UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
263 13th Avenue South
St. Petersburg, Florida 33701-5505
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NOV 14 2014

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SER-2013-11222

Jacksonville District Corps of Engineers
Department of the Army
P.O. Box 4970
Jacksonville, Florida 32232

Re: SAJ-2009-05545, Broward County Board of County Commissioners, Broward Segment II Beach Renourishment, Pompano Beach, Lauderdale By The Sea, Fort Lauderdale, Broward County, Florida

Dear Sir or Madam:

Enclosed is the National Marine Fisheries Service's (NMFSs) Biological Opinion ("Opinion") based on our review of impacts associated with the Broward Segment II Beach Renourishment project. This Opinion is based on project-specific information provided in the consultation package as well as NMFS's review of published literature. This Opinion analyzes the project effects on swimming sea turtles, threatened corals and corals proposed for listing as threatened or endangered, smalltooth sawfish, and designated critical habitat for elkhorn and staghorn corals. We believe that the fill associated with the Broward Segment II Beach Renourishment project is likely to adversely affect green sea turtles, elkhorn and staghorn coral, and elliptical star coral, but is not likely to jeopardize their continued existence. We also believe that the proposed project will not adversely modify designated critical habitat for elkhorn and staghorn coral.

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

Sincerely,

Miles M Croom
for Roy E. Crabtree, Ph.D.
Regional Administrator

Enclosure

File: 1514-22.P.

Endangered Species Act - Section 7 Consultation
Biological Opinion

Agency:	United States Army Corps of Engineers (USACE)
Applicant:	Broward County
Activity:	Broward Segment II Beach Renourishment, Ft. Lauderdale, Broward County, Florida
Consulting Agency:	National Marine Fisheries Service (NMFS) Southeast Regional Office Protected Resources Division NMFS Consultation No. SER-2013-11222
Date Issued:	11/14/2014
Approved By:	Miles M Croom for Roy E. Crabtree, Ph.D. Regional Administrator

Glossary of Commonly Used Acronyms

CCA	Crustose Coralline Algae
DPS	Distinct Population Segment
DWH	Deepwater Horizon
EPA	Environmental Protection Agency
ESA	Endangered Species Act of 1973
HCD	Habitat Conservation Division
ITS	Incidental Take Statement
MMPA	Marine Mammal Protection Act of 1972
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
ODMDS	Ocean Dredged Material Disposal Site
RBO	Regional Biological Opinion
RPMs	Reasonable and Prudent Measures
SARBO	South Atlantic Regional Biological Opinion
SEFSC	Southeast Fisheries Science Center
SERO	Southeast Regional Office
STSSN	Sea Turtle Stranding and Salvage Network
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service

Background

Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. §1531 et seq.), requires that each federal agency ensure that any action authorized, funded, or carried out by the 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 those species. When the action of a federal agency may affect a protected species or its critical habitat, that agency is required to consult with either National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service (USFWS), depending upon the protected species that may be affected.

Consultations on most listed marine species and their designated critical habitat are conducted between the action agency and NMFS. Consultations are concluded after NMFS determines the action is not likely to adversely affect listed species or critical habitat or issues a Biological Opinion ("Opinion") that determines whether a proposed action is likely to jeopardize the continued existence of a federally-listed species, or destroy or adversely modify federally-designated critical habitat. The Opinion also states the amount or extent of listed species incidental take that may occur and develops nondiscretionary measures that the action agency must take to reduce the effects of said anticipated/authorized take. The Opinion may also recommend discretionary conservation measures. No incidental destruction or adverse modification of critical habitat may be authorized. The issuance of an Opinion detailing NMFS's findings concludes ESA Section 7 consultation.

This document represents NMFS's Biological Opinion ("Opinion") based on our review of impacts associated with Broward County's proposed beach renourishment in Broward County, Florida. This Opinion analyzes project effects on sea turtles, whales, smalltooth sawfish, staghorn coral, and designated critical habitat for loggerhead sea turtles and elkhorn and staghorn corals in accordance with Section 7 of the ESA. NMFS based this Opinion on project information provided by the USACE as well as published literature and the best available scientific and commercial information. It is NMFS's Biological Opinion that the action, as proposed, is not likely to jeopardize the continued existence of sea turtles or staghorn coral, and is not likely to destroy or adversely modify the designated critical habitat for loggerhead sea turtles or elkhorn and staghorn corals.

BIOLOGICAL OPINION

1 Consultation History

On April 16, 2013, the USACE submitted a public notice for the Broward Segment II beach project. NMFS requested and received additional information via email, the latest of which was received on September 20, 2013. This project is related to a project previously permitted by the USACE known as Segment III. The permit the USACE issued for the Segment III project included a condition that the Segment II permit would be contingent upon satisfactory mitigation for Segment III impacts. In late May 2014, the USACE issued a report indicating that post-construction impacts to hard bottom habitat at Segment III were much greater than expected (approximately 36 acres of unanticipated impacts). NMFS believes that these unanticipated impacts were due to the incompatible beach fill material which was sourced from offshore borrow areas. The USACE's Engineer Research and Development Center (ERDC) has since conducted an independent review of Segment II which determined that the equilibrium toe of fill (ETOF) and the impacts estimates made by the USACE are conservative. The ERDC report also noted that the because the sediment is coming from an upland source and is being processed prior to placement, and not from an in-water borrow site, quality control should be able to be performed in a much more robust manner, and minimize the potential for chronic turbidity plumes. Formal consultation was initiated on September 20, 2013.

2 Description of the Proposed Action

This consultation addresses the Broward Segment II beach renourishment located within Pompano Beach and Lauderdale By The Sea, Broward County, Florida (see Figure 1). The total time frame for completing the project is approximately 3 years. The proposed project components are as follows:

1. Place approximately 706,700 cubic yards (yd^3) of sand along 26,100 feet (ft) of shoreline via truck haul.
2. Place an additional 20,000 yd^3 of sand along the upper beach profile between Florida Department of Environmental Protection monuments R51 and R72 to construct a vegetated dune.
3. Place approximately 6.8 acres of prefabricated artificial reef via barge.
4. Relocate all the ESA-listed corals (16 colonies, according to the resource sruvey) from within the impact area (the 4.9 acres which will be covered by sand within the ETOF) in accordance with the transplantation protocols (Appendix A) and the Draft Coral Transplantation Plan received by email on September 5, 2014 (Appendix C).
5. USACE will submit a detailed monitoring plan for the transplanted corals prior to construction.
6. The USACE shall establish random cross-shore monitoring transects on the artificial reef, and shall conduct monitoring using video survey and quadrat sampling as per the detailed artificial reef monitoring plan (Final Compensatory Mitigation Plan revised September 25, 2014 [Appendix D]). Monitoring of the artificial reef shall occur annually during summer months for 3 years following construction. Turbidity monitoring will be implemented in accordance with the detailed requirements in the Florida Department of Environmental Protection Agencey (FDEP) permit 0314535-

001-JC (Appendix B) and the final biological monitoring plan to be developed in concert with NMFS.

7. Construction will occur during daylight hours only.
8. Monitoring of nearshore hard bottom communities shall be conducted to document any unanticipated impacts from project construction, such as degradation of communities due to burial and/or sedimentation and scouring effect of excessive sediment transport, and shall include monitoring of nearshore hard bottom east (seaward) of the ETOF and the hard bottom adjacent to the construction template in both longshore directions. Monitoring shall be conducted in summer before construction, immediately after construction (immediately after construction the survey shall be conducted in early post-construction summer after initial placement) and then years 1, 2, and 3 post-construction (total of 5 surveys) during summer (May through September) in accordance with the detailed hard bottom monitoring plan to be developed in concert with NMFS. The USACE shall incorporate the additional monitoring suggested in the ERDC report (Appendix E) as part of the final biological monitoring plan.

Sand will be obtained from upland mines in south Florida and transported to the project site by trucks. The sand will be stockpiled at several locations and then distributed via dump trucks and other heavy equipment. Work will be conducted during November 1 through April 30 to avoid sea turtle nesting season, and may last up to 3 years.

3 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 this project includes the nearshore waters of Pompano Beach and Lauderdale By The Sea, Broward County, Florida (see Figure 1).

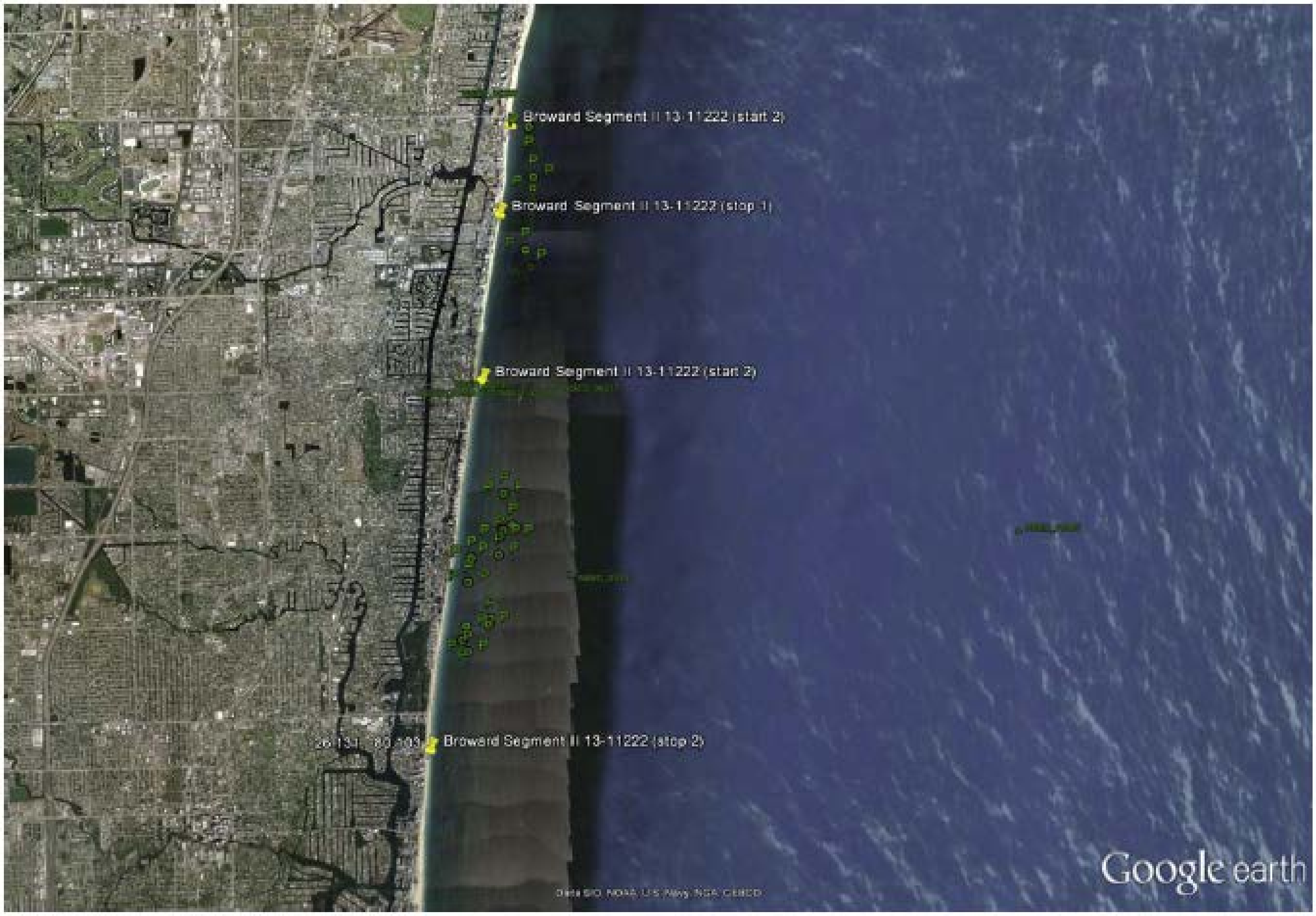

Figure 1. Location of Broward Segment II project. Known colonies of *Acropora* corals are indicated in green (©2013 Google).

4 Status of Listed Species and Critical Habitat

The following endangered (E), threatened (T), and proposed species (P), and designated critical habitat under the jurisdiction of NMFS may occur in or near the action area.

Table 1. Listed and Proposed Species and Critical Habitat Likely to Occur in or Near the Project Area

Common Name	Listed Species Scientific Name	Status
Turtles		
Green sea turtle	*Chelonia mydas*[1]	E/T
Kemp's ridley sea turtle	*Lepidochelys kempii*	E
Leatherback sea turtle	*Dermochelys coriacea*	E
Loggerhead sea turtle	*Caretta caretta*[2]	T

[1] Green turtles are listed as threatened except for the Florida and Pacific coast of Mexico breeding populations, which are listed as endangered.
[2] Northwest Atlantic Ocean (NWA) DPS

Hawksbill sea turtle	*Eretmochelys imbricata*	E
Fish		
Smalltooth sawfish	*Pristis pectinata*[3]	E
Invertebrates and Marine Plants		
Staghorn coral	*Acropora cervicornis*	T
Elkhorn coral	*Acropora palmata*	T
Designated Critical Habitat		
Elkhorn/staghorn coral		
Loggerhead sea turtle migratory/breeding habitat within Logg-N-19		

4.1 Species and Critical Habitat Not Likely to be Adversely Affected

NMFS has analyzed the routes of potential project effects in the marine environment on 5 species of sea turtles (loggerhead, Kemp's ridley, leatherback, hawksbill, and green), and smalltooth sawfish, for the proposed action. We have determined the potential routes of effects to sea turtles and smalltooth sawfish: (1) injury or death from potential interactions with construction equipment, and (2) avoidance of the area during construction operations due to disturbance caused by placement of materials and lighting. Loss of foraging habitat within the construction footprint could also affect sea turtles. Of these, the effects from habitat loss are the only potential adverse effects for certain turtle species, as discussed below and in the Effects of the Action section.

Smalltooth Sawfish

Smalltooth sawfish are unlikely to be found within the nearshore beach area as they are generally found in mangrove areas and shallow euryhaline areas. In the unlikely event that a sawfish is found within the project area, effects include the risk of injury from in-water construction machinery which will be discountable due to the species' ability to move away from the project site if disturbed. Smalltooth sawfish may be affected by being temporarily unable to use the area due to avoidance of construction activities, related noise, and physical exclusion from areas blocked by turbidity curtains. These effects will be insignificant, given the projects localized, intermittent in-water construction work. Additionally, turbidity controls will only enclose a small portion of the project sites at any time, will be removed after construction, and will not appreciably block use of the areas by ESA-listed species. The applicant's implementation of NMFS's *Sea Turtle and Smalltooth Sawfish Construction Conditions*, dated March 23, 2006, will further reduce the risk of injury with the requirement that all work be stopped if a sea turtle or smalltooth sawfish is observed less than 50 ft from the moving equipment.

Sea Turtles

Effects to sea turtles include the risk of injury from in-water construction machinery (heavy equipment vehicles which may operate below MWH during sand movement and grading operations), which will be discountable due to the species' ability to move away from the project site if disturbed. Sea turtles may be affected by being temporarily unable to use the sites due to avoidance of construction activities, related noise, and physical exclusion from areas blocked by turbidity curtains. These effects will be insignificant, given the project's localized, intermittent in-water construction work and because construction will only take place outside of sea turtle nesting season. Additionally, turbidity controls will only enclose a small portion of the project site at any time, will be removed after construction, and will not appreciably block use of the area by ESA-listed species. The applicant's implementation of NMFS's *Sea Turtle and Smalltooth Sawfish*

[3] The U.S. DPS

Construction Conditions will further reduce the risk of injury with the requirement that all work be stopped if a sea turtle or smalltooth sawfish is observed less than 50 ft from the moving equipment.

Critical Habitat for Loggerhead Sea Turtles

The project occurs in critical habitat for loggerheads, specifically Unit Logg-N-19, which includes concentrated breeding habitat and constricted migratory corridor habitat. The project is not expected to impact the primary constituent elements (PCEs) and thus the habitat itself. Three PCEs support breeding habitat: (1) high concentrations of reproductive male and female loggerheads; (2) proximity to primary Florida migratory corridor; and (3) proximity to Florida nesting grounds. The PCEs for constricted migratory habitat are (1) constricted continental shelf area relative to nearby continental shelf waters that concentrate migratory pathways, and (2) passage conditions to allow for migration to and from nesting, breeding, and/or foraging areas. Sand placement will not alter the PCEs for breeding habitat as it will not impact the seasonal (during mating/nesting/hatching season - May through October) high concentration of reproductive individuals in the area nor the proximity to the nesting grounds or migratory corridor. The PCEs for the constricted migratory corridor will not be impacted as the project will not alter the passage conditions of the corridor. Therefore, effects to loggerhead critical habitat are discountable.

4.2 Species and Critical Habitat Likely to be Adversely Affected

NMFS believes that the proposed project may affect green sea turtles, elkhorn and staghorn coral, and elkhorn and staghorn coral-designated critical habitat.

4.2.1 Sea Turtles

The following subsections are synopses of the best available information on the status of the sea turtle species that are likely to be adversely affected by 1 or more components of the proposed action, including information on the distribution, population structure, life history, abundance, and population trends of each species and threats to each species. The biology and ecology of these species as well as their status and trends inform the effects analysis for this Opinion. Additional background information on the status of sea turtle species can be found in a number of published documents: recovery plans for the Atlantic green sea turtle (NMFS and USFWS 1991), and loggerhead sea turtle (NMFS and USFWS 2008a); Pacific sea turtle recovery plans (NMFS and USFWS 1998a; NMFS and USFWS 1998b; NMFS and USFWS 1998c; NMFS and USFWS 1998b); and sea turtle status reviews, stock assessments, and biological reports (Conant et al. 2009; NMFS-SEFSC 2001; NMFS-SEFSC 2009a; NMFS and USFWS 1995b; NMFS and USFWS 2007a; NMFS and USFWS 2007b; NMFS and USFWS 2007c; NMFS and USFWS 2007d; NMFS and USFWS 2007e; TEWG 1998; TEWG 2000a; TEWG 2007; TEWG 2009).

4.2.1.1 General Threats Faced by All Sea Turtle Species

Sea turtles face numerous natural and anthropogenic threats that shape their status and affect their ability to recover. As many of the threats are the same or similar in nature for all listed sea turtle species, we discuss those identified in this section in a general sense for all listed sea turtles. We then discuss threat information specific to a particular species in the corresponding status section where appropriate.

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

In addition to domestic fisheries, sea turtles are subject to direct as well as incidental capture in numerous foreign fisheries, further impeding the ability of sea turtles to survive and recover on a global scale. For example, pelagic stage sea turtles, especially loggerheads and leatherbacks, circumnavigating the Atlantic are susceptible to international longline fisheries including the Azorean, Spanish, and various other fleets (Aguilar et al. 1995; Bolten et al. 1994; Crouse 1999). Bottom longline and gillnet fishing are known to occur in many foreign waters, including (but not limited to) the northwest Atlantic, western Mediterranean, South America, West Africa, Central America, and the Caribbean. Shrimp trawl fisheries are also operating off the shores of numerous foreign countries and pose a significant threat to sea turtles similar to the impacts seen in U.S. waters. Many unreported takes or incomplete records by foreign fleets make it difficult to characterize the total impact that international fishing pressure is having on listed sea turtles. Nevertheless, international fisheries represent a continuing threat to sea turtle survival and recovery throughout their respective ranges.

Non-Fishery In-Water Activities

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

Coastal Development and Erosion Control

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

Environmental Contamination

Multiple municipal, industrial, and household sources, as well as atmospheric transport, introduce various pollutants such as pesticides, hydrocarbons, organochlorides (e.g., DDT, PCBs, and PFCs), and others that may cause adverse health effects to sea turtles (Garrett 2004; Grant and Ross 2002; Hartwell 2004; Iwata et al. 1993). Acute exposure to hydrocarbons from petroleum products released into the environment via oil spills and other discharges may directly injure individuals through skin contact with oils (Geraci 1990), inhalation at the water's surface, and ingesting compounds while feeding (Matkin and Saulitis 1997). Hydrocarbons also have the potential to impact prey populations, and therefore may affect listed species indirectly by reducing food availability in the action area. In 2010, there was a massive oil spill in the Gulf of Mexico at BP's Macondo well. Official estimates are that the Deepwater Horizon Oil Spill, as it came to be known, released millions of barrels of oil into the Gulf of Mexico. Additionally, approximately 1.8 million gallons of chemical dispersant were applied on the seawater surface and at the wellhead to attempt to break down the oil. At this time, the assessment of total direct impact to sea turtles has not been determined. Additionally, we do not know the long-term impacts to sea turtles because of habitat impacts, prey loss, and subsurface oil particles and oil components broken down through physical, chemical, and biological processes.

Marine debris is a continuing problem for sea turtles. Sea turtles living in the pelagic environment commonly eat or become entangled in marine debris (e.g., tar balls, plastic bags/pellets, balloons, and "ghost" fishing gear) as they feed along oceanographic fronts where debris and their natural food items converge. This is especially problematic for sea turtles that spend all or significant portions of their life cycle in the pelagic environment (i.e., leatherbacks, juvenile loggerheads, and juvenile green turtles).

Climate Change

There is a large and growing body of literature on past, present, and future impacts of global climate change exacerbated and accelerated by human activities. Some of the likely effects commonly mentioned are sea level rise, increased frequency of severe weather events, and change in air and water temperatures. NOAA's climate information portal provides basic background information on these and other measured or anticipated effects (see http://www.climate.gov).

Climate change impacts on sea turtles currently cannot be predicted with any degree of certainty; however, significant impacts to the hatchling sex ratios of sea turtles may result (NMFS and USFWS 2007c). In sea turtles, sex is determined by the ambient sand temperature (during the middle third of incubation) with female offspring produced at higher temperatures and males at lower temperatures within a thermal tolerance range of 25°-35°C (Ackerman 1997). Increases in global temperature could potentially skew future sex ratios toward higher numbers of females (NMFS and USFWS 2007c).

The effects from increased temperatures may be intensified on developed nesting beaches where shoreline armoring and construction have denuded vegetation. Erosion control structures could potentially result in the permanent loss of nesting beach habitat or deter nesting females (NRC 1990). Sea level rise will exacerbate these impacts. If females nest on the seaward side of the erosion control structures, nests may be exposed to repeated tidal overwash (NMFS and USFWS 2007c). Sea level rise from global climate change is also a potential problem for areas with low-lying beaches where sand depth is a limiting factor, as the sea may inundate nesting sites and decrease available nesting habitat (Baker et al. 2006; Daniels et al. 1993; Fish et al. 2005). The loss of habitat as a result of climate change could be accelerated due to a combination of other environmental and oceanographic changes such as an increase in the frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion (Antonelis et al. 2006; Baker et al. 2006).

Other changes in the marine ecosystem caused by global climate change (e.g., ocean acidification, salinity, oceanic currents, dissolved oxygen levels, nutrient distribution) could influence the distribution and abundance of lower trophic levels (e.g., phytoplankton, zooplankton, submerged aquatic vegetation, crustaceans, mollusks, forage fish) which could ultimately affect the primary foraging areas of sea turtles.

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

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

Actions Taken to Reduce Threats
Actions have been taken to reduce anthropogenic impacts to sea turtles from various sources, particularly since the early 1990s. These include lighting ordinances, predation control, and nest relocations to help increase hatchling survival, as well as measures to reduce the mortality of pelagic immatures, benthic immatures, and sexually mature age classes from various fisheries and other marine activities. Some actions have resulted in significant steps towards reducing the recurring sources of mortality of sea turtles in the environmental baseline and improving the status of all sea turtle populations in the Atlantic and Gulf of Mexico. For example, the TED regulation published on February 21, 2003 (68 FR 8456), represent a significant improvement in the baseline effects of trawl fisheries on sea turtles, though shrimp trawling is still considered to be one of the largest source of anthropogenic mortality for most of our sea turtle species (NMFS-SEFSC 2009a).

4.2.1.2 Green Sea Turtle
The green sea turtle was listed as threatened under the ESA on July 28, 1978, except for the Florida and Pacific coast of Mexico breeding populations, which were listed as endangered.

Species Description and Distribution
The green sea turtle is the largest of the hardshell marine turtles, growing to a weight of 350 lb (159 kg) and a straight carapace length of greater than 3.3 ft (1 m). Green sea turtles have a

smooth carapace with 4 pairs of lateral (or costal) scutes and a single pair of elongated prefrontal scales between the eyes. They typically have a black dorsal surface and a white ventral surface, although the carapace of green sea turtles in the Atlantic Ocean has been known to change in color from solid black to a variety of shades of grey, green, or brown and black in starburst or irregular patterns (Lagueux 2001).

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

Differences in mitochondrial DNA properties of green sea turtles from different nesting regions indicate there are genetic subpopulations (Bowen et al. 1992; Fitzsimmons et al. 2006). Despite the genetic differences, sea turtles from separate nesting origins are commonly found mixed together on foraging grounds throughout the species' range. However, such mixing occurs at extremely low levels in Hawaiian foraging areas, perhaps making this central Pacific population the most isolated of all green sea turtle populations occurring worldwide (Dutton et al. 2008).

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

The complete nesting range of green sea turtles within the southeastern United States includes sandy beaches between Texas and North Carolina, as well as the U.S.V.I. and Puerto Rico (Dow et al. 2007; NMFS and USFWS 1991). However, the vast majority of green sea turtle nesting within the southeastern United States occurs in Florida (Johnson and Ehrhart 1994; Meylan et al. 1995). Principal U.S. nesting areas for green sea turtles are in eastern Florida, predominantly Brevard through Broward counties. For more information on green sea turtle nesting in other ocean basins, refer to the 1991 Recovery Plan for the Atlantic Green Turtle (NMFS and USFWS 1991) or the 2007 *Green Sea Turtle 5-Year Status Review* (NMFS and USFWS 2007a).

*Life History Informati*on

Green sea turtles reproduce sexually, and mating occurs in the waters off nesting beaches. Mature females return to their natal beaches (i.e., the same beaches where they were born) to lay eggs

(Balazs 1982; Frazer and Ehrhart 1985) every 2-4 years while males are known to reproduce every year (Balazs 1983). In the southeastern United States, females generally nest between June and September, and peak nesting occurs in June and July (Witherington and Ehrhart 1989). During the nesting season, females nest at approximately 2-week intervals, laying an average of 3-4 clutches (Johnson and Ehrhart 1996). Clutch size often varies among subpopulations, but mean clutch size is around 110-115 eggs. In Florida, green sea turtle nests contain an average of 136 eggs (Witherington and Ehrhart 1989). Eggs incubate for approximately 2 months before hatching. Survivorship at any particular nesting site is greatly influenced by the level of anthropogenic stressors, with the more pristine and less disturbed nesting sites (e.g., along the Great Barrier Reef in Australia) showing higher survivorship values than nesting sites known to be highly disturbed (e.g., Nicaragua [Campbell and Lagueux 2005; Chaloupka and Limpus 2005]).

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

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

Status and Population Dynamics

Population estimates for marine turtles do not exist because of the difficulty in sampling turtles over their geographic ranges and within their marine environments; however, researchers have used nesting data to study trends in reproducing sea turtles over time. A summary of nesting trends is provided in the most recent 5-year status review for the species (NMFS and USFWS 2007b) organized by ocean region (i.e., Western Atlantic Ocean, Central Atlantic Ocean, Eastern Atlantic Ocean, Mediterranean Sea, Western Indian Ocean, Northern Indian Ocean, Eastern Indian Ocean, Southeast Asia, Western Pacific Ocean, Central Pacific Ocean, and Eastern Pacific Ocean). Trends at 23 of the 46 nesting beach sites reviewed in the 5-year status review found that nesting at 10 of the sites appeared to be increasing, nesting at 9 appeared to be stable, and nesting at 4 appeared to be decreasing. With respect to regional trends, the Pacific, the Western Atlantic, and the Central Atlantic regions appeared to show more positive trends (i.e., more nesting sites increasing than decreasing) while the Southeast Asia, Eastern Indian Ocean, and possibly the Mediterranean Sea regions appeared to show more negative trends (i.e., more nesting sites decreasing than increasing). These regional determinations should be viewed with caution since trend data was only available for about half of the total nesting concentration sites examined in the review and site-specific data availability appeared to vary across all regions.

The Western Atlantic region (i.e., the focus of this Opinion) was one of the best performing in terms of abundance in the entire review as there were no sites that appeared to be decreasing. The 5-year status review for the species identified 8 geographic areas considered to be primary sites for green sea turtle nesting in the Atlantic/Caribbean and reviewed the trend in nest count data for each (NMFS and USFWS 2007a). These sites include (1) Yucatán Peninsula, Mexico; (2) Tortuguero, Costa Rica; (3) Aves Island, Venezuela; (4) Galibi Reserve, Suriname; (5) Isla Trindade, Brazil; (6) Ascension Island, United Kingdom; (7) Bioko Island, Equatorial Guinea; and (8) Bijagos Achipelago, Guinea-Bissau. Nesting at all of these sites was considered to be stable or increasing with the exception of Bioko Island and the Bijagos Archipelago where the lack of sufficient data precluded a meaningful trend assessment for either (NMFS and USFWS 2007a). Seminoff (2004) likewise reviewed green sea turtle nesting data for 8 sites in the western, eastern, and central Atlantic, including all of the above with the exception that nesting in Florida was reviewed in place of Isla Trindade, Brazil. Seminoff (2004) concluded that all sites in the central and western Atlantic showed increased nesting, with the exception of nesting at Aves Island, Venezuela, where nesting is stable, while both sites in the Eastern Atlantic demonstrated decreased nesting. These sites are not inclusive of all green sea turtle nesting in the Atlantic; however, other sites are not believed to support nesting levels high enough that would change the overall status of the species in the Atlantic (NMFS and USFWS 2007a). More information about site-specific trends for the other major ocean regions can be found in the most recent 5-year status review for the species (see NMFS and USFWS 2007a).

By far, the largest known nesting assemblage in the Western Atlantic region occurs at Tortuguero, Costa Rica. According to monitoring data on nest counts, as well as documented emergences (both nesting and non-nesting events [i.e., false crawls]), there appears to be an increasing trend in this nesting assemblage since monitoring began in the early 1970s. For instance, from 1971-1975 there were approximately 41,250 average annual emergences documented and this number increased to an average of 72,200 emergences from 1992-1996 (Bjorndal et al. 1999). Troëng and Rankin (Troëng and Rankin 2005) collected nest counts from 1999-2003 and also reported increasing trends in the population consistent with the earlier studies, with nest count data suggesting 17,402-37,290 nesting females per year (NMFS and USFWS 2007a). Modeling by Chaloupka et al. (2008) using data sets of 25 years or more resulted in an estimate of the Tortuguero, Costa Rica, population of nesting females growing at 4.9% annually.

In the continental United States, green sea turtle nesting occurs along the Atlantic coast, primarily along the central and southeast coast of Florida where an estimated 200-1,100 females nest each year (Meylan et al. 1994; Weishampel et al. 2003). Occasional nesting has also been documented along the Gulf coast of Florida (Meylan et al. 1995). More recently, green sea turtle nesting has occurred in North Carolina on Bald Head Island, just east of the mouth of the Cape Fear River, on

Onslow Island, and on Cape Hatteras National Seashore. In 2010, a total of 18 nests were found in North Carolina, 6 nests in South Carolina, and 6 nests in Georgia (nesting databases maintained on www.seaturtle.org).

In Florida, FWRI has established index beaches to standardize data collection methods and effort on key nesting beaches. Since establishment of the index beaches in 1989, the pattern of green sea turtle nesting has generally shown biennial peaks in abundance with a positive trend during the ten years of regular monitoring (Figure 7). According to data collected from Florida's index nesting beach surveys from 1989-2012, green sea turtle nest counts across Florida have increased approximately 10-fold from a low of 267 in the early 1990s to a high of 10,701 in 2011. Two consecutive years of nesting declines in 2008 and 2009 caused some concern, but this was followed by increases in both 2010 and 2011, followed by another decrease in 2012 (Figure 2). Modeling by Chaloupka et al. (2008) using data sets of 25 years or more has resulted in an estimate of the Florida nesting stock at the Archie Carr National Wildlife Refuge growing at an annual rate of 13.9%.

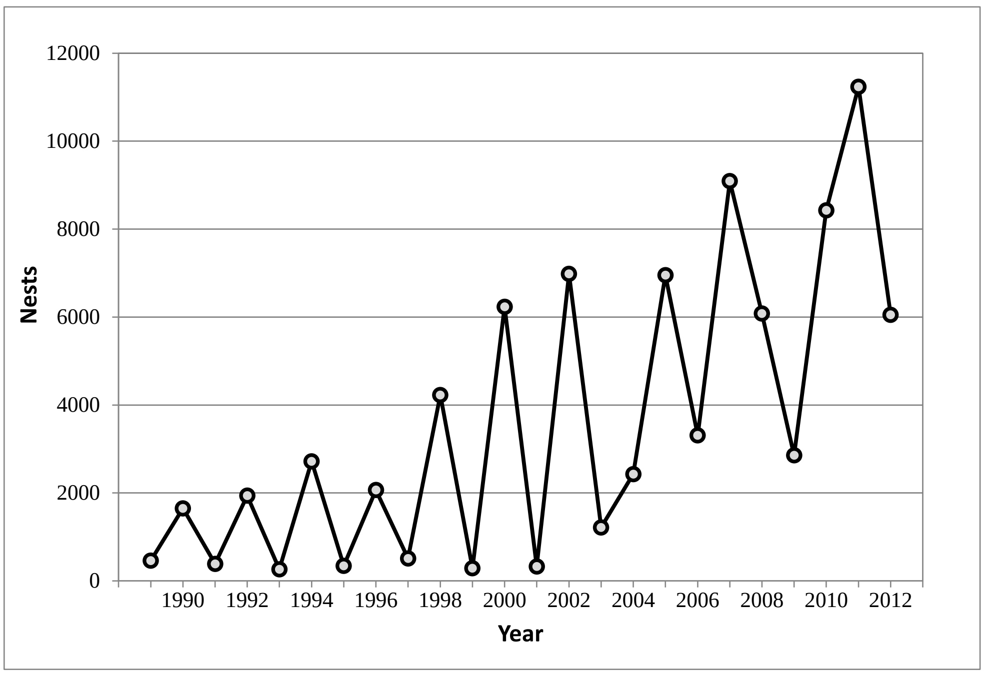

Figure 2. Green sea turtle nesting at Florida index beaches since 1989

Threats

The principal cause of past declines and extirpations of green sea turtle assemblages has been the overexploitation of the species for food and other products. Although intentional take of green sea turtles and their eggs is not extensive within the southeastern United States, green sea turtles that nest and forage in the region may spend large portions of their life history outside the region and outside U.S. jurisdiction, where exploitation is still a threat. Green sea turtles also face many of the same threats as other sea turtle species, including destruction of nesting habitat from storm events, oceanic events such as cold-stunning, pollution (e.g., plastics, petroleum products, petrochemicals), ecosystem alterations (e.g., nesting beach development, beach nourishment and shoreline stabilization, vegetation changes), poaching, global climate change, fisheries interactions, natural predation, and disease. There is a discussion on general sea turtle threats in Section 4.2.1.1.

Beach nourishment projects can result in burial of nearshore hard bottom, affecting forage resources of juvenile green turtles. In the project area, juvenile green sea turtles use nearshore hard bottom habitats (0 to 4 meters deep) as their primary developmental habitat. Much of this habitat is patchily distributed between 200 and 400 meters offshore. Relief ranges from nearly flat and small mounds that are emergent at low tide, to slightly deeper structures that remain submerged. Most nearshore hard bottom is separated by large expanses of sand which would make it difficult for juvenile turtles to find similar habitat nearby.

A post-project study conducted by Makowski and Kruenpel (2007) of the Broward Segment III beach renourishment indicated that there was a 29.8% decline of juvenile green turtles adjacent to one section of the project. Another section showed a 10% decline. Although the overall abundance changes were not statistically significant, Prekel et al. (2007) suggested that the declines may be correlated to temporary reductions in food resources from the burial of nearshore hard bottom. Turbidity from beach nourishment projects may also result in poor water quality which impacts food resources of juvenile green sea turtles.

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

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

4.2.2 Corals: Elkhorn and Staghorn

Elkhorn and staghorn corals were listed as threatened under the ESA in May 2006 (71 FR 26852). At the beginning of each of the following subsections we present general information about corals that pertains to all the listed coral species. Specific information is then presented for each species in the action area.

Species Description

Corals are marine invertebrates in the phylum Cnidaria, which include true stony ("scleractinian") corals, the blue corals, and fire corals. All of the currently-listed corals in the NMFS Southeast Region (North Carolina through Texas and the U.S. Caribbean) are stony corals. Stony corals are characterized by polyps with multiples of 6 tentacles around the mouth for feeding and capturing prey items in the water column (Brainard et al. 2011a). Most stony corals form complex colonies made up of a tissue layer of polyps growing on top of a calcium carbonate skeleton, which the polyps produce through the process of calcification.

All of the listed coral species are reef building species, which are capable of rapid calcification rates because of their symbiotic relationship with single-celled dinoflagellate algae, zooxanthellae, which occur in great numbers within the host coral tissues. Zooxanthellae photosynthesize during the daytime, producing an abundant source of energy for the host coral that enables rapid growth. At night, polyps extend their tentacles to filter-feed on microscopic particles in the water column, such as zooplankton, providing additional nutrients for the host coral. In this way, reef-building corals obtain nutrients autotrophically (i.e., via photosynthesis) during the day, and heterotrophically (i.e., via predation) at night (Brainard et al. 2011b).

Staghorn and Elkhorn Coral

Staghorn coral (*Acropora cervicornis*) and elkhorn coral (*Acropora palmata*) are branching species that occur throughout the wider Caribbean. Staghorn corals have straight or slightly curved, cylindrical branches that look like deer antlers. Elkhorn coral colonies develop frond-like branches, which appear flattened to near round and typically radiate outward from a central trunk and resemble the antlers of an elk. Both species range in color from golden yellow to brown, and the growing tips tend to be lighter or lack color. Individual staghorn coral colonies can reach up to 5 ft (1.5 m) across but may form thickets composed of multiple colonies that are difficult to tell apart. Elkhorn coral colonies can grow to at least 6.5 ft (2 m) in height and 13 ft (4 m) in diameter and can form dense, interlocking thickets. Elkhorn and staghorn corals are reef-building species that provide important habitat for other reef organisms, and other reef-building corals cannot fill the unique structural and ecological role of these 2 coral species (Bruckner 2002a).

Distribution

In general, the corals in the Southeast Region are widely distributed throughout the western Atlantic, Caribbean, and Gulf of Mexico. Corals need hard substrate on which to settle and form; however, only a narrow range of suitable environmental conditions allows coral to grow and exceed loss from physical, chemical, and biological erosion. Reef-building corals do not thrive outside a narrow temperature range of 25°-30°C, but they are able to tolerate temperatures outside this range for brief periods of time, depending on how long and severe the exposure to extremes, as well as other biological and environmental factors. Two other important factors influencing suitability of habitat are light and water quality. Reef-building corals require light for photosynthesis of their symbiotic algae, and poor water quality can negatively affect both coral growth and recruitment. Availability of light generally limits how deep corals are found. Hydrodynamic condition (e.g., high wave action) is another important habitat feature, as it influences the growth, mortality, and reproductive rate of each species adapted to a specific hydrodynamic zone.

Elkhorn and Staghorn Coral

Elkhorn coral naturally occurs on spur-and-groove, bank reef, patch reef, and transitional reef habitats, as well as on limestone ridges, terraces, and hard bottom habitats (Cairns 1982; Davis 1982; Gilmore and Hall 1976; Goldberg 1973; Jaap 1984; Miller et al. 2008; Wheaton and Jaap 1988). Elkhorn coral commonly grows in turbulent, shallow water on the fore reef, reef crest, and in the shallow spur-and-groove zone (Cairns 1982; Miller et al. 2008; Rogers et al. 1982; Shinn 1963) in water depths ranging from 3-15 ft (1-5 m). Less commonly, elkhorn has been found in back reef environments and water depths up to 100 ft (30 m).

Elkhorn coral is widely distributed throughout the western Atlantic and Caribbean. Areas occupied by this coral within U.S. jurisdiction are limited to 4 counties in the state of Florida, the Flower Garden Banks National Marine Sanctuary in the western Gulf of Mexico, Puerto Rico, U.S. Virgin Islands, and Navassa Island. There is currently no evidence of range constriction for this species, though populations throughout the range have decreased substantially since the 1970s.

In Florida, living elkhorn coral is relatively scarce offshore of Broward and Miami-Dade counties and is more common southward. Fossil elkhorn coral reef framework extends from Palm Beach County throughout the Florida Keys and discontinuously to the Dry Tortugas. In Puerto Rico, elkhorn coral occurs at varying densities off all coasts of the main island and around some of its smaller islands. Dense, tall thickets of elkhorn coral are present in only a few reefs along the southwest, north, and west shore of the main island and isolated offshore locations (Schärer et al. 2009; Weil et al. 2002). In addition to live colonies, large stands of dead elkhorn currently exist on the fringing coral reefs along the shoreline (e.g., Punta Picúa, Punta Miquillo, Río Grande, Guánica, La Parguera, and Mayagüez). The U.S. Virgin Islands also support populations of elkhorn coral. Elkhorn coral is present around most of St. Croix, and elkhorn colony density in Buck Island National Monument is higher in the northern and eastern areas around the island (Mayor et al. 2006). There are limited quantitative data on the presence of elkhorn coral around the islands off St. Thomas; however, the species has been reported anecdotally. There are several areas around the island of St. John that support healthy populations of elkhorn (Grober-Dunsmore et al. 2007). Last, there are 2 known colonies of elkhorn coral at Flower Garden Banks National Marine Sanctuary, located 100 mi (161 km) off the coast of Texas in the Gulf of Mexico. The 2 known colonies were discovered only recently in 2003 and 2005 (Zimmer et al. 2006).

Staghorn coral commonly grows in water ranging from 15 to 65 ft (5-20 m) in depth and rarely in waters to 196 ft (60 m) (Davis 1982; Jaap 1984; Jaap et al. 1989; Wells 1933). Staghorn coral is widely distributed throughout the western Atlantic and Caribbean. Areas occupied by this coral within U.S. jurisdiction are limited to 4 counties in the state of Florida, Puerto Rico, U.S. Virgin Islands, and Navassa Island. There is currently no evidence of range constriction for this species, though populations throughout the range have decreased substantially since the 1970s.

In Florida, staghorn coral has been documented along the east coast as far north as Palm Beach County. It occurs in deeper water (50-100 ft, 16-30 m) at its northernmost range (Goldberg 1973;

E. Tichenor, Palm Beach County Reef Rescue, pers. comm. to Jennifer Moore, NMFS 2008) and is distributed across its depth range (15-100 ft, 5-30 m) off Broward and Miami-Dade Counties, the Florida Keys, and the Dry Tortugas (Jaap 1984). Off the shore of Broward County, staghorn corals form extensive thickets, which are the largest known remaining populations within U.S. jurisdiction. In Puerto Rico, coral reefs with varying densities staghorn corals are off all coasts of the main island and around some of its smaller islands. Dense, tall thickets staghorn coral are present in only a few reefs along the southwest, north, and west shore of the main island and isolated offshore locations (Schärer et al. 2009; Weil et al. 2002). In the U.S. Virgin Islands, staghorn corals occur off St. Croix, St. Thomas, and St. John (Brainard et al. 2011a).

Life History Information

Corals use a number of diverse reproductive modes (Figure 3). Most coral species reproduce sexually and asexually. Corals reproduce sexually by developing eggs and sperm within the polyps. Some coral species have separate sexes (gonochoric), while others are both sexes at the same time (hermaphroditic). Strategies for fertilization are by "brooding" or "broadcast spawning" (i.e., internal or external fertilization, respectively). Asexual reproduction occurs through fragmentation when pieces of a colony break off and re-attach to hard substrate to form a new colony. Fragmentation results in multiple genetically-identical colonies. In many species of branching corals, fragmentation is a common and sometimes dominant means of propagation.

Depending on the mode of fertilization, coral larvae (called planulae) undergo development either mostly within the mother colony (brooders) or outside in the ocean (broadcast spawners). In either mode of larval development, planula larvae presumably experience considerable mortality (up to 90% or more) from predation or other factors prior to settlement and metamorphosis. Such mortality cannot be directly observed, but is inferred from the large amount of eggs and sperm spawned versus the much smaller number of recruits observed later. Coral larvae are relatively poor swimmers; therefore, their dispersal distances largely depend on how long they remain in the water column and the speed and direction of water currents transporting the larvae. The documented maximum larval life span is 244 days (*Montastraea magnistellata* [Graham et al. 2008]), which suggests that the potential for long-term dispersal of coral larvae, at least for some species, may be substantially greater than previously thought and may partially explain the large geographic ranges of many species.

Biological and physical factors that have been shown to affect spatial and temporal patterns of coral recruitment include:

- substratum availability and community structure (Birkeland 1977)
- grazing pressure (Rogers et al. 1984; Sammarco 1985)
- fecundity, mode, and timing of reproduction (Harriott 1985; Richmond and Hunter 1990)
- behavior of larvae (Goreau et al. 1981; Lewis 1974)
- hurricane disturbance (Hughes and Jackson 1985)
- physical oceanography (Baggett and Bright 1985; Fisk and Harriott 1990)
- the structure of established coral assemblages (Harriott 1985; Lewis 1974)
- chemical cues (Morse et al. 1988)

In general, upon proper stimulation coral larvae settle on appropriate substrates. Some evidence indicates that chemical cues from crustose coralline algae (CCA), microbial films, and/or other reef organisms (Gleason et al. 2009; Morse et al. 1996; Morse et al. 1994; Negri et al. 2001) or acoustic cues from fish and crustaceans in reef environments (Vermeij et al. 2010) stimulate settlement behaviors. Once a settlement site is chosen, the larvae attach to the surface and lay down a calcium carbonate skeleton. Successful recruitment of larvae is the only way new genetic individuals enter a population, thereby maintaining or increasing genotypic diversity (i.e., number of individuals if a population of clonal organisms). The larval stage is also important, as it is the only phase in the life cycle of corals where dispersal occurs over long distances. This helps genetically link populations and provides the potential to re-populate depleted areas. Because newly-settled corals barely protrude above the substrate, juveniles need to reach a certain size to limit damage or mortality from threats such as grazing, sediment burial, and algal overgrowth (Bak and Elgershuizen 1976; Birkeland 1977; Sammarco 1985). Once recruits reach about 1-2 years post-settlement, growth and mortality rates appear similar across species. In some species, it appears that there is virtually no limit to colony size beyond structural integrity of the colony skeleton, as polyps apparently can bud indefinitely.

Stony corals require hard substrate for settlement of their larvae, and presence of other benthic organisms (e.g., macroalgae) can preclude settlement. Encrusting sponges and soft corals, zoanthids, and macroalgae are major coral competitors because of their ability to blanket large areas of the sea floor. The presence of macroalgae inhibits coral settlement both by competing for space and by trapping sediment that can abrade and smother small recruits. Juvenile corals are the most susceptible to overgrowth and mortality from these competitors, and corals are generally better able to compete as they grow larger (Bak and Elgershuizen 1976; Birkeland 1977).

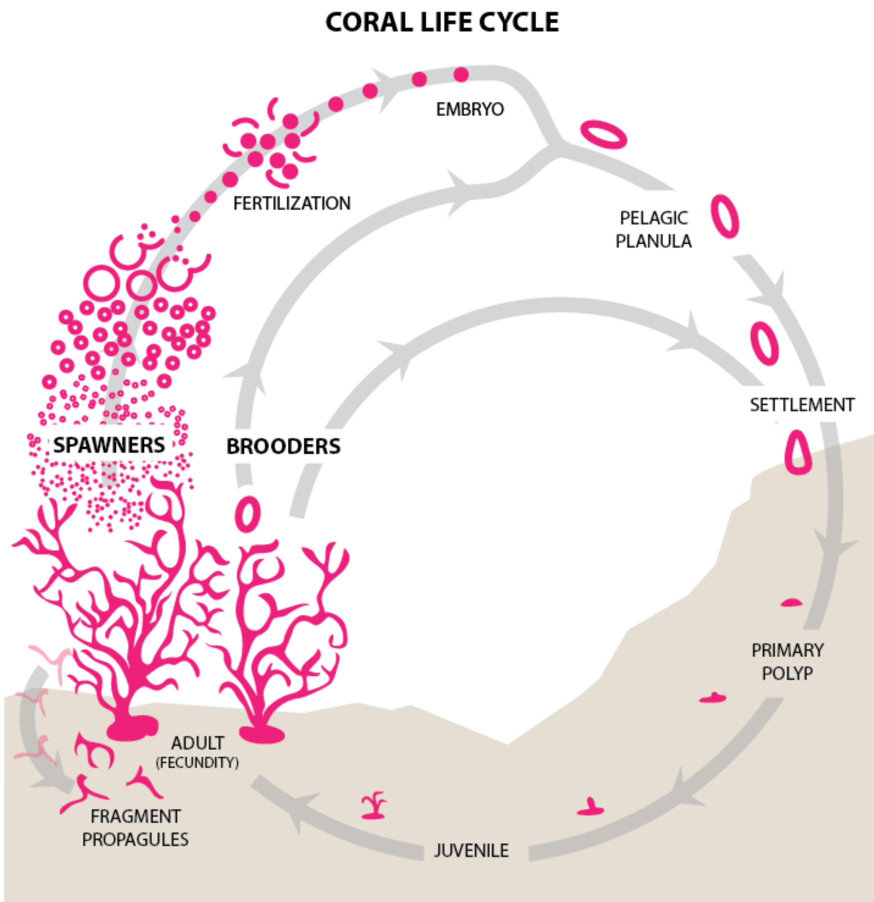

Figure 3. Coral life cycle showing different life history stages for broadcast spawners versus brooders, as well as asexual fragmentation. (Reproduced from Brainard et al. 2011. Diagram prepared by Amanda Toperoff, NOAA PIFSC).

Elkhorn and Staghorn Coral

Elkhorn and staghorn corals reproduce both sexually and asexually. Both species are hermaphroditic and are broadcast spawners (Szmant 1986); however, neither species can self-fertilize, and 2 genetically distinct parents are required to produce viable larvae (Baums et al. 2005a). Elkhorn and staghorn corals release gametes a few nights after the full moon during July, August, or September; however, some populations may have spawning events during 2 months. Estimated size at sexual maturity for elkhorn coral is 1.5 ft^2 colony height (1,600 cm^2) though fertile colonies as small as 20 in^2 (128 cm^2) have been found (Soong and Lang 1992). Staghorn colonies reach sexual maturity at 6.5 in (17 cm) in branch length, but reproductive colonies 3.5 in (9 cm) in branch length have been observed (Soong and Lang 1992). Skeletal growth rates of elkhorn and staghorn corals are fast relative to other Caribbean coral species. Linear extension rates range from 1-4.5 in (3-11.5 cm) per year for staghorn coral (Becker and Mueller 2001; Gladfelter et al. 1978; Jaap 1974; Shinn 1966; Shinn 1976; Vaughan 1915) and from 1.5-4 in (4-11 cm) per year for elkhorn coral (Becker and Mueller 2001; Garcia et al. 1996; Gladfelter et al. 1978; Jaap 1974; Vaughan 1915). New recruits and juveniles typically grow at slower rates. Larger colonies of both species have higher fertility rates and produce proportionally more gametes than small colonies since basal and branch tip tissue are not fertile (Soong and Lang 1992). Fertilized eggs develop into planula larvae over several days in the water column. When larvae are ready to settle, they swim down to the bottom where they crawl along the surface searching for an appropriate settlement site. Certain species of CCA help settlement and post-settlement survival in both staghorn and elkhorn coral (Ritson-Williams et al. 2009).

Population Dynamics and Status

Documenting population dynamics for corals is confounded by several unique life history characteristics. Particularly, clonality and asexual reproduction makes it particularly difficult to census a species to determine population abundance estimates. This can only truly be done by genotypically tracking individual colonies within a set area over time to determine if a new colonies in the population are new sexual recruits or colonies formed by asexual reproduction or partial mortality (Williams et al. 2006). This is why coral abundance estimates are usually reported in percent cover rather than number of individuals.

Asexual reproduction can play a major role in maintaining local populations, but in the absence of sexual recruitment, it can also lead to decreased resilience to stressors due to decreased genetic diversity. Since corals cannot move and are dependent upon external fertilization to produce larvae, fertilization success declines greatly as adult density declines. In populations where fragmentation happens often, the number of genetically distinct adults is even lower than colony density. Likewise, when there are fewer adult colonies, there are also fewer sources of fragments to provide for asexual recruitment. These conditions imply that once a population declines to or below a certain level (i.e., the number of adults in an area is too low for sexual reproduction to be effective), the chances for recovery are low. Thus local (reef-scale) reductions in colony numbers and size may prevent recovery for decades.

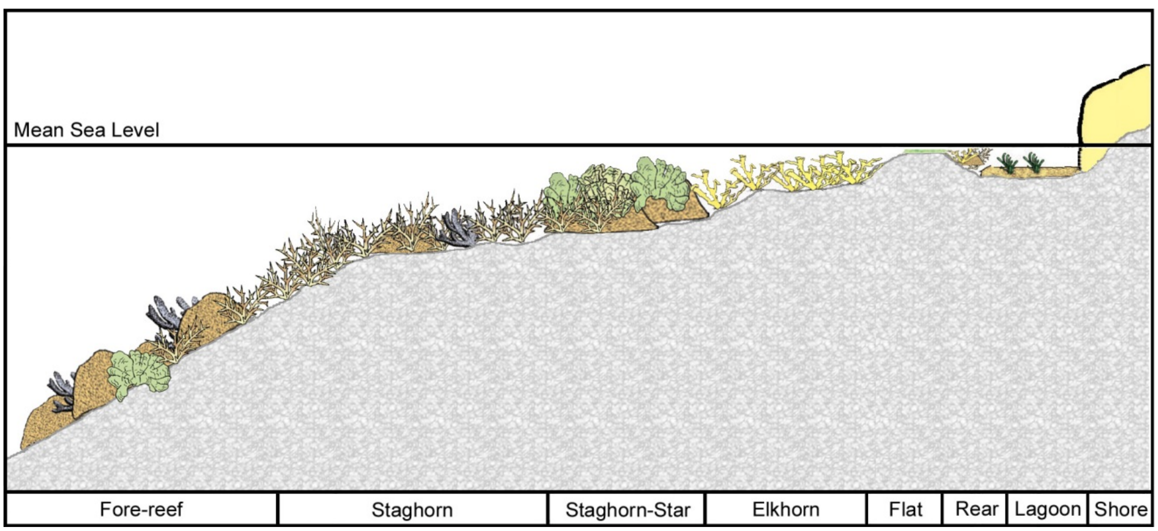

Figure 4. Generalized reef zone schematic (Acropora Biological Review Team 2005)

Elkhorn Coral

Historically, elkhorn was historically one of the dominant coral species and principle contributors to reef creation in the Atlantic and Caribbean. It commonly formed vast thickets, lending its names to a distinct zone in classical descriptions of Caribbean reef morphology (Figure 4). In the decades of the 1960s and 1970s, many Caribbean reefs were described as having an elkhorn (*A. palmata*) zone based upon high coverage, colony density, and in some cases, near exclusiveness of these species at particular depths (Goreau 1959).

Few historical estimates for elkhorn coral population sizes are available because of its historically abundant status, its ability to produce clones through fragmentation, and its tendency to grow together to form complex thickets where individual colonies are difficult to tell apart. Although quantitative data on former distribution and abundance are scarce, in the few locations where quantitative data are available (e.g., Florida Keys, Dry Tortugas, Belize, Jamaica, and the U.S. Virgin Islands), declines in abundance (coverage and colony numbers) are estimated at greater than 97% (*Acropora* Biological Review Team 2005). Elkhorn coral underwent a precipitous decline throughout its ranges in the early 1980s due to mortality events associated with white band disease outbreaks and subsequent hurricane damage (Kramer 2002; Rogers et al. 2002). Although this downward trend continues, local extinctions (i.e., at the island or country scale) have not been definitively documented. In addition to declines in numbers of colonies and percent cover, the total surface area of live tissue is now much less than in the past because colonies are smaller and sometimes encrusting rather than complex, three-dimensional structures (Rogers et al. 2002).

Miller et al. (2013) extrapolated population abundance of elkhorn coral in the Florida Keys from stratified random samples across habitat types. Extrapolated population estimates of elkhorn coral were 0.6 ± 0.5 (SE) million colonies in 2005, 1.0 ± 0.3 (SE) million colonies in 2007, and 0.5 ± 0.3 (SE) million colonies in 2012 (Miller et al. 2013). Relative to the abundance of other corals in the Florida Keys region, elkhorn coral was among the least abundant, ranking among corals that are naturally rare in abundance. No colonies of elkhorn coral were observed in surveys of the Dry Tortugas in 2006 and 2008 (Miller et al. 2013). The size class distribution of the Florida Keys population included both small and large individuals (>260 cm), but after 2005 the majority of the colonies were in the smaller size classes. Excluding the smallest size class (0-20 cm) which had relatively little partial mortality, partial mortality was approximately 20-70% in 2005, 5-50% in 2007, and 15-90% in 2012 across all other size classes (Miller et al. 2013).

Puerto Rico contains the greatest extent of elkhorn coral in the U.S. Caribbean (Schärer et al. 2009). A survey of 431 random points in suitable habitat for elkhorn coral in 6 marine protected areas in Puerto Rico in 2006-2007 revealed a variable density of 0 to 52 elkhorn coral colonies per 100 m^2, with average density of 3.3 colonies per 100 m^2 (Schärer et al. 2009). Total loss of elkhorn coral was evidenced in 13.6% of the random survey areas where only dead standing colonies were present (Schärer et al. 2009).

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

Zubillaga et al. (2005) report densities of 3.2 colonies of elkhorn coral per 10 m^2 in Los Roques National Park, Venezuela. At 10 sites surveyed in the national park in 2003 to 2004, density ranged from 0 to 3.4 colonies per 10 m^2 with 4 of the sites showing only standing dead colonies (Zubillaga et al. 2008). In the 6 sites with live colonies, small (0.1–50 cm^2) and medium-sized (50–4,550 cm^2) colonies predominated over larger-sized (4,550–16,500 cm^2) colonies.

In some populations, the recent trend in elkhorn abundance seems to conform to a pattern of stability punctuated by episodic, catastrophic declines. After the initial declines in the 1980s due to hurricanes and disease, a major El Niño/La Niña Southern Oscillation cycle in 1997-1998 resulted in a large bleaching event and a loss of coral in the Caribbean and the Atlantic (Wilkinson and Souter 2008). Catastrophic mortality events for elkhorn coral, defined as a 50% reduction within monitored populations, occurred in 2005 in the U.S. Virgin Islands due to mass-bleaching events (Lundgren and Hillis-Starr 2008; Muller et al. 2008) and in the Florida Keys due to hurricanes and disease (Williams et al. 2008).

In St. John, U.S. Virgin Islands, colonies of elkhorn coral increased in abundance at eight of 11 sites, particularly in the smallest size class, between 2001 and 2003, though the number of colonies in the largest size class decreased during this period (Grober-Dunsmore et al. 2006). Colonies of elkhorn coral monitored monthly between 2003 and 2009 in Haulover Bay on St. John suffered bleaching and mortality from disease but showed an increase in abundance and size by the end of the monitoring period (Rogers and Muller 2012). Surveys at 10 sites around St. John in 2004 and 2010 showed density did not significantly change in the 6 years between surveys; size frequency distribution did not significantly change at 7 of the 10 sites, though 2 sites showed an increased abundance of large-sized (> 51 cm) colonies (Muller et al. 2013).

In contrast, monitored colonies in the upper Florida Keys showed a greater than 50% loss of tissue as well as a decline in the number of colonies and a decline in the dominance by large colonies between 2004 and 2010 (Vardi et al. 2012; Williams and Miller 2012). Williams and Miller (2012) found that the recovery trajectory of elkhorn coral in the Florida Keys following the 2005 mass-mortality event is likely to be 10 years or more. Meanwhile, mass mortalities in this population have been observed more frequently than every 10 years (i.e., 1997-1998 and 2005). A population model based on monitoring in the Florida Keys has shown that the largest individuals have the greatest contribution to the rate of change in population size (Vardi et al. 2012). Williams et al. (2008) report recruitment failure between 2004 and 2007 in the upper Florida Keys after a major hurricane season in 2005; less than 5% of the fragments produced recruited into the population. Monitoring of elkhorn coral in the middle and lower Florida Keys between 2010 and 2013 had mixed trends. Population densities remained relatively stable at 2 of the sites but decreased at 2 of the sites by 21% and 28% (Lunz 2013).

Similar patterns of mass mortality (i.e., approximately 50% loss during Hurricane Omar in 2007) and slow rates of recovery have been observed in Curaçao's elkhorn populations as well (Williams et al. unpublished data). Elkhorn coral monitored in Curaçao between 2009 and 2011 decreased in abundance, increased in colony size, and tissue abundance remained the same after hurricane damage (Bright et al. 2013). The authors explained the apparently paradoxical trends of increasing colony size but similar tissue abundance likely resulted from the loss of small-sized colonies that skewed the distribution to larger size classes, rather than colony growth.

Simulation models using data derived from population matrix models of monitored elkhorn coral colonies in Curaçao (2006-2011), the Florida Keys (2004-2011), Jamaica (2007-2010), Navassa (2006 and 2009), Puerto Rico (2007 and 2010), and the British Virgin Islands (2006 and 2007) indicate that most of these populations will continue to decline in size and extent by 2100 if background environmental conditions remain unchanged (Vardi 2011). Jamaica is the only studied location where populations were projected to grow in abundance. Populations in Navassa were projected to remain stable while those in the British Virgin Islands were predicted to decrease slightly from their initially very low levels. Populations in all other locations in the study (Florida, Curaçao, and Puerto Rico) were predicted to decline to zero by 2100. Jamaica, Navassa, and the British Virgin Islands did not experience physical disturbance events (storms) during the study period, which may contribute to the differing projected trends in these locations.

A report on the status and trends of Caribbean corals over the last century indicates that after the large mortality events of the 1970s and 1980s, cover of elkhorn coral has remained relatively stable (though drastically reduced) throughout the region as has the frequency of reefs at which elkhorn coral was described as the dominant coral (IUCN 2013). Still, the report also indicates that the number of reefs with elkhorn coral present has steadily declined since the 1980s through 2011.

Fragmentation is the most common way of forming new colonies in acroporid corals (Bak and Criens 1982; Davis 1977; Gilmore and Hall 1976; Hughes 1985; Tunnicliffe 1981). Yet, elkhorn coral retains moderate to high levels of genotypic diversity (i.e., the ratio of genetically distinct individuals to all colonies in a population) in many geographic areas (Baums et al. 2010; Baums et al. 2006; Vollmer and Palumbi 2007), though areas with low levels of genotypic diversity also exist. For instance, Baums et al. (2006) report elkhorn coral thickets at several sites in the Florida Keys are constituted by a single genetic individual, indicating a high reliance on asexual reproduction to maintain these populations. In a study of genetic exchange and clonal population structure in elkhorn corals, Baums et al. (2005b) found that the eastern Caribbean[4] has experienced little or no recent genetic exchange with populations in the western Caribbean.[5] Puerto Rico is an area of mixing between the 2 regions. Baums et al. (2005b) also stated that populations of elkhorn corals in the eastern Caribbean were denser and more genotypically diverse, suggesting a greater contribution from sexual recruitment. Studies have found that genetic exchange is restricted between populations separated by greater than 300 miles (500 km), emphasizing the importance of locally diverse populations for the recovery of this species (Baums et al. 2010; Baums et al. 2006; Vollmer and Palumbi 2007).

Settlement of elkhorn larvae is rarely detected in coral recruitment studies (Bak and Engel 1979; Rylaarsdam 1983; Sammarco 1980). Studies from across the wider Caribbean, however, confirm 2 overall patterns of sexual recruitment of elkhorn coral: (1) low juvenile densities relative to other coral species; and (2) low juvenile densities relative to the commonness of adults (Porter 1987). This pattern suggests that the composition of the adult population is dependent upon variable recruitment and likely reflects the dominance of asexual reproduction by fragmentation for these species (i.e., surviving fragments are usually large and never undergo a “juvenile” stage). Fragmentation can provide a mechanism for locally maintaining and expanding elkhorn coral populations. In many locations populations of elkhorn coral have been reduced to such an extent that the potential for recovery through re-growth of fragments is limited. Similarly, as the density of elkhorn coral colonies has declined, gametes become diluted, successful sexual reproduction is less likely and results in reduced potential for exchange of genetic material between populations that are spatially further apart (Bruckner 2002b). Contributing to density concerns for elkhorn

[4] Baums et al. (2005b) considered the eastern Caribbean to be St. Vincent and the Grenadines, the U.S. Virgin Islands, Curaçao, and Bonaire.
[5] Baums et al. (2005b) considered the western Caribbean to be Bahamas, Florida, Mexico, Panama, Navassa, and Mona Island.

coral are observations that spawning does not occur at the same time. Observations at sites in the Florida Keys where distinct genotypes do co-occur in close proximity indicate that they often spawn on different nights preventing effective larval production (Miller et al. unpublished data). Thus there is substantial evidence to suggest that sexual recruitment of both elkhorn corals is currently compromised and limiting the potential for recovery.

Staghorn Coral

Historically, staghorn coral was historically one of the dominant coral species and principle contributors to reef creation in the Atlantic and Caribbean. It commonly formed vast thickets, lending its names to a distinct zone in classical descriptions of Caribbean reef morphology (**Error! Reference source not found.**). In the decades of the 1960s and 1970s, many Caribbean reefs were described as having an elkhorn (*A. palmata*) zone based upon high coverage, colony density, and in some cases, near exclusiveness of these species at particular depths (Goreau 1959).

Few historical estimates for staghorn coral population sizes are available because of its historically abundant status, its ability to produce clones through fragmentation, and its tendency to grow together to form complex thickets where individual colonies are difficult to tell apart. Although quantitative data on former distribution and abundance are scarce, in the few locations where quantitative data are available (e.g., Florida Keys, Dry Tortugas, Belize, Jamaica, and the U.S. Virgin Islands), declines in abundance (coverage and colony numbers) are estimated at greater than 97% (*Acropora* Biological Review Team 2005). Staghorn coral underwent precipitous declines throughout its range in the early 1980s due to mortality events associated with white band disease outbreaks and subsequent hurricane damage (Kramer 2002; Rogers et al. 2002); however, there are some small pockets of remnant robust populations such as in southeast Florida (Vargas-Angel et al. 2003), Honduras (Keck et al. 2005; Riegl et al. 2009), and Dominican Republic (Lirman et al. 2010).

Miller et al. (2013) extrapolated population abundance of staghorn coral in the Florida Keys and Dry Tortugas from stratified random samples across habitat types. Population estimates of staghorn coral in the Florida Keys were 10.2 ± 4.6 (SE) million colonies in 2005, 6.9 ± 2.4 (SE) million colonies in 2007, and 10.0 ± 3.1 (SE) million colonies in 2012. In the Dry Tortugas population estimates were 0.4 ± 0.4 (SE) million colonies in 2006 and 3.5 ± 2.9 (SE) million colonies in 2008, though the authors note their sampling scheme in the Dry Tortugas was not optimized for staghorn coral. In both the Florida Keys and Dry Tortugas, most of the population was dominated by small colonies less than 30 cm diameter. In the Florida Keys, partial mortality was highest in 2005, with up to 80% mortality observed, and lowest in 2007 with a maximum of 30%. In 2012, partial mortality ranged from 20%-50% across most size classes.

The recent trends in abundance for both species seem to conform to a pattern of stability punctuated by episodic, catastrophic declines. After the initial declines in the 1980s due to hurricanes and disease, a major El Niño/La Niña Southern Oscillation cycle in 1997-1998 resulted in a large bleaching event and a loss of coral in the Caribbean and the Atlantic (Wilkinson and Souter 2008).

There have been several reports of local trends in abundance. Lidz and Zawada (2013) observed 400 colonies of staghorn coral along 70.2 km of transects near Pulaski Shoal in the Dry Tortugas where the species had not been seen since the cold water die-off of the 1970s, but no thickets were observed. Cover of staghorn coral increased on a Jamaican reef from 0.6% in 1995 to 10.5% in 2004 (Idjadi et al.) and 44% by 2005, but then collapsed after the 2005 bleaching event and subsequent predation to less than 0.5% in 2006 (Quinn and Kojis 2008). Walker et al. (2012) report increasing size of 2 thickets (expansion of up to 7.5 times the original size of one of the thickets) monitored off southeast Florida but also noted that cover within monitored plots concurrently decreased by about 50%, highlighting the dynamic nature of staghorn coral as it moves around with fragmentation and re-attachment.

Riegl et al. (2009) monitored staghorn coral in photo plots on the fringing reef near Roatan, Honduras from 1996 to 2005. Staghorn coral cover was 0.42% in 1996, declined to 0.14% in 1999 after the Caribbean bleaching event in 1998 and mortality from run-off associated with a Category 5 hurricane, and decreased further to 0.09% in 2005. Staghorn coral colony frequency decreased 71% between 1997 and 1999. In sharp contrast, offshore banks near Roatan had dense thickets of staghorn coral with 31% cover in photo-quadrats in 2005 and appeared to survive the 1998 bleaching event and hurricane, most likely due to bathymetric separation from land and greater flushing. Modeling showed that under undisturbed conditions, retention of the dense staghorn coral stands on the banks off Roatan is likely with a possible increased shift towards dominance by other coral species.

A report on the status and trends of Caribbean corals over the last century indicates that after the large mortality events of the 1970s and 1980s, cover of staghorn coral has remained relatively stable (though much reduced) throughout the region as has the frequency of reefs at which staghorn coral was described as the dominant coral (IUCN 2013). The report also indicates that the number of reefs with staghorn coral present declined during the 1980s, remained relatively stable (though lower) in the 1990s, and then continued to decrease through 2011.

Fragmentation is the most common way of forming new colonies in staghorn corals (Bak and Criens 1982; Davis 1977; Gilmore and Hall 1976; Hughes 1985; Tunnicliffe 1981). Yet, staghorn coral retains moderate to high levels of genotypic diversity (i.e., the ratio of genetically distinct individuals to all colonies in a population) in many geographic areas (Baums et al. 2010; Baums et al. 2006; Vollmer and Palumbi 2007), though areas with low levels of genotypic diversity also exist. Baums et al. (2010) report staghorn coral at other Florida sites showed higher levels of diversity, indicating a more even reliance on sexual and asexual reproduction. Studies have found that genetic exchange is restricted between populations separated by greater than 300 miles (500 km), emphasizing the importance of locally diverse populations for the recovery of these 2 species (Baums et al. 2010; Baums et al. 2006; Vollmer and Palumbi 2007).

Settlement of staghorn larvae is rarely detected in coral recruitment studies (Bak and Engel 1979; Rylaarsdam 1983; Sammarco 1980). Studies from across the wider Caribbean, however, confirm 2 overall patterns of sexual recruitment of staghorn corals: (1) low juvenile densities relative to other coral species; and (2) low juvenile densities relative to the commonness of adults (Porter 1987). This pattern suggests that the composition of the adult population is dependent upon variable recruitment and likely reflects the dominance of asexual reproduction by fragmentation for these species (i.e., surviving fragments are usually large and never undergo a “juvenile” stage).

Fragmentation can provide a mechanism for locally maintaining and expanding staghorn coral populations. In many locations, populations of staghorn coral have been reduced to such an extent that the potential for recovery through re-growth of fragments is limited. Similarly, as the density staghorn coral colonies has declined, gametes become diluted, successful sexual reproduction is less likely and results in reduced potential for exchange of genetic material between populations that are spatially further apart (Bruckner 2002b). Contributing to density concerns for staghorn coral are observations that spawning does not occur at the same time. Observations at sites in the Florida Keys where distinct genotypes do co-occur in close proximity indicate that they often spawn on different nights preventing effective larval production (Miller et al. unpublished data). Thus there is evidence to suggest that sexual recruitment of staghorn coral is currently compromised and limiting the potential for recovery.

Threats

Ocean Warming

Mean seawater temperatures in reef-building coral habitats have increased during the past few decades and are predicted to continue to rise between now and 2100 (IPCC 2013). More importantly, the frequency of warm-season temperature extremes (warming events) in reef-building coral habitat has increased during the past 2 decades and is also predicted to increase between now and 2100 (IPCC 2013). The primary observable coral response to ocean warming is bleaching of coral colonies, wherein corals expel their symbiotic algae (zooxanthellae) in response to stress. Bleaching can affect coral growth, maintenance, reproduction, and survival. An episodic increase of only 1°-2°C above the normal local seasonal maximum ocean temperature can induce bleaching. Although corals can withstand mild to moderate bleaching, severe, repeated, or prolonged bleaching can lead to colony death and has led to the mass mortality of many coral species during the past 30 years.

In addition to coral bleaching, ocean warming detrimentally affects virtually every life-history stage in reef-building corals. For one Indo-Pacific *Acropora* species, abnormal embryonic development occurs at 32°C, and complete fertilization failure occurs at 34°C (Negri et al. 2007). Further, symbiosis establishment, larval survivorship, and settlement success are impaired in some coral species at temperatures as low as 30°-32°C (Randall and Szmant 2009; Ross et al. 2013; Schnitzler et al. 2012). Warmer temperatures accelerate the rate of larval development for spawning species, which reduces dispersal distances, the likelihood of successful settlement, and the potential for replenishment of depleted areas (Randall and Szmant 2009).

Multiple threats stress corals simultaneously or sequentially, whether the effects are cumulative, synergistic, or antagonistic. Ocean warming is likely to interact with many other threats, especially considering the long-term consequences of repeated thermal stress, since ocean warming is expected to worsen over this century. Increased seawater temperature interacts with coral diseases to reduce coral health and survivorship. Coral disease outbreaks often have accompanied or immediately followed bleaching events and follow seasonal patterns of high seawater temperatures. The effects of greater ocean warming (i.e., increased bleaching, which kills or weakens colonies) are expected to interact with the effects of higher storm intensity (i.e., increased breakage of dead or weakened colonies) in the Caribbean, resulting in increased rates of coral declines. Likewise, land-based runoff, pollution, or other local stressors may worsen bleaching impacts by increasing coral susceptibility to bleaching and/or increasing the duration of lowered growth after a bleaching event (Carilli et al. 2009; Wooldridge 2009).

Ocean Acidification
Ocean acidification is a result of increased greenhouse gas accumulation, primarily carbon dioxide, in the atmosphere. Ocean acidification is a drop in the pH of seawater that occurs in response to increases in atmospheric carbon dioxide levels that change ocean carbonate chemistry (Caldeira and Wickett 2003). The aragonite saturation state measures the concentration of carbonate ions in the ocean. Corals use carbonate ions to build calcium carbonate skeletons. Thus decreasing pH and aragonite saturation state are expected to have a major impact on corals and other marine organisms this century by making it more difficult for them to build their skeletons (Fabry 2008). Numerous laboratory and field experiments have shown a relationship between elevated carbon dioxide and decreased calcification rates in particular corals and other calcium carbonate secreting organisms such as CCA (Bates et al. 2009; De Putron et al. 2010; Doney et al. 2009; Langdon et al. 2003). Low-saturation-state water also decreases the rate of biochemical processes that create the cements that infill reefs. A major potential impact from ocean acidification is a reduction in the structural stability of corals and reefs, which results both from increases in bioerosion and decreases in reef cementation. As atmospheric carbon dioxide rises globally, reef-building corals are expected to calcify more slowly and become more fragile.

Laboratory experiments have shown that a declining aragonite saturation state slows the start of, and the rate at which, newly settled coral larvae create carbonate skeletons (Albright et al. 2008; Cohen et al. 2007; Cohen et al. 2009). Slower growth implies even higher rates of mortality for newly settled corals that are vulnerable to overgrowth competition, sediment smothering, and incidental predation until they reach a refuge at larger colony size. In addition to effects on growth and calcification, recent laboratory experiments have shown that increased carbon dioxide also substantially impairs coral fertilization and settlement success (Albright et al. 2010), suggesting a potential further reduction in recruitment. Community medium-scale studies (Jokiel et al. 2008; Kuffner et al. 2008) showed dramatic declines in the growth rate of CCA and other reef organisms and an increase in the growth of fleshy algae at atmospheric carbon dioxide levels expected later this century. The decrease in CCA growth, coupled with rapid growth of fleshy algae will result in less available habitat for settlement and recruitment of new coral colonies.

Acidification is likely to interact with other threats. Ocean acidification may reduce the temperature threshold at which bleaching occurs (Anthony et al. 2011). Reduced skeletal growth compromises the ability of coral colonies to compete for space against algae, which grows more quickly as nutrient over-enrichment increases. Reduced skeletal density weakens coral skeletons, resulting in greater colony breakage from natural and human-induced physical damage.

Disease
Coral diseases are common and significant threats affecting most coral species. Disease can cause mortality, reduced sexual and asexual reproductive success, and impaired 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. In the case of corals, the host is a complex community of organisms, which includes the coral animal, symbiotic zooxanthellae, and microbial symbionts.

Scientific understanding of individual disease causes in corals remains very poor. Lack of identification of specific pathogens of many coral diseases has hindered the ecological understanding of diseases and the ability to manage them effectively. Several authors have suggested there is a link between increased incidence of coral disease with increased temperature (Bruno et al. 2007; Harvell et al. 1999; Muller et al. 2008; Patterson et al. 2002) that may make corals more prone to infection or make pathogens more potent. An increased prevalence of infectious disease outbreaks has been associated with thermal stress even at temperatures below those required to cause mass bleaching (Bruno et al. 2007). In addition, disease outbreaks have followed bleaching events (Brandt and McManus 2009) and hurricanes (Bruckner and Bruckner 1997; Halley et al. 2001; Miller and Williams 2007; Williams et al. 2008), indicating greater susceptibility to disease when corals are stressed.

Trophic Effects of 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 called a ‘phase shift’ (Hughes 1994). Phase shifts can result when fishing removes species that are particularly important in structuring coral reef ecosystems (Mumby et al. 2007). Effects of fishing can 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. 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 may then collapse into an alternative stable state–a persistent phase shift in which algae replace corals as the dominant reef species (Mumby et al. 2007). Although algae can have negative effects on adult coral colonies (i.e., overgrowth, bleaching from toxic compounds), the ecosystem-level effects of algae are primarily from inhibited coral recruitment. Filamentous algae can prevent the recruitment of coral larvae by creating sediment traps that obstruct access to a hard substrate for attachment. Additionally, macroalgae reduces coral recruitment through occupation of the available space, shading, abrasion, chemical poisoning, and infection with bacterial disease (Rasher et al. 2012; Rasher and Hay 2010; Rasher et al. 2011).

The trophic effects of fishing are likely to interact with many other threats. For example, when carnivorous fishes are overfished, corallivorous fish populations may increase, resulting in greater predation on corals (Burkepile and Hay 2007). Further, some corallivores are vectors of disease and can transmit disease from one coral colony to another as they transit and consume from each coral colony (Aeby and Santavy 2006). Increasing corallivore abundance results in transmittal of disease to higher proportions of the corals within the population.

Sedimentation

Human activities in coastal watersheds introduce sediment into the ocean by a variety of mechanisms; including river discharge, surface run-off, groundwater seeps, and atmospheric deposition. Elevated sediment levels are generated by poor land use practices and coastal and nearshore construction, including dredging. Nearshore sediment levels will also likely increase with sea level rise due to erosion at the shoreline and re-suspension of lagoonal sediments.

The most common direct effect of sedimentation is deposition of sediment on coral surfaces as it settles out from the water column. Corals with certain morphologies (e.g., mounding) can passively reject settling sediments or corals can actively displace sediment by ciliary action or mucous production, both of which require energetic expenditures (Bak and Elgershuizen 1976; Dallmeyer et al. 1982; Lasker 1980; Stafford-Smith 1993; Stafford-Smith and Ormond 1992).

Corals that are unsuccessful in removing sediment will be smothered and die (Golbuu et al. 2003; Riegl and Branch 1995; Rogers 1983). Sediment can also induce sublethal effects, such as reductions in tissue thickness (Flynn et al. 2006) and excess mucus production (Marszalek 1981). In addition, suspended sediment can reduce the amount of light in the water column, making less energy available for coral photosynthesis and growth (Anthony and Hoegh Guldberg 2003; Bak 1978; Rogers 1979). While some corals may be more tolerant of short-term elevated levels of sedimentation, sediment stress and turbidity can induce bleaching (Philipp and Fabricius 2003; Rogers 1979). Finally, sediment impedes fertilization of spawned gametes (Gilmour 2002; Humphrey et al. 2008) and reduces larval settlement, as well as the survival of recruits and juveniles (Birrell et al. 2005; Fabricius et al. 2003).

Sedimentation is also likely to interact with many other threats. For example, when coral communities that are chronically affected by sedimentation experience a warming-induced bleaching event and associated disease outbreaks, the consequences for corals can be much more severe than in communities not affected by sedimentation.

Nutrients

Nutrients (e.g., nitrogen and phosphorous) are added to coral reefs from both point sources (readily identifiable inputs from a single source such as a pipe or drain) and non-point sources (inputs that occur over a wide area and are associated with particular land uses). Anthropogenic sources of nutrients include sewage, agricultural runoff, river and inlet discharges, and groundwater. Development of coastlines and destruction of mangrove forests compound the problem of anthropogenic nutrient runoff, as mangroves are able to filter massive amounts of nutrients and sediment caused by development. Natural processes bring nutrients to coral reefs as well, such as delivery of nutrient-rich deep water by internal waves and upwelling.

Elevated nutrients affect corals through 2 main mechanisms: direct impacts on coral physiology and indirect effects through nutrient-stimulation of other community components (e.g., macroalgae and filter feeders) that compete with corals for space on the reef. Coral reefs are adapted to low nutrient levels, and overabundance of nutrients can cause an imbalance that affects the entire ecosystem. Nutrient-rich water can enhance benthic algae and phytoplankton growth rates in coastal areas, resulting in overgrowth, competition, and algal blooms. Excess nutrient loads affect coral physiology and the balance between corals and their zooxanthellae (Szmant 2002). Increased nutrients can decrease calcification and reduce skeletal density. Either condition results in corals that are more prone to breakage or erosion. Increased levels of nutrients can also compromise coral health (Hodel and Vargas-Angel 2007). Notably, individual species have varying tolerance to increased nutrients.

Nutrients are likely to interact with many other threats. For example, when coral communities that are chronically affected by nutrients experience a warming-induced bleaching event and associated disease outbreaks, the consequences for corals can be much more severe than in communities not affected by nutrients. Additionally, experimental studies on diseased coral species indicate that nutrient augmentation adjacent to active disease lesions substantially increases disease severity (Bruno et al. 2003).

Sea Level Rise

Sea level rise may affect various coral life history events, including larval settlement, polyp development, and juvenile growth. It may also contribute to adult mortality and colony fragmentation, mostly due to increased sedimentation and decreased water quality (reduced light availability) caused by coastal inundation. The best available information suggests that sea level will continue to rise due to thermal expansion and the melting of land and sea ice. Many corals that inhabit the relatively narrow zone near the ocean surface have rapid growth rates when healthy, which allowed them to keep up with sea level rise during the past periods of rapid climate change associated with de-glaciation and warming. Although, depending on the rate and amount of sea level rise, rapid rises can lead to reef drowning. Rapid rises in sea level could affect many coral species by both submerging them below their common depth range and, more likely, by degrading water quality through coastal erosion and potentially severe sedimentation or enlargement of lagoons and shelf areas.

Rising sea level is likely to cause mixed responses in coral species depending on their depth preferences, sedimentation tolerances, and growth rates. Further, the nearshore topography can affect the impact sea level rise has on corals. Reductions in growth rate due to local stressors, bleaching, infectious disease, and ocean acidification may prevent the species from keeping up with sea level rise (e.g., from growing at a rate that will allow them to continue to occupy their preferred depth range despite sea level rise). Additionally, lack of suitable new habitat, limited success in sexual recruitment, coastal runoff, and transition from natural to constructed shorelines will compound some corals' ability to survive rapid sea level rise.

Predation

Predation on some coral genera, including *Acropora*, is a chronic, though occasionally acute, energy drain (Cole et al. 2008; Rotjan and Lewis 2008). Predators of Caribbean corals include snails, polychaete worms, and several species of fishes. The effects of chronic and frequent predation on corals are usually inconsequential but can become significant once the coral population decreases below a threshold. If the living coral cover is substantially reduced by natural or anthropogenic disturbances, the effects of predation become larger even if the rate of predation does not change. The increased focus of predation on the fewer remaining colonies causes the colony to use energy in defense and could result in a reduced rate of healing and/or fecundity or reduced resistance to stressors and/or disease. Additionally, corallivore populations can also increase due to removal of carnivorous predators (i.e., predators of the corallivores) through fishing. Over-predation can lead to significant coral declines when the rate of coral predation is higher than the rate of healing or coral population replenishment.

Predation is likely to interact with other threats. For instance, predation of coral colonies can increase the likelihood of coral disease infection, and likewise diseased colonies may be more likely to be preyed upon. Additionally, nutrient runoff from land stimulates phytoplankton blooms, which provide food for the larvae of invertebrate corallivores and can cause outbreaks of these predators (Birkeland 1982; Fabricius et al. 2010).

Toxins and Contaminants

Toxins and bioactive contaminants may be delivered to coral reefs via either point or non-point sources. The general effects of contaminants on coral communities are reductions in coral growth, coral cover, and coral species richness (Keller et al. 1991; Loya and Rinkevich 1980; Pait et al. 2007), and a shift in community composition to more tolerant species (Rachello-Dolmen and

Cleary 2007). Contaminant effects are species-specific and may have harmful effects in combination that would not be evident under experimental exposure to an individual substance.

Laboratory experiments have shown chemical contaminants are harmful to corals. However, linking coral decline to specific contaminants in the environment can be difficult. Low concentrations (parts per billion) of organic chemical contaminants including hydrocarbons (Negri and Heyward 2000), anti-foulants (Knutson et al. 2012), pesticides (Negri and Heyward 2001), and metals such as copper, zinc, and iron (Bielmyer et al. 2010; Reichelt-Brushett and Harrison 2000; Reichelt-Brushett and Harrison 2005; Vijayavel et al. 2012) can impact physiological function at various life stages. Estrogen compounds at concentrations that occur in urban or sewage-affected coastal waters (i.e., 2 ng L^{-1}) can affect coral growth and fecundity (Tarrant et al. 2004). In laboratory experiments, various compounds found in common sunscreens caused coral bleaching (Danovaro et al. 2008). Both oil and chemical dispersants are toxic to coral larvae (Epstein et al. 2000; Negri and Heyward 2000; Goodbody-Gringley et al., unpublished data; K. Ritchie, Mote Marine Lab, pers. comm. to A. Moulding, NMFS, February 2012). While toxic and biologically active substances impair corals, their effects are largely "silent," causing chronic and often sublethal stress or contributing to mortality of unapparent cause.

Physical Impacts

Coral reefs must endure physical damage from many different sources and threats acting over a range of spatial and temporal scales. Extreme wave events, such as those generated by severe tropical hurricanes, are naturally occurring processes that are typically viewed as acute disturbances. Direct physical effects from vessel groundings, anchor damage, and coastal construction activities, such as dredging, mining, and drilling, are somewhat analogous to storm damage in that they are relatively discrete events, although they generally occur over much smaller spatial scales than do storms. Other human-induced disturbances, such as those caused by tourism and recreational events, fishing gear, and marine debris, can have pervasive, chronic physical consequences. Chronic stresses reduce the ability of corals to recover from acute events (Connell et al. 1997). The relationships between injury interval and time required for reef recovery are the primary factors in evaluating equilibrium of the system (Connell 1978).

Elkhorn and Staghorn Corals

Elkhorn and staghorn corals displayed severe impacts in the 1998 and 2005 bleaching events, and high temperatures and bleaching have been correlated with coral disease. In work on the 2005 Caribbean bleaching event, Muller et al. (2008) found that elkhorn colonies showed higher disease prevalence with high temperature exposure and colonies that had bleached suffered greater levels of disease mortality. The shallow reef habitat in which staghorn corals, and particularly elkhorn corals, grow is especially vulnerable to increasing air and sea temperatures that accompany global climate change.

Laboratory experiments have shown that acidification reduces skeletal deposition and initiation of calcification in newly settled corals (Albright et al. 2008; Cohen et al. 2007; Cohen et al. 2009). In addition, recent laboratory experiments have shown that acidification also substantially impairs fertilization and settlement success in elkhorn coral (Albright et al. 2010). Some CCA species provide chemical cues for settlement and enhanced post-settlement survivorship of *Acropora* larvae (Harrington et al. 2004; Ritson-Williams et al. 2010), suggesting a potential further reduction in recruitment as acidification impacts CCA growth.

White band disease is believed to be the main cause of the initial region-wide decline of elkhorn and staghorn corals (Aronson and Precht 2001), and disease continues to be a major threat to the 2 species. A transmissible disease termed rapid tissue loss affects staghorn coral (Williams and Miller 2005). Additionally, both elkhorn and staghorn corals are affected by ciliates (a group of protozoans characterized by the presence of hair-like organelles [Croquer et al. 2006]). A strain of bacteria present in human sewage and wastewater, *Serratia marcescens*, has been identified as the causal agent of white pox that affects elkhorn coral and indicates a possible human source for this disease (Krediet et al. 2009; Patterson et al. 2002; Sutherland et al. 2010).

Predation is a threat to elkhorn and staghorn corals both through direct removal of tissue and through indirect effects. Known predators include snails (*Coralliophila abbreviata*), fireworms (*Hermodice carunculata*), 2 species of damselfishes (*Stegastes planifrons* and *Microspathodon chrysurus*), and the stoplight parrotfish (*Sparisoma viride*). All of these predators are generalists, feeding on a wide range of coral species, and in some cases algae; however, *C. abbreviata* has been attributed as a driver of mortality and decline in elkhorn coral in the Florida Keys (Williams and Miller 2012). Predation effects are more pronounced in areas where elkhorn and staghorn coral abundance or colony sizes are reduced, and predation pressure remains constant.

Elkhorn and staghorn corals appear to be particularly sensitive to sediment deposition and shading effects from increased sediment. Because they are highly dependent upon sunlight for nourishment (Lewis 1977; Porter 1976), elkhorn and staghorn corals are very susceptible to increases in water turbidity. Both elkhorn and staghorn corals have poor capacity to remove coarser sediments (250-2000 µm) and only slightly more capacity for removing finer sediments (62-250 µm) (Hubbard and Pocock 1972). Water movement (turbulence) and gravity are probably more important in removing sediments from these species than their capabilities of sloughing sediments in still water (Porter 1987). A sedimentation rate of 200 mg cm^{-2} can cause both lethal (Rogers 1983) and sublethal damage resulting in compromised coral health (Hodel and Vargas-Angel 2007) in these species.

Nutrients impact *Acropora* corals both directly and indirectly. Nutrients from land-based sources of pollution can cause habitat loss through the stimulation of growth of algae that can occupy space on the reef (Lapointe et al. 2005). Increased levels of nutrients also reduce growth rates in staghorn corals (Renegar and Riegl 2005) and compromise their health (Hodel and Vargas-Angel 2007).

Acropora corals are sensitive to chemical contaminants. Staghorn coral displayed higher susceptibility to copper toxicity than two other coral species tested; effects included depressed photosynthesis, decreased growth, tissue accumulation, and other physiological changes at exposures as low as 4 µg L^{-1} (Bielmyer et al. 2010). Staghorn coral treated with various compounds found in common sunscreens experienced rapid and complete bleaching, even at extremely low concentrations (Danovaro et al. 2008). The response of staghorn coral exposed to drilling muds produced during offshore oil and gas exploration included reduced calcification and reduced tissue soluble protein levels (Kendall et al. 1983).

The branching morphology of elkhorn and staghorn corals makes them particularly vulnerable to physical damage. Major storm events are a natural threat to elkhorn and staghorn corals that result in local population declines (Rogers et al. 1982; Woodley et al. 1981). There are observations from diverse geographical locations of coral disease outbreaks following hurricane disturbances including Puerto Rico, (Bruckner and Bruckner 1997), Navassa, the Florida Keys, (Miller and Williams 2007; Williams et al. 2008), Bonaire, Curaçao, (*Acropora* Biological Review Team 2005), and Honduras (Halley et al. 2001). Historically, tropical storms likely fostered propagation of elkhorn and staghorn coral thickets through fragmentation, but recent observations from periods of frequent hurricane impacts in the Florida Keys document a lack of successful recruitment of fragments and a severe population decline (Williams et al. 2008). Staghorn and elkhorn corals are less able to successfully reproduce asexually due to high mortality of fragments, and reduced colony density and reef rugosity (Alvarez-Filip et al. 2009) that lessen the likelihood of retaining storm-generated fragments in suitable habitat (Williams et al. 2008). Man-made abrasion and breakage impacts to reefs are chronic and cumulative, and occur on an ongoing basis (e.g., derelict fishing gear, vessel grounding and anchoring, fishing, diver interaction).

4.2.3 Elkhorn and Staghorn Coral Designated Critical Habitat

NMFS designated elkhorn and staghorn coral critical habitat in November 2008 (50 CFR 226). Elkhorn and staghorn corals require hard, consolidated substrate, including attached, dead coral skeleton, for their larvae to settle. Within the geographical area occupied by a listed species, critical habitat consists of specific areas on which those physical or biological features essential to the conservation of the species are found. For elkhorn and staghorn coral, the physical feature of critical habitat essential to the conservation of the species is substrate of suitable quality and availability, in water depths from the mean high water line to 30 m, for support of 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 and turf macroalgae, and sediment cover. A shift in benthic community structure from coral-dominated to algae-dominated that has been documented since the 1980s means that the settlement of larvae or attachment of fragments is often unsuccessful (Hughes and Connell 1999). Sediment accumulation on suitable substrate also impedes sexual and asexual reproductive success by preempting available substrate and smothering coral recruits.

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

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

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

Figure 5**,** below, shows the boundaries of the Florida area of *Acropora* critical habitat. The Florida area contains 3 sub-areas. The shoreward boundary for Florida sub-area A begins at the 6-ft (1.8 m) contour at the south side of Boynton Inlet, Palm Beach County at 26° 32′ 42.5″ N; then runs due east to the point of intersection with the 98-ft (30 m) contour; then follows the 98-ft (30 m) contour to the point of intersection with latitude 25° 45′ 55″ N, Government Cut, Miami-Dade County; then runs due west to the point of intersection with the 6-ft (1.8 m) contour, then follows the 6-ft (1.8 m) contour to the beginning point. The shoreward boundary of Florida sub-area B begins at the MLW line at 25° 45′ 55″ N, Government Cut, Miami-Dade County; then runs due east to the point of intersection with the 98-ft (30 m) contour; then follows the 98-ft (30 m) contour to the point of intersection with longitude 82°W; then runs due north to the point of intersection with the South Atlantic Fishery Management Council (SAFMC) boundary at 24° 31′ 35.75″ N; then follows the SAFMC boundary to a point of intersection with the MLW line at Key West, Monroe County; then follows the MLW line, the SAFMC boundary (see 50 CFR 600.105(c)), and the COLREGS line (see 33 CFR 80.727. 730, 735, and 740) to the beginning point. The seaward boundary of Florida sub-area C (the Dry Tortugas) begins at the northern intersection of the 98-ft (30 m) contour and longitude 82° 45’ W; then follows the 98–ft (30 m) contour west around the Dry Tortugas, to the southern point of intersection with longitude 82° 45’ W; then runs due north to the beginning point.

Critical habitat does not include the following particular areas: (1) all areas subject to the 2008 Naval Air Station Key West Integrated Natural Resources Management Plan, (2) all areas containing existing (already constructed) federally authorized or permitted man-made structures such as aids-to-navigation (ATONs), artificial reefs, boat ramps, docks, pilings, maintained channels, or marinas, (3) all waters identified as existing (already constructed) federally authorized channels, and (4) all waters of the Restricted Anchorage Area as described at 33 CFR 334.580, beginning at a point located at 26° 05′ 30’’ N, 80 03′ 30’’ W; proceed west to 26° 05′ 30″ N, 80° 06′ 30″ W; thence, southerly to 26° 03′ 00″ N, longitude 80° 06′ 42″ W; thence, east to latitude 26° 03′ 00″ N, 80° 05′ 44″ W; thence, south to 26° 01′ 36″ N, 80° 05′ 44″ W; thence, east to 26° 01′ 36″ N, 80° 03′ 30″ W; thence, north to the point of beginning.

The proposed project takes place in sub-area B within the Florida area of critical habitat. The entire Florida area is comprised of 1,329 square miles of designated critical habitat.

Threats

The final critical habitat rule for elkhorn and staghorn coral identifies several sources of threat to the essential feature. Suitable habitat available for larval settlement and recruitment, and asexual fragment reattachment and recruitment of these coral species is particularly susceptible to impacts from human activity because of the shallow water depth range (less than 98 ft [30 m]) in which elkhorn and staghorn corals commonly grow and the essential feature occurs. The proximity of this habitat to coastal areas subjects this feature to impacts from multiple activities, including, but not limited to dredging and disposal activities, stormwater runoff, coastal and maritime construction, land development, wastewater and sewage outflow discharges, point and non-point source pollutant discharges, fishing, placement of large vessel anchorages, and installation of submerged pipelines or cables. The impacts from these activities, combined with those from natural factors (e.g., major storm events), significantly affect the quality and quantity of available substrate for these threatened species to successfully sexually and asexually reproduce.

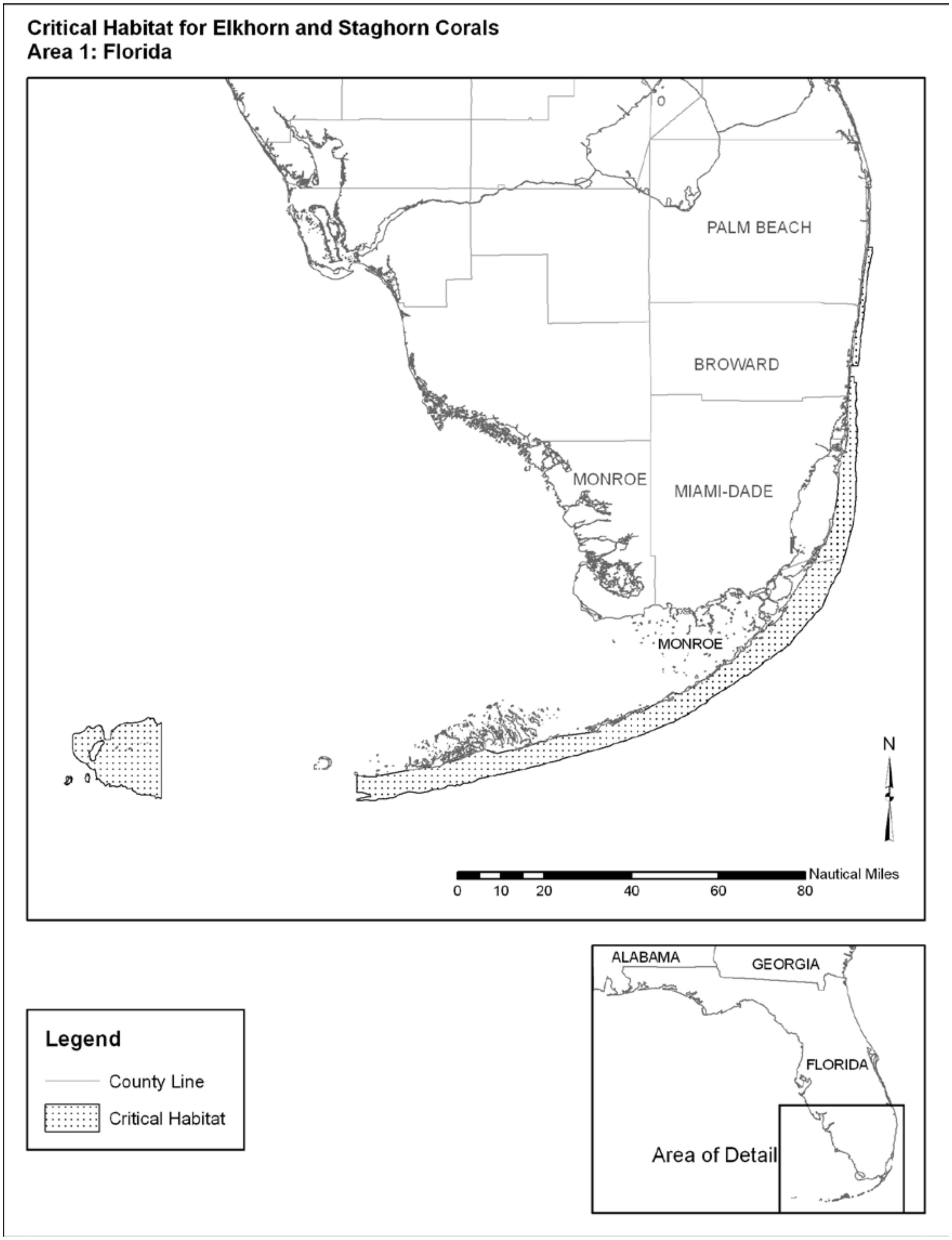

Figure 5. Florida unit designated critical habitat for *Acropora cervicornis* and *Acropora palmata* (50 CFR Parts 223 and 226 Endangered and Threatened Species; Critical Habitat for Threatened Elkhorn and Staghorn Corals; Final Rule)

5 Environmental Baseline

This section is a description of the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat (including designated critical habitat), and ecosystem, within the action area.[6] 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 the 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 action 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.

5.1 Sea Turtles

5.1.1 Status of Sea Turtles within the Action Area

Green sea turtles occur in the action area and may be adversely affected by the project. The action area includes nesting beach and important foraging habitat (e.g., nearshore hard bottom), but does not include any known breeding habitat. Sea turtles found in the immediate project area may travel widely throughout the Atlantic, Gulf of Mexico, and Caribbean Sea, and individuals found in the action area can potentially be affected by activities anywhere within this wide range. These impacts outside of the action area are discussed and incorporated as part of the overall status of the species as detailed in Section 3 above. Sea turtles that occur in the action area are highly migratory, as are all sea turtles species worldwide. For the species that are globally listed, the status of these species in the Atlantic (see Section 4) most accurately reflects the species' status within the action area. In Section 4, we presented available information on sea turtle population abundance and trends by species.

5.1.2 Factors Affecting Sea Turtles in the Action Area

NMFS has completed a number of Section 7 consultations to address the effects of federally-permitted fisheries and other federal actions on threatened and endangered sea turtle species, and when appropriate, has authorized the incidental taking of these species. Each of those

[6] 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).

consultations sought to minimize the adverse impacts of the action on sea turtles. NMFS has undertaken conservation actions under the ESA to address sea turtle takes in the fishing and shipping industries and other activities such as USACE dredging operations. The summary below of federal actions and the effects these actions have had or are having on sea turtles 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 Vessel Activity and Operations
Potential sources of adverse effects from federal vessel operations in the action area include operations of the USN and USCG. NMFS has conducted formal consultations with the USCG and the USN on their vessel operations. Through the Section 7 process, where applicable, NMFS has and will continue to establish conservation measures for all these agency vessel operations to avoid or minimize adverse effects to listed species. Refer to the biological opinions for the USCG (NMFS 1995) and the USN (NMFS 1996, 1997a) for details on the scope of vessel operations for these agencies and conservation measures being implemented as standard operating procedures.

Dredging
The construction and maintenance of federal navigation channels and excavation of sediment from sand mining sites ("borrow areas") conducted by the USACE has been identified as a source of sea turtle mortality. Hopper dredges in the dredging mode are capable of moving relatively quickly, compared to sea turtle swimming speeds and can thus overtake, entrain, and kill sea turtles as the suction draghead of the advancing dredge overtakes the resting or swimming turtle. Entrained sea turtles rarely survive. NMFS completed a regional biological opinion on the impacts of USACE's South Atlantic coast hopper-dredging operations in 1997 for dredging in the USACE's South Atlantic Division (NMFS 1997b). The regional biological opinion on South Atlantic hopper dredging (SARBO) of navigational channels and borrow areas determined that hopper dredging would not adversely affect leatherback sea turtles in the South Atlantic Division (i.e., coastal states of North Carolina through Key West, Florida). The opinion did determine hopper dredging in the South Atlantic Division would adversely affect 4 sea turtle species (i.e., green, hawksbill, Kemp's ridley, and loggerheads) but would not jeopardize their continued existence. An ITS for those species was issued. Reinitiation of consultation on the SARBO has been triggered for a number of reasons, including listing of new species and designation of critical habitat that may be affected by these dredging activities.

ESA Permits
Sea turtles are the focus of research activities authorized by Section 10 permits under the ESA. Regulations developed under the ESA allow for the issuance of permits allowing take of certain ESA-listed species for the purposes of scientific research under Section 10(a)(1)(a) of the ESA. Authorized activities range from photographing, weighing, and tagging sea turtles incidentally taken in fisheries, to blood sampling, tissue sampling (biopsy), and performing laparoscopy on intentionally captured sea turtles. The number of authorized takes varies widely depending on the research and species involved, but may involve the taking of hundreds of sea turtles annually. Most takes authorized under these permits are expected to be (and are) nonlethal, although lethal takes are sometimes authorized. Before any research permit is issued, the proposal must be reviewed under the permit regulations. In addition, since issuance of the permit is a federal activity, issuance of the permit by NMFS must also be reviewed for compliance with Section

7(a)(2) of the ESA to ensure that issuance of the permit does not result in jeopardy to the species or adverse modification of its critical habitat.

Federally-Managed Fisheries
Threatened and endangered sea turtles are adversely affected by fishing gears used throughout the continental shelf of the action area. Hook-and-line gear, trawl, and pot fisheries have all been documented as interacting with sea turtles.

For all fisheries for which there is a Fishery Management Plan (FMP) or for which any federal action is taken to manage that fishery, impacts have been evaluated under Section 7.

Finfish Fisheries
Adverse effects on threatened and endangered species from several types of fishing gear occur in the action area of the proposed action. Efforts to reduce the adverse effects of commercial fisheries are addressed through the ESA Section 7 process. Trawl, hook-and-line, gillnet, and cast net gear fisheries have all been documented as interacting with sea turtles. Several formal consultations have been conducted on the following fisheries that NMFS has determined are likely to adversely affect threatened and endangered species (including sea turtles): the South Atlantic and Gulf of Mexico coastal migratory pelagic fishery, and the Atlantic Highly Migratory Species shark fishery. An Incidental Take Statement (ITS) has been issued for interactions with sea turtles in each of these fisheries.

NMFS completed a Section 7 consultation on the continued authorization of the coastal migratory pelagic fishery in the South Atlantic (NMFS 2007c) where hook-and-line, gillnet, and cast net gears are used. The recreational sector uses hook-and- line gear. The hook-and-line effort is primarily trolling. The biological opinion concluded that green, hawksbill, Kemp's ridley, leatherback, and loggerhead sea turtles may be adversely affected by operation of the fishery.

In 2012, NMFS issued a biological opinion on the continued authorization of Highly Migratory Species Atlantic shark fisheries (NMFS 2012). This commercial fishery uses bottom longline and gillnet gear. The recreational sector of the fishery uses only hook-and-line gear. To protect declining shark stocks, the proposed action seeks to greatly reduce the fishing effort in the commercial component of the fishery. These reductions are likely to greatly reduce the interactions between the commercial component of the fishery and sea turtles. The biological opinion concluded that green, hawksbill, Kemp's ridley, leatherback, and loggerhead sea turtles may be adversely affected by operation of the fishery but that the proposed action was not expected to jeopardize the continued existence of any of these species.

Southeastern Shrimp Trawl Fisheries
Southeast U.S. shrimp fisheries target primarily brown, white, and pink shrimp in inland waters and estuaries through the state-regulated territorial seas and in federal waters of the EEZ. As sea turtles rest, forage, or swim on or near the bottom, they are captured by shrimp trawls pulled along the bottom. In 1990, the National Research Council (NRC) concluded that the Southeast shrimp trawl fisheries affected more sea turtles than all other activities combined and was the most significant anthropogenic source of sea turtle mortality in the U.S. waters, in part due to the high reproductive value of turtles taken in this fishery (NRC 1990).

On May 9, 2012, NMFS completed a Biological Opinion that analyzed the continued implementation of the sea turtle conservation regulations and the continued authorization of the Southeast U.S. shrimp fisheries in federal waters under the Magnuson-Stevens Act (NMFS 2012). The Opinion also considered a proposed amendment to the sea turtle conservation regulations that would withdraw the alternative tow time restriction at 50 CFR 223.206(d)(2)(ii)(A)(*3*) for skimmer trawls, pusher-head trawls, and wing nets (butterfly trawls) and instead require all of these vessels to use TEDs. The Opinion concluded that the proposed action would not jeopardize the continued existence of any sea turtle species. An ITS was provided that used trawl effort and capture rates as proxies for sea turtle take levels. The Biological Opinion requires NMFS to minimize the impacts of incidental takes through monitoring of shrimp effort and regulatory compliance levels, conducting TED training and outreach, and continuing to research the effects of shrimp trawling on listed species. Subsequent to the completion of this opinion, NMFS withdrew the proposed amendment to require TEDs in skimmer trawls, pusher-head trawls, and wing nets. Consequently, NMFS reinitiated consultation on November 26, 2012. Consultation was completed in April 2014 and determined the continued implementation of the sea turtle conservation regulations and the continued authorization of the Southeast U.S. shrimp fisheries in federal waters under the MSFCMA was not likely jeopardize the continued existence of any sea turtle species. The ITS maintained the use of anticipated trawl effort and fleet TED compliance as surrogates for numerical sea turtle takes. .

Beach Nourishment
The USACE issues Clean Water Act permits for disposal of material in navigable waters of the United States, including beach nourishment. The activity of beach nourishment, especially when impacts include the loss of nearshore hard bottom habitat along the east coast of Florida, has been documented to result in injury and death of juvenile green sea turtles. Juvenile green turtles are known to utilize these high-energy, dynamic habitats for foraging and as refuge, and show a preference for this habitat even when abundant deeper-water sites are available. The loss of such limited habitat, especially when considering the cumulative loss as a result of beach nourishment activities occurring along the entire range of the habitat and continually over time, is expected to result in loss of foraging opportunities and protective refuge. The stresses are also expected to contribute to mortality of individuals already in poor condition as a result of disease or other factors (NMFS 2008a). Beach nourishment permitted by the USACE also often involves use of a hopper dredge to collect nourishment material, thus posing another route of adverse effects to sea turtles.

State or Private Actions
Maritime Industry
Private and commercial vessels, including fishing vessels, operating in the action area of this consultation also have the potential to interact with ESA-listed species. The effects of fishing vessels, recreational vessels, or other types of commercial vessels on listed species may involve disturbance or injury/mortality due to collisions or entanglement in anchor lines. Commercial traffic and recreational pursuits can also adversely affect sea turtles through propeller and boat strikes. The Sea Turtle Stranding and Salvage Network (STSSN) includes many records of vessel interaction (propeller injury) with sea turtles where there are high levels of vessel traffic. The extent of the problem is difficult to assess because of not knowing whether the majority of sea turtles are struck pre- or post-mortem. It is important to note that minor vessel collisions may not kill an animal directly, but may weaken or otherwise affect it so it is more likely to become

vulnerable to effects such as entanglements. NMFS and the USCG have completed several formal consultations on individual marine events that may affect sea turtles.

Coastal Development
Beachfront development, lighting, and beach erosion control all are ongoing activities along the Florida coastline. These activities potentially reduce or degrade sea turtle nesting habitats or interfere with hatchling movement to sea. Nocturnal human activities along nesting beaches may also discourage sea turtles from nesting sites. The extent to which these activities reduce sea turtle nesting and hatchling production is unknown. However, more and more coastal counties are adopting stringent protective measures to protect hatchling sea turtles from the disorienting effects of beach lighting.

State Fisheries
Commercial state fisheries are located in the nearshore habitat areas that comprise the action area. Recreational fishing from private vessels also occurs in the area. Observations of state recreational fisheries have shown that loggerhead sea turtles are known to bite baited hooks and frequently ingest the hooks. Hooked turtles have been reported by the public fishing from boats, piers, and beach, banks, and jetties and from commercial anglers fishing for reef fish and for sharks with both single rigs and bottom longlines (NMFS 2001). Additionally, lost fishing gear such as line cut after snagging on rocks, or discarded hooks and line, can also pose an entanglement threat to sea turtles in the area. A detailed summary of the known impacts of hook-and-line incidental captures to loggerhead sea turtles can be found in the TEWG reports (1998; 2000).

In August of 2007, NMFS issued a regulation (72 FR 43176, August 3, 2007) to require any fishing vessels subject to the jurisdiction of the United States to take observers upon NMFS's request. The purpose of this measure is to learn more about sea turtle interactions with fishing operations, to evaluate existing measures to reduce sea turtle takes, and to determine whether additional measures to address prohibited sea turtle takes may be necessary.

Other Potential Sources of Impacts in the Environmental Baseline

Marine Debris and Acoustic Impacts
A number of activities that may affect listed species in the action area of this consultation include anthropogenic marine debris and acoustic impacts. The impacts from these activities are difficult to measure. Where possible, conservation actions are being implemented to monitor or study impacts from these sources.

Marine Pollution and Environmental Contamination
Sources of pollutants along the coastal areas include atmospheric loading of pollutants such as polychlorinated biphenyls (PCBs), stormwater runoff from coastal towns and cities into rivers and canals emptying into bays and the ocean, and groundwater and other discharges (Carpenter et al. 1986). Nutrient loading from land-based sources such as coastal community discharges is known to stimulate plankton blooms in closed or semi-closed estuarine systems (Bowen and Valiela, 2001; Rabalais 2002, Rabalais et al 2002). The effects on larger embayments are unknown. Although pathological effects of oil spills have been documented in laboratory studies of marine mammals and sea turtles (Vargo et al. 1986), the impacts of many other anthropogenic toxins have not been investigated.

Coastal runoff, marina and dock construction, dredging, aquaculture, oil and gas exploration and extraction, increased under water noise and boat traffic can degrade marine habitats used by sea turtles (Colburn et al. 1996). The development of marinas and docks in inshore waters can negatively impact nearshore habitats. An increase in the number of docks built increases boat and vessel traffic. Fueling facilities at marinas can sometimes discharge oil, gas, and sewage into sensitive estuarine and coastal habitats. Although these contaminant concentrations do not likely affect the more pelagic waters, the species of turtles analyzed in this biological opinion travel between near shore and offshore habitats and may be exposed to and accumulate these contaminants during their life cycles.

There are studies on organic contaminants and trace metal accumulation in green and leatherback sea turtles (Aguirre et al. 1994; Caurant et al. 1999; Corsolini et al. 2000). Mckenzie et al. (1999) measured concentrations of chlorobiphenyls and organochlorine pesticides in sea turtle tissues collected from the Mediterranean (Cyprus, Greece) and European Atlantic waters (Scotland) between 1994 and 1996. Omnivorous loggerhead turtles had the highest organochlorine contaminant concentrations in all the tissues sampled, including those from green and leatherback turtles (Storelli et al. 2008). Dietary preferences were likely the main differentiating factor among species. Decreasing lipid contaminant burdens with turtle size were observed in green turtles, most likely attributable to a change in diet with age. Sakai et al. (1995) found the presence of metal residues occurring in loggerhead turtle organs and eggs. Storelli et al. (1998) analyzed tissues from twelve loggerhead sea turtles stranded along the Adriatic Sea (Italy) and found that characteristically, mercury accumulates in sea turtle livers while cadmium accumulates in their kidneys, as has been reported for other marine organisms like dolphins, seals and porpoises (Law et al. 1991).

Conservation and Recovery Actions Benefiting Sea Turtles

NMFS has implemented a series of regulations aimed at reducing potential for incidental mortality of sea turtles from commercial fisheries in the action area. These include sea turtle release gear requirements for Atlantic HMS and Gulf of Mexico reef fish fisheries, and TED requirements for the southeastern shrimp fisheries. These regulations have relieved some of the pressure on sea turtle populations.

Under Section 6 of the ESA, NMFS may enter into cooperative research and conservation agreements with states to assist in recovery actions of listed species. NMFS has agreements with the state of Florida. Prior to issuance of these agreements, the proposal must be reviewed for compliance with Section 7 of the ESA.

Other Actions

A 5-year status review has recently been completed for green sea turtles. The review was conducted to comply with the ESA mandate for periodic evaluation of listed species to ensure that their threatened or endangered listing status remains accurate. The review determined that no delisting or reclassification of a species status (i.e., threatened or endangered) was warranted at the time. However, further review of species data for the green sea turtles was recommended, to evaluate whether DPSs should be established for this species (NMFS and USFWS 2007).

Summary and Synthesis of Environmental Baseline for Sea Turtles

In summary, several factors adversely affect sea turtles in the action area. These factors are ongoing and are expected to occur contemporaneously with the proposed action. Fisheries in the action area likely had the greatest adverse impacts on sea turtles in the mid- to late 1980s, when effort in most fisheries was near or at peak levels. With the decline of the health of managed species, effort since that time has generally been declining. Over the past 5 years, the impacts associated with fisheries have also been reduced through the Section 7 consultation process and regulations implementing effective bycatch reduction strategies. However, interactions with commercial and recreational fishing gear are still ongoing and are expected to occur contemporaneously with the proposed action. Other environmental impacts including effects of vessel operations, additional military activities, dredging, oil and gas exploration, permits allowing take under the ESA, private vessel traffic, and marine pollution have also had and continue to have adverse effects on sea turtles in the action area in the past.

5.2 Corals

5.2.1 Status of Listed Corals within the Action Area

In Section 4.2.2, we described the range-wide status of listed corals. Within the Broward County, staghorn coral occurs in some of the largest densities within the United States. Recent surveys conducted by the National Coral Reef Institute have identified 35 dense patches of staghorn coral between Hollywood and Fort Lauderdale. Seven patches are near previously known existing locations and 28 are near newly identified areas. Initial approximations of areal coverage suggest the sites totaled over 110,000 m^2 of previously unknown dense patches of staghorn coral. These new discoveries have the potential of more than tripling the area of previously documented staghorn coral (B. Walker, National Coral Reef Institute, pers. comm. to J. Karazsia, NMFS, October 21, 2013).

According to the environmental assessment and resource surveys conducted by Nova Southeastern University scientists, elkhorn and staghorn coral are present nearby the action area.

5.2.2 Factors Affecting Listed 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 and proposed 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). NMFS has completed a number of Section 7 consultations to address the effects of federal actions on staghorn corals, and when appropriate, has authorized the incidental taking of this species. Each of those consultations sought to minimize the adverse impacts of the action on staghorn coral. 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 *A. cervicornis*. The opinion concluded trap gear used in the fishery may adversely affect *A. cervicornis* 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.

- **EPA and 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 corals (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 *Acropora* via fragmentation/breakage or abrasion. The activities may also affect listed 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 RBO is currently undergoing a reinitiation of consultation due to the listing of *A. cervicornis* and *A. palmata*, among other things.

- **EPA-regulated discharge of pollutants, such as oil, toxic chemicals, radioactivity, carcinogens, mutagens, teratogens, or organic nutrient-laden water, including sewage water, into the waters of the United States.** Elevated discharge levels 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 corals. NMFS is engaged in consultation with the EPA regarding their approval of the state's standards.

- **Coral Nurseries.** NMFS has issued 3 separate biological opinions for the establishment of staghorn coral nurseries and restoration projects within Broward County (one to Biscayne National Park, one to NMFS Habitat Conservation/Restoration Center, and one to The Nature Conservancy). The activities include collecting coral fragments and growing them within nurseries and then outplanting them onto the natural reefs. In all cases NMFS has determined that the nursery and restoration activities would not jeopardize the continued existence of staghorn corals.

Other Non-Federal Actions Affecting Listed Corals.
Poor boating and anchoring practices, as well as poor diving and snorkeling techniques cause abrasion and breakage of *Acropora cervicornis* and *Acropora palmata*. 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 *Acropora cervicornis* populations and continue to cause mortality.

Hurricanes and large coastal storms could also significantly harm *Acropora cervicornis* and *Acropora palmata*. Due to their branching morphology, they are 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

Research, restoration, and education and outreach activities, as part of the NMFS's ESA program, as well as through NOAA's Coral Reef Conservation Program (CRCP), are ongoing through the Southeast Region. NOAA's Restoration Center and state and territorial partners conduct grounding response and restoration activities throughout the U.S. jurisdictions. The summaries below discuss these measures in more detail.

Regulations Reducing Threats to Listed Corals

Numerous management mechanisms exist to protect corals or coral reefs in general. Prior to the ESA listing of elkhorn and staghorn corals, federal regulatory mechanisms and conservation initiatives most beneficial to branching corals have focused on addressing physical impacts, including damage from fishing gear, anchoring, and vessel groundings. NMFS has implemented a Section 4(d) rule to establish "take" prohibitions for listed corals. Such regulations are determined to be necessary and advisable to provide for the conservation of threatened species, and may prohibit many actions automatically prohibited for endangered species, including but not limited to: importing or exporting species from or into the United States; taking of species from U.S. waters, its territorial sea, or the high seas; or possessing or selling species. On October 29, 2008, NMFS published a final Section 4(d) rule extending all the Section 9 take prohibitions to listed elkhorn and staghorn corals. These prohibitions include the import, export, or take of elkhorn or staghorn corals for any purpose, including commercial activities. The 4(d) rule for listed *Acropora* has exceptions for some activities, including scientific research and species enhancement, and restoration carried out by authorized personnel.

In addition, the Coral Reef Conservation Act and the two Magnuson-Stevens Act Coral and Reef Fish Fishery Management Plans (Caribbean) 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.

The State of Florida regulates activities that involve and occur in coral reefs in Florida. Statutes and rules protect all corals from collection, commercial exploitation, and injury/destruction on the sea floor (FS 253.001, 253.04, Chapter 68B-42.008 and 68B-42.009), except as authorized by a Special Activity License for the purposed of research. Additionally, Florida has a comprehensive state regulatory program that regulates most land, including upland, wetland, and surface water alterations throughout the state.

Other Listed Coral Conservation Efforts: Recovery Planning and Implementation

A draft recovery plan for elkhorn and staghorn corals is required by a settlement agreement to be published no later than September 7, 2014. The recovery team is comprised of fishers, scientists, managers, and agency personnel from Florida, Puerto Rico, and U.S.V.I., and federal representatives. Similar plans will be identified for proposed coral species should the listings become finalized.

Even in the absence of a recovery plan, NMFS and its partners have implemented numerous recovery actions since the time of listing, consistent with NMFS's Recovery Outline for elkhorn and staghorn corals. Generally, these activities fall into the following categories:

- Monitoring and mapping
- Life history, disease, and threat impact research
- In-situ and ex-situ propagation and outplanting
- Reduction of and restoration of impacts from physical disturbances
- Reduction of impacts from land-based sources of pollution
- Outreach and education

Summary and Synthesis of Environmental Baseline for Listed Corals

In summary, several factors are presently adversely affecting listed corals within the action area. These factors are ongoing and are expected to occur contemporaneously with the proposed action:

- Disease outbreaks
- Temperature-induced bleaching events
- Ocean acidification
- Major storm events
- Upland and coastal activities that will continue to degrade water quality and decrease water clarity necessary for coral growth
- Dredge-and-fill activities
- Interaction with fishing gear and adverse effects of fishing
- Vessel traffic that will continue to result in abrasion and breakage due to accidental groundings and poor anchoring techniques
- Poor diving and snorkeling techniques that will continue to abrade and break corals

These activities are expected to combine to adversely affect the recovery of elkhorn and staghorn corals throughout their ranges, and in the action area.

5.3 Status of Elkhorn and Staghorn Coral Designated Critical Habitat within the Action Area

In Section 4.2.6, we described the range-wide status of designated *Acropora* critical habitat. In summary, the Florida area of *Acropora* spp. critical habitat comprises approximately 1,329 square miles (3,442 km^2) of marine habitat offshore of Palm Beach, Broward, Miami-Dade, and Monroe Counties, Florida, and encompasses the entire Florida Reef Tract beginning east of Palm Beach County and extending south along the Florida Keys. Within the action area, there are approximately 7 km^2 of designated critical habitat.

Factors Affecting Critical Habitat within the Action Area

Localized adverse effects to designated critical habitat in the action area are likely from many of the same stressors affecting the critical habitat throughout their range, namely activities that may increase turf or macroalgal cover (i.e., releases of nutrients or reduction in herbivory) or increase sediment cover.

Federal Actions

Numerous activities funded, authorized, or carried out by federal agencies have been identified as threats and may affect elkhorn and staghorn corals' critical habitat in the action area. To date, however, few consultations on activities affecting critical habitat within the action area have been completed.

- **USACE-permitted dredge-and-fill activities.** The activities may impact critical habitat by physically altering or removing benthic habitat suitable for colonization. Dredge-and-fill activities may also cause increases in sedimentation that may cause loss of substrate for fragment reattachment or larval settlement. The 1997 RBO on navigation channel maintenance using hopper dredges is currently undergoing a reinitiation of consultation, to address the impacts of these activities on coral critical habitat among other things, and will evaluate the effects of certain dredge-and-fill activities that occur within the action area. In the past century, 3 major ports have been constructed in southeast Florida. A total of approximately 772 acres of coral reef habitat have been impacted via direct removal and burial (Walker et al. 2012). Several beach renourishment projects have been completed in Broward County. In 2006, Segment III renourishment project resulted in over 36 acres of nearshore reef impacts via sediment burial (Prekel et al. 2008).

- **EPA-regulated discharge of pollutants, such as oil, toxic chemicals, radioactivity, carcinogens, mutagens, teratogens, or organic nutrient-laden water, including sewage water, into the waters of the United States.** Elevated nutrients can lead to increased algal growth. 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 corals. NMFS is engaged in consultation with the EPA regarding their approval of the state's standards.

Other Non-Federal Actions Affecting Elkhorn and Staghorn Critical Habitat.
The State of Florida regulates activities that involve and occur in coral reefs in Florida. Statutes and rules protect all corals from collection, commercial exploitation, and injury/destruction on the seafloor (FS 253.001, 253.04, Chapter 68B-42.008 and 68B-42.009), except as authorized by a Special Activity License for the purposed of research. Therefore, the State regulates alterations to the reef. Additionally, Florida has a comprehensive state regulatory program that regulates most land, including upland, wetland, and surface water alterations throughout the state, resulting in regulation of land-based sources of nutrients or sediment that may adversely affect *Acropora* critical habitat.

Vessel groundings and anchor damage from commercial and recreational vessels within southeast Florida have historically resulted in severe negative impacts to the Florida Reef Tract. According to Sansgaard (2013) the Florida Department of Environmental Protection's (FDEP) Coral Reef Conservation Program (CRCP) has responded to, and managed, 124 of incidents related to vessel groundings and anchor damage. Typically only large vessel groundings alter the substrate to render it unconsolidated. However, several of the documented events have been large vessels. For example, in 2006, the M/V Clipper Lasco (a 645-ft cargo ship) grounded offshore of Fort Lauderdale resulting in over 6,000 square feet (ft^2) of reef impacted. However, due to the large number of vessel groundings in the area, the U.S. Coast Guard relocated the anchorage and no large vessel groundings have occurred since 2009.

Conservation and Recovery Actions Benefiting Coral Critical Habitat in the Action Area
The NOAA 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, thus indirectly benefiting *Acropora* designated critical habitat. The Coral Reef Conservation Act and the two 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.

5.4 Summary and Synthesis of Environmental Baseline

In summary, several factors are presently adversely affecting green sea turtles, listed corals, and designated critical habitat for elkhorn and staghorn corals in the action area. These factors are ongoing and are expected to occur contemporaneously with the proposed action:

- Interaction with commercial and recreational fishing gear
- Dredge-and-fill activities, including channel dredging and beach re-nourishment/restoration activities
- Runoff containing toxins and pollutants from land-based sources
- Disease outbreaks
- Major storm events
- Upland and coastal activities will continue to degrade water quality and decrease water clarity necessary for coral growth
- Poor vessel anchoring techniques as well as poor diving and snorkeling techniques will continue to abrade and break corals

These activities are expected to combine to adversely affect the recovery of green sea turtles, listed corals throughout their ranges, and in the action area.

6 Effects of the Action

As described below, NMFS believes that the proposed action may adversely affect green sea turtles, elkhorn and staghorn coral under the ESA, and designated critical habitat for elkhorn and staghorn coral. 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 any of these species or likely to cause destruction or adverse modification to critical habitat.

6.1 Effects of the Action on Sea Turtles

In Section 3, we determined listed species of sea turtles likely to be adversely affected via any or all portions of the proposed action are limited to green sea turtles. Potential routes of adverse effects of the proposed action on green sea turtles are limited to habitat loss.

Sand mined from upland sources will be placed onto the beach and into the nearshore waters adjacent to Pompano Beach and Lauderdale By The Sea. NMFS believes this activity is likely to adversely affect green sea turtles due to loss (by sand deposition on top) of nearshore hard ground that is functioning as foraging habitat for green sea turtles. Loss of foraging habitat is potentially an adverse effect by affecting a sea turtle's fitness and growth.

It is difficult to estimate the number of sea turtles that may be affected by the proposed action, as that would require estimates of juvenile sea turtle abundance in the action area and knowledge of their use of the area. Studies on the use of nearshore hard bottom habitat by juvenile green sea turtles have been undertaken at various locations along the east coast of Florida, but data on green turtle abundance and trends is limited. Research in nearby Indian River County resulted in a total of 195 juvenile greens (190 individuals plus 5 recaptures) being sampled from 1989-1995 by nets, with an overall mean catch per unit effort (CPUE) of 6.28 greens/km-hour soak time of the tangle net. The research does not estimate the number of turtles that utilize a given area of habitat. Results from the study showed that turtle CPUE fluctuated greatly over time (both year and season) and the authors could not conclude whether that variability was a result of seasonal fluctuations in abundance and density, or changes in water and weather conditions impacting catchability (Ehrhart et al. 1996).

Makowski et al. (2006) studied the habitat use and home range movements of juvenile green sea turtles along a shallow, worm-rock reef tract in Palm Beach, Florida. They found that when sufficient resources are available, individuals may develop affinities to specific areas for activities, such as foraging and/or resting. The results of this study suggest that juvenile green turtles occupy stable home ranges along the nearshore worm-rock reefs of southeast Florida during summer and fall. In addition to foraging efficiency, knowledge of their physical environment may provide turtles a greater familiarity with escape routes, hiding places, and shelter from environmental extremes (Bailey 1984; Alcock 2001). Such habitat affinity among juvenile green turtles has been demonstrated at other foraging areas (e.g., Brill et al. 1995; Renaud et al. 1995; Seminoff et al. 2002). Renaud et al. (1995) recorded some of the smallest daily movements for juvenile green turtles at a jettied pass in Texas. Their study incorporated extremely narrow jetty channels, where marine algae were the most readily available food source. In contrast, Seminoff et al. (2002) reported home ranges of 12 green turtles in Bahia de los Angeles, Gulf of California, Mexico, of 5.84 to 39.08 square kilometers. As the largest green turtle home ranges reported to date, Seminoff et al. (2002) suggested these home ranges resulted from the substantial distance between macroalgae food sources and benthic shelter sites within the 60-km² Bahía de los Angeles. Based on these and other studies of green turtle home range areas, Makowski et al. (2006) suggest that differences among green turtle home range size in relation to the varying physical structure of each foraging site supplies further evidence that both home range size and shape, and thus the behavior of the turtles, are determined by the distribution of resources in a specific area.

While the Makowski et al. (2006) study provided home range area estimates for the 6 turtles that were tracked in Palm Beach, we were not able to use this study to estimate population density for 2 reasons: (1) the small sample size (n = 6), and (2) the study identifies considerable overlap in core areas with neighboring turtles, suggesting that the turtles in the study were using common foraging areas.

The nearshore hard bottom and reef habitats in Broward County serve as developmental foraging and resting habitat for juvenile green turtles. Wershoven and Wershoven (1992) completed a 5-year study (1986-1991) on juvenile green turtles in their nearshore habitat of Broward County. They conducted SCUBA dives on a year-round basis. In Broward County, the offshore area consists of 3 main reef tracts that run parallel to the shore (the inner, middle, and outer reef). The nearshore reef extends from 75 to 375 meters offshore, and is 4 to 7 meters in depth. Reefs are colonized by soft and hard corals, with algae proliferating on the limestone (Wershoven and

Wershoven 1992). Wershoven and Wershoven conducted their study on the nearshore first reef tract, where juvenile green turtles are most frequently sighted. They surveyed a 20-meter by 1600-meter (32,000-square-meter [m^2]) area on the first reef tract using SCUBA. Dives were conducted during the day and night. The turtles in the study were captured and brought to the surface where they were examined, measured, and released. The turtles were also tagged prior to release. Recaptured turtles whose tags were over 3 years old were given additional tags. During the 5-year study period (1986-1991), 134 juvenile green turtles were captured; 37 of the juvenile green turtles were re-encountered; 97 of the juvenile green turtles were captured only once. Turtles were captured during all months, with April, May, June, and August being the most productive while September and December were the least productive months (Wershoven and Wershoven 1992).

The results of the Wershoven and Wershoven (1992) study indicate that nearshore reef habitats likely support some juvenile green sea turtles with strong site affinity or residency (the re-encounters), and other juvenile green sea turtles that use the habitat with less regularity or affinity. Because 37 turtles were re-encountered, it is reasonable to believe that these 37 individuals were residents of the area. The other 97 turtles captured were likely utilizing the area for foraging and resting during some part of the year, but it is possible that they did not have a strong affinity to the habitat since they were not recaptured.

Both types of juvenile green turtles (i.e., strong site affinity vs. less affinity) currently using the 4.9 acres of reef habitat that will be lost as a result of the proposed project will be affected by the loss of foraging and resting/refuge habitat. The loss of foraging and resting areas could lead to a decrease in health due to malnourishment and an increase in stress due to disorientation and a greater exposure to predators. These effects may lead to short-term disorientation and decreased health and long-term displacement to other nearshore foraging and resting areas outside of the action area. Causing a decrease in a turtle's health can lead to injury or death. These individuals may be more susceptible to predation (compared to juvenile green turtles that have adequate foraging and resting/refuge habitat) while they are searching for alternate foraging and resting/refuge habitat. We believe the effects of having to locate habitat on turtles that do not have a particular affinity to the study area will be much less significant than the effect on turtles with home ranges or strong affinity to the project site, as those without the strong affinity are more likely transient or otherwise have not already established a dependence on the project site. (This has the potential to become a greater issue if cumulative losses of hard bottom along the entire range of the habitat result in significant habitat decreases.) In contrast, we believe that some or all juvenile green sea turtles with strong affinity or residency in a particular reef habitat may be adversely affected by loss of that habitat.

In order to determine the number of turtles that may be injured or killed due to habitat loss from sand placement in nearshore waters, we will use the numbers from Wershoven and Wershoven (1992) as a proxy to determine the number of resident juvenile green turtles that will be affected by the proposed action as this is the best scientific information we have on juvenile green turtle densities on nearshore hard bottoms. If we convert the size of their study area (32,000 m^2) to acres, then the study area encompassed 7.9 acres. If we assume that recapture indicates strong site affinity or residency, then 37 juvenile green turtles that were recaptured were resident in approximately 7.9 acres of nearshore habitat. If we divide 37 individuals by 7.9 acres, this equals 5 resident juvenile green sea turtles per acre of this habitat type (actual total is 4.68 turtles rounded up to 5 turtles).

According to the environmental assessment provided by the USACE (Final Environmental Assessment dated July 2013), the proposed action would impact a maximum of approximately 4.9 acres of nearshore hard bottom habitat. If we assume the permanent loss of 4.9 acres of nearshore hard bottom, then the proposed project would displace approximately 25 juvenile green turtles (i.e., 5 turtles per acre multiplied by 4.9 acres = 24.15 turtles). Given that studies of juvenile green turtles have shown that dynamic, nearshore hard bottom habitat is a highly preferred habitat for foraging and resting/refuge, even when substantial areas of reef and other habitat are available in nearby waters seaward of the nearshore hard bottom, it is apparent that the habitat has a premium value to the juvenile greens as developmental habitat. The loss of important foraging and refuge/rest areas to resident turtles can lead to decreased health and fitness which can lead to injury, reduced growth (affecting future survival and fecundity), or even death in the case of individuals already physiologically vulnerable as a result of disease or other environmental stressors. Green turtles in the proposed action area have not been documented with fibropapillomatosis, and no other unusual diseases or physiological stressors are known in the action area, and thus death is unlikely to result from displacement. Although there is the potential for the displaced resident juvenile sea turtles to move to nearby, non-impacted hard bottom, this habitat type is limited and we do yet not know the carrying capacity for green turtles. Similar projects are impacting this habitat along its entire span from Brevard County to Broward County, which both reduces the total acreage available as well as decreasing the connectivity between areas of exposed hard bottom.

In summary, the proposed action would impact a maximum of approximately 4.9 acres of nearshore hard bottom habitat, displacing an estimated 25 juvenile green turtles with strong site affinity to the impacted area. This habitat has a premium value to the juvenile greens as developmental habitat, and its loss can lead to decreased health and fitness which can lead to injury, reduced growth (affecting future survival and fecundity), or even death if the turtles are already under other major physiological stresses. In the case of the 25 turtles expected to be displaced by this activity, assuming they are not already under major physiological stresses, a general nonlethal decrease in health and fitness can reasonably be expected.

6.2 Effects of the Action on ESA-Designated Coral Critical Habitat

As described below, NMFS believes the proposed action will adversely affect designated critical habitat for staghorn coral. The Florida area, which will be affected by the proposed action, comprises approximately 1,329 square miles (mi^2) of listed coral critical habitat. The physical feature essential to the conservation of staghorn and elkhorn corals is defined as substrate of suitable quality and availability, in water depths from mean high water to 30 m, to support larval settlement and recruitment, and reattachment of asexual fragments. Substrate of suitable quality and availability is defined as natural consolidated hard bottom or dead coral skeleton that is free from turf or fleshy macroalgae cover and sediment cover. According to the draft environmental assessment, there are approximately 4.9 acres of coral critical habitat that will be adversely affected by the project via burial from nearshore sand placement. Based on these adverse and beneficial effects to critical habitat, we must evaluate whether the proposed action may result in the destruction or adverse modification of critical habitat; if so, NMFS must develop reasonable and prudent alternatives to avoid such impacts.

The creation and resuspension of sediments during construction will result in sediment transport and deposition onto the essential feature, rendering it temporarily unsuitable and unavailable for coral recruitment and growth. Sedimentation affects larval settlement and recruitment, and fragment attachment. Sediment accumulation on dead coral skeletons and exposed hard substrate reduces the amount of available substrate suitable for coral larvae settlement and fragment reattachment. Even small increases in sedimentation can significantly reduce coral recruitment and survivorship (Babcock and Smith 2000), and sediments coupled with turf algae further impede recruitment (Birrell et al. 2005). Further supporting the impact sedimentation has on recruitment, coral larvae of some species settle preferentially on vertical surfaces to avoid sediments and cannot successfully establish themselves in shifting sediment (U.S. Army Engineer Research Development Center 2005). Last, survivorship of branching coral fragments is significantly affected by the type of substrate, with increased mortality being linked to the presence of sandy sediments (Lirman 2000). Therefore, if sediments are present and deposited on the area adjacent to the beach fill area, critical habitat may be unavailable for coral larvae and fragment recruitment and growth.

A previously constructed beach nourishment (Broward Segment III) resulted in unanticipated sedimentation impacts to approximately 36 acres of hard bottom. Broward County is currently working with FDEP to develop a mitigation plan for those impacts. In addition, special condition number 52 in the USACE permit number SAJ-1999-5545, requires that the USACE coordinate with NMFS to review the available monitoring data and determine what additional mitigation is required. A comprehensive monitoring plan will be developed for the currently proposed project in order to capture any unanticipated impacts beyond the 4.9 acres estimated to be affected by Segment II renourishment. This plan will include considerable input from NMFS's Protected Resources and Habitat Conservation Divisions. Based on the above information NMFS has determined that the proposed action will result in the permanent loss of 4.9 acres of designated critical habitat for elkhorn and staghorn coral.

The proposed project includes creation of 6.8 acres of pre-fabricated artificial reef modules. The reef modules will provide similar physical features as the nearshore hardbottom. The low relief (approximately 2 ft) modules will be spaced so that there is the same ratio of sand to hardbottom as the existing nearshore hardbottom and will include similar substrate as the nearshore hardbottom (limestone surface) to facilitate recruitment of organisms found on the natural hardbottom. The modules will be placed in a similar water depth as the nearshore hardbottom and will include a benthic habitat with interstitial spaces that provides refuge for benthic organism. The modules will be placed outside the impact area in sandy substrate, at least 50 feet from any existing hardbottom. Because the reef modules will not be placed on the essential feature of critical habitat, we believe there will be no effect to critical habitat resulting from the placement of reef modules.

6.3 Effects of the Action on Elkhorn and Staghorn Coral

We believe that the proposed project will adversely affect elkhorn and staghorn coral. Scientists at Nova Southeastern University conducted a survey in April 2011 to document the distribution and relative abundance of elkhorn and staghorn coral within the nearshore environment of the project area. The survey area was extensive (7 km^2) and was designed so that nearshore hard bottom and nearshore ridge complex were included in the surveys. Survey sites spanned the entire length of the Segment II shoreline, starting from the previously mapped nearshore hard bottom edge and extending eastward (offshore) 400 m. The survey was conducted using the NMFS Recommended

Survey Protocol for *Acropora* species in Support of Section 7 Consultation which requires a 2-tiered survey for large project areas consisting of the following tiers:

1. Conduct a structured 20-min timed swim from a referenced center point (i.e., downline). If 5 or less colonies are encountered, collect the required data on those colonies and proceed to next sampling site. If more than 5 colonies are encountered, process to Tier 2.
2. Conduct 3 belt transects from the referenced center point at 3 random bearings. Each belt transect should measure 4 m x 50 m, for a total of 200 m^2 sampled. Record all required data for all colonies encountered along the transect.

Survey results were examined with respect to distance from the hard bottom edge and location relative to areas proposed to be nourished. A total of 8 elkhorn colonies were identified at 4 sites within the survey area (see Table 2), 3 of these sites are offshore sections off of beaches that are proposed to be nourished. Seven of these colonies were less than 100 cm in diameter, and 6 had greater than 90% live tissue cover. Only one site that contained elkhorn coral was within 150 m of the hard bottom edge.

Table 2. Summary data for the *Acropora palmata* colonies identified within the total project area

Colony	Site	Distance from HB Edge	City	Length (cm)	Width (cm)	Height (cm)	% Live
1	44	250m	Ft. Lauderdale	60	50	40	95
2	390	150m	Ft. Lauderdale	80	85	65	10
3	532	450m	Lauderdale By The Sea	55	44	38	100
4	547	450m	Lauderdale By The Sea	215	185	100	90
5	547	450m	Lauderdale By The Sea	13	7	8	60
6	547			15	14	9	100
7	547	450m	Lauderdale by the Sea	12	7	8	100
8	547	450m	Lauderdale by the Sea	18	10	8	20

Staghorn coral was identified at 340 of the 714 tier 1 sites (see Table 3), and 38% had more than 5 colonies. Staghorn was found offshore both cities in Segment II, and at all distances from the nearshore hard bottom edge. Mean density at sites with greater than 5 colonies was 0.1 (± 0.3) colonies per m^2. Estimated site density ranged from 0 to 1.7 colonies per m^2. The measured mean colony length was 32.6 cm (± 32.3), and the mean percent live colony tissue was estimated to be 56.6 % (± 28.0%). More staghorn was found at the offshore sites off of beaches proposed to be nourished than those not proposed for nourishment, and at higher densities. An area offshore Ft. Lauderdale between R61 and R70 (n = 108 survey sites), a section of beach proposed to be nourished, was observed to have particularly high abundance of *A. cervicornis*. Within this area, 85% of the sites had at least 1 colony, 80% had more than 5 colonies, 28% had more than 50 colonies, and 25% had more than 150 colonies. Five sites within this same area also had Tier 2 densities greater than 0.5 colonies per m^2. Although the results of this project illustrate the patchy distribution of *A. cervicornis*, it is important to note that *A. cervicornis* colonies were observed along the entire survey area.

Table 3. Summary Data for Staghorn Coral Species Adjacent to Broward Segment II (Gilliam and Walker 2012)

Relative Abundance

Distance from HB Edge	Total Survey Sites	No. Sites Species Present	No. Sites > 5 Colonies	No. Tier 2 Sites	Abundance Categories					
					0	1-5	6-25	26-50	51-149	≥150
50 m	173	38	27	19	135	11	13	5	6	3
150 m	174	77	62	43	97	15	20	9	15	18
250 m	175	99	75	---	76	24	21	13	26	15
350 m	175	109	95	---	66	14	25	14	31	25
450 m	17	17	15	---	0	2	1	2	1	11
Total	714	340	274	62	374	66	80	43	79	72

Distance from HB Edge	Total Survey Sites	No. Sites Species Present	No. Sites > 5 Colonies	Abundance Categories					
				0	1-5	6-25	26-50	51-149	≥150
50	87	11	8	76	3	3	1	3	1
150	88	29	19	59	10	5	5	4	5
250	88	37	28	51	9	11	5	7	5
350	88	41	34	47	7	8	4	12	10
450	10	10	8	0	2	0	2	1	5
Total	361	128	97	233	31	27	17	27	26

The placement of sand in the beach system through sand nourishment can contribute to a seaward shift of the average beach and nearshore edge position (the ETOF) resulting in direct burial of nearshore hardbottoms. In some cases, beach renourishment activities may also result in increased sedimentation beyond the ETOF due to differences in the sediment characteristics between those sediments that occur naturally along the project shoreline and the sediments used as fill material. This may lead sublethal effects to corals in the area. Sediments that are most susceptible for transport beyond the ETOF are those that are smaller than the average median grain size of sediments that naturally occur on the beach, i.e., "finer sediments." To evaluate the potential for project related sedimentation impacts beyond the ETOF, a comparison was made between the amount of finer sediments that exist naturally in the beach system and the amount of these same sized materials that occur in the proposed beach fill material. We assume that finer sediments in the fill material would be displaced from the beach and transported to seaward of the ETOF if the amount of finer material in the fill material is greater than that which exists naturally on the existing beach.

Analysis for the proposed upland sand sources suggests that the use of the upland sand will not introduce any excess of fine sediments to the beach system beyond that which occurs naturally. That is, the upland sand, which is processed at the upland mine, has a larger average grain size and lower percentage of fine sediments than the native sand. Thus, there will not be an excess of fine material introduced to the beach system which would be released from the beach and available for transport to the area beyond the ETOF. As such, it is not anticipated that *Acropora* colonies located seaward of the ETOF will be impacted by the project. Therefore, impacts to elkhorn and staghorn corals are limited to colonies within the area where the ETOF will overlap the hardbottom. The ETOF from the proposed project overlaps with 15 sites that documented the presence of *A. cervicornis* during the survey conducted by Gilliam et al. (2012). Three of these sites are located along the Pompano Beach project area and 12 are along the Lauderdale By The Sea/Ft. Lauderdale project area. These sites had relatively low density of *Acropora*, which is likely a factor of their proximity to the nearshore hard bottom edge. Higher densities were observed farther from shore (Gilliam et al. 2012). Table 4 presents the *Acropora* survey sites that are within the 4.9 acres bounded by the ETOF where *Acropora* colonies were documented. During the Tier 1 survey, an abundance category was recorded (0, 1-5, 6-25, 26-50, 51-149, 150+) for each survey area. The maximum number from the abundance category recorded was used to calculate the density of colonies present within each survey area in order to provide a conservative estimate of the actual abundance. The relative abundance of *Acropora* colonies within the impact area was then calculated based on the area of impact, which resulted in a potential incidental take of 15 colonies of *A. cervicornis*.

Table 4. *Acropora* survey data from the sites that overlap with the ETOF. The Tier 1 abundance is based on the maximum value from the abundance range recorded providing the density of *Acropora* within each survey area.

Acropora* Survey Site No.	**Tier 1 Max Abundance (colonies)**	**Area Surveyed (m^2)**	**Tier 1 Density (col m^{-2})**	**Area of Impact (m^2)†**	**Relative Abundance (col) w/in Impact Area‡**
P 597	5	10,000	0.0005	16.94	0.008
P 577	25	10,000	0.0025	655.33	1.638
P 573	25	10,000	0.0025	3011.22	7.528
FL 377	5	10,000	0.0005	90.21	0.045
FL 301	5	10,000	0.0005	14.65	0.007
FL 289	25	10,000	0.0025	218.43	0.546
FL 273	50	10,000	0.0050	373.10	1.865
FL 265	25	10,000	0.0025	114.90	0.287
FL 257	50	10,000	0.0050	17.91	0.090
FL 249	50	10,000	0.0050	38.62	0.193
FL 225	25	10,000	0.0025	273.76	0.684
FL 217	25	10,000	0.0025	160.30	0.401
FL 209	25	10,000	0.0025	151.52	0.379
FL 205	25	10,000	0.0025	337.35	0.843
FL 201	25	10,000	0.0025	83.66	0.209
TOTAL	**390**	**150,000**	**0.0026**	**5557.90**	**14.450**

* Gilliam et al. (2012). P = Pompano project area; FL = LBTS/Ft. Lauderdale project area

† The area where the ETOF overlaps with the *Acropora* survey areas

‡ Relative density is based on the Tier 1 density multiplied by the area of impact.

Similarly, there was one *A. palmata* colony recorded within the area that will be buried by the ETOF. This opinion will require transplantation of the 1 known *A. palmata* colony and all 15 *A. cervicornis* colonies out of the project area to nearby suitable reef sites as a reasonable and prudent measure (RPM) to reduce the impact of effects of the action as proposed. Lirman et al. (2010) indicated that coral clippings as small as 2 cm in length can be transplanted successfully if the transplant site is nearby. However, clippings of approximately 5 cm in length are recommended if they must be transported to a recipient site some distance away, due to higher mortality rates associated with transportation of smaller clippings. Similarly, 2 *Acropor*a coral nurseries, 1 in Broward County and1in Miami-Dade County, have successfully transplanted 3-cm coral fragments of *Acropora cervicornis*. Based on work with the *Acropora* nursery in Broward County, there is no minimum size for acroporid relocation in terms of the biology of the species (David S. Gilliam, Nova Southeastern University, NCRI Ph.D., pers. comm. to Kelly Logan, NMFS, February 11, 2011.) As previously mentioned in Section 4.2.2 above, asexual fragmentation is the main reproductive method of elkhorn and staghorn coral; therefore, NMFS believes that transplantation of colonies smaller than 10 cm is feasible. The colonies within the project area range in size from 12.6 cm to 63.5 cm in length, and are therefore capable of surviving transplantation.

Collection of small elkhorn and staghorn fragments (i.e., approximately 5-cm fragments) will also be required to help achieve recovery goals for the species. Collection of fragments will reduce the impact of take by providing a secondary inventory within a controlled nursery setting. This will help to ensure that the genetic material of each of the transplanted colonies will survive even if the larger transplanted colony does not. Fragments will be grown in nurseries, increasing population sizes and protecting genetic diversity. These fragments will be collected via careful breaking of the branch tips of the coral colonies using pliers or other small hand tools, or will be fragments of opportunity created during transplantation. The collections will be made by coral experts and trained professionals.

Even though the transplantation and fragment collection actions involve directed take of elkhorn and staghorn coral, they constitute legitimate RPMs because they reduce the level of almost certain lethal take of elkhorn and staghorn coral through direct burial, allow the colonies to be collected and relocated out of the project footprint to where they will have a high likelihood of continued survival, and ensure the survival of the unique genetic material of the transplanted colonies, and the potential use of the material in future restoration activities. The (ESA Section 7) Consultation Handbook (USFWS and NMFS 1998) expressly authorizes such directed take as an RPM (see page 4-53). Therefore, NMFS will evaluate the expected level of elkhorn and staghorn coral take through relocation and fragment collection, so that these levels can be included in the evaluation of whether the proposed action will jeopardize the continued existence of the species.

NMFS believes that the collection of small tissue samples from elkhorn and staghorn colonies will result in temporary effects on coral colonies. The collection of approximately 5-cm-long branch tip tissue samples from single staghorn coral colonies will result in a small reduction of coral colony biomass; however, this effect is expected to be temporary with recovery through tissue replacement and/or coral colony growth. Elkhorn and staghorn coral's dominant mode of reproduction is through asexual fragmentation (see Section 4.2.2 for further discussion). *Acropora palmata* lesions at the point of fragment detachment have been shown to begin regeneration within 2 weeks of fragmentation (Lirman 2000), with regeneration rates being positively correlated with decreasing size of lesion and proximity to growing tip. The size of the lesion created in this project will be a function of the diameter of the branch being clipped. The diameter of staghorn coral branches ranges from 0.25 to 1.5 cm. Lirman (2000) showed that a 3-cm^2 lesion regenerated completely within 100 days. Given that the rate of recovery is an exponential decay, it is expected that lesions 0.25 to 1.5 cm in diameter (less than 2.25 cm^2) will recover much faster than in Lirman's study.

Furthermore, the proposed collection of tissue samples from elkhorn and staghorn colonies will occur at the outermost portion of the branch tip of the coral colony. Soong and Lang (1992) observed that, in *A. cervicornis*, large polyps and basal tissues located 1.0 to 4.5 cm from the colony base were infertile, and larger eggs were located in the mid-region of colony branches. Gonads located within 2 to 6 cm of the colony's branch tips always had smaller eggs than those in the mid-region (Soong and Lang 1992). Larger colonies (as measured by surface area of the live colony) have higher fertility rates (Soong and Lang 1992). Thus the effect of this activity on coral colony reproduction is insignificant. Given that the collected tissue samples are small in size (~5 cm) relative to coral colony size, that the effects of collecting such fragments are temporary, that fragmentation is a natural reproductive mode, and that these fragments will be collected from the outermost portion of the coral branch tip where smaller eggs are found, it is not likely that survival or reproductive output of staghorn coral colonies will be measurably reduced by the proposed action.

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 (Maragos 1974; Birkeland et al. 1979; Harriott and Fisk 1988; Hudson and Diaz 1988; Guzman 1991; Kaly 1995; Becker and Mueller 1999; Tomlinson and Pratt 1999; Hudson 2000; Lindahl 2003; NCRI 2004). Herlan and Lirman (2008) documented a 17.3% mortality rate in *Acropora cervicornis* coral fragments after transplantation to a coral nursery in Biscayne National Park. The authors stated the mortality rate might have been increased due to stress caused by relatively high water temperatures during fragmentation, not necessarily by the process itself. This observation has been supported by other nursery managers who report post-relocation coral fragment mortality rates less than 5% (Ken Nedimeyer, Coral Restoration Foundation pers. comm.to Audra Livergood 2009 and Sean Griffin, NMFS pers. comm. to Kelly Logan October 10, 2014).

NMFS believes that the single colony of *A. palmata* and the 15 colonies of *A. cervicornis* could be lethally taken during the beach nourishment if not relocated. We believe coral transplantation will be 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 have confidence that transplantation survival rates similar to those noted elsewhere will be likely in this case. We believe a 17% coral fragment morality rate may be artificially high, brought on more by unusual environmental conditions than actual transplantation. To be conservative, we use a 17% mortality rate in our estimates; however, we believe actual mortality may be lower. Therefore, we anticipate an 83% survival rate of transplanted colonies.

In summary, the 15 known staghorn colonies and 1 known elkhorn colony will be relocated, with fragments collected from each relocated colony for genotyping. Of the colonies transplanted, we anticipate that up to 3 staghorn colonies (17% x 15 colonies = 2.55) will suffer mortality after relocation and result in lethal takes; the remaining 1 elkhorn and 12 staghorn colonies will survive.

7 Cumulative Effects

Cumulative effects include the effects of *future* state, tribal, or local private actions—i.e., that are not already in the baseline—that are reasonably certain to occur in the action area considered in this opinion. Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of the ESA (50 CFR 402.14). Actions that are reasonably certain to occur would include actions that have some demonstrable commitment to their implementation, such as funding, contracts, agreements or plans.

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 human activities described in the environmental baseline. The present human uses of the action area, such as commercial shipping, are expected to continue, though some may occur at increased levels, frequency or intensity in the near future.

8 Jeopardy Analysis

The analyses conducted in the previous sections of this Opinion provide the basis on which we determine whether the proposed action would be likely to jeopardize the continued existence of green sea turtles and elkhorn and staghorn coral. In Section 6, we outlined how the proposed action would affect these species at the individual level and the magnitude of those effects based on the best available data. Next, we assess each of these species' response to the effects of the proposed action, in terms of overall population effects, and whether those effects will jeopardize their continued existence in the context of the status of the species (Section 4), the environmental baseline (Section 5), and the cumulative effects (Section 7).

It is the responsibility of the action 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 species or threatened species…" (ESA Section 7(a)(2)). Action agencies must consult with and seek assistance from the NMFS to meet this responsibility. NMFS must ultimately determine in a Biological Opinion whether the action jeopardizes listed species. To *jeopardize the continued existence of* is defined as "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). The following jeopardy analysis first considers the effects of the action to determine if we would reasonably expect the action to result in reductions in reproduction, numbers, or distribution of green sea turtles or elkhorn and staghorn coral. The analysis next considers whether any such reduction would in turn result in an appreciable reduction in the likelihood of survival of these species in the wild, and the likelihood of recovery of these species in the wild.

8.1 Green Turtles

The potential nonlethal displacement of 25 green turtles due to sand placement in the nearshore waters will not result in a reduction in the species' numbers. These nonlethal takes would not result in a potential reduction in future reproduction. Green sea turtles are highly migratory, and individuals from all Atlantic nesting populations may range throughout the Gulf of Mexico, Atlantic Ocean, and Caribbean Sea. Because all the potential interactions are expected to occur at random throughout the proposed action area and sea turtles generally have large ranges in which they disperse, the distribution of green sea turtles in the action area is expected to be unaffected. Therefore, we believe that the non-lethal displacement of 25 green turtles is not expected to result in a reduction in the species' numbers and reproduction and will not result in any reduction in the species' range.

We also considered the recovery objectives in the recovery plan prepared for the U.S. populations of green sea turtles that may be affected by the predicted reduction in numbers and reproduction. The recovery plan for green sea turtles (NMFS and USFWS 1991) lists the following relevant recovery objectives relevant to the effects of the proposed action:

- The level of nesting in Florida has increased to an average of 5,000 nests per year for at least 6 years. Nesting data must be based on standardized surveys. Between 2001 and 2006, an average of 5,039 green turtle nests were laid annually in Florida, with a low of 581 in 2001 and a high of 9,644 in 2005 (NMFS and USFWS 2007a). That average increased to 7,436 nests per year for the 6-year period of 2004-2009. Data from the index nesting beach program in Florida support the dramatic increase in nesting. In 2007, there were 9,455 green turtle nests found just on index nesting beaches, the highest since index beach monitoring began in 1989. The number fell back to 6,385 in 2008, but that is thought to be part of the normal biennial nesting cycle for green turtles (FWC Index Nesting Beach Survey Database). An additional drop to just below 3,000 nests was seen on the index nesting beaches in 2009, but the occasional break from the normal biennial pattern is not without precedent, as there were 2 consecutive years of increase from 2003-2005 (FWC Index Nesting Beach Survey Database). State nesting data for 2013 show an increase in green turtle nests to 36,195, the highest number of nests since 1988 (FWRI Web site: http://myfwc.com/research/wildlife/sea-turtles/nesting/beach-survey-totals/).

- A reduction in stage class mortality is reflected in higher counts of individuals on foraging grounds. Currently, there are no reliable estimates of the number of immature green sea turtles that inhabit coastal areas (where they come to forage) of the southeastern United States. Yet, information on incidental captures of immature green sea turtles at the St. Lucie Power Plant (they have averaged 215 green sea turtle captures per year from 1977-2002) in St. Lucie County, Florida, show that the annual number of immature green sea turtles captured has increased significantly in the past 26 years (FPL 2002). Ehrhart et al. (2007) has also documented a significant increase in in-water abundance of green turtles in the Indian River Lagoon area.

This species is currently showing a very large increasing nesting trend in Florida, with nesting numbers already approaching or exceeding those required by the recovery plan for the species. Therefore, we believe that the non-lethal displacement of 25 green turtles is not expected to result in a reduction in numbers and reproduction, and will not have any detectable influence on the population and nesting trends noted above. Thus the proposed action will not interfere with achieving the recovery objectives above and will not result in an appreciable reduction in the likelihood of green sea turtles' recovery in the wild.

8.2 Elkhorn and StaghornCoral

In the following analysis, we evaluate the effects of the lethal take and nonlethal relocation of corals from the proposed project. Over the course of the 3-year project, we do not expect the proposed action to have any measurable impact on the reproduction, numbers, or distribution of the species.

As discussed in Section 6 (Effects of the Action), the proposed project is likely to adversely affect a maximum of 3 colonies of staghorn coral through lethal take. Another 13 colonies of staghorn and 1 colony of elkhorn will be relocated and survive.

We must now determine if the action would reasonably be expected to appreciably reduce, either directly or indirectly, the likelihood of elkhorn and staghorn coral's survival and recovery in the wild.

Elkhorn and Staghorn Corals

We estimate the proposed action may result in take of a single colony of *Acropora palmata* and 15 colonies of *Acropora cervicornis* by transplantation, and that 3 of the staghorn colonies may suffer post-transplantation mortality. As discussed above, the collection of tissue sample fragments from each of the transplanted coral colonies will not result in reductions in numbers or reproduction of coral colonies.

The proposed action will not affect the species' current geographic range. Since relocated colonies will remain in the same area, no change in species distribution is anticipated. The anticipated mortalities of up to 3 of the 15 transplanted colonies would result in a reduction in *A. cervicornis* distribution in the immediate action area. Still, the species is found throughout the wider Caribbean region. In Florida, *A. cervicornis* and *A. palmata* is generally found from Palm Beach County through Monroe County. The action area for this project is located in the middle of this range. The potential mortality of up to 3 colonies of staghorn coral would cause no noticeable change or fragmentation in the distribution of the species, either in Florida or the Wider Caribbean. The RPMs for this action require the USACE to relocate 15 staghorn colonies and 1 elkhorn colony from out of the path of potential mortality from the project, to appropriate reef habitat nearby. This RPM further minimizes the potential of species range fragmentation.

The potential mortality of 3 transplanted colonies of *A. cervicornis* would constitute a reduction in the numbers of the species, and those losses might also result in a loss of reproduction. However, a high number of colonies are believed to be still in existence through the species' range. Surveys within Miami-Dade County at Biscayne National Park have identified 112 colonies of *A. cervicornis* on 4 patch reefs. The project will eventually sample 5,000 patch reefs (D. Corsett, Biscayne National Park, pers. comm. 2009). If this current rate of occurrence holds, as many as 140,000 *A. cervicornis* colonies may exist inside the park alone. Even if this number is off by half, there may still be as many as 70,000 colonies occurring within just a portion of Miami-Dade County. Miller et al. (2008) estimate over 13 million *A. cervicornis* colonies likely exist currently in the Florida Keys, and while the absolute number of colonies is unknown, it is estimated that as many as a billion individual colonies may exist range wide (71 FR 26852; May 9, 2006). The loss of up to 3 colonies is unlikely to have any measurable effect on the other colonies. As discussed in Section 4.2.2 above, staghorn coral propagates mainly through asexual fragmentation. The potential loss of up to 3 colonies would cause no noticeable change in the distribution of the species and would not appreciably reduce the number of colonies available for fragmentation, therefore it is not likely to cause a measurable reduction in the species ability to reproduce. It has been noted that sexual recruitment of elkhorn and staghorn corals is limited or absent in most locations. NMFS believes that this is due to lack of suitable habitat available for larval settlement and is not caused by any shortage of gametes being released by reproductive colonies surviving in the wild.

Although no change in elkhorn or staghorn distribution was anticipated, we concluded lethal takes of staghorn coral would result in a reduction in absolute population numbers that may also reduce reproduction. We believe these reductions are unlikely to appreciably reduce the likelihood of survival of the species in the wild, because the action will not negatively affect critical metrics of the status of the species. The following analysis considers the effects of the anticipated loss of 3 colonies on the likelihood of recovery in the wild. The lethal take of up to 3 of *A. cervicornis* 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. Therefore, the action will result in a reduction in *A. cervicornis* reproduction, but would not have a measurable effect on the distribution of the species within the Florida unit or throughout its range.

A recovery plan for elkhorn and staghorn coral is not yet available, though a list of threats and causal listing factors exists (Table 5). Anthropogenic abrasion and breakage, and sedimentation, are currently considered moderate threats to *Acropora*. The *Acropora* Biological Review Team (BRT) concluded that secondary stressors should be the main focus of regulatory and recovery actions such that the species would be better able to adapt to and recover from the continuing impacts of primary stressors such as diseases and rising sea surface temperatures. Further, as noted in the critical habitat rule (73 FR 72210, November 26, 2008), the loss of suitable habitat is one of the greatest threats to the recovery of listed coral populations. Increasing sexual and asexual reproduction in order to increase abundance, distribution, and genetic diversity, is the key objective for the conservation of the species. Currently, sexual recruitment of elkhorn and staghorn corals is limited in some areas and absent in most locations studied. Compounding the difficulty of documenting sexual recruitment is the difficulty of visually distinguishing some sexual recruits from asexual recruits (Miller et al. 2007). Hughes and Connell (1999) have documented that the limited availability of appropriate substrate has reduced the successful settlement of larvae or attachment of fragments since the 1980s. Natural consolidated hard substrate is necessary for elkhorn and staghorn coral recruits to attach and grow. In addition to being limited, the availability of appropriate habitat for successful sexual and asexual reproduction is susceptible to becoming reduced further due to overgrowth of fleshy macroalgae. Similarly, sediment accumulation impedes sexual and asexual reproductive success by covering available substrate and smothering coral recruits. Turf algae also preempts space and exacerbates the effect of sedimentation by trapping sediment. As described above, features that will facilitate successful larval settlement and recruitment, and reattachment and recruitment of asexual fragments, are essential to the conservation of elkhorn and staghorn corals. Without successful recruits (both sexual and asexual), the species will not increase in abundance, distribution, and genetic diversity.

The proposed action may adversely affect elkhorn and staghorn coral through transplantation and potential mortality of a few staghorn colonies. As mentioned above, NMFS believes that reproduction in elkhorn and staghorn corals is not limited by the current population size (i.e. number of gametes available from colonies of reproductive size), but rather by the limited availability of suitable habitat for larval settlement and fragment attachment. Therefore, we believe that the loss of up to 3 staghorn colonies is not likely to reduce the chances of *A. cervicornis'* reproductive success or recovery in the wild. Tissue samples will be collected from every transplanted colony and transferred to a permitted *Acropora* nursery that will further preserve the genotypic material from the transplanted colonies. These fragments and their genetic material will thus be available for future re-transplantation.

Stressors such as sedimentation lead to abrasion, disease, and physical responses (such as increases in mucous production) that affect the corals' ability to generate enough energy to reproduce sexually. The proposed action may cause temporary impacts through sedimentation. The USACE will be required to conduct sedimentation monitoring and sedimentation levels are expected to return to background levels upon project completion. The proposed project would not cause an increase in any of the other stressors listed in Table 5. Therefore, NMFS believes that sedimentation caused by the proposed action is not likely to reduce the chances of elkhorn and staghorn corals' recovery in the wild.

Table 5. Rank of stressor severity to *Acropora* without (w/out) and with (w/) prohibition/protection of existing regulatory mechanisms (regulations)* (*Acropora* BRT 2005)

Stressor	***A. cervicornis***	
	Rank w/o Regs	Rank w/ Regs
Disease	5+	5+
Temperature	5	5
Over-harvest	5*	1
Natural abrasion and breakage	4	4
Anthropogenic abrasion and breakage	2	1
Competition	3	3
Predation	3	3
Sedimentation	3	2
African Dust	1	1
CO_2	1	1
Nutrients	1	1
Sea level rise	1	1
Sponge boring	1	1
Contaminants	U	U
Loss of genetic diversity	U	U

*A rank of 5 represents the highest threat, 1 the lowest, and U undetermined/unstudied.

9 Analysis of Destruction or Adverse Modification of Designated Critical Habitat

Critical habitat was designated for elkhorn and staghorn corals, in part, because further declines in the low population sizes of the species could lead to threshold levels that make the chances for recovery low. More specifically, low population sizes for these species could eventually lead to an Allee effect and lower effective density (of genetically distinct adults required for sexual reproduction), and a reduced source of fragments for asexual reproduction and recruitment. In other words, a staghorn coral mate may be too far away for successful sexual reproduction to occur. Furthermore, lack of suitable habitat limits recovery of elkhorn and staghorn coral by limiting the available substrate for larval settlement and fragment attachment. Therefore, the key conservation objective of designated critical habitat is to facilitate increased incidence of successful sexual and asexual reproduction (i.e., increase the potential for sexual and asexual reproduction to be successful), which in turn facilitates increases in the species' abundance, distribution, and genetic diversity. To this end, our analysis of whether the proposed action is likely to destroy or adversely modify designated critical habitat seeks to determine if the adverse effects of proposed action on the essential features of designated *Acropora* critical habitat will appreciably reduce the capability of the critical habitat to facilitate an increased incidence of successful sexual and asexual reproduction. This analysis takes into account the current status of each species; for example, the level of increased incidence of successful reproduction that needs to be facilitated may be different depending on the recovery status of elkhorn and staghorn corals in the action area. This analysis also takes into account the geographic and temporal scope of the proposed action, recognizing that functionality of critical habitat necessarily means that it must currently and in the future continue to support the conservation of the species and progress toward recovery.

The key objective for the conservation and recovery of listed coral species identified for the designated critical habitat is the facilitation of an increase in the incidence of sexual and asexual reproduction by providing substrate for larval settlement and fragment attachment. Recovery cannot occur without protecting the essential feature of critical habitat from destruction or adverse modification because the quality and quantity of suitable substrate for listed corals affects their reproductive success. The proposed action will result in the permanent loss of up to 4.9 acres of critical habitat via direct burial. Therefore, this portion of critical habitat will be permanently unavailable and unsuitable for coral recruitment.

As noted in the critical habitat rule, the key objective for the conservation and recovery of listed coral species is the facilitation of an increase in the incidence of sexual and asexual reproduction. Recovery cannot occur without protecting the essential feature of critical habitat from destruction or adverse modification because the quality and quantity of suitable substrate for listed corals affects their reproductive success. Impacts from dredging would permanently remove less than 0.000006% of the total amount of critical habitat within the Florida unit, and less than 0.02% of the potentially suitable habitat within the action area. The project seeks to offset some of these impacts through the placement of 6.38 acres of artificial reef modules which will provide similar physical features as the nearshore hardbottom. NMFS does not believe that the loss of 4.9 acres of critical habitat will impede the recovery of the listed corals in the action area or range-wide. We also believe that the placement of the 6.8 acres of artificial reef modules will further reduce the impact by providing similar habitat features for future coral recruitment. Therefore, the proposed project would not destroy or adversely modify the designated critical habitat for listed corals.

10 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 green sea turtles or elkhorn and staghorn corals. These analyses focused on the impacts to, and population responses of, these species. Because the proposed action will not reduce the likelihood of survival and recovery of these species, it is our Opinion that the proposed action is also not likely to jeopardize the continued existence of these species.

After reviewing the current status of elkhorn and staghorn coral critical habitat, the environmental baseline, the effects of the proposed actions, and the cumulative effects, it is our Opinion that the proposed project will not impede the critical habitat's ability to support the conservation of staghorn or elkhorn corals and therefore will not destroy or adversely modify the critical habitat.

11 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. *Take* is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. *Incidental take* is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. 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).

NMFS must estimate the extent of 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 extent of take that NMFS anticipates will occur as a result of implementing the proposed action. If actual take exceeds an amount (or geographic or temporal extent) specified here, the exemption from the prohibition on take will be invalid for the excess amount, and re-initiation of consultation is required.

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)).

11.1 Extent of Anticipated Take – Green Sea Turtles

NMFS anticipates incidental take will consist of a total of 25 green sea turtles via nonlethal displacement due to loss of nearshore hard bottom foraging habitat.

Effect of the Take
NMFS has determined the anticipated level of incidental take specified in Section 11.1 is not likely to jeopardize the continued existence of green sea turtles if the project is developed as proposed.

11.2. Extent of Anticipated Take – Elkhorn and Staghorn Corals

NMFS has determined that the proposed project will result in the take of 15 staghorn corals and 1 elkhorn coral via transplantation; 3 of the staghorn colonies may be lethally taken through mortality associated with transplantation.

Effect of the Take
NMFS has determined the anticipated take specified in Section 11.2 is not likely to jeopardize the continued existence of elkhorn or staghorn corals if the project is developed as proposed.

12 Reasonable and Prudent Measures (RPMs)

Section 7(b)(4) of the ESA requires NMFS to issue a statement specifying the impact of any incidental take on listed species, which results from an agency action otherwise found to comply with Section 7(a)(2) of the ESA. It also states that the RPMs necessary to minimize the impacts of take and the terms and conditions to implement those measures must be provided and must be followed to minimize those impacts. Only incidental taking by the federal agency or applicant that complies with the specified terms and conditions is authorized.

The RPMs and terms and conditions are specified as required by 50 CFR 402.12 (i)(1)(ii) and (iv) to document the incidental take by the proposed action and to minimize the impact of that take on staghorn coral. These measures and terms and conditions are nondiscretionary, and must be implemented by the USACE or the contractor 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 contractor 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 and appropriate to minimize impacts of the incidental take of staghorn and elkhorn coral colonies during the proposed action. The following RPMs and associated terms and conditions are established to implement these measures, and to document incidental takes. Only incidental takes that occur while these measures are in full implementation are authorized. These restrictions remain valid until reinitiation and conclusion of any subsequent Section 7 consultation.

1. Pre-construction survey. The USACE will conduct a pre-construction survey to document all listed species prior to construction as detailed in the Final Biological Monitoring plan which will be approved by NMFS prior to beginning construction.

2. The USACE must ensure that all colonies of listed coral species are relocated from within the project impact area and 10 m buffer zone east of the project prior to beginning construction as detailed in the final coral transplantation plan (Appendix C).

3. USACE shall ensure preservation of genetic material of transplanted colonies of elkhorn and staghorn coral as detailed in the final coral transplantation plan (Appendix C).

4. Coral Mitigation plan. The USACE must implement the Final Compensatory Mitigation Plan revised September 25, 2014 (Appendix D).

5. Environmental monitoring plan. The USACE must conduct environmental monitoring to assess whether environmental impacts of the project exceed thresholds identified in the EA.

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.

13 Terms and Conditions

In order to be exempt from liability for take prohibited by Section 9 of the ESA, USACE must comply with the following terms and conditions, which implement the RPMs described above. These terms and conditions are nondiscretionary.

1. USACE must conduct a preconstruction survey and record the location and size of all listed corals and provide this information to NMFS. The survey areas will include all hardbottom offshore of the beaches to be noursished (which were included in the original 7-km area in the surveys provided to NMFS for consultation) out to 50 m and north and south for 100 m. (RPM 1)

2. 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 established protocols (see Appendix A) and the attached coral transplantation plan (Appendix C). Qualified individuals following the protocols in Appendices A and C must conduct transplantation. The USACE must ensure that all transplanted colonies are relocated to the artificial reef prior to construction and placed in groups by species at appropriate densities. If the artificial reef can not be constructed prior to the beach fill operations, then coral colonies must be transplanted to suitable habitat near their original location, but no closer than 400 ft from the edge of the beach fill area. For the purposes of this opinion, suitable habitat is considered: similar depth as origin (+/- 5ft), uncolonized (by corals, soft corals or sponges, turf algae must be removed prior to coral placement) hard substrate, appropriate water quality (based on water quality data and local knowledge), and minimal chances of other disturbances (boat groundings, damage caused by curious divers/fishers). (RPM 2)

3. USACE must record the original location of each transplanted colony, as well as the location of each colony after transplantation. The data for acroporid corals must be submitted to the central acroporid geodatabase maintained by the Florida Fish and Wildlife Conservation Commission (FFWCC). USACE must contact Rene Baumstock, Ph.D., of FWC at (727) 896-8626, prior to transplantation to discuss data collection and reporting requirements. (RPM 2)

4. The transplant monitoring plan shall include the monitoring of all the listed corals transplanted from the project area. The monitoring plan shall also include monitoring of corals already at the transplant site (if not using the artificial reef area) to compare the health and survivorship of transplants with corals naturally occurring at the transplant site. (RPM 2)

5. USACE must submit any changes to transplantation protocols, and ensure that the qualifications of any persons conducting transplantation are submitted to NMFS, Protected Resources Division, Southeast Regional Office, Protected Resources Division, 263 13th Avenue South, St. Petersburg, Florida 33701. (RPM 2)

6. USACE must ensure that all appropriate natural resource permits are obtained prior to relocation of corals. (RPMs 2 and 3)

7. USACE must ensure a 5-cm fragment is collected from each transplanted colony of elkhorn and staghorn. The fragment must be collected from the axial tip of healthy branches (i.e., apparently free of disease, algae, or boring sponge infestations), using hand tools (e.g., clipper). Should colonies being transplanted fragment during handling, all fragments shall be collected in lieu of collecting an axial tip. Any fragments larger than 5-cm shall be relocated according to transplantation protocols, fragments 5-cm or less shall be transplanted to the nursery. All fragments must remain in seawater until transferred to the custody of a licensed Coral Nursery within the sub-region. (RPM 3)

8. USACE shall ensure the availability of adequate funds are provided to the appropriate licensed coral nursery to cover the costs of vessel use, man power, and equipment necessary to secure the relocated coral fragments. Current estimates for this type of work are between $100-$150 per fragment. (RPM 3)

9. USACE shall implement the Final Compensatory Mitigation Plan revised September 25, 2014 (Appendix D). (RPM 4)

10. USACE shall coordinate with NMFS to develop the final Biological Monitoring Plan prior to construction. The final monitoring plan shall incorporate the recommendations from the ERDC report (Appendix E) . (RPM 4)

11. USACE shall conduct sedimentation/turbidity monitoring and environmental monitoring of the nearshore hard bottom as required by the Joint Coastal Permit Broward County Segment II Beach Nourishment and Restoration Permit No.0314535-001-JC (Appendix B) and will submit a final biological and environmental monitoring plan which will be developed in concert with NMFS. (RPM 5)

12. In the event that monitoring of the hard bottom habitat indicates that listed coral species are likely to be adversely impacted by project-related turbidity, sedimentation, or physical impacts in a manner or to a degree that would exceed the adverse impacts considered in this Opinion, USACE shall implement an adaptive management plan to avoid or minimize the impacts. The USACE's adaptive management plan shall be coordinated with and approved by NMFS prior to implementation. (RPM 5)

14 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 further the conservation of listed coral species. NMFS strongly recommends that these measures be considered and implemented, and requests to be notified of their implementation.

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 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.

3. NMFS strongly recommends that the USACE, in consultation with PRD, utilize its authority to carry out programs for the conservation of listed corals. Pursuant to ESA Section 7(a)(1), the USACE should develop a program to donate a fragment of each acroporid colony directly impacted by all authorized or permitted activities to an appropriate coral nursery.

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.

15 Reinitiation of Consultation

As provided in 50 CFR Section 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) 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, (2) 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 (3) a new species is listed or critical habitat designated that may be affected by the identified action.

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APPENDIX A

Transplantation Protocols

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.

Prior to elkhorn or staghorn colony collection, a 5-cm fragment must be collected from each parent colony. The fragment must be collected from the axial tip of healthy branches using hand tools (e.g., clipper). Fragments must remain in seawater until transfer to the custody of the Nova Southeastern University *Acropora* nursery. USACE must coordinate with the *Acropora* nursery prior to collecting these samples to ensure safe transfer. If, for some reason, the Nova Southeastern University *Acropora* nursery is unable to accept the fragments, then the USACE will transport them to the permitted *Acropora* nursery within Miami-Dade County as soon as operationally feasible and no more than 24 hours after collection. USACE will immediately notify NMFS of the change in nursery location.

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. During transportation to the transplant site, the corals must be covered. Transplantation should occur as soon as operationally feasible, and no more than 24 hours after the colony is removed from its original location. The collected colonies must be kept at the original depth until transplantation commences (i.e., cached on site).

The USACE must ensure that all transplanted colonies are re-located to the artificial reef. If the artificial reef can not be constructed prior to beach fill operations then colonies must be relocated to suitable habitat near their original location. The colonies must be transplanted no closer than 400 ft from the project area in 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 as follows: similar depth as origin (+/- 5 ft); means consolidated hard bottom (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/fishers). All efforts should be made to transplant the colony 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 All Fill Epoxy for elkhorn/staghorn colonies. Before applying the adhesive to the substrate, it must be cleaned of any sediment or algae. The adhesive 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 adhesive with proper care. Transplanted colonies must be no closer than 0.75 m 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.

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

MARJORY STONEMAN DOUGLAS BUILDING
3900 COMMONWEALTH BOULEVARD
TALLAHASSEE, FLORIDA 32399-3000

RICK SCOTT
GOVERNOR

HERSCHEL T. VINYARD JR.
SECRETARY

CONSOLIDATED JOINT COASTAL PERMIT SOVEREIGN SUBMERGED LANDS AUTHORIZATION

PERMITTEE:
Broward County Board of County Commissioners
Eric Myers, Natural Resource Administrator
115 South Andrews Avenue
Fort Lauderdale, FL 33301

AGENT:
Christopher G. Creed, P.E.
Olsen Associates, Inc.
2618 Herschel Street
Jacksonville, FL 32204

PERMIT INFORMATION:
Permit Number: 0314535-001-JC

Project Name: Broward County Segment II Beach Nourishment and Restoration

County: Broward

Issuance Date: January 31, 2014

Expiration Date: January 31, 2029

REGULATORY AUTHORIZATION:

This permit is issued under the authority of Chapter 161 and Part IV of Chapter 373, Florida Statutes (F.S.), and Title 62, Florida Administrative Code (F.A.C.). Pursuant to Operating Agreements executed between the Department of Environmental Protection (Department) and the water management districts, as referenced in Chapter 62-113, F.A.C., the Department is responsible for reviewing and taking final agency action on this activity. **This permit supersedes Permit 0163435-005-JC, as previously modified.**

PROJECT DESCRIPTION:

The project involves the placement of beach-compatible sand along 4.9 miles of the Broward County coastline, between Hillsboro Inlet and Port Everglades. This includes beach nourishment at Pompano Beach and Lauderdale-by-the-Sea; beach restoration at northern Fort Lauderdale; dune construction within the Lauderdale-by-the-Sea and Fort Lauderdale segments; and construction of 6.8 acres of artificial reef as mitigation for direct impacts to 4.9 acres of nearshore hardbottom. The width of the construction template (measured as the seaward distance from the range monuments) for the Pompano Beach segment varies from 203 to 270 feet, the width for the Lauderdale-by-the-Sea segment varies from 153 to 188 feet, and the width for the Fort Lauderdale segment varies from 71 to 244 feet. The dune will have a crest width of 10 feet, a crest height of +11 feet (NAVD) and side slopes of 1:2 (vertical:horizontal). Beach-compatible fill material will be obtained from the following upland borrow areas: E.R. Jahna Ortona Mine, Stewart Immokalee Mine, Vulcan Witherspoon Mine and Cemex Davenport Mine. The sand will be transported to the proposed locations via truck-haul or railcar.

PROJECT LOCATION:

The beach nourishment sites are located within Pompano Beach (from DEP monument R-36 to R-41.3) and Lauderdale-By-The-Sea (from R-51 to R-53). The beach restoration site is located within Fort Lauderdale (from R-53 to R-72). The artificial reef will be located in the nearshore, approximately between R-44 and R-46. The north reach, in Pompano Beach, is located in Section 5, Township 49 South, and Range 43 East. The south reach, in Lauderdale-By-The-Sea and Fort Lauderdale, is located in Sections 6, 18, 19, 30 and 31, Townships 49 and 50 South, Ranges 42 and 43 East. Both reaches and the artificial reef are located in Broward County and extend into the Atlantic Ocean, Class III Waters, not in Outstanding Florida Waters.

PROPRIETARY AUTHORIZATION:

This activity also requires a proprietary authorization, as the activity is located on sovereign submerged lands held in trust by the Board of Trustees of the Internal Improvement Trust Fund (Board of Trustees), pursuant to Article X, Section 11 of the Florida Constitution, and Sections 253.002 and 253.77, F.S. The activity is not exempt from the need to obtain a proprietary authorization. The Board of Trustees delegated, to the Department, the responsibility to review and take final action on this request for proprietary authorization in accordance with Section 18-21.0051, F.A.C., and the Operating Agreements executed between the Department and the water management districts, as referenced in Chapter 62-113, F.A.C. This proprietary authorization has been reviewed in accordance with Chapter 253, F.A.C., and the policies of the Board of Trustees.

As staff to the Board of Trustees, the Department has reviewed the project described above, and has determined that the beach restoration and artificial reef activities qualify for a Letter of Consent to use sovereign, submerged lands, as long as the work performed is located within the boundaries as described herein and is consistent with the terms and conditions herein. Therefore, consent is hereby granted, pursuant to Chapter 253.77, F.S., to perform the activity on the specified sovereign submerged lands.

COASTAL ZONE MANAGEMENT:

This permit constitutes a finding of consistency with Florida's Coastal Zone Management Program, as required by Section 307 of the Coastal Zone Management Act.

WATER QUALITY CERTIFICATION:

This permit constitutes certification of compliance with state water quality standards pursuant to Section 401 of the Clean Water Act, 33 U.S.C. 1341.

OTHER PERMITS:

Authorization from the Department does not relieve you from the responsibility of obtaining other permits (Federal, State or local) that may be required for the project. When the Department received your permit application, a copy was sent to the U.S. Army Corps of Engineers (Corps) for review. The Corps will issue their authorization directly to you, or contact you if additional information is needed. If you have not heard from the Corps by now, we recommend that you contact the nearest Corps regulatory office for status and further information. Failure to obtain Corps authorization prior to construction could subject you to federal enforcement action by that agency.

AGENCY ACTION:

The above named Permittee is hereby authorized to construct the work outlined in the project description and project location of this permit and shown on the approved permit drawings, plans and other documents attached hereto. This agency action is based on the information submitted to the Department as part of the permit application, and adherence with the final details of that proposal shall be a requirement of the permit. **This permit and authorization to use sovereign submerged lands are subject to the General Conditions and Specific Conditions, which are a binding part of this permit and authorization.** Both the Permittee and their Contractor are responsible for reading and understanding this permit (including the permit conditions and the approved permit drawings) prior to commencing the authorized activities, and for ensuring that the work is conducted in conformance with all the terms, conditions and drawings.

GENERAL CONDITIONS:

1. All activities authorized by this permit shall be implemented as set forth in the plans and specifications approved as a part of this permit, and all conditions and requirements of this permit. The permittee shall notify the Department in writing of any anticipated deviation from the permit prior to implementation so that the Department can determine whether a modification of the permit is required pursuant to section 62B-49.008, Florida Administrative Code.

2. If, for any reason, the permittee does not comply with any condition or limitation specified in this permit, the permittee shall immediately provide the Bureau of Beaches and Coastal Systems and the appropriate District office of the Department with a written report containing the following information: a description of and cause of noncompliance; and the period of noncompliance, including dates and times; or, if not corrected, the anticipated time the noncompliance is expected to continue, and steps being taken to reduce, eliminate, and prevent recurrence of the noncompliance.

3. This permit does not eliminate the necessity to obtain any other applicable licenses or permits that may be required by federal, state, local, special district laws and regulations. This permit is not a waiver or approval of any other Department permit or authorization that may be required for other aspects of the total project that are not addressed in this permit.

4. This permit conveys no title to land or water, does not constitute State recognition or acknowledgment of title, and does not constitute authority for the use of sovereignty land of Florida seaward of the mean high-water line, or, if established, the erosion control line, unless herein provided and the necessary title, lease, easement, or other form of consent authorizing the proposed use has been obtained from the State. The permittee is

responsible for obtaining any necessary authorizations from the Board of Trustees of the Internal Improvement Trust Fund prior to commencing activity on sovereign lands or other state-owned lands.

5. Any delineation of the extent of a wetland or other surface water submitted as part of the permit application, including plans or other supporting documentation, shall not be considered specifically approved unless a specific condition of this permit or a formal determination under section 373.421(2), F.S., provides otherwise.

6. This permit does not convey to the permittee or create in the permittee any property right, or any interest in real property, nor does it authorize any entrance upon or activities on property which is not owned or controlled by the permittee. The issuance of this permit does not convey any vested rights or any exclusive privileges.

7. This permit or a copy thereof, complete with all conditions, attachments, plans and specifications, modifications, and time extensions shall be kept at the work site of the permitted activity. The permittee shall require the contractor to review the complete permit prior to commencement of the activity authorized by this permit.

8. The permittee, by accepting this permit, specifically agrees to allow authorized Department personnel with proper identification and at reasonable times, access to the premises where the permitted activity is located or conducted for the purpose of ascertaining compliance with the terms of the permit and with the rules of the Department and to have access to and copy any records that must be kept under conditions of the permit; to inspect the facility, equipment, practices, or operations regulated or required under this permit; and to sample or monitor any substances or parameters at any location reasonably necessary to assure compliance with this permit or Department rules. Reasonable time may depend on the nature of the concern being investigated.

9. At least forty-eight (48) hours prior to commencement of activity authorized by this permit, the permittee shall submit to the Bureau of Beaches and Coastal Systems (JCP Compliance Officer) and the appropriate District office of the Department a written notice of commencement of construction indicating the actual start date and the expected completion date and an affirmative statement that the permittee and the contractor, if one is to be used, have read the general and specific conditions of the permit and understand them.

10. If historic or archaeological artifacts, such as, but not limited to, Indian canoes, arrow heads, pottery or physical remains, are discovered at any time on the project site, the permittee shall immediately stop all activities in the immediate area that disturb the soil in the immediate locale and notify the State Historic Preservation Officer and the Bureau of Beaches and Coastal Systems (JCP Compliance Officer). In the event that unmarked human remains are encountered during permitted activities, all work shall stop in the

immediate area and the proper authorities notified in accordance with Section 872.02, F.S.

11. Within 30 days after completion of construction or completion of a subsequent maintenance event authorized by this permit, the permittee shall submit to the Bureau of Beaches and Coastal Systems (JCP Compliance Officer) and the appropriate District office of the Department a written statement of completion and certification by a registered professional engineer. This certification shall state that all locations and elevations specified by the permit have been verified; the activities authorized by the permit have been performed in compliance with the plans and specifications approved as a part of the permit, and all conditions of the permit; or shall describe any deviations from the plans and specifications, and all conditions of the permit. When the completed activity differs substantially from the permitted plans, any substantial deviations shall be noted and explained on two paper copies and one electronic copy of as-built drawings submitted to the Bureau of Beaches and Coastal Systems (JCP Compliance Officer).

SPECIFIC CONDITIONS:

1. Pursuant to Chapter 161.141, F.S., prior to construction of the beach restoration, the Board of Trustees must establish the line of mean high water for any area affected by this project that does not already have an Erosion Control Line (ECL). This is required to establish the boundary line between sovereignty lands of the state bordering on the Atlantic Ocean and the upland properties between R-53 and R-72. No work shall commence until the Erosion Control Line has been executed to the satisfaction of the Department.

2. All reports or notices relating to this permit shall be sent to the Department's JCP Compliance Officer (e-mail address: JCP Compliance@dep.state.fl.us), unless otherwise specified in the specific conditions.

3. The Permittee shall not store or stockpile tools, equipment, materials, etc., within littoral zones or elsewhere within surface waters of the state without prior written approval from the Department. Storage, stockpiling or access of equipment on, in, over or through hardbottom, seagrass (or other aquatic vegetation) beds or wetlands is prohibited unless within a work area or ingress/egress corridor specifically approved by this permit. Anchoring or spudding of vessels and barges within beds of aquatic vegetation or over hardbottom areas is also prohibited.

4. The Permittee shall not conduct project operations or store project-related equipment in, on or over dunes, or otherwise impact dune vegetation, outside the approved staging, beach access and dune restoration areas designated in the permit drawings.

5. No work shall be conducted under this permit until the Permittee has received a written Notice to Proceed from the Department. At least 30 days prior to the requested date of

issuance of the notice to proceed, the Permittee shall submit a written request for a Notice to Proceed, along with the following items for review and approval by the Department:

a. Final plans and specifications that are consistent with the project description in this permit and the approved permit drawings. Both the estimated direct and secondary impacts, fill volume, and associated project construction dimensions will be updated to reflect the most current pre-construction conditions;

b. Documentation that the Erosion Control Line has been executed and recorded in the County Records;

c. Turbidity monitoring qualifications;

d. Biological monitoring qualifications;

e. Department approved biological monitoring plan.

f. Mitigation plan to include coral transplantation.

6. **Comprehensive Review of the Restoration:** After the beach at Fort Lauderdale (R-53 through R-72) is restored, it will be necessary to evaluate its performance before it is subsequently nourished. Prior to the first nourishment event at Fort Lauderdale (following the initial restoration), the Permittee shall submit a report in accordance with the approved physical and biological monitoring plans to the Department to assess the effects of the project. If the beach restoration did not meet the design expectations or if the adverse impacts exceeded expectations, revisions to the design may be required. Work may not commence on subsequent nourishment activities until after the Permittee receives a written Notice to Proceed, which may require modification of the permit.

7. **Pre-Construction Conference.** The Permittee shall conduct a pre-construction conference to review the specific conditions and monitoring requirements of this permit with Permittee's contractors, the engineer of record, and the JCP Compliance Officer (or designated alternate). In order to ensure that appropriate representatives are available, at least twenty-one (21) days prior to the intended commencement date for the permitted construction, the Permittee is advised to contact the Department, and the other agency representatives listed below:

JCP Compliance Officer
e-mail: JCP Compliance@dep.state.fl.us

DEP District Office
Submerged Lands & Environmental Resources
400 North Congress Avenue, Suite 200

West Palm Beach, FL 33401-2913
(561) 681-6600

The Permittee is also advised to schedule the pre-construction conference at least a week prior to the intended commencement date. At least seven (7) days in advance of the pre-construction conference, the Permittee shall provide written notification, advising the participants (listed above) of the **agreed-upon** date, time and location of the meeting, and also provide a meeting agenda and a teleconference number.

The Permittee may wish to combine this Pre-Construction Conference with the marine turtle Pre-Construction Meeting (see Specific Condition 10).

8. Sediment quality control and quality assurance procedures shall be conducted in accordance with the Sediment Quality Control\Quality Assurance Plan dated September 17, 2012, incorporated by reference as a specific condition for approval. The use of one or more of the following mines is approved as a sand source for construction: Stewart Immokalee Mine, Vulcan Witherspoon Mine, Jahna Ortona Mine and Cemex Davenport Mine.

Marine Turtle Nesting Beach Protection

9. All derelict concrete, metal, and coastal armoring material and other debris shall be removed from the beach prior to any material placement to the maximum extent practicable. If debris removal activities will take place during shorebird breeding or sea turtle nesting seasons, the work shall be conducted during daylight hours only and shall not commence until completion of daily seabird, shorebird or sea turtle surveys each day. All excavations and temporary alterations of the beach topography shall be filled or leveled to the natural beach profile prior to 9 p.m. each day unless otherwise authorized.

10. **Pre-Construction Meeting:** A meeting between representatives of the contractor, the FWS, the FWC, the permitted sea turtle surveyor and other species surveyors as appropriate, shall be held prior to commencement of work on projects. Advance notice of at least 10 business days shall be provided prior to conducting this meeting. The meeting will provide an opportunity for explanation and/or clarification of the protection measures, as well as additional guidelines when construction occurs during nesting season, such as staging equipment and reporting within the work area, as well as follow up meetings during construction.

11. Beach nourishment and restoration shall be started after October 31 and be completed before May 1.

12. Construction-related activities are authorized to occur on the nesting beach (seaward of existing coastal armoring structures or the dune crest) at the beginning and end of the sea

turtle nesting season (March 1 through April 30 and November 1 through November 30) under the following conditions:

a. A daily marine turtle nest survey of the nesting beach in the vicinity of the project (including areas of beach access) shall be conducted starting March 1 and continue through November 30 during the years of construction. In other years, daily surveys shall begin March 1 and continue through October 15. Surveys shall be conducted daily between sunrise and 9 a.m. and shall continue until the last marked nest has hatched to assess hatching success.

b. For sand placement projects that occur during the period from March 1 through April 30 or November 1 through November 30, daily early morning surveys (before 9 a.m.) shall be conducted for sea turtle nests and eggs shall be relocated per the following requirements:

   i. Only those nests on the nourished beach that may be affected by the construction activities shall be relocated. Nests requiring relocation shall be moved no later than 9 a.m. the morning following deposition to a nearby self-release beach site in a secure setting, where artificial lighting will not interfere with hatchling orientation and that has been approved by FWC. Relocated nests shall not be placed in organized groupings. Relocated nests shall be randomly staggered along the length and width of the beach, in settings that are not expected to experience daily inundation by high tides or known to routinely experience severe erosion and egg loss, or that are subject to artificial lighting. Nest relocations in association with construction activities shall cease when sand placement activities no longer threaten nests.

   ii. Nests deposited within areas where construction activities have ceased or will not occur for 65 days, or nests laid in the nourished berm prior to tilling, shall be marked and left in place unless other factors threaten the success of the nest. The turtle permit holder shall install an on-beach marker at the nest site and/or a secondary marker at a point as far landward as possible to assure that future location of the nest will be possible should the on-beach marker be lost. No activity shall occur within this area, nor shall any activities occur that could result in impacts to the nest. Nest sites shall be inspected daily to assure nest markers remain in place and the nest has not been disturbed by the project activity.

c. No construction activity may commence until the marine turtle survey has been completed for the active and upcoming construction area each day and cleared by the permitted sea turtle surveyor present on site.

13. It is the responsibility of the Permittee to ensure that the project area and access sites are surveyed for marine turtle nesting activity. Nesting surveys and egg relocations shall only be conducted by persons with prior experience and training in these activities and who are duly authorized to conduct such activities through a valid permit issued by FWC, pursuant to F.A.C 68E-1. Please contact FWC's Marine Turtle Management Program in Tequesta at MTP@myfwc.com for information on the permit holder in the project area.

14. During the sea turtle nesting season, the contractor shall not extend the beach fill more than 500 feet along the shoreline between dusk and the following day until the daily nesting survey has been completed and the beach cleared for fill advancement. An exception to this may occur if there is permitted sea turtle surveyor present on-site to ensure no nesting and hatching sea turtles are present within the extended work area. If the 500 feet is not feasible for the project, the Permittee may submit a request for an alternate distance to FWC, and FWC will decide if that distance is acceptable during the preconstruction meeting. Once the beach has been cleared and the necessary nest relocations have been completed, the contractor will be allowed to proceed with the placement of fill during daylight hours until dusk, at which time the 500-foot length limitation shall apply.

15. During the period from March 1 through April 30, daytime surveys shall be conducted for leatherback sea turtle nests beginning March 1. Nighttime surveys for leatherback sea turtles shall begin when the first leatherback crawl is recorded within the project or adjacent beach area through April 30, or until completion of the project (whichever is earliest). Nightly nesting surveys shall be conducted from 9 p.m. until 6 a.m. The project area shall be surveyed at 1-hour intervals (since leatherbacks require at least 1.5 hours to complete nesting, this will ensure all nesting leatherbacks are encountered) and eggs shall be relocated per the preceding requirements.

16. Sand compaction shall be monitored in the area of sand placement immediately after completion of the project, and prior to March 1st, for three (3) subsequent years. Compaction shall be monitored in accordance with a protocol agreed to by the FWS, FWC and the Permittee. The requirement for compaction monitoring can be eliminated if the decision is made to till regardless of post-construction compaction levels. Out-year compaction monitoring and remediation are not required if placed material no longer remains on the beach.

    At a minimum, the protocol below shall be followed. If the average value for any depth exceeds 500 pounds per square inch (psi) for any two or more adjacent stations, then that area shall be tilled immediately prior to the following date listed above. If values exceeding 500 psi are distributed throughout the project area, but in no case do those values exist at two adjacent stations at the same depth, then consultation with the FWC or FWS will be required to determine if tilling is required. If a few values exceeding 500 psi are present randomly within the project area, tilling will not be required.

a. Compaction sampling stations shall be located at 500-foot intervals along the project area. One station shall be at the seaward edge of the dune/bulkhead line (when material is placed in this area), and one station shall be midway between the dune line and the high water line (normal wrack line).

b. At each station, the cone penetrometer shall be pushed to a depth of 6, 12 and 18 inches, three times at each depth (three replicates). Material may be removed from the hole if necessary to ensure accurate readings of successive levels of sediment. The penetrometer may need to be reset between pushes, especially if sediment layering exists. Layers of highly compact material may lie over less compact layers. Replicates shall be located as close to each other as possible, without interacting with the previous hole and/or disturbed sediments. The three replicate compaction values for each depth shall be averaged to produce final values for each depth at each station. Reports shall include all 18 values for each transect line, and the final 6 averaged compaction values.

c. No compaction sampling shall occur within 300 feet of any shorebird nest.

d. Any vehicles operated on the beach in association with compaction surveys shall operate in accordance with the FWC's Best Management Practices for Operating Vehicles on the Beach (http://myfwc.com/conservation/you-conserve/wildlife/beach-driving/).

17. If tilling is required as specified above, the area shall be tilled to a depth of 36 inches. All tilling activity shall be completed prior to the marine turtle nesting season. If tilling occurs during shorebird nesting season, shorebird surveys prior to tilling shall be required per the Shorebird Conditions included within this document. It is the responsibility of the contractors to avoid tilling, scarp removal, or dune vegetation planting in areas where nesting birds are present. Each pass of the tilling equipment shall be overlapped to allow thorough and even tilling. If the project is completed during the marine turtle nesting season, tilling shall not be performed in areas where nests have been left in place or relocated. If compaction measurements are taken, a report on the results of the compaction monitoring shall be submitted electronically to FWC at marineturtle@myfwc.com prior to any tilling actions being taken.

a. No tilling shall occur within 300 feet of any shorebird nest.

b. If flightless shorebird young are observed within the work zone or equipment travel corridor, a Shorebird Monitor shall be present during the operation to ensure that equipment does not operate within 300 feet of the flightless young.

c. A relatively even surface, with no deep ruts or furrows, shall be created during tilling. To do this, chain-linked fencing or other material shall be dragged over those areas as necessary after tilling.

d. Tilling shall occur landward of the wrack line and avoid all vegetated areas 3 square feet or greater with a 3-foot buffer around the vegetated areas. The slope between the mean high water line and the mean low water line shall be maintained in such a manner as to approximate natural slopes.

e. Any vehicles operated on the beach in association with tilling shall operate in accordance with the FWC's Best Management Practices for Operating Vehicles on the Beach (http://myfwc.com/conservation/you-conserve/wildlife/beach-driving/).

18. Weekly visual surveys for escarpments along the project area shall be made immediately after completion of the sand placement and prior to February 1st for three (3) subsequent years if sand from the project still remains on the beach. Weekly reports shall be submitted by Friday each week to marineturtle@myfwc.com.

Escarpments that interfere with sea turtle nesting or that exceed 18 inches in height for a distance of at least 100 feet shall be leveled and the beach profile shall be reconfigured to minimize scarp formation by March 1st. Any escarpment removal shall be reported by location to FWC. If the project is completed during the sea turtle nesting and hatching season, escarpments may be required to be leveled immediately, while protecting nests that have been relocated or left in place. If, during the nesting and hatching season, there is any subsequent reformation of escarpments that interfere with sea turtle nesting or that exceed 18 inches in height for a distance of 100 feet, the Permittee shall immediately contact FWC to determine the appropriate action to be taken. If it is determined that escarpment leveling is required during the nesting or hatching season, the FWS or FWC will provide a brief written authorization that describes methods to be used to reduce the likelihood of impacting existing nests. An annual summary of escarpment surveys and actions taken shall be submitted electronically to marineturtle@myfwc.com along with the annual summary as described below. If escarpment removal occurs during shorebird breeding season, shorebirds surveys shall be required prior to removal per the *Shorebird Conditions* included within this document. (NOTE: Out-year escarpment monitoring and remediation are not required if placed material no longer remains on the dry beach).

a. No heavy equipment shall operate within 300 feet of any shorebird nest.

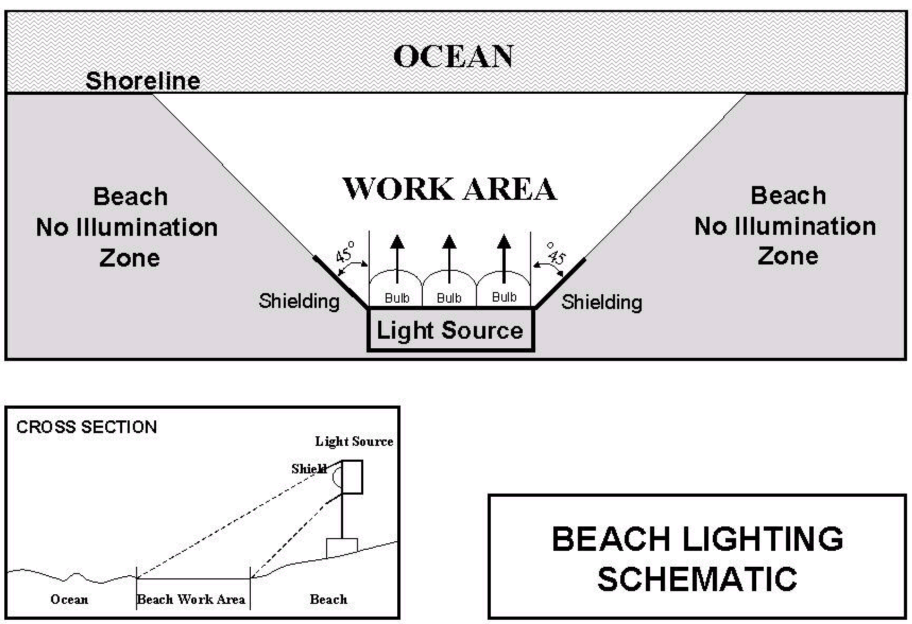
b. If flightless shorebird young are observed within the work zone or equipment travel corridor, a Shorebird Monitor shall be present during the operation to ensure that equipment does not operate within 300 feet of the flightless young.

c. Any vehicles operated on the beach in association with escarpment surveys or removal shall operate in accordance with the FWC's Best Management Practices for Operating Vehicles on the Beach (http://myfwc.com/conservation/you-conserve/wildlife/beach-driving/).

d. All Terms and Conditions in the FWS Programmatic Piping Plover Biological Opinion, dated May 22, 2013, shall be met as required in that document.

e. Staging areas for construction equipment shall be located off the beach from March 1 through April 30 and November 1 through November 30, if off-beach staging areas are available. Nighttime storage of construction equipment not in use shall be off the beach to minimize disturbance to sea turtle nesting and hatching activities.

Figure 1.



Construction activities shall be limited to daylight hours only: therefore, no direct lighting of the beach and nearshore waters shall occur during construction. If lighting of onshore equipment becomes necessary, lighting shall be minimized through reduction, shielding, lowering, and appropriate placement to avoid excessive illumination of the water's surface and nesting beach while meeting all Coast Guard, EM 385-1-1, and OSHA requirements. Light intensity of lighting equipment shall be reduced to the minimum standard required by OSHA for General Construction areas, in order not to misdirect sea turtles. Shields shall be affixed to the light housing and be large enough to block light from all lamps from being transmitted outside the construction area (**Figure 1**).

19. In the event a sea turtle nest is excavated during construction activities, the permitted person responsible for egg relocation for the project shall be notified immediately so the eggs can be moved to a suitable relocation site.

20. Upon locating a dead or injured sea turtle adult, hatchling, or egg that may have been harmed or destroyed as a direct or indirect result of the project, the Permittee shall be responsible for notifying the Sea Turtle Stranding and Salvage Network (STSSN) at SeaTurtleStranding@myfwc.com. Care shall be taken in handling injured sea turtles or eggs to ensure effective treatment or disposition, and in handling dead specimens to preserve biological materials in the best possible state for later analysis.

Nesting Seabird and Shorebird Protection Conditions

21. Nesting seabird and shorebird (i.e. shorebird) surveys should be conducted by trained individuals (Bird Monitor) with proven shorebird identification skills and avian survey experience. In the event that a suitable individual cannot be found, the Permittee shall contact the FWC Regional Species Biologist (Figure 2) for further direction. A qualified Bird Monitor(s), with their contact information, summary of qualifications, including bird identification skills, and avian survey experience, shall be provided to FWC prior to any construction or hiring for shorebird surveys and consultation. Bird Monitors shall use the following survey protocols:

    a. Bird Monitors shall review and become familiar with the general information, employ the data collection protocol, and implement data entry procedures outlined on the FWC's Florida Shorebird Database (FSD) website (www.FLShorebirdDatabase.org). An outline of data to be collected, including downloadable field data sheets, is available on the website.

    b. Breeding season varies by species. Most species have completed the breeding cycle by September 1, but flightless young may be present through September. The following dates are based on the best available information regarding ranges and habitat use by species around the state:

Broward County	1 April through 1 September

    Breeding season surveys shall begin on the first day of the breeding season, or 10 days prior to project commencement (including surveying activities and other pre-construction presence on the beach), whichever is later. During construction related activities, surveys shall be conducted through August 31st or until all breeding activity has concluded.

    c. Breeding season surveys shall be conducted in all potential beach-nesting bird habitats within the project boundaries that may be impacted by construction or pre-construction activities. Areas that do not include project-related activities may be excluded from surveys. One or more shorebird survey routes shall be established in the FSD website to cover these areas.

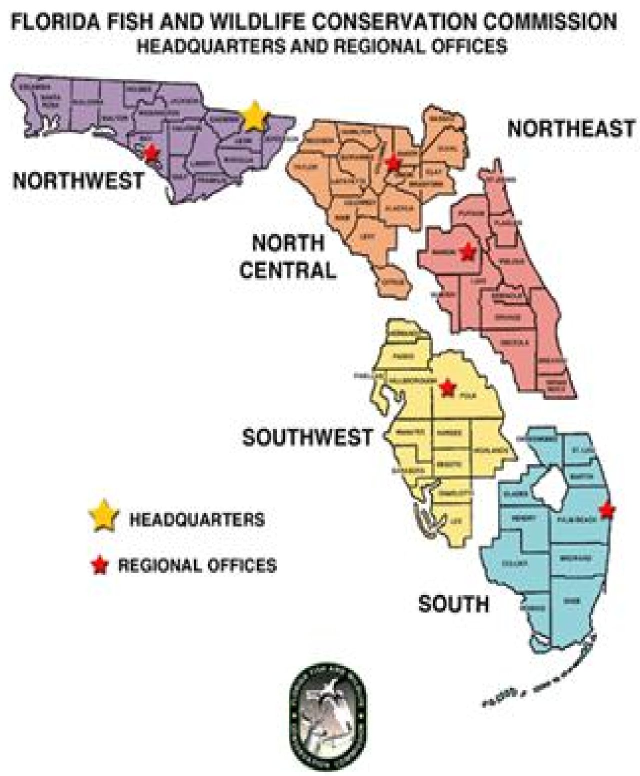
d. During the pre-construction and construction phases of the project, surveys for detecting breeding activity and the presence of flightless chicks shall be completed on a daily basis prior to movement of equipment, operation of vehicles, or other activities that could potentially disrupt breeding behavior or cause harm to the birds or their eggs or young.

e. Surveys shall be conducted by walking the length of the project area and visually surveying for the presence of shorebirds exhibiting breeding behavior, shorebird/seabird chicks or shorebird/seabird juveniles, as outlined in the FSD *Breeding Bird Protocol for Shorebirds and Seabirds*. Use of binoculars is required.

If an ATV or other vehicle is needed to cover large project areas, operators shall adhere to the FWC's Best Management Practices for Operating Vehicles on the Beach (http://myfwc.com/conservation/you-conserve/wildlife/beach-driving/). Specifically, the vehicle shall be operated at a speed <6 mph and run at or below the high-tide line. The Bird Monitor shall stop at no greater than 200 meter intervals to visually inspect for breeding activity.

f. Once breeding is confirmed by the presence of a scrape, eggs or young, the Bird Monitor shall notify the FWC Regional Species Conservation Biologist (**Figure 2**) within 24 hours. All breeding activity shall be reported to the FSD website within one week of data collection.

Figure 2.
Florida Fish and Wildlife Conservation Commission
Regional Species Biologist - Contacts for Shorebird Issues



Northwest Region
Dr. John Himes
FL Fish and Wildlife
Conservation Commission
3911 Highway 2321
Panama City, FL 32409-1658
(850) 265-3676

North Central Region
Dr. Terry Doonan
FL Fish and Wildlife
Conservation Commission
P.O. Box 177
Olustee, FL 32072
(386) 758-0525

Northeast Region
Mr. Alex Kropp
FL Fish and Wildlife
Conservation Commission
1239 S.W. 10th Street
Ocala, FL 34474-2797
(352) 732-1225

Southwest Region
Ms. Nancy Douglass
FL Fish and Wildlife
Conservation Commission
3900 Drane Field Road
Lakeland, FL 33811-1299
(863) 648-3205

South Region
Mr. Ricardo Zambrano
FL Fish and Wildlife
Conservation Commission
8535 Northlake Boulevard
West Palm Beach, FL 33412
(561) 625-5122

22. **Seabird and Shorebird Buffer Zones and Travel Corridors:** Within the project area, the Permittee shall establish a disturbance-free buffer zone around any location where shorebirds have been engaged in breeding behavior, including territory defense. A 300 foot-wide buffer is considered adequate based on published studies. However, a smaller, site-specific buffer may be implemented upon approval by the FWC Regional Species Conservation Biologist (**Figure 2**) as needed. All sources of human disturbance (including pedestrians, pets and vehicles) shall be prohibited in the buffer zone.

    a. The Bird Monitor shall keep breeding sites under sufficient surveillance to determine if birds appear agitated or disturbed by construction or other activities in adjacent areas. If birds do appear to be agitated or disturbed by these activities, then the width of the buffer zone shall be increased immediately to a sufficient size to protect breeding birds.

    b. Reasonable and traditional pedestrian access should not be blocked where breeding birds will tolerate pedestrian traffic. This is generally the case with lateral movement of beach-goers walking parallel to the beach at or below the highest tide line. Pedestrian traffic may also be tolerated when breeding was initiated within 300 feet of an established beach access pathway. The Permittee shall work with the FWC Regional Species Biologist to determine if pedestrian access can be accommodated without compromising nesting success.

    c. Designated buffer zones shall be marked with posts, twine and signs stating “Do Not Enter, Important Nesting Area” or similar language around the perimeter that includes the name and a phone number of the entity responsible for posting. Posts should not exceed 3 feet in height once installed. Symbolic fencing (twine, string or rope) should be placed between all posts at least 2.5 feet above the ground and rendered clearly visible to pedestrians. If pedestrian pathways are approved by the FWC Regional Species Conservation Biologist within the 300foot buffer zone, these should be clearly marked. The posting shall be maintained in good repair until breeding is completed or terminated. Although solitary nesters may leave the buffer zone with their chicks, the posted area continues to provide a potential refuge for the family until breeding is complete. Breeding is not considered to be completed until all chicks have fledged.

    d. No construction activities, pedestrians, movement of vehicles or stockpiling of equipment shall be allowed within the buffer area.

    e. Travel corridors shall be designated and marked outside the buffer areas so as not to cause disturbance to breeding birds. Heavy equipment, other vehicles or pedestrians may transit past breeding areas in these corridors. However, other activities such as stopping or turning shall be prohibited within the designated travel corridors adjacent to the breeding site. When flightless chicks are present within or adjacent to travel corridors, movement of vehicles shall be accompanied by the Bird Monitor who will ensure no chicks are in the path of the moving vehicle and no tracks capable of trapping flightless chicks result.

f. To discourage nesting within the travel corridor, it is recommended that the Permittee should maintain some activity within these corridors on a daily basis, without disturbing any nesting shorebirds documented on site or interfering with sea turtle nesting, especially when those corridors are established prior to commencement of construction.

23. **Notification.** If shorebird breeding occurs during construction activities, a bulletin board shall be placed and maintained in the construction staging area with the location map of the construction site showing the bird breeding areas and a warning, clearly visible, stating that "NESTING BIRDS ARE PROTECTED BY LAW INCLUDING THE FLORIDA ENDANGERED AND THREATENED SPECIES ACT AND THE STATE and FEDERAL MIGRATORY BIRD ACTS".

Post-construction Monitoring and Reporting Marine Turtle Protection Conditions:

24. Reports on all marine turtle nesting activity shall be provided for the initial marine turtle nesting and hatching season (March 1 through November 15) and for up to three additional nesting seasons as follows:

a. For the initial nesting season and the following year, the number and type of emergences (nests or false crawls) shall be reported per species in accordance with **Table 1**. An additional year of nesting surveys may be required if nesting success for any species on the nourished beach is less than 40%.

b. For the initial nesting season, reproductive success shall be reported per species in accordance with **Table 1**. Reproductive success shall be reported for all sea turtle nests if possible. Otherwise a statistically significant number of nests for each species shall be reported.

c. In the event that the reproductive success documented by species meets or exceeds required criteria in accordance with **Table 1**, monitoring for reproductive success shall be recommended, but not required for the second year post-construction.

d. Monitoring of nesting activity in the seasons following construction shall include daily surveys and any additional measures authorized by the FWC. Summaries shall include all crawl activity, nesting success rates, hatching success of all relocated nests, hatching success of a representative sampling of nests left in place (if any) by species, project name, applicable project permit numbers and dates of construction.

Data shall be reported for the nourished areas and shall include number of nests lost to erosion or washed out. Summaries of nesting activity shall be submitted in electronic format (Excel spreadsheets) to the FWC Imperiled Species Management section at MTP@myfwc.com. All summaries shall be submitted by January 15 of the following year. The FWC Excel spreadsheet is available upon request from MTP@myfwc.com.

Table 1. Marine Turtle Monitoring:

Metric	Duration	Variable	Criterion
Nesting Success	Year of construction, one year to two or three years post construction if placed sand remains on beach and variable does not meet criterion based on previous year	Number of nests and non-nesting emergences by day by species	40% or greater
Hatching Success	Year of construction and one to three years post construction if placed sand remains on beach and variable does not meet criterion based on previous year	Number of hatchlings by species to completely escape egg	Average of 60% or greater (data must include washed out nests)
Emergence Success	Year of construction and one to three years post construction if placed sand remains on beach and variable does not meet success criterion based on previous year	Number of hatchlings by species to emerge from nest onto beach	Average must not be significantly different than the average hatching success
Disorientation	Year of construction and one to three years post construction if placed sand remains on beach	Number of nests and individuals that misorient or disorient	
Lighting Surveys	Two surveys the year following construction , one survey between May 1 and May 15 and second survey between July 15 and August 1	Number, location and photographs of lights visible from nourished berm, corrective actions and notifications made	100% reduction in lights visible from nourished berm within one to two month period
Compaction	Not required if the beach is tilled prior to nesting season each year placed sand remains on beach	Shear resistance	Less than 500 psi
Escarpment Surveys	Weekly during nesting season for up to three years each year placed sand remains on the beach	Number of scarps 18 inches or greater extending for more than 100 feet that persist for more than 2 weeks	Successful remediation of all persistent scarps as needed

25. Two lighting surveys shall be conducted of all artificial lighting visible from the nourished berm. The first survey shall be conducted prior to construction, with a second survey conducted immediately post-construction. The survey shall be conducted to include a landward view from the seaward most extent of the new beach profile. The survey should follow standard techniques for such a survey and include number and type of visible lights, location of lights and photo documentation. A report summarizing all lights visible shall be submitted to FWC Imperiled Species Management Section at marineturtle@myfwc.com by the 1st of the month following the survey. A summary report shall be provided, documenting what corrective actions have been taken, and all compliance and enforcement actions shall also be submitted by December 15 of that year. After the annual report is completed, a meeting shall be set up with the Permittee, FWC and the FWS to discuss the survey report, as well as any documented sea turtle disorientations in or adjacent to the project area.

MONITORING REQUIRED:

26. Physical monitoring shall be conducted in accordance with the Physical Monitoring Plan dated May 31, 2013, incorporated by reference as a specific condition for approval.

27. Water Quality - Turbidity shall be monitored as follows:

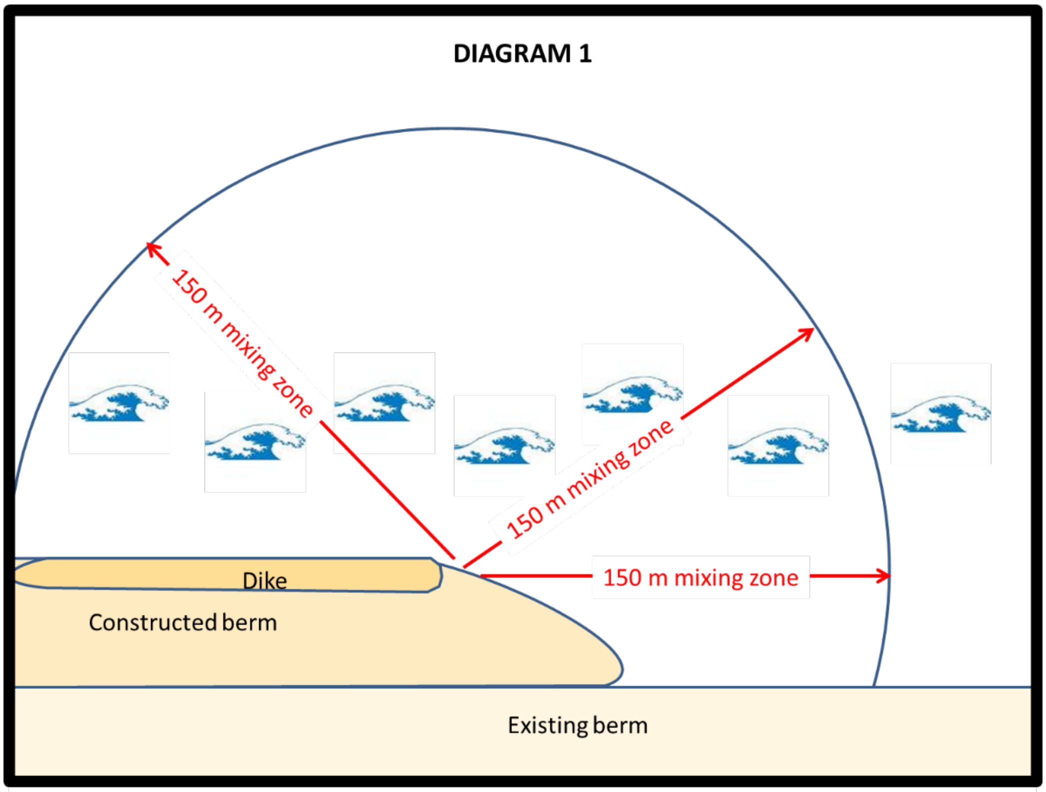
Units: Nephelometric Turbidity Units (NTUs).

Frequency: Three (3) times per day, at least 4 hours apart, during all filling operations. Sampling shall be conducted **while the highest project-related turbidity levels are crossing the edge of the mixing zone.** The compliance samples and the corresponding background samples shall be collected at approximately the same time, i.e., one shall immediately follow the other.

Location: Background: At surface, mid-depth, and (for sites with depths greater than 25 feet) 2 meters above the bottom, clearly outside the influence of any artificially generated turbidity plume or the influence of an outgoing inlet plume. Samples shall be collected at least 300 meters up-current from any portion of the beach that has been, or is being, filled during the current construction event, at the same distances offshore as the associated compliance samples.

Compliance: At surface, mid-depth, and (for sites with depths greater than 25 feet) 2 meters above the bottom. Samples shall be collected in the densest portion of the turbidity plume, where the plume intercepts the nearest edge of hardbottom lying beyond the equilibrium toe of fill (ETOF) or at 150 meters downcurrent from the point of discharge into the Atlantic

Ocean**, whichever is closest**. *Note: If the plume flows parallel to the shoreline, the densest portion of the plume may be close to shore, in shallow water. In that case, it may be necessary to access the sampling location from the shore, in water that is too shallow for a boat. See Diagram 1.*



Calibration: The instruments used to measure turbidity shall be fully calibrated with primary standards within one month of the commencement of the project, and at least once a month throughout the project. Calibration with secondary standards shall be verified each morning prior to use, after each time the instrument is turned on, and after field sampling using two secondary turbidity "standards" that that bracket the anticipated turbidity samples. If the post-sampling calibration value deviates more than 8% from the previous calibration value, results shall be reported as estimated and a description of the problem shall be included in the field notes.

Analysis of turbidity samples shall be performed in compliance with DEP-SOP-001/01 FT 1600 Field Measurement of Turbidity:

http://publicfiles.dep.state.fl.us/dear/sas/sopdoc/2008sops/ft1600.pdf

If the turbidity monitoring protocol specified above prevents the collection of accurate data, the person in charge of the turbidity monitoring shall contact the JCP Compliance Officer to establish a more appropriate protocol. Once approved in writing by the Department, the new protocol shall be attached to the permit and shall be implemented without the need for a formal permit modification.

28. The **compliance** locations given above shall be considered the limits of the temporary mixing zone for turbidity allowed during construction. If monitoring reveals turbidity levels at the **compliance** sites that are greater than 29 NTUs above the corresponding background turbidity levels, construction activities shall **cease immediately** and not resume until corrective measures have been taken and turbidity has returned to acceptable levels. This turbidity monitoring shall continue every hour until background turbidity levels are achieved or until otherwise directed by the Department. The Permittee shall notify the Department's JCP Compliance Officer via email at JCP Compliance@dep.state.fl.us of such an event within 24 hours, and send a copy to the Department's Southeast District office. The subject line of the email shall state "TURBIDITY EXCEEDANCE". When reporting a turbidity exceedance, the following information shall also be included:

    a. the Project Name; the Permit Number; location and level (NTUs above background) of the turbidity exceedance;

    b. the time and date that the exceedance occurred; and

    c. the time and date that construction ceased.

    Prior to re-commencing the construction, a report shall be emailed to the Department with the same information that was included in the "Exceedance Report", plus the following information:

    a. turbidity monitoring data collected during the shutdown documenting the decline in turbidity levels and achievement of acceptable levels;

    b. corrective measures that were taken; and

    c. cause of the exceedance.

TURBIDITY REPORTS

29. Turbidity Reports. All turbidity monitoring data shall be submitted within one week of analysis. The data shall be presented in tabular format, indicating the measured turbidity levels at the compliance sites for each depth, the corresponding background levels at each depth and the number of NTUs over background at each depth. Any exceedances of the turbidity standard (29 NTUs above background) shall be highlighted in the table. In addition to the raw and processed data, the reports shall also contain the following information:

a. time of day samples were taken;

b. dates of sampling and analysis;

c. GPS location of sample

d. depth of water body;

e. depth of each sample;

f. antecedent weather conditions, including wind direction and velocity;

g. tidal stage and direction of flow;

h. water temperature;

i. a map (overlaid on an aerial photograph) indicating the sampling locations, discharge locations, and direction of flow;

j. a statement describing the methods used in collection, handling, storage and analysis of the samples;

k. a statement by the individual responsible for implementation of the sampling program concerning the authenticity, precision, limits of detection, calibration of the meter and accuracy of the turbidity and GPS data;

l. When samples cannot be collected, include an explanation in the report. If unable to collect samples due to severe weather conditions, include a copy of a current report from a reliable, independent source, such as an online weather service.

Monitoring reports shall be submitted by email to the JCP Compliance Officer. In the subject line of the reports, on the cover page to the submittal and at the top of each page, include the Project Name, Permit Number and the dates of the monitoring interval. Failure to submit reports in a timely manner constitutes grounds for revocation of the permit.

Nearshore Hardbottom Monitoring:

30. Monitoring of nearshore hardbottom communities shall be conducted to document any unanticipated impacts from project construction, such as degradation of communities due to burial and/or sedimentation and scouring effect of excessive sediment transport, and shall include monitoring of nearshore hardbottom east (seaward) of the ETOF and the hardbottom adjacent to the construction template in both long shore directions. Monitoring shall be conducted in summer before construction, immediately after construction (immediately after construction survey shall be conducted in early post-

construction summer after initial placement) and then years 1, 2 and 3 post-construction (total of 5 surveys) during summer (May through September).

31. Nearshore monitoring shall include hardbottom edge mapping, monitoring of permanent transects and use of aerial imagery. Monitoring of *Acropora cervicornis* (a listed scleractinian coral) shall be conducted along the project area, in specially designated stations.

   a. Nearshore hardbottom edge mapping shall be conducted by a diver equipped with a DGPS antenna. Mapping shall include the project extent, 1,000 meters downdrift of the project construction template and 600 meters updrift.

   b. 150-meter long transects shall be established during the pre-construction survey, starting from the ETOF or nearshore hardbottom edge. The Permittee shall conduct the following: video survey, quadrat sampling, line-intercept records of sand patches (over 0.5 meter long by interception), and 1-meter interval sediment depth measurements along transects.

      i. Video surveys: A video survey shall be conducted of the entire 150-meter long transect at each location.

         1. Each transect shall be sampled using high-definition digital video. For the 150-meter transect, the diver shall swim at a speed of 20 meters/5 minutes (~4-5 meters/minute) with a constant camera distance of 35 cm. If the diver is moved off the transect by surge, the diver shall return to the point where he/she was disturbed by the wave action, and resume filming at that point. The video transects shall be reviewed during the course of the survey to ensure that there are no gaps in the data due to diver error and that the quality of the video is acceptable for video analysis. Any missing video transect data or poor quality video shall be re-filmed during the course of the event.

         2. Landscape panoramic views shall be recorded with the digital video camera at the start and end of each transect, and at each interruption of the transect by a sand gap/recommencement at the next hardbottom ridge or hardbottom exposure. Additionally, close-up video of the tag marking the eyebolt at these locations or meter mark on the transect line shall be filmed for a frame of reference for the observer viewing the video record. Close-up digital still video and/or photographs shall be obtained of representative benthos along each transect to aid in identification during video analysis. Still photographs shall be obtained using the digital camera to document vertical ledges, large colonies of

scleractinian corals (if observed) along the transect or adjacent to transect (within underwater visibility during transect establishment), and changes in benthic landscape along the transect. Voucher sampling of macroalgae shall be conducted as needed to assist with video/photo identification of macroalgae genera.

3. Each video transect shall be reviewed for qualitative changes in benthic community cover/composition in comparison to the pre-construction surveys, and previous annual surveys. If the qualitative review of the video transect suggests sedimentation impacts or cross-shore transport of sediments over the benthic community along the remaining portions of the transect, and the results of the sedimentation monitoring and quadrat assessments indicate burial of hardbottom communities, additional quantitative analysis of the video transects may be required as directed by the Department to determine the extent of the Project-related impacts.

ii. Quadrat Sampling: Each transect shall have 1-meter^2 permanent quadrat sampling stations, with the first one being located along the nearshore hardbottom edge. Quadrats shall not be established in sand gaps between hardbottom ridges or sand patches; however if covered by sand during the monitoring period quadrats remain in the place where they were originally established.

1. Within each quadrat, a visual estimate shall be conducted of the percent cover and genus / species identification (if specified in parenthesis) for following functional groups: macroalgae (identification and percent cover of two dominant species within quadrat), turf algae, cyanobacteria, encrusting calcareous algae, sponges, with a separate assessment of percent cover of boring sponge (*Cliona/Piona* spp), tunicates, zoanthids, hydroids, worm rock (*Phragmatopoma lapidosa*), octocorals (genus level), and scleractinian corals (species level).

2. Individual counts shall be conducted for all octocorals, scleractinian corals, and sponges (not including *Cliona* spp.) within the quadrat.

3. Percent cover of exposed hardbottom substrate, coarse unconsolidated substrate (rubble, shell hash, rhodoliths), and sand shall be recorded, in addition to the maximum physical relief of hardbottom from the lowest point to highest point in the quadrat.

ii. Line-intercept measurements of sand patches of greater than 0.5 meter intercepting each transect shall be conducted.

iv. Interval sediment depth measurements shall be conducted at each meter mark along the entire length of transect.

c. The following shall be provided to the Department within 60 days of completion of the survey: all raw data from the hardbottom surveys including data sheets; Excel spreadsheet with all quadrat data, data of interval sediment measurements and line-intercept data; shape file of hardbottom edge survey, videos and photos.

d. A nearshore hardbottom monitoring report shall be prepared and submitted to the Department for review within 90 days of the completion of each of the following post-construction monitoring events: immediate post-construction, first annual, second annual, and third annual survey. Commencement of annual survey shall be reported the same day, and then monitoring progress shall be reported weekly until the completion of each survey, at which point the JCP Compliance Officer shall be notified that the survey is complete. The immediate post-construction report, and all following reports, shall compare data to pre-construction results and to each previous post-construction report. A final report shall be prepared following the conclusion of the third year of post-construction monitoring and shall summarize and compare data of all reports. Reports shall analyze and discuss any observed burial, sedimentation, or changes to benthic communities based on the monitoring. Data shall be analyzed to determine any unpredicted direct and secondary impacts to hardbottom communities from the Broward County Shore Protection Project Segment II. Each annual report shall also include the results of the annual summer hardbottom delineation and a comparison of exposed hardbottom acreage delineated during all hardbottom investigations.

Annual monitoring reports shall include: 1) A map including the project area and adjacent hardbottom resources and monitoring transects overlaid onto recent, clear aerial photographs (in digital format); 2) Analysis of sedimentation on the transects outside the ETOF (including the updrift and downdrift hardbottom monitoring sites) based on line-intercept data, interval sediment depth measurements and data from quadrats; 3) Multivariate analysis of quantitative data with subsequent analysis of benthic biological components on the transects east of the ETOF (*e.g.*, percent cover and density by corals, octocorals, sponges and algae); 4) A comparison of post-construction monitoring results to pre-construction monitoring results; 5) A figure comparing the most recent annual hardbottom delineation and all previous hardbottom delineations; 6) Calculation of buried and exposed hardbottom acreage and comparison to previous hardbottom acreages; and 7) The report and all data shall be provided in digital format.

Nearshore Hardbottom Mitigation:

32. To further minimize the potential impacts to the hardbottom community, the Permittee shall transplant coral species from the project site to suitable sites that will not be affected by beach nourishment or restoration. Prior to construction, the Permittee shall submit a Coral Transplantation Plan to the Department for review and approval. The Plan shall depict a suitable location, species to be considered and size to be considered for transplantation.

33. Based on the UMAM analysis of impacts performed by the Department, this permit only approves 4.9 acres of impacts to nearshore hardbottom, mitigated by a 6.8-acre artificial reef.

34. Artificial reefs, consisting of modules, shall be constructed as mitigation to offset the impacts to hardbottom. The perimeter of the mitigation site shall encompass an area within 10 acres, and the actual footprint of the artificial reefs shall cover 6.8 acres of the sea floor. The modules shall be placed in single layers at least 2-feet high and no shallower than 8 feet in depth.

35. Immediately following construction of the artificial reef, divers shall conduct a line-intercept survey as part of the as-built survey in order to estimate percent of net reef cover. During the line-intercept survey, divers shall swim the length of each transect and record the presence of artificial reef substrate on the transect line. Based on the data collected along all transects, the percent net module cover and percent sand cover within the artificial reef site shall be calculated and reported. The goal of this is to ensure that the artificial reef reflects a similar hardbottom to sand ratio as the natural hardbottom as determined by the baseline and/or pre-construction survey(s).

36. Within 30 days following construction of the artificial reef, the Permittee shall complete the Florida Fish & Wildlife Conservation Commission's ***FLORIDA ARTIFICIAL REEF MATERIALS PLACEMENT REPORT AND POST-DEPLOYMENT NOTIFICATION*** using the form provided on their web page: http://myfwc.com/docs/Conservation/FWCArtificialReefMaterialPlacementReport.pdf. The completed form shall be submitted to the Florida Fish & Wildlife Conservation Commission, Division of Marine Fisheries, Artificial Reef Program, 620 S. Meridian Street, Tallahassee, FL 32399 and a copy e-mailed to the JCP Compliance Officer. In addition to attaching the completed form, please indicate on the e-mail that the information is being submitted for the Broward County Segment II Restoration project, Permit No. 0314535-001-JC.

Mitigation Monitoring and Success Criteria:

37. In order to monitor benthic colonization and succession, the following monitoring protocol shall be followed in accordance with the approved mitigation plan:

a. The Permittee shall establish random cross-shore monitoring transects on the artificial reef, and shall conduct monitoring using video survey and quadrat sampling as described in Specific Condition 31, above. Monitoring of the artificial reef shall occur annually during summer months for three years following construction.

b. Mapping of Artificial Reef. During the final (third) monitoring survey on the Artificial Reef, biologists shall also map the artificial reef in order to determine the total acreage.

c. Success criteria. Success would be achieved when the benthic community and colonization of the mitigation reef has been documented to be comparable to the benthic community and species composition documented in the impact area during the preconstruction survey. The criteria for successful mitigation shall be defined by: 1) An obvious trend toward similarity in the benthic community between the artificial reef and the natural hardbottom by the time of the completion of the monitoring period; 2) percent cover by each of the major groups of organisms (functional groups) in the mitigation site shall be no less than it was in the impact site (difference shall be statistically insignificant); and 3) a line-intercept survey shall demonstrate that net amount of reef *versus* sand did not change from the time of construction due to subsidence (not more than 5% buried from results of initial survey).

d. Reports. A first (one year after construction), second and third annual artificial reef monitoring report shall be provided within 90 days of the completion of each annual monitoring event, for three years following placement of the artificial reef. Monitoring progress shall be reported weekly until the completion of each survey, at which point the JCP Compliance Officer shall be notified that the survey is complete. Each annual report shall document the colonization of the artificial reef and compare the species composition on this reef to that documented in the impact area during the preconstruction survey.

Annual monitoring reports shall include: 1) A map including the project, adjacent hardbottom resources and monitoring transects, the artificial reef and associated monitoring transects overlaid onto recent, clear aerial photographs; 2) An analysis of quantitative data on benthic biological components on artificial reef monitoring transects (e.g., percent cover by corals, octocorals, sponges, and algae); 3) A comparative analyses of the artificial reef and natural hardbottom communities in the area of impact to determine mitigation success; 4) Current acreage of artificial reef (for Final report only); and 5) Video and photo documentation; and 6) The Report and all data shall be provided in digital format on external hard drive.

Executed in Tallahassee, Florida.

STATE OF FLORIDA DEPARTMENT
OF ENVIRONMENTAL PROTECTION

Danielle H. Irwin, Deputy Director
Division of Water Resource Management

FILING AND ACKNOWLEDGMENT

FILED, on this date, pursuant to Section 120.52, Florida Statutes, with the designated Department Clerk, receipt of which is hereby acknowledged.

Deputy Clerk	01/31/2014 Date

Attachments: Permit Drawings (approved January 31, 2014)
Physical Monitoring Plan (dated May 31, 2013)
QA/QC Plan (dated September 17, 2012)

DRAFT

CORAL TRANSPLANTATION PLAN

FOR THE

BROWARD COUNTY SHORE PROTECTION PROJECT

SEGMENT II

FDEP PERMIT NUMBER: 0314535-001-JC

USACE PERMIT NUMBER: SAJ-1999-05545 (SP-GGL)

TABLE OF CONTENTS

FIGURES

TABLES

INTRODUCTION

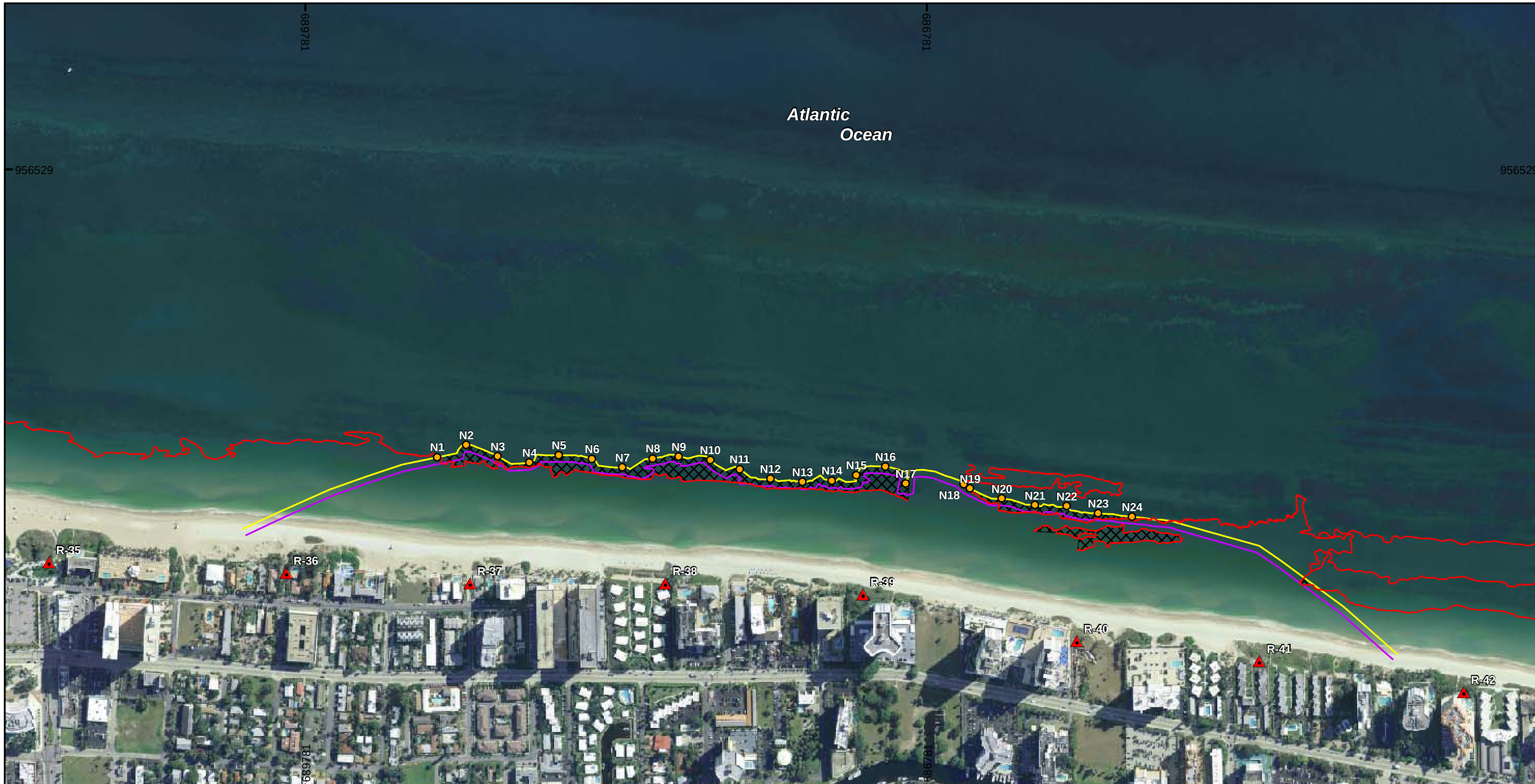
This Coral Transplantation Plan was prepared in compliance with the Broward County Shore Protection Project (SPP) Segment II Florida Department of Environmental Protection (FDEP) Permit Number 0314535-001-JC, Specific Condition No. 32 which requires an FDEP-Approved Coral Transplantation Plan prior to construction.

The equilibrium toe of fill (ETOF) overlaps 4.9 acres of nearshore natural hardbottom and may result in burial of coral colonies located within this habitat. In order to minimize these impacts, coral colonies that meet specific criteria will be transplanted out of the impact area to suitable relocation areas. A subset of the transplanted colonies will be monitored for attachment success and growth. Based on data collected from quadrats sampled within 50 meters from the hardbottom edge during the Segment II baseline characterization survey (CB&I, 2012), it is estimated that more than 2000 qualifying (≥ 10 cm maximum diameter of live tissue) stony coral colonies may be present within the investigation area.

1.0 CORAL TRANSPLANT INVESTIGATION

Marine biologists will survey the area where the equilibrium toe of fill (ETOF) overlaps the nearshore natural hardbottom (impact area) to locate qualifying stony coral colonies for relocation. The search area within the ETOF will be guided by areas of hardbottom determined from the 2011 hardbottom delineation (CB&I, 2012). If additional hardbottom is exposed at the time of the investigation, it will be surveyed as well. The investigation area will also include a 10 m buffer zone east and parallel to the ETOF (Figure 1). Qualifying coral colonies located in the buffer zone will also be removed and transplanted as a conservative measure in the event of any unanticipated project impacts.

Survey points are proposed every 50 m along the ETOF buffer line to guide the investigation and create manageable survey sites (Figure 1). Each survey site will be 50 m in length (north to south) and will vary in width (east to west) depending on the extent of exposed hardbottom within the ETOF. Buoys will be dropped at two consecutive survey point locations to mark the northeast and southeast boundaries of each survey site. The hardbottom edge will serve as the western margin of each survey site. Two biologists will investigate each site beginning at the northeast corner and swimming west to the hardbottom edge. They will then swim south 10 m (counting kicks) and then back east using the dropped buoys as visual boundaries. They will continue this meandering search pattern until the entire survey area has been investigated.



Notes:

1. Coordinates are in feet based on the Florida State Plane Coordinate System, East Zone, North American Datum of 1983 (NAD83).
2. 2014 aerial photography provided by Broward County.

Legend:

- Coral Transplant Investigation Sites
- Coral Transplant Investigation Area
- Proposed Mitigation Sites
- 2011 Hardbottom Edge
- 2012 ETOF 10m Buffer
- 2012 ETOF
- FDEP Monuments

N

0 250 500 Feet

1 inch = 500 feet

TITLE:

Broward County SPP Segment II Coral Transplant Investigation Area Pompano Beach

CB&I
COASTAL PLANNING & ENGINEERING, INC.
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Coastal Engineering
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Jacksonville, FL 32210
(904) 387-6114

Date: 08/20/14	By: ALS	Comm N0. : 152429	Figure 1a

G:\Enterprise\Broward\152429_ReefSitingSeismic\mxd\Coral_Transplant_2.mxd

Path: G:\Enterprise\Broward\152429_ReefSitingSeismic\mxd\Coral_Transplant_4.mxd

Notes:

1. Coordinates are in feet based on the Florida State Plane Coordinate System, East Zone, North American Datum of 1983 (NAD83).
2. 2014 aerial photography provided by Broward County.

Legend:

- Coral Transplant Investigation Sites
- Coral Transplant Investigation Area
- Proposed Mitigation Sites
- 2011 Hardbottom Edge
- 2012 ETOF 10m Buffer
- 2012 ETOF
- FDEP Monuments

N

0 250 500 Feet

1 inch = 500 feet

TITLE:

Broward County SPP Segment II Coral Transplant Investigation Area Ft. Lauderdale

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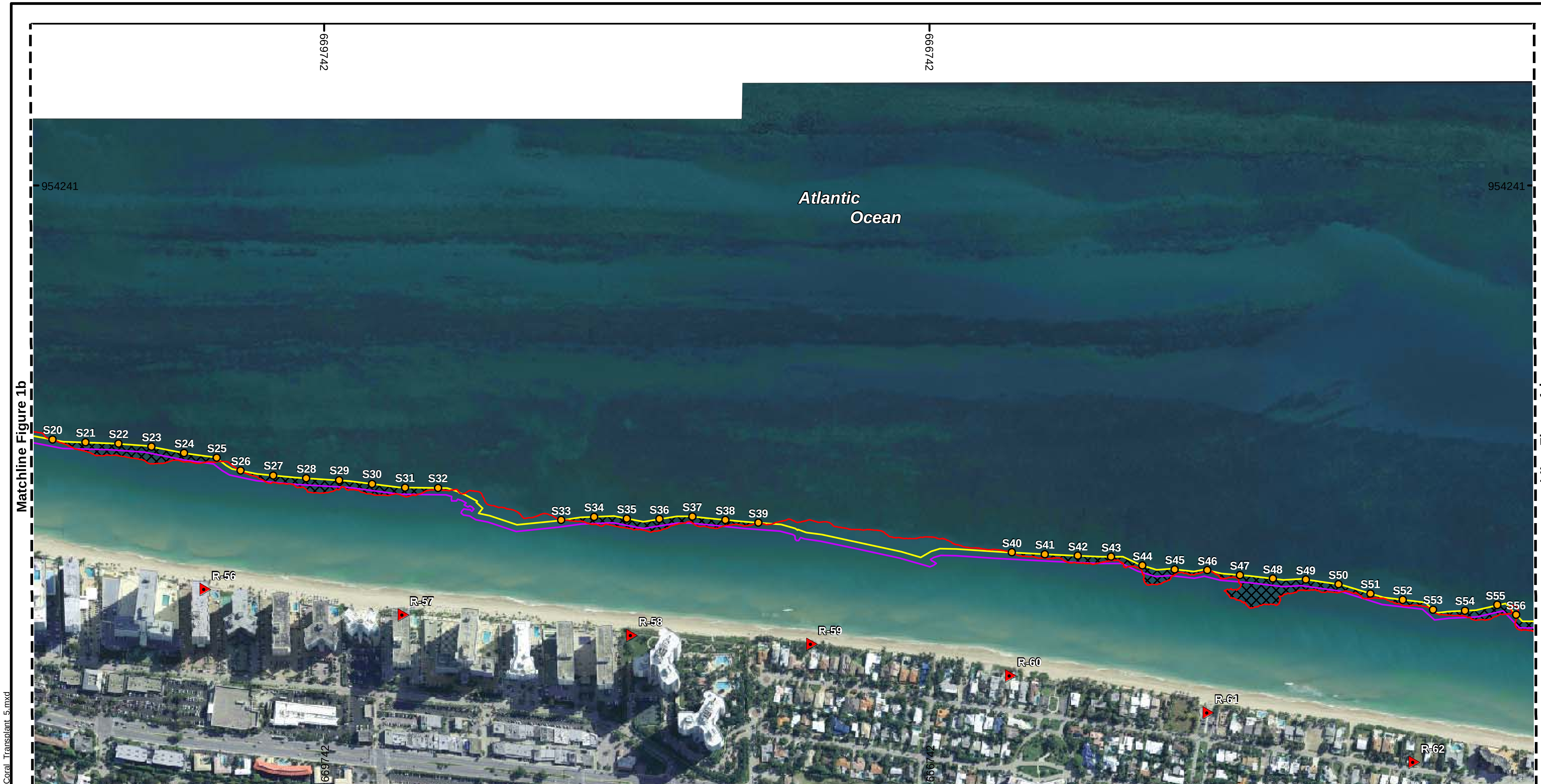
Date: 08/20/14	By: ALS	Comm N0. : 152429	Figure 1b



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Notes:

1. Coordinates are in feet based on the Florida State Plane Coordinate System, East Zone, North American Datum of 1983 (NAD83).
2. 2014 aerial photography provided by Broward County.

Legend:

- Coral Transplant Investigation Sites
- Coral Transplant Investigation Area
- Proposed Mitigation Sites
- 2011 Hardbottom Edge
- 2012 ETOF 10m Buffer
- 2012 ETOF
- FDEP Monuments

N

0 250 500 Feet

1 inch = 500 feet

TITLE:

Broward County SPP Segment II Coral Transplant Investigation Area Ft. Lauderdale

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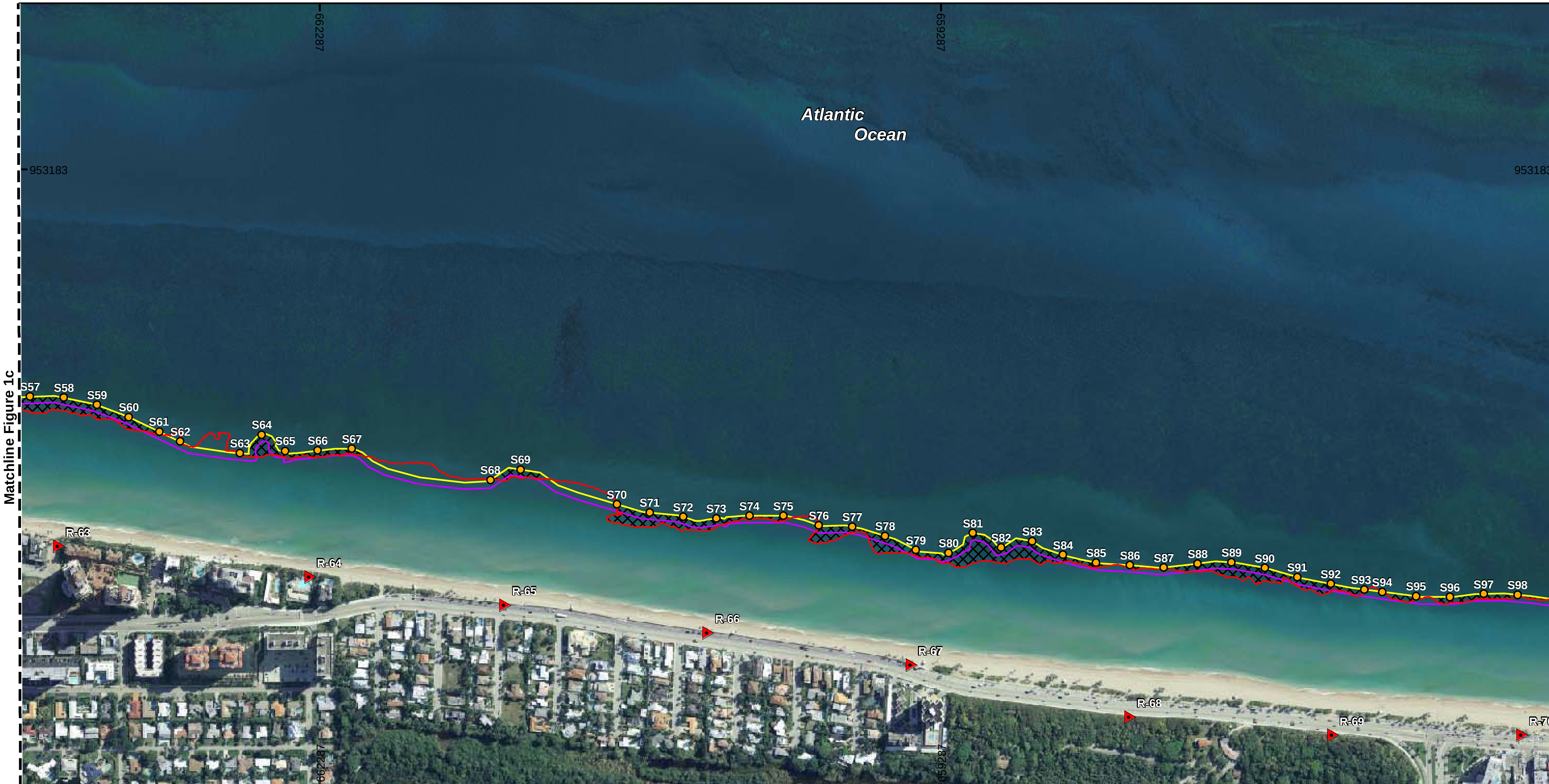
Date: 08/20/14	By: ALS	Comm N0. : 152429	Figure 1c



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Notes:

1. Coordinates are in feet based on the Florida State Plane Coordinate System, East Zone, North American Datum of 1983 (NAD83).
2. 2014 aerial photography provided by Broward County.

Legend:

- Coral Transplant Investigation Sites
- Coral Transplant Investigation Area
- Proposed Mitigation Sites
- 2011 Hardbottom Edge
- 2012 ETOF 10m Buffer
- 2012 ETOF
- FDEP Monuments

N

0 250 500 Feet

1 inch = 500 feet

TITLE:

Broward County SPP Segment II Coral Transplant Investigation Area Ft. Lauderdale

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Date: 08/20/14	By: ALS	Comm N0. : 152429	Figure 1d

Notes:

1. Coordinates are in feet based on the Florida State Plane Coordinate System, East Zone, North American Datum of 1983 (NAD83).
2. 2014 aerial photography provided by Broward County.

Legend:

- Coral Transplant Investigation Sites
- Coral Transplant Investigation Area
- Proposed Mitigation Sites
- 2011 Hardbottom Edge
- 2012 ETOF 10m Buffer
- 2012 ETOF
- FDEP Monuments

N

0 250 500 Feet

1 inch = 500 feet

TITLE:

Broward County SPP Segment II Coral Transplant Investigation Area Ft. Lauderdale

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Date: 08/20/14	By: ALS	Comm N0. : 152429	Figure 1e

Path: G:\Enterprise\Broward\152429_ReefSitingSeismic\mxd\Coral_Transplant_7.mxd

2.0 TRANSPLANTATION METHODS

2.1 Coral Transplantation Criteria

Coral Species Federally Listed under the ESA

All scleractinian coral species that are listed under the Endangered Species Act (ESA) will be removed from the investigation area for transplantation. This includes *Acropora cervicornis, Acropora palmata, Dendrogyra cylindrus, Orbicella* complex (*O. annularis, O. faveolata*, and O. *franksi*), and *Mycetophyllia ferox*. Corals that exhibit obvious signs of disease or bleaching will not be removed for relocation.

Non-Listed Coral Species

Scleractinian coral species that are not listed under the ESA will be removed and transplanted if they have a maximum size (diameter) greater than or equal to 10 cm of live tissue. Previous projects have required the maximum size to be greater than or equal to 15 cm, however based on recommendations by Lindeman and Ruppert (2010) and field observations by Gilliam *et al.* (2007), the 10 cm threshold is more applicable to this habitat.

2.2 Relocation Areas

As part of the mitigation for the anticipated impact to the nearshore hardbottom, an artificial reef will be constructed to closely mimic the characteristics of the adjacent nearshore habitat. The artificial reef will reflect the typical low relief limestone pavement found on the natural hardbottom. Placement criteria for the Segment II artificial reef are as follows: 1) offshore of the predicted ETOF or outside of the project area limits; 2) no shallower than the 8-ft depth contour; and 3) will maintain a 50-ft buffer from all nearshore hardbottom. The artificial reef will be deployed offshore of Segment II between R-49 and R-50 in 16-18 ft water depth and between R-52 and R-54 in 17-19 ft water depth (see Figure 1). Construction of the artificial reef is planned to be completed in spring/summer 2015.

In the event that the Segment II artificial reef is not completed prior to nourishment construction, the coral colonies removed from the impact area will be transplanted to the artificial reef built in 2003 as mitigation for the Segment III SPP. The artificial reef is located in two areas of Segment III between R-101 and R-104 and between R-123 and R-126. It is constructed of limestone boulders measuring 4 to 6 ft in diameter placed in the nearshore zone in water depths of approximately 12 to 20 ft. Stony coral colonies from the Segment III impact area were transplanted to this reef between R-101 and R-102, and, based on two years of monitoring these transplants, this has been a very successful relocation area (Gilliam *et al.,* 2007).

2.3 Coral Colony Removal and Relocation

Divers will remove all qualifying coral colonies from the substrate using a hammer and chisel. The colonies will be kept at the original depth until transplantation commences (i.e., cached on site). When a colony is ready for transplantation, it will be transferred to a topside bin (located on the boat) containing seawater and covered in order to control the temperature and to reduce light exposure. Transplantation should occur as soon as it is logistically possible and no more than 24 hours after the coral colony was removed from its original location.

Prior to each coral transplantation, the receiver substrate will be cleared of any sediment and fouling organisms (e.g., algae, tunicates, hydroids, sponges) to provide a clear surface to facilitate the attachment of the coral. Colonies will be attached to the substrate using Portland Type II cement, Portland Type II cement mixed with molding plaster, or epoxy (e.g., Aquamend, Epoxyclay Aqua, All Fill Epoxy). The material used will be chosen based on the size of the colony and which will be most effective in securing the coral to the substrate. The material will be pressed onto the cleared substrate and the coral will then be pressed into the material. Care will be taken to not cover any live coral tissue with the cement or epoxy.

Weather conditions for transplanting must be ideal (flat seas and good water visibility). Careful planning with particular attention to the weather will be required to efficiently locate, remove and relocate coral colonies. Therefore, this effort is scheduled to take commence in summer 2015.

Notes:

1. Coordinates are in feet based on the Florida State Plane Coordinate System, East Zone, North American Datum of 1983 (NAD83).
2. 2014 aerial photography provided by Broward County.

Legend:

Segement II Proposed Mitigation Sites

2011 Hardbottom Edge

FDEP Monuments

0 250 500 Feet

1 inch = 500 feet

TITLE:

Broward County SPP Segment II
Segment II Relocation Area

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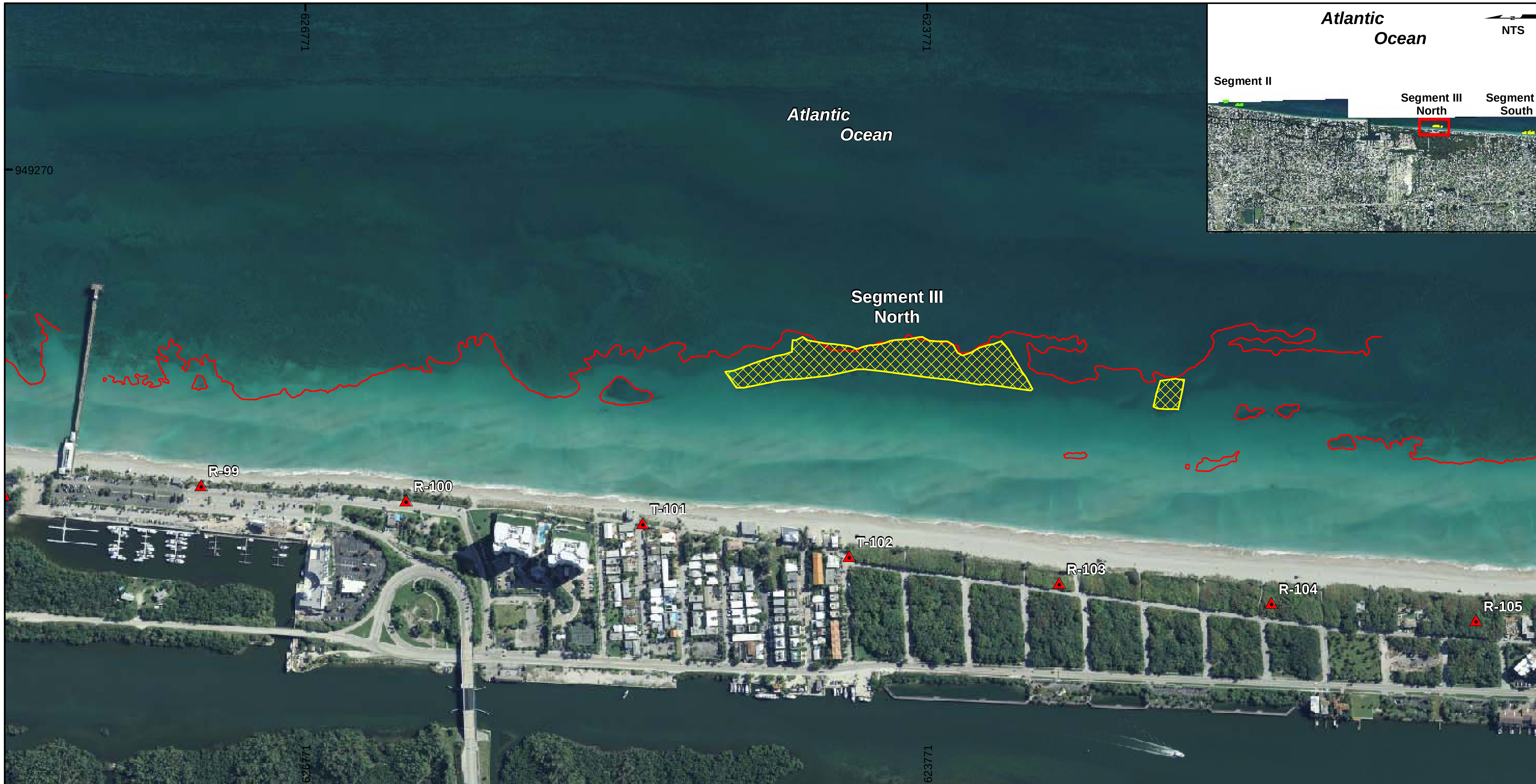
Date: 08/20/14	By: HMV	Comm N0. : 152429	**Figure 2a**

Path: G:\Enterprise\Broward\152429_ReefSitingSeismic\mxd\Relocation Area 1.mxd



Notes:

1. Coordinates are in feet based on the Florida State Plane Coordinate System, East Zone, North American Datum of 1983 (NAD83).
2. 2014 aerial photography provided by Broward County.

Legend:

- Segment III Artificial Reef
- 2011 Hardbottom Edge
- FDEP Monuments

0 250 500 Feet

1 inch = 500 feet

TITLE:

Broward County SPP Segment II Segment III Relocation Area

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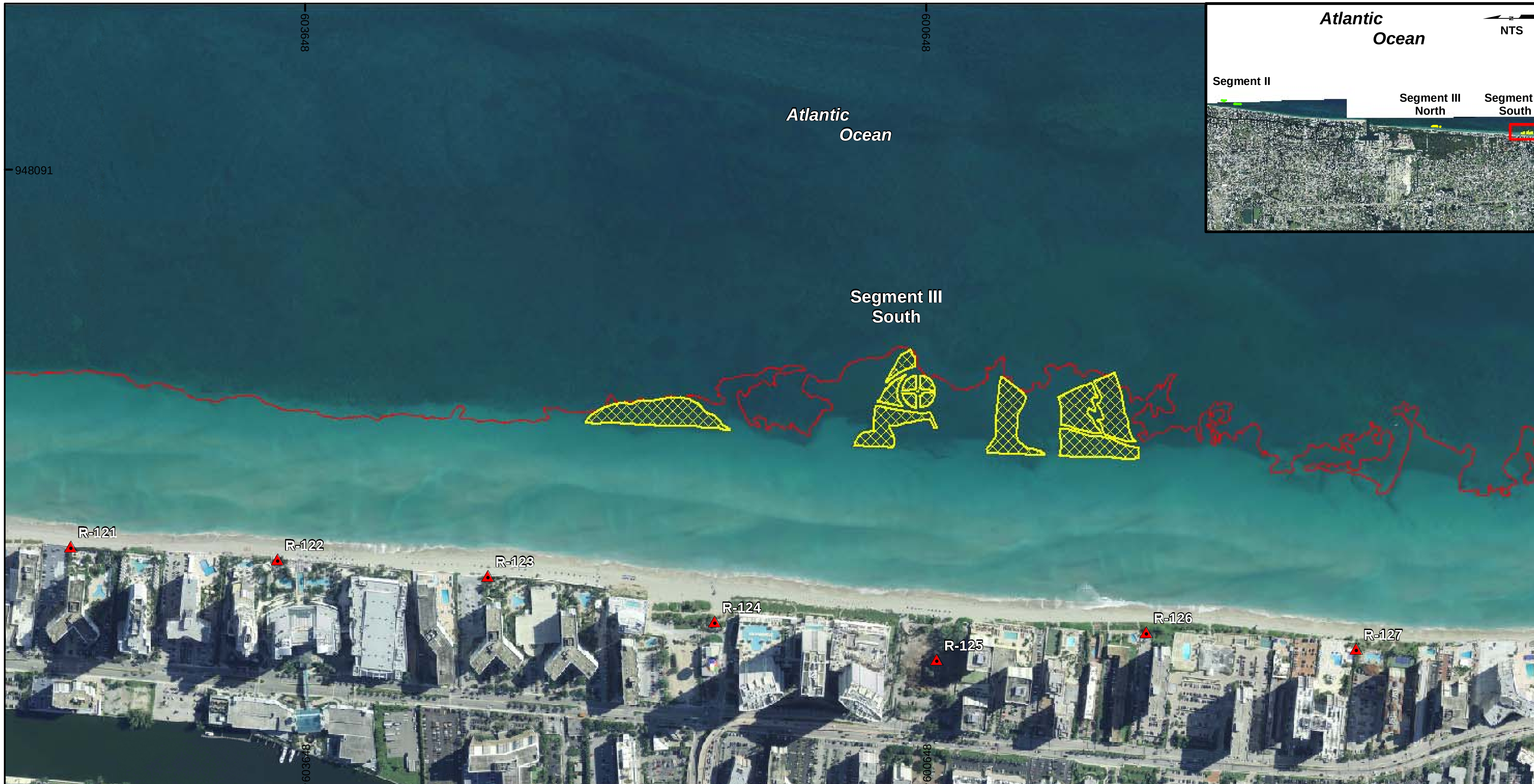
Date: 08/20/14	By: HMV	Comm N0. : 152429	**Figure 2b**

Path: G:\Enterprise\Broward\152429_ReefSitingSeismic\mxd\Relocation Area 2.mxd



Notes:

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Legend:

Segment III Artificial Reef

2011 Hardbottom Edge

FDEP Monuments

0 250 500 Feet

1 inch = 500 feet

TITLE:

Broward County SPP Segment II Segment III Relocation Area

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Date: 08/20/14 | By: HMV | Comm N0. : 152429 | **Figure 2c**

Path: G:\Enterprise\Broward\152429_ReefSitingSeismic\mxd\Relocation Area 3.mxd

3.0 MONITORING

To monitor the transplanted corals, a subset comprising 25% of the total number of colonies transplanted will be marked with identification tags. The tags will be placed next to each colony and secured to the substrate using a nail and epoxy. The subset is to be representative of the species composition of the total transplanted colonies. The following information will be recorded for each tagged colony during each survey: location (collection and transplant site), depth (collection and transplant site), total length and total width (cm), length and width of live tissue (cm), health and condition (i.e., percent disease, bleached, partial mortality, boring sponge, or overgrowth), attachment status (secure, loose or missing), and colony edge growth (i.e., expansion of tissue onto receiver substrate). A photograph of each tagged colony will be taken using a framer-mounted camera with the colony tag visible in the frame. These planar images will be analyzed using Coral Point Count with Excel Extensions (CPCe, http://www.nova.edu/ocean/cpce/index.html) to measure changes in tissue area over time. Also, any new coral recruits observed within 25 cm of the transplants will be identified and recorded *in situ*.

Monitoring of the transplanted coral colonies shall take place once immediately after transplantation efforts, and semi-annually for two (2) years following transplantation efforts for a total of five (5) post-transplantation monitoring events (Table 1).

Table 1. Monitoring schedule of coral transplants.

Year	Season	Phase
2015	Summer	Immediate Post-Transplantation
2016	Winter	6-Months Post-Transplantation
2016	Summer	12-Months Post-Transplantation
2017	Winter	18-Months Post-Transplantation
2017	Summer	24-Months Post-Transplantation

4.0 MEASUREMENT OF SUCCESS

The subset of transplanted corals will be used to determine the success of all transplanted corals. Measures of success will include attachment (percent securely attached), growth (increase in planar tissue area), and measures of recruitment based on data collected within 25 cm of each transplanted colony. The previous coral transplantation effort to the mitigative artificial reef associated with the Broward County SPP Segment III was a success – after two years of monitoring, 100% of the tagged corals remained securely attached to the artificial reef, 99% had live tissue and 85% had a measureable increase in live tissue area (Gilliam *et al.,* 2007).

Based on the Segment III transplantation success, it is anticipated that the coral transplantation program for Segment II will have similar results.

5.0 LITERATURE CITED

Gilliam, D.S., R.E. Dodge, and N.R. Stephens. 2007. Broward County Shore Protection Project Stony Coral Transplantation and Monitoring Final Report: 2-Year Post-Transplantation Event. Prepared for the Broward County Board of County Commissioners. 54 p.

Lindeman K. and T. Ruppert. 2010. Policy Recommendations and Training to Improve Agency Permitting, Compliance, and Enforcement for Coral Resource Conservation in Southeast Florida. Florida Department of Environmental Protection. Miami, FL. 207 p.

COMPENSATORY MITIGATION PLAN

FOR THE

BROWARD COUNTY SHORE PROTECTION PROJECT

SEGMENT II

FDEP PERMIT NUMBER: 0314535-001-JC

USACE PERMIT NUMBER: SAJ-1999-05545 (SP-GGL)

August 28, 2014

Revised September 25, 2014

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APPENDICES

1.0 Goals and Objectives

The Broward County Shore Protection Project (SPP) Segment II project proposes to restore two reaches of eroded shoreline by placement of approximately 663,430 cubic yards (cy) of sand by means of a truck haul approach. The project includes sand placement along: 1) 1.0-mile of shoreline in Pompano Beach and Lauderdale-by-the-Sea (LBTS) (R-36 to R-41.3) and; 2) 4.0-miles of shoreline in LBTS and Ft. Lauderdale (R-51 to R-72) (Figure 1). Throughout this document, the northern project area (R-36 to R-41.3) is referred to as the POMP project area and the southern project area (R-51 to R-72) is referred to as the FTL project area. The project design is shown in the permit sketches, provided as Appendix A.

Broward County has designed this project to avoid and minimize impacts to nearshore hardbottom to the maximum extent practicable, including constructing the project using a truck haul approach instead of dredging an offshore borrow area and hydraulically pumping the sand through a pipeline to the project area. However, the project is still anticipated to directly impact nearshore hardbottom due to beach profile equilibration. This Compensatory Mitigation Plan (CMP), prepared under guidance provided in the Mitigation Rule (33 CFR 332.4(c)), outlines Broward County's plan to provide compensatory mitigation for adverse impacts to nearshore hardbottom. This section describes the nearshore hardbottom resources that will be impacted, the proposed mitigation sites and specifications, and the manner in which the mitigation will restore the ecological functions lost due to anticipated project impacts to the nearshore hardbottom habitat.

The specific goals of the CMP are:

1. To provide compensatory mitigation to offset impacts to 4.9 ac of nearshore hardbottom resources due to Segment II nourishment construction.
2. To create 6.8 ac of mitigation in the form of a low relief artificial reef designed to mimic the ecological function of the nearshore hardbottom habitat that will be impacted. The reef shall:
    a. Include similar physical features as the nearshore hardbottom - low relief (approximately 2 ft) modules spaced at the same ratio of sand to hardbottom as the nearshore hardbottom;
    b. Include similar substrate as the nearshore hardbottom - limestone surface that facilitates recruitment of organisms found on the natural hardbottom;
    c. Be placed in a similar water depth as the nearshore hardbottom that will be impacted;

d. Include a benthic habitat with interstitial spaces that provides refuge for benthic organisms; and
e. Create a habitat that fully offsets the functional loss of the impacted hardbottom.

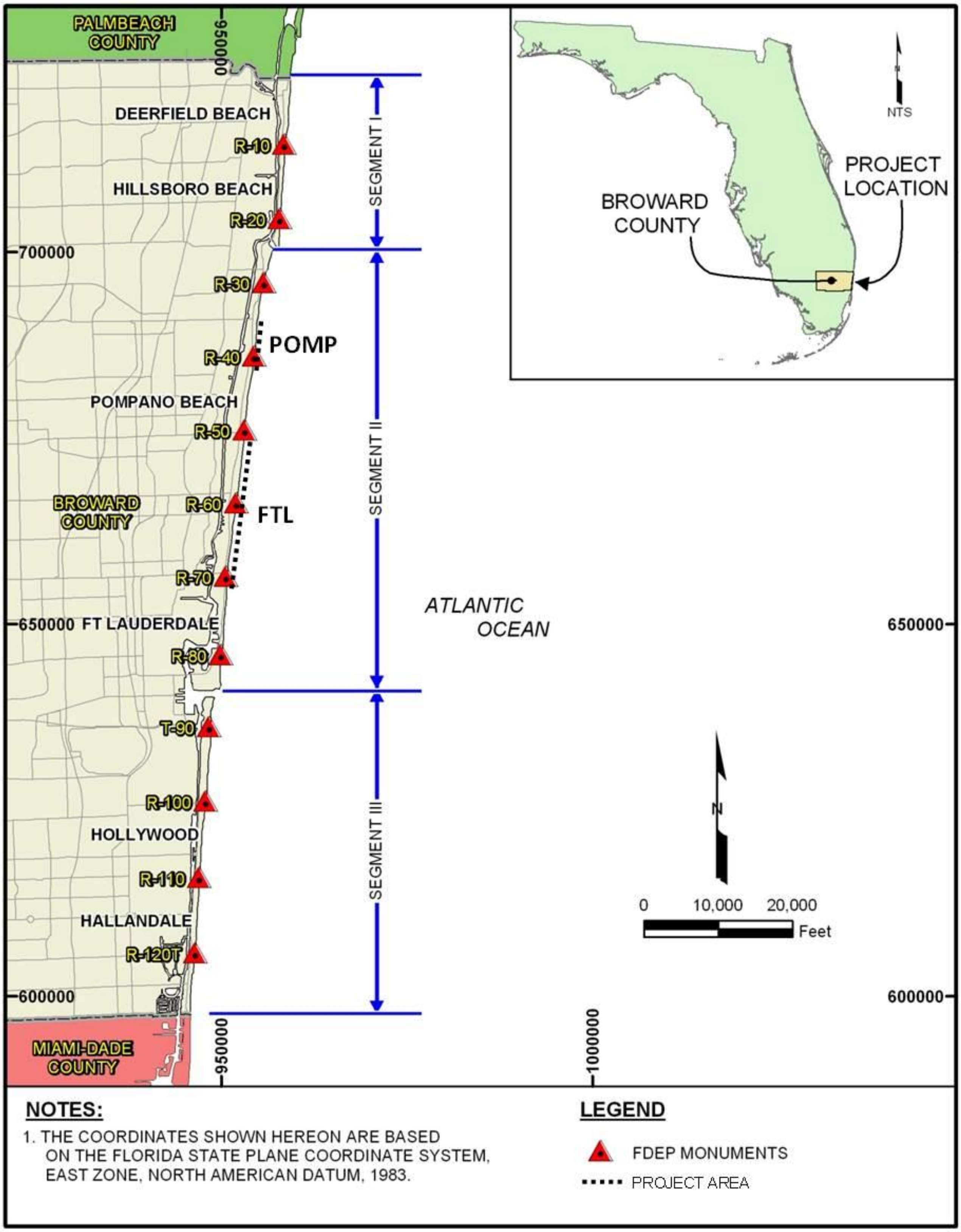


Figure 1. Project location map.

1.1 Impact Site

Due to direct sand placement and subsequent spreading (equilibration) of sand, it is anticipated that 7.6 acres of area beyond the hardbottom edge will be directly impacted: 2.5 ac in the POMP project area (R-36 to R-41.3) and 5.1 ac in the FTL project area (R-51 to R-72) (Figure 1). A benthic characterization survey was conducted in the summer/fall of 2012 to assess the habitat adjacent to the project areas (CB&I and OAI, 2013). This included a quadrat-based assessment to quantify the benthos as well as shore-perpendicular transects to determine sediment conditions. During this survey, relief measurements were taken within each quadrat, which provided the basis for determining the percentage of low (≤ 30 cm) and high relief (> 30 cm) habitat adjacent to both project areas. The ratio of low to high relief was very similar along both project areas (Table 1) with low relief habitat encompassing approximately 80% of the hardbottom. Shore-perpendicular transects were sampled from the nearshore hardbottom edge to 150 m (492 ft) east of the edge. Line-intercept for sediment was recorded to determine the hardbottom to sand ratio along each project area. These data revealed habitats with very different hardbottom to sand ratios. Based on the line-intercept data from 0 to 150 m from the hardbottom edge, the hardbottom habitat adjacent to the POMP project area was characterized as 37% hardbottom and 63% sand; whereas the FTL project area hardbottom habitat was 77% hardbottom and 23% sand (Table 1). Based on the gross impact areas of 2.5 ac and 5.1 ac, net impacts to hardbottom were determined to be 0.9 ac in the POMP project area and 4.0 ac in the FTL project area for a total 4.9 ac of impacted hardbottom (Table 1). It should be noted that direct impacts from project sand placement are not anticipated to extend beyond 30 m from the hardbottom edge; however, based on Florida Department of Environmental Protection (FDEP) guidance, data from the entire transect length (150 m) was used since it represented the most conservative estimate of hardbottom coverage and direct impacts.

Table 1. Characterization of POMP and FTL impact areas.

Project Reach	Low : High Relief Ratio	HB : Sand Ratio	Gross HB Impact Area	Net HB Impact Area
POMP project area (R-36 to R-41.3)	79 : 21	37 : 63	2.5 ac	0.9 ac
Low Relief			2.0 ac	0.7 ac
High Relief			0.5 ac	0.2 ac
FTL project area (R-51 to R-72)	81 : 19	77 : 23	5.1 ac	4.0 ac
Low Relief			4.1 ac	3.2 ac
High Relief			1.0 ac	0.8 ac
TOTAL	--	--	7.6 ac	**4.9 ac**

The nearshore hardbottom environment adjacent to the Broward County Segment II project area consists primarily of low-relief (< 30 cm) colonized pavement and shallow ridge habitat.

Some areas are well-scoured, covered only in turf algae and pioneering organisms, while other areas support a diverse benthic community including several species of macroalgae, scleractinian corals, octocorals, sponges, tunicates and other invertebrates. The dominant macroalgal species are encrusting red calcareous algae, *Dictyota* sp., *Dasya* sp., and *Laurencia* sp. The most abundant scleractinian coral is *Siderastrea siderea*, and other common scleractinians include *Solenastrea bournoni*, *Diploria clivosa*, and *Montastraea cavernosa*. Octocorals are very abundant and are regularly seen emerging from sediment over recently buried hardbottom habitat. Common octocorals are *Pseudopterogorgia americana*, *Gorgonia ventalina*, and *Briareum asbestinum*. The zoanthid *Palythoa caribaeorum* and several species of sponges are commonly observed. Bioeroding sponges are also often found in this habitat including *Cliona deletrix*, *C. varians* and *Pione lampa*. The nearshore habitat supports a complex benthic community and provides an important settlement and nursery habitat for immigrating larvae of many important fisheries species. It is also provides foraging habitat for juvenile green sea turtles.

In addition to constructing the project using a truck haul methodology rather than dredge an offshore borrow area, Broward County will further minimize the potential impacts to the hardbottom community by transplanting coral species from the project impact area to suitable sites that will not be affected by beach nourishment. The Draft Coral Transplantation Plan (CB&I and OAI, 2014a) includes suitable transplantation sites and coral species and size classes to be considered for transplantation as well as the monitoring protocol for the transplanted corals. Compensatory mitigation and monitoring are required for the impacted hardbottom habitat, as described below.

2.0 Site Selection

In order to offset lost ecological functions from the burial of hardbottom from the Segment II Project, Broward County proposes to provide in-kind mitigation through construction of artificial reef substrate within the vicinity of and similar depths to the impact area. The mitigation will be located in Broward County and extend into the Atlantic Ocean, Class III Waters. The County determined that suitable mitigation sites should be located near the proposed impact site, preferably in water depths less than about 20 feet. Further, to avoid impacts from the mitigation structures themselves, the mitigation sites must be located on sandy seafloor where there are no hardbottom resources. These areas must also have a relatively thin sand layer, covering subsurface rock and or consolidated rubble that will prevent and or minimize settlement of the mitigation units. Broward County developed the following artificial reef site placement criteria:

1. Offshore of the predicted ETOF or outside of the project area limits;

2. No shallower than the 8-ft depth contour;
3. Maintain a 50-ft buffer from all nearshore hardbottom;
4. Similar water depth to impacted hardbottom resources.

The criteria listed above place the artificial reef outside the anticipated project impact area and protect the existing natural hardbottom during construction of the mitigative reef while placing the reef within the vicinity of these resources. This location maintains proximity and connectivity to aquatic resources, which will allow recruitment of organisms from adjacent hardbottom onto the artificial reef, thereby increasing the likelihood that the artificial reef will succeed at developing a natural community similar to that found on the impacted nearshore hardbottom.

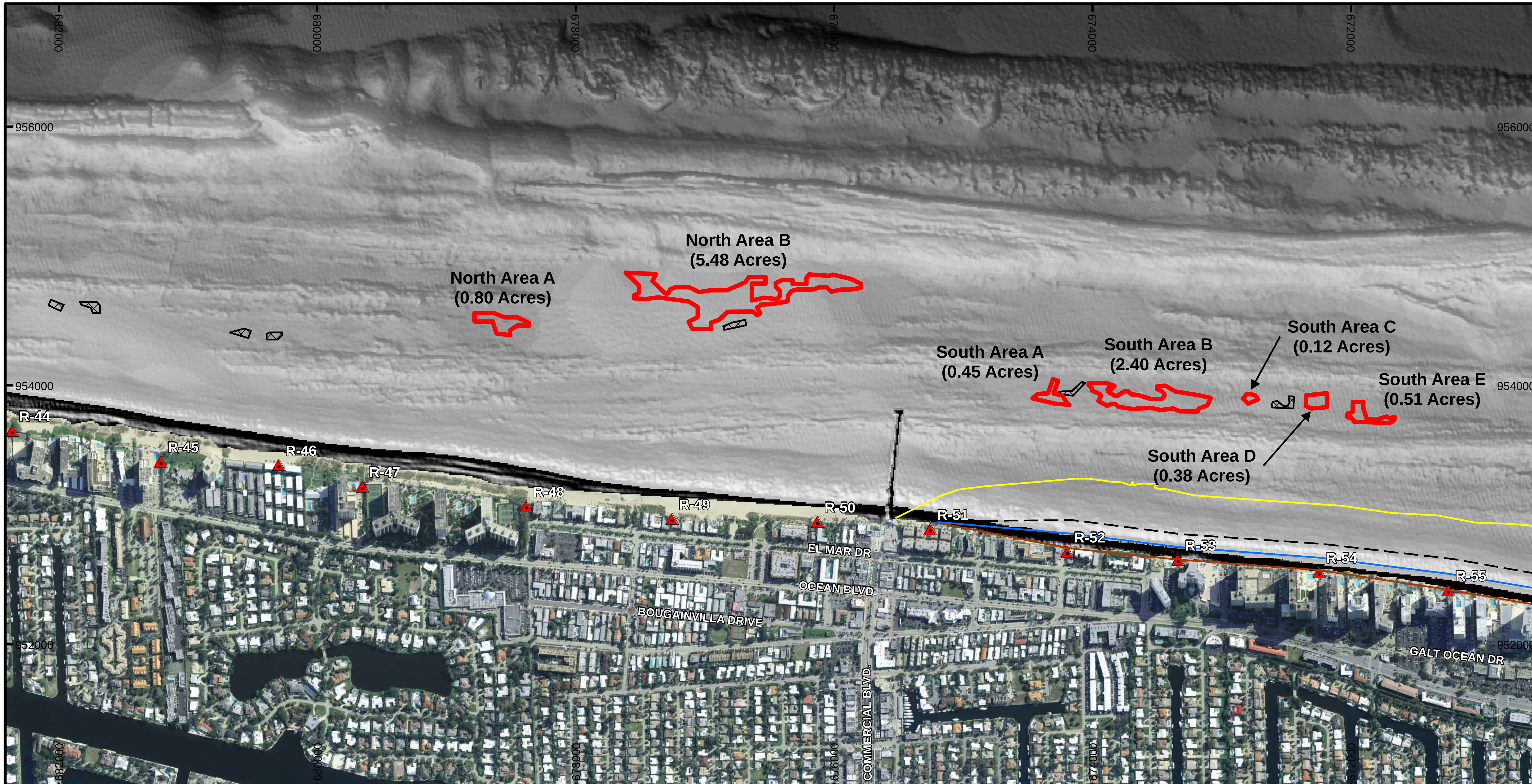
2.1 Site Selection Process

In order to locate suitable sites that meet the above criteria, Broward County completed a comprehensive review of the nearshore habitat using clear imagery from aerial photographs, 2008 LADS survey data, southeast Florida benthic habitat maps (Walker, 2012) and 2011 hardbottom edge mapping in the immediate vicinity of the proposed Segment II project. This process led to the identification of three candidate areas with potential for placement of the mitigation units. Appendix B presents a map series that shows the refinement of these areas. Figure B-1 presents the outline of potential Areas A, B and C with background layers of the LADS and benthic habitat maps (Walker, 2012) and Figure B-2 presents the same areas with background layers of the LADS and aerial imagery. The three investigation areas were subsequently surveyed with seismic sub-bottom survey equipment to map sediment thickness above subsurface rock and consolidated rubble substrate. Sediment thicknesses in these three areas ranged from less than 0.5 ft to more than 10 ft (Figure B-3). Using maps created from the isopach sand thickness data, the extent of potential mitigation sites was refined to include areas with a maximum sand thickness of 2.5 ft. The northernmost area, Area A, was eliminated from consideration since the majority of the area had sediment thicknesses greater than 2.5 ft. From Areas B and C, 10 acres of sandy seafloor were identified to have sand thickness over solid rock and consolidated rubble substrate between 1 and 2.5 ft.

2.2 Proposed Mitigation Sites

Based on the selection criteria and subsequent data review and field surveys, Broward County proposes that the artificial reef be constructed in two general areas of Segment II between R-49 and R-50 in 16-18 ft water depth (North Area) and between R-51.5 and R-54.5 in 17-19 ft water depth (South Area) (Figure 2). In the North Area, two mitigation sites were identified (north Areas A and B) and in the South Area, five mitigation sites were identified (South Areas A-E). Seven (7) contingency areas were also identified between R-44 and R-54. Additional details regarding the location of the mitigations sites, including GPS coordinates for each site, are included in Attachment 1 of the Revised Mitigation Plan for the Broward County Shore Protection Project Segment II, which is provided as Appendix C. The selection of these mitigation sites is practical in terms of cost for construction, existing technology, and logistics. Broward County has constructed nearshore artificial reefs for previous projects, and this type of artificial reef module has been constructed and deployed for other projects in southeast Florida. The artificial reef shall cover 6.8 ac of seafloor within a 10-ac footprint.

The proposed mitigation structures will provide the intended mitigating effect. Given the nature of the rock and consolidated rubble beneath the proposed mitigation area, the likelihood of unanticipated settlement is minimal or effectively non-existent. Further, these sites are beyond the first outcrop of nearshore hardbottom, which reduces the potential for



G:\Enterprise\Broward\152429_ReefSitingSeismic\mxd\Project Location Map.mxd

Notes:

1. Coordinates are in feet based on the Florida State Plane Coordinate System, East Zone, North American Datum of 1983 (NAD 83).
2. 2014 aerial photography provided by Broward County.
3. Bathymetric surface based on the 2008 Tenix LADS Survey collected between July 12 and August 24, 2008.

Legend:

- Contingency Area
- Proposed Mitigation Area

2012 Project Design

- Landward Limit of Fill
- Construction Berm
- Construction Toe of Fill
- Equilibrium Toe of Fill
- FDEP Monuments

N

Feet
0 200 400

1 inch = 800 feet

TITLE:

Project Location Map
Broward County Segment II
Proposed Mitigation Sites
Broward County, Florida

CB&I
COASTAL PLANNING & ENGINEERING, INC.
2481 N. W. BOCA RATON BOULEVARD
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PH. (561) 391-8102
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olsen associates, inc.
Coastal Engineering
4438 Herschel Street
Jacksonville, FL 32210
(904) 387-6114

Date: 08/25/14	By: HMV	Comm No. : 152429	Figure 2

substantive future sediment accumulation around the mitigation structures. The mitigation units themselves will be sized such that they will be individually stable under the influence of tide, current, and wave conditions that area reasonable likely to occur for storm events with a return period of at least 25 years. Thus, movement due to such conditions is unlikely.

Broward County received authorization for the Broward County SPP Segment II project area from the State Historic Preservation Officer (SHPO) on December 12, 2012 (DHR No. 2012-05148). The USACE requested formal consultation with National Marine Fisheries Service (NMFS) on April 17, 2013, which was initiated on June 27, 2013; consultation is currently ongoing as of August 28, 2014. Consultation with NMFS covers the construction of both the beach nourishment project and the mitigative artificial reef.

3.0 Site Protection Instrument

The mitigation will be constructed on sovereign submerged lands of the State of Florida. This mitigation is authorized by the State of Florida under FDEP Permit No. 0314535-001-JC. Broward County will be responsible for the construction and management of the artificial reef. The USACE will have access to the mitigation site subsequent to the issuance of a Department of the Army permit.

4.0 Baseline Information

This section describes the baseline conditions found at the impact site and the proposed mitigation sites.

4.1 Impact Site

It is anticipated that the Broward County Shore Protection Project Segment II will impact 7.6 acres of nearshore marine habitat located east of the ETOF as a result of direct sand placement and subsequent spreading (equilibration) of sand. Based on the ratio of hardbottom to sand within this impact area, it is anticipated that a net impact to 4.9 ac may occur (see Table 1). Section 1.1 of this mitigation plan describes the benthic community found in this habitat and summarizes the results of the 2012 benthic characterization survey (CB&I and OAI, 2013). The nearshore marine habitat may be utilized by listed species, including sea turtles, manatees, smalltooth sawfish, *Acropora* spp. corals, as well as the five coral species recently listed. It also provides designated critical habitat for *Acropora* corals. Broward County and the USACE are currently coordinating with NMFS for potential project impacts to federally listed species and critical habitat.

4.2 Mitigation Sites

Based on the results the UMAM evaluation (Appendix D), 6.64 ac of mitigation are required to offset impacts to 4.9 ac of hardbottom habitat (Table 2) using the USACE time lag values (6.8 ac are required using the FDEP time lag values). The County has committed to constructing an artificial reef that will cover 6.8 ac of seafloor within a 10-ac footprint. Within this 10-ac footprint, the 6.8 ac of artificial reef will be spaced so as to replicate the spacing of the natural nearshore hardbottom habitat. The mitigation sites are located between R-47 and R-50 in 16-18 ft water depth (North Areas A and B) and between R-51.5 and R-54.5 in 17-19 ft water depth (South Areas A-E) (Figure 2). These areas are characterized by sand over lying hardbottom with sand depths between 1 and 2.5 ft, and are located at least 50 ft from hardbottom resources. Section 2.0 of this mitigation plan describes the mitigation site selection.

5.0 Determination of Credits

In order to determine the amount of compensatory mitigation necessary to offset unavoidable impacts to nearshore hardbottom, a UMAM evaluation was conducted. This UMAM assessment was based on the area of predicted impact from the project design (ETOF) and the habitat data collected during the 2012 nearshore benthic characterization (CB&I, 2013). Four separate UMAM evaluations were conducted to include the POMP project area low and high relief habitat, and the FTL low and high relief habitat. This analysis assumes a 2-year time lag (USACE t-factor of 1.02) for the low relief hardbottom and a 5-year time lag (USACE t-factor of 1.07) for the high relief hardbottom. Based on the results of UMAM for indirect impacts (provided as Appendix D), 6.64 ac of mitigation are required for 4.9 ac of impacted hardbottom habitat (Table 2). This results in an impact to mitigation ratio of 1:1.36.

Using the FDEP t-factors (1.03 for 2 years and 1.14 for 5 years), 6.8 acres of mitigation are required for impacts to 4.9 ac of nearshore hardbottom (impact to mitigation ratio of 1:1.39). This is mandated in FDEP Permit No. 0314535-001-JC and will be constructed by the County.

In UMAM, the input factors that determine mitigation requirements are:

1. The area (ac) of impact;
2. The parameters of the impact area without and with the project;
3. The parameters of the mitigation area without and with the project;
4. The risk factor; and
5. The time lag (t-factor).

Area of Impact

The area of impact for the proposed project was determined through analysis of an equilibrium toe of fill (ETOF) based on the fill volume and relief of the nearshore hardbottom resources. The ETOF overlapped 1.0 ac of nearshore hardbottom in the POMP project area and 3.9 ac in the FTL project area (see Table 1).

Parameters of the impact area

There are three parameters that the impact and mitigation areas are scored on (from 0 to 10) without and with the proposed project. These are Location & Landscape, Water Environment and Community Structure. For the proposed project, each parameter was scored less than optimal (10) due to the proximity of this habitat adjacent to a highly urbanized area. Factors that regularly affect the habitat include heavy recreational use and its location between two navigable inlets. Recreational activities that often have negative impacts to the hardbottom/reef habitat include fishing, boating (anchor damage), scuba diving, and snorkeling. Additionally, the location of these resources between Hillsboro Inlet and Port Everglades Inlet subject this area to continuous impacts from land based sources of pollution. Sand bypassing at the Hillsboro inlet (on average approximately 100,000 cy/year) also contributes to nearshore hardbottom habitat degradation in Segment II. Additional reductions in function are specified under each parameter and area evaluated.

Location & Landscape (L&L)

Impact area. Without the proposed project, the L&L scores for low and high relief hardbottom in both impact areas were 9 out of 10. Although small variations in the hardbottom edge occur over time, this habitat is almost continuously exposed, and thus provides suitable substrate and relief for the recruitment of benthic species. It has good connectivity with hardbottom resources located farther offshore as well as alongshore. With the project, the L&L score in the impact area was reduced to 0 since it would be buried by sand and would no longer function as hardbottom habitat.

Mitigation area. Without the artificial reef, the L&L of the mitigation site was scored as a 0 due to the absence of hardbottom. With the project, the mitigation site was elevated back up to a 9 since the artificial reef will be located in the nearshore zone in close proximity to nearshore hardbottom resources. It will be placed in similar (slightly deeper but more stable from the standpoint of environmental stress) water depth (16-20 ft) with similar relief (less than 2 ft), and it will be constructed with a limestone surface to facilitate benthic recruitment that resembles the community on the nearshore hardbottom. The close proximity (50 ft) to the natural hardbottom will also ensure connectivity for larval recruitment of benthic and motile flora and fauna.

Water Environment

The water environment was scored as an 8 without and with the project for both the impact sites and the mitigation site. The reduced function of an 8 was given due to the project area's location between two inlets and constant exposure to freshwater runoff and land based sources of pollution. However, it is not anticipated that the water environment will be permanently impacted at the impact or the mitigation site due to the proposed project.

Community Structure

Impact area. Without the proposed project, the community structure for the low relief hardbottom in POMP was scored as an 8. It was observed during the baseline benthic characterization that this hardbottom habitat had a less complex benthic community compared to the low relief hardbottom offshore of the FTL project area, which was scored as a 9. The FTL project area also has lower sand cover and does not experience the same level of impacts from sand bypassing as the POMP project area does.

The high relief hardbottom habitat was scored as a 9 for both project areas due to the presence of a developed, persistent and stable benthic community. Sediment does not tend to accumulate for extended periods of time as it does in the lower relief area. With the project, the community structure score in the impact area was reduced to 0 since it would be buried by sand and would no longer function as hardbottom habitat.

Mitigation area. Without the artificial reef, the community structure of the mitigation site was scored as a 0 due to the absence of hardbottom. With the project, the mitigation site was elevated to one value less than the pre-project impact scores for each area. Although it is anticipated that the artificial reef will recruit a similar benthic community as the natural hardbottom, it is acknowledged that it may not function exactly as the hardbottom habitat it is meant to mimic.

Risk Factor

The UMAM risk factor is scored from 1 to 3 in 0.25 increments to assess the degree of uncertainty in proposed mitigation. Deploying limestone substrate as mitigation for impacts to nearshore hardbottom resources is a generally approved by regulatory agencies. Depending on the relief of the mitigation, it is generally agreed to have minimal risk; however, it is not considered no (or de minimus) risk. The proposed mitigation was therefore given a risk factor of 1.25.

Time Lag (t-factor)

The time lag, also known as the t-factor, designates the number of years it will take the mitigation to achieve success. It was determined that the mitigation would achieve success based on the success criteria listed in Section 8.0. For the low relief hardbottom that is subject to sand scour and does support as complex of a habitat as the high relief hardbottom, a time lag of 2 years (USACE t-factor – 1.02) for the mitigation to achieve success was used. It is expected that the artificial reef will take longer to achieve success based on the function of the high relief hardbottom; therefore, a time lag of 5 years (USACE t-factor – 1.07) was assigned.

Justification of UMAM Input Scores

The primary rationale for these scores is based on the recruitment and succession of the benthic community on the Broward County SPP Segment III mitigative artificial reef built in 2003. After 3 years, 90% of the functional groups, scleractinian species and octocoral genera were present on the artificial reef compared to the natural hardbottom. By 5 years post-construction, the artificial reef scleractinian species richness and diversity, size class structure and density resembled the natural hardbottom (CPE, 2009). The octocoral community followed a similar trend based on genus richness and genus diversity; however, although the size structure profile resembled that of the natural hardbottom, octocoral density was still greater on the natural hardbottom.

Table 2. UMAM evaluation of the impact and mitigation sites with all scoring to determine required compensatory mitigation. The USACE time lag was applied in this table. The FDEP time lag results in 6.8 ac of mitigation.

UMAM Evaluation		Pompano/LBTS				LBTS/Ft. Lauderdale			
		Low Relief		High Relief		Low Relief		High Relief	
		W/O	With	W/O	With	W/O	With	W/O	With
IMPACT	Impact Area (ac)		0.7		0.2		3.2		0.8
	Location & Landscape	9	0	9	0	9	0	9	0
	Water Environment	8	8	8	8	8	8	8	8
	Community Structure	8	0	9	0	9	0	9	0
	Score	0.83	0.27	0.87	0.27	0.87	0.27	0.87	0.27
	Delta	0.57		0.60		0.60		0.60	
	FL	0.41		0.12		1.91		0.46	
MITIGATION	Location & Landscape	0	9	0	9	0	9	0	9
	Water Environment	8	8	8	8	8	8	8	8
	Community Structure	0	7	0	8	0	8	0	8
	Score	0.27	0.80	0.27	0.83	0.27	0.83	0.27	0.83
	Delta	0.53		0.57		0.57		0.57	
	Time Lag	1.02		1.07		1.02		1.07	
	Risk Factor	1.25		1.25		1.25		1.25	
	RFG	0.41		0.40		0.44		0.40	
	Acres of Mitigation	**0.99**		**0.28**		**4.29**		**1.08**	
TOTAL MITIGATION		**6.64**							

6.0 Mitigation Work Plan

In order to offset lost ecological functions of the impacted hardbottom resources, Broward County proposes to construct 6.8 ac of mitigative artificial reef over an approximate 10 acre site located between R-49 and R-50 and between R-52 and R-54 (see Section 2 and Figure 2).

6.1 Timing of Mitigation

The artificial reef is scheduled for construction in spring/summer 2015. Beach nourishment is tentatively scheduled for construction to start in winter/spring 2015.

6.2 Construction Schedule

Land-based staging and unit fabrication of the mitigation modules may occur at any time during the year. Unit deployment will occur during late-spring, summer, and early fall months when sea conditions are most favorable for working offshore of Broward County. It is the goal of

Broward County to initiate unit fabrication in the spring of 2015 with unit deployment beginning in late spring. The total time to complete the mitigation project is not known at this time given uncertainties with fabrication and deployment rates. Time required to deploy the mitigation units will be highly dependent upon the amount of suitable working conditions during the summer months.

6.3 Construction Methods

The mitigation units will be constructed at an upland staging area. Although the units will be constructed with concrete, the finished upper surface will be populated with highly irregular limerock stones (Figure 3), varying in size from 4-14 inches. These surficial stones will replicate the irregular nature and rugosity of the natural hardbottom within the anticipated impact area. The completed units will be loaded onto a barge, likely in Port Everglades, and transported to the offshore mitigation site. The units will be handled and deployed on the seabed by a barge mounted crane. The mitigation units will be deployed directly upon the sandy seabed with no excavation or manipulation of grades before or after deployment. The modules shall be placed in single layers at least 2-feet high and no shallower than 8 feet in depth. Section 6.4 includes proposed mitigation reef specifications. A protective 50-ft buffer will be maintained between the mitigation structures and adjacent nearshore hardbottom in order to protect the natural hardbottom during mitigation construction. Survey controls and diver quality assurance review will be implemented to ensure that the units are deployed at the location and configuration intended. Within 30 days following construction of the artificial reef, Broward County will complete the Florida Fish & Wildlife Conservation Commission's (FWC) "Florida Artificial Reef Materials Placement Report and Post-Deployment Notification".

6.4 Proposed Mitigation Reef Specifications

The County proposes to create an artificial habitat that closely mimics the characteristics of adjacent nearshore habitat, which is typically low relief limestone pavement interrupted by areas of higher complexity. The artificial reef should replicate the physical appearance, texture, relief, and ecological function of the habitat it is meant to replace. A recent deployment of mitigative artificial reef in Palm Beach County included modules consisting of a concrete slab with limestone cobbles. Broward County is proposing a similar substrate to mimic the low relief nearshore hardbottom habitat of Segment II.

The material being proposed as a mitigative artificial reef are reef modules constructed of a precast reinforced concrete slab. Limestone cobbles will be placed into the upper surface of the slab while the concrete is still wet (Figure 3). This ensures that the surface of the module is almost entirely exposed limestone. Texturally, limestone is a natural material and will provide a suitable replacement for the impacted nearshore reef substrate.

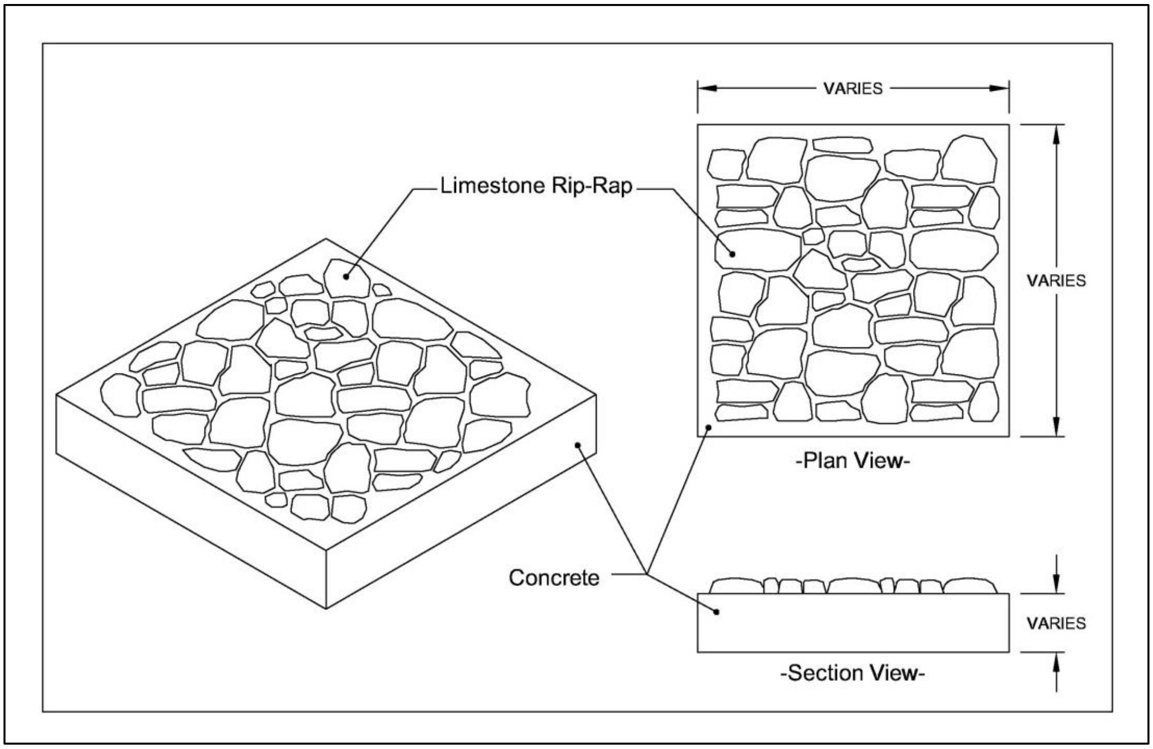

Figure 3. Conceptual sketch of proposed mitigation reef unit.

7.0 Maintenance Plan

Broward County will conduct mid-construction surveys and an immediate post-construction as-built survey to ensure the mitigative reef is constructed properly. A line-intercept survey will be conducted on the artificial reef as part of the as-built in order to estimate percent of net reef cover. The goal of this is to ensure that the artificial reef site reflects a similar hardbottom to sand ratio as the pre-construction natural hardbottom. Annual surveys will also be conducted for three years post-construction to document that the reef is providing appropriate mitigation for hardbottom impacts. During the third (and final) annual mitigation monitoring, the edge of the artificial reef will be delineated to quantify the total acreage of functional artificial reef.

The mitigation units will be sized to provide sufficient mass to be stable under the influence of wave and currents conditions that may occur for a storm with a return period of at least 50 years and a minimum factor of safety against sliding and overturning of 1.5. The units will be made of concrete with sufficient internal steel reinforcing and minimum concrete cover to provide durability for handling and installation and in-place service. It is not unreasonable to expect that the design life of the structures will exceed 70 years.

8.0 Performance Standards

Success of the compensatory mitigation project will be achieved when the benthic community and colonization of the mitigation reef have been documented to be comparable to the benthic community and species composition which were observed in the impact area during pre-construction. The monitoring and reporting requirements are described in Section 9. The mitigation success criteria shall include:

1. An obvious trend toward similarity in the benthic community between the artificial reef and the natural hardbottom by the completion of the monitoring period;

2. Percent cover by each of the major groups of organisms (functional groups) in the mitigation site shall be no less than it was in the impact site (difference shall be statistically insignificant);

3. 90% of the functional groups, octocoral genera and scleractinian coral species shall be present on the artificial reef compared to the natural hardbottom; and

4. A line-intercept survey shall demonstrate that net amount of reef versus sand did not change from the time of construction due to subsidence (not more than 5% buried from results of initial survey).

9.0 Monitoring Requirements

The mitigative artificial reef monitoring methods and schedules are described below. Additional monitoring details are included in the Broward County Shore Protection Project Segment II Draft Biological Monitoring Plan (CB&I and OAI, 2014b).

9.1 Mitigative Artificial Reef Monitoring

Broward County will monitor the artificial reef for benthic colonization and succession in order to detect whether the success criteria (defined in Section 8.0) have been met.

9.1.1 Artificial Reef Monitoring Schedule

Broward County will conduct an immediate post-construction artificial reef line-intercept survey, and will then monitor the artificial reef annually for three years following construction of the mitigative reef, for a total of four (4) artificial reef surveys. All three annual post-construction monitoring events will occur in summer (May through September) (Table 3).

Table 3. Artificial reef monitoring schedule and tasks to be completed during each monitoring event.

Year	Season	Phase	Task Completed
2015	Summer	Immediate Post-Mitigation	Line-Intercept
2016	Summer	1-Year Post-Mitigation	Benthic Quadrats Video/Photo
2017	Summer	2-Year Post-Mitigation	Benthic Quadrats Video/Photo
2018	Summer	3-Year Post-Mitigation	Benthic Quadrats Video/Photo Line-Intercept Edge Delineation

9.1.2 Artificial Reef Monitoring Methodology

9.1.2.1 30-m Transects

Benthic recruitment and succession will be monitored on the 6.8-acre artificial reef for three years following deployment of the mitigation reef modules. Twenty-eight (28), 30-m transects will be established and monitored with several methodologies, including quadrat assessments using the BEAMR methodology, line-intercept, and video documentation. These surveys will be conducted annually during the summer months (May through September) for three years following artificial reef construction. These data shall be compared to the pre-construction data collected on the natural hardbottom habitat to determine mitigation success (as defined in Section 8.0).

Benthic Ecological Assessments

Six (6) 1-m^2 quadrats will be sampled along each 30-m transect to evaluate the benthic cover of the artificial reef modules. BEAMR samples three characteristics of the benthos: physical structure, planar percent cover of sessile benthos, and density of coral and sponges. As with all non-consumptive surveys, BEAMR is necessarily constrained to visually conspicuous organisms with well-defined, discriminating characteristics for identification.

Physical characteristics recorded from quadrats include the maximum topographic relief (cm) and the maximum sediment depth (cm). Maximum relief is measured from the lowest to the highest point in the quadrat inclusive of attached hard substratum including organisms with stony skeletons (i.e., relief measurements do not include octocorals, tunicates, macroalgae, etc.). Three (3) sediment depth measurements will be taken in areas of sand within each quadrat, and maximum sediment depth (which must be at least 1 cm deep) will be recorded. The length of the ruler determines the maximum detectable sediment depth at a given point, e.g., for a 30 cm ruler, the value 30 denotes sediment ≥ 30 cm deep.

Estimates of the planar percent cover of all sessile benthos are pooled to 19 major functional groups that include: sediment, macroalgae, turf algae, encrusting red algae, sponge, hydroid, octocoral, scleractinian coral, tunicate, bare hard substrate, anemone, barnacle, bryozoan, bivalve, *Millepora* spp., seagrass, sessile annelid, wormrock, and zoanthid. When one or more functional groups occupy an area less than 1% of the total area surveyed, they are recorded under the category *Other*. Although the specific functional groups under the *Other* designation may be recorded as < 1% each, *Other* must add up to at least 1% to represent their collective presence. The breakdown of macroalgae genera and bioeroding sponge species percent cover that occupy at least 1% cover are also recorded. The two dominant macroalgae species shall also be identified.

Quad Label: Sample Name or #		List indiv coral sp. size (cm), Macroalgae Genus %, Clionaid spg sp. % + Cyano %	% cover or max size (cm)
Max Relief (cm)			
Max Sediment Depth (cm)			
Sessile Benthos…	**% Cover**		
Sediment- (circle all: sand shell mud)			
Macroalgae- Fleshy+Calcareous			
Turf-algae+cyanobacteria			
Encrusting Red Algae			
Sponge			
Hydroid			
Octocoral			
Stony Coral			
Tunicate			
Bare Hard Substrate			
Clionaid sponge present?	Y or N		
other-…			

Density is estimated by individual/colony count. Individual counts shall be conducted for all octocorals, scleractinian corals and sponges (not including clionaids). The maximum diameter (cm) and species of each stony coral (Scleractinia) and the maximum height (cm) and genus of each soft coral (Octocorallia) are recorded. Encrusting octocorals are measured by their maximum diameter (cm) similar to stony corals. Although coral colonies are measured to the nearest centimeter, individuals that are less than 1 cm will be recorded as < 1 cm to differentiate from colonies that are truly 1 cm. Any abnormal conditions of the colony e.g., bleaching, disease, and encrusting organisms, are also noted.

Video Documentation

Video documentation will be conducted along a survey tape stretched the length of each 30-m artificial reef transect. A close-up of the transect name clearly written on a waterproof slate shall be recorded for each video transect. The video will be recorded at a height of 40 cm above the substrate and a speed of approximately 4-5 meters per minute so that it is acceptable for video analysis, if required at a later date. Landscape panoramic views (360°) shall be recorded at the start and end of each transect. Additionally, a panoramic view shall be recorded at the start and end of each interruption of the benthos by a sand gap that extends for more than 10 m.

Representative photographs will be taken along the entire length of each for documentation purposes with particular attention paid to vertical ledges, large scleractinian coral colonies, and changes in benthic landscape along the transect.

Line-Intercept

A line-intercept survey shall be conducted on the artificial reef immediately following construction to estimate percent of net reef cover. The goal of this survey is to ensure that the artificial reef mimics the hardbottom coverage documented on the nearshore natural hardbottom as reported in the baseline characterization report and permit application. A line-intercept survey will be conducted again three years post-mitigation deployment to demonstrate that the net amount of reef versus sand did not change since construction due to subsidence (not more than 5% buried from result of immediate post-mitigation survey).

The line-intercept method has been shown to be an efficient method for collection of ecologically significant data on coral reefs (Loya, 1978) and will be used to document the spacing between mitigation reef modules. These data provide greater spatial resolution than most methods and are readily employed along transects. A biologist will document the location of the reef boundaries interrupted by sand patches larger than 0.5 m in length (by the transect interception) to determine the ratio of sand to reef.

Transect Locations

Twenty-eight (28), 30-m transects will be established on the artificial reef (four per acre) to document benthic recruitment and succession. Transects will extend from the edge of the reef for a distance of 30 m and will generally be oriented from west to east. Eye-bolts will be used to permanently mark the transect ends, and additional 6-inch long stainless steel pins will be installed along each permanent transect to ensure repeatability for post-construction monitoring. Once established, the east (start) and west (end) termini of each transect will be marked with DGPS. Proposed transect start (west end) locations are provided in Table 6. These locations may be adjusted in the field during transect establishment. New coordinates will be collected at all transects during pre-construction.

Table 4. Proposed locations of 28, 30-m artificial reef transects.

Transect	Latitude	Longitude
AR01	26.1977	-80.0905
AR02	26.1975	-80.0905
AR03	26.1946	-80.0897
AR04	26.1944	-80.0897
AR05	26.1938	-80.0897
AR06	26.1934	-80.0904
AR07	26.1926	-80.0900
AR08	26.1906	-80.0896
AR09	26.1860	-80.0922
AR10	26.1830	-80.0924
AR11	26.1845	-80.0923
AR12	26.1848	-80.0923
AR13	26.1833	-80.0924
AR14	26.1841	-80.0924
AR15	26.1803	-80.0924
AR16	26.1804	-80.0924
AR17	26.1795	-80.0927
AR18	26.1843	-80.0924
AR19	26.1829	-80.0924
AR20	26.1832	-80.0924
AR21	26.1930	-80.0902
AR22	26.1927	-80.0900
AR23	26.1924	-80.0900
AR24	26.1910	-80.0895
AR25	26.1835	-80.0924
AR26	26.1802	-80.0924
AR27	26.1794	-80.0927
AR28	26.1793	-80.0927

Artificial Reef Mapping

The boundaries of the artificial reef shall be mapped one time during the third annual survey. The mapping survey is conducted *in situ* by biologists following outer boundary of the artificial reef. A buoy with a Differential Global Positioning System (DGPS) antenna linked to a topside laptop computer running HYPACK navigational software is towed along reef edge to record the position of the reef boundary. The reef edge will be presented on a map within the 3-year post-mitigation annual monitoring report and a shapefile will be provided as well.

9.1.3 Artificial Reef Monitoring Reporting

Monitoring reports shall be completed after the 1-year, 2-year and 3-year post-deployment surveys of the artificial reef and shall be provided within 90 days after completion of each annual monitoring event. The JCP Compliance Officer and the USACE shall be notified at the commencement and completion of each monitoring event, along with weekly progress updates throughout monitoring. Each annual report shall document the colonization of the artificial reef and compare the species composition on this reef to that documented in the impact area during the pre-construction survey.

Annual monitoring reports shall be provided in digital format and shall include:

1) A map including the project, adjacent hardbottom resources with monitoring transects, the artificial reef with monitoring transects overlaid onto recent, clear aerial photographs;
2) An analysis of quantitative data on benthic biological components on artificial reef monitoring transects (e.g., percent cover by corals, octocorals, sponges, and algae);
3) A comparative analyses of the artificial reef and natural hardbottom communities to determine mitigation success;
4) Area of artificial reef (for Final report only); and
5) Video and photo documentation.

Within 30 days following construction of the artificial reef, Broward County will complete the Florida Fish & Wildlife Conservation Commission's (FWC) "Florida Artificial Reef Materials Placement Report and Post-Deployment Notification":
http://myfwc.com/docs/Conservation/FWCArtificialReefMaterialPlacementReport.pdf.

10.0 Long-term Management Plan

Based on previous performance of artificial reefs in southeast Florida, including Broward County, it is anticipated that the proposed mitigative artificial reef substrate will succeed at offsetting project impacts to the nearshore natural hardbottom. The County will implement a Biological Monitoring Plan that includes monitoring the mitigative artificial reef to ensure the colonization and development of the reef proceeds as anticipated. However, if the benthic community on the artificial reef is not similar to the impacted hardbottom resources after three years of monitoring, Broward County will conduct additional monitoring, if required. The County will coordinate with state and federal agencies to determine a path forward if the mitigation does not succeed at offsetting hardbottom impacts.

11.0 ADAPTIVE Management Plan

Adaptive management techniques may occur during the mandated monitoring period (pre-construction through 3 years post-construction). For example, if the artificial reef does not display an obvious trend toward similarity to the nearshore natural hardbottom habitat, transplantation techniques may be implemented. In this scenario, Broward County will evaluate their existing budget (including FDEP cost sharing funds) for this project to determine availability of funds to implement remedial actions. Impacts to the artificial reef as a result of a hurricane (or other storm events) or sea level rise are considered acts of nature. The County will not be responsible for reparations due to acts of nature.

12.0 Financial Assurances

Broward County's beach management program is funded through the Federal Shore Protection Project, Florida Beach Management Funding Assistance Program, Broward County Tourist Development Tax (TDT), and contributions from local beachfront community general revenue. All of these funding sources are expected to be secure for the foreseeable future and available to address any future project contingencies that may arise including additional mitigation for unanticipated impacts to the nearshore hardbottom habitat due to project construction.

Federal Funding. The Broward County Federal Shore Protection Project was authorized by Section 301 of the 1965 River and Harbor Act, Public Law 89-298 passed October 27, 1965 (79 STAT.1090). The project is described in House Document 91, 89th Congress. Authority was granted "to permit construction of the beach erosion control features of the projects by local interests, if they desire, with subsequent reimbursement of the Federal share of the beach erosion control work done by them after initiation of the survey study, provided that the work is approved by the Chief of Engineers as being in accordance with the authorized projects." The sponsor for the Segment II project is the Board of County Commissioners, Broward County, Florida. Since 1976, the Federal government has spent in excess of $50 million on beach restoration and renourishment projects along the Broward County shoreline.

The Federal cost-sharing rate for the Broward County Segment II shoreline is 55.1% (USACE, 2014). That is, for qualifying project areas, the Federal government will pay 55.1% of all project related costs. This includes planning, engineering, design, permitting NEPA coordination, construction, mitigation, and post-project monitoring.

State Funding. Funding assistance for beach projects throughout the State of Florida is available through the Florida Beach Management Funding Assistance Program. The program works in concert with local sponsors to achieve the protection, preservation and restoration of the coastal sandy beach resources of the State. Under the program, financial assistance in amounts up to 50% of project costs is available to the local sponsor (any state, county, municipality, township, or special district) for shore protection activities. The funds can be used to support beach restoration and nourishment activities including project design, engineering studies, environmental studies, mitigation, maintenance, monitoring, and other beach erosion prevention related activities consistent with the adopted Strategic Beach Management Plan. The program is authorized by Section 161.101, Florida Statutes. Since its inception in 1964, the Program has been a primary source of funding for local governments to address beach erosion control and preservation activities.

Local Funding. The Broward County Tourist Development Tax (TDT), which is sometimes referred to as resort tax, bed tax, local option tourist tax or transient rental tax, was approved by voter referendum in 1980 to support a Broward County Tourist Development Plan. The Broward County TDT rate is 5%. Living quarters and accommodations in a hotel, apartment hotel, motel, resort motel, apartment, apartment motel, rooming house, mobile home park, recreational vehicle park, single family dwelling, beach house, cottage, condominium, or any other sleeping accommodations that are rented for a period of six months or less are subject to the TDT. In 2013, the TDT generated $47.6 million. This revenue can be used by the County for tourist related advertising, promotion and development; project and activities related to tourist promotion; and development of community, civil and convention facilities.

Since 1980, the TDT has been used to fund Broward County's beach management program and related activities. For eligible expenses, the County has recovered a portion of these expenses through the cost-sharing agreements they maintain with the USACE, State of Florida DEP, and local communities. For most expenses related to beach management and associated projects, Broward County fronts all required funding and subsequently seeks reimbursement from the Federal, State, and local governments.

These funding and cost-sharing opportunities are expected to remain available to Broward County for the purposes of the beach management program and associated project beyond the timeframe necessary to ensure the County's responsibilities regarding project related impacts are met.

13.0 Literature Cited

CB&I Coastal Planning & Engineering, Inc. (CB&I) and Olsen Associates, Inc. (OAI). 2013. Broward County Shore Protection Project Segment II Benthic Characterization Report.

CB&I Coastal Planning & Engineering, Inc. (CB&I) and Olsen Associates, Inc. (OAI). 2014a. Broward County Shore Protection Project Segment II Draft Coral Transplantation Plan. August 2014.

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Walker, B.K. 2012. Spatial Analyses of Benthic Habitats to Define Coral Reef Ecosystem Regions and Potential Biogeographic Boundaries along a Latitudinal Gradient. PLoS ONE 7(1): e30466. doi:10.1371/journal.pone.0030466

APPENDIX E

Technical Review of:

Broward County Shore Protection Project – Segment II Assessment of Potential Project Related Effects to Nearshore Hardbottom
&
DRAFT Biological Monitoring Plan For The Broward County Shore Protection Project Segment II

Comments by: Mr. Coraggio Maglio
Reviewed by: Mrs. Tanya Beck and Dr. Julie Rosati

The approach employed for this assessment seems reasonable and scientifically acceptable, although very conservative. The assumptions employed for this assessment are conservative at each and every step through the evaluation process. These compounding conservative assumptions have led to a highly conservative estimate of potential hardbottom impact.

Definitions:
Environmental effects evaluated under NEPA include direct, indirect and cumulative effects. According to Title 40, Sections 1508.7 and 1508.8, Code of Federal Regulations (CFR):

- ☐ ***Direct effects***… are caused by the action and occur at the same time and place
- ☐ ***Indirect effects***…are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable
- ☐ ***Cumulative impact*** is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions.

The terms "effects" and "impacts" are synonymous in these regulations (***40 CFR 1508.8***) and are used interchangeably in this handbook ("Cumulative Effects Evaluation Hnadbook" Florida Department of Transportation, Environmental Management Office. December 2012).

Assessment:
Upon review of this assessment report the following items are notable.

1. The equilibrium beach profile (EBP) utilized is based on an empirical average composite beach profile which is horizontally translated to account for the initial fill placement volume.
2. The EBP analysis is extremely conservative in that it does not account for the steepened beach profile due to the proposed use of coarser borrow material. It also does not account for alongshore dispersion of material and assumes a "closed alongshore cell" where sediment can only spread in the cross-shore direction.
3. In review of secondary impacts, the assumption that the sedimentation over exposed hardbottom is permanent and ubiquitous across the high relief reef is

highly conservative as the sedimentation of less than 10 cm would have great spatial variability. This new beach fill material will also disperse through time due to normal coastal processes.

4. The methodologies and assumptions employed in this analysis were developed and established in concert with FDEP.

5. The proposed monitoring plan adequately addresses the longer-term (>1 year) potential impacts to adjacent resources.

<u>Comments:</u>

☐ There could be indirect (secondary) effects to hardbottoms beyond the EBP due to sedimentation and turbidity. Given the characteristics of the proposed sand source, the project related contribution to this may be less than or equal to existing natural seasonal or episodic conditions, especially if the placed fill is well sorted and coarser than existing as is shown in this assessment. The determination of the source of impacts, natural versus anthropogenic, is why an intensive monitoring program with a control location far away from the project site, but with similar coastal forcing, is necessary.

☐ Since the sediment is coming from an upland source and is being processed prior to placement, and not from an in-water borrow site, quality control should be able to be performed in a much more robust manner, and minimize the potential for chronic turbidity plumes. The potential for secondary impacts should still be monitored even though the occurrence of such an event appears unlikely given the proposed borrow sources.

☐ The proposed monitoring plan does not adequately address quantification of short-term impacts (<1 year) to adjacent resources. These impacts can be very difficult to determine their source, whether caused by natural phenomenon or anthropogenic activity.

Recommendations:

☐ When relic deposits of sediment from an external source are initially placed in the active coastal system, there is the potential for initial cross-shore spreading of this material beyond the anticipated fill extent (average EBP) because of the initial sorting and redistribution of sediments to their appropriate profile locations and due to the unconsolidated condition of mechanically placed fill materials as then acted upon by the energetic wave environment. To measure and monitor this phenomenon, it is recommended that an intensive monitoring program be established to quantify the sedimentation that occurs due to the placement, and its spatial extent, against a control site far outside of the project area but with similar coastal forcing. This level of monitoring may be necessary to provide the reasonable assurance to ensure there are no unanticipated impacts above natural conditions.

☐ Suggest installing remote sensing stations or performing dive surveys following significant process events (ex. wave heights of 6 feet) at a small subsets of the proposed transects (5 project transects and 5 control transects) during the first 6 months post placement, with at a minimum dive surveys at 3 and 6 months post placement. The data collection effort for the first 6 months following placement should solely focus on sediment depth along the transect and not other more difficult to quantify longer term biological parameters.