagrass and coral habitats and, in the case of Coral Bay, mangrove wetlands, provide nursery habitat for scalloped hammerhead sharks in the U.S. Caribbean

(DeAngelis et al. 2008). Scalloped hammerhead sharks are caught in commercial and recreational fisheries in Puerto Rico and USVI and, based on the size of animals reported in landing data, these are largely neonates and juveniles. Scalloped hammerhead sharks from the Indo-West Pacific DPS are present in the Pacific Islands. Data from the Pacific indicate that juvenile scalloped hammerheads prefer to aggregate in deeper water during the day and areas of high hammerhead abundance correspond to locations of greater turbidity, higher sedimentation and nutrient flow, and areas where the current is strongest (Duncan Seraphin and Holland 2006; Bessudo et al. 2011). Neonate and juvenile aggregations are more common in nearshore nursery habitats, such as Kaneohe Bay in Oahu, Hawaii and inner Apra Harbor, Guam (Miller et al. 2014). Thus, it is likely that neonate, juvenile, and adult scalloped hammerhead sharks from the Indo-West Pacific and Central and Southwest Atlantic DPSs may be present in the action area during activities associated with the proposed action.

There are hard bottom and reef habitats containing colonies of ESA-listed corals in waters of the action area based on CRCP monitoring surveys and research projects and other information available to NMFS, including from previous consultations for CRCP and non-CRCP actions. Rough cactus coral, staghorn coral, and pillar coral are not present in FGBNMS but are present in the other U.S. jurisdictions in the Atlantic/Caribbean. The rest of the listed Atlantic/Caribbean coral species are present in FGBNMS, Florida, USVI, and Puerto Rico. Of the Indo-Pacific corals, *Acropora globiceps* is reported in American Samoa, CNMI, and PRIA. *A. jacquelineae*, *A. retusa*, *A. speciosa*, and *Isopora crateriformis* are reported in American Samoa. *Euphyllia paradivisa* is reported in American Samoa and CNMI. *Seriatopora aculeata* is reported in CNMI. Elkhorn and staghorn coral critical habitat is present in the Atlantic/Caribbean portion of the action area in Florida, Puerto Rico, and USVI. Critical habitat is proposed for the other five Atlantic/Caribbean coral species in this portion of the action area as well. Critical habitat is also proposed for the seven coral species in the Pacific portion of the action area considered in this opinion. Thus, it is likely that sexual and asexual recruits of varying ages of ESA-listed Atlantic/Caribbean and Indo-Pacific corals and designated and proposed coral critical habitat may be present in the action area during activities associated with the proposed action.

7.2.2 **Response**

Given the exposure discussed above, in this section we describe the range of responses among ESA-listed Nassau grouper; scalloped hammerhead shark (Indo-West Pacific and Central and Southwest Atlantic DPSs), corals, elkhorn and staghorn coral critical habitat, and proposed critical habitat for Atlantic/Caribbean and Indo-Pacific coral species, as applicable, associated with habitat loss, damage, or alteration; biological sampling and use of in-water equipment; and organism collection and transport. 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.

7.2.2.1 Collisions

Equipment collisions with ESA-listed corals may occur. Based on consultations on proposed actions with similar activities, such as the use of towed sensors by the Navy around Vieques, Puerto Rico, collisions with the marine bottom and ESA-listed corals occur infrequently, but result in breakage of coral colonies when they do occur. A collision with ESA-listed coral colonies was reported as part of past survey work by the Navy as part of underwater cleanup activities around Vieques. The collision resulted in breakage of two coral colonies. The equipment was modified to minimize the potential for additional collisions and no further interactions with ESA-listed coral colonies were reported during the survey. Based on the information provided by the CRCP, towed equipment is not used frequently with AUV/ROV surveys conducted in Florida in 2020-2021 and in Puerto Rico and USVI in 2021-2022. Similarly, based on the information provided by CRCP, there were multibeam surveys done in Florida in 2018-2020, and in Puerto Rico in 2018-2019. The required BMPs include measures to minimize the potential for entanglement of lines from ROVs and other towed equipment in coral colonies and their habitat, but the potential for collision cannot be eliminated, particularly when vessels are towing equipment. Collisions with ESA-listed corals cause breakage and abrasion of the 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 the collisions will bleach and/or be infected by disease. Depending on the size of the colony, the size of the equipment, and the severity of the collision, the 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 (based on information from surveys conducted by the Navy around Vieques, Puerto Rico during which only two coral colonies were damaged by collision) associated with equipment collisions, though we expect these to be rare. CRCP projects involving the use of ROVs and towed equipment such as multibeam sonar have occurred only in Florida, Puerto Rico, and USVI and the surveys using these equipment take place in different years in Florida than in the U.S. Caribbean based on the information provided by CRCP. If we make a conservative estimate based on the report from survey work using similar equipment around Vieques to err on the side of caution, two ESA-listed coral colonies in Puerto Rico and USVI, or in Florida may be damaged due to collisions with towed equipment in years when surveys occur in any of these jurisdictions. Surveys using towed equipment were not reported in the Pacific but we would expect the same potential for effects to ESA-listed coral colonies from collisions if they were to occur in any of the U.S. Pacific coral jurisdictions. The effects of collisions with ESA-listed corals by equipment are discussed further in Section 9.

7.2.2.2 Installation of Structures in Hard Substrate

Anchors to secure marker buoys, recreational and other mooring buoys, or equipment are the components of in-water structures proposed for installation in hard bottom habitats, including coral reefs. Anchors may be steel rods, rebar, concrete blocks or pyramids, or the Halas anchor system. Steel rods and rebar are most commonly used to anchor instruments such as temperature recorders, calcification accretion units, and bioerosion monitoring units. Concrete anchors are most commonly used to anchor nursery structures or to serve as a base for nursery structures and to anchor some types of equipment. The Halas anchor system is most commonly used to anchor different types of buoys, including mooring and marker buoys. Other 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 elkhorn and staghorn coral critical habitat. If adequate distance from corals and their habitat is not present between the moving tackle and areas containing corals and there is too much slack in the tackle, particularly in areas with high movement due to wind, currents, and/or wave action, moving tackle may rub on and abrade coral colonies and hard substrate. The area occupied by anchors represents an area where coral recruits cannot settle and grow. In the case of concrete anchors, colonization of the concrete structure may occur over time but the structures have to remain submerged for periods of months to years prior to being colonized by corals.

In terms of benthic coral nurseries, these are typically installed near coral reef habitats but are often in uncolonized sand bottom. Based on the information provided by the CRCP, a coral nursery was installed in Saipan, CNMI in fiscal year 2020 in coral habitat that is anchored with cinder blocks, but the structures are located in areas of sand. The University of Guam has a coral nursery in Piti, but it has not received CRCP funds to date. Other information on nurseries indicates that the number of benthic structures in a nursery can range from five to 20 on cinder blocks in Puerto Rico and five to 65 in USVI. The number in a nursery in Florida can range from approximately 40 to over 500. A cinder block has a footprint of approximately 1,200 cm^2 (192 in^2), meaning there could be a total area of 2.4 m^2 (26 ft^2) of marine bottom occupied by cinder blocks in a single nursery in Puerto Rico and 7.8 m^2 (84 ft^2) in a single nursery in USVI. In Florida, there could be a total area of 60 m^2 (646 ft^2) in a single nursery. In 2010, there were four sites with benthic structures in USVI nurseries (two in St. Croix and two in St. Thomas), or a total of 31.2 m^2 (336 ft^2) of marine bottom in USVI occupied by benthic nursery structures in a given year. In 2013 in Puerto Rico, there was one site with 20 benthic coral nursery structures and another with 10, or a total of 3.6 m^2 (38.7 ft^2) of marine bottom in Puerto Rico occupied by benthic nursery structures in a given year. While many of these structures are located in areas containing coral habitats, they are usually installed in sand bottom or other uncolonized areas that do not contain the PBF. However, in order to take a conservative approach to estimate potential impacts, we will assume that the total marine bottom that could be affected by benthic nursery structures is equivalent to the amount of coral habitat containing ESA-listed coral colonies that could be affected by the installation of benthic coral nursery structures. This is likely an overestimate because these areas may not contain the PBF and not all the coral nurseries present in the U.S. coral jurisdictions were/are supported by CRCP funds. The available information regarding coral nurseries is limited so sources from previous NMFS consultations, in addition to the information provided by the CRCP, were considered the best available information.

Information provided by CRCP also indicates that cinder blocks were used to anchor structures in eight sites in Florida in fiscal year 2018 and 2019, to anchor one instrument in MHI in fiscal year 2019, and to anchor two instruments in PRIA in fiscal year 2020. Thus, if we assume a maximum number of eight structures anchored in coral habitat using cinder blocks or similarly-sized concrete anchors in any U.S. coral jurisdiction in a given year, there could be a total of 0.96 m^2 (10 ft^2) of coral habitat occupied by these anchors.

Based on project-specific information provided by CRCP, in American Samoa there were as many as 217 in-water structures (largely instruments to measure temperature, calcification, and bioerosion) in a given year installed in coral habitats with rebar or steel rod anchors. In Florida, in a given year, there were 39, 38 in the Gulf of Mexico, 125 in the MHI, 45 in the NWHI, 114 in Puerto Rico, 105 in PRIA, 133 in USVI, 267 in CNMI (although this includes some that may be installed in sand or zip tied to non-living substrate), and 77 in Guam (although this number includes some instruments attached to existing rebar with zip ties for which ESA/EFH consultations were completed). Each steel rod or rebar anchor will have a maximum impact footprint of 180 cm^2 (28 in^2). The small footprint where rebar and steel rod anchors are installed would no longer be available for coral recruits to settle and grow. These anchors would not be installed in ESA-listed coral colonies so only future recruits would be affected by the loss of settlement area within the footprint of each anchor. Based on the numbers of in-water structures, there could be up to 3.9 m^2 (42 ft^2) of coral habitat occupied by steel rods or rebar in American Samoa, 0.4 m^2 (4.3 ft^2) in Florida, 0.4 m^2 (4.3 ft^2) in the Gulf of Mexico, 1.35 m^2 (14.5 ft^2) in the MHI, 0.5 m^2 (5.4 ft^2) in the NWHI, 1.2 m^2 (13 ft^2) in Puerto Rico, 1.1 m^2 (11.8 ft^2) in the PRIA, 1.4 m^2 (15 ft^2) in the USVI, 4.8 m^2 (51.92 ft^2) in CNMI, and 1.39 m^2 (14.97 ft^2) in Guam in a given year. In addition to steel pins and rebar used for anchoring in-water structures and mooring equipment, metal pins or rebar may be driven into hard substrate to mark permanent transects for monitoring. These may have a maximum impact area similar to that of metal anchors for mooring equipment, but, because most of the permanent transect areas for activities such as NCRMP monitoring have already been established, we do not anticipate that the total impact footprint for transect markers will be large. We are not able to quantify the total potential area of impacts in each U.S. coral jurisdiction but, because the total area calculations for the use of metal anchors for mooring equipment is likely an overestimate, the footprint of any permanent transect markers should fall within the total calculated footprints for all metal anchors for mooring instruments.

Floating coral nursery structures are anchored using steel rods and rebar as well. In Saipan, a coral nursery is increasing the number of floating structures to 40 in fiscal year 2021 with CRCP funds. CRCP is also providing funds for the expansion of a coral nursery in Cocos Lagoon in Guam. There are approximately 12 trees with some fish habitat structures and one chandelier-style tree. The current permitting for this nursery allows for up to 15 structures using embedded anchors. In coral nurseries in Florida, some had as many as 200 trees per site. Information from the CRCP and Mission: Iconic Reefs indicates that all floating coral nurseries in Florida are currently installed in sand. However, to be conservative, we provide an estimate of coral habitat effects from these nurseries to account for possible shading and future installation of floating coral nurseries in areas that may contain ESA-listed coral colonies. In Puerto Rico there were up to 42 and in USVI there were up to 65 floating coral nursery structures. Based on the numbers of nursery structures, there could be up to 0.4 m^2 (4.3 ft^2) of coral habitat affected by the installation of metal anchors to hold floating nursery structures in CNMI, up to 0.27 m^2 (2.92 ft^2) in Guam, up to 2.2 m^2 (24 ft^2) in Florida, 0.45 m^2 (4.8 ft^2) in Puerto Rico, and up to 0.7 m^2 (7.5 ft^2) in USVI. There was also a temporary nursery in Hawaii that was created and operated with CRCP funding with approximately 24 anchors to hold floating structures for a total of 0.26 m^2 (2.8 ft^2) of habitat affected by the installation of anchors. In addition to the footprint of the anchors, the floating nursery structures, particularly those that are tables, create shade, which can lead to declines in health of coral colonies within the shadowed area or a shift in which species are present. Thus, the footprint of coral habitat that may be affected by floating coral nursery structures is larger than the footprint of direct impacts from installation of anchors. Coral trees are not expected to have a large shadow due to their form, but could affect an additional 2.25 m^2 (24 ft^2) of habitat per tree. In nurseries with floating tables, 3.75 m^2 (40 ft^2) of habitat could be affected by shading. We do not have detailed information regarding the number of floating table structures present in in-water coral nurseries in each jurisdiction so we will assume the number is similar to that for trees. Using the number of coral trees as a proxy for the potential number of floating tables in CNMI, Guam, Hawaii, Florida, Puerto Rico, and USVI, and because the size of floating tables is larger than trees, we calculated the additional coral habitat that could be affected by shading in each jurisdiction. Based on our calculations, up to 150 m^2 (1,615 ft^2) in CNMI, 90 m^2 (960 ft^2) in Guam, 22.5 m^2 (242 ft^2) in Hawaii, 750 m^2 (8,073 ft^2) in Florida, 157.5 m^2 (1,695 ft^2) in Puerto Rico, and 244 m^2 (2,626 ft^2) in USVI could be affected by shading in a given year in a given nursery. The total area of coral habitat effects from shading includes the area affected by the installation of anchors as anchors are placed at the base of trees, at the ends of lines, and at the corners of floating tables and other floating nursery structures.

In-water structures such as floating coral nurseries that are located in such a way as to cause shading of ESA-listed corals could cause the corals to suffer health consequences. A study of the effects of shading by a pier on *Siderastrea siderea* and *Pseudodiploria 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). *Pseudodiploria 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 if these structures are relatively fixed rather than in constant motion with the waves and currents (such as buoys). As for benthic coral nursery structures, we recognize that many of these floating nursery structures are located in areas of sand bottom or other uncolonized areas in coral habitats but we are taking a conservative approach to estimate potential impacts and we assume that the total marine bottom we estimate could be affected by anchoring and shading from floating nursery structures is equivalent to the amount of coral habitat containing ESA-listed coral colonies that could be affected by the installation, operation and maintenance of the structures. We do not expect coral nursery structures to be installed in the PRIA or NWHI, but coral nursery sites could be established in American Samoa or Guam with sizes similar to those in CNMI or MHI.

Coral nursery structures may also affect ESA-listed coral colonies through breakage and abrasion if structures or associated anchor tackle are located too close to coral colonies or if components of the nurseries move over time or due to storms.

In addition to cinder block anchors, larger concrete anchors are used as bases for coral outplanting and as secondary anchors for bottom-deployed equipment and in-water structures such as coral farming units in some areas where oceanographic conditions require additional stability. One of these anchors occupies a maximum of 0.22 m^2 (2.37 ft^2) of marine bottom in coral habitat. Based on the information provided by CRCP, the use of these types of anchors is rare in comparison to the use of cinder blocks and metal anchors, and is most commonly associated with temporary anchoring of monitoring equipment. One of these anchors was deployed in American Samoa for 24 hrs, one in Florida for 10 months, one in the MHI for 24 hrs, and one in the NWHI for 24 hrs. Thus, there could be a short-term effect on coral habitat from the placement of one of these anchors in any of the U.S. coral jurisdictions in a given year. When these anchors are used as substrate for coral outplanting, they may provide settlement habitat for coral planulae rather than removing potential settlement habitat from an area. However, based on information provided by CRCP, the coral outplantings supported by CRCP since 2018 have not used concrete anchors as bases.

Halas anchors are used to install mooring buoys in hard bottom habitats, including coral habitat. The area affected by the installation of these anchors is 78.5 cm^2 (12 in^2) per anchor. The total coral habitat area affected by the installation of buoys depends on the total number of buoys to be installed. Information provided by CRCP regarding mooring buoy projects supported since 2018 included information on the number of buoys installed for a project in Florida that involved the installation and subsequent maintenance of 208 buoys. Based on the number of buoys installed, a total of 1.6 m^2 (17 ft^2) of habitat was affected by the installation of the Halas anchors to secure the buoys, assuming all the buoys were installed in hard substrate, which may be an overestimate. ONMS indicated that an additional 15 m^2 (161.4 ft^2) of coral habitat in sanctuaries in Florida may be affected by the installation of mooring buoy anchors. The CRCP also supported the installation of markers on a reef flat in Guam in fiscal year 2021, but the markers will be four posts secured to the hard substrate by drilling, affecting the same size area per marker as for each Halas anchor (78.5 cm^2 [12 in^2]). Thus, in Guam, 314 cm^2 (48.7 in^2) of coral habitat will be affected by the installation of the markers. The installation of mooring and other markers is meant to reduce the potential for anchoring and grounding effects to coral habitats, which cause larger scale effects than the effects of installation of anchors for these buoys and markers.

Similar to the potential loss of small areas that could serve as settlement habitat for coral planulae due to the installation of anchor systems, whether concrete or metal, the functionality of elkhorn and staghorn coral critical habitat and proposed critical habitat for Atlantic/Caribbean and Indo-Pacific coral species considered in this opinion as settlement habitat would only be affected within the footprint of anchors if these are located within critical habitat. Removal of small areas of hard substrate due to drilling or placement of concrete structures from areas containing the PBFs for elkhorn and staghorn coral critical habitat and proposed coral critical habitat would result in, at a minimum, damage to coral critical habitat. The function of the area of critical habitat as habitat suitable for settlement and growth of ESA-listed corals would be lost. Depending on the scale of the projects involving installation of anchors and associated shading, natural recovery of the habitat may not occur.

Overall, damage to ESA-listed coral colonies and habitat loss or damage due to installation of different types of anchors associated with activities such as the installation and operation of in-water equipment, coral nurseries, and buoys and markers 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 elkhorn and staghorn coral critical habitat and for proposed critical habitat for listed corals in the Atlantic/Caribbean and U.S. Pacific. The effects of the fitness consequences to ESA-listed corals and loss of function of areas of critical habitat are discussed further in Section 9.

7.2.2.3 Organism Collection, Handling and Treatment

Organism collection, handling, relocation, and treatment will occur because of biological sampling, coral disease management, outplanting or relocation projects, and for coral nurseries. Biological sampling using various nets, traps, tents, and other collectors described in Sections 3.2.1.5 and 3.2.2 to collect coral reef organisms including fish, corals, and other invertebrate species. Coral disease management will occur as described in Section 3.2.2. Coral nurseries and associated coral collection, outplanting, and relocation of corals and other invertebrates will occur as described in Sections 3.2.2 and 3.3. These activities will occur in habitat areas used by

Nassau grouper, scalloped hammerhead sharks, and ESA-listed corals, including habitats that are designated or proposed for critical habitat designation for ESA-listed corals.

Biological sampling as part of CRCP activities includes the collection and tagging of fish and invertebrates. In order to collect fish for tagging, fishing gear such as hook-and-line, nets, and traps are used. Thus, Nassau grouper and scalloped hammerhead sharks, particularly juveniles (and neonates in the case of sharks) in nearshore, shallow waters, and juveniles and adults in deeper waters in coral and associated habitats could be caught as bycatch. These species could also be targeted in biological sampling, although the information provided by CRCP indicated that there are no plans to support studies targeting sharks. In addition, the information provided by the CRCP indicated that Nassau grouper have rarely been observed during biological sampling and have never been collected during sampling using fishing gear. Most gear is checked frequently, meaning fish should be captured and released alive. However, if gear is left soaking for hours or days or if gear is used to sample fish from deeper waters, there is a greater probability of injury or mortality. In the case of Nassau grouper, if adult fish are sampled or caught as bycatch in deeper waters, they may suffer barotrauma when brought to the surface. Sharks do not have a swim bladder (like groupers do), but they can still suffer some of the effects of barotrauma if they are caught in deeper waters and brought to the surface due to the collection of gases in their tissues. A study that examined the effects of barotrauma in red snapper using tagged fish that were treated using venting, non-venting, and descending treatments after capture found 72% survival, 15% immediate mortality, and 13% delayed mortality (within 72 hr of release). Therefore, up to 18% of Nassau grouper and scalloped hammerhead sharks captured intentionally or as bycatch could die as a result of capture (Curtis et al. 2015).

Tagging fish may also result in mortality, particularly for internal tags such as passive internal acoustic transponder tags. Mortality is more likely in juvenile fish (age-0/1) based on studies using salmonids (Dare 2003; Gries and Letcher 2002; Muir et al. 2001); although Hamel et al. (2013) tagged age-1 pallid sturgeon with fork lengths of 214-358 mm (8.2-14.1 in) and reported no mortality after 189 days. In addition to the slight possibility of mortality as a result of the use of internal tags, there may be short-term negative effects from the use of internal and external tags such as elevated stress levels, bleeding, and injuries at the injection or insertion site. T-bar and other anchor tags are typically interlocked between inter-neural cartilages in the dorsal fin, which can result in potential bleeding and/or injury from the injecting needle used to insert the tags (Collins et al. 1994). Injection of T-bar tags into the dorsal musculature may result in raw sores that can enlarge over time with tag movement (Collins et al. 1994; Hamel et al. 2012). Anecdotal evidence on sturgeon suggests that delayed mortality associated with T-bar tags is low (Moser et al. 2000). Studies on the effects of injecting anchor tags on the growth rate of different fish species sow variable results with reduced growth rates reported for lemon sharks and northern pike and no effect on growth rates reported for largemouth bass (Manire and Gruber 1991; Scheirer and Coble 1991; Tranquilli and Childers 1982). The most commonly reported problems with external tags are tissue damage, premature tag loss, and decreased swimming capacity, but the effects are context and species-dependent (Jepsen et al. 2015). Reduced growth and survival have been recorded in some species, but direct mortality caused by external tagging appears to be rare (Jepsen et al. 2015). The potential for injury is reduced when tags are injected or applied by experienced researchers. In addition to the potential for mortality or injury, the effects of the use of anesthetic and the response of fish to tag placement, whether internal or external, can make them more vulnerable to predation, particularly as they recover from anesthetic use or as injuries heal, as well as in cases where external tags lead to slower swimming rates. Therefore, should CRCP support tagging studies that involve Nassau grouper or scalloped hammerhead sharks, there could be fitness consequences to individual fish.

The use of tents and other methods to collect coral gametes will result in the removal of ESA-listed coral gametes from in-water habitats where the corals are spawning. Plankton surveys conducted near the mouth of Jobos Bay, Puerto Rico using a 200 μm net along the same transect in August 2013, and August-October 2015 detected coral larvae at the water surface and a mid-depth (23-36 ft) during both daytime and nighttime sampling. Densities of coral larvae at the water surface were lower than at mid-depth but this difference was determined not to be statistically significant (FERC 2016). Peak densities of coral larvae lasted an average of three to five days within seven to 11 days after the full moon. The highest coral larvae density was 6,532 larvae per 100 m^3 in a nighttime mid-depth tow in September, and coral larvae densities were greater in September sampling overall. Studies in Puerto Rico have reported elkhorn, staghorn, lobed star, boulder star, and mountainous star corals spawning in August and September after the full moon, and pillar coral also spawning after the August full moon (Williams 2006). Mortality of coral larvae for broadcast spawners can be more than 90% (Nishikawa and Sakai 2005). For brooding corals, larval mortality is estimated as 50-60% within the first few days after spawning (Harii et al. 2002). Therefore, although large numbers of coral gametes may be removed from the action area in the U.S. coral jurisdictions where this type of biological sampling occurs, these numbers are likely to be within the range of natural mortality experienced by coral larvae in the wild. Thus, the overall consequences of the collection of coral gametes may be to increase coral the amount of fertilized larvae produced from a broadcast spawning event and increase larval survival as the larvae will not be subjected to predation, which is the main reason for the high mortality rates experienced by coral larvae.

Coral coring results in the removal of coral tissue to collect tissue samples for research. Large cores are approximately 10-15 cm (4-6 in) in diameter and 0.55 m (1.6-16 ft) in length and small cores are approximately 2.5 cm (1 in) in diameter and 0.5-1.0 m (0.2-20 in) in length. Based on information from CRCP, small cores have been collected from up to six coral colonies (*Orbicella faveolata*) per reef site in Florida and medium cores from up to 40 coral colonies (including *Orbicella annularis*, *O. faveolata*, and *O. franksi*) in a site in Florida. The information in Table 2 (Section 3.2) indicates that coring involving the collection of large cores has occurred in Florida and resulted in sampling of elkhorn, staghorn, and lobed, boulder, and mountainous star corals. Coring using small cores has occurred in Puerto Rico resulting in sampling of elkhorn and staghorn corals, and coring using large and small cores has occurred in USVI resulting in sampling of *Acropora prolifera* (a hybrid of elkhorn and staghorn coral that is not ESA-listed; small core) and elkhorn and staghorn corals (large cores). Using the information from the Florida project that involved coring of 40 coral colonies, we can make a conservative assumption that this is the maximum number of ESA-listed coral colonies that may be sampled using coring in a U.S. coral jurisdiction in a given year. The cored area is filled with concrete, epoxy or other materials to provide a surface for coral regrowth and minimize the amount of exposed tissue that could then attract corallivores or disease vectors. Thus, coring is expected to result in partial tissue loss but the probability of mortality is minimized by post-sampling treatment. Even if the sampled coral does not suffer mortality, there are fitness consequences associated with recovery after coring, including the need to expend energy to regrow tissue, which may result in affected coral colonies, particularly broadcast spawners, not reproducing in the year when coring occurs. There may also be reduced fitness due to the stress of tissue loss that may make sampled coral colonies more prone to disease or susceptible to bleaching.

Coral disease treatment also results in the removal of coral tissue, both diseased and healthy, in order to create a barrier between healthy and infected tissue where the disease treatment application occurs. At this time, the only disease treatment is occurring in the Atlantic/Caribbean in response to SCTLD. The greatest number of diseased colonies treated based on information from the CRCP was 150 colonies at each treatment site with a 1 cm (0.39 in) diameter treatment line on each colony in Puerto Rico in 2020 with the treatment including pillar coral. Other projects in Florida, Puerto Rico, and USVI used a 2 cm (0.8 in) wide treatment line and included treatment of pillar coral, lobed star, boulder star, and rough cactus coral. Thus, if we use a conservative estimate, up to 150 colonies of ESA-listed corals per disease treatment site in each U.S. Atlantic/Caribbean coral jurisdiction could be treated. However, given that disease treatment is only done on coral colonies with signs of SCTLD and the disease leads to rapid tissue loss and high mortality in infected colonies, the effects of tissue removal as a result of disease treatment are likely to be indistinguishable from the effects of the disease.

Fragments are collected from ESA-listed corals for coral nurseries, research, and outplanting as part of restoration projects, and polyps are collected for research and some for restoration once polyps are grown out in laboratory settings. Based on information from CRCP, collection of coral fragments, ranging from large (>10 cm [3.9 in]) to small (<4 cm [1.6 in]), for research includes collection from elkhorn, staghorn, pillar, and mountainous star corals in Florida, Puerto Rico and the USVI from up to 50 colonies per species. Collection of small coral fragments includes collection from *Acropora globiceps* in CNMI and Guam from up to 60 colonies of this ESA-listed coral. Polyps (<1 cm^2 [0.155 in^2]) are also collected from ESA-listed species in Florida including elkhorn, staghorn, and the star coral complex from up to 1,000 coral colonies with a maximum of 40 coral colonies targeted per reef (that can be from ESA-listed or non-ESA-listed colonies). Projects involving polyp collection from other U.S. coral jurisdictions could occur in the future so the information from Florida is assumed to be a reasonable estimate of the number of ESA-listed coral colonies that could be affected by this activity. Fragments collected for coral nurseries are collected from wild colonies and as fragments of opportunity in Guam, Puerto Rico, CNMI, USVI, Florida, MHI, and American Samoa. In CNMI, fragments were collected from 40 parent colonies, including from *Acropora globiceps*. In Puerto Rico, up to 1,000 fragments were collected as fragments of opportunity from elkhorn coral. Fragments may be collected from other ESA-listed corals in Puerto Rico, Florida and USVI. In the U.S. Pacific, *Acropora globiceps* is the ESA-listed coral most commonly used for fragment collection from wild colonies, but the only in-water coral nursery in 2021 was in CNMI based on information from the CRCP. A maximum of 10 fragments are collected from a single coral colony based on information provided by CRCP.

For Mission: Iconic Reefs, fragments of various sizes (5-20 cm [2-7.9 in] diameter) will be grown from gametes collected from wild colonies, taken from existing nurseries, or collected as fragments of opportunity. The project contemplates the outplanting of a total of 1,015,777 elkhorn; 575,076 star coral complex; 796,539 pillar; 39,129 staghorn; and 696,823 other small stony corals (that include rough cactus coral) fragments by the end of phase 2. CRCP outplanting activities that are not part of Mission: Iconic Reefs are at a much smaller scale. Based on information from the CRCP, a maximum of 1,000 elkhorn and 400 pillar coral fragments were outplanted in projects in Puerto Rico, and a maximum of 500 coral colonies (mix of lobed star, mountainous star, pillar, and elkhorn corals) were outplanted in projects in USVI. In the U.S. Pacific, a maximum of 200 coral fragments were outplanted per site in CNMI, including non-ESA-listed corals and *Acropora globiceps*. Other outplanting projects in the MHI and American Samoa did not involve ESA-listed corals. It is important to note that many of the coral fragments used in coral nurseries, outplanting projects, and Mission: Iconic Reefs come from corals of opportunity or from the collection of fragments from existing coral colonies that are then grown in the coral farms such that *in situ* collection from wild colonies becomes extremely infrequent for functioning nurseries.

There could be 10% mortality of transplanted corals, if coral colonies are used in restoration or other projects rather than fragments, based on coral transplant work in Puerto Rico, such as that for the USACE San Geronimo restoration project in the Condado Lagoon, San Juan, Puerto Rico in 2006. There could be 1% mortality of coral fragments, based on information provided by the CRCP that included fragment survival data. Transplanted corals and coral fragments could also suffer temporary declines in health due to the stress of transplantation. Temporary declines in the health of coral colonies and fragments that survive transplantation would be evidenced by bleaching and/or partial tissue mortality, and a lack of sexual reproduction within the first spawning season following transplantation in the case of transplanted coral colonies. Portions of the tissue where removal of the colony occurs could suffer mortality, as well as be more susceptible to disease and bleaching, meaning there could be full or partial mortality of donor colonies. Because transplanted fragments are often from coral nurseries, mortality of fragments will largely represent mortality of cultivated corals rather than the loss of wild corals.

Sample collection such as coral coring that involves the physical removal of portions of coral colonies, as well as the placement of temporary nets and other structures for gamete collection, may affect designated and proposed critical habitat for ESA-listed corals in the action area. The physical removal of samples represents the removal of structure if portions of uncolonized hard substrate are affected during removal rather than only the coral colony from which material is collected. The placement of temporary structures for gamete collection interferes, though on a short-term basis, with the function of critical habitat because these structures interfere with the ability of coral larvae to settle. The temporary structures may also cause some breakage/abrasion of substrate, leading to minor damage. In terms of the use of fishing gear, the required BMPs mandate the use of fishing gear in a way that minimizes potential effects to benthic habitat. However, there could still be movement to or placement of fishing gear in areas containing coral critical habitat that could result in breakage or abrasion of habitat, causing damage and reducing the ability of the habitat to function as suitable substrate for coral recruitment and growth. We are not able to estimate the amount of designated or proposed coral critical habitat that may be affected by these CRCP activities in each U.S. coral jurisdiction in a given year.

Overall, biological sampling using fishing gear, equipment to collect coral gametes, coral coring, and coral fragment collection for research, nurseries, relocation, and outplanting, and coral disease management will lead to the removal and relocation of coral tissue of varying sizes and life stages. The effects of tissue removal, as well as transport stress in the case of corals that are moved to laboratories, nurseries, outplanted, or otherwise related, will result in a reduction in fitness for affected ESA-listed corals in the U.S. coral jurisdictions in the action area. Habitat loss or damage due to the removal of substrate and the temporary presence of fishing gear and sample collection structures will result in a reduction in the function of areas containing the PBFs for elkhorn and staghorn coral critical habitat and for proposed critical habitat for listed corals in the Atlantic/Caribbean and U.S. Pacific. The effects of the fitness consequences to ESA-listed corals and loss of function of areas of critical habitat are discussed further in Section 9.

7.2.3 **Programmatic Analysis**

In the previous sections we evaluated the exposure and response to ESA-listed Nassau grouper, scalloped hammerhead shark (Indo-West Pacific and Central and Southwest Atlantic DPSs), corals, elkhorn and staghorn coral designated critical habitat, and proposed critical habitat for Atlantic/Caribbean and Indo-Pacific corals as a result of the proposed action. In this section, we evaluate whether the implementation of the applicable BMPs is sufficient to ensure that the action will not increase the risk to populations of ESA-listed species or PBFs for designated or proposed critical habitat associated with the implementation of the proposed action.

Most of the required BMPs in this opinion were developed by the CRCP and have been required for projects that are funded or carried out by CRCP at least since the 2018 program modifications if not before. Some of the required BMPs were modified to address comments and concerns

NMFS provided CRCP during technical assistance for this consultation. It is important to consider that, while the consultation covers an indefinite period, most of the activities are those that produce stressors that we do not expect to result in adverse effects to ESA-listed species or designated critical habitat. With the implementation of the required BMPs, other activities that could result in adverse effects will avoid or minimize potential effects to ESA-listed species and designated critical habitat for elkhorn and staghorn corals to a level that is not likely to result in adverse effects. Of the activities that will produce stressors that may result in adverse effects, specifically towing of in-water equipment and operation of ROVs, coral coring, organism collection (including the use of fishing gear) and transport, installation of anchors in hard substrate, and coral disease treatment, only installation of anchors, collection of and disease treatment in ESA-listed corals are expected to occur frequently. The collection and transplant of organisms that is part of the Mission: Iconic Reefs activities are also expected to be frequent and occur at a large scale. The goal of these activities is to restore reef sites in the Florida Keys. The transplant of corals and coral fragments to underwater nurseries and to outplanting sites as part of CRCP and Mission: Iconic Reefs activities, as well as coral disease treatment, are expected to ultimately benefit ESA-listed corals because these activities are meant to minimize the loss of colonies from and increase the number of colonies in the populations within the action area. For activities that produce stressors that may result in adverse effects to ESA-listed Nassau grouper, scalloped hammerhead shark, and corals, the implementation of the BMPs will reduce the effects of the proposed action such that we do not expect adverse population-level consequences over the lifetime of the proposed action. Any effects of activities such as bycatch and tagging or directed catch or collection of these species would be subject to project-specific review and tiered consultation to further analyze the effects and develop additional BMPs and/or a supplemental ITS, if necessary or appropriate, with associated monitoring and reporting requirements. The implementation of the required BMPs will reduce the effects of the action on the PBF for elkhorn and staghorn coral critical habitat and proposed coral critical habitat in the Atlantic/Caribbean and Pacific in order to maintain the function of the habitats and, thus, their conservation value.

7.2.4 Summary of the Effects of the Action on Nassau Grouper, Scalloped Hammerhead Shark, ESA-Listed Corals, and Designated and Proposed Critical Habitat for ESA-Listed Corals

The implementation of the action, particularly surveys using towed equipment and/or ROVs, coral coring, biological sampling using fishing gear, installation of structures in hard substrate, coral disease treatment, and the collection and transport of organisms and fragments (in the case of corals), is expected to result in the take of Nassau grouper, scalloped hammerhead sharks (Central and Southwest Atlantic and Indo-West Pacific DPSs) and ESA-listed corals, and effects to elkhorn and staghorn coral critical habitat and proposed critical habitat for Atlantic/Caribbean corals and Indo-Pacific corals.

Collisions

We estimate that collisions with ESA-listed coral colonies in the action area associated with the use of towed equipment will result in breakage of up to two ESA-listed coral colonies in each of the U.S. jurisdictions where towed equipment is used in a given year based on the occurrence of collisions with two coral colonies in a similar survey done by the Navy in Vieques, as discussed previously in this opinion. Because surveys often take place in Puerto Rico and USVI in the same year, and may also occur in Florida, there could be up to four ESA-listed coral colonies of any species taken due to damage from collisions by towed equipment in these jurisdictions in a given year.

Installation of Anchors and In-Water Structures

We are unable to estimate the number of future recruits of ESA-listed corals that will be affected by the loss of habitat for settlement due to installation of concrete structures and anchors, but we can estimate the amount of habitat. We estimate a total area of 60 m^2 (646 ft^2) of coral habitat in Florida in a single nursery will be occupied by benthic nursery structures, 2.4 m^2 (26 ft^2) in a single nursery in Puerto Rico, and 7.8 m^2 (84 ft^2) in a single nursery in USVI in a given year. The only benthic coral nursery in the U.S. Pacific for which we have information is that in Saipan, but the nursery was installed in sand, thus did not have a footprint in coral habitat. The total coral habitat area affected by benthic nursery structures in a given year in each jurisdiction will depend on the total number of structures in a nursery and the total number of nurseries. We estimate a total of 0.96 m^2 (10 ft^2) of coral habitat will be occupied by cinder blocks or similarly-sized concrete anchors for anchoring equipment to the marine bottom in any U.S. coral jurisdiction in a given year. These numbers may be refined by project-specific review, tiered consultations, and programmatic reviews. We also estimate a maximum of 0.22 m^2 (2.37 ft^2) of marine bottom in coral habitat in each U.S. coral jurisdictions may be occupied by concrete anchors that are of a larger size than cinder blocks in a given year.

Similarly, we estimate the total coral habitat area affected by anchoring of in-water equipment with steel rods or rebar in a given year, to be up to 3.9 m^2 (42 ft^2) in American Samoa, 0.4 m^2 (4.3 ft^2) in Florida, 0.4 m^2 (4.3 ft^2) in the Gulf of Mexico, 1.35 m^2 (14.5 ft^2) in the MHI, 0.5 m^2 (5.4 ft^2) in the NWHI, 1.2 m^2 (13 ft^2) in Puerto Rico, 1.1 m^2 (11.8 ft^2) in the PRIA, 1.4 m^2 (15 ft^2) in the USVI, 4.8 m^2 (51.92 ft^2) in CNMI, and 1.39 m^2 (14.97 ft^2) in Guam in a given year. For floating nursery structures anchored by steel rods or rebar, we estimate a total area of 150 m^2 (1,615 ft^2) in CNMI, 90 m^2 (960 ft^2) in Guam, 22.5 m^2 (242 ft^2) in Hawaii, 750 m^2 (8,073 ft^2) in Florida, 157.5 m^2 (1,695 ft^2) in Puerto Rico, and 244 m^2 (2,626 ft^2) in USVI in a single nursery in a given year, including both anchor footprints and the area directly shaded by the floating structures. We anticipate that, if nurseries are established in Guam and/or American Samoa in the future, the area of potential habitat affected will be similar to that in CNMI and the MHI. Shading may extend beyond the footprint of the structure, affecting nearby ESA-listed coral colonies, and breakage and abrasion of colonies may also occur if tackle or other structural components are too close to colonies and move with waves and currents or if components of the structures are displaced during storms.

The area affected by the installation of Halas anchors is 78.5 cm^2 (12 in^2) per anchor. A project in Florida that involved the installation of 208 buoys affected a total of 1.6 m^2 (17 ft^2) of habitat, other installations of mooring buoys in Florida affected 15 m^2 (161.4 ft^2) of coral habitat, and a project in Guam involving the installation of four posts markers will affect a total of 314 cm^2 (48.7 in^2) of coral habitat. Therefore, the total coral habitat area to be affected will vary by jurisdiction and project type with projects involving markers having a smaller total area of effects to coral habitats and projects involving the installation of mooring buoys having a larger, but still small, effect to marine habitat.

Organism Collection, Transplant, Treatment

The use of fishing gear to capture marine species could result in bycatch of Nassau grouper and scalloped hammerhead sharks. Similarly, tagging of these species, if supported by CRCP in the future, could result in mortality, injury, or increased predation. The take of Nassau grouper and scalloped hammerhead sharks as a result of capture in fishing gear and/or tagging could affect juveniles (and neonates in the case of sharks) and adults of both species, though younger life stages would be more likely to experience mortality than adults. We are not able to estimate the amount of take of Nassau grouper or scalloped hammerhead sharks at this time because CRCP has not supported any projects that involved tagging of these species or reported any bycatch of these species in the limited number of biological sampling projects that have taken place since 2018 that used fishing gear. This information will be determined as part of future tiered consultations for specific CRCP projects. However, it is important to note that any activities targeting Nassau grouper or scalloped hammerhead shark would be considered directed take and are therefore not included in the ITS for this opinion.

The collection of coral gametes will result in the take of ESA-listed corals in U.S. coral jurisdictions. However, while we are unable to estimate the amount of this take, the natural rate of mortality of more than 90% for broadcast spawning corals means that the collection of gametes is likely increasing the number of future coral recruits rather than decreasing it because many of the gametes collected for fertilization are later outplanted to reefs from which they were collected as small coral recruits. The collection of coral gametes is directed take and is not included in the ITS for this opinion.

We estimate that as many as 40 ESA-listed coral colonies from each listed coral species in a U.S. jurisdiction in a given year could be cored. We also estimate that up to 150 colonies of ESA-listed corals per disease treatment site in each U.S. Atlantic/Caribbean coral jurisdiction could be taken, though treated corals would suffer full or partial mortality without the treatment as a result of SCTLD. Targeting ESA-listed corals in coring activities and disease treatment is considered directed take and is not included in the ITS for this opinion.

We estimate that fragments may be collected from up to 50 wild coral colonies per ESA-listed species in Florida, Puerto Rico and the USVI per collection site in a given year as part of research activities and up to 60 colonies of *Acropora globiceps* per collection site per year in CNMI and Guam. Polyps may be collected from a maximum of 40 ESA-listed coral colonies per species per reef collection site in a given year. In the U.S. Pacific, *Acropora globiceps* is the ESA-listed species most likely to be used for collection of fragments and we estimate that up to 40 colonies per collection site may be affected in a given year. We estimate that up to 1,000 fragments may be collected as fragments of opportunity from ESA-listed coral species in Puerto Rico, Florida and USVI, and a maximum of 10 fragments per wild colony may also be collected in Atlantic/Caribbean and Pacific jurisdictions.

Mission: Iconic Reefs plans to outplant 1,015,777 elkhorn; 575,076 star coral complex; 796,539 pillar; 39,129 staghorn; and 696,823 other small stony corals (that include rough cactus coral) fragments. We estimate that CRCP outplanting activities (other than Mission: Iconic Reefs) will involve outplanting of up to 1,000 elkhorn and 500 fragments from other ESA-listed coral species in the Atlantic/Caribbean and a maximum of 200 *Acropora globiceps* in U.S. Pacific jurisdictions within the range of this species. These estimates are on a per site per year basis. Most of the outplanted corals are from coral farms or corals of opportunity. We also estimate 10% mortality for any transplanted coral colonies (if used) and 1% mortality of fragments collected for research, coral nurseries, or outplanting. The collection of coral colonies and fragments for research, coral nurseries, and outplanting is considered directed take and is not included in the ITS for this opinion.

We are unable to estimate the area of designated and proposed coral critical habitat that will be lost by the physical removal of organisms as part of sample collection or the portion that will be damaged through abrasion of substrate due to the temporary placement of structures such as tents to collect gametes and fishing gear in a given year in each U.S. coral jurisdiction. However, the area of lost habitat is equivalent to the total area cored and the area of other tissue collection, such as collection of large colony fragments from massive or sheet corals, but not branching corals unless fragment collection from these includes the removal of the base or portions of the base of the colony. The total area of habitat damaged by temporary structures such as collection nets or fishing gear is equivalent to the size of the portions of the tent or fishing gear resting on hard substrate in areas designated or proposed for designation as coral critical habitat.

Summary Estimates of Effects

These summary estimates are based on information provided by the CRCP on activities that have occurred to date in coral jurisdictions and include directed and incidental take. There may be additional take in the future for which project-specific review and potentially tiered consultation, including an ITS for incidental take, would be required, as described in Section 3.5.2.

- Collisions: four ESA-listed corals of any species in a given year in Puerto Rico, Florida, and/or USVI
- Anchors:
  - Benthic Nursery Structures (Concrete Anchors): 0.96 m^2 (10 ft^2) of coral habitat in a given year in any jurisdiction
  - Other Concrete Anchors: 0.22 m^2 (2.37 ft^2) of coral habitat in a given year in any jurisdiction
  - In-Water Equipment, Metal Anchors:
    - 3.9 m^2 (42 ft^2) of coral habitat in American Samoa
    - 0.4 m^2 (4.3 ft^2) in Florida
    - 0.4 m^2 (4.3 ft^2) in the Gulf of Mexico
    - 1.35 m^2 (14.5 ft^2) in the MHI
    - 0.5 m^2 (5.4 ft^2) in the NWHI
    - 1.2 m^2 (13 ft^2) in Puerto Rico
    - 1.1 m^2 (11.8 ft^2) in the PRIA
    - 1.4 m^2 (15 ft^2) in the USVI
    - 4.8 m^2 (51.92 ft^2) in CNMI
    - 1.39 m^2 (14.97 ft^2) in Guam in a given year
  - Floating Nursery Structures, Metal Anchors:
    - 150 m^2 (1,615 ft^2) of coral habitat in CNMI
    - 90 m^2 (960 ft^2) in Guam
    - 22.5 m^2 (242 ft^2) in Hawaii
    - 750 m^2 (8,073 ft^2) in Florida
    - 157.5 m^2 (1,695 ft^2) in Puerto Rico
    - 244 m^2 (2,626 ft^2) in USVI in a single nursery in a given year
  - Halas Anchors: Variable effects to coral habitat with up to 15 m^2 (161.4 ft^2) in coral habitat in Florida due to mooring buoy anchor installation in a given year
- Shading, Breakage and Abrasion: We are unable to estimate the numbers of ESA-listed coral colonies that could be affected by shading from in-water structures such as floating nurseries, or breakage and abrasion from tackle and other components of in-water structures moving against colonies with wave and current movement or if components are dislodged during storms.
- Bycatch: We are unable to estimate the number of individuals of Nassau grouper in Florida, USVI and Puerto Rico, or scalloped hammerhead shark, Central and Southwest Atlantic DPS in U.S. Atlantic/Caribbean jurisdictions or Indo-West Pacific DPS in U.S. Pacific jurisdictions that could be affected, but juvenile and adult Nassau grouper and neonate and juvenile sharks could be captured as bycatch in fishing gear.
- Tagging (Directed Take): Unable to estimate for Nassau grouper in Florida, USVI and Puerto Rico, or scalloped hammerhead shark, Central and Southwest Atlantic DPS in

U.S. Atlantic/Caribbean jurisdictions or Indo-West Pacific DPS in U.S. Pacific jurisdictions but will affect juvenile and adult Nassau grouper and neonate and juvenile sharks

- Coral Gamete and Other Research Collection (Directed Take): Numbers vary, but may occur in any U.S. jurisdiction in a given year
- Coral Coring (Directed Take): 40 ESA-listed coral colonies from each listed coral species in a U.S. jurisdiction in a given year
- Coral Disease Treatment (Directed Take): Up to 150 colonies of ESA-listed corals per disease treatment site in a given reef each U.S. Caribbean coral jurisdiction; up to 1,220 ESA-listed coral colonies per year in Florida (https://coral-disease-myfwc.hub.arcgis.com/).
- Coral Fragment Collection, Transport, and Relocation (Directed Take):
  - Mission: Iconic Reefs:
    - 1,015,777 elkhorn
    - 575,076 star coral complex
    - 796,539 pillar
    - 39,129 staghorn
    - 696,823 other small stony corals (that include rough cactus coral)
  - CRCP outplanting activities (other than Mission: Iconic Reefs):
    - Up to 1,000 elkhorn per site
    - Up to 500 fragments from other ESA-listed coral species in the Atlantic/Caribbean per site
    - Maximum of 200 *Acropora globiceps* in the U.S. Pacific jurisdictions within the range of this species per site
    - 10% mortality for any transplanted coral colonies (if used) and 1% mortality of fragments
- Fishing Gear, Coral Coring, and Temporary Structures: Unable to estimate the total habitat area affected by these activities in each U.S. coral jurisdiction in a given year but expected to be equivalent to the size of the gear and structures and the area cored per sampling site.

8 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 C.F.R. §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 for the stressors and activities described in the Environmental Baseline (Section 6), including climate change, fishing, vessel operation and traffic, aquaculture, research activities, coastal and marine development, military activities, and natural disturbance. We expect these to continue into the foreseeable future at current levels with some exceptions, as described below.

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. Ocean acidification is also expected to continue further affecting corals and their habitat value for species such as Nassau grouper and scalloped hammerhead sharks, particularly neonates and juveniles of this species. These changes due to climate change could lead to shifts in nearshore marine habitats and prey abundance and distribution, as well as availability of habitat for ESA-listed corals, Nassau grouper, and scalloped hammerhead sharks.

Fishing and research activities are expected to continue into the foreseeable future. We are not aware of any proposed or anticipated changes in fishing and research activities that would substantially change the impacts of these activities on Nassau grouper, scalloped hammerhead sharks, and ESA-listed corals, elkhorn and staghorn coral designated critical habitat, and proposed critical habitat for corals in the Atlantic/Caribbean and Indo-Pacific. As noted in the Environmental Baseline (Section 6.3), AOA designations were proposed in two areas in 2021, one of which is in the Gulf of Mexico. Other areas under consideration for future AOAs are in the U.S. Caribbean and the Executive Order contemplates the potential establishment of AOAs across the U.S., including its island jurisdictions. Therefore, aquaculture activities may increase throughout the action area with the designation of AOAs and the desire on the part of the U.S. to develop a strong aquaculture industry. Future aquaculture projects within and outside these AOAs are likely to require permits from EPA and the USACE that will be subject to ESA section 7 consultation requirements.

Military activities are ongoing in portions of the Pacific action area, as well as in the Gulf of Mexico and Florida. In Puerto Rico, cleanup of former military sites is ongoing and terrestrial cleanup activities that can generate stormwater runoff and associated sediment transport to nearshore waters due to vegetation clearing and demolition operations. Once terrestrial cleanup activities are complete in Puerto Rico, there could be increases in coastal development and vessel traffic in various locations. Similarly, coastal and marine development are expected to continue throughout the action area. 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 scalloped hammerhead sharks, Nassau grouper, and ESA-listed corals.

9 INTEGRATION AND SYNTHESIS

The *Integration and Synthesis* section is the final step in our assessment of the risk posed to ESA-listed species and designated and proposed critical habitat because of implementing the action. In this section, we add the *Effects of the Action* (Section 7) to the *Environmental Baseline* (Section 6) and the *Cumulative Effects* (Section 8) 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 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 5.2).

Some ESA-listed species and designated critical habitat 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 to be not likely to adversely affect some ESA-listed species and designated critical habitat (Sections 5.1 and 7.1).

The following discussions separately summarize the probable risks the proposed action poses to Nassau grouper, scalloped hammerhead shark (Indo-West Pacific and Central and Southwest Atlantic DPSs), ESA-listed corals, elkhorn and staghorn coral critical habitat, and proposed critical habitat for Atlantic/Caribbean and Indo-Pacific 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 activities involving towing of underwater equipment, use of nets and traps in biological sampling, in-water structures in areas containing coral habitat, coral tissue sampling, and collection and transport of ESA-listed corals. Additionally, while we discussed the potential effects of some activities currently occurring on a small scale, the implementation of larger-scale activities, project-specific review and potentially tiered consultations may be required to fully consider the extent and effects of these. In addition, we did not discuss the effects of the implementation of activities involving novel techniques for coral restoration and recovery or response to sea surface temperature rise (such as the installation of shade cloths in reefs). These will require tiered consultations in order to fully consider their effects on the ESA-listed species and critical habitats considered in this opinion.

9.1 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 C.F.R. §402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

Based on our effects analysis, adverse effects to ESA-listed species are likely to result from the action. The following discussions summarize the probable risks that CRCP and Mission: Iconic Reefs activities (where applicable) pose to ESA-listed species that are likely to be exposed over the lifetime of the action. These summaries integrate our exposure and response analyses from Section 7.

9.1.1 **Nassau Grouper**

We believe there is the potential for lethal and non-lethal take of juvenile or adult Nassau grouper as bycatch due to the use of fishing gear or as targeted species for tagging in Florida, Puerto Rico and/or USVI in years when biological sampling of this type takes place. We are unable to estimate the total potential take of this species due to this type of biological sampling but we expect it to be low because Nassau grouper have rarely been seen in CRCP fish survey projects. Any take from biological sampling will be addressed in tiered consultations for CRCP projects involving the use of fishing gear and/or targeted tagging of this species.

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 and recovery of Nassau grouper depends largely on the current abundance and the degree to which population growth rates may be negatively impacted by the action. There are currently no reliable estimates of population abundance and trends but Sadovy et al. (2018) estimated the overall population at 3,000. Fishing of Nassau grouper has been prohibited in the U.S. Caribbean and there is some evidence that multispecies SPAGS now include Nassau grouper in increasing numbers (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 affect reproductive output. Juveniles and adults may be captured during biological sampling involving the use of fishing gear and those that suffer mortality would never reproduce while those that suffer non-lethal take could have delayed growth, in the case of juveniles, or a temporary loss of reproductive potential in the case of adults. Similarly, if CRCP supports projects targeting Nassau grouper for tagging, some of the fish could suffer mortality related to barotrauma, stress, or delayed mortality associated with injury from surgery to insert internal tags. Stress and injury from capture, handling, and tagging could also lead to non-lethal take and delays in reproduction or declines in growth in the case of juveniles. However, given the limited amount of biological sampling using fishing gear supported by the CRCP and the lack of any fish tagging projects targeting Nassau grouper as of 2021, as well as the large habitat areas available to juvenile and adult Nassau grouper where no CRCP activities involving the use of fishing gear or tagging 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 with historic spawning aggregations consisting of tens of thousands of individuals in some cases and the current overall population estimate of the species being 10,000 and potentially declining (NMFS 2013). 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. The major threat to Nassau grouper is fishing.

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 and Atlantic waters that are within the species' range is prohibited. The action will cause a small decrease in reproductive potential. The number of individuals that may be affected by the proposed action is likely a small portion of the population of Nassau grouper present in the action area.

The potential take of juvenile and adult Nassau grouper due to bycatch (in fishing gear) or directed take (tagging) in years when biological sampling using fishing gear and tagging occurs is not likely to reduce population numbers over time given current population sizes and expected recruitment. Similarly, while we cannot estimate the exact numbers of take of adult and juvenile Nassau grouper that may occur as a result of CRCP biological sampling activities involving the use of fishing gear and tagging, 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 identified for Nassau grouper and will not result in an appreciable reduction in the likelihood of Nassau grouper's recovery in the wild. We conclude that the action will not jeopardize the continued existence of Nassau grouper.

9.1.2 Scalloped Hammerhead Shark (Central and Southwest Atlantic and Indo-West

Pacific DPSs)

We believe there is the potential for lethal and non-lethal take of neonate or juvenile scalloped hammerhead shark as bycatch due to the use of fishing gear or as targeted species for tagging throughout the action area in years when biological sampling of this type takes place. We are unable to estimate the total potential take of these species (Central and Southwest Atlantic and Indo-West Pacific DPSs) due to this type of biological sampling but we expect it to be low because scalloped hammerhead sharks have not been reported in CRCP fish survey projects based on the information provided by CRCP. Any take from biological sampling will be evaluated further in tiered consultations for CRCP projects involving the use of fishing gear and/or targeted tagging of scalloped hammerhead sharks.

No reductions in the distribution or current geographic range of Central and Southwest Atlantic and Indo-West Pacific DPSs of scalloped hammerhead shark 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 and recovery of these DPSs of scalloped hammerhead shark depends largely on the current abundance and the degree to which population growth rates may be negatively impacted by the action. For Hawaii, the effective population size was calculated as 3,200 using a 5.7 year generation time and 1,199 using a 16.7 year generation time. For the east coast of the U.S., the effective population size was calculated as 36,000,000 using a 5.7 year generation time and 12,000,000 using a 16.7 year generation time. In terms of mean population sizes, Duncan Seraphin and Holland (2006) estimated mean population sizes in Hawaii during peak densities (i.e., summer season) to range from 2,300 to 7,700 sharks born per year. Hayes et al. (2009) estimated a population size of 25,000 to 28,000 in 2005 for the northwestern Atlantic and Gulf of Mexico scalloped hammerhead stock. Lethal take of scalloped hammerhead shark as a result of the action would lead to reductions in reproductive output and non-lethal take could also affect reproductive output. Neonates and juveniles may be captured during biological sampling involving the use of fishing gear and those that suffer mortality would never reproduce while those that suffer non-lethal take could have delayed growth. Similarly, if CRCP supports projects targeting scalloped hammerhead sharks for tagging, some of the fish could suffer mortality related to barotrauma, stress, or delayed mortality associated with injury from surgery to insert internal tags. Stress and injury from capture, handling, and tagging could also lead to non-lethal take and delays in reproduction or declines in growth in the case of juveniles. However, given the limited amount of biological sampling using fishing gear supported by the CRCP and CRCP statements that the program does not anticipate supporting shark tagging projects, as well as the large habitat areas available to neonate and juvenile scalloped hammerhead sharks in the Atlantic/Caribbean and Pacific portion of the action area where no CRCP activities involving the use of fishing gear or tagging 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 scalloped hammerhead shark in the wild.

A recovery plan is not available for the scalloped hammerhead shark. The major threat to scalloped hammerhead shark is fishing both as targeted catch and as bycatch, as well as due to shark finning.

To determine if the action will appreciably reduce the likelihood of recovery for scalloped hammerhead shark, 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. The Central and Southwest Atlantic and Indo-West Pacific DPSs were listed as threatened. Scalloped hammerhead shark are present in the action area but there are no estimates of the number of these animals from each DPS present in each of the U.S. coral jurisdictions in the action area other than those stated above. 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 is regulated. The action will cause a small decrease in reproductive potential. The number of individuals that may be affected by the proposed action is likely a small portion of the population of scalloped hammerhead sharks from the Central and Southwest Atlantic and Indo-West Pacific DPSs present in the action area.

The potential take of neonate and juvenile scalloped hammerhead shark due to bycatch (in fishing gear) or directed take (tagging) in years when biological sampling using fishing gear and tagging occurs is not likely to reduce population numbers over time given current population sizes and expected recruitment. Similarly, while we cannot estimate the exact numbers of take of neonate and juvenile scalloped hammerhead shark that may occur as a result of CRCP biological sampling activities involving the use of fishing gear and tagging, 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 of scalloped hammerhead shark (Central and Southwest Atlantic and Indo-West Pacific DPSs) and will not result in an appreciable reduction in the likelihood of scalloped hammerhead shark's recovery in the wild. We conclude that the action will not jeopardize the continued existence of the Central and Southwest Atlantic or Indo-West Pacific DPSs of scalloped hammerhead shark.

9.1.3 **ESA-Listed Corals**

As discussed in this Opinion, thousands of ESA-listed coral colonies are expected to be adversely affected by the action, largely due to collection and transplant. Though some mortality of ESA-listed corals will occur as a result of the proposed action, most of the take of corals is part of activities to restore coral habitats and propagate the species.

In most cases, we are unable to separate our estimates of take from different activities into the numbers of colonies of each listed coral species that may be affected. The Mission: Iconic Reefs activity has the best-defined estimates of the expected numbers of ESA-listed corals to be collected and outplanted as part of the initiative. However, data from CRCP, other consultations, and scientific literature indicate that Atlantic/Caribbean acroporid and star corals are the most abundant species while pillar and rough cactus corals are naturally rare in this portion of the action area. In the U.S. Pacific, information provided by the CRCP indicates that *Acropora globiceps* is the ESA-listed coral that is used in many CRCP-supported activities while the other ESA-listed Indo-Pacific corals considered in this opinion are not commonly used in activities involving directed take of listed corals.

We estimate 40 coral colonies from each listed coral species in a U.S. jurisdiction in a given year when this activity occurs will be taken. In the U.S. Pacific, a maximum of 200 colonies or fragments of *Acropora globiceps* will be taken in each U.S. jurisdiction where it occurs in a given year when CRCP activities occur. We are unable to estimate the number of corals of other ESA-listed Indo-Pacific species that will be taken. We estimate that at least 1,004 elkhorn coral fragments or colonies will be taken annually as a result of CRCP activities and an additional 1,015,777 fragments total over the two phases of Mission: Iconic Reefs; at least 504 staghorn coral fragments or colonies will be taken annually as a result of CRCP activities and an additional 39,129 fragments over the two phases of Mission: Iconic Reefs; at least 654 coral fragments or colonies from the star coral complex and an additional 575,076 fragments for Mission: Iconic Reefs; at least 654 pillar coral fragments or colonies and an additional 796,539 fragments for Mission: Iconic Reefs; and at least 654 rough cactus coral fragments or colonies and an additional unknown number of fragments for Mission: Iconic Reefs. These take estimates do not include the collection of coral gametes as part of CRCP activities. Of the collected coral fragments and coral colonies, 1-10% would be expected to suffer mortality as a result of handling and transplant stress when these occur. Most of the fragments used in outplanting activities will be from coral nurseries, but some will be corals of opportunity. All coral collection activities are directed take.

Elkhorn and Staghorn Corals

The abundance of elkhorn and staghorn coral is thought to have declined by up to 97% from what it was before the mass mortality in the 1970s and 80s and recent population models forecast the extirpation of elkhorn coral from some locations over the foreseeable future, including a site in Vieques that was included in the Jackson et al. (2014b) report. The presence of staghorn coral on reefs throughout its range has continued to decrease. Elkhorn corals occupy habitats from back reef environments to turbulent water on the fore reef, reef crest, and shallow spur-and-groove zone, which moderates the species' vulnerability to extinction although many of the reef environments it occupies will experience highly variable thermal regimes and ocean chemistry due to climate change. Staghorn corals occupy a broad range of depths and multiple, heterogeneous habitat types, including deeper waters, which moderates the species' vulnerability to extinction over the foreseeable future. Elkhorn coral abundance is at least hundreds of thousands of colonies but likely to decrease in the future with increasing threats. Staghorn coral abundance is at least tens of millions of colonies but likely to decrease in the future with increasing threats.

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. We estimate 1,004 elkhorn coral and at least 504 staghorn coral fragments or colonies annually from CRCP activities and an additional 1,015,777 elkhorn and 39,129 staghorn fragments total over the two phases of Mission: Iconic Reefs will be taken and there will be additional take of these two coral species from other CRCP activities. This take is likely to be a fraction of the total present in the action area. Population estimates from the Florida Keys and St. Croix indicate there are at least hundreds of thousands of elkhorn coral colonies. There are at least tens of millions of colonies of staghorn coral based on population estimates from the Florida Keys and Dry Tortugas combined. It is important to note that the largest take numbers are associated with Mission: Iconic Reefs and involve coral fragment collection from corals of opportunity and coral nurseries and thus will have minimal effects to natural populations of ESA-listed corals in the action area. The loss of elkhorn and staghorn coral colonies as a result of CRCP actions, if mortality occurs, 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, at least temporarily.

Despite the potential loss of elkhorn and staghorn coral colonies and reproductive potential, the areas to be affected are part of large reef systems in Florida, Puerto Rico, and USVI, as well as FGBNMS. Whether the expected effects to elkhorn and staghorn corals would appreciably reduce their likelihood of survival and recovery depends largely on the current abundance and the degree to which population growth rates may be negatively impacted by the action. 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, any loss of reproductive potential represented by lethal take of elkhorn colonies or non-lethal take that leads to a temporary loss of reproduction due to factors such as transplant stress due to the proposed action will not measurably impact the species' abundance in the action area 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, particularly due to the 1-10% mortality from transplant stress, and at least a temporary loss in reproductive potential due to the action will not appreciably reduce staghorn coral's ability to survive in the wild. The expected survival and growth of transplanted corals is projected to foster sexual and asexual reproduction resulting in an overall increase in adundance of staghorn corals in the Atlantic/Caribbean portion of the action area in the future.

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 2015a).

The recovery plan 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% of consolidated reef habitat in 1 – 5 m water depth within the forereef zone. Thickets are defined as either a) colonies $\geq$ 1 m diameter in size at a density of 0.25 colonies per m^2 or b) live elkhorn coral benthic cover of approximately 60%. Populations with these characteristics should be present throughout the range and maintained for 20 years.

Staghorn coral: Thickets are present throughout approximately 5% of consolidated reef habitat in 5 – 20 m water depth within the forereef zone. Thickets are defined as either a) colonies ≥ 0.5 m diameter in size at a density of 1 colony per m^2 or b) live staghorn coral benthic cover of approximately 25%. Populations with these characteristics should be present throughout the range and maintained for 20 years.

Objective 2: Eliminate or Sufficiently Abate Global, Regional, and Local Threats

Criterion 6: Loss of Recruitment Habitat

Abundance (Criterion 1 above) addresses the threat of Loss of Recruitment Habitat because the criterion specifies the amount of habitat occupied by the 2 species. If Criterion 1 is met, then this threat is sufficiently abated; or

Throughout the ranges of these 2 species, at least 40% of the consolidated reef substrate in 1 – 20 m depth within the forereef remains free of sediment and macroalgal cover as measured on a broad reef to regional spatial scale.

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 CRCP and for other consultations involving ESA-listed Atlantic/Caribbean corals, elkhorn or staghorn coral thickets are present in the action area but invasive sampling and operation of towed equipment or other activities that may affect coral colonies are not likely to occur in areas with elkhorn or staghorn thickets due to compliance with the required BMPs that include measures to minimize potential effects to ESA-listed corals. 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 proposed action, we do not believe there will be an appreciable reduction in the likelihood of recovery in the wild for elkhorn and staghorn corals. 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 a tissue loss disease documented in 2017 (see Section 6.2.5.3). The species 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 1 – 25 m in depth but the low coral cover of this species makes it difficult to extrapolate monitoring data in order to determine trends in abundance. 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, at least temporarily until transplanted colonies grow and contribute to asexual and sexual recruits. We estimate that at least 654 pillar coral fragments or colonies annually from CRCP activities and an additional 796,539 fragments total over the two phases of Mission: Iconic Reefs will be taken and there will be additional take of this coral species from the installation and operation of temporary and permanent in-water structures. Pillar corals are most likely to be affected by disease treatment and collection and transplant. Transplanted corals are likely to suffer partial tissue mortality and bleaching and 10-10% of coral colonies and 1% of fragments are likely to die as a result of the stress of transplantation. As for elkhorn and staghorn corals, it is important to note that the largest take numbers for pillar coral are associated with Mission: Iconic Reefs and involve coral fragment from corals of opportunity and coral nurseries and thus will have minimal effects to natural populations of ESA-listed corals in the action area. 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 disease mortality, 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 various portions of the action area based on NCRMP data. 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 physical removal of substrate, installation of in-water structures and their anchors, and the use of fishing gear and other sampling equipment that is placed temporarily on the marine bottom. 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 given that population estimates from the Florida Keys indicate there are tens of thousands of colonies, although this number is declining due to SCTLD. 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. 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 FGBNMS, 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, at least temporarily until transplanted colonies grow and contribute to asexual and sexual recruits. Rough cactus corals are most likely to be affected by biological sampling, disease treatment, and collection and transplant. Transplanted corals and fragments are likely to suffer partial tissue mortality and bleaching and 1-10% 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 and recovery depends largely on the current abundance and the degree to which population growth rates may be negatively impacted by the action.

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. 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), meaning that it is expected to be more resistant to environmental stress than other listed coral species. NCRMP surveys documented the species in various portions of the action area. We believe the loss of rough cactus corals as a result of the 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 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 rough cactus corals are unknown but the species does appear to have experienced a decline in Florida. Therefore, recovery will depend on successful sexual reproduction and reducing mortality of extant populations. The key challenges will be moderating the impacts of ocean warming associated with climate change and decreasing susceptibility to disease, which may be furthered through reduction of local stressors. The recovery of 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 physical removal of substrate, installation of in-water structures and their anchors, and the use of fishing gear and other sampling equipment that is placed temporarily on the marine bottom. The area affected is a small portion of the species' range and the estimated 654 rough cactus coral fragments or colonies annually from CRCP activities and an additional unknown number of fragments over the two phases of Mission: Iconic Reefs 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. 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.

No reductions in distribution or the geographic range of lobed star, boulder star, and mountainous star corals is expected as a result of the action.

We conclude that the action will result in a reduction in numbers of these species. We estimate that at least 654 coral fragments or colonies from the star coral complex will be taken annually due to CRCP activities and an additional 575,076 fragments total over the two phases of Mission: Iconic Reefs will be taken. 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. Population estimates based on sampling in the Florida Keys estimated there were millions of colonies of these species. 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 and recovery depends largely on the current abundance and the degree to which population growth rates may be negatively impacted by the action. 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 m, 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 and 2017 hurricanes. 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 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 overfishing).

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 physical removal of substrate, installation of in-water structures and their anchors, and the use of fishing gear and other sampling equipment that is placed temporarily on the marine bottom. 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. We conclude the action is not likely to jeopardize the continued existence of lobed star, mountainous star, and boulder star corals.

Acropora globiceps

The overall relative abundance of *Acropora globiceps* is uncommon, but ranges from rare to common, depending on the location. In U.S. waters, *Acropora globiceps* occurs in Guam, CNMI, American Samoa, PRIA, and the NWHI.

No reductions in distribution or the geographic range of *Acropora globiceps* is expected as a result of the action.

We conclude that the action will result in a reduction in numbers of this species. It is not possible for us to estimate the total numbers of colonies that will be taken, although we estimate that 200 colonies of this species could be taken in each U.S. jurisdiction where the species occurs in a given year. The number of colonies taken are likely to be a fraction of the total present in the action area because the absolute abundance of the species is estimated as tens of millions of colonies. The loss of *Acropora globiceps* coral colonies will result in a reduction in absolute population numbers of the 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 this 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 this species would appreciably reduce its likelihood of survival and recovery depends largely on the current abundance and the degree to which population growth rates may be negatively impacted by the action. Information on the distribution and cover of *Acropora globiceps* in the U.S. Pacific indicate that it is widely distributed in Guam, CNMI, and American Samoa but only reported from specific reefs in the NWHI and PRIA. The species is considered to have a depth range of 0-20 m (0-66 ft). Based on *Acropora globiceps'* distribution and relative abundance, NMFS (2014a) estimated the absolute abundance of *Acropora globiceps* to be at least tens of millions of colonies. Dietzel et al. (2021) estimated its absolute abundance at 654 million colonies.

As for the Atlantic/Caribbean coral species that were listed in September 2014 that will also be affected by the action, a recovery outline was developed by NMFS for the Indo-Pacific coral species considered in this opinion (available at https://media.fisheries.noaa.gov/dam-migration/corals_recovery_outline_19_indo-pacific.pdf). The recovery outline is meant to serve as interim guidance to direct recovery efforts and planning until a full recovery plan is finalized. The Recovery Needs Assessment in the recovery outline concludes that *Acropora globiceps* is one of two ESA-listed Indo-Pacific corals that are most restricted in terms of depth range, making them more vulnerable to frequent changes in environmental conditions, extremes, high irradiance, and effects from multiple stressors. The key challenges will be moderating the impacts of ocean warming associated with climate change and ocean acidification, 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 listed Indo-Pacific corals should be present throughout as much of their historic ranges as future environmental changes allow, and may expand their ranges into new locations with more favorable habitat conditions in the future. NMFS acknowledged that changing environmental conditions on a global scale are the primary drivers of the status of these corals; therefore, their future distributions may not be reasonably expected to reflect past distributions. Recovery of the species will require conservation of the coral reef ecosystem through threat abatement and facilitation of adaptation to changing conditions to ensure a high probability of survival into the future.

The species' life history characteristics have enabled it to remain relatively persistent but population information for Indo-Pacific corals overall and *Acropora globiceps* specifically based on data from Guam following large-scale bleaching events since 2013 indicate the population has been in decline for decades but this decline has accelerated recently. The action will not affect life history vulnerabilities or increase the species' vulnerability to ocean warming, disease, or acidification. The action will cause a small decrease in reproductive potential and will affect habitat for the species through physical removal of substrate, installation of in-water structures and their anchors, and the use of fishing gear and other sampling equipment that is placed temporarily on the marine bottom. 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 *Acropora globiceps* coral colonies present in the action area. Therefore, we believe that the impacts to *Acropora globiceps* 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 the species' likelihood of recovery in the wild. We conclude the action is not likely to jeopardize the continued existence of *Acropora globiceps*.

Acropora jacquelineae

The overall relative abundance of *Acropora jacquelineae* to be rare to uncommon. In U.S. waters, *Acropora jacquelineae* occured in American Samoa, although more recent surveys have not encountered this species in the U.S. Pacific (Smith 2021b).

No reductions in distribution or the geographic range of *Acropora jacquelineae* is expected as a result of the action.

We conclude that the action will result in a reduction in numbers of this species. It is not possible for us to estimate the total numbers of colonies that will be taken but these are likely to be a fraction of the total present in the action area given the total population size of tens of millions of colonies for this species. The loss of *Acropora jacquelineae* coral colonies will result in a reduction in absolute population numbers of the 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 this 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 this species would appreciably reduce its likelihood of survival and recovery depends largely on the current abundance and the degree to which population growth rates may be negatively impacted by the action. Information on the distribution and cover of *Acropora jacquelineae* in the U.S. Pacific indicates that it has been found on some reefs in American Samoa, although more recent surveys have not reported observations of the species (Smith 2021b). The species is considered to have a depth range of 10-35 m (33-115 ft). Based on information from Richards et al. (2008); and Richards et al. (2019), *Acropora jacquelineae* had a population estimate of 31,599,000 colonies, and an effective population size of 3,476,000 colonies.

As stated above, a recovery outline was developed by NMFS for the Indo-Pacific coral species considered in this opinion (available at https://media.fisheries.noaa.gov/dam-migration/corals_recovery_outline_19_indo-pacific.pdf). The recovery outline is meant to serve as interim guidance to direct recovery efforts and planning until a full recovery plan is finalized. The Recovery Needs Assessment in the recovery outline concludes that *Acropora jacquelineae* is one of three ESA-listed Indo-Pacific coral species that are limited primarily to the Coral Triangle area in the western central Pacific. The Coral Triangle area is projected to have the most rapid and severe impacts from climate change and localized human impacts for coral reefs over the 21st century and multiple ocean warming events in this area suggest future warming may be more severe than average in this part of the world. Thus, the constrained range of *Acropora jacquelineae* will affect its ability to recover because of the likelihood of severe and increasing threats in the Coral Triangle area, largely associated with climate change. Another factor that will affect its ability to recover is that a threat event that has the potential to impact many colonies at once may lead to a high proportion of genetically unique individuals affected by the threat at a given time due to the species' effective population size and concentration in a particular geographic area.

The recovery vision statement in the outline states that populations of listed Indo-Pacific corals should be present throughout as much of their historic ranges as future environmental changes allow, and may expand their ranges into new locations with more favorable habitat conditions in the future. NMFS acknowledged that changing environmental conditions on a global scale are the primary drivers of the status of these corals; therefore, their future distributions may not be reasonably expected to reflect past distributions. Recovery of the species will require conservation of the coral reef ecosystem through threat abatement and facilitation of adaptation to changing conditions to ensure a high probability of survival into the future.

The species' life history characteristics have enabled it to remain relatively persistent but population information for Indo-Pacific corals overall indicate populations have been in decline for decades but this decline has accelerated recently. The action will not affect life history vulnerabilities or increase the species' vulnerability to ocean warming, disease, or acidification. The action will cause a small decrease in reproductive potential and will affect habitat for the species through physical removal of substrate, installation of in-water structures and their anchors, and the use of fishing gear and other sampling equipment that is placed temporarily on the marine bottom. 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 *Acropora jacquelineae* coral colonies present in the action area. Therefore, we believe that the impacts to *Acropora jacquelineae* 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 the species' likelihood of recovery in the wild. We conclude the action is not likely to jeopardize the continued existence of *Acropora jacquelineae*.

Acropora retusa

The overall relative abundance of *Acropora retusa* is rare to common, depending on the location. In U.S. waters, *Acropora retusa* occurs in Guam, CNMI, American Samoa, and PRIA.

No reductions in distribution or the geographic range of *Acropora retusa* is expected as a result of the action.

We conclude that the action will result in a reduction in numbers of this species. It is not possible for us to estimate the total numbers of colonies that will be taken but these are likely to be a fraction of the total present in the action area given the total population size of tens of millions of colonies for this species. The loss of *Acropora retusa* coral colonies will result in a reduction in absolute population numbers of the 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 this 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 this species would appreciably reduce its likelihood of survival and recovery depends largely on the current abundance and the degree to which population growth rates may be negatively impacted by the action. Information on the distribution and cover of *Acropora retusa* in the U.S. Pacific indicate that it is reported from certain reefs in Guam, CNMI, American Samoa and PRIA, but does not appear to be widely distributed, although this may be due to the limited amount of coral survey data available. The species is considered to have a depth range of 0-18 m (0-60 ft; Smith 2021a). Based on *Acropora retusa*'s distribution and relative abundance, NMFS (2014a) estimated the absolute abundance of *Acropora retusa* to be at least millions of colonies. Dietzel et al. (2021) estimated its absolute abundance at 540 million colonies.

As stated previously, a recovery outline was developed by NMFS for the Indo-Pacific coral species considered in this opinion (available at https://media.fisheries.noaa.gov/dam-migration/corals_recovery_outline_19_indo-pacific.pdf). The recovery outline is meant to serve as interim guidance to direct recovery efforts and planning until a full recovery plan is finalized. The Recovery Needs Assessment in the recovery outline concludes that *Acropora retusa* is one of two ESA-listed Indo-Pacific corals that are most restricted in terms of depth range, making them more vulnerable to frequent changes in environmental conditions, extremes, high irradiance, and effects from multiple stressors. The key challenges will be moderating the impacts of ocean warming associated with climate change and ocean acidification, 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 listed Indo-Pacific corals should be present throughout as much of their historic ranges as future environmental changes allow, and may expand their ranges into new locations with more favorable habitat conditions in the future. NMFS acknowledged that changing environmental conditions on a global scale are the primary drivers of the status of these corals; therefore, their future distributions may not be reasonably expected to reflect past distributions. Recovery of the species will require conservation of the coral reef ecosystem through threat abatement and facilitation of adaptation to changing conditions to ensure a high probability of survival into the future.

The species' life history characteristics have enabled it to remain relatively persistent but population information for Indo-Pacific corals overall indicate populations have been in decline for decades but this decline has accelerated recently. The action will not affect life history vulnerabilities or increase the species' vulnerability to ocean warming, disease, or acidification. The action will cause a small decrease in reproductive potential and will affect habitat for the species through physical removal of substrate, installation of in-water structures and their anchors, and the use of fishing gear and other sampling equipment that is placed temporarily on the marine bottom. 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 *Acropora retusa* coral colonies present in the action area. Therefore, we believe that the impacts to *Acropora retusa* 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 the species' likelihood of recovery in the wild. We conclude the action is not likely to jeopardize the continued existence of *Acropora retusa*.

Acropora speciosa

Based on the results of DeVantier and Turak (2017) and Fenner (2020b), the overall relative abundance of *Acropora speciosa* is considered to be rare to uncommon by NMFS. In U.S. waters, *A. speciosa* occurs on Guam, American Samoa, and PRIA.

No reductions in distribution or the geographic range of *Acropora speciosa* is expected as a result of the action.

We conclude that the action will result in a reduction in numbers of this species. It is not possible for us to estimate the total numbers of colonies that will be taken but these are likely to be a fraction of the total present in the action area given the total population size of millions of colonies for this species. The loss of *Acropora speciosa* coral colonies will result in a reduction in absolute population numbers of the 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 this 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 this species would appreciably reduce their likelihoods of survival and recovery depends largely on the current abundance and the degree to which population growth rates may be negatively impacted by the action. Information on the distribution and cover of *Acropora speciosa* in the U.S. Pacific indicates that it is reported on specific reefs in American Samoa and PRIA and does not appear to be widely distributed. The species is considered to have a depth range of approximately 12-40 m (39-131 ft), although it may be present in deeper waters based on observations of colonies in depths up to 46 m (151 ft;

Smith 2021a). Based on information from Richards et al. (2008); and Richards et al. (2019), *Acropora speciosa* had a population estimate of 10,942,000 colonies, and an effective population size of 1,204,000 colonies (NMFS 2014a). Dietzel et al. (2021) estimated its absolute abundance at 19.2 million colonies.

As stated previously, a recovery outline was developed by NMFS for the Indo-Pacific coral species considered in this opinion (available at https://media.fisheries.noaa.gov/dam-migration/corals_recovery_outline_19_indo-pacific.pdf). The recovery outline is meant to serve as interim guidance to direct recovery efforts and planning until a full recovery plan is finalized. The Recovery Needs Assessment in the recovery outline concludes that *Acropora speciosa* has an effective population size of two million or fewer colonies, making it more vulnerable to threat events because a relatively small effective population size means a high proportion of genetically unique individuals could be affected by a threat at any given time, affecting the ability of the species to recover. The key challenges will be moderating the impacts of ocean warming associated with climate change and ocean acidification, 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 listed Indo-Pacific corals should be present throughout as much of their historic ranges as future environmental changes allow, and may expand their ranges into new locations with more favorable habitat conditions in the future. NMFS acknowledged that changing environmental conditions on a global scale are the primary drivers of the status of these corals; therefore, their future distributions may not be reasonably expected to reflect past distributions. Recovery of the species will require conservation of the coral reef ecosystem through threat abatement and facilitation of adaptation to changing conditions to ensure a high probability of survival into the future.

The species' life history characteristics have enabled it to remain relatively persistent but population information for Indo-Pacific corals overall indicate populations have been in decline for decades but this decline has accelerated recently. The action will not affect life history vulnerabilities or increase the species' vulnerability to ocean warming, disease, or acidification. The action will cause a small decrease in reproductive potential and will affect habitat for the species through physical removal of substrate, installation of in-water structures and their anchors, and the use of fishing gear and other sampling equipment that is placed temporarily on the marine bottom. 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 *Acropora speciosa* coral colonies present in the action area. Therefore, we believe that the impacts to *Acropora speciosa* 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 the species' likelihood of recovery in the wild. We conclude the action is not likely to jeopardize the continued existence of *Acropora speciosa*.

Euphyllia paradivisa

The overall relative abundance of *Euphyllia paradivisa* is rare to common, depending on the location. In U.S. waters, *Euphyllia paradivisa* occurs in American Samoa.

No reductions in distribution or the geographic range of *Euphyllia paradivisa* is expected as a result of the action.

We conclude that the action will result in a reduction in numbers of this species. It is not possible for us to estimate the total numbers of colonies that will be taken but these are likely to be a fraction of the total present in the action area given the absolute abundance estimate of tens of millions of colonies for this species. The loss of *Euphyllia paradivisa* coral colonies will result in a reduction in absolute population numbers of the 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 this 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 this species would appreciably reduce their likelihoods of survival and recovery depends largely on the current abundance and the degree to which population growth rates may be negatively impacted by the action. Information on the distribution and cover of *Euphyllia paradivisa* in the U.S. Pacific indicate that it is in American Samoa in a greater depth range than was previously considered for this species. The species is considered to have a depth range of 2-40 m (6.5-131 ft), but was reported on Tutuila in 49 m in 2016 (161 ft; Smith 2021a). Based on *Euphyllia paradivisa'*s distribution and relative abundance, NMFS (2014a) estimated the absolute abundance of *Euphyllia paradivisa* to be at least tens of millions of colonies. However, the estimate was based on the assumptions that *Euphyllia paradivisa*'s distribution was smaller and its abundance lower than more recent information from surveys in deeper waters suggest and is thus likely to be an underestimate.

As stated previously, a recovery outline was developed by NMFS for the Indo-Pacific coral species considered in this opinion (available at https://media.fisheries.noaa.gov/dam-migration/corals_recovery_outline_19_indo-pacific.pdf). The recovery outline is meant to serve as interim guidance to direct recovery efforts and planning until a full recovery plan is finalized. The Recovery Needs Assessment in the recovery outline concludes the key challenges will be moderating the impacts of ocean warming associated with climate change and ocean acidification, 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 listed Indo-Pacific corals should be present throughout as much of their historic ranges as future environmental changes allow, and may expand their ranges into new locations with more favorable habitat conditions in the future. NMFS acknowledged that changing environmental conditions on a global scale are the primary drivers of the status of these corals; therefore, their future distributions may not be reasonably expected to reflect past distributions. Recovery of the species will require conservation of the coral reef ecosystem through threat abatement and facilitation of adaptation to changing conditions to ensure a high probability of survival into the future.

The species' life history characteristics have enabled it to remain relatively persistent but population information for Indo-Pacific corals overall indicate populations have been in decline for decades but this decline has accelerated recently. The action will not affect life history vulnerabilities or increase the species' vulnerability to ocean warming, disease, or acidification. The action will cause a small decrease in reproductive potential and will affect habitat for the species through physical removal of substrate, installation of in-water structures and their anchors, and the use of fishing gear and other sampling equipment that is placed temporarily on the marine bottom. 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 *Euphyllia paradivisa* coral colonies present in the action area. Therefore, we believe that the impacts to *Euphyllia paradivisa* 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 the species' likelihood of recovery in the wild. We conclude the action is not likely to jeopardize the continued existence of *Euphyllia paradivisa*.

Isopora crateriformis

Based on the information summarized above, we consider the relative abundance of *Isopora crateriformis* to be rare to common, depending on the location. In U.S. waters, *Isopora crateriformis* occurs in American Samoa.

No reductions in distribution or the geographic range of *Isopora crateriformis* is expected as a result of the action.

We conclude that the action will result in a reduction in numbers of this species. It is not possible for us to estimate the total numbers of colonies that will be taken but these are likely to be a fraction of the total present in the action area given the absolute abundance estimate of tens of millions of colonies for this species. The loss of *Isopora crateriformis* coral colonies will result in a reduction in absolute population numbers of the 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 this 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 this species would appreciably reduce their likelihoods of survival and recovery depends largely on the current abundance and the degree to which population growth rates may be negatively impacted by the action. Information on the distribution and cover of *Isopora crateriformis* in the U.S. Pacific indicates that it is found only in American Samoa. The species is considered to have a depth range of 0-12 m (0-39 ft), but surveys in 2015 and 2018 around Tutuila found the species in depths 0-30 m (0-98 ft; Smith 2021a). Based on *Isopora crateriformis'*s distribution and relative abundance, NMFS (2014a) estimated the absolute abundance of *Isopora crateriformis* to be at least millions of colonies. Dietzel et al. (2021) estimated its absolute abundance at 69.6 million colonies.

As stated previously, a recovery outline was developed by NMFS for the Indo-Pacific coral species considered in this opinion (available at https://media.fisheries.noaa.gov/dam-migration/corals_recovery_outline_19_indo-pacific.pdf). The recovery outline is meant to serve as interim guidance to direct recovery efforts and planning until a full recovery plan is finalized. The Recovery Needs Assessment concludes the key challenges to recovery will be moderating the impacts of ocean warming associated with climate change and ocean acidification, 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 listed Indo-Pacific corals should be present throughout as much of their historic ranges as future environmental changes allow, and may expand their ranges into new locations with more favorable habitat conditions in the future. NMFS acknowledged that changing environmental conditions on a global scale are the primary drivers of the status of these corals; therefore, their future distributions may not be reasonably expected to reflect past distributions. Recovery of the species will require conservation of the coral reef ecosystem through threat abatement and facilitation of adaptation to changing conditions to ensure a high probability of survival into the future.

The species' life history characteristics have enabled it to remain relatively persistent but population information for Indo-Pacific corals overall and *Isopora crateriformis* specifically based on data from Guam following large-scale bleaching events since 2013 indicate the population has been in decline for decades but this decline has accelerated recently. The action will not affect life history vulnerabilities or increase the species' vulnerability to ocean warming, disease, or acidification. The action will cause a small decrease in reproductive potential and will affect habitat for the species through physical removal of substrate, installation of in-water structures and their anchors, and the use of fishing gear and other sampling equipment that is placed temporarily on the marine bottom. 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 *Isopora crateriformis* coral colonies present in the action area. Therefore, we believe that the impacts to *Isopora crateriformis* 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 the species' likelihood of recovery in the wild. We conclude the action is not likely to jeopardize the continued existence of *Isopora crateriformis*.

Seriatopora aculeata

Based on the results of DeVantier and Turak (2017) and Fenner (2020b), NMFS considers the overall relative abundance of *Seriatopora aculeata* to be uncommon. In U.S. waters, *Seriatopora aculeata* is reported from Guam and CNMI, although recent surveys have not reported the species and it may have been extirpated from Guam following the 2013 tsunami (Smith 2021b).

No reductions in distribution or the geographic range of *Seriatopora aculeata* is expected as a result of the action.

We conclude that the action will result in a reduction in numbers of this species. It is not possible for us to estimate the total numbers of colonies that will be taken but these are likely to be a fraction of the total present in the action area given the absolute abundance estimate of millions of colonies for this species. The loss of *Seriatopora aculeata* coral colonies will result in a reduction in absolute population numbers of the 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 this 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 this species would appreciably reduce their likelihoods of survival and recovery depends largely on the current abundance and the degree to which population growth rates may be negatively impacted by the action. Information on the distribution and cover of *Seriatopora aculeata* in the U.S. Pacific indicates that it is likely rare, with reports from Guam and CNMI and more recent surveys not finding any colonies of the species (Smith 2021b). The species is considered to have a depth range of 3-40 m (10-131 ft). Based on *Seriatopora aculeata'*s distribution and relative abundance, NMFS (2014a) estimated the absolute abundance of *Seriatopora aculeata* to be at least millions of colonies.

As for the Atlantic/Caribbean coral species that were listed in September 2014 that will also be affected by the action, a recovery outline was developed by NMFS for the Indo-Pacific coral species considered in this opinion (available at https://media.fisheries.noaa.gov/dam-migration/corals_recovery_outline_19_indo-pacific.pdf). The recovery outline is meant to serve as interim guidance to direct recovery efforts and planning until a full recovery plan is finalized. The Recovery Needs Assessment in the recovery outline concludes the key challenges will be moderating the impacts of ocean warming associated with climate change and ocean acidification, 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 listed Indo-Pacific corals should be present throughout as much of their historic ranges as future environmental changes allow, and may expand their ranges into new locations with more favorable habitat conditions in the future. NMFS acknowledged that changing environmental conditions on a global scale are the primary drivers of the status of these corals; therefore, their future distributions may not be reasonably expected to reflect past distributions. Recovery of the species will require conservation of the coral reef ecosystem through threat abatement and facilitation of adaptation to changing conditions to ensure a high probability of survival into the future.

The species' life history characteristics have enabled it to remain relatively persistent but population information for Indo-Pacific corals overall indicate populations have been in decline for decades but this decline has accelerated recently. The action will not affect life history vulnerabilities or increase the species' vulnerability to ocean warming, disease, or acidification. The action will cause a small decrease in reproductive potential and will affect habitat for the species through physical removal of substrate, installation of in-water structures and their anchors, and the use of fishing gear and other sampling equipment that is placed temporarily on the marine bottom. 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 *Seriatopora aculeata* coral colonies present in the action area. Therefore, we believe that the impacts to *Seriatopora aculeata* 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 the species' likelihood of recovery in the wild. We conclude the action is not likely to jeopardize the continued existence of *Seriatopora aculeata*.

9.2 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.

9.2.1 Elkhorn and Staghorn Coral Designated Critical Habitat

The Puerto Rico elkhorn and staghorn coral critical habitat marine unit comprises approximately 3,582 km^2 (1,383 mi^2) of marine habitat. The St. Thomas/St. John unit comprises approximately

313 km2 (121 mi^2), and the St. Croix critical habitat unit comprises approximately 326 km^2 (126 mi^2) of marine habitat. The Florida critical habitat unit comprises approximately 3,442 km^2 (1,329 mi^2) of marine habitat. The key objective for the conservation and recovery of Atlantic acroporid corals that forms the basis for the critical habitat designation is the facilitation of an increase in the incidence of sexual and asexual reproduction. Recovery cannot occur without protecting the PBF of quality and quantity of suitable substrate because it affects their reproductive success. As noted in the rule designating acroporid coral critical habitat (73 FR 72210, November 26, 2008), the loss of suitable habitat is one of the greatest threats to the recovery of listed elkhorn and staghorn coral populations. Man-made stressors have the greatest impact on habitat quality for listed elkhorn and staghorn corals.

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. 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 Elkhorn and Staghorn Coral Critical Habitat (Section 5.2.3.2), the Environmental Baseline (Section 6), the Effects of the Action (Section 7), and Cumulative Effects (Section 8).

The essential feature of critical habitat for elkhorn and staghorn coral is substrate of adequate quantity and quality to allow for settlement and growth where adequate quality refers to the need for hard substrate to be free of high macroalgal growth and sediment cover as these impede the settlement and growth of elkhorn and staghorn corals. Thus, we need to assess whether the potential loss of or damage to critical habitat areas due to alterations to this habitat through the physical removal of substrate, installation of in-water structures and their anchors, and the use of fishing gear and other sampling equipment that is placed temporarily on the marine bottom rise to the level of adversely modifying or destroying the designated critical habitat when considered as a whole. Specifically, whether these activities will result in diminished function of the PBF of elkhorn and staghorn coral critical habitat such that settlement and growth of sexual and asexual recruits are impaired, also affecting the recovery criteria for elkhorn and staghorn corals.

Our analysis indicates that some activities are likely to have permanent effects to small areas of coral critical habitat, including the installation of anchor pins and other metal anchors in hard substrate, coring and other removal of hard substrate, installation of concrete anchors in hard substrate, and temporary placement of structures and fishing gear in hard substrate. We estimated the potential effects of these activities to be 0.96 m^2 (10 ft^2) of coral habitat from concrete anchors for benthic nursery structures; 0.22 m^2 (2.37 ft^2) from concrete anchors for other in-water installations such as equipment mooring; 0.4 m^2 (4.3 ft^2) in Florida, 1.2 m^2 (13 ft^2) in Puerto Rico, and 1.4 m^2 (15 ft^2) in the USVI from metal anchors for equipment mooring; and 750 m^2 (8,073 ft^2) in Florida, 157.5 m^2 (1,695 ft^2) in Puerto Rico, and 244 m^2 (2,626 ft^2) in USVI from metal anchors for anchoring floating coral nursery structures in each year these activities are conducted. In addition, coral habitat effects equal to the total area of coring and temporary structures or fishing gear placed on hard substrate for sample collection will occur in each year these activities are conducted.

Impacts to coral critical habitat from installation of anchor pins and other metal anchors in hard substrate, coring and other removal of hard substrate, installation of concrete anchors in hard substrate, and temporary placement of structures and fishing gear in hard substrate are expected to be localized and are not expected to result in the loss or degradation of large areas containing the PBF of elkhorn and staghorn coral critical habitat in Puerto Rico, USVI, or Florida. We base this on the current presence of elkhorn and staghorn corals in areas containing the PBF throughout the action area in the Puerto Rico critical habitat unit, the USVI critical habitat units, and the Florida critical habitat units. Within the Puerto Rico elkhorn and staghorn coral critical habitat marine unit, approximately 756 km^2 (292 mi^2) are likely to contain the PBF of ESA-designated elkhorn and staghorn coral critical habitat, based on the amount of coral, rock reef, colonized hard bottom, and other coralline communities mapped by NOAA's NOS Biogeography Program in 2000 (Kendall et al. 2001). Within the St. Thomas/St. John and St. Croix critical habitat units, 300 km^2 (116 mi^2) are likely to contain the PBF based on the amount of coral habitat mapped by NOAA in 2000 (Kendall et al. 2001). A similar estimate is not available for Florida because comprehensive mapping of the areas containing coral habitats has not been completed, but it is likely to be at least similar to the estimate for the U.S. Caribbean. Therefore, we do not expect the effects of the action to appreciably diminish the overall value of the designated critical habitat for the conservation of elkhorn and staghorn corals in the action area. We conclude that the proposed action will not result in the destruction or adverse modification of elkhorn and staghorn coral critical habitat in the Puerto Rico, Florida or USVI units.

9.2.2 **Proposed Atlantic/Caribbean Coral Critical Habitat**

The proposed coral critical habitat for *Orbicella annularis*, *O. faveolata*, *O. franksi*, *Dendrogyra cylindrus*, and *Mycetophyllia ferox* includes 28 mostly overlapping specific occupied areas containing PBFs essential to the conservation of all of these species in Florida, Puerto Rico, USVI, FGBNMS, and Navassa Island. The areas contain 15,000 km^2 (5,900 mi^2) of marine habitat. The recovery vision statement in the recovery outline for these listed coral species states that populations of these corals should be present across their historic ranges with populations large enough and genetically diverse enough to support successful reproduction and recovery from mortality events and dense enough to maintain ecosystem function. The initial focus of the recovery action plan will be to protect extant populations and the species' habitat through reduction of threats. As for elkhorn and staghorn corals, recovery cannot occur without protecting the PBF of sites supporting the normal function of all life stages of threatened corals and serve as reproductive, recruitment, growth, and maturation habitat.

The key objective for the conservation and recovery of these five threatened corals that forms the basis for the critical habitat designation is the availability of sites with a complex combination of substrate and water column characteristics that support normal functions of all life stages of the corals. Recovery cannot occur without protecting the PBF of reproductive, recruitment, growth, and maturation habitat because it affects the reproductive and recruitment success, growth and survival of these coral species in the wild. As noted in the proposed rule to designate critical habitat for these species (85 FR 76302, November 27, 2020), spatial and temporal patterns of coral recruitment are affected by substrate availability. Sites must have appropriate attachment substrate, in association with warm, aragonite-supersaturated, oligotrophic, clear marine water as these are essential to reproduction and recruitment, survival, and growth of all life stages of the five species of coral. These sites can be affected by ocean acidification and ocean warming, trophic effects of reef fishing, nutrient enrichment, sedimentation, and contamination.

Therefore, the key conservation objective of designated elkhorn and staghorn coral critical habitat is to support the normal function of all life stages of these five corals, which in turn facilitates increase in the species' abundance, distribution, and genetic diversity. To this end, our analysis seeks to determine whether or not the action is likely to destroy or adversely modify proposed critical habitat in the context of the Status of Proposed Atlantic/Caribbean Coral Critical Habitat (Section 5.2.4), the Environmental Baseline (Section 6), the Effects of the Action (Section 7), and Cumulative Effects (Section 8).

The essential feature of proposed critical habitat for these five corals is reproductive, recruitment, growth and maturation habitat where sites that support the normal function of all life stages of threatened corals 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. Thus, we need to assess whether the potential loss of or damage to critical habitat areas due to alterations to this habitat through the physical removal of substrate, installation of in-water structures and their anchors, and the use of fishing gear and other sampling equipment that is placed temporarily on the marine bottom rise to the level of adversely modifying or destroying the designated critical habitat when considered as a whole. Specifically, whether these activities will result in diminished function of the PBF of proposed coral critical habitat such that the normal function of all life stages of these five species are impaired, also affecting the recovery of these corals.

As noted in Section 9.2.1, our analysis indicates that some activities are likely to have permanent effects to small areas of coral critical habitat, including the installation of anchor pins and other metal anchors in hard substrate, coring and other removal of hard substrate, installation of concrete anchors in hard substrate, and temporary placement of structures and fishing gear in hard substrate. We estimated the potential effects of these activities to be 0.96 m^2 (10 ft^2) of coral habitat from concrete anchors for benthic nursery structures; 0.22 m^2 (2.37 ft^2) from concrete anchors for other in-water installations such as equipment mooring; 0.4 m^2 (4.3 ft^2) in Florida, 1.2 m^2 (13 ft^2) in Puerto Rico, and 1.4 m^2 (15 ft^2) in the USVI from metal anchors for equipment mooring; and 750 m^2 (8,073 ft^2) in Florida, 157.5 m^2 (1,695 ft^2) in Puerto Rico, and 244 m^2 (2,626 ft^2) in USVI from metal anchors for anchoring floating coral nursery structures in each year these activities are conducted. In addition, coral habitat effects equal to the total area of coring and temporary structures or fishing gear placed on hard substrate for sample collection will occur in each year these activities are conducted. We did not estimate the amount of habitat that might be affected by activities in FGBNMS, but metal anchors from the installation of in-water equipment are expected to affect 0.4 m^2 (4.3 ft^2) of coral habitat in the Gulf of Mexico, which is likely to be within FGBNMS. Other activities could also affect proposed critical habitat for listed corals in this area.

Impacts to coral critical habitat from installation of anchor pins and other metal anchors in hard substrate, coring and other removal of hard substrate, installation of concrete anchors in hard substrate, and temporary placement of structures and fishing gear in hard substrate are expected to be localized and are not expected to result in the loss or degradation of large areas containing the PBF of proposed coral critical habitat in Puerto Rico, USVI, Florida, or FGBNMS. We base this on the current presence of listed corals in areas (though the distribution of the species varies slightly with some species not reported in FGB) containing the PBF throughout the action area. As stated in Section 9.2.1, within the Puerto Rico elkhorn and staghorn coral critical habitat marine unit, approximately 756 km^2 (292 mi^2) are likely to contain the PBF and approximately 300 km^2 (116 mi^2) within the St. Thomas/St. John and St. Croix critical habitat units. Because the proposed critical habitat for the five species of threatened corals overlaps with elkhorn and staghorn coral critical habitat and extends further than designated elkhorn and staghorn coral critical habitat, we expect a larger area is likely to contain the PBF for proposed coral critical habitat in addition to the areas in Florida and FGBNMS for which we do not have estimates of the likely area containing the PBF. Therefore, we do not expect the effects of the action to appreciably diminish the overall value of the proposed critical habitat for the conservation of pillar, rough cactus, lobed star, mountainous star, and boulder star corals in the action area. We conclude that the proposed action will not result in the destruction or adverse modification of proposed coral critical habitat in Puerto Rico, Florida, USVI, or FGBNMS.

9.2.3 **Proposed Indo-Pacific Coral Critical Habitat**

The proposed coral critical habitat for *Acropora globiceps*, *A. jacquelineae*, *A. retusa*, *A. speciosa*, *Euphullia paradivisa*, *Isopora crateriformis*, and *Seriatopora aculeata* includes 17 specific occupied areas containing PBFs essential to the conservation of these species in the U.S. Pacific. The areas contain 600 km^2 (230 mi^2) of marine habitat, which is only a small portion of the coral habitat estimated to be present in the U.S. Pacific[15] based, in part, on the limited

[15] The coral reef resources of American Samoa are estimated as 296 km^2 with 25 km^2 of that in federal waters; the coral reef area in federal waters in Guam is 110 km^2, which is 60% of the total reef reef area in Guam; CNMI coral

distribution of many of the ESA-listed Indo-Pacific corals in U.S. waters. The recovery vision statement in the outline states that populations of listed Indo-Pacific corals should be present throughout as much of their historic ranges as future environmental changes allow, and may expand their ranges into new locations with more favorable habitat conditions in the future. NMFS acknowledged that changing environmental conditions on a global scale are the primary drivers of the status of these corals; therefore, their future distributions may not be reasonably expected to reflect past distributions. Recovery of the species will require conservation of the coral reef ecosystem through threat abatement and facilitation of adaptation to changing conditions to ensure a high probability of survival into the future.

The key conservation objective that facilitates the Recovery Vision in the recovery outline for these species, and that can be assisted through the designation of critical habitat, is supporting successful reproduction and recruitment, and survival and growth of all life stages, by abating threats to coral habitat. Recovery cannot occur without protecting the PBF of reproductive, recruitment, growth, and maturation habitat because it affects the reproductive and recruitment success, growth and survival of these coral species in the wild. As noted in the proposed rule to designate critical habitat for these species (85 FR 76262, November 27, 2020), spatial and temporal patterns of coral recruitment are affected by substrate availability. Sites must have appropriate attachment substrate, in association with warm, aragonite-supersaturated, oligotrophic, clear marine water as these are essential to reproduction and recruitment, survival, and growth of all life stages of these species of coral. These sites can be affected by ocean acidification and ocean warming, trophic effects of reef fishing, nutrient enrichment, sedimentation, and contamination.

Therefore, the key conservation objective of designated Indo-Pacific coral critical habitat is to support the normal function of all life stages of these seven corals, which in turn facilitates increase in the species' abundance, distribution, and genetic diversity. To this end, our analysis seeks to determine whether or not the action is likely to destroy or adversely modify proposed critical habitat in the context of the Status of Proposed Indo-Pacific Coral Critical Habitat (Section 5.2.5), the Environmental Baseline (Section 6), the Effects of the Action (Section 7), and Cumulative Effects (Section 8).

The essential feature of proposed critical habitat for these seven corals is reproductive, recruitment, growth and maturation habitat where sites that support the normal function of all life stages of threatened corals 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. Thus, we need to assess whether the potential loss of or damage to critical habitat areas due to alterations to this habitat through the physical

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reef area is 579 km^2, all of which is under federal jurisdiction; and the coral reef resources in the NWHI are 9,124 km^2 (Green 2016).

removal of substrate, installation of in-water structures and their anchors, and the use of fishing gear and other sampling equipment that is placed temporarily on the marine bottom rise to the level of adversely modifying or destroying the designated critical habitat when considered as a whole. Specifically, whether these activities will result in diminished function of the PBF of proposed coral critical habitat such that the normal function of all life stages of these five species are impaired, also affecting the recovery of these corals.

Our analysis indicates that some activities are likely to have permanent effects to small areas of coral critical habitat, including the installation of anchor pins and other metal anchors in hard substrate, coring and other removal of hard substrate, installation of concrete anchors in hard substrate, and temporary placement of structures and fishing gear in hard substrate. We estimated the potential effects of these activities to be 0.96 m^2 (10 ft^2) of coral habitat from concrete anchors for benthic nursery structures; 0.22 m^2 (2.37 ft^2) from concrete anchors for other in-water installations such as equipment mooring; 3.9 m^2 (42 ft^2) in American Samoa, 1.35 m^2 (14.5 ft^2) in the MHI, 0.5 m^2 (5.4 ft^2) in the NWHI, and 11.1 m^2 (11.8 ft^2) in PRIA from metal anchors for equipment mooring; and 150 m^2 (1,615 ft^2) in CNMI and 22.5 m^2 (242 ft^2) in the MHI from metal anchors for anchoring floating coral nursery structures in each year these activities are conducted. In addition, coral habitat effects equal to the total area of coring and temporary structures or fishing gear placed on hard substrate for sample collection will occur in each year these activities are conducted.

Impacts to coral critical habitat from installation of anchor pins and other metal anchors in hard substrate, coring and other removal of hard substrate, installation of concrete anchors in hard substrate, and temporary placement of structures and fishing gear in hard substrate are expected to be localized and are not expected to result in the loss or degradation of large areas containing the PBF of proposed coral critical habitat in the U.S. Pacific. We base this on the current presence of listed corals in areas (though the distribution of the species varies with jurisdiction) containing the PBF throughout the action area. Therefore, we do not expect the effects of the action to appreciably diminish the overall value of the proposed critical habitat for the conservation of *Acropora globiceps*, *A. jacquelineae*, *A. retusa*, *A. speciosa*, *Euphullia paradivisa*, *Isopora crateriformis*, and *Seriatopora aculeata* in the action area. We conclude that the proposed action will not result in the destruction or adverse modification of proposed coral critical habitat in CNMI, Guam, American Samoa, the MHI, the NWHI, and PRIA.

10 Conclusion

After reviewing the current status of the 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 Nassau grouper (*Epinephelus striatus*); scalloped hammerhead shark (*Sphyrna lewini*, Central and Southwest Atlantic and Indo-West Pacific DPSs); lobed star (*Orbicella annularis*), mountainous star (*Orbicella faveolata*), boulder star (*Orbicella franksi*), elkhorn (*Acropora palmata*), staghorn (*Acropora cervicornis*), pillar (*Dendrogyra cylindrus*), rough cactus (*Mycetophyllia ferox*), *Acropora globiceps*, *A. jacquelineae*, *A. retusa*, *A. speciosa*, *Euphyllia paradivisa*, *Isopora crateriformis*, and *Seriatopora aculeata* corals; or to result in the destruction or adverse modification of elkhorn and staghorn coral critical habitat or proposed critical habitat for the other Atlantic/Caribbean and Indo-Pacific coral species.

It is also NMFS biological opinion that the action is not likely to adversely affect the following ESA-listed species and designated critical habitat: giant manta ray (*Mobila birostris*); smalltooth sawfish (*Pristis pectinata*; U.S. populations); oceanic whitetip shark (*Carcharhinus longimanus*); Kemp's ridley (*Lepidochelys kempii*), Olive ridley (*Lepidochelys olivacea*, Mexico's Pacific coast breeding population and populations other than Mexico's Pacific coast breeding population), green (*Chelonia mydas*; North Atlantic DPS, South Atlantic DPS, Central North Pacific DPS, Central South Pacific DPS, and Central West Pacific DPS), leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*), and loggerhead (*Caretta caretta*; Northwest Atlantic DPS, South Pacific DPS, and North Pacific DPS) sea turtles; blue (*Balaenoptera musculus*), North Atlantic right (*Eubalaena glacialis*), North Pacific right whale (*Eubalaena japonica*), humpback (*Megaptera novaeangliae*; Western North Pacific DPS), fin (*Balaenoptera physalus*), sei (*Balaenoptera borealis*), Rice's (*Balaenoptera riceii*), and sperm (*Physeter macrocephalus*) whales; false killer whale (*Pseudorca crassidens*; Main Hawaiian Islands Insular DPS); Hawaiian monk seal (*Monachus schauinslandi*); and chambered nautilus (*Nautilus pompilius*); designated critical habitat for smalltooth sawfish, Main Hawaiian Islands Insular DPS false killer whale, Hawaiian monk seal, North Atlantic DPS green sea turtle, hawksbill sea turtle, leatherback sea turtle, and Northwest Atlantic DPS loggerhead sea turtle.

11 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) of the ESA 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 this ITS.

Directed take is not part of the ITS, though it is considered in this opinion in order to analyze the effects of the proposed action and determine whether the action may jeopardize the continued existence of ESA-listed species. Directed take that is part of the proposed action includes coral disease treatment, coral coring, and all coral collection activities (i.e., collection of gametes, polyps, and various size fragments) for ESA-listed corals. Directed take would also include tagging of Nassau grouper and scalloped hammerhead shark (Central and Southwest Atlantic and Indo-West Pacific DPSs) if projects of this nature are supported in the future.

Of the ESA-listed threatened coral species for which there may be directed take as part of the action analyzed in this opinion, only Acropora palmata and Acropora cervicornis have an ESA section 4(d) rule (73 FR 64264). The 4(d) rule for these species includes exceptions to the take prohibitions. One exception states that no ESA section 10 permit is required for scientific research and enhancement activities as long as the principal investigator(s) obtains the required state/territorial permits for the work from the agencies identified in the rule. The second exception states that no ESA section 10 permit is required for federal, state, and territorial agency personnel, or their designees as applicable, when they are performing specific restoration activities directed at the two listed coral species under an existing legal authority that provides for such restoration such as the Coral Reef Conservation Act and the National Marine Sanctuaries Act.

11.1 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 C.F.R. §402.14(i)(1)(i)). The amount of take represents the number of individuals (colonies for ESA-listed corals) 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). Where it is not practical to quantify the number of individuals that are expected to be taken by the action, a surrogate (e.g., similarly affected species or habitat or ecological conditions) may be used to express the amount or extent of anticipated take (50 C.F.R. §402.14(i)(1)(i)).

We anticipate the CRCP and Mission: Iconic Reefs activities that are part of the proposed action are reasonably likely to result in the incidental take of ESA-listed species by death, injury, or harassment. Specifically, we anticipate the following incidental take of ESA-listed corals (including through damage to or loss of coral habitat) in the action area:

- 4 ESA-listed coral colonies of any species in a given year in Puerto Rico, Florida, and/or USVI due to collisions;
- An undefined number of ESA-listed coral colonies and recruits for which a surrogate is identified below from in-water structure placement and operation, including due to shading, abrasion by tackle or other components with wave and current movement, or damage from components that move during storms and

- A variable amount of habitat from anchor installation, use of temporary structures such as for coral gamete collection, and use of fishing gear in any jurisdiction resulting in the loss of future recruitment habitat and, thus future coral recruits in these areas.

As noted, incidental take of ESA-listed corals may occur due to direct and habitat-related effects of this action on ESA-listed coral colonies and future recruits. This take cannot be accurately quantified as numbers of current and future ESA-listed coral colonies because there have not been detailed inventories of ESA-listed coral colonies completed for the U.S. coral jurisdictions considered in this opinion, nor do we have an accurate assessment of the reproductive success of existing colonies. The presence of ESA-listed coral colonies and the suitability of sites to attract recruits is affected by a number of biotic and abiotic interacting factors. The distribution and abundance of ESA-listed coral colonies and future recruits of these species cannot be attributed solely to their response to habitat conditions. NMFS also cannot precisely predict the number of colonies of each species that are present in a given habitat area and are reasonably certain to demonstrate physiological responses, or the number of future recruits that are reasonably certain to be affected by the degradation or loss of settlement habitat. It is not feasible to easily determine the number of colonies of each species affected by exposure to habitat damage or loss from activities associated with the proposed action. Further, the effects on future recruitment cannot be readily observed without extensive monitoring of coral spawning and settlement throughout the action area or detailed laboratory experiments. However, many of the activities described in this opinion are intended to increase the number of ESA-listed coral colonies, which would also increase the number of future recruits available to settle in the action area, and the habitat effects described in this opinion will result in very small total areas of habitat affected in each jurisdiction on an annual basis in comparison to the areal extent of critical habitat units and the area within these units likely to contain the PBFs.

Where it is not practical to quantify the number of individuals that are expected to be taken by the action, a surrogate (i.e., similarly affected species or habitat or ecological condition) may be used to express the amount or extent of anticipated take (50 C.F.R. §402.14(i)(1)(i)). A surrogate may be used when the following three conditions are met: the ITS: (i) describes the causal link between the surrogate and take of the listed species; (ii) explains why it is not practical to express the amount or extent of anticipated take or to monitor take-related impacts in terms of individuals of the listed species; and (iii) sets a clear standard for determining when the level of anticipated take has been exceeded.

For projects involving the installation of permanent or temporary in-water structures and their operation, NMFS will use quantitative measurements of the number of projects with activities that affect coral habitat and the area of habitat effects as surrogates of incidental take of the ESA-listed coral species. From NCRMP and other surveys in the action area, we have some site-specific data for the listed coral species considered in this opinion but these data are not collected regularly and cannot be used to estimate the numbers of ESA-listed coral colonies within a given project area or which species are present in a given project area with any certainty. Incidental take caused by indirect (habitat-related) effects of the action on ESA-listed coral species and future recruits cannot be accurately quantified and the distribution and abundance of these species cannot be attributed solely to their response to the effects of installation and operation of temporary and permanent in-water structures. Therefore, specifying the amount of take from indirect effects associated with temporary and permanent in-water structure placement and operation is not practicable. The effects on future recruitment cannot be readily observed without extensive monitoring of reproduction throughout the action area where CRCP or Mission: Iconic Reefs activities involving temporary and permanent in-water structure installation and operation occur, or through laboratory experiments. Because it is not practical to express the amount of anticipated take or to monitor take-related impacts from the installation and operation of temporary and permanent in-water structures in terms of individuals of the different ESA-listed coral species, we must use a surrogate measures to express the amount or extent of incidental take from these activities.

We find it reasonable to assume there is a positive relationship between the areal extent of coral habitat affected by the placement and operation of temporary and permanent in-water structures and the exposure of ESA-listed coral species to indirect effects such as breakage, abrasion, shading, and loss of future recruitment habitat. We have estimates of the amount of habitat area expected to be impacted by the installation of in-water structures (see Section 7.2 for per structure estimates) with total habitat area to be affected by CRCP activities per year estimated as:

- Coral Nurseries:
  - 0.96 m^2 (10 ft^2) of coral habitat in a given year in any jurisdiction from benthic coral nursery structures;
  - 150 m^2 (1,615 ft^2) of coral habitat in CNMI, 90 m^2 (960 ft^2) in Guam, and 22.5 m^2 (242 ft^2) in MHI from metal anchors for a single nursery in a given year; and
  - 750 m^2 (8,073 ft^2) of coral habitat in Florida, 157.5 m^2 (1,695 ft^2) in Puerto Rico, and 244 m^2 (2,626 ft^2) in USVI from metal anchors for a single nursery in a given year.
- Anchors (other than for coral nurseries):
  - 0.22 m^2 (2.37 ft^2) of coral habitat in a given year in any jurisdiction from concrete anchors;
  - 15 m^2 (161.4 ft^2) of coral habitat for mooring buoy anchors in Florida;
  - 3.9 m^2 (42 ft^2) of coral habitat in American Samoa, 4.8 m^2 (51.92 ft^2) in CNMI, 1.39 m^2 (14.97 ft^2) in Guam, 1.35 m^2 (14.5 ft^2) in the MHI, 0.5 m^2 (5.4 ft^2) in the NWHI, and 1.1 m^2 (11.8 ft^2) in the PRIA from metal anchors for in-water equipment mooring in a given year;

- 0.4 m^2 (4.3 ft^2) of coral habitat in Florida, 0.4 m^2 (4.3 ft^2) in the Gulf of Mexico, 1.2 m^2 (13 ft^2) in Puerto Rico, and 1.4 m^2 (15 ft^2) in the USVI from metal anchors for in-water equipment mooring in a given year;

We can use these estimates as surrogates for specifying the amount or extent of incidental take of ESA-listed coral colonies in each jurisdiction based on the type and number of structures to be installed as part of CRCP projects in a given year. We are able to determine when this surrogate measure of take has been exceeded if the calculated habitat area to be affected in a particular jurisdiction in a given year (based on the number and type of temporary and permanent in-water structures installed and operated) exceeds the estimates detailed above. For the foregoing reasons, the three criteria for using a surrogate have been met, and the use of affected habitat area as a surrogate for incidental take of ESA-listed corals is quantifiable and may be monitored, serving the intended role as a reinitiation trigger.

At this time, we are unable to quantify the potential incidental take of ESA-listed fish, specifically Nassay grouper and scalloped hammerhead shark, as bycatch in fishing gear. There could be lethal or non-lethal take of adult and juvenile Nassau grouper and juvenile and neonate scalloped hammerhead shark in years when some of these activities are implemented. However, because projects using fishing gear will require project-specific review and may require tiered consultations, we will determine the amount of incidental take of these species as part of future project-specific reviews and tiered consultations, as applicable.

The take listed above does not include take resulting from the implementation of novel coral restoration and recovery activities or any changes in technology or methods as part of activities that are otherwise as described in this opinion. This take will be determined during tiered consultations. We anticipate all life stages of ESA-listed corals will experience lethal or non-lethal take as a result of these activities, though most of this will be directed take. Similarly, we anticipate adverse effects to elkhorn and staghorn critical habitat and proposed coral critical habitat from some activities, such as the installation of shade cloths and those requiring installation of anchor systems or other alteration of habitat that may result in take of ESA-listed coral colonies or future recruitment. Any associated take would be part of future tiered consultations as well.

Section 7(b)(4)(C) of the ESA provides that take of ESA-listed marine mammals may be included in the ITS of a biological opinion only if the taking is authorized under section 101(a)(5) of the MMPA. At this time, we do not anticipate impacts to ESA-listed marine mammals from the proposed activities but, if the activities change in the future or if new information becomes available indicating that take of marine mammals will occur as a result of the proposed action, a tiered consultation would be required and no incidental take under the ESA could occur until and unless MMPA authorization is granted.

11.2 Reasonable and Prudent Measures

The RPMs described below must be undertaken by the CRCP, ONMS, NCCOS, and OHC, as applicable, 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, necessary or appropriate RPMs and Terms and Conditions to implement the measures must be provided. Only incidental take resulting from the agency actions and any specified RPMs and Terms and Conditions identified in the Incidental Take Statement are exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA.

Reasonable and prudent measures are measures that are necessary or appropriate to minimize the amount or extent of incidental take (50 C.F.R. §402.02). NMFS believes the RPMs described below are necessary and appropriate to minimize the impacts of incidental take on Nassau grouper, scalloped hammerhead shark (Indo-West Pacific and Central and Southwest Atlantic DPSs), and ESA-listed corals:

1. The CRCP, ONMS, NCCOS, and OHC shall implement the optional BMPs described in Section 3.2.6 as required measures, as appropriate, to minimize the potential take of ESA-listed corals, Nassau grouper and scalloped hammerhead shark. The CRCP, ONMS, NCCOS, and OHC shall require that organizations receiving funding or authorization for the activities that are part of this consultation comply with all BMPs in Sections 3.2.6 and 3.5.1 rather than being recommended to do so.
2. Additional measures to minimize effects to ESA-listed corals and their habitat associated with potential collisions, installation and operation of in-water structures and equipment, placement of temporary structures and use of fishing gear, and removal of or damage to substrate as described in this opinion shall be implemented prior to commencement of these activities in fiscal year 2022 to the extent practicable. Any changes to these in-water activities from those described in this opinion would require project-specific review and potentially tiered consultation.
3. Existing coral nurseries and other in-water structures and their associated anchor systems shall be evaluated to determine the extent of effects to ESA-listed coral colonies and their habitat due to the proximity of in-water structures. Based on the results of the evaluation, changes to nurseries and other in-water structures and anchor systems may be developed in cooperation with OPR and the applicable region(s) to minimize effects.
4. For projects commencing after the date consultation is concluded, CRCP and other NOAA entities funding, authorizing, and carrying out Mission: Iconic Reefs activities

shall monitor the effectiveness of these measures as described below in the Terms and Conditions.

11.3 Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, the Federal action agency (i.e., CRCP, NCCOS, ONMS, and OHC) must comply (or must ensure than any grantee or other entity funded or authorized by one of these agencies complies) with the following terms and conditions, which implement the RPMs described above. These include the take minimization, monitoring and reporting measures required by the section 7 regulations (50 C.F.R. §402.14(i)). The terms and conditions detailed below for each of the RPMs include monitoring and minimization measures where needed.

1. To implement RPM #1, the language of the optional BMPs (Section 3.2.6) will change to shall. Documentation of implementation of BMPs (Sections 3.2.6 and 3.5.1) applicable to particular projects and any issues with implementation that may require modification of BMPs as part of regular programmatic reviews will be part of required project reports to CRCP or Mission: Iconic Reefs for those receiving funding or authorization to improve compliance with implementation of these avoidance and minimization measures to be protective of ESA-listed corals.
2. To implement RPM #2, additional measures to minimize potential effects to ESA-listed corals and their habitat from collisions, installation and operation of in-water structures and equipment, placement of temporary structures, and removal of or damage to substrate shall include the following requirements, where applicable:
    a. The operation of towed equipment will be done in water depths and along routes selected to minimize potential collisions with known locations of ESA-listed coral colonies.
    b. During surveys involving towing equipment, boats will travel between 2-3 knots and self-propelled equipment such as ROVs and AUVs will operate at similar speeds.
    c. Towed and self-propelled equipment will operate at the water surface if the water depth is less than 1 m (4 ft) to ensure clearance from the marine bottom or the tops of coral colonies.
    d. Any known collisions with ESA-listed coral colonies or coral habitats will be documented, including the location, water depth, vessel or instrument (i.e., AUV, ROV) speed, weather and sea state, photographs and an assessment of the damage to ESA-listed coral colonies or coral habitat that includes the size of the impact area or measurements of the coral colony damaged as a result of a collision if a safe means to collect such information is available. This information will be

submitted to OPR, OHC, and the relevant region(s) within 48 hrs of any collisions.

e. Biological sampling involving the removal of hard substrate, when done in areas containing ESA-listed coral colonies or when targeting ESA-listed coral colonies, will include marking or recording the location of sample collection. If practicable, the same principal investigator or someone who is familiar with the original sampling would conduct opportunistic monitoring to assess the effects of sampling when sites are visited during other activities covered under this consultation.

f. Pre- and post-installation surveys will be conducted to document the location of any new ESA-listed coral colonies relative to the final location of in-water structures and their components such as anchors. The anchor point locations will be inspected prior to installation activities to ensure no new ESA-listed coral recruits are present. If recruits are present, the area will be surveyed to select a new anchor point or points. Post-installation surveys will assess whether new colonization has occurred within 3 m (10 ft) of an anchor point and its tackle to determine whether the movement of the anchor tackle will impact new recruits and, if so, whether a new anchor location should be selected to minimize these effects.

g. Contingency measures will be included in all projects that intend to install in-water structures for periods of months to years. Measures should include the removal or redesign of structures if opportunistic monitoring finds they are causing damage to ESA-listed coral colonies or their habitat from interactions with gear or shading. If measurable effects from gear interaction or shading are observed, reinitiation of consultation may be necessary.

h. All operations involving installation and subsequent removal of in-water structures will be conducted in a way that will minimize contact with the seafloor and surrounding benthic organisms, including ESA-listed corals.

i. All in-water structures must be removed to the extent practicable once they are no longer in use. If metal anchors were installed in hard substrate, the anchor may be left in place with all tackle removed if the removal of the anchor would damage the habitat. If concrete anchors were deployed and can be removed without damaging the substrate, they should be removed and any ESA-listed corals that have colonized them should be transplanted to suitable substrate. If concrete anchors cannot be removed without damaging the substrate, they should be opportunistically inspected to ensure they are not causing damage to surrounding habitat. If damage due to the presence of these anchors is observed, a tiered consultation will be required to evaluate these effects. Removal of in-water structures shall occur in compliance with any permits that authorized installation.

j. ESA-listed coral recruits on tackle or other structures not intended for specific coral research projects that are maintained and eventually removed from the water, will be removed from the man-made structure and transplanted to nearby natural hard substrate (or to a coral nursery structure) as feasible.

k. If a lift bag/balloon is used for installation and/or removal of in-water structures, divers will inflate it and guide components to the seafloor or to the water surface during deployment/retrieval from a vessel. A lift bag/balloon will only be used in areas with a water depth of 1.2 m (4 ft) or greater and no ESA-listed corals within approximately 3 m (10 ft) of the location for installation of structures.

l. Floating lines made of polypropylene or suitable substitute will be used during actions using lift bags/balloons to prevent lines from affecting benthic habitat.

m. Nets and lines for sampling fish will only be used in coral habitat if the gear will be used at or near the water surface in a way that will not result in interactions with ESA-listed corals or their habitat.

3. To implement RPM #3, data will be collected as part of the first programmatic report upon completion of this consultation for existing coral nurseries and other in-water structures that are being operated or funded by CRCP, ONMS, NCCOS, and/or OHC for which an ESA section 7 consultation has not already been completed, and installation of new coral nurseries and other in-water structures. These data will be used to determine whether the installation and operation of the structures are adversely affecting ESA-listed corals and their habitat.

   a. The evaluation will include an assessment of the distance from all in-water structures at a given site to naturally-occurring ESA-listed coral colonies and habitat containing the PBF for elkhorn and staghorn critical habitat and/or for proposed critical habitat for Atlantic/Caribbean or Indo-Pacific corals, depending on the location of the nursery.

   b. The evaluation will also include information regarding maintenance of the structures, including information regarding movement of or damage to the structures due to storms, design flaws, proximity to live bottom, recreational vessels or other factors in the area (e.g., anchor drag, marine debris, fishing gear). This information could include whether movement resulted in transport of nursery components to coral habitats and/or damage to ESA-listed corals, the frequency of events, and component failure that necessitated maintenance of structures and led to potential effects to ESA-listed corals or abrasion due to the proximity of components to live bottom, if such information is available.

c. A report containing the results of the evaluation will be submitted to NMFS (OPR and the applicable regions). The report should include, based on the frequency of loss or movement of specific structures due to component failures or storms or due to the proximity of structures to live bottom, a determination as to whether there are any in-water structures, including coral nurseries, for which the location and/or design of the structures should be altered in order to minimize the potential for these to continue occurring in order to reduce potential effects to ESA-listed corals and their habitat.

d. If the results of the evaluation find that measurable effects to coral habitat (as the surrogage for ESA-listed coral colonies) are occurring due to breakage, abrasion, shading, or other damage caused by the installation and operation of coral nurseries and other in-water structures, the CRCP, NCCOS, ONMS, and/or OHC, as applicable, will coordinate with OPR and the applicable region(s) to determine the course of action needed to minimize the effects. Changes may include alterations to the location, design, or operation of coral nurseries and other in-water structures and anchor systems. The required BMPs will be updated to incorporate any changes, as applicable. If the evaluation finds that the surrogate for take of ESA-listed corals is exceeded as a result of the installation and operation of in-water structures, reinitiation of consultation is required.

4. To implement RPM #4, the CRCP, ONMS, NCCOS, and OHC must provide NMFS with data collected as part of all monitoring required under these terms and conditions as described above, as well as any monitoring reports generated over the lifetime of the project and following project completion, including as part of the programmatic reviews to be conducted for this consultation.

12 Conservation Recommendations

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. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on ESA-listed species or critical habitat, to help implement recovery plans or develop information (50 C.F.R. §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 CRCP or the NOAA agencies engaged in Mission: Iconic Reefs activities, where applicable:

1. If sea turtles, marine mammals, or ESA-listed fish are active in close proximity to the planned deployment site for fishing gear, deployment of gear will be delayed until the animals are no longer observed in the area or a period of 30 min has passed. If sea turtles or marine mammals are active in close proximity to a trap, it will be temporarily pulled to

avoid possible entanglement. Entanglement of ESA-listed species may require reinitiation of consultation.

2. If a sea turtle or marine mammal is observed in close proximity to towed or self-propelled equipment, the equipment will be returned to the work vessel until the animal has exited the area of its own accord and has not been seen for 30 min.
3. Vessels used during activities under the proposed action should maintain a log detailing sightings of ESA-listed species in marine habitats. The log should include, but not be limited to, the following: date and time, location coordinates using a GPS unit, species identification to the extent possible or to lowest known taxon level when not possible to identify to genus and/or species, behavior of the animals when observed, one or more photographs (if possible), and any actions taken because of sighting the animals. Copies of the logs should be submitted to NMFS OPR ESA Interagency Cooperation Division and the appropriate regions as part of programmatic reporting requirements.
4. Any collisions with and/or injury to a marine mammal or sea turtle shall be reported immediately to the appropriate NMFS office and local authorized stranding/rescue response organizations (see https://www.fisheries.noaa.gov/report for regional contact information for reporting). Personnel engaged in activities associated with the proposed action when sightings of injured or dead animals occur should report these sightings immediately to NMFS and the appropriate local authority regardless of whether the injury/death was caused by activities that are part of this consultation. Collisions with ESA-listed fish should also be reported to NMFS.
5. When planning transit routes, deep water routes should be preferentially selected where possible.
6. A bow-mounted video camera with real-time feed to the surface and/or a forward-facing camera with real-time feed mounted on towed or self-propelled equipment may be used to monitor during surveys to ensure the equipment is operating at the desired elevation above the seafloor and that contact with the seafloor and any obstacles (including corals) is avoided, particularly when performing operations in shallow waters or in areas with variable relief.
7. Turbidity should be visually monitored underwater during in-water and watershed construction activities. In the event prolonged sediment plumes above natural concentrations are generated and persistent for periods longer than those observed during storms in the project area because of the activity, construction activity should cease and measures to reduce turbidity should be implemented prior to commencing the activity again.
8. Success monitoring of outplanted corals should be conducted on an opportunistic basis or as part of a monitoring plan developed for outplants. Monitoring should 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 or bleaching, 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.

9. CRCP should use a mapping application to track the location of CRCP-funded projects so that scientists, students, and others can use these sites to perform coral monitoring activities to supplement data from the completed CRCP projects.

In order for NMFS Office of Protected Resources Interagency Cooperation Division to be kept informed of actions minimizing or avoiding adverse effects on, or benefiting, ESA-listed species or their critical habitat, the CRCP, ONMS, OHC, and/or NCCOS (as applicable) should notify the Interagency Cooperation Division of any conservation recommendations they implement in their final action.

13 Reinitiation Notice

This concludes formal programmatic consultation with the CRCP for implementation of program activities, and the CRCP, ONMS, NCCOS, and OHC (Restoration Center) for the implementation of Mission: Iconic Reefs activities as described in Section 3 of this opinion. Consistent with 50 C.F.R. §402.16(a), reinitiation of formal consultation is required and shall be requested by the Federal agency, where discretionary Federal involvement or control over the action has been retained or is authorized by law and:

(1) The amount or extent of taking specified in the incidental take statement is exceeded.
(2) New information reveals effects of the agency action that may affect ESA-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.
(4) A new species is listed or critical habitat designated under the ESA that may be affected by the action.

This opinion considered the effects of the action on proposed critical habitat for Atlantic/Caribbean and Indo-Pacific corals. If those designations are finalized, the opinion will be updated to reflect this and to address any changes based on the final designations.

14 Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. Under the MSA, this consultation is intended to promote the conservation of EFH as necessary to support sustainable fisheries and the managed species' contribution to a healthy ecosystem. For the purposes of the MSA, EFH means "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity," and includes the physical, biological, and chemical properties that are used by fish (50 C.F.R. §600.10). Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 C.F.R. §600.810). Section 305(b) of the MSA also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH. Such recommendations may include measures to avoid, minimize, mitigate, or otherwise offset the adverse effects of the action on EFH (50 C.F.R. §600.905(b)).

This analysis is based, in part, on the descriptions of EFH designated by the WPRFMC, the Gulf Council, the SAFMC, and the CFMC, and highly migratory species for portions of the action area where each council has jurisdiction and contained in the FMPs developed by these councils and approved by the Secretary of Commerce.

14.1 Essential Fish Habitat Affected by the Project

The proposed action and action area for this consultation are described in Section 3 and 4 of this document. The action area includes areas designated as EFH for various species in the Atlantic, Caribbean and Pacific and HAPCs designated by the Gulf Council, SAFMC, and CFMC. EFH in the action area includes wetlands, submerged aquatic vegetation, coral habitats, and the marine water column where CRCP activities will take place throughout the seven U.S. coral jurisdictions.

14.2 Adverse Effects on Essential Fish Habitat

The effects analyses in Sections 5 and 7 describe the adverse effects of the proposed action on ESA-listed species, designated critical habitat, and EFH. Some of the ESA-listed species are also managed under the MSA and are included in FMPs, and which have designated EFH. Additionally, some designated critical habitat overlaps with designated EFH in U.S. coral jurisdictions. Because of the breadth of species covered in this opinion and the overlap between ESA-listed species, designated critical habitat and EFH, we are reasonably certain the effects analysis is relevant to the effects of the proposed action on EFH.

While the ESA analysis of effects is relevant to EFH, there will be some additional or distinct effects to EFH or HAPCs, which are noted in Sections 5 and 7.

14.3 Essential Fish Habitat Conservation Recommendations

Some impacts to EFH have already been minimized as part of the proposed action because of the required implementation of BMPs developed by the CRCP (identified as PDCs in Section 3.5.1) and some impacts cannot be minimized. However, because there are no ESA-listed corals in the the eight Main Hawaiian Islands, we determined that EFH conservation recommendations are necessary to avoid, minimize, mitigate, or otherwise offset the adverse effects on EFH from implementation of program activities as described in Section 3 of this opinion.

The following EFH Conservation Recommendations should be applied to CRCP's activities that occur in the eight Main Hawaiian Islands where all hardbottom habitats are designated as EFH, in order to provide protection for coral reefs where EFH is designated but corals are not ESA-listed.

<u>EFH Conservation Recommenation 1</u>

For activities in the eight Main Hawaiian Islands, the CRCP should implement the following "optional" BMPs that are described in Section 3.2.6 in addition to the applicable "required" BMPs that are described in Section 3.5.1; such that receiving funding or authorization for the activities that are part of this consultation will also require implementation.

i. Scuba and snorkel operations:
    a. The dive team lead will make sure that underwater conditions (e.g., visibility, current speeds) and weather are suitable for diving to ensure the safety of divers and their ability to avoid damaging sensitive underwater habitats.
    b. The point of entry and exit will be carefully selected to avoid damaging coral.
    c. During all in-water activities, participants in education programs and other activities should avoid stepping on/standing on corals, and kicking coral colonies while swimming.

ii. Instruments Moored to the Seafloor:
    a. The installation and removal of in-water structures for research equipment should be performed by divers; all equipment should be removed to the extent practicable once the study is complete. Removal of in-water structures will comply with any permits that authorized their installation.

iii. Coral Nursery:
    a. Project leads will need to obtain all permits, including verification of USACE permit requirements for development or expansion of in-water nurseries.
    b. New coral nursery sites shall be selected in a way that minimizes potential adverse effects of the installation and operation of the site on coral colonies and their habitat. New nursery sites and modifications to existing coral nurseries will be preferentially located in areas of unconsolidated substrate (i.e., sand or coral

rubble) with no seagrass, corals, sponges, or other sessile benthic organisms growing on substrate.

   i. The siting and design of new nursery sites should be in keeping with oceanographic and physical characteristics of the site and should account for storm conditions in the area to prevent damage and loss of structural components that could become tangled on coral colonies and their habitat. Coral nurseries will not be placed in locations where the typical sea state is often rough and may result in frequent damage to or movement of the structures.

c. The combined area of individual structures in a single coral nursery, regardless of configuration, will not occupy more than one acre of seafloor at a single site unless in uncolonized sand bottom. Staging and work areas (i.e., areas not occupied by a structure) for nursery construction, maintenance, and monitoring are not included in this size limit. New nurseries or modifications to existing nurseries that would require installation of structures in or shading of coral habitat, should initiate a supplemental EFH consultation with PIRO.
d. The installation of in-water structures will be performed by divers.
e. A nursery maintenance and monitoring plan will be developed for each coral nursery or for a region and will include the applicable required BMPs (Section 3.5.1) such as those for divers and vessel operation, and a training plan for all personnel and volunteers who will be involved in the creation, operation, and/or maintenance of the nursery. The plan should include information regarding the schedule and methodology for removal of structures that are no longer needed, functional, or of a design that has become obsolete.

   i. The removal of in-water structures will be performed by divers. Structures will be removed when no longer in use or when the condition of the structures is such that they are no longer functional due to age or storm damage, for example.

f. Structures should be constructed in a manner that ensures the structures will not move or flip during storm events or due to human impacts such as anchor drag:

   i. Stabilization of structures can be achieved with the use of weights and/or penetrating anchor systems such as Duckbill® or Helix® anchors or rebar driven to sufficient depth to prevent movement or lifting of the structures.

g. Anchors for new, long-term coral nursery structures (e.g., trees in a coral nursery) will be installed only in uncolonized, unconsolidated bottoms. Anchors and associated tackle and any associated swing radius, if applicable, will not be within 15.2 m (50 ft) from hard bottom and coral reef habitats to avoid potential impacts from movement of structures or their components during regular wave and current movement. Anchors shall be inspected at least twice a year and following large storm events to ensure that anchors and the nursery structures they support are still in place and have not moved to areas containing corals where they could cause damage.

iv. Coral Restoration/Transplantation/Relocation:
   a. Restoration projects should ensure suitable site selection (e.g., not selecting a location where corals were not in existence) and follow-up monitoring (and, when applicable, include monitoring of the control sites where corals were collected from, a scientific hypothesis, and experimental design) to ensure that lessons learned from the project can be applied to future efforts, thereby mitigating their potential for causing significant adverse impacts.

v. When relocating, avoid placing the transplanted corals and any required equipment (e.g., tools, sensors, weights, etc.) on live habitat-forming organisms such as corals or sponges.

vi. When transporting live coral either from a collection site to a nursery or a nursery to an outplanting site:
   a. Corals should be handled as little as possible.
   b. Coral colonies/fragments should not be in contact with each other to prevent additional harm to their structures and tissue.
   c. If a bucket or container is used for transportation and transportation will be above water (such as on a vessel to get from the origin site to the transplant site), the seawater should be routinely changed to avoid prolonged exposure to increased water temperatures.
   a. Corals should be reattached the same day they are removed or stored at *in-situ* or *ex-situ* nurseries, or other appropriate temporary holding facilities, with appropriate conditions to promote health (e.g., water flow).

vii. Coral Fragment Collection:
   a. Monitor, if possible, the parent coral colonies from which samples have been taken to track and record whether tissue regeneration across the lesions has occurred.

viii. Reduce Impacts of Biological Sampling-Related Fishing Gear:
   a. Nets should be monitored at all times to ensure they do not become entangled with corals. If entanglement does occur, cut the net rather than damage corals.

ix. Bottom Sediment Sample Collection:
   a. Minimize collecting bottom samples in seagrass.

x. For projects that may temporarily increase sedimentation:
   a. Due to the high risk of sedimentation or suspended material, operations should be halted during peak stony coral mass spawning periods in the region where sampling will occur to the extent practicable. To allow for coral recruitment, sediment-generating activities should be limited for a three-week period after the primary spawning event as much as possible.

b. Avoid sediment-generating activities during known soft coral spawning periods if soft corals are observed at or near the site. Sediment-generating activities should be restricted for three weeks beginning one week after the full moon of each spawning period to protect the spawning season for soft corals if they are present to the extent practicable.

xi. Buoy Installation:

a. Buoys should be preferentially installed in uncolonized, unconsolidated bottom.
b. If the bottom tackle is longer than 3 m (10 ft), the installation site should include a circular buffer with a radius equal to the length of the tackle. Buoys should be preferentially installed at locations with no or low vertical relief and no live coral colonization within a 3 m (about 10 ft) of the estimated swing radius of anchor chain or other tackle to avoid breakage or abrasion of sessile benthic organisms from the movement of buoy and tackle.
c. All buoy mooring systems with ground tackle should have floats/subsurface buoys on the lines or anchor chains to prevent any tackle from dragging on the bottom. The float/subsurface buoy should be attached to the buoy chain above the chain attachment point to the bottom anchor in order to prevent the anchor chain from dragging on the seafloor should the chain become detached from the anchor.
d. A helical screw anchor, duckbill anchor, or drill and epoxied pin anchor, depending on substrate type, should be used to minimize the footprint of the anchor in the marine bottom.
e. GPS locations will be collected for the buoys once installation is complete. Monitoring of buoys should be done from the surface and using divers on an opportunistic basis, including following storms, to determine whether buoys moved and require reinstallation.

xii. Watershed Restoration Activities:

a. Avoid using products with large concentrations of pesticides.
b. Avoid planting vegetation when a storm is approaching.

<u>EFH Conservation Recommenation 2</u>

For activities in the eight Main Hawaiian Islands, the CRCP should implement the following additional measures to minimize effects to EFH associated with potential collisions, installation and operation of in-water structures and equipment, placement of temporary structures and use of fishing gear, and removal of or damage to substrate consistent with the Terms and Conditions (see Section 11.3) that implement the Reasonable and Prudent Measures #1, 2, and 4 of the ITS:

i. The operation of towed equipment should be done in water depths and along navigation routes selected to minimize potential collisions with corals designated as EFH.
ii. During surveys involving towing equipment, boats should travel between 2-3 knots and self-propelled equipment such as ROVs and AUVs should operate at similar speeds.

iii. Towed and self-propelled equipment should operate at the water surface if the water depth is less than 1 m (4 ft) to ensure clearance from the marine bottom or the tops of coral colonies.

iv. Any known collisions with coral colonies or coral habitats will be documented, including the location, water depth, vessel or instrument (i.e., AUV, ROV) speed, weather and sea state, photographs and an assessment of the damage to coral colonies or coral habitat that includes the size of the impact area or measurements of the coral colony damaged as a result of a collision if a safe means to collect such information is available. This information will be submitted to OPR, OHC, and the relevant region(s) within 48 hrs of any collisions.

v. Biological sampling involving the removal of hard substrate, when done in areas containing coral colonies or when targeting coral colonies, will include marking or recording the location of sample collection. If practicable, the same principal investigator or someone who is familiar with the original sampling would conduct opportunistic monitoring to assess the effects of sampling when sites are visited during other activities covered under this consultation.

vi. All operations involving installation and subsequent removal of in-water structures will be conducted in a way that will minimize contact with the seafloor and surrounding benthic organisms, including corals.

vii. All in-water structures must be removed to the extent practicable once they are no longer in use. If metal anchors were installed in hard substrate, the anchor may be left in place with all tackle removed if the removal of the anchor would damage the habitat. If concrete anchors were deployed and can be removed without damaging the substrate, they should be removed and corals that have colonized them should be transplanted to suitable substrate. If concrete anchors cannot be removed without damaging the substrate, they should be opportunistically inspected to ensure they are not causing damage to surrounding habitat.

viii. Corals that grow on tackle or other structures not intended for specific coral research projects that are maintained and eventually removed from the water, will be removed from the man-made structure and transplanted to nearby natural hard substrate (or to a coral nursery structure) as feasible.

ix. If a lift bag/balloon is used for installation and/or removal of in-water structures, divers should inflate it and guide components to the seafloor or to the water surface during deployment/retrieval from a vessel. A lift bag/balloon will only be used in areas with a water depth of 1.2 m (4 ft) or greater and with no corals designated as EFH within approximately 3 m (10 ft) of the location for installation of structures.

x. Floating lines made of polypropylene or suitable substitute will be used during actions using lift bags/balloons to prevent lines from affecting benthic habitat.

xi. Nets and lines for sampling fish will only be used in coral habitat if the gear will be used at or near the water surface in a way that will not result in interactions with corals designated as EFH.

Required Response to EFH Conservation Recommendations

As required by section 305(4)(B) of the MSA, the CRCP activities that are part of the proposed action considered in this consultation must provide a detailed response in writing to OHC within 30 days after receiving EFH Conservation Recommendations. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of our EFH Conservation Recommendations unless the Federal agency and NMFS have agreed to use alternative timing for the Federal agency response. The response must include a description of the measures proposed by the agency for avoiding, minimizing, mitigating, or otherwise offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the Conservation Recommendations, the Federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with us over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects (40 C.F.R. §600.920(k)(1)).

14.4 Supplemental Consultation

The CRCP and/or NOAA agencies or programs conducting Mission: Iconic Reefs activities that are part of the proposed action must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for our EFH Conservation Recommendations (50 C.F.R. §600.920(l)).

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