UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
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St. Petersburg, Florida 33701-5505
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F/SER31: KL

MAY 08 2017

Ingrid Gilbert
Chief, Miami Permits Section
Jacksonville District Corps of Engineers
U.S. Department of the Army
9900 Southwest 107th Avenue, Suite 203
Miami, Florida 33176

Dear Sir or Madam:

The enclosed Biological Opinion ("Opinion") responds to your request for consultation with us, the National Marine Fisheries Service (NMFS), pursuant to Section 7 of the Endangered Species Act for the following action.

Permit Number	Applicant	SER Number	Project Type(s)
SAJ-2006-06547	Port of Miami	SER-2016-17891	Port of Miami Bulkhead Realignment

The Opinion considers the effects of bulkhead realignment at the Port of Miami (POM) on the following listed species: sea turtles, smalltooth sawfish, mountainous star, boulder star, and lobed star corals. NMFS concludes that the proposed action is not likely to adversely affect sea turtles and smalltooth sawfish. NMFS also concludes that the proposed action is not likely to jeopardize the continued existence of mountainous star, boulder star, and lobed star corals.

We look forward to further cooperation with you on other projects to ensure the conservation of our threatened and endangered marine species and designated critical habitat. If you have any questions on this consultation, please contact Kelly Logan, Consultation Biologist, by phone at 727-460-9258, or by email at Kel.Logan@noaa.gov.

Sincerely,

For Roy E. Crabtree, Ph.D.
Regional Administrator

Enclosure (s) Enc.: Biological Opinion
cc: Jocelyn.Karazsia@noaa.gov
File: 1514-22.F.4

Endangered Species Act - Section 7 Consultation
Biological Opinion

Action Agency: United States Army Corps of Engineers, Jacksonville District (USACE)

Activity: Bulkhead Realignment, POM, Miami, Dade County, Florida.

Consulting Agency: Protected Resources Division
Southeast Regional Office
National Marine Fisheries Service

Consultation Number SER-2016-17891

Approved by:

For Roy E. Crabtree, Ph.D., Regional Administrator
NMFS, Southeast Regional Office
St. Petersburg, Florida

Date Issued: May 8, 2017

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Acronyms and Abbreviations

DPS	Distinct Population Segment
ESA	Endangered Species Act
EPA	Environmental Protection Agency
NAD	North American Datum
NMFS	National Marine Fisheries Service
POM	Port of Miami
PRD	Protected Resources Division
SE	Standard Error
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service

Units of Measurement

cm	centimeters
cm^2	Square centimeters
ft	Feet
ft^2	Square feet
in	Inches
m	Meter
m^2	Square meters

Background

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

Consultation is required when a federal action agency determines that a proposed action "may affect" listed species or designated critical habitat. Consultation is concluded after NMFS determines that the action is not likely to adversely affect listed species or critical habitat or issues a Biological Opinion ("Opinion") that identifies whether a proposed action is likely to jeopardize the continued existence of a listed species, or destroy or adversely modify critical habitat. If either of those outcomes is projected, NMFS must identify reasonable and prudent alternatives to the action as proposed that avoid jeopardy or destruction or adverse modification. The Opinion states the amount or extent of incidental take of the listed species that may occur, develops measures (i.e., reasonable and prudent measures - RPMs) to reduce the effect of take, and recommends conservation measures to further the recovery of the species. .

This document represents NMFS's Opinion based on our review of impacts associated with the proposed action to issue a permit within Miami Dade County, Florida. This Opinion analyzes the project's effects on threatened and endangered species and designated critical habitat, in accordance with Section 7 of the ESA. We based it on project information provided by the USACE, the consultant, and other sources of information, including the published literature cited herein.

1. CONSULTATION HISTORY

We received your letter requesting consultation on April 7, 2016. Updated project information was received via emails dated May 9 and 18, 2016, and November 17, 2016, and we initiated formal consultation on the latter date.

2. DESCRIPTION OF THE PROPOSED ACTION AND ACTION AREA

2.1 Proposed Action

The applicant intends to realign the bulkhead at the POM on north side of Dodge Island in order to accommodate larger cruise ship vessels. The work will be completed in 4 phases (Figure 1) and includes the following:

Phase 1: Construct a new cruise berth 7 that will begin at station 72+40, and extend approximately 1,460 feet (ft) east along the north side of the Port ending at station 87+00. Construction includes the rehabilitation and re-alignment of approximately 1,225 ft of bulkhead, creation of approximately 235 ft of new bulkhead behind an existing riprap revetment, and the construction of approximately 230 ft of temporary return wall to connect with the riprap revetment to the east with approximately 30 ft of new riprap. The realignment of the bulkhead will require the removal of 144,000 square feet (ft^2) of upland material in the area between the existing bulkhead and the new bulkhead and 42,000 ft^2 of dredging to the depth of approximately -37 ft. The realignment of the bulkhead on the western end of the project will require 4,555 ft^2 of fill behind approximately 280 ft of new bulkhead that is 15 ft waterward (north) of the existing bulkhead. This phase is expected to take up to 16 months for construction.

Phase 2: Construction of a new cruise berth 8 east of berth 7. Berth 8 will measure approximately 1,460 ft beginning at station 87+00. The temporary return wall constructed for berth 7 will be removed and a new approximately 240 ft return wall will be constructed on the eastern end. Construction includes installation of a new bulkhead, removal of approximately 290,000 ft^2 of uplands, and dredging 126,000 ft^2 of material to a depth of approximately -37 ft. Phase 2 is expected to last up to 16 months for construction.

Phase 3: Extension of berth 7 westward 287 ft. including extending the bulkhead northward by approximately 178 ft and placing approximately 51,100 ft^2 of fill behind the new bulkhead. Phase 3 is expected to take 6 months to complete.

Phase 4: Rehabilitation of the existing berths 1-6. Work includes moving the existing 86,840-ft bulkhead northward by approximately 54 ft. and placing 370,000 ft^2 of fill behind the new bulkhead. Phase 4 is expected to take up to 6 months to complete.

The applicant will adhere to NMFS's *Sea Turtle and Smalltooth Sawfish Construction Conditions.* Prior to the commencement of construction activities, floating turbidity barriers shall be installed in conformance with the terms and conditions of the regulatory permits and the turbidity control plan for the project. Turbidity monitoring will be performed in accordance with permit requirements. In-water work will be stopped if turbidity measurements exceed allowable limits above background as described in Florida Department of Environmental Protection water quality certification and the USACE's permit conditions. Dredging will only occur in Phases 1 and 2 using a mechanical dredge. All dredged material will be disposed of at an upland site. Pile installation will occur in open water or on land; details are provided in Table 1 below. Work in the uplands may continue 24 hours per day, but the USACE and the applicant state that all in-water work will occur only during daylight hours.

The proposed project also includes required mitigation in the form of construction of an 83,750 ft^2 artificial reef using reef modules to be placed within an existing permitted artificial reef site located in approximately 25 ft water depth north of the main channel in the Atlantic Ocean. The artificial reef site does not contain any seagrass or coral resources other than previously permitted artificial reef modules. Reef modules will consist of gabion stainless steel baskets that will be filled with rip rap boulders. These baskets will be closed on all sides except for the top which will be layered with the rip rap coral-laden boulders. Miami Dade Department of Environmental Resources requires that no boulders smaller than 36 inches (in) diameter shall be placed on the open top of the baskets unless they have been tightly wedged between the larger 36 in boulders. This requirement is to ensure that the reef modules do not pose a risk of entrapment for sea turtles. Reef materials will only be placed within the previously permitted artificial reef site on sandy bottom. The applicant has agreed to conduct reef cleanup activities to remove any derelict fishing gear at 6 months, 1 year, and 2 years post installation of artificial reef materials.

Hard and soft corals and sponges are living on the existing bulkhead and rip rap and within the 150 meter (m) mixing zone. As a condition of this Opinion, prior to construction, all ESA listed corals identified during relocation field work, will be relocated to a transplantation site on the eastern end of the Port on Dodge Island and monitored for survivorship in accordance with the attached coral relocation plan (Appendix A) and the monitoring plan (Appendix B). All non-ESA listed corals over 10 centimeters (cm) will also be relocated as per the applicant's coral relocation and monitoring plan (Appendix B). The existing rip rap within Phases 1 and 2 that have corals on the rip rap will also be moved to the artificial reef site.

According to the biological resources assessment dated March 2016, there are approximately 11 colonies of *Orbicella* coral (not identified to the species level) within the action area. *Orbicella* corals were only found on the existing bulkheads, none were found growing on rip rap. Although only 3 colonies of *Orbicella* were found during the surveys, the survey area only included a portion of the project area. Extrapolating to the total area of the bulkheads (8,454 square meters [m^2]) gives us a density of 0.001 colonies per m^2, or 11 colonies, within the project area. The terms and conditions of this Opinion will require relocation of all ESA listed corals located during the relocation field work. The project does not contain mangroves or seagrass.

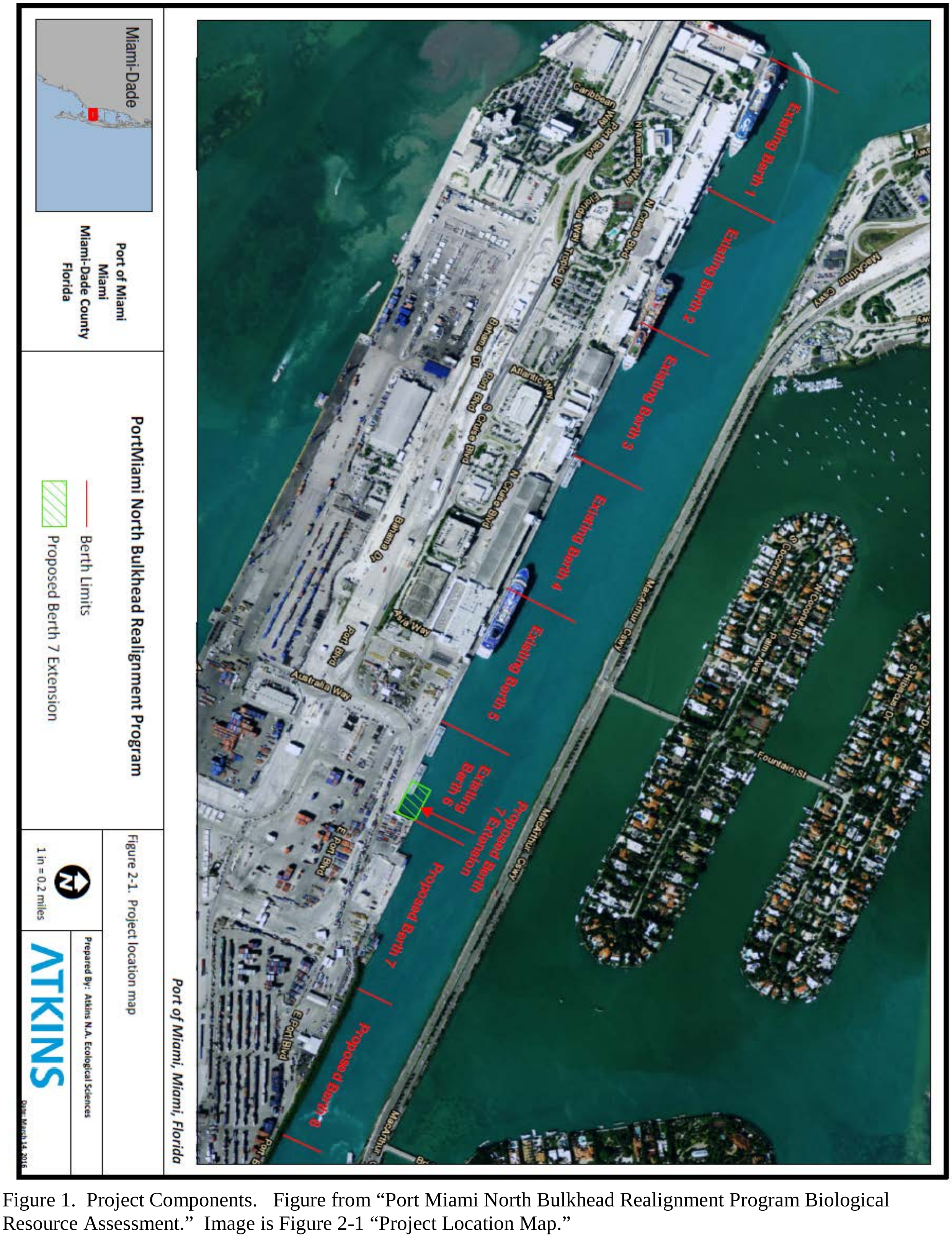

Figure 1. Project Components. Figure from "Port Miami North Bulkhead Realignment Program Biological Resource Assessment." Image is Figure 2-1 "Project Location Map."

Table 1. Pile Sizes and Installation Methodology.

Pile Material	Installation Method	Number of piles	Pile size, (in)	Maximum number of piles to be driven per day	Average number of strikes per pile
Metal	Vibratory Hammer and Impact Hammer	153 - Berth 7 on land – final installation depth on all piles is -60 ft	42	The piles will be initially installed using a Vibratory Hammer and predrilled to 57 ft. The last 3 ft (installation to 60 ft) will be installed using an Impact Hammer	90 – based upon Florida Department of Transportation guidance of an estimated 30 strikes per foot X 3 ft = 90 strikes
Metal	Vibratory Hammer and Impact Hammer	50 – Berth 7 in open water; installation will start at -37 ft and final installation depth is -60 ft	42	5 - the piles will be initially installed using a Vibratory Hammer and predrilled to 57 ft. The last 3 ft (installation to 60 ft) will be installed using an Impact Hammer	90 – based upon Florida Department of Transportation guidance of an estimated 30 strikes per foot X 3 ft = 90 strikes
Metal	Vibratory Hammer and Impact Hammer	210 – Berth 8 All piles installed on land - final installation depth on all piles is 60 ft	42	The piles will be initially installed using a Vibratory Hammer and predrilled to 57 ft. The last 3 ft (installation to 60 ft) will be installed using an Impact Hammer	90 – based upon Florida Department of Transportation guidance of an estimated 30 strikes per foot X 3 ft = 90 strikes

2.2 Action Area

The action area is defined by regulation as “all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action” (50 CFR 402.02). The action area for the proposed project includes the water and submerged land within Figure 2 and includes:

1. the areas surrounding the berths to be expanded as well as up to 32,808 ft (10,000 m) to include the behavioral noise radius defined in Section 3.1.1 below;

2. the coral relocation area; and
3. the artificial reef site.

The project is located at the POM, Miami Dade County, Florida. The coordinates of the berth areas are 25.774167°N latitude, 80.163611°W longitude (North American Datum 1983 [NAD 1983]). The coordinates for the artificial reef area are: northwest corner 25.775250°N, 80.108967°W, northeast corner 25.775217°N, 80.103837°W, southwest corner 25.767817°N, 80.109017°W, southeast corner 25.767783°N, 80.103900°W (NAD 1983). The coordinates for the coral relocation site are 25.767333°N, 80.145694°W.

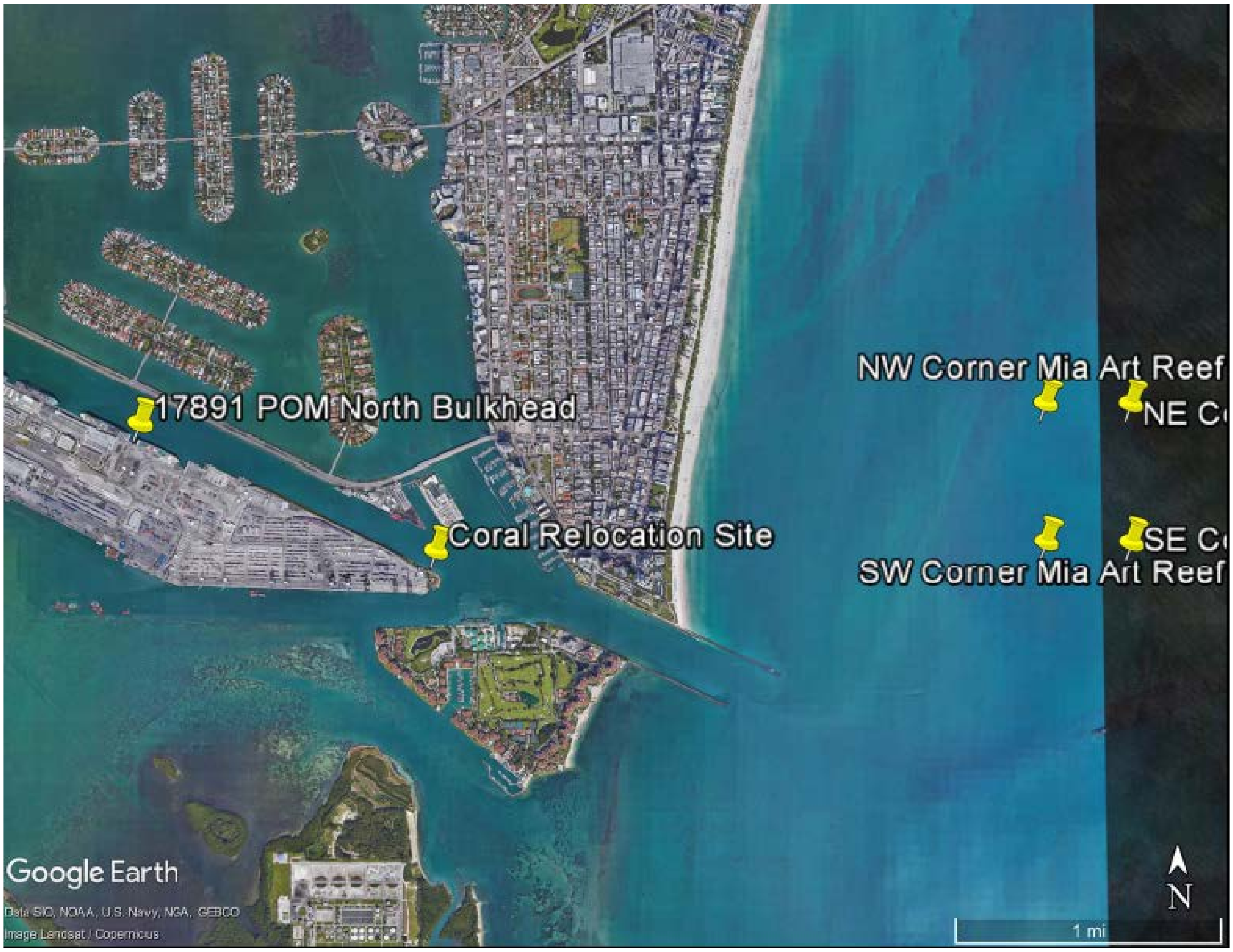

Figure 2. Project location. (© 2017 Google)

3. STATUS OF LISTED SPECIES AND CRITICAL HABITAT

This section identifies ESA-listed species and designated critical habitat under NMFS's jurisdiction that may occur in or near the action area and evaluates which of those may be affected by the proposed action. Effects determinations are summarized in Table 2. The section also describes the status of listed species and/or critical habitat that may be adversely affected by the proposed action.

Table 2. Effects Determination(s) for Species and Critical Habitat the Action Agency or NMFS Believes May Be Affected by the Proposed Action

Species	ESA Listing Status	Action Agency Effect Determination	NMFS Effect Determination
Sea Turtles			
Green (North and South Atlantic distinct population segments [DPSs])	T	NLAA	NLAA
Kemp's ridley	E	NLAA	NLAA
Leatherback	E	NLAA	NLAA
Loggerhead (Northwest Atlantic Ocean DPS)	T	NLAA	NLAA
Hawksbill	E	NLAA	NLAA
Fish			
Smalltooth sawfish (U.S. DPS)	E	NLAA	NLAA
Invertebrates			
Mountainous Star Coral	T	LAA	LAA
Pillar Coral	T	LAA	NE
Rough Cactus Coral	T	LAA	NE
Lobed Star Coral	T	LAA	LAA
Boulder Star Coral	T	LAA	LAA
Critical Habitat			
Loggerhead	Logg-N-19	No determination	NLAA
Elkhorn and Staghorn	Florida Unit	No determination	NE
E = endangered; T = threatened; NLAA = may affect, not likely to adversely affect; NE = no effect, LAA= likely to adversely affect.			

You determined that the proposed action may affect pillar coral and rough cactus coral. Resource surveys indicated that none of these species have been documented within the proposed project area. Therefore, we believe that these species are not present and there are no potential routes of effects to these species from the proposed action.

The artificial reef area is located within designated critical habitat for elkhorn and staghorn corals. The feature essential to the conservation of elkhorn and staghorn coral (also known as the essential feature) is substrate of suitable quality and availability in water depths from the mean high water line to 30 m in order to support successful larval settlement, recruitment, and reattachment of fragments. "Substrate of suitable quality and availability" means consolidated hard bottom or dead coral skeletons free from fleshy macroalgae or turf algae and sediment cover. The artificial reef area of the proposed project is a previously permitted artificial reef and contains only sand habitat and previously deployed artificial reef materials. As such, it lacks the essential features and is not functioning as critical habitat. There are no potential routes of effect to coral critical habitat. Therefore we believe that the proposed action will not affect designated critical habitat for elkhorn and staghorn coral.

3.1 Species and Critical Habitat Not Likely to be Adversely Affected

3.1.1 Sea Turtles and Smalltooth Sawfish

All 5 ESA-listed sea turtles and smalltooth sawfish can be found in or near the action area and may be affected by the project. We have concluded that these species are not likely to be adversely affected by the proposed action for the reasons described below.

Direct Physical Effects

According to members of the Miami Dade Environmental Resource Division who conduct regular aerial surveys for manatees and other species, sea turtles are rarely sighted in this area of the bay. Although we believe that sea turtles and smalltooth sawfish are unlikely to be found within the berth areas or channel of the POM due to the noise and constant vessel traffic associated with an active port facility, potential effects to any sea turtles and smalltooth sawfish that happen to be within the project area include the risk of interaction with construction equipment including barges. We believe the chance of injury or death from interactions with mechanical equipment and associated barges is discountable as these species are mobile and are likely to avoid the areas during construction. Adherence to NMFS's *Sea Turtle and Smalltooth Sawfish Construction Conditions* will further help workers spot ESA-listed species near the project area and avoid interactions with these species during construction activities.

Sea turtles and smalltooth sawfish may be using the artificial reef site and may be injured if struck by the placement of artificial reef materials. Artificial reef material will be barged to the site and then dumped overboard at the desired location. Mobile species are able to avoid interaction with this type of placement. The artificial reef plans state that divers will survey the location prior to material placement and observers will be present to watch for species in the area. Therefore, physical impacts are extremely unlikely to occur, and the risk of injury to sea turtles and smalltooth sawfish from artificial reef placement is considered discountable. Operations will cease immediately if a sea turtle or smalltooth sawfish is seen within a 50-ft radius of the equipment. Activities will not resume until the protected species has departed the project area of its own volition.

Sea turtles can become trapped in certain artificial reef structures. It is possible for a sea turtle to position itself under the edge of open-bottom reef structures and then become wedged or trapped inside the reef material when trying to extract itself. The artificial reef structures and materials are designed to prevent entanglement and entrapment of listed species by using closed bottom baskets with rip rap boulders sized and installed in such a manner that there will be no gaps or openings for sea turtles to become trapped inside. Based on these requirements, entrapment in artificial reefs is extremely unlikely to occur, and thus the risk is considered discountable.

Sea turtles and smalltooth sawfish can become entangled in fishing debris that accumulates on artificial reefs. Because of their design (constructed of closed baskets containing concrete boulder materials) the reef modules are not likely to accumulate derelict fishing gear (Barnette, M. Risk analysis of artificial reef development in regards to sea turtle conservation in Florida. NMFS Southeast Regional Office Protected Resources Division Memorandum. October 13, 2016). The artificial reef area is located more than 2,000 m offshore of the POM in approximately 25 ft of water. While fishing could occur in this area it is less likely than in other locations due to the shallow water depths. In order to further minimize the risk of fishing debris (e.g., broken fishing line and fishing gear), the applicant will conduct an underwater cleanup at 6 months, 1 year, and 2 years post installation. Therefore, we believe the risk of entanglement for sea turtles and smalltooth sawfish is discountable.

Foraging and Refuge

Sea turtles and smalltooth sawfish may be affected by being temporarily unable to use the construction sites for foraging or refuge habitat due to avoidance of construction activities and physical exclusion from areas blocked by turbidity curtains. The site contains corals and sponges and may contain jellyfish, crustaceans, and mollusks that serve as prey for sea turtles and sawfish. The areas surrounding the project site are expected to contain the same resources, and sea turtles and sawfish will be able to continue to use these surrounding resources both during and after the project. Therefore, we believe that effects to sea turtles and smalltooth sawfish from temporary exclusion from foraging and refuge habitat are insignificant because the project will not impair feeding or sheltering.

The placement of artificial reef materials could affect foraging or refuge resources used by sea turtles and sawfish. We believe this effect will be insignificant since the materials will be placed on sandy bottom areas that may have fish, jellyfish, crustaceans, and mollusks that serve as prey for the listed sea turtles and sawfish. However, potential impacts to these foraging resources will be minimal given the small footprint of the artificial reefs. Further, the areas surrounding the artificial reef sites are expected to contain the same resources, and sea turtles and sawfish will be able to continue to these surrounding resources both during and after deployment.

Noise

Effects to listed species as a result of noise created by construction activities can physically injure animals in the affected areas or change animal behavior in the affected areas. Injurious effects can occur in 2 ways. First, immediate adverse effects can occur to listed species if a single noise event exceeds the threshold for direct physical injury. Second, effects can result from prolonged exposure to noise levels that exceed the daily cumulative exposure threshold for the animals, and these can constitute adverse effects if animals are exposed to the noise levels for sufficient periods. Behavioral effects can be adverse if such effects interfere with animals migrating, feeding, resting, or reproducing, for example. Our evaluation of effects to listed species as a result of noise created by construction activities is based on the analysis prepared in support of the Opinion for SAJ-82.[1] The noise analysis in this consultation evaluates effects to ESA-listed fish and sea turtles identified by NMFS as potentially affected in the table above.

Based on our noise calculations, installation of up to 50 new 42-in metal piles by vibratory hammer (limited to 5 piles per day) will not result in any form of injurious noise effects. The noise source level used for this analysis was based on the vibratory installation of a 72-in steel pipe pile. This installation method could result in behavioral effects at radii of up to 152 ft (46 m) for sea turtles and up to 707 ft (215 m) from the source for ESA-listed fishes. Given the

[1] NMFS. Biological Opinion on Regional General Permit SAJ-82 (SAJ-2007-01590), Florida Keys, Monroe County, Florida. June 10, 2014.

mobility of sea turtles and ESA-listed fish species, we expect them to move away from noise disturbances. The nearest seawall is approximately 800 ft across from the pile driving area, giving listed species plenty of room to move away from noise disturbances. Because the pile driving will occur in an open water area and there is similar habitat nearby, we believe this effect will be insignificant. If an individual chooses to remain within the behavioral response zone, it could be exposed to behavioral noise impacts during pile installation. Since installation will occur only during the day, these species will be able to resume normal activities during quiet periods between pile installations and at night. Therefore, installation of piles by vibratory hammer will not result in any injurious noise effect, and we anticipate any behavioral effects will be insignificant.

The applicant intends to use an impact hammer to drive the piles for the final 3 ft. Based on our noise calculations, the installation of 42-in metal piles by impact hammer for the last 3 ft requiring up to 450 strikes per day (90 strikes per piles x maximum 5 piles per day) will not cause single-strike injurious noise effects, because the single sound exposure level (sSEL) was below the injury threshold of 187 dB. Peak-pressure injurious noise effects could occur within 61 ft of the pile. However, impact hammer would only be used for the final 3 ft after the use of vibratory hammer for the initial installation. Sea turtles and smalltooth sawfish would likely vacate the area during the vibratory driving and no longer be found within the injury radius by the time the impact hammer is used. Further, the use of NMFS's *Sea Turtle and Smalltooth Sawfish Construction Conditions* would require work to stop if a listed species is observed within 50-ft of operating equipment which would encompass the 61 ft injury radius. Therefore, the likelihood of a sawfish or sea turtle suffering injury from peak-pressure is discountable. The daily cumulative sound exposure level (cSEL) of multiple pile strikes over the course of a day may cause injury to ESA-listed fishes and sea turtles at a radius of up to 1,417 ft (432 m). We believe that this is an overestimate because the noise estimates are based on 60-in steel piles and the proposed project will use 42-in piles which would lead to a smaller injury radius. Again, sea turtles are rare in the project area, and are not expected to be within the port berths and channel area. Much of the area will be closed off by turbidity curtains which will further reduce the chances of any sea turtle or smalltooth sawfish being within the injury radius. Due to the mobility of sea turtles and ESA-listed fish species, we expect them to move away from noise disturbances during the vibratory hammer installation and before cumulative injury actually occurs. Because we anticipate the animal will move away, we believe that an animal's suffering physical injury from noise is extremely unlikely to occur. Thus, we believe the likelihood of any injurious cSEL effects occurring is discountable. An animal's movement away from the injurious impact zone is a behavioral response, with the same effects discussed below.

Based on our noise calculations, impact hammer pile installation of 42-in piles could also cause behavioral effects at radii of 7,068 ft (2,154 m) for sea turtles and 32,808 ft (10,000 m) for ESA-listed fishes. The in-water pile installation area is located within berth 6 and noise will be somewhat contained within the POM by the existing seawalls and land masses, preventing it from spreading across the bay as sound cannot travel through the solid land masses. Due to the mobility of sea turtles and smalltooth sawfish, we expect them to move away from noise disturbances. Because there is similar habitat nearby, both north and south of the project area, we believe behavioral effects will be insignificant. If an individual chooses to remain within the behavioral response zone, it could be exposed to behavioral noise impacts during pile installation. Since installation will occur only during the day and will be limited to 5 piles per day, these species will be able to resume normal activities during quiet periods between pile installations and at night. Therefore, we anticipate any behavioral effects will be insignificant.

3.1.2 Loggerhead Critical Habitat

The artificial reef area is located within critical habitat unit LOGG-N-19 for the Northwest Atlantic (NWA) Ocean DPS of loggerhead sea turtles.

Loggerhead Sea Turtle (NWA DPS) Breeding Habitat: Primary constituent elements (PCEs) that support this habitat include high densities of reproductive male and female loggerhead sea turtles, proximity to primary Florida migratory corridor, and proximity to Florida nesting grounds. As this project is not expected to reduce local sea turtle densities, or alter the access to the migratory corridor, or alter the access and distance to Florida nesting grounds, we do not expect any impacts from the proposed project to affect this critical habitat component.

Loggerhead Sea Turtle (NWA DPS) Constricted Migratory Habitat: This habitat is defined as high-use migratory corridors that are constricted (i.e., limited in width) by land on one side and the edge of the continental shelf and Gulf Stream on the other side. PCEs that support this habitat include constricted continental shelf area relative to nearby continental shelf waters that concentrate migratory pathways, and passage conditions to allow for migration to and from nesting, breeding, and/or foraging areas. Deployment of artificial reef material will not significantly impede or interfere with migratory pathways, and passage conditions to allow for migration to and from nesting, breeding, and/or foraging areas. Sea turtles can easily maneuver over and around the reef modules. Therefore, we believe that effects to constricted migratory habitat from the project will be insignificant.

3.2 Status of Species Likely to be Adversely Affected

Surveys provided by the consultant indicated that *Orbicella* corals are present within the action area. The survey did not identify the corals to a species level; therefore, we will evaluate the projects effects on each of the 3 species.

3.2.1 Overview of Status of Corals

All 3 species of *Orbicella* (lobed star, boulder star, and mountainous star) coral occur on shallow coral reefs (see Figure 2) widely throughout wider-Caribbean, including south Florida, Puerto Rico, U.S. Virgin Islands, and the Gulf of Mexico (only star corals). Due to their broad distribution and sessile nature, these species may occur within the action area. The following paragraphs will address the general threats to all coral species as well as the distribution, life history, population structure, abundance, population trends, and unique threats to each species of coral.

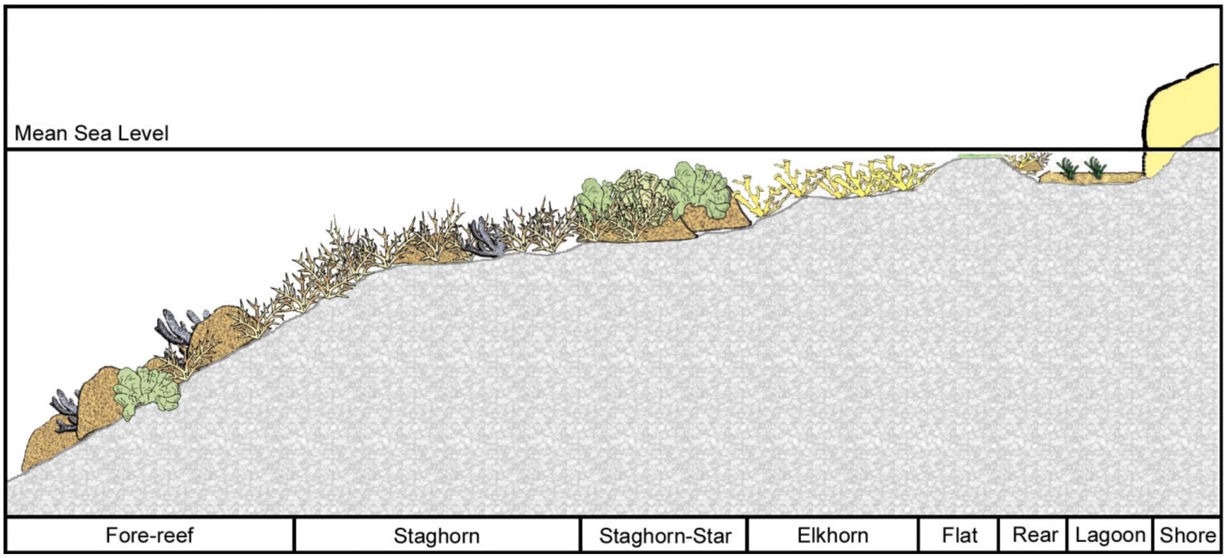

Figure 3. Reef zonation schematic example modified from several reef zonation-descriptive studies (Bak 1977; Goreau 1959).

General Threats Faced by All Coral Species

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

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

Ocean Warming

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

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

Ocean Acidification

Ocean acidification is a result of global climate change caused by increased CO_2 in the atmosphere and dissolving into seawater. Reef-building corals produce skeletons made of the aragonite form of calcium carbonate. Ocean acidification reduces aragonite concentrations in seawater, making it more difficult for corals to build their skeletons. Ocean acidification has the potential to cause substantial reduction in coral calcification and reef cementation. Further, ocean acidification impacts adult growth rates and fecundity, fertilization, pelagic planula settlement, polyp development, and juvenile growth. Ocean acidification can lead to increased colony breakage, fragmentation, and mortality. Based on observations in areas with naturally low pH, the effects of increasing ocean acidification may also include reductions in coral size, cover, diversity, and structural complexity.

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

Diseases

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

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

Trophic Effects of Reef Fishing

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

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

Sedimentation

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

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

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

3.2.2 Mountainous Star Coral
On September 10, 2014, NMFS listed mountainous star coral as threatened (79 FR 53851). Lobed star coral (*Orbicella annularis*), mountainous star coral (*Orbicella faveolata*), and boulder star coral (*Orbicella franksi*) are the 3 species in the *Orbicella annularis* star coral complex. These 3 species were formerly in the genus *Montastraea*; however, recent work has reclassified the 3 species in the *annularis* complex to the genus *Orbicella* (Budd et al. 2012). The star coral species complex was historically one of the primary reef framework builders throughout the wider Caribbean. The complex was considered a highly plastic, single species –*Montastraea annularis*– with growth forms ranging from columns, to massive boulders, to plates. In the early 1990s, Weil and Knowlton (1994) suggested the partitioning of these growth forms into separate species, resurrecting the previously described taxa, *Montastraea* (now *Orbicella*) *faveolata*, and *Montastraea* (now *Orbicella*) *franksi.* These 3 species were differentiated on the basis of morphology, depth range, ecology, and behavior (Weil and Knowton 1994). Subsequent reproductive and genetic studies have supported the partitioning of the *annularis* complex into 3 species.

Some studies report on the 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. Species-specific information is reported when available. Information about *Orbicella annularis* published prior to 1994 will be attributed to the species complex, since it is dated prior to the split of *Orbicella annularis* into 3 separate species.

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

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

Life History Information
The star coral species complex has growth rates ranging from 0.02-0.5 in (0.06-1.2 centimeters [cm]) per year and averaging approximately 0.3 in (1 cm) linear growth per year. Mountainous star coral's growth rate is intermediate between the other star coral complex species (Szmant et al., 1997). They grow more slowly in deeper water and in water that is less clear.

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

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

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

Mountainous star coral has slow growth rates, late reproductive maturity, and low recruitment rates. Colonies can grow very large and live for centuries. Large colonies have lower total

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

mortality than small colonies, and partial mortality of large colonies can result in the production of clones. The historical absence of small colonies and few observed recruits, even though large numbers of gametes are produced on an annual basis, suggests that recruitment events are rare and were less important for the survival of the 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, we conclude that the buffering capacity of this life history strategy has been reduced by recent population declines and partial mortality, particularly in large colonies.

Status and Population Dynamics

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

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

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

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). In a 1995 survey of 16 reefs in the Florida Keys, mountainous star coral ranked as the coral species with the second highest percent cover (Murdoch and Aronson 1999). On 84 patch reefs (10 ft [3 m] to 16.5 ft [5 m] depth) spanning 149 miles (240 kilometers) in the Florida Keys, mountainous star coral was the third most abundant coral species comprising 7% of the 17,568 colonies encountered. It was present at 95% of surveyed reefs between 2001 and 2003 (Lirman and Fong 2007). In surveys of 280 sites in the upper Florida Keys in 2011, mountainous star coral was present at 87% of sites visited

(Miller et al. 2011). In 2003 on the East Flower Garden Bank, mountainous star coral comprised 10% of the 76.5% coral cover on reefs 105-132 ft (32-40 m), and partial mortality due to bleaching, disease, and predation were rare at monitoring stations (Precht et al. 2005).

Colony density ranges from approximately 0.1-1.8 colonies per 108 ft^2 (10 m^2) and varies by habitat and location. In surveys along the Florida reef tract from Martin County to the lower Florida Keys, density of mountainous star coral was approximately 1.6 colonies per 108 ft^2 (10 m2Wagner et al. 2010). On remote reefs off southwest Cuba, density of mountainous star coral was 0.12 ± 0.20 (SE) colonies per 33 ft (10 m) transect on 38 reef-crest sites and 1.26 ± 1.06 (SE) colonies per 33 ft (10 m) transect on 30 reef-front sites (Alcolado et al. 2010). In surveys of 1,176 sites in southeast Florida, the Dry Tortugas, and the Florida Keys between 2005 and 2010, density of mountainous star coral ranged between 0.17 and 1.75 colonies per 108 ft^2 (10 m^2) and was highest on mid-channel reefs followed by offshore patch reefs and fore-reefs (Burman et al. 2012). Along the east coast of Florida, density was highest in areas south of Miami at 0.94 colonies per 108 ft^2 (10 m^2) compared to 0.11 colonies per 108 ft^2 (10 m^2) in Palm Beach and Broward Counties (Burman et al. 2012).

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

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

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

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

Threats

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

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

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

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

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

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

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

Summary of Status

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

3.2.3 Lobed Star Coral

Species Description and Distribution

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

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

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

Life History Information

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

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

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

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

In addition to low recruitment rates, lobed star corals have late reproductive maturity. Colonies can grow very large and live for centuries. Large colonies have lower total mortality than small colonies, and partial mortality of large colonies can result in the production of clones. The historical absence of small colonies and few observed recruits, even though large numbers of gametes are produced on an annual basis, suggests that recruitment events are rare and were less important for the survival of the lobed star coral species complex in the past (Bruckner 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.

Status and Population Dynamics

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

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

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

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

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

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

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

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

Cover of lobed star coral at Yawzi Point, St. John, U.S. Virgin Islands declined from 41% in 1988 to approximately 12% by 2003 as a rapid decline began with the aftermath of Hurricane Hugo in 1989. This decline continued between 1994 and 1999 during a time of 2 hurricanes (1995) and a year of unusually high sea temperature (1998) but percent cover remained statistically unchanged between 1999 and 2003. Colony abundances declined from 47 to 20 colonies per approximately 10 ft^2 (1 m^2) between 1988 and 2003, due mostly to the death and fission of medium-to-large colonies (≥ 24 in^2 [151 cm^2]). Meanwhile, the population size class structure shifted between 1988 and 2003 to a higher proportion of smaller colonies in 2003 (60% less than 7 in^2 [50 cm^2] in 1988 versus 70% in 2003) and lower proportion of large colonies (6% greater than 39 in^2 [250 cm^2] in 1988 versus 3% in 2003). The changes in population size structure indicated a population decline coincident with the period of apparent stable coral cover. Population modeling forecasted the 1988 size structure would not be reestablished by recruitment and a strong likelihood of extirpation of lobed star coral at this site within 50 years (Edmunds and Elahi 2007).

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

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

Threats

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

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

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

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

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

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

Summary of Status

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

3.2.4 Boulder Star Coral

Species Description and Distribution

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

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

Life History Information

The star coral species complex has growth rates ranging from 0.02-0.5 in (0.06-1.2 cm) per year and averaging approximately 0.3 in (1 cm) linear growth per year. Boulder star coral is reported to be the slowest of the 3 species in the complex (Brainard et al. 2011). They grow more slowly in deeper water and in less clear water.

All 3 species of the star coral complex are hermaphroditic broadcast spawners[4], with spawning concentrated on 6-8 nights following the full moon in late August, September, or early October, depending on timing of the full moon and location. Boulder star coral spawning is reported to be about 1- 2 hours earlier than lobed star coral and mountainous star coral. All 3 species are largely self-incompatible (Knowlton et al. 1997; Szmant et al. 1997). Fertilization success measured in the field was generally below 15% for all 3 species, as it was closely linked to the number of colonies concurrently spawning. In Puerto Rico, minimum size at reproduction for the star coral species complex was 13 in^2 (83 cm^2).

Successful recruitment by the star coral species complex appears to always have been rare. Only a single recruit of *Orbicella* was observed over 18 years of intensive observation of approximately 130 ft^2 (12 m^2) of reef in Discovery Bay, Jamaica. Many other studies throughout the Caribbean also report negligible to absent recruitment of the species complex. Of 351 colonies of boulder star coral tagged in Bocas del Toro, Panama, larger colonies were noted to spawn more frequently than smaller colonies between 2002 and 2009 (Levitan et al. 2011).

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

In addition to low recruitment rates, lobed star corals have late reproductive maturity. Colonies can grow very large and live for centuries. Large colonies have lower total mortality than small colonies, and partial mortality of large colonies can result in the production of clones. The historical absence of small colonies and few observed recruits, even though large numbers of gametes are produced on an annual basis, suggests that recruitment events are rare and were less important for the survival of the lobed star coral species complex in the past (Bruckner 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.

Status and Population Dynamics

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

Boulder star coral is reported as common. In a 1995 survey of 16 reefs in the Florida Keys, boulder star coral had the highest percent cover of all species (Murdoch and Aronson 1999). In

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

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

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

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

Reported density is variable by location and habitat and is reported to range from 0.02 to 1.05 colonies per ~100 ft^2 (10 m^2). In surveys of 1,176 sites in southeast Florida, the Dry Tortugas, and the Florida Keys between 2005 and 2010, density of boulder star coral ranged between 0.04 and 0.47 colonies per ~100 ft^2 (10 m^2) and was highest on the offshore patch reef and fore-reef habitats (Burman et al. 2012). In south Florida, density was highest in areas south of Miami at 0.44 colonies per ~100 ft^2 (10 m^2) compared to 0.02 colonies per ~100 ft^2 (10 m^2) in Palm Beach and Broward Counties (Burman et al. 2012). Along the Florida reef tract from Martin County to the lower Florida Keys, density of boulder star coral was ~0.9 colonies per ~100 ft^2 (10 m^2) (Wagner et al. 2010). On remote reefs off southwest Cuba, colony density was 0.083 ± 0.17 (SD) per ~100 ft^2 (10 m^2) transect on 38 reef-crest sites and 1.05 ± 1.02 colonies per ~100 ft^2 (10 m^2) transect on 30 reef-front sites (Alcolado et al. 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 ~20 in [50 cm]) that had similar frequency of colonies with and without partial mortality (Alcolado et al. 2010).

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

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

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

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

Threats

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

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

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

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

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

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

Summary of Status

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

4. ENVIRONMENTAL BASELINE

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

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

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

4.1 Status of *Orbicella* Corals within the Action Area

In Section 3.2.1, we described the range-wide status of *Orbicella* corals. Within Miami Dade County, all 3 species of *Orbicella* corals occur in varying, but relatively low densities (Gilliam

2011). Based on surveys within the proposed project area, we estimate there are approximately 11 colonies of *Orbicella* coral within the action area (not identified to species).

4.2 Factors Affecting *Orbicella* Corals within the Action Area

Coral colonies are non-motile and susceptible to relatively localized adverse effects as a result. Localized adverse effects to listed corals in the action area are likely from many of the same stressors affecting these species throughout their range, namely ocean warming, ocean acidification, disease, anthropogenic breakage and intense weather events (i.e., hurricanes and extreme cold water disturbances). To date NMFS has not conducted any Section 7 consultations for effects to *Orbicella* corals within the action area. The summary below of federal actions and the effects of these actions includes only those federal actions in, or with effects within, the action area that have already concluded or are currently undergoing formal Section 7 consultation.

Federal Actions

Federal actions that may adversely affect listed and proposed corals in the action area include:

- **Commercial and recreational fisheries authorized by the National Marine Fisheries Service.** Certain types of fishing gear (e.g., hook-and-line, trap gear, nets) may adversely affect coral species. NMFS previously completed a biological opinion evaluating the impacts of Gulf of Mexico/South Atlantic spiny lobster fishery on staghorn coral. The opinion concluded trap gear used in the fishery may adversely affect listed corals via fragmentation/breakage and abrasion (primarily from storm mobilized trap gear), but those effects were not likely to jeopardize the species continued existence. NMFS is continuing to collect data to analyze the impacts of federal fisheries and will conduct ESA Section 7 consultations as appropriate.

- **USACE-permitted discharges to surface waters and dredge-and-fill.** Shoreline and riparian disturbances (whether in the riverine, estuarine, marine, or floodplain environment) resulting in discharges may retard or prevent the reproduction, settlement, reattachment, and development of listed (e.g., land development and runoff, and dredging and disposal activities, result in direct deposition of sediment on corals, shading, and lost substrate for fragment reattachment or larval settlement). These activities can directly affect ESA listed corals via fragmentation/breakage or abrasion. The activities may also affect listed and proposed coral species by physically altering or removing benthic habitat suitable for colonization. Dredge-and-fill activities may also cause increases in sedimentation that may cause shading, deposition of sediment onto coral colonies, and/or loss of substrate for fragment reattachment or larval settlement. The 1997 South Atlantic Regional Biological Opinion covering hopper dredging activity by the USACE is currently undergoing a reinitiation of consultation due to the listing of 7 species of coral, among other things, and does not currently authorize any adverse impacts to listed coral species. The POM expansion project (SER-2011-00029) was recently completed within the action area and may contribute to effects to *Orbicella* species within the project area via sedimentation. The project included dredging and expansion of the main channel using a cutterhead dredge and resulted in extensive sedimentation impacts to the surrounding reef areas. Although most of the impacts were seen outside of the port berths, along the channel and up to several hundred meters away, it is possible that sediments from the project are also affecting listed corals within the currently proposed project area.

- **POM Anchorage.** NMFS issued a Biological Opinion (SER-2016-18083) to the USACE on January 31, 2017, for the anchorage area off shore of POM. The USACE's permit authorizes the reduction of the existing anchorage area and splitting it into 2 separate locations, one for smaller vessels and one for larger vessels. While the new locations will reduce impacts to coral critical habitat there will still be impacts to approximately 31 acres of critical habitat. The artificial reef for the proposed action is located approximately 1,000 m from the nearest edge of the small anchorage area.

- **EPA regulated discharge of pollutants or approval of water quality standards under the Clean Water Act.** Elevated discharge levels of many pollutants may cause direct mortality, reduced fitness, or habitat destruction/modification. The EPA has been involved in ongoing litigation over the sufficiency of standards promulgated by the State of Florida to regulate discharges of nutrients into state waters, including habitats occupied by the listed and proposed corals. NMFS is engaged in ongoing consultation with the EPA regarding their approval of the state's standards. The most recent consultation with EPA, FPR-2015-9234, analyzed the EPA's approval of a variety of water quality standards including nutrient concentrations and dissolved oxygen. NMFS concluded that the criteria were not likely to adversely affect ESA listed corals or their designated critical habitat.

Non-Federal Actions Affecting Listed Corals.
Poor boating and anchoring practices, as well as poor diving and snorkeling techniques cause abrasion and breakage of staghorn coral. Commercial and recreational vessel traffic can adversely affect listed corals through propeller scarring, propeller wash, and accidental groundings. Anthropogenic sources of marine pollution, while difficult to attribute to a specific federal, state, local or private action, may indirectly affect corals in the action area. Sources of pollutants in the action area include atmospheric loading of pollutants such as PCBs, storm water runoff from coastal towns, and runoff into canals and rivers that empty into bays and groundwater. Nutrients, contaminants, and sediment from point and non-point sources cause direct mortality and the breakdown of normal physiological processes. Additionally, these stressors create an unfavorable environment for reproduction and growth.

Nutrient loading from land-based sources, such as coastal communities and agricultural operations, are known to have adverse effects on corals. Lapointe et al. (2004) directly linked wastewater discharges in the Florida Keys with adverse effects to the nearby coral reef communities. Within the past 6 years, offshore wastewater outfalls in Broward County have been decommissioned, as part of implementation of Chapter 2008-232, Laws of Florida, which prohibits the construction of new domestic wastewater ocean outfalls, sets out a timeline for the elimination of existing domestic wastewater ocean outfalls by 2025, and requires that a majority of the wastewater previously discharged be beneficially reused. This law was enacted in part because of the adverse effects of effluent to corals.

Diseases have been identified as a major cause of coral decline. Although the most severe mortality resulted from an outbreak in the early 1980s, diseases (i.e., white band disease) are still present in staghorn coral populations and continue to cause mortality.

Hurricanes and large coastal storms could also significantly harm staghorn coral. Due to its branching morphology, it is especially susceptible to breakage from extreme wave action and storm surges. Historically, large storms potentially resulted in an asexual reproductive event, if the fragments encountered suitable substrate, attached, and grew into a new colony. However, in the recent past, the amount of suitable substrate is significantly reduced; therefore, many fragments created by storms die. Hurricanes are also sometimes beneficial, if they do not result in heavy storm surge, during years with high sea surface temperatures, as they lower the temperatures providing fast relief to corals during periods of high thermal stress (Heron et al. 2008). However, major hurricanes have caused significant losses in coral cover and changes in the physical structure of many reefs. According to the NOAA Historical Hurricane Tracks website, approximately, 29 hurricanes or tropical storms have impacted the area within 20 nautical miles of Fort Lauderdale, since records have been kept (1859-2013).

Several types of fishing gears used within the action area may adversely affect listed corals. Longline, other types of hook-and-line gear, and traps have all been documented as interacting with corals in general, though no data specific to listed corals are available. Available information suggests hooks and lines can become entangled in reefs, resulting in breakage and abrasion of corals. Traps have been found to be the most damaging; lost traps and illegal traps were found to result in greater impact to coral habitat because they cause continuous habitat damage until they degrade.

Conservation and Recovery Actions Benefiting Listed Corals
The National Oceanic and Atmospheric Association Coral Reef Conservation Program provides funding for several activities with an education and outreach component for informing the public about the importance of the coral reef ecosystem and the status of listed corals. The Southeast Regional Office of NMFS has also developed outreach materials regarding the listing of elkhorn and staghorn corals, the Section 4(d) regulations, and the designation of critical habitat. These materials have been circulated to constituents during education and outreach activities and public meetings, and as part of other Section 7 consultations, and are readily available on the website: http://sero.nmfs.noaa.gov/pr/esa/acropora.htm.

Numerous management mechanisms exist to protect corals and the habitats on which they grow. The Coral Reef Conservation Act and the 2 Coral and Coral Reef Fishery Management Plans under the Magnuson-Stevens Act require the protection of corals and prohibit the collection of hard corals. Depending on the specifics of zoning plans and regulations, marine protected areas (MPAs) can help prevent damage from collection, fishing gear, groundings, and anchoring; however, no MPAs occur within the action area.

5. EFFECTS OF THE ACTION
Effects of the action include direct and indirect effects of the action under consultation, as well as the effects of any interrelated or interdependent activities. Indirect effects are those that result

from the proposed action, occur later in time (i.e., after the proposed action is complete), but are still reasonably certain to occur.

As described below, NMFS believes that the proposed action may adversely affect mountainous star, lobed star, and boulder star corals. Because the action will result in adverse effects to these species we must evaluate whether the action is likely to jeopardize the continued existence of the species.

5.1 Orbicella Corals

According to the biological resources assessment dated March, 2016, the proposed project will impact 11 colonies of *Orbicella* coral. The biological assessment did not identify the corals to a species level; therefore, we will use data from other surveys in the region to determine the regionally appropriate density of each species and apply that to the total number of colonies to find the number of each species expected to be impacted by the project.

Surveys conducted by Klug (2015) from Biscayne National Park north to the Hillsboro Inlet found that mountainous star coral was most abundant, occurring at a density of 0.0367 colonies per m^2 on average across colonized pavement and the inner reef, and boulder star coral occurred at a density of 0.0250 colonies per m^2. The study did not document any colonies of lobed star coral. NMFS has compiled additional data from various surveys throughout Miami-Dade County ranging from 2005-2015 (Clark et al. 2015; Klug 2015) (Table 3). These data also show mountainous star coral as the most abundant species in the region.

Table 3. *Orbicella* Coral Density by Species

Species	Survey Year	Density (colonies/m^2)
O. annularis (lobed star coral)	2010	0.1
	2011	0.1
O. faveolata (mountainous star coral)	2006	0.1
	2006	0.2
	2007	0.4
	2008	0.1
	2010	0.1
	2010	0.1
	2010	0.1
	2010	0.2
	2011	0.1
	2015	0.1
	2015	0.1
O. franksi (boulder star coral)	2006	0.2
	2006	0.1
	2006	0.1
	2009	0.1
Average Density (colonies/m^2)		
O.annularis	*O. faveolata*	*O. franski*
0.10	0.15	0.13

Abundance by Species (%)		
26%	40%	34%
Estimated Number of Colonies in the Action Area		
3 (26% of 11)	4 (40% of 11)	4 (26% of 11)

To calculate the abundance percentages for each species we take the average density and divide by the total density of all 3 species (0.10+0.15+0.13=0.38) then multiply by 100. Using *O. annularis* as an example gives us 26% (0.10/0.38 = 0.26 x 100 = 26%). As shown in Table 3, by using the average densities by species and converting them to percentages we can then estimate the number of colonies of each species within the project area. Doing so gives 4 colonies of mountainous star coral (40% of 11 colonies = 0.4 x 11 = 4.4 rounded to 4), 4 colonies of boulder star coral (34% of 11 colonies = 0.34 x 11 = 3.74 rounded to 4), and 3 colonies of lobed star coral (26% of 11 colonies = 0.26 x 11 = 2.86 rounded to 3).

Coral transplantation can successfully relocate colonies that would likely suffer injury or morality if not moved. Provided that colonies are handled with skill, are reattached properly, and the environmental factors at the reattachment site are conducive to their growth (e.g., water quality, substrate type), many different species of coral have been shown to survive transplantation well (Birkeland et al. 1979; Guzmán 1991; Harriott and Fisk 1987; Hudson and Diaz 1988; Hudson 2000; Lindahl 2003; Maragos 1974). When relocating scleractinian corals to a similar environment we expect a survival rate of 90% or higher (Tom Moore, NMFS pers. comm. to Kelly Logan, March 17, 2017).

NMFS believes that the 4 colonies of mountainous star, 4 colonies of boulder star, and 3 colonies of lobed star coral would be lethally taken during the bulkhead realignment if not relocated. The March 2016 surveys documented the location of 3 of these colonies, the others are assumed to be in the project area based on extrapolation of those previous surveys. However, the predicted colonies may not actually be found during relocation efforts. Therefore, we believe that 3 colonies will be successfully relocated and up to 8 colonies could be permanently lost due to the project, if not found and relocated. Standard coral transplanting techniques (Appendix A) are highly successful and relocating these corals outside the project area is appropriate to minimize the impact of this take. Similar habitat, influenced by the same environmental conditions currently affecting these colonies, exists nearby the proposed project. Because suitable transplantation habitat is nearby and proper handling techniques are available and will be required (see Appendix A), we expect that coral transplant survival rates for this project will be similar to those noted elsewhere. We believe a 10% coral morality rate is conservative and actual mortality may be even lower. Therefore, we anticipate a 90% survival rate of transplanted coral colonies.

In summary, 3 colonies of *Orbicella* will be relocated. We believe this will include 1 colony of mountainous star coral, 1 colony of boulder star coral, and 1 lobed star coral colony. All other colonies of ESA-listed corals encountered during relocation efforts will also be relocated. However, we believe that up to 8 colonies of *Orbicella* (3 mountainous star, 3 boulder star, and 2 lobed star corals) may be lethally taken by the project if not found during the relocation efforts. Of the colonies transplanted, we anticipate that up to 1 *Orbicella* colony will suffer mortality after relocation. Therefore our estimates indicate that 9 *Orbicella* colonies will be taken and that 2 transplanted colonies will survive.

6. CUMULATIVE EFFECTS

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

NMFS is not aware of any future projects that may contribute to cumulative effects.

Within the action area, major future changes are not anticipated in addition to the ongoing activities and processes described in the environmental baseline. The present human uses of the action area are expected to continue, though some may occur at increased levels, frequency, or intensity in the near future.

7. JEOPARDY ANALYSIS

The analyses conducted in the previous sections of this Opinion serve to provide a basis to determine whether the proposed action is likely to jeopardize the continued existence of mountainous star, boulder star, or lobed star corals. In Section 5.0, we outlined how the proposed actions can affect these species. Now we turn to an assessment of the species' response to these impacts, in terms of overall population effects, and whether those effects of the proposed actions, when considered in the context of the status of the species (Section 3.0), the environmental baseline (Section 4.0), and the cumulative effects (Section 6.0), will jeopardize the continued existence of the affected species.

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

7.1 Mountainous Star, Boulder Star, and Lobed Star Corals

In the following analysis, we evaluate the effects of the lethal take and nonlethal relocation of mountainous star, boulder star, and lobed star corals from the action area.

As discussed in Section 5 (Effects of the Action), the proposed project is likely to adversely affect a maximum of 4 colonies of mountainous star, 4 colonies of boulder star, and 3 colonies of lobed star coral. Of these, we anticipate that 2 colonies will successfully be relocated, 1 will suffer mortality from relocation events and up to 8 colonies may be lethally taken by the proposed action if not found during relocation efforts.

Lobed Star Coral

Relocated colonies will remain in the same area. The proposed action will not affect the species' current geographic range. The species is found throughout U.S. waters of the western Atlantic and greater Caribbean, including Florida and the Gulf of Mexico. Within its range it is found within federally protected waters in the Flower Garden Bank Sanctuary, Dry Tortugas National Park, Virgin Islands National Park/Monument, Biscayne National Park, Florida Keys National Marine Sanctuary, Navassa National Wildlife Refuge, and the Buck Island Reef National Monument. Figure 5 shows the density of lobed star coral near the POM. The proposed action will not result in a reduction of lobed star coral distribution or fragmentation of the range since we expect that lobed star coral will persist within the action area due to relocation of colonies (from the impact area to the artificial reef area) and will continue to be capable of reproducing. Therefore, the reproductive potential of the species in this portion of its range will persist. Based on the above, no reduction in the distribution of the species is anticipated.

Although no change in lobed star coral distribution was anticipated, we concluded lethal takes would result in a reduction in absolute population numbers that may also reduce reproduction. The anticipated loss of up to 3 colonies would reduce the population by that amount, compared to the number that would have been present in the absence of the proposed action, assuming all other variables remained the same.

According to the resource surveys dated March, 2016, all of the *Orbicella* corals that were found were in the smaller size classes and no corals were observed larger than 40-cm longest linear dimension. Reproductive potential is positively correlated with colony size. In the species for which we have estimates of size at first reproduction, all are larger than 40 cm (average ~100 cm). Thus, we assume that these corals are not currently reproductive. Further, given the relatively slow growth rates of the proposed corals (~0.5 -1 cm/yr) we do not anticipate that these colonies would reach reproductive maturity over the duration of the project (i.e., 5 years). Therefore, we believe that the proposed project will not result in a reduction in reproduction of lobed star corals in the wild.

While it is now widely accepted that lobed star coral is only 1 of 3 valid species (the others being boulder star and mountainous star), long-term monitoring data sets and previous ecological studies did not distinguish among them, referring instead to the *Orbicella* complex. Although the biological review team that conducted the status review that resulted in the proposal to list these species estimated extinction risk separately for each species, much of the information available is for the complex as a whole (Brainard et al. 2011). An estimated maximum of 3 colonies of lobed star coral will be lethally taken during the proposed action. There is ample evidence that it has declined dramatically throughout its range (but perhaps at a slower pace than its fast-paced Caribbean colleagues, *Acropora palmata* and *Acropora cervicornis*). However, the *Orbicella* complex has historically been a dominant species on Caribbean and Florida coral reefs, characterizing the so-called "buttress zone" and "annularis zone" in the classical descriptions of Caribbean reefs (Goreau, 1959). Therefore, we believe that, even with the recent declines, there are still high numbers of lobed star coral throughout its range. As compared to the range-wide population estimates, the potential loss of up to 3 colonies would cause no noticeable change in the population of the species. Therefore, we believe the proposed action will not reduce appreciably the likelihood of survival in the wild.

Factors that increase the extinction risk for lobed star coral include very low productivity (growth and recruitment), documented dramatic declines in abundance, its restriction to the degraded reefs of the wider Caribbean region, and its preferential occurrence in shallow habitats. The threats to lobed star coral are generally the same threats affecting coral reefs throughout the world (climate change impacts, fishing impacts, and land-based sources of pollution impacts). Specifically, disease and ocean warming are the two biggest threats that will impact the potential for recovery of all listed coral species. Global threats to listed coral species are exacerbated further by local threats such as nutrients, sedimentation, and the trophic effects of fishing, which degrade coral condition and habitat and increase synergistic stress effects (e.g., bleaching, disease). While the proposed project would lead to a small decrease in abundance, it would not increase any of these threats.

We have not completed a recovery plan for lobed star corals, but the recovery vision statement in the NMFS Recovery Outline indicates that populations of lobed star coral should be present across the historical range, with populations large enough and genetically diverse enough to support successful reproduction and recovery from mortality events and dense enough to maintain ecosystem function. Recovery of these species will require conservation of the coral reef ecosystem through threats abatement to ensure a high probability of survival into the future. The proposed project would not prevent any of these recovery goals and by relocating existing colonies within the same region the action would preserve the genetic material of the colonies and support future reproduction. Therefore, NMFS believes that the proposed action is not likely to reduce the likelihood of lobed star coral recovery in the wild.

Mountainous Star Coral

Relocated colonies will remain in the same area. The proposed action will not affect the species' current geographic range. The species is present throughout U.S. waters of the western Atlantic and greater Caribbean, including Florida and the Gulf of Mexico. Within its range it is found within federally protected waters in the Flower Garden Bank Sanctuary, Dry Tortugas National Park, Virgin Islands National Park/Monument, Biscayne National Park, Florida Keys National Marine Sanctuary, Navassa National Wildlife Refuge, and the Buck Island Reef National Monument. Figure 5 shows the density of mountainous star coral near the POM. The proposed action will not result in a reduction of mountainous star coral distribution or fragmentation of the range since we expect that mountainous star coral will persist within the action area due to relocation of colonies (from the impact area to the artificial reef area) and will continue to be capable of reproducing. Therefore, the reproductive potential of the species in this portion of its range will persist. Based on the above, no reduction in the distribution of the species is anticipated.

Although no change in mountainous star coral distribution was anticipated, we concluded lethal takes would result in a reduction in absolute population numbers that may also reduce reproduction. The anticipated loss of 4 colonies would reduce the population by that amount, compared to the number that would have been present in the absence of the proposed action, assuming all other variables remained the same.

According to the resource surveys conducted in March, 2016, all of the *Orbicella* coral colonies occur in the smaller size classes and no corals were observed larger than 40-cm longest linear dimension. Reproductive potential is positively correlated with colony size. In the species for which we have estimates of size at first reproduction, all are larger than 40 cm (average ~100 cm). Thus, we assume that these corals are not currently reproductive. Further, given the relatively slow growth rates of the proposed corals (~0.5 -1 cm/yr) we do not anticipate that these colonies would reach reproductive maturity over the duration of the project (i.e., 5 years). Therefore, we believe that the proposed project will not result in a reduction in reproduction of mountainous star corals in the wild.

As discussed above, long-term monitoring data sets and previous ecological studies did not distinguish among the 3 recognized *Orbicella* species, referring instead to the *Orbicella* complex. Although the status review for the listing estimates extinction risk separately for each species, much of the information available is for the complex as a whole (Brainard et al. 2011). An estimated maximum of 4 colonies of mountainous star coral will be lethally taken during dredging activities. There is ample evidence that it has declined dramatically throughout its range (but perhaps at a slower pace than its fast-paced Caribbean colleagues, elkhorn and staghorn corals [*Acropora palmata* and *Acropora cervicornis*]). However, the *Orbicella* complex has historically been a dominant species on Caribbean and Florida coral reefs, characterizing the so-called "buttress zone" and "annularis zone" in the classical descriptions of Caribbean reefs (Goreau, 1959). Therefore, we believe that even with the recent declines that there are still high numbers of mountainous star coral throughout its range. As compared to the range-wide population estimates, the potential loss of up to 4 colonies would cause no noticeable change in the population of the species. Therefore, we believe the proposed action will not reduce appreciably the likelihood of survival in the wild.

Factors that increase the extinction risk for mountainous star coral include very low productivity (growth and recruitment), documented dramatic declines in abundance, its restriction to the degraded reefs of the wider Caribbean region, and its preferential occurrence in shallow habitats. The threats to mountainous star coral are generally the same threats affecting coral reefs throughout the world (climate change impacts, fishing impacts, and land-based sources of pollution impacts). Specifically, disease and ocean warming are the two biggest threats that will impact the potential for recovery of all listed coral species. Global threats to listed coral species are exacerbated further by local threats such as nutrients, sedimentation, and the trophic effects of fishing, which degrade coral condition and habitat and increase synergistic stress effects (e.g., bleaching, disease). While the proposed project would lead to a small decrease in abundance, it would not increase any of these threats.

We have not completed a recovery plan for mountainous star corals, but the recovery vision statement in the NMFS Recovery Outline indicates that populations of mountainous star coral should be present across the historical range, with populations large enough and genetically diverse enough to support successful reproduction and recovery from mortality events and dense enough to maintain ecosystem function. Recovery of these species will require conservation of the coral reef ecosystem through threats abatement to ensure a high probability of survival into the future. The proposed project would not prevent any of these recovery goals and by relocating existing colonies within the same region the action would preserve the genetic material of the colonies and support future reproduction. Therefore, NMFS believes that the proposed action is not likely to reduce the likelihood of mountainous star coral recovery in the wild.

Boulder Star Coral
Relocated colonies will remain in the same area. The proposed action will not affect the species' current geographic range. The species is present throughout U.S. waters of the western Atlantic and greater Caribbean, including Florida and the Gulf of Mexico. Within its range it is found within federally protected waters in the Flower Garden Bank Sanctuary, Dry Tortugas National Park, Virgin Islands National Park/Monument, Biscayne National Park, Florida Keys National Marine Sanctuary, Navassa National Wildlife Refuge, and the Buck Island Reef National Monument. Figure 5 shows the density of boulder star coral near the POM. The proposed action will not result in a reduction of boulder star coral distribution or fragmentation of the range since we expect that boulder star coral will persist within the action area due to relocation of colonies (from the impact area to the artificial reef area) and will continue to be capable of reproducing. Therefore, the reproductive potential of the species in this portion of its range will persist. Based on the above, no reduction in the distribution of the species is anticipated.

Although no change in boulder star coral distribution was anticipated, we concluded lethal takes would result in a reduction in absolute population numbers that may also reduce reproduction. The anticipated loss of 4 colonies would reduce the population by that amount, compared to the number that would have been present in the absence of the proposed action, assuming all other variables remained the same.

According to the resource surveys conducted in March, 2016, all of the *Orbicella* coral colonies occur in the smaller size classes and no corals were observed larger than 40 cm longest linear dimension. Reproductive potential is positively correlated with colony size. In the species for which we have estimates of size at first reproduction, all are larger than 40 cm (average ~100 cm). Thus, we assume that these corals are not currently reproductive. Further, given the relatively slow growth rates of the proposed corals (~0.5-1 cm/yr), we do not anticipate that these colonies would reach reproductive maturity over the duration of the project (i.e., 5 years). Therefore, we believe that the proposed project will not result in a reduction in reproduction of boulder star corals in the wild.

As discussed above, long-term monitoring data sets and previous ecological studies did not distinguish among the 3 recognized *Orbicella* species, referring instead to the *Orbicella* complex. Although the status review for the listing estimates extinction risk separately for each species, much of the information available is for the complex as a whole (Brainard et al. 2011). An estimated maximum of 4 colonies of knobby star coral will be lethally taken during dredging activities. There is ample evidence that it has declined dramatically throughout its range (but perhaps at a slower pace than its fast-paced Caribbean colleagues, *Acropora palmata* and *Acropora cervicornis*). However, the *Orbicella* complex has historically been a dominant species on Caribbean and Florida coral reefs, characterizing the so-called "buttress zone" and "annularis zone" in the classical descriptions of Caribbean reefs (Goreau, 1959). Therefore, we believe that even with the recent declines that there are still high numbers of boulder star coral throughout its range. As compared to the range-wide population estimates, the potential loss of up to 4 colonies would cause no noticeable change in the population of the species. Therefore, we believe the proposed action will not reduce appreciably the likelihood of survival in the wild.

Factors that increase the extinction risk for boulder star coral include very low productivity (growth and recruitment), documented dramatic declines in abundance, its restriction to the degraded reefs of the wider Caribbean region, and its preferential occurrence in shallow habitats. The threats to boulder star coral are generally the same threats affecting coral reefs throughout the world (climate change impacts, fishing impacts, and land-based sources of pollution impacts). Specifically, disease and ocean warming are the two biggest threats that will impact the potential for recovery of all listed coral species. Global threats to listed coral species are exacerbated further by local threats such as nutrients, sedimentation, and the trophic effects of fishing, which degrade coral condition and habitat and increase synergistic stress effects (e.g., bleaching, disease). While the proposed project would lead to a small decrease in abundance, it would not increase any of these threats.

We have not completed a recovery plan for lobed star corals, but the recovery vision statement in the NMFS Recovery Outline indicates that populations of boulder star coral should be present across the historical range, with populations large enough and genetically diverse enough to support successful reproduction and recovery from mortality events and dense enough to maintain ecosystem function. Recovery of these species will require conservation of the coral reef ecosystem through threats abatement to ensure a high probability of survival into the future. The proposed project would not prevent any of these recovery goals and by relocating existing colonies within the same region the action would preserve the genetic material of the colonies and support future reproduction. Therefore, NMFS believes that the proposed action is not likely to reduce the likelihood of boulder star coral recovery in the wild.

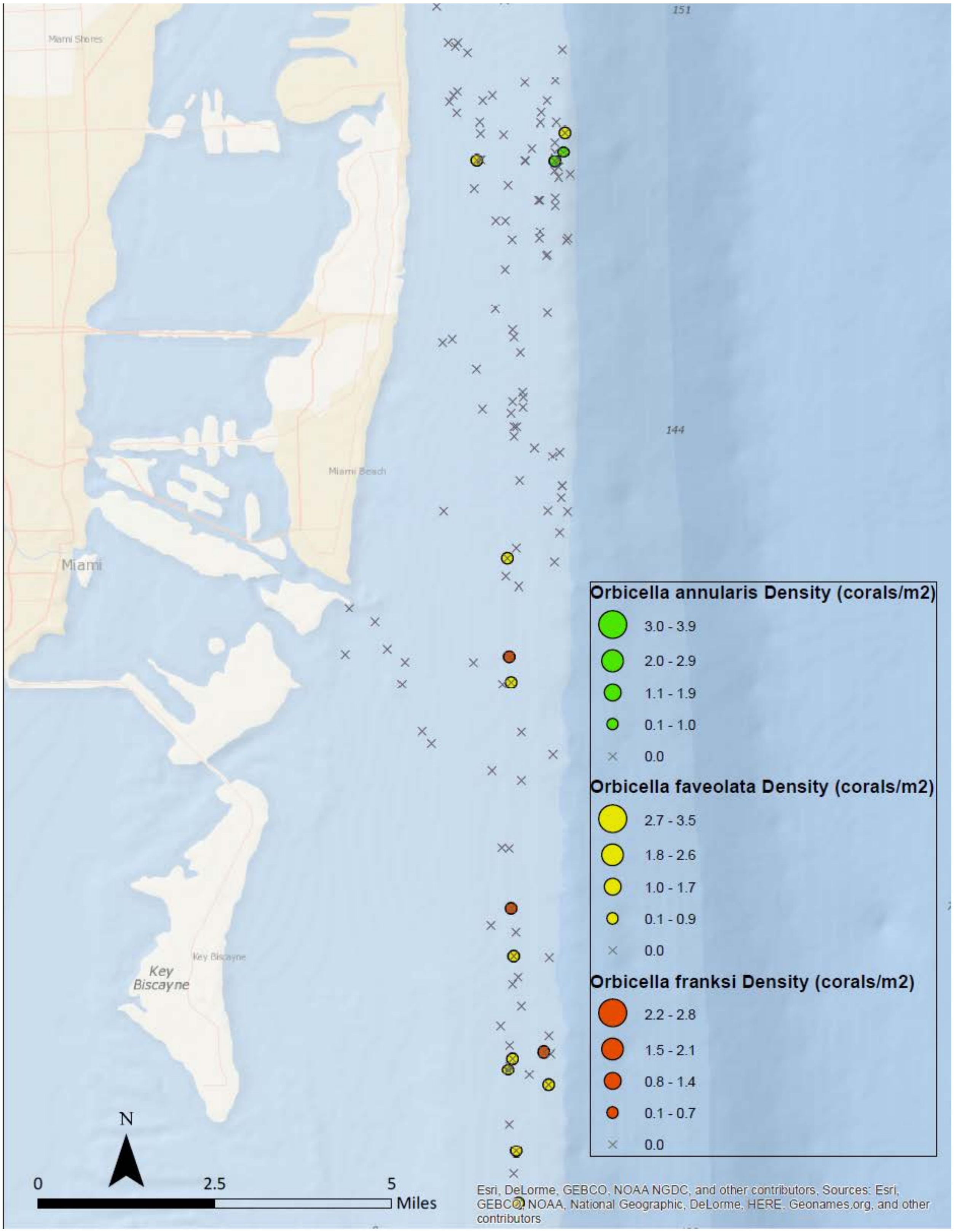

Figure 4. *Orbicella* coral densities near the POM. Figure provided by Jennifer Moore, NMFS.

8. CONCLUSION

Using the best available data, we analyzed the effects of the proposed action in the context of the status of the species, the environmental baseline, and cumulative effects, and determined that the proposed action is not likely to jeopardize the continued existence of mountainous star, boulder star, and lobed star corals.

9. INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and federal regulation pursuant to Section 4(d) of the ESA prohibit take of endangered and threatened species, respectively, without special exemption. Under the terms of Section 7(b)(4) and Section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement (ITS). The take of *Orbicella sp.* has not been prohibited by a section 4(d) regulation. However, non-prohibited take is included in the ITS and RPMs and terms and conditions are required.

Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. NMFS must estimate the type and extent of incidental take expected to occur from implementation of the proposed action to frame the limits of the take exemption provided in the Incidental Take Statement. These limits set thresholds that, if exceeded, would be the basis for reinitiating consultation. The following section describes the type and extent of take that NMFS anticipates will occur as a result of implementing the proposed action, and on which NMFS has based its determination that the action is not likely to jeopardize listed species.

The USACE has a continuing duty to regulate the activity covered by this incidental take statement. If the USACE (1) fails to assume and implement the terms and conditions or (2) fails to require the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the USACE must report the progress of the action and its impact on the species to NMFS as specified in the Incidental Take Statement (50 CFR §402.14(i)(3)).

9.1 Extent of Anticipated Take –Mountainous Star, Boulder Star, and Lobed Star Corals

NMFS has determined that the proposed project will result in the take of up to:

- 4 colonies of mountainous star coral.
- 4 colonies of boulder star coral.
- 3 colonies of lobed star coral.

Of these 11 colonies, NMFS has determined that up to 9 colonies may be taken lethally as follows:

- Up to 1 mountainous star colony may be lethally taken through mortality associated with transplantation.

- Up to 3 mountainous star coral, 3 boulder star coral, and 2 lobed star coral colonies may be lethally taken by the project if they are not found during relocation efforts.

9.2 Effect of the Take

NMFS has determined the anticipated take specified in Section 9.1 is not likely to jeopardize the continued existence of mountainous star, boulder star, or lobed star corals if the project is developed as proposed.

10. REASONABLE AND PRUDENT MEASURES (RPMs)

Section 7(b)(4) of the ESA requires NMFS to identify RPMs necessary to minimize the impacts of predicted incidental take and terms and conditions to implement those measures. Only incidental taking by the federal agency or applicant that complies with the specified terms and conditions is authorized.

These measures and terms and conditions are nondiscretionary, and must be implemented by the USACE or the applicant in order for the protection of Section 7(o)(2) to apply. The USACE has a continuing duty to regulate the activity covered by this ITS. If the USACE or the applicant fails to adhere to the terms and conditions of the ITS through enforceable terms, and/or fails to retain oversight to ensure compliance with these terms and conditions, the protective coverage of Section 7(o)(2) may lapse. To monitor the impact of the incidental take, the USACE or the contractor must report the progress of the action and its impact on the species to NMFS as specified in the ITS [50 CFR 402.12(i)(3)].

NMFS has determined that the following RPMs are necessary or appropriate to minimize impacts of the incidental take of mountainous star, boulder star, and lobed star coral colonies during the proposed action.

1. The USACE must ensure that all colonies of listed coral species are relocated from within the project impact area prior to beginning construction.

2. The USACE must conduct biological and environmental monitoring.

11. TERMS AND CONDITIONS

The USACE must comply with the following terms and conditions, which implement the RPMs described above. These terms and conditions are nondiscretionary.

1. Relocation of listed coral species: Since transplantation can be stressful on corals and the natural environment is variable, we believe the best way to minimize stress and ensure the survival of all transplanted colonies is to follow the attached ESA listed coral transplantation and monitoring plan (Appendix A) and monitoring plan (Appendix B). Qualified individuals following the protocols in Appendix A must conduct transplantation. (RPM 1)

2. USACE must record the original location of each transplanted colony, as well as the location of each colony after transplantation. (RPM 1)

3. USACE must ensure that all appropriate natural resource permits are obtained prior to relocation of corals. (RPM 1)

4. USACE shall conduct monitoring of relocated corals in accordance with procedures in Appendix A. (RPM 2)

5. USACE shall submit copies of all mitigation and monitoring reports to NMFS at the letterhead address. The USACE must provide NMFS with all data collected during monitoring events conducted, as well as any monitoring reports generated following the completion of the proposed project. The monitoring programs shall include reporting requirements to ensure NMFS, USACE, and other relevant agencies are aware of corrective actions being taken when thresholds are exceeded, as well as ensure NMFS receives data related to the condition of listed corals in the area due to the importance of these listed species. (RPMs 1-2).

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 endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

NMFS believes the following conservation recommendations are reasonable, necessary, and appropriate to conserve and recover *Orbicella* corals. NMFS strongly recommends that these measures be considered and adopted.

1. NMFS recommends that in addition to the proposed sharing of monitoring and reporting data, the USACE provide NMFS's Southeast Region Protected Resource Division (PRD), with the collected data submitted for all projects permitted concerning listed coral species.

2. NMFS recommends that the USACE provide the location and size of all non-listed corals to all persons who hold the proper permits and who may be interested in rescuing those corals for use in research or educational activities.

In order to keep NMFS informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, NMFS requests notification of the implementation of any conservation recommendations.

13. REINITIATION OF CONSULTATION

As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained (or is authorized by law) and if (1) the amount or extent of taking specified in the proposed action is exceeded, (2) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered, (3) the identified action is subsequently modified in a manner that causes an effect to listed species or critical habitat that was not considered in the Biological Opinion, or (4) a new species is listed or critical habitat designated that may be affected by the identified action.

14. LITERATURE CITED

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15. APPENDIX A

Coral Relocation Protocols for ESA Listed Corals

All relocation field activities, data collection, analysis and reporting will be supervised by a marine biologist (minimum academic requirement is M.S. degree in related field, or equivalent experience) with experience in coral transplantation and survival monitoring. The qualifications of any persons conducting transplantation work must be submitted to NMFS Protected Resources Division, for review.

The colonies will be collected carefully using a hammer and chisel. Upon collection, the colonies must be kept in bins and maintained in seawater at all times. The collected colonies must be kept at the original depth until transplantation commences (i.e., cached on site). Transplantation should occur as soon as operationally feasible, and no more than 24 hours after the colony is removed from its original location. During transportation to the transplant site, the corals must be covered.

The USACE must ensure that all transplanted colonies are re-located to suitable habitat near their original location. The colonies must be transplanted to an area of suitable habitat/substrate resembling that of the colonies original location as soon as operationally feasible. For the purposes of this opinion, suitable habitat is considered: similar depth as origin (+/- 5 ft); means consolidated hardbottom (to include the artificial boulder reef site) or dead coral skeleton that is free from fleshy macroalgae cover and sediment cover occurring in water depths from the mean high water (MHW) line to 30 meters (98 ft); appropriate water quality (based on water quality data and local knowledge), and minimal chances of other disturbances (boat groundings, damage caused by curious divers/fisherman). All efforts should be made to transplant the fragment to the same depth from which it was removed (i.e., +/- 5 ft).

The material used to attach the colonies to suitable substrate must be Portland cement. Before applying the Portland cement to the substrate, it must be cleaned of any sediment or algae. The Portland cement should then be taken out of the dry lock bag and pressed against the clean substrate. The transplanted colonies must then be pressed gently into the Portland cement with proper care. Transplanted colonies must be no closer than 0.75 meters from one another.

To assist in monitoring efforts, a plastic identification tag must be attached adjacent to each transplanted colony. Finally, the collected location, length, width, depth and orientation of each colony to be transplanted will be recorded. The transplanted location and depth of each colony, as well as the species and identification number, will be recorded.

16. APPENDIX B

CORAL REMOVAL, RELOCATION AND MONITORING PLAN

(adapted from Florida Keys National Marine Sanctuary staff recommendations for removal relocation and attachment)

All scleractinian (hard) corals greater than 10 cm in diameter and octocorals (soft corals) greater than 10 cm in length will be relocated from the existing bulkheads. The Resource Report provides an estimate that there are approximate 175 coral colonies of this size along the existing bulkhead within the area proposed for berth 7. The relocation site for these corals is a riprap site at the eastern end of Dodge/Lummus adjacent to the Pilot facility (North latitude 25° 46' 02.4" West latitude 080° 08' 44.5"). The riprap with corals will be transported to the offshore artificial reef site located in 25 ft water depth north of Government Cut outside of the Port entrance.

CORAL REMOVAL FROM BULKHEADS

- Tools: putty knife, paint tools (5-in-one tool or paint scraper), chipping hammer, other thin bladed tools with beveled edges, baskets or buckets; chisels with thin blades may be tested, but chisels are generally too thick-bladed such that they cause fragmentation of the coral colony.
  NOTE: No power tools or heavy pry bars will be utilized. The vibration and/or transfer from these tools will cause fragmentation of coral colonies.
- Some sort of rubber gloves will be used to handle the corals: Playtex or surgical gloves (plastic coated gloves are best) will be worn while handling corals to minimize mucous removal and abrasion, be conscious of and minimize disease transmission. Try to choose only disease free coral candidates.
- Initiate removal by clearing all encrusting organisms from the edges of the corals: chip sponges, tunicates, turkey wing oysters or other crustaceans; take care to prevent damage to the thin edges of corals; once removed, this creates an access point or ledges to get started with chipping corals.
  Efforts must be made to remove the coral colony in whole condition, so work patiently and systematically, according to the following protocols.
- Chisel or loosen colony edges with putty knife or other thin-bladed, beveled-edge tools, while working the entire circumference (N,S,E,W).
- Hammer concrete or metal surfaces adjacent to colony, as shock waves can help release the coral bond from some surfaces.
- Continue to chisel or loosen colony very carefully until it loosens and limestone dust is released from underside of colony, but stop just short of popping coral off or it will fall and get damaged.
- Use your fingers to pop off colony, just before it falls off.
- Place corals with the polyps up or in transport baskets for transport/caching; metal encrusted surfaces must not touch or rest on live coral surfaces.
- Cache like species only in nursery or holding area baskets; avoid or minimize colony tissue touching
  NOTE: Different species must NOT touch in overnight holding area baskets or nurseries, be certain to account for movement in baskets due to surge/waves over time.

CORAL REATTACHMENT TO OTHER THAN ORIGINAL SUBSTRATE

Choose appropriate orientation: if corals are from a vertical or sloped, elevated surface, then identify sloping (if not vertical) recipient location up off the bottom, where possible, especially for plating colonies: (See site selection & evaluation criteria below).

- Take care NOT to place corals too close to other naturally occurring or previously transplanted colonies. Do not transplant multiple colonies too close to one another allowing for colony growth, tissue recolonization and plating. (Inspect other colonies of like species for maximum sizes to identify adequate spacing considerations).

- Prep recipient surfaces with wire brush and/or chipping hammer: removing all algae (macro, fine filamentous), sediment, silt, encrusting and boring organisms (sponges, tunicates, crustaceans, etc.); take care to avoid other corals or those obscured by macro algae, (i.e., coral recruits). Additionally, be sure to prep underside of coral fragment or colony, removing any algae, sediment, silt, boring organisms, (sponges, tunicates, crustaceans, etc.), this is important especially if corals have been in a holding for a period of time; chip /flake off as much metal or rusting iron as practicable.
- Portland Type II cement/molding plaster mix of 4:1 ratio for quick setting and easy sculpting, especially for small colonies around 15 cm diameter.
- Minimize contact of concrete with live surface of coral and all coral tissue: clean gloved hands of concrete before placing coral colony on top of concrete ball; hand fan all tissue clear of any concrete that comes into contact with live coral surfaces immediately before it becomes imbedded/entrained in tissue mucous or poly calices.
- Place a ball of concrete on the prepared surface, place coral colony underside on cement ball and wedge coral down by gently wiggling colony, allow concrete to encompass bare, dead edges of coral colony base.
- Practice sculpting concrete around base of coral and cover or fill in bare rock surfaces, shore up edges leaving no bare rock edges or ledges to prevent boring organism recruitment.
  NOTE: It is critical that the cement be brought as closely to the edge of the living tissue and cover all the exposed skeleton, as practicable, to reduce the opportunity for bio-eroding organisms to invade the injured coral.
- For larger colonies (>15 cm) cement and molding plaster will be used as the adhesive to directly attach the larger coral fragments (>15 cm). In some instances, a 50/50 mixture of silica sand and cement may be used, and molding plaster minimized, especially when working with exceptionally large colonies (>40 cm), a ratio of 6:1 or 8:1 ratio (Portland cement:plaster) may be advised.

ADDITIONAL CONDITIONS AND GUIDELINES

The following conditions must be met to ensure the success of the re-attachment and stabilization in order to minimize secondary impacts during the restoration project period.

- At all times, extreme caution should be taken to prevent cement 'fallout' from landing on living tissue. Small lumps and cement particulate that accidentally settle out on living coral should immediately be removed via means of 'hand fanning'. Be certain to inspect the adjacent area and corals nearby for 'fallout' and hand fan accordingly upon completion of each daily project.
- All excess cement will be collected from the transplant site and disposed of offsite (land based). No excess cement will remain underwater and rinsing of mixing and storage materials should be minimized and contained.
- A mapping of all corals reattached must be developed and submitted as part of the baseline monitoring package. This map product must be georeferenced, show locations of corals by ID code and depths, and should be created immediately upon completion of the transplanting project, while coral transplants are easily identified.
  Photography should be used to document all work performed. Provide photos with reports and utilize for long term monitoring. A reference photograph of each relocated coral will be taken with a scaled reference item in the image, and all relocated corals will be identified by species, depth and a unique ID (e.g. S.sid 001).

RELOCATION OF THE RIPRAP BOULDERS WITH CORALS ATTACHED

Boulder and Coral Estimates

The Resource Report provides estimates of the number of boulders and boulders with corals within the area of proposed Berth 7. The riprap boulder area within proposed berth 7 is approximately 5,265 ft^2 and it was estimated that there is 1 boulder within 4 ft^2 or approximately 1,316 boulders (note: this approximates the concept that each boulder is approximately 1 yd^3). The percent occupation of corals on boulders was estimated in the transects within the area of proposed Berth 8 which is east of the area of proposed Berth 7. The percentage of boulders with corals increased from east to west within proposed Berth 8; therefore the conservative 60% of boulders contain corals has been used to estimate the boulders with corals within the riprap area of proposed Berth 7. An estimated 790 of the 1,316 boulders in the riprap area of proposed Berth 7 have corals on them leaving an estimated 526 boulders without corals. The Resource Report estimates that approximately 1,331 corals colonies occur on the riprap within proposed Berth 7.

As the riprap boulders are removed from the site, there will be boulders with and without corals attached.

- The boulders with corals attached will be carefully lifted from the bottom and placed on a barge. Lift bars or rings may be drilled and placed into the boulders for lifting. The boulders with corals will be kept wet between pick up and transfer to the artificial reef site.
- The boulders without corals attached will be lifted and placed on the barge in what is determined to be the most practical means. These boulders do not need to be kept wet.
- Boulders without corals will be placed along the bottom of the 65' long transition bulkhead starting about 35' east of the Berth 7 bulkhead to the Berth 8 existing rip rap area.
- At the artificial reef site POM A (Figure 1), the remaining boulders without corals attached will be placed on the bottom first and the boulders with corals attached will be placed on top of them in a stacked row. The rows will go across the artificial reef site along the east west axis to simulate spur and patch reef formations, as created on the artificial reef site POM B (Figure 2) for withstanding the predominant wave energy from the east.

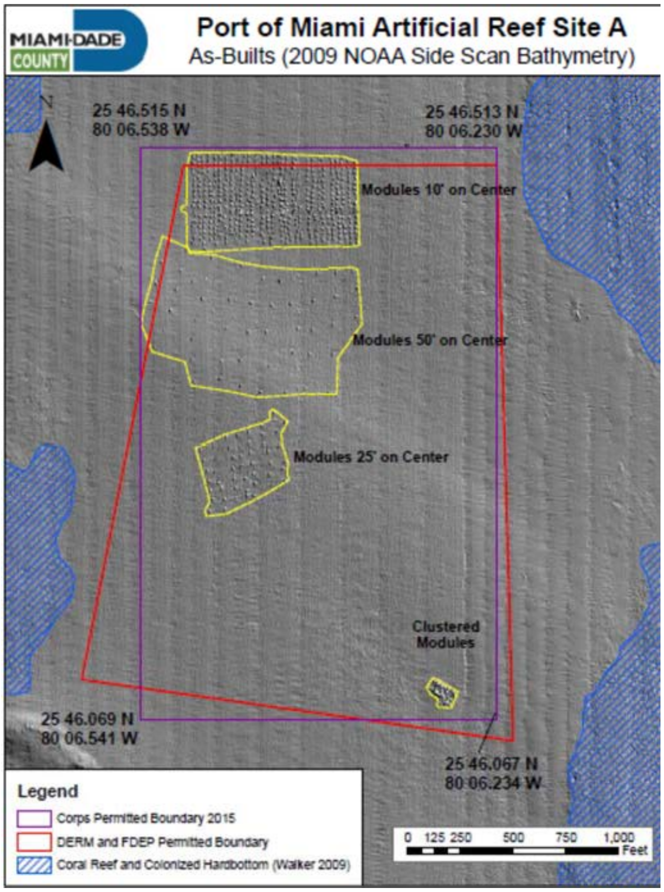

Figure 1. Artificial Reef Site POM A and the material currently within the site.

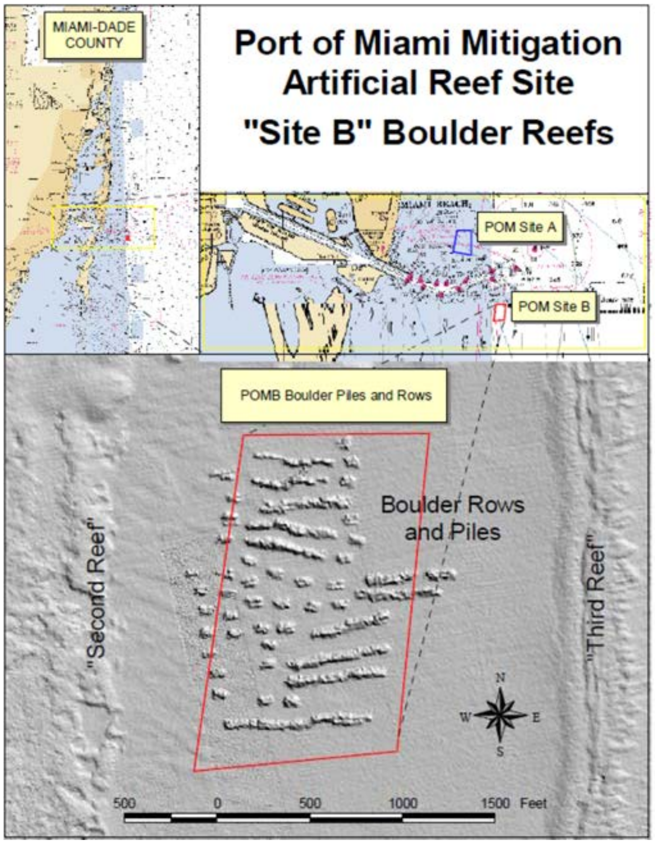

Figure 2. Spur and Patch Reef configuration created in Artificial Reef Site POM B.

Monitoring of Transplanted Corals and Rip Rap Boulders

As described above, each transplanted coral will be photographed with a scale in the photo when they are transplanted. In addition, they will be physically measures for height and largest diameter. Notes will be made on condition of the transplant (e.g. necrosis, fouling). Corals and octocorals that are removed and relocated specifically for mitigation purposes will be monitored for attachment success and survival at one week (at any time during the first week), six months, one year and two years postrelocation. At those intervals, the corals will be monitoring for presence, survivorship, and condition (e.g. disease, necrosis, fouling). Greater than 75% of all the non-listed corals and 90% of listed corals are required to survive the transplant procedure and 85% survival is required for the surviving monitored coral colonies after two years. The transplanted coral will be photographed with a scale in the photograph. A set of corals of the same species that are transplanted that are already existing on the riprap at the transplant site will be selected and monitored as controls for comparison to the transplanted corals.

The relocated boulders at the artificial reef site will be monitored for stability (e.g. movement and subsidence) and generally for colonization by attached organisms and fish attraction at 12 and 24 months after relocation.