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Fishery Ecosystem Plan II
Shallow Coral Reef Habitat and Shallow Coral
Draft
June 2017

Shallow Coral Reef Habitat

Description and distribution

Shallow water coral reefs and coral communities exist within the southern geographical areas under Council authority. In this document these habitats are defined as occurring in depths generally less than 50 meters. Depending upon many variables, stony corals (those secreting reef-building habitat structure) may dominate a habitat, be a significant component, or be individual colonies within a community characterized by other fauna (e.g., sponges or macroalgae). In some areas stony corals have grown in such profusion that their old skeletons accumulate and form reef structure (e.g., coral reefs). In other areas, corals grow as a less dominant component of benthic communities on geologically derived hard substrates (e.g., coral communities). Octocorals, though they do not contribute to reef framework, do contribute greatly to reef complexity and diversity. This section focuses on those ecosystems under Council authority having Scleractinians as an important member of the community. Hardbottom communities that have little or no Scleractinians are treated in the Live/Hardbottom Habitat section of this document.

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1. Reef biogeography, habitat, and community types:

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North Florida to North Carolina

Coral assemblages from north Florida north to North Carolina, are dominated by ahermatypic stony coral species and gorgonians, although some hermatypic species do occur off North Carolina (MacIntyre and Pilkey 1969) and Georgia (Hunt 1974). The very limited coral assemblages within this area are found on shallow-water hardbottom habitats ((Johnston 1976); off Georgia and South Carolina (Stetson et al. 1962; Porter 1978 personal communication; Thomas 1978 personal communication); and North Carolina (Huntsman 1984; MacIntyre and Pilkey 1969)) and deep-water banks (*Oculina* spp.). These are further described in deep water coral Section of this document.

North Florida to St. Lucie Inlet

From St. John's Inlet to St. Lucie Inlet coral assemblages are relatively sparse and low in diversity as compared to reefs further south. Coral colonies are commonly located on non-coral-derived consolidated carbonate sediments (Avent et al. 1977). Corals are most common in the nearshore hardbottom and along two reef tracts (20 m, 30 m). The two major reef tracts consist of ledges of up to 3 m relief. While the outer 30 m shelf tract runs through the majority of this region, the 20 m shelf tract runs intermittently. Coral assemblages include octocorals (*Lophogorgia, Leptogorgia, Eunicea, Antillorgia* spp.), and scleractinian coral (*Oculina diffusa*, *Oculina varicosa*, and *Siderastrea* spp.). Both temperate and subtropical fish and invertebrate species are represented in this region. At the shelf-edge, high relief (up to 25 m) pinnacles begin at 50 m depth where *Oculina varicosa* form massive branching colonies (Reed 1980). For a more extensive review of the deep water *Oculina* reefs Section.

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Southeast Florida

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The Florida Reef Tract (FRT) extends approximately 577 km from the St. Lucie Inlet (Martin County), southward to the Dry Tortugas banks. Off the mainland coast of southeast Florida, the northern extension of the FRT extends from Martin County approximately 170 km south into Miami-Dade County. From central Palm Beach County south to, in particular offshore Broward County, southern Miami-Dade County the reef system is described as a series of linear (Inner, Middle, and Outer) reef complexes (referred to as reefs, reef tracts, or reef terraces). These complexes run parallel to shore, generally at depths approximately 6m to 20m. In addition there are extensive nearshore ridges and colonized pavement areas nearer to shore (Moyer et al. 2003; Banks et al. 2007; Walker et al. 2008). Although these high latitude habitats are near the environmental threshold for significant coral reef growth, they are colonized by an extensive coral reef community which is quite similar within the linear reefs. This region has a similar diversity of key functional groups (stony corals, octocorals, sponges, and macroalgae) to that of the southern regions of the FRT (the Florida Keys and Dry Tortugas) but contributions of these groups to benthic cover may vary (Ruzicka et al. 2010; Ruzicka et al. 2012, Gilliam et al. 2015).

The nearshore ridges and colonized pavement areas occur within a km of shore in water depths generally less than 5 m and are most prominent off Palm Beach, Broward, and Miami-Dade counties. This habitat is defined as flat, low relief, solid carbonate rock with variable sand cover within the most nearshore areas (Walker et al. 2008). In Palm Beach and Martin Counties, the sessile community in less than 3 m is dominated primarily by turf and macroalgae. The dominant scleractinian at these depths are *Siderastrea* species (CSA 2009). In a number of these shallow water areas, the sabellariid polychaete *Phragmatopoma lapidosa* (know as worm rock) can be a dominant component of the habitat. South of these counties, these habitats have been documented to contain areas with the highest stony coral cover and the greatest abundance of larger (>2m) stony corals (dominated by *Montastrea cavernosa* and *Orbicella faveolata)* in the region (Gilliam et al. 2015; Gilliam et al. 2015, Walker...). In this area, this habitat also contains

perhaps the most abundant population of staghorn coral, *Acropora cervicornis,* in the Council management area (Vargas-Angel et. al 2006, Walker et al. 2012, Gilliam et al. 2015; Gilliam et al. 2015, D'Antonio et al. 2016).

The Inner Reef occurs within 1 km of shore and crests in 3 to 7 m depths. The Middle Reef crests in 12 to 14 m depths, and Outer Reef crests in 15 to 21 m depths. A large sand area generally separates the Inner and Middle, and the Middle and Outer, reef complexes. The Inner and Middle Reefs extend from northern Broward County south into Miami-Dade County. The Outer Reef occurs within 3 km of shore and is the most continuous reef complex extending from central Palm Beach County south into Miami-Dade County. The community in these reefs includes over 30 species of stony corals and a diverse assemblage of gorgonians and sponges (Gilliak et al. 2015). The common stony coral species include: *Montastrea cavernosa*, *Siderastrea siderea*, *Porites astreoides*, *Solenastrea bournoni*, *Meandrina meandrites*, and *Dichocoenia stokesii*. Octocorals (gorgonians) and sponges generally have a greater density than stony corals. Some of the common octocoral genera include: *Eunicea*, *Antillogorgia*, *Muricea*, *Plexaurella*, *Pterogorgia* and *Icilogorgia* (Goldberg 1973). Very large (>1m wide) barrel sponges, *Xestospongia muta*, are conspicuous and quite abundant in certain areas of the Middle and Outer Reefs.

Florida Keys

The southernmost component of the Florida Reef Tract includes the area south of Soldier Key to the Dry Tortugas banks. Along the nearshore environs to the deep fore reef adjacent to the straits of Florida, coral-associated habitats consist of nearshore hardbottom communities, patch reefs, and a semi-continuous series of offshore bank-barrier reefs (reef flats, spur and groove) (summarized in Marszalek et al. 1977, Jaap 1984, and Chiappone 1996). These habitats boast a wide bathymetric distribution, from the intertidal to great depths, and are currently colonized by calcifying algae (e.g., *Halimeda*), sponges, octocorals, and a few species of stony corals. Local environmental conditions, driven by water exchange between Florida Bay and the Atlantic Ocean, dictate which species colonize the substrate.

Low relief hardbottom communities occur within 2 km of shore on the Florida Bay and Atlantic sides of the islands. These communities are highly diverse (as described in Chiappone and Sullivan 1994) and dominate the Florida Keys in terms of areal extent (Chiappone 1996).

The patch reef habitat is constructed by a few species of massive stony corals; most often the principal species is *Orbicella annularis*, boulder star coral. Other common foundation building species include *Colpophyllia natans* and *Siderastrea siderea*. Common octocoral genera found on patch reefs include: *Antillogorgia*, *Pseudoplexaura*, *Gorgonia*, *Muricea* and *Plexaurella*. Patch reefs are concentrated in the area off Elliott Key (Biscayne National Park), north Key

Largo (John Pennekamp Coral Reef State Park, Florida Keys National Marine Sanctuary, FKNMS), and in the Hawk Channel area from Marathon to Key West (FKNMS).

The outer bank reefs are the seaward-most reefs in the Florida Keys coastal ecosystem. These reefs are most commonly visited by the diving and snorkeling charters. Their principal, unique feature is the spur and groove system (Shinn 1963). The system is a series of ridges and channels facilitating water transport from seaward to inshore. The coral most responsible for building the spurs was *Acropora palmata* (Shinn 1963), whose population has since experienced significant decline. The spur and groove systems occur in depths that range from a few centimeters to 10 meters. Beyond 10 meters, the spur and groove formation may or may not continue seaward as very low relief structures. Often, this habitat subunit is referred to as the fore-reef and may continue to about 30 m depth. Seaward, sediment beds separate the fore-reef from deeper reef formations in 40 m depth. Stony coral cover has significantly declined over time in this system at both shallow and offshore fore-reefs, and a transition to octocoral dominance is most evident at shallow fore-reefs (Ruzicka et al. 2014). Octocorals of the genus *Antillogorgia*, *Gorgonia*, *Pseudoplexaura, Muricea*, *Eunicea* and *Plexaurella* are commonly found in these outer bank reefs.

The Tortugas Banks are a variation of the deeper reefs found in Dry Tortugas National Park. The depths are greater than 20 m and extend to 40 m. The foundation is Pleistocene karst limestone. The extensive banks host a major grouper and snapper fishery, including a critical 46 square mile spawning ground currently protected as a Research Natural Area. The banks have abundant coral of a few species. Black coral (Order Antipatharia) are common on the outer edge of the bank.

2. Ecological Functions

Coral reefs and hardbottom have many functional roles within the SAFMC jurisdiction. These functions include complex issues such as trophic relationships, shelter, and cross-shelf and large-scale population connectivity via reproduction. High diversity of reef residents support complex trophic relationships and novel routes of productivity, including significant bio-calcification, which provides the architectural structure. The details of these relationships and functions have been examined in several recent large compilations such as Mora (2015) and Birkeland (2015).

3. Use

Healthy coral reefs are among the most biologically diverse and economically valuable ecosystems on earth, providing valuable and vital economic goods and ecosystem services. Coral ecosystems are a source of food for millions; protect coastlines from storms and erosion; provide habitat, spawning, and nursery grounds for economically and recreationally important fish species; provide jobs and income to local economies from fishing, recreation, and tourism; are a source of new medicines, and are hotspots of marine biodiversity.

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4. Current Habitat Management

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Federal

Essential Fish Habitat

The 1996 federal reauthorization of the Magnuson Stevens Act (the Sustainable Fisheries Act) mandated that all eight federal fishery management councils identify Essential Fish Habitat (EFH) in their jurisdiction and amend all Fishery Management Plans (FMPs) as applicable. The SAFMC followed the enabling language and treated EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity". The SAFMC also identified EFH - Habitat Areas of Particular Concern (HAPCs), which are EFH areas that include one of these four attributes: provide important ecological functions; are sensitive to environmental degradation; include a habitat type that is/will be stressed by development; or include a habitat type that is rare (SAFMC, 1998a).

EFH applies to each life stage of managed species and different life stages of the same species often use different habitats. All coral and hardbottom habitats are designated as EFH-HAPC for the 60 reef species currently in the Snapper Grouper FMP as well as the Spiny Lobster. Additionally, other components of reef habitat such as sponges are EFH for Spiny Lobster. The habitat source document for these designations (SAFMC, 1998b) provided much rationale and content used also in first FEP document. Many administrative details on how EFH is used in coral conservation permitting among federal, state, and local agencies are reviewed in Lindeman and Ruppert (2011).

Place-based management:

The South Atlantic region includes a range of federally managed areas with coral reef habitats, most notably the Florida Keys National Marine Sanctuary (NOAA) and two units of the National Park Service (Dry Tortugas and Biscayne National Parks). Each of these areas has its own management plan, including some areas set aside as marine reserves.

The Florida Keys National Marine Sanctuary (FKNMS) was designated in 1990 for protection in response to concerns about the decline of the reef ecosystem in the area (FKNMS Protection Act 1990). Today, the FKNMS protects more than 9,946 km2 (2,900 nautical mi2) of Florida Keys coastal and ocean waters. With the designation, several protective measures were immediately put into place, such as prohibiting oil exploration, mining, or any type of activity that would alter the seafloor, and restricting large shipping traffic. Anchoring on, touching, and collecting coral are all restricted within sanctuary waters. The FKNMS is jointly administered by the State of

Florida and the National Oceanic and Atmospheric Administration (NOAA). The FKNMS management plan was first established in 1998 and implemented a network of zones and protected areas as well as strategies including mooring buoys and a water quality protection program. Additional Ecological Reserves were implemented in the Dry Tortugas region in 2001. NOAA is currently undertaking the first comprehensive review of the management plan, zoning plan and regulations. This review is a public process that will eventually culminate in an updated management plan and potential modifications to regulations, marine zones, and the sanctuary boundary.

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Two components of the National Park system manage coral reef habitats in the south Atlantic region, Biscayne National Park and Dry Tortugas National Park. Biscayne National Park was designated in 1980 (after prior status as Biscayne National Monument) and protects habitats adjacent to the south Florida urban area including Biscayne Bay, the barrier islands, and out to the reef tract. Biscayne NP recently released its first general management plan (June 2015) which includes a marine reserve zone incorporating both fore-reef and patch reef habitats. Dry Tortugas, administered under the management of Everglades National Park, was designated in 1992 and protects relatively remote marine habitats, 113 km southwest of Key West with visitation largely limited to ferry or sea plane. The general management plan for Dry Tortugas NP was amended in 2001 incorporating a zoning scheme including 46% of the park area in a Research Natural Area, the highest level of habitat protection where natural processes are protected from human impact (including fishing).

Endangered Species Act Critical Habitat:

Under the Endangered Species Act of 1973, critical habitat may be designated by NOAA Fisheries for the conservation of threatened and endangered species under its jurisdiction. Critical Habitat designations were made for ESA listed corals, *Acropora palmata* and *A. cervicornis*, in 2008 to include hardbottom habitats < 30m depth deemed suitable to support recruitment of these corals (namely, stable hard substrate free of algae and sediment). Under this designation, over 3,000 sq km of habitat in the south Atlantic region are protected from destruction or 'adverse modification' by actions undertaken, funded, or permitted by federal entities.

State of Florida

In 2009, the Florida Legislature passed the Coral Reef Protection Act (CRPA, s. 403.93345, Florida Statutes [F.S.]) to increase protection of coral reef resources on sovereign submerged lands off the coasts of Martin, Palm Beach, Broward, Miami-Dade, and Monroe counties.

The CRPA authorizes the Florida Department of Environmental Protection (FDEP), as the state's lead trustee for coral reef resources, to protect coral reefs through timely and efficient assessment

and recovery of monetary damages resulting from vessel groundings and anchoring-related injuries. To carry out the intent of the Act, the FDEP also has the authority to enter into delegation agreements with state and local government agencies with coral reefs in their jurisdictions. The CRPA is overseen by the FDEP Coral Reef Conservation Program which works with FDEP regulatory or legal entities to ensure the Act is enforced.

In addition to the CRPA, the FWC's Marine Life Rule (Rule 68B-42.009, Florida Administrative Code [F.A.C.]) also provides protection for coral reef resources through the prohibition of take, destruction, and sale of marine corals, sea fans, and encrusting octocorals.

State Parks and Aquatic Preserves

Several Florida State Parks and Aquatic Preserves have boundaries extending into the nearshore marine environment (Chapter 258, Florida Statutes and Chapter 62D-2, Florida). These Parks and Preserves manage submerged lands within these boundaries while FWC manages fisheries resources.

Administrative Code and Florida Aquatic Preserve Act of 1975 (Section 258.35, Florida Statutes)). State parks are charged to, "*promote the state park system for the use, enjoyment, and benefit of the people of Florida and visitors; to acquire typical portions of the original domain ... as to emblemize the state's natural values; conserve these natural values for all time; ... to enable the people of Florida and visitors to enjoy these values without depleting them; ...; to contribute to the tourist appeal of Florida".*

While Aquatic preserves are charged to, "*be managed primarily for the maintenance of essentially natural conditions, the propagation of fish and wildlife, and public recreation, including hunting and fishing where deemed appropriate by the Board, and the managing agency. ..."*

State Park boundaries for John D. MacArthur Beach State Park in Palm Beach County, John U. Lloyd Beach State Park in Broward County, Bill Baggs Cape Florida State Park in Miami-Dade County, and Indian Key, Long Key, Curry Hammock, and Bahia Honda State, and Fort Zachary Taylor Historic state parks in Monroe County extend into the water up to 400 ft. from the Mean High Water Line (F.A.C 62D-2.014.9b). Other coastal managed areas such as St. Lucie Inlet Preserve State Park in Martin County; Biscayne Bay-Cape Florida to Monroe County Line Aquatic Preserve in Miami-Dade County; Lignumvitae Key Botanical State Park, San Pedro Underwater Archaeological Preserve State Park, and Lignumvitae Key and Coupon Bight Aquatic Preserves in Monroe County extend up to a mile offshore. As the first undersea park in the U.S., John Pennekamp Coral Reef State Park, was dedicated in 1960 and encompasses approximately 70 nautical square miles.

Local Action Strategies

While the reefs in the lower two-thirds of the FRT have had coordinated management for many years, the northern one-third in southeast Florida has lacked a comprehensive management plan and, until recently, an understanding of the local impacts and use in that region. Current initiatives in southeast Florida are bringing together the science and stakeholders to recommend management actions that preserve these reef resources while balancing resource use and protection.

In 1998, the United States Coral Reef Task Force (USCRTF) was established by Presidential Executive Order #13089 to lead U.S. efforts to preserve and protect coral reef ecosystems. During the eighth meeting of the USCRTF, held in Puerto Rico in 2002, the Task Force adopted the Puerto Rico Resolution, which called for the development of Local Action Strategies (LAS) by each of the seven member U.S. states, territories and commonwealths. These LAS are locally-driven roadmaps for collaborative and cooperative action among federal, state, territory and non-governmental partners which identify and implement priority actions needed to reduce key threats to coral reef resources. The goals and objectives of the LAS are closely linked to those found in the U.S. National Action Plan to Conserve Coral Reefs, adopted by the U.S. Coral Reef Task Force in 2000.

With guidance from the U.S. Coral Reef Task Force, the Florida Department of Environmental Protection (FDEP) and the Florida Fish and Wildlife Conservation Commission (FWC) coordinated the formation of a team of interagency marine resource professionals (state, regional, local, and federal), scientists, and reef resource stakeholders to form the Southeast Florida Coral Reef Initiative (SEFCRI) in 2004.

The SEFCRI which is coordinated and chaired by FDEP, while not a regulatory body, identified the reefs from St. Lucie Inlet in Martin County to the northern boundary of Biscayne National Park as their area of focus due to the lack of understanding of these reefs as well as the lack of a coordinated management plan. The SEFCRI identified the priority threats to southeast Florida's reef resources and developed 140 projects to better understand and reduce those threats. One of the original projects was to: "*Develop and* [sic] *effective, balanced, and comprehensive management strategy for improved resource protection...Organize and hold public workshops to obtain input on the condition and usage trends, possible resource goals, and the potential (i.e. rationale, effectiveness, alternative approaches, etc.) of traditional fishery management and special management zones to achieve targets*."

A major management effort, the *OUR FLORIDA REEFS* community planning process for southeast Florida's coral reefs, was recently completed in June 2016. Hosted by the SEFCRI, this

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planning process brought together the community of local residents, reef users, business owners, visitors, and the broader public in Miami-Dade, Broward, Palm Beach, and Martin counties to discuss the future of coral reefs in this region. This process is designed to increase public involvement in the future management of southeast Florida's coral reefs by seeking input from a broad range of community members and reef stakeholders on the development of recommendations that can become part of a comprehensive management strategy to ensure healthy coral reefs in the future. The recommended management actions (RMAs) developed through the process address issues from land based sources of pollution; maritime industry and coastal construction; fishing, diving, boating, and other uses; enforcement; education and outreach; and place-based management. The majority of these RMAs were broadly supported by the Community Working Groups, though a few were highly controversial.

5. Ongoing Threats

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Many local actions create or exacerbate detrimental impacts to shallow coral reef ecosystems. Coastal construction and infrastructure development are particularly common near the urban centers from Palm Beach to Miami-Dade counties (Shivlani et al. 2011, Walker et al 2012). Dredge and fill activities such as beach nourishment and port maintenance and expansion result in direct loss of habitat and cumulative as well as acute effects to coral communities through increased turbidity and sedimentation (Wanless and Maier, 2007; Jordan et al. 2010). Beach nourishment activities are on-going especially within Palm Beach, Broward, and Miami-Dade counties. Recent (2015) port dredging at Port Miami greatly exceeded planned impacts by sedimentation to coral reef habitat, with another large dredging project upcoming at Port Everglades (Fort Lauderdale).

Overfishing has been suggested to result in a global decline of piscine predators with subsequent significant changes in the numbers of herbivores (Mumby et al. 2006). In the Caribbean, parrotfish overfishing has been hypothesized to be pivotal in adversely affecting corals in this region (Jackson et al. 2014). Decreases in parrotfish could result in increased macroalgae, which directly outcompetes corals for space or inhibits coral recruitment. However, in the Florida Keys, herbivore-targeting fishing efforts have been relatively nonexistent (Bohnsack et al. 1994). Fishing activities such as that of trap fisheries more clearly create disturbance to reef benthic communities. Although trap fishers report generally avoiding coral reef habitats, ocean dynamics result in an accumulation of trap debris in coral-associated habitats (Uhrin et al 2014). These authors estimate the presence of almost two million items of lobster trap debris in the Florida Keys National Marine Sanctuary. The cover of benthic sessile fauna is reduced by ~ 10 % in areas affected by trap movement, events occurring over a wind threshold of 2 days duration at 15 kt (Lewis et al. 2009).

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Water quality degradation from regional water management activities, sewage, coastal runoff, and local use likely have detrimental impacts (reviewed by Gregg 2013) with documented detriments to coral health (see Section XXX corals). However, reef-scale impacts of water quality are difficult to partition from the myriad stressors, which co-occur on reefs in the region. It is highly likely that both coastal hardening/construction and coastal water quality degradation will be exacerbated in the near future by rapid sea level rise from global climate change (Koch et al. 2015).

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Invasive lionfish (*Pterois* spp.) likely continue to alter the structure of coral reef fish and invertebrate communities (Albins and Hixon 2008; Albins 2013, 2015; Green et al. 2014), and thus potentially alter coral reef ecosystem function. Lionfish impacts arise predominantly via direct predation (lionfish are voracious generalist predators - Morris and Akins 2009, Muñoz et al. 2011), but also likely occur through competition - e.g., for habitat or prey. Assessing the community- and broader-level impacts of lionfish is a critical need (see related text in Section 6).

With nearly 6 million residents in Martin (146,000), Palm Beach (1.3 million), Broward (1.75 million), and Miami-Dade (2.5 million) Counties, and millions of visitors every year, awareness and appreciation of reef resources in the northern portion of the reef tract is severely lacking (US Census Bureau 2010).

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6. Summary Recommendations

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The United States Coral Reef Task Force (USCRTF) was established in 1998 by Presidential Executive Order to lead U.S. efforts to preserve and protect coral reef ecosystems. The USCRTF includes leaders of 12 Federal agencies, seven U.S. States, Territories, Commonwealths, and three Freely Associated States. The USCRTF helps build partnerships, strategies, and support for on-the-ground action to conserve coral reefs. (From http://www.coralreef.gov/ecosystem/)

USCRTF Recommendations:

- Understand coral reef community dynamics and the impacts of human-caused and natural stressors;
- Identify possible management strategies to mitigate negative impacts; and
- Evaluate the effectiveness of these management actions after they are implemented.

Knowledge Gaps:

- Tropicalization: effects of anticipated shifting species assemblages with warming temperatures.

- Where needed, expand knowledge of the distribution and benthic community attributes of coral reef ecosystems (e.g., via expanded mapping efforts in intermediate depths, 30-50m)

Lionfish:

- While there have been multiple studies documenting local-scale effects of invasive lionfish (*Pterois* spp.) predation on native fish species (Albins and Hixon 2008; Albins 2013, 2015; Green et al. 2014), none of those studies have occurred in SAFMC-managed waters (a majority of the studies were performed in Bahamian waters), and no studies in any area have assessed the effect of lionfish predation over relatively broad scales. Barbour et al, 2011 developed a model which predicted an annual exploitation rate between 35 and 65% would be required to cause recruitment overfishing on lionfish populations. Research is needed to further assess the realized effects of lionfish, via predation and potentially competition, on coral reef fish community structure at broader spatial scales (e.g., sub-regional, regional, ecosystem).

- There is considerable interest in controlling, reducing or depleting local lionfish populations through culling efforts (e.g., via spearfishers). Usseglio et al. 2017, has developed a framework that allows managers to predict the removal effort required to achieve specific targets (represented as the percent of lionfish remaining on the reef) Green et al. 2014 found that reductions in density of 25-92%, depending on the reef, were required to suppress lionfish below levels predicted to overconsume prey. On reefs where lionfish were kept below threshold densities, native prey fish biomass increased by 50 70%. Additional research may be needed to refine (1) the effectiveness of culling efforts, in terms of the frequency and intensity of culling needed to maintain lionfish below targeted densities, (2) what target densities are most appropriate (e.g., near-zero, low, moderate…) in terms of reducing probable ecosystem impacts, and (3) assessing the trade-offs between the costs of culling efforts and the benefits (ecological and fishery-related) derived from those efforts.

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- Assess and monitor spatial and temporal patterns in use of coral reef ecosystems in terms of fishing, snorkeling / diving and other uses.

- Assess efficacy (direct and indirect results) of management actions such as MPAs.

- Identify fish and invertebrate spawning habitats or locations, and the degree to which spawning aggregations are targeted by fishers.

- Due to repeated reef impacts from large dredging and beach projects in the area, from direct disturbance and ongoing turbidity, (Wanless & Maier 2007), there is a need

for better understanding chronic and acute turbidity and/or sedimentation on coral reef habitats.

Summary Management Recommendations:

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- Develop and implement numeric water quality standards, including for turbidity, that are protective of coral reef habitats (Gregg 2013)

- "Focused removal of submerged trap debris from especially vulnerable habitats such as reefs and hardbottom, where trap debris density is high, would mitigate key habitat issues but would not address ghost fishing or the cost of lost gear." (Uhrin et al 2014)

- Diadema restoration (Acropora Recovery Plan, and Florida Pillar Coral Action Plan)

- The Our Florida Reefs Community Working Groups have developed and vetted Recommended Management Actions to improve conservation of southeast Florida reef ecosystems. The final Recommended Management Actions, including a prioritized ranking, are available here:
- http://ourfloridareefs.org/rmacomment/.
  A key recommendation was for a coordinated management plan which includes a network of areas-of-interest for place-based management. This network of place-based management could include coordination with existing managed areas (e.g. see State Parks and Aquatic Preserves), creation of areas for seasonal protection, marine reserves, and areas identified for restoration. This RMA, though ranked in the top priority category by the Community Working Groups, has met with sharp disagreement from some stakeholder sectors and FWC.

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- Coral reef habitats are impacted by ongoing and repeated damage from dredging and coastal construction projects in the region. Given increasing environmental stressors on coral reefs in the region, added stress from construction projects may be temporally partitioned from predictable sensitive ecological processes and stressors (Fraser et al. 2017). Much construction-related damage should also be preventable under existing regulations, but improvements in permitting, monitoring, implementation, compliance and enforcement are needed. Specific recommendations for such improvement are provided in Lindeman and Ruppert (2011) include
  - Development of a template by permitting agencies with standard language for 'special conditions' to avoid, minimize, and monitor coral impacts
  - Development by NMFS of regulatory criteria to identify 'destruction or adverse modification' of ESA Critical Habitat, replacing the current working definition.

7. References

Albins, M.A., and Hixon, M.A. 2008. Invasive Indo-Pacific lionfish Pterois volitans reduce recruitment of Atlantic coral-reef fishes. Mar Ecol Prog Ser 367:233–238.

Albins, M.A., 2013. Effects of invasive Pacific red lionfish Pterois volitans versus a native predator on Bahamian coral-reef fish communities. Biol Invasions 15:29–43.

Albins, M.A., 2015. Invasive Pacific lionfish Pterois volitans reduce abundance and species richness of native Bahamian coral-reef fishes. Mar Ecol Prog Ser 522:231–243.

Avent, R.M, King, M.E., and Gore, R.H., 1977. Topographic and faunal studies of the shelf-edge prominences off the central eastern Florida Coast. Internationale Revue der gesamten Hydrobiologie und Hydrographie 62(2):185-208.

Birkeland, C. (ed) 2015. Coral Reefs in the Anthropocene. 271 pp. Springer.

Chiappone, M., 1996. Marine Benthic Communities of the Florida Keys. In: Site Characterization for the Florida Keys National Marine Sanctuary and Environs, Vol. 4. The Preserver.

Chiappone, M., and Sullivan K.M., 1994. Ecological structure and dynamics on nearshore hard-bottomcommunities of the Florida Keys. Bulletin of Marine Science 54(3): 747-756

Fraser, M.W., et al. 2017. Effects of dredging on critical ecological processes for marine invertebrates, seagrasses and macroalgae, and the potential for management with environmental windows using Western Australia as a case study. Ecological Indicators 78:229-242.

Gilliam, D.S., Walton, C.J., Brinkhuis, V., Ruzicka, R., and M. Colella. 2015. Southeast Florida Coral Reef Evaluation and Monitoring Project 2014 Year 12 Final Report. Florida DEP Report #RM085. Miami Beach, FL. pp. 43.

Goldberg, W.M. 1973. The ecology of the coral-octocoral communities off the southeast Florida coast: geomorphology, species composition, and zonation. Bulletin of Marine Science 23(3): 465-488.

Green, S.J., Akins, J.L., Maljkovic, A., and Côté, I.M., 2012. Invasive lionfish drive Atlantic coral reef fish declines. PLoS ONE 7:DOI:10.1371/journal.pone.0032596.

Gregg, K. 2013. Literature Review and Synthesis of Land-Based Sources of Pollution

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Affecting Essential Fish Habitats in Southeast Florida. Report prepared for NMFS Southeast Regional Office. Available from http://www.dep.state.fl.us/coastal/programs/coral/reports/LBSP/LBSP_EFH_Lit_Review_and_Synth_Final.pdf

Jaap, W.C., 1984. The Ecology of South Florida Reefs: A Community Profile. U.S. Fish and Wildlife Service, Office of Biological Sciences. Washington D.C. FWS/OBS-82/08. 138 pp.

Jordan, L.K.B., Banks, K.W., Fisher, L.E., Walker, B.K., and Gilliam, D.S., 2010. Elevated sedimentation on coral reefs adjacent to a beach nourishment project. Marine Pollution Bulletin 60(2):261-71.

Koch, M.S., Coronado, C., Miller, M.W., Rudnick, D.T., Stabenau, E., Halley, R.B., Sklar, F.H., 2015. Climate change projected effects on coastal foundation communities of the Greater Everglades using a 2060 scenario: Need for a new management paradigm. Environ Manage 55:857-875

Kuffner, I.B., Lidz, B.H., Hudson, J.H., Anderson, J.S., 2014. A century of ocean warming on Florida Keys coral reefs: historic in situ observations. Estuar Coasts:1-12

Lewis, C.F., Slade, S.L., Maxwell, K.E., Matthews, T.R. 2009. Lobster trap impact on coral reefs: Effects of wind-driven trap movement. N Z J Mar Freshwater Res 43:271-282

Lindeman, K.C. and Ruppert, T. 2011. Policy recommendations and training to improve agency permitting, compliance, and enforcement for coral resource conservation in southeast Florida. Florida Dept. of Environmental Protection, Southeast Florida Coral Reef Initiative, 207 pp.

Marszalek, D.S., Babashoff, G., Noel, M.R, Worley, D.R. 1977. Reef distribution in south Florida. Proc 3rd Int Coral Reef Symp 2:223-229

Mora, C. (ed.). 2015. Ecology of fishes on coral reefs. Cambridge Univ. Press

Morris, J.A. Jr., and Akins, J.L., 2009. Feeding ecology of invasive lionfish (Pterois volitans) in the Bahamian archipelago. Environ Biol Fish 86:389–398.

Muñoz, R.C., Currin, C.A., Whitfield, P.E., 2011. Diet of invasive lionfish on hard bottom reefs of the Southeast USA: insights from stomach contents and stable isotopes. . Mar Ecol Prog Ser 432:181–193.

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National Marine Fisheries Service. 2015. Recovery Plan for Elkhorn (Acropora palmata) and Staghorn (A. cervicornis) Corals. Prepared by the Acropora Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland

Reed, J.K., 1980. Distribution and structure of deep-water Oculina varicosa coral reefs off central eastern Florida. Bulletin of Marine Science 30(3): 667-677.

Ruzicka, R. R., Colella, M. A., Porter, J. W., Morrison, J. M., Kidney, J. A., Brinkhuis, V., Lunz, K.S., Macaulay, K. A., Bartlett, L. A., Meyers, M. K., and Colee, J., 2014. Temporal changes in benthic assemblages on Florida Keys reefs 11 years after the 1997/1998 El Niño. Marine Ecology Progress Series. 489: 124-141.

SAFMC. 1998a. Final comprehensive amendment addressing essential fish habitat in fishery management plans of the south Atlantic region. Including a final environmental impact statement/supplemental environmental impact statement, initial regulatory flexibility analysis, regulatory impact review, and social impact assessment/fishery impact statement. Charleston, South Carolina. 136 p.

SAFMC. 1998b. Final habitat plan for the South Atlantic region: essential fish habitat requirements for fishery management plans of the South Atlantic Fishery Management Council. Charleston, South Carolina. 639 p.

Shivlani, M., Estevanez, M., McManus, L., Kruer, C., and Murray, T., 2011. Reference Document and Guide to the Evaluation of Permitted Coastal Construction ActivitiesThat Affect Coral Reef and Coastal Resources in Southeast Florida. Contract Report to SEFCRI and Florida Dept of Env Protection. Pg. iv and 159. Available from:http://www.dep.state.fl.us/coastal/programs/coral/reports/MICCI/MICCI_07_11_Reference_Document.pdf

Uhrin, A.V., Matthews, TR, Lewis, C., 2014. Lobster trap debris in the Florida Keys National Marine Sanctuary: distribution, abundance, density, and patterns of accumulation. Marine and Coastal Fisheries 6:20-32

Wanless, H. and Maier, K., 2007. An evaluation of beach renourishment sands adjacent to reefal settings, Southeast Florida. Southeastern Geology 45(1):25-42.

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SHALLOW WATER CORALS

Coral as used in this document means *Gulf and South Atlantic prohibited coral*, as defined in 50 CFR §622.2 as follows:

Gulf and South Atlantic prohibited coral means, in the Gulf and South Atlantic, one or more of the following, or a part thereof:
(1) Coral belonging to the Class Hydrozoa (fire corals and hydrocorals).
(2) Coral belonging to the Class Anthozoa, Subclass Hexacorallia, Orders Scleractinia (stony corals) and Antipatharia (black corals; though these are predominantly distributed in deeper (>50m) habitats).

1. Taxonomy and Life History

Stony corals are marine invertebrates that secrete a calcium carbonate skeleton. Stony corals include members of both the Class Hydrozoa (fire corals and lace corals) and Order Scleractinia (true stony corals). Most reef-building corals are zooxanthellate, hosting symbiotic algae from the genus *Symbiodinium* in their gastrodermal cells. These symbionts provide a phototrophic contribution to the coral's energy budget, enhance calcification, and give the coral most of its color. The largest colonial members of the Scleractinia help produce the carbonate structures known as coral reefs in shallow tropical and subtropical seas around the world.

For the purpose of this plan, Octocorals include species belonging to the Class Octocorallia, Order Alcyonacea (soft corals and gorgonians). Similar to stony coral corals, octocorals are colonial animals with a polyp as the individual building unit and may contain endosymbiotic algae (zooxanthellae). Unlike stony coral, octocorals do not secrete a calcium carbonate skeleton but have an axial skeleton mainly composed of collagen fibers in a proteinaceous matrix.

Table 1. Classification of corals included under the Council's Coral, Coral reefs and Live/ Hard Bottom Fishery Management Plan.

Phylum Cnidaria
Subphylum Medusozoa
Class Hydrozoa
Order Anthoathecata
Suborder Capitata
Family Milleporidae (fire, stinging corals)

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Suborder Filifera
Family Stylasteridae (lace corals)
Subphylum Anthozoa
Class Anthozoa
Subclass Hexacorallia (or Zoantharia)
Order Scleractinia
Subclass Octocorallia
Order Alcyonacea (soft corals)
Suborder Alcyoniidae (soft corals)
Suborder Scleraxonia (gorgonians)
Suborder Holaxonia (gorgonians)
Suborder Calcaxonia (gorgonians)

Corals can reproduce asexually when fragments break off and reattach to the reef. However, corals also have a complex life cycle including pelagic (sexual) larval and sessile, usually colonial, adult phases. There are a multitude of breeding systems described among scleractinian corals (Baird et al. 2009) with the primary categories being brooding vs. broadcast spawning, and hermaphroditic vs. gonochroic. The primary reef-building species in the region, including *Acropora* spp. and *Orbicella* spp. are hermaphroditic (colonies produce both eggs and sperm), broadcast spawners (gametes are shed into the water column where they undergo fertilization and development). Dilution, advection, and other environmental stressors in the open ocean environment yield lower rates of fertilization, higher rates of larval mortality, and greater average dispersal distance by broadcasted, compared with brooded larvae. Brooded larvae are released with symbionts inherited from the parent colony enabling them to renew energy reserves via photosynthesis and are generally able to settle soon after they are released from the parent colony. In contrast, broadcast larvae must rely on lipid reserves from its egg and remain in the water column from a few days to weeks to complete larval development prior to settlement competence. Hence, broadcasting species (with few exceptions, predominantly *Siderastraea siderea*) generally display much lower rates of larval recruitment than brooding species, in some cases vanishingly low. It is likely that both low larval production and declining habitat quality (due to sediments, turf and macroalgae) contribute to low recruitment in broadcast-spawning, reef-building corals in the region.

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After metamorphosis onto appropriate hard substrata, metabolic energy is diverted to colony growth and maintenance. Because newly settled corals barely protrude above the substratum, juveniles need to reach a certain size to reduce damage or mortality from impacts such as grazing, sediment burial, and algal overgrowth (Bak and Elgershuizen 1976; Birkeland 1977; Sammarco 1985). Generally, mounding corals grow slowly; most growth rates (linear extension) for *Montastraea*, *Porites*, and *Diploria* are less than 1 cm per year. Hubbard and Scaturo (1985) report average extension rates of 0.12-0.45 cm/yr for several species including *Stephanocoenia*

intersepta, *Agaricia agaricites*, *Diploria labyrinthiformis*, *Colpophyllia natans*, *Montastraea cavernosa*, *Porites astreoides*, and *Siderastrea siderea*. Growth rates for branching species are generally higher, with branch extension rates over 10 cm per year commonly reported for *Acropora cervicornis* in the Florida Keys, and even higher rates of total productivity in local in situ *A. cervicornis* nurseries (Lirman et al. 2014). However, long term reductions in coral growth rates are expected under near term future scenarios of climate warming/temperature extremes and acidification (refs) as these stressors reduce the efficiency of calcification.

Octocorals have not been studied as extensively as scleractinian corals and their reproductive biology is poorly known for most species. In 2009, Simpson performed a review of published literature on octocoral reproduction and all known reproduction systems of octocorals are described therein. Like scleractinian corals, both sexual and asexual reproduction have been documented in octocorals. Types of asexual reproduction include fragmentation, fission (commonly observed in encrusting species), and development of new colonies from stolons or runners. Asexual reproduction is known to be more common in true "soft corals" and is limited to only a few octocoral species found in Florida. The vast majority of gorgonian octocorals reproduce sexually by broadcast spawning or brooding (either internally or externally). The reproductive strategy of external or surface brooding has been documented in octocorals, where eggs are released passively onto the surface of the colony (Benayahu and Loya 1983, Brazeau and Lasker 1990, Gutiérrez-Rodriguez and Lasker 2004). While sampling female colonies of *Antillogorgia* (*Pseudopterogorgia*) *elisabethae*, Gutiérrez-Rodriguez and Lasker (2004) did not find developing embryos or planulae inside the polyps, and they suggested that fertilization occurred either internally immediately before the eggs were released or externally on the surface of the maternal colony.

As with stony corals, octocoral planulae settle onto an appropriate substratum and undergo metamorphosis into a feeding polyp. Octocorals are known to settle in shaded microhabitats, such as the underside of settlement plates, small cavities in the substratum or under clumps of macroalgae. Studies suggest that this settlement behavior may be influenced by turbulent eddies that facilitate larval settlement and an avoidance response to unfavorable conditions such as high light intensity, low tides, predator grazing pressure, and sedimentation (Simpson 2009, Benayahu and Loya 1987). Studies have indicated that successful settlement and recruitment into a population occurs at a low rate (Lasker et al. 1998, Simpson 2009). Lasker et al. (1998) suggested that extremely high post-settlement mortality of new recruits indicates that successful settlement may be more related to water column and post-settlement survival than to gamete production and fertilization rates. Despite low recruitment rates, octocorals are excellent spacial competitors and are known to have much higher growth rates in general as compared to most species of scleractinian corals. Cary (1914) discussed the obvious advantage of young octocorals over stony coral recruits in that their most rapid growth is perpendicular to the substratum,

keeping the most active growing part of the colony in a favorable position for resource allocation.

2. Abundance and Trends of coral populations

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Scleractinians

SEFL

The reefs offshore the mainland coast of southeast Florida, the northern extension of the Florida Reef Tract (FRT), have a similar stony coral diversity to that of the southern regions of the FRT (the Florida Keys and Dry Tortugas) and much of the Caribbean, but benthic cover, 2-5%, is generally lower and colony size, average less than 20 cm diameter, is generally smaller (Gilliam et al 2014, Gilliam et al 2015). Nearly 30 species of stony corals have been identified, but six species (*Montastraea cavernosa*, *Siderastrea siderea*, *Porites astreoides*, *Stephanocoenia intersepta*, *Agaricia agaricites*, and *Meandrina meandrites*) contribute greatly to benthic cover and colony density (Gilliam et al 2014, Gilliam et al 2015). Three of these species (*M. cavernosa*, *S. siderea*, and *P. astreoides*) were also identified as being three of the most common species in the Florida Keys (Ruzicka et al. 2013) and in the Dry Tortugas (Ruzicka et al. 2012). Two long-term monitoring programs have been operating since at least 2003 and neither had documented a significant trend in stony coral benthic cover up until 2015 (Gilliam et al 2014, Gilliam et al 2015), in contrast to much of the Caribbean (Gardner et al. 2003, Jackson et al. 2014) and the southern regions of the FRT (Ruzicka et al. 2014). However, severe thermal stress events and a continuing coral disease outbreak have resulted in severe declines in colony density for several scleractinian species, approaching local extinction for *Dendrogyra cylindrus, Meandrina meandrites*, and *Dichocoenia stokesii* by 2016 (Gilliam et al. unpubl data).

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FLK

Coral reefs are in a state of transition in the Florida Keys (FLK). Following the 1997/1998 El Niño event, stony corals showed little recovery and continued to be a dwindling part of the benthic assemblage at deep and shallow forereefs. The declines in stony coral cover at the deep and shallow forereefs can be attributed to the continued loss of the dominant, framework-building coral *M. annularis* (Ruzicka et al. 2013). Within the Florida Keys, patch reefs contain the highest cover of any habitat while backcountry patch reefs have the lowest. Coral cover in 2015 was 6.2%, nearly 1% lower than the steady trend recorded in 2013 and 2014 (FWC 2016). In terms of abundance, aggregated for the 40 CREMP sites, *Siderastrea siderea*, *Porites astreoides*, *Stephanocoenia intersepta*, and *Undaria/Agaricia agaricites* are the four most common corals. Of these four, only *Siderastrea siderea* and *Porites astreoides* are top contributors to coral cover. Corals like *Undaria/Agaricia agaricites* are relatively small in size and contribute little to overall coral cover. Between 2014 and 2015, the abundance of eight of the nine corals was not significantly different in 2015 as compared to previous years.

Undaria/Agaricia agaricites was the only coral that demonstrated a significant decline in abundance between 2015 and all other years tested. It is plausible that even though the abundance of the other most abundant species has remained similar, partial mortality inflicted as a result of the 2014 bleaching event could have reduced the amount of living tissue associated with these corals.

Octocorals

SEFL

Octocorals are a significant component of the reef community along the FRT. Offshore southeast Florida octocoral colony density and species diversity tend to be greater than those of stony corals. Octocoral benthic cover, 3-20%, is also generally higher than stony coral. Octocoral cover has shown a significant decreasing trend in parts of the region (Gilliam et al 2015) which is in contrast to significantly increasing trend identified in the Florida keys (Ruzicka et al. 2014).

FLK

An overall trend of increasing cover was reported for octocorals Keys-wide and across all reef types, resulting in a shift in community structure at the deep and shallow forereefs (Ruzicka et al. 2013). Octocoral cover continued to rise following the 2010 winter cold-water mortality and is the second greatest contributor to benthic cover after macroalgae. Since the 2014 bleaching event, octocoral cover has declined from 15% to 12.8% between 2014 and 2015. The transition from stony coral to octocoral-dominated communities has been reported before; however, all examples are exclusive to the Pacific Ocean (Fox et al. 2003, Stobart et al. 2005).

3. Threats

Mounting threats of myriad sorts have resulted in drastic declines in scleractinian corals, both in the South Atlantic region and throughout the Caribbean, over the past few decades. Recent analyses of extinction risk for seven coral species concluded that global changes (including warming and changing ocean chemistry) along with disease pose the greatest threat to coral extinction (Brainard et al 2011). These global threats are superimposed and interaction with additional stressors at the local level (also reviewed in Brainard et al. 2011). The relative importance of these local stressors vary somewhat across the South Atlantic region, related to the local human population density and use along the coast.

Global climate change has already caused significant coral declines in the region due to notable increases in year-round local reef sea surface temperature documented over the past century and an estimated annual increase of 0.9°C over the past 3 decades (Kuffner et al 2014). As a result, the occurrence of warm temperature stress above bleaching thresholds is projected to occur annually within the next decade, much sooner than global climate models predict (Manzello 2015). Mass coral bleaching events have resulted from warm temperature extremes in 1997-8, 2005, 2014 and 2015. Many corals die directly from bleaching and also from subsequent coral

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disease outbreaks following the physiological stress of bleaching (Brandt & McManus 2009). Due to high latitude, episodic cold water events also affect South Atlantic corals, particularly in 2010 when cold water caused mass coral mortality, especially in nearshore patch reef habitats (Lirman et al. 2011).

Coastal water quality in the region is affected by broad scale regional water management actions, sewage via both offshore outfalls and seepage from septic tanks, runoff and stormwater. The effect of these combined constituents, including endocrine disruptors, pesticides, nutrients, freshwater, etc. are poorly characterized (but see Downs et al. 2005, Edge et al 2013, Ross et al. 2015) but most certainly detrimental to health of corals in the region, consequently reducing their physiological scope to deal with global stressors.

Meanwhile, fishes are engaged in important positive feedbacks with corals including grazing to maintain benthic habitat quality and nutrient delivery (Shantz et al. 2015). Although parrotfishes are not highly targeted in local fisheries as in other Caribbean regions allowing persistence of high grazing (Paddack et al. 2006), this is a factor which should be monitored as fisheries preferences may change over time.

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While the effects of many stressors causing direct coral mortality are relatively easy to observe, many sublethal stressors such as sedimentation, water-born toxicants, acidification, chronic temperature stress, and non-lethal diseases impair the replenishment capacity of coral populations both by impairing larval output and by impairing larval survival and/or recruitment (e.g., Jones et al. 2015, Albright et al 2010).

The effects of ocean acidification (i.e. changes in the carbonate chemistry of ocean waters), water quality, and trophic disruption threats are less well characterized for octocorals, though warm temperature bleaching and disease have both been documented, particularly in sea fans. Unlike scleractinians, some octocorals are also subject to harvest (Miller et al. 2014).

4. Management

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Scleractinian corals are currently managed under a zero-take FMP and are protected as Essential Fish Habitat - Habitat Areas of Particular Concern. Seven species in the region are also protected as threatened species under the US Endangered Species Act, with one of these (*Dendrogyra cylindrus*) previously designated as a Threatened species by the state of Florida. Hence, an ESA Recovery Plan (for *Acropora palmata* and *A. cervicornis*) and Florida Species Action Plan (for *D. cylindrus*) both provide relevant actions for coral conservation and restoration in the region.

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Octocorals are currently managed by the State of Florida under chapter 68B of the Florida Administrative Code (FAC). The State of Florida defines octocorals as "any erect, non-encrusting species of the Subclass Octocorallia, except the species *Gorgonia flabellum* and *G. ventalina*" which are prohibited (FAC 68B-42.002). Up to six octocoral colonies per day may be collected recreationally with a Florida Recreational Saltwater Fishing License (FAC 68B-42.005). There are no trip limits on the harvest of octocorals for commercial purposes, though the fishery is limited to properly licensed commercial harvesters. However, the annual quota for octocorals harvested in State of Florida and adjacent Federal waters is 70,000 colonies (FAC 68-42.006). No power tools may be used to harvest colonies and only one inch of attached substrate around the perimeter of the base of the octocoral holdfast may be removed (FAC 68B-42.006, 68B-42.007, FAC 68B-42.008). Octocorals must be collected and landed live and stored in a re-circulating live-well or oxygenated system aboard the collection vessel (FAC 68B-42.0035).

Areas that are closed to octocoral collection include Atlantic Federal waters north of Cape Canaveral, Biscayne National Park, and in the Stetson-Miami Terrace Deep Water Coral Habitat Area of Particular Concern, as well as the Pourtales Terrace Deep Water Habitat Area of Particular Concern adjacent to Florida state waters (68B-42.0036 F.A.C.). Additional area closures for marine life collection exist in southeastern Florida, including National Parks (Everglades, Biscayne, Dry Tortugas) and specific areas within the Florida Keys National Marine Sanctuary, including the Key Largo Management Area (formerly Key Largo National Marine Sanctuary), the Looe Key Management Area (formerly Looe Key National Marine Sanctuary), and various smaller no-take zones including sanctuary preservation areas, special-use/research-only areas, and ecological reserves (Miller et al. 2014). For further information, Miller et al. (2014) prepared an in-depth description of the U.S South Atlantic Octocoral Fishery.

5. Summary Recommendations

Coral Knowledge Gaps:

- Efficacy and improvement of coral (proactive) restoration strategies (Hunt and Sharp 2014)
- Efficacy of coral predator removal or other mitigation (Acropora Recovery Plan)
- Carrying capacity of coral disease, predation, (Acropora Recovery Plan)
- Impact threshold levels for nutrients, sedimentation, toxicants (Acropora Recovery Plan)
- Determine causal factors in coral disease impacts, especially regarding interactions with temperature and local anthropogenic stressors. (Acropora Recovery Plan)
- Due to repeated reef impacts from large dredging and beach projects in the area, from direct disturbance and ongoing turbidity, there is a need for better understanding of chronic and acute turbidity and/or sedimentation on all life phases of shallow corals, including recruitment.

Coral Summary Management Recommendations

- Enhanced legal enforcement of Florida Coral Reef Protection Act (Florida Pillar Coral Action Plan)
- Improve coastal construction project permitting/compliance/mitigation to achieve 'no net loss' of coral

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6. References

Albright, R., Mason, B., Miller, M., and Langdon, C., 2010. Ocean acidification compromises recruitment success of the threatened Caribbean coral *Acropora palmata*. Proceedings of the National Academy of Sciences 107:20400-20404

Ault, J.S., Smith, S.G., and Bohnsack, J.A., 2005. "Evaluation of average length as an estimator of exploitation status for the Florida coral-reef fish community." ICES Journal of Marine Science 62.3: 417-423.

Ault, Jerald S., et al., 2005. "Towards sustainable multispecies fisheries in the Florida, USA, coral reef ecosystem." Bulletin of Marine Science 76.2: 595-622.

Ault, Jerald S., et al., 2001. Site characterization for Biscayne National Park: assessment of fisheries resources and habitats. US Department of commerce, NOAA Technical Memorandum NMFS-SEFSC-468.

Baird, A.H., Guest, J.R., and Willis, B.L., 2009. Systematic and biogeographical patterns in the reproductive biology of scleractinian corals. Annual Review of Ecology, Evolution, and Systematics 40:551-571

Barbour, A.B., Allen, M.S., Frazer, T.K., Sherman, K.D., 2011. Evaluating the Potential Efficacy of Invasive Lionfish (Pterois volitans) Removals. PLoS ONE 6(5): e19666. doi:10.1371/journal.pone.0019666

Benayahu, Y. and Y. Loya. 1983. Surface brooding in the Red Sea soft coral Parerythropodium fulvum fulvum (Forskaal, 1775). Biological Bulletin 165: 353-369.

Benayahu, Y. and Y. Loya. 1987. Long-term recruitment of soft-corals (Octocorallia: Alcyonacea) on artificial substrata at Eliat (Red Sea). Marine Ecology Progress Series 38: 161-167.

Brainard, R.E., Birkeland, C., Eakin, C.M., McElhany, P., Miller, M.W., Patterson, M., Piniak, G.A., 2011. Status review report of 82 candidate coral species petitioned under the U.S. Endangered Species Act. NOAA Tech Memo NOAA-TM-NMFS-PIFSC-27. U.S. Dept. Commerce

Brandt, M.E., and McManus, J.W., 2009. Disease incidence is related to bleaching extent in reef-building corals. Ecology 90:2859-2867

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Brazeau, D.A. and H.R. Lasker. 1990. Sexual reproduction and external brooding by the Caribbean gorgonian Briareum asbestinum. Marine Biology 104: 465-474.

Cary, L. R. 1914. Observations upon the growth-rate and oecology of gorgonians. Carnegie Inst. Wash. Pub. 182: 79-99.

Downs, C., Fauth, J., Robinson, C., Curry, R., Lanzendorf, B., Halas, J., Woodley, C., 2005. Cellular diagnostics and coral health: Declining coral health in the Florida Keys. Mar Pollut Bull 51:558-569

Stobart, B., Teleki, K., Buckley, R., Downing, N., Callow, M., 2005. Coral recovery at Aldabra Atoll, Seychelles: five years after the 1998 bleaching event. Philos Trans R Soc Lond A 363: 251−255 Sweatman H, Delean

Edge, S.E., Shearer, T.L., Morgan, M.B., Snell, T.W., 2013. Sub-lethal coral stress: Detecting molecular responses of coral populations to environmental conditions over space and time. Aquatic Toxicology 128–129:135-146

Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute. Coral Reef Evaluation and Monitoring Project Executive Summary 2016.

Frazer, T.K., Jacoby, C.A., Edwards, M.A., Barry, and S.C., Manfrino, C.M., 2012. Coping with the lionfish invasion: can targeted removals yield beneficial effects? Reviews in Fisheries Science 20(4):185191 DOI 10.1080/10641262.2012.700655. Garcia E, Holtermann K. 1998. Calabash Caye, Turneffe Islands

Fox, H.E., Pet, J.S., Dahuri, R., Caldwell, R.L., 2003. Recovery in rubble fields: long-term impacts of blast fishing. Mar Pollut Bull 46: 1024−1031

Gardner, T.A., Cote, I.M., Gill, J.A., Grant, A., and Watkinson, A.R.. 2003. Long-term region-wide declines in Caribbean corals. Science 301:958-960.

Green, S.J., Dulvy, N.K., Brooks, A.M., Akins, J.L., Cooper, A.B., Miller, S., Côté, I.M.. 2014. Linking removal targets to the ecological effects of invaders: a predictive model and field test. Ecological Applications 24(6):13111322 DOI 10.1890/13-0979.1.

Green, S.J., and I. Cote, 2012. Consumption Potential of Invasive Lionfish (*Pterois volitans*) On Caribbean Coral Reefs, Department of Biological Sciences Simon Fraser University 8888 University Drive Burnaby, BC V5A1S6 Canada

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Gutierrez-Rodriguez, C., and H.R. Lasker. 2004. Reproductive biology, development, and planula behavior in the Caribbean gorgonian Pseudopterogorgia elisabethae. Invertebrate Biology 123(1):54-67.

Hunt, J. and Sharp, W., 2014. Developing a Comprehensive Strategy for Coral Restoration for Florida.State Wildlife Grant Award T-32-R 1169 Final Report. http://myfwc.com/media/2982098/CoralRestoration.pdf

Jackson, J.B.C., Donovan, M.K., Cramer, K.L., and Lam, V.Ve., 2014. Status and Trends of Caribbean Coral Reefs: 1970-2012. Gland, Switzerland: Global Coral Reef Monitoring Network, IUCN. p 304.

Jones, R., Ricardo, G.F., Negri, A.P., 2015. Effects of sediments on the reproductive cycle of corals. Mar Pollut Bull 100:13-33

Kuffner, I.B., Lidz, B.H., Hudson, J.H., Anderson, J.S., 2014. A century of ocean warming on Florida Keys coral reefs: historic in situ observations. Estuar Coasts:1-12

Lasker, H.R., K. Kim, and M.A. Coffroth. 1998. Production, settlement, and survival of plexaurid gorgonian recruits. Marine Ecology Progress Series 162: 111-123.

Lirman, D., Schopmeyer, S., Galvan, V., Drury, C., Baker, A.C., Baums, I.B., 2014. Growth Dynamics of the Threatened Caribbean Staghorn Coral Acropora cervicornis: Influence of Host Genotype, Symbiont Identity, Colony Size, and Environmental Setting. PLoS ONE 9:e107253

Lirman, D., Schopmeyer, S., Manzello, D., Gramer, L.J., Precht, W.F., Muller-Karger, F., Banks, K., Barnes, B., Bartels, E., Bourque, A., Byrne, J., Donahue, S., Duquesnel, J., Fisher, L., Gilliam, D., Hendee, J., Johnson, M., Maxwell, K., McDevitt, E., Monty, J., Rueda, D., Ruzicka, R., Thanner, S., 2011. Severe 2010 cold-water event caused unprecedented mortality to corals of the Florida Reef Tract and reversed previous survivorship patterns. PLoS ONE 6:e23047

Miller, S.L., Espitia, P., Chiappone, M., Rutten, L.M., 2014. Description of the U.S. South Atlantic Octocoral Fishery: 2014 Final Report to the South Atlantic Fishery Management Council. National Coral Reef Institute, Nova Southeastern University Oceanographic Center, Dania Beach, FL. 184 pp

Miller, S.L., Espitia, P., Chiappone, M., Rutten, L.M., 2014. Description of the U.S. South Atlantic Octocoral Fishery: 2014 Final Report to the South Atlantic Fishery Management

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Council. National Coral Reef Institute, Nova Southeastern University Oceanographic Center, Dania Beach, FL. 184 pp

Paddack, M., Cowen, R., and S. Sponaugle, 2006. Grazing pressure of herbivorous coral reef fishes on low coral-cover reefs. Coral Reefs 25:461-472

Ross, C., Olsen, K., Henry, M., Pierce, R., 2015. Mosquito control pesticides and sea surface temperatures have differential effects on the survival and oxidative stress response of coral larvae. Ecotoxicology 24:540-552

Ruzicka, R. R., Colella, M. A., Porter, J. W., Morrison, J. M., Kidney, J. A., Brinkhuis, V., Lunz, K.S., Macaulay, K. A., Bartlett, L. A., Meyers, M. K., and J. Colee. 2014. Temporal changes in benthic assemblages on Florida Keys reefs 11 years after the 1997/1998 El Niño. Marine Ecology Progress Series. 489: 124-141

Shantz, A.A., Ladd, M.C., Shrack, E., and Burkepile D.E., 2015. Fish-derived nutrient hotspots shape coral reef benthic communities. Ecol Appl

Simpson, A. 2009. Reproduction in Octocorals (Subclass Octocorallia): A Review of Published Literature. Version 16 July 2009. In Deep-Sea Corals Portal, http://www.ucs.louisiana.edu/~scf4101/Bambooweb/.

Stobart, B., Teleki, K., Buckley, R., Downing, N., Callow, M., 2005. Coral recovery at Aldabra Atoll, Seychelles: five years after the 1998 bleaching event. Philos Trans R Soc Lond A 363: 251−255 Sweatman H, Delean

Usseglio, et al., 2017. Effectiveness of removals of the invasive lionfish: how many dives are needed to deplete a reef? PeerJ 5:e3043; DOI 10.7717/peerj.3043

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Coral population enhancement/gardening (Acropora Recovery Plan and Our Florida Reefs Recommended Management Action (OFR-RMA))

Enhanced mooring balls in sensitive areas (Florida Pillar Coral Aciton Plan; OFR-RMA)

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