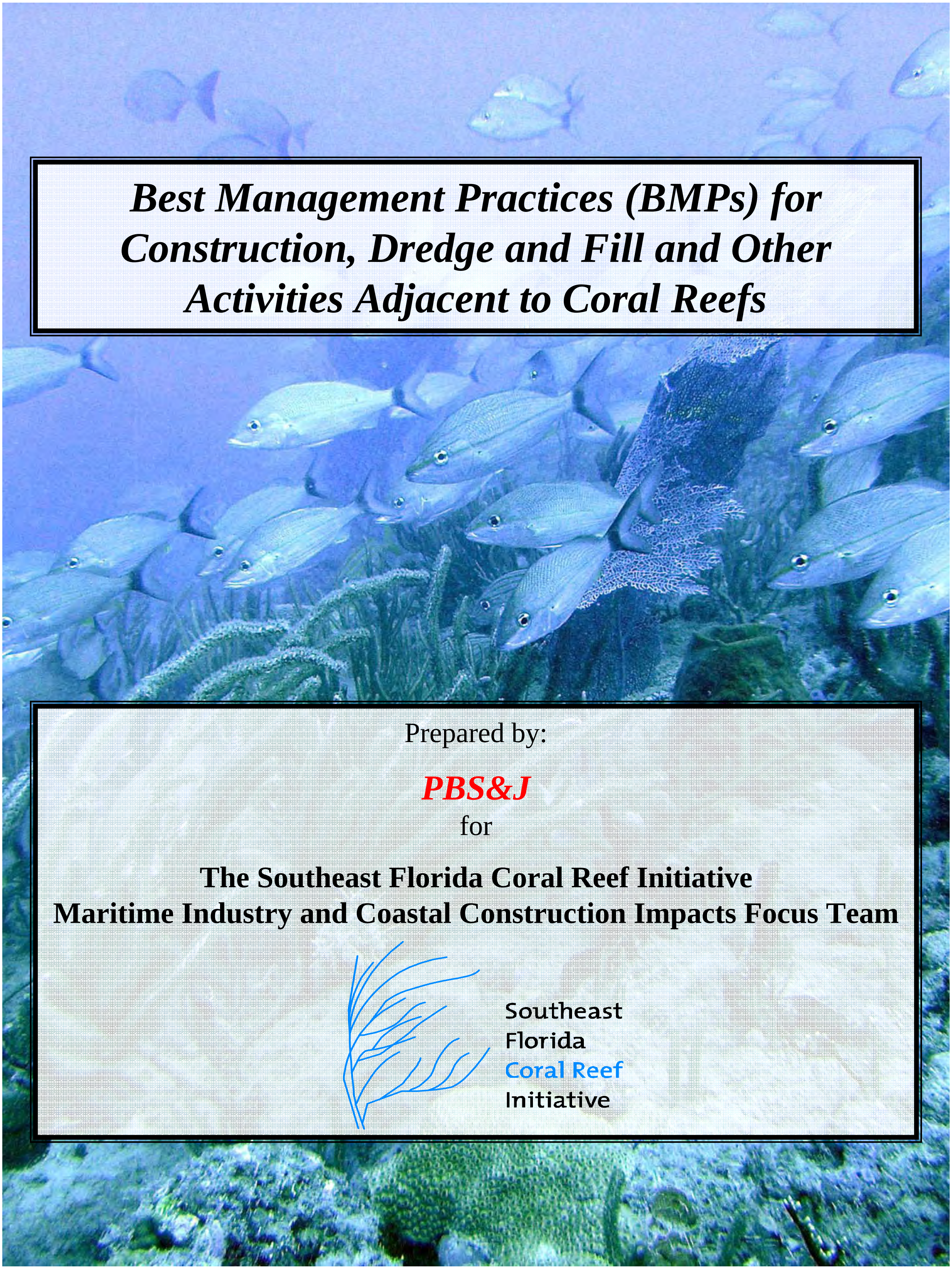


Best Management Practices (BMPs) for Construction, Dredge and Fill and Other Activities Adjacent to Coral Reefs

Prepared by:

PBS&J

for

The Southeast Florida Coral Reef Initiative
Maritime Industry and Coastal Construction Impacts Focus Team

Southeast
Florida
Coral Reef
Initiative

Best Management Practices (BMPs) for Construction, Dredge and Fill and Other Activities Adjacent to Coral Reefs

Prepared by

PBS&J

Completed in fulfillment of contract RM6011 for the:

Southeast Florida Coral Reef Initiative (SEFCRI)
Maritime Industry and Coastal Construction Impacts (MICCI) Focus Team
Local Action Strategy Project # 6

and

Florida Department of Environmental Protection (FDEP)
Coral Reef Conservation Program (CRCP)
1277 N.E. 79th Street Causeway
Miami, FL 33138

Cover Photo by Dr. Vladimir Kosmynin

This project and the preparation of these workshop proceedings were funded in part by a Coastal Zone Management grant, Award No. NA05N0S4191008, from the National Oceanic and Atmospheric Administration (NOAA) through a contract with the Office of Coastal and Aquatic Managed Areas of the Florida Department of Environmental Protection (FDEP). The total cost of the project was $30,000, of which $20,000 was provided by NOAA. The views expressed herein are the views of the authors and workshop participants and do not necessarily reflect the views of the State of Florida, FDEP, NOAA or any of its sub agencies.

February 2008

FOREWORD

Humans have extended their reach over land and sea, altering the natural landscape to suit human wants and needs. As a species, we have been responsible for habitat alteration, loss, and destruction with ramifications beyond our current day. These alterations have come at the expense of natural environments which housed plants and animals, whose populations have been effected, sometimes irreparably, as in the case of species extinctions, due to changes in their environment. As our understanding of anthropogenic effects on natural systems has grown, we have incorporated our understanding into the management of natural resources. A topic in conservation biology that has become popular in the last 20 years has been the concept of ecosystem management. Ecosystem management is defined as the integration of ecological, social, and economic objectives for natural resource management. Ecological objectives focus on the maintenance and enhancement of biological diversity, ecosystem integrity, and the sustainability of natural resources (Ecosystem Management Research Institute 2007). According to the Report of the Ecological Society of America Committee on the Scientific Basis for Ecosystem Management, ecosystem management includes the following: 1) sustainability, 2) sound ecological models and understanding, 3) understanding complexity and interconnectedness, 4) recognition of the dynamic character of ecosystems, 5) attention to context and scale, 6) acknowledgment of humans as ecosystem components, and 7) commitment to adaptability and accountability (Christensen et al. 1996).

Sustainability is a core principle of ecosystem management and is considered a prerequisite objective for resource management plans. Management plans should be derived from the best current models of successful ecosystem function and resource managers need a sound understanding of natural processes. Ecosystem management also depends on research and monitoring at all organizational levels, from individuals to populations to communities, etc. It is important to note that change is a defining characteristic of all ecosystems and any attempt to "freeze" nature may result in project failure. Ecosystem processes occur over extensive spatial and temporal scales, thus, there is no single appropriate scale or timeframe for management plans. Management plans require regular review and updates which follow from monitoring and research results. Humans are an important part of ecosystems; however, humans are the cause of most challenges associated with natural resource sustainability. Growing populations and increasing demand for natural resources require well-supported management initiatives and the ability to respond to human demand in a sustainable way. Adaptability and accountability are essential elements of ecosystem management and managers must be able to adapt to the unique characteristics of any particular area.

An ecosystem management approach takes into consideration all of the components of an ecosystem and manages resources and projects in a manner which preserves and maintains each component as much as possible. For coastal construction in and around coral reefs this means taking into account submerged aquatic vegetation (SAV), mangrove, and upland communities as well as nearshore sand and hardbottom communities and their interaction with coral reefs.

In 2004, the Florida Department of Environmental Protection (FDEP) established a Coral Reef Conservation Program (CRCP) to plan, direct, and coordinate the implementation of the Southeast Florida Coral Reef Initiative (SEFCRI). The primary objective of the SEFCRI, through its agency, industry, and concerned citizen partners is coral reef protection balanced with sustainable resource use; each project in the SEFCRI region is viewed with an ecosystem management philosophy. Extending from the Florida Keys, through Biscayne Bay and into southeast Florida, the coral reef/hardbottom ecosystems in these regions comprise the larger Florida Reef Tract. Best Management Practices (BMPs) for Coastal Construction Activities adjacent to coral reefs will benefit SAV and mangrove communities, which are part of the coral reef ecosystem. At the same time, BMPs for communities other than the coral reef are necessary for their direct protection and the protection of the reef. With this in mind, included at the end of this document are some BMPs, which address activities in SAV, mangrove, and upland areas.

TABLE OF CONTENTS

1.0 Introduction

Best Management Practices (BMPs) are defined herein as the physical, structural and/or managerial practices that when used singly or in combination, prevent or minimize adverse impacts to environmental resources resulting from coastal construction activities. The majority of existing BMPs that address water quality and sedimentation impacts have been developed for upland construction activities in order to reduce or eliminate runoff of pollutants and sediment into wetlands and surface waters. BMPs were first developed and implemented by the Soils Conservation Service in response to significant soil losses on farms due to wind and water-based erosion (Helms 2007). Examples include contour plowing and maintenance of tree lines along farm field boundaries. The principal goal is maintaining water quality and eliminating or reducing erosion generated sedimentation. However, existing BMPs for marine construction in the open ocean environment for the protection of submerged aquatic resources are fewer in number.

The Best Management Practices (BMPs) presented in this document were developed as part of a Local Action Strategy of the Southeast Florida Coral Reef Initiative (SEFCRI) (FDEP 2004) to guide the coastal construction industry, environmental planners, managers and regulators in planning, permitting and implementing projects adjacent to coral reef and hardbottom habitats. The purpose of these BMPs is to reduce, minimize and/or eliminate impacts to coastal habitats and reef ecosystems potentially impacted by coastal construction activities. This BMP document will be a living document subject to changes and additional recommendations evolving from lessons learned.

Coral reefs and their associated communities are one of the richest, yet most sensitive, ecosystems in the marine environment. These communities provide habitat and food for fishes, materials for new medicines, revenue from tourism and recreation and protection to uplands from coastal storms. Scientists and resource managers have been concerned for many years that increasing stress from human activities is contributing to the decline of coral reef communities.

> *The value of coral reef ecosystems is matched only by their vulnerability to harmful environmental changes, particularly those resulting from human activities. Ultimately success or failure in conserving these highly complex and valuable ecosystems will depend on how well we can develop and apply proactive, precautionary measures (USCRTF 2000).*

Reported knowledge about the economical and environmental value of coral is abundant, but sometimes diffuse. Indirect impacts of dredging and marine construction often can only be measured after time. Little is known about the long-term detrimental effects of dredging and coastal construction activities on coral reef communities (International Navigation Association Environmental Commission - EnviCom Working Group 15, 2005).

Background

Early development in southeast Florida was lead by construction of the Florida East Coast Railway (FECR). The FECR reached West Palm Beach in 1894 and extended to Miami in 1896. The presence of the FECR resulted in an economical and efficient means of transporting people and goods to southeast Florida. This contributed heavily to subsequent population and construction booms (Flagler Museum 2006). Today, construction and development in southeast Florida continues to grow with coastal areas being some of the most valuable and sought after lands in the state of Florida.

The southeast coast of Florida is bordered by a series of barrier islands that separate the bays, lagoons, and estuaries from the Atlantic Ocean. These barrier islands continue to be in great demand for residential and commercial development in addition to recreational use. Acting as the mainland's first line of defense, barrier islands are highly vulnerable to the forces of winds, waves, and storms which protect the back barrier marsh and coastal estuary habitats. Loss of this protection would have catastrophic effects on these highly productive systems.

Across these barrier islands, multiple inlets have been created and stabilized, first to accommodate commercial vessel access to major ports and the Atlantic Intracoastal Waterway (AIWW) and, as a by product, provide recreational access to the Atlantic Ocean. Inlets within the SEFCRI region include St. Lucie Inlet, Jupiter Inlet, Lake Worth Inlet, South Lake Worth Inlet, Boca Raton Inlet, Hillsboro Inlet, Port Everglades Inlet, Bakers Haulover Inlet, Miami Harbor/Government Cut, Norris Cut Inlet, and Bear Cut Inlet. The unintentional but significant result of inlet creation has been large changes to the shoreline throughout this region.

The northern extension of the Florida Reef Tract is located just 1.5 km from the densely populated and heavily urbanized southeast Florida coast. Spanning 170 km from the northern border of Biscayne National Park in Miami-Dade County to the St. Lucie Inlet in Martin County (Figure 1), the reefs and hardbottom areas in this region support a rich and diverse biological community.

Although the southeast Florida reef system is subjected to impacts from a variety of sources (e.g. resource use, land-based sources of pollution, etc.), this document focuses on reducing the detrimental impacts from coastal construction activities including, but not limited to, beach nourishment projects, fiber optic cable and pipeline installation, and port maintenance and expansion.

Figure 1: The Southeast Florida Coral Reef Initiative is targeting the counties of Miami-Dade, Broward, Palm Beach and Martin, and the coastal waters from the northern border of Biscayne National Park to the S. Lucie Inlet. Source: FDEP CRCP

Coastal Construction Industry Stakeholders

Coastal construction industry stakeholders include federal, state, and local government agencies as well as non-governmental environmental organizations, recreational interests and the public. Marine contractors, port authorities, and recreational boaters are also among the stakeholders having an interest in coastal construction activities. For the purpose of this study, a detailed list of agencies and industry stakeholders for the SEFCRI Region are provided in Appendix 1.

Coastal Construction Impacts

The rapid growth of population and tourism over the past several decades in the SEFCRI region has contributed to increasing pressures on the coastal ecosystem. Coastal construction activities have been implicated in a number of adverse impacts in marine and coastal environments. Some of these impacts have received scientific investigation and some remain subjective.

A U.S. Fish and Wildlife report (2004) prepared pursuant to Resolution 4 from the 8th Coral Reef Task Force meeting held on October 2-3, 2002, in San Juan, Puerto Rico, concluded that projects involving filling and dredging for beach nourishment and port development have caused the most impacts to coral reef habitats in South Florida since 1985. The 26 Florida projects (16 completed; 10 pending) reviewed in this report impacted 217 acres of reef, and mitigated with 113 acres of artificial reef.

The South Atlantic Fishery Management Council (SAFMC) has published a document entitled Policies for the Protection and Restoration of Essential Fish Habitats from Beach Dredging and Filling and Large Scale Coastal Construction Projects. The findings of this document present an assessment of threats to Essential Fish Habitat (EFH) posed by large scale coastal construction activities. These policies are designed to avoid, minimize and offset damages to EFH caused by these types of activities. To learn more about SAFMC's Policies, the document may be accessed at: http://www.safmc.net/Portals/0/HabitatPolicies/BeachPolicy.pdf

Coastal construction projects may benefit one or more components of the marine ecosystem while at the same time adversely impacting others (USACE 1989). The following section discusses adverse impacts to marine habitats that may result from coastal construction activities.

Direct Impacts

Direct impacts from construction equipment can result in dislodgement, fragmentation, and injury/death to reef organisms (Figure 2). Dredging activities may cause reef damage during placement of dredge heads, barge spuds, anchors, cables, booms, and pipelines. The placement of telecommunications cables directly on the reef may crush, dislodge, fragment, or kill benthic organisms from the original installation and also from periodic shifting from storm events after installation. Improperly sited artificial reefs could affect natural reefs when installed on top of or in close proximity to natural hardbottom communities. Movement of artificial reef

Figure 2: Fiber optic cable directly impacting a *Montastraea cavernosa* colony. Source: Cry of the Water

material during major storm events can damage natural reef communities in close proximity to artificial reefs. This may occur if the artificial reef material is not stable or not suitable for placement in a particular area.

Coastal construction activities such as the blasting of reef framework, which may be associated with channel creation or widening projects, can convert reef habitat to a different habitat type and may also result in a total loss of reef organisms and structure. Vessel groundings on hardbottom and coral reefs can result in complete destruction of habitat in the area of direct contact and degradation of neighboring habitat. Additionally, vessel anchors can damage coral reef and hardbottom communities. From 1994 to 2006, over 11 acres of coral reef and hardbottom habitat were injured or destroyed in Broward County from groundings and anchoring impacts (Collier et al. 2007). Physical burial of the reef, including burial by sediment deposition, can also result in habitat loss. Physical impacts due to burial of deep habitats offshore may also be associated with dredging activities in the nearshore. Ocean dredge material disposal sites (ODMDS) associated with coastal construction may impact deep benthic organisms and mobile fauna associated with these habitats. In particular, the commercially important deepwater fishery resources, such as tilefish and snowy grouper may also be affected by these activities (Karazsia pers. comm.).

Turbidity and Sedimentation Impacts

The accumulation of sediment on coral reefs (Figure 3) or "sedimentation" associated with coastal construction can have negative impacts on coral reefs and is a ubiquitous cause of coral reef degradation (Rogers 1990; Riegl 1995). Sedimentation occurs as a result of both natural (land and reef erosion) and anthropogenic events. During coastal construction, large quantities of sediment may be disturbed and can easily enter coastal marine environments. This introduction of sediment increases the turbidity of the water column. Turbidity is a measure of water clarity and is associated with suspended particles and reduced visibility (Trnka et al. 2006; USGS 2007). Coastal marine environments experience wide ranges of turbidity as a result of natural physical forces, coastal construction, and terrestrial runoff (Rogers 1990; Fabricius 2005).

Any sediments in the water column cause turbidity, however, there is a large range of impacts depending on the character of the sediment and the physical environment. In the study of soils and sediment, several organizations have attempted to develop sediment descriptors based on grain size. According to the Unified Soil Classification System, sediment grains sizes can be generally described as gravel (75 mm to 4.75 mm), sand (4.75 mm to 0.075 mm) or silt and clay (< 0.075mm). The silt and clay category is often referred to as 'fine' material. Coarse material cannot stay suspended in the water column unless there is a significant amount of energy (waves, currents) present in the water. Large particles easily drop out of suspension near the point of disturbance. Fine material, or 'fines', on the other hand, is easily kept in suspension and is the largest contributor to turbidity and the reduction in light penetration.

Sedimentation and turbidity are issues that are often associated with both marine and terrestrial construction activities. Potential anthropogenic sources of sedimentation and turbidity occurring in the marine environment include dredging (offshore and nearshore); hopper barge overflow; the disposal of dredge material (ocean and upland), beach and dune sand placement, the creation of spoil islands; the construction of coastal structures such as docks, piers, jetties, and breakwaters; and the construction of stormwater discharge pipes and outfalls. Natural sources of sedimentation are the suspension of bed material due to currents and waves. Coral reefs and hardbottom communities may be negatively impacted, if the sedimentation is in excess of that commonly experienced by the corals in their natural environment. Sedimentation may have the following negative effects on corals: 1) coral mortality by smothering or burial (Loya 1976; Cortes and Risk 1985; Riegl 1995; Fabricius and Wolanski 2000; Nugues and Roberts 2003; Philipp and Fabricius 2003); 2) reduction of coral growth by scraping or shading (Dodge et al. 1974; Loya 1976; Anthony 1999); 3) decrease in photosynthetic activity of zooxanthellae, and increase in mucus production by coral (Riegl and Branch 1995; Yentsch et al. 2002; Philipp and Fabricius 2003); and 4) decrease in coral fecundity, coral larval settlement, and early survival (Hodgson 1990; Babcock and Davies 1991; Hunte and Wittenberg 1992; Stafford-Smith 1993; Gilmour 1999). A large-scale dredging project and corresponding monitoring event were conducted on Miami Beach beginning in 1977 (Marszalek 1981). Monitoring revealed that approximately one centimeter of sediment was deposited on the nearby reef surface in less than two hours (Marszalek 1981). Scleractinian corals suffered the most damage and were observed actively cleaning themselves of sediments (Marszalek 1981). Partial mortality and paling were also observed on affected coral colonies (Marszalek 1981). Small colonies of *Dichocoenia stokesii* and *Montastraea cavernosa* displayed bands of dead tissue adjacent to the substrate, as a result of burial (Marszalek 1981).

Telesnicki and Goldberg (1995a) examined the physiological responses of two Caribbean corals, *Dichocoenia stokesii* and *Meandrina meandrites*, to elevated levels of turbidity in vitro. Results of the three-week study showed increased mucus production and an increase in respiration, but no apparent decrease in the photosynthesis in either coral species. The authors concluded that turbidity levels of 29 NTU can result in both short- and long-term stress to corals (Telesnicki and Goldberg 1995a). Telesnicki and Goldberg (1995b) compared the measurement of turbidity by Nephelometric Turbidity Unit (NTU) and transmissometry (T) and their relevance to water quality standards. They compared field measurements of turbidity with various standards and found that standards do not realistically reflect turbidity in the field (Telesnicki and Goldberg 1995b). The Atlantic States Marine Fisheries Commission concluded that appropriate standards must be set based on the "organisms present in the coastal areas, with some areas requiring more stringent standards" and that the current Florida standard of 29 NTU's "may not be conservative enough and state agencies may want to re-examine their turbidity standards" (Greene 2002).

Figure 3: Sedimentation at Paul's Reef. Source: Dr. Vladimir Kosmynin

According to Ongley (1996), turbidity limits the amount of sunlight reaching the seafloor, reducing the photosynthetic ability of corals and eventually leading to coral reef degradation. During the Miami Beach dredging project, Marszalek (1981) observed a general increase in turbidity throughout the study area and turbidity levels varied depending on proximity to the dredge, tidal cycles, and weather conditions. An extensive transect survey completed during the winter of 1980 concluded that 3% to 32.4% (an average of 9.7%) of coral colonies exhibited signs of coral stress; a large increase from the 5% measured in 1978 (Marszalek 1981).

As part of the Broward County beach nourishment project, coral reef monitoring began in 2000 to gather coral population, sedimentation rates, and coral health indicator data for comparison purposes during and after the beach nourishment project. Gilliam et al. 2001 showed pre-construction mean coral density of 2.6 ± 1.22 colonies/m^2 and mean live coral cover 4.34% ± 9.72. Pooled data from September 2003 and September/October 2004 revealed the highest sedimentation rates occurred at the first reef (92.86 ± 16.92 mg/cm^2/day), followed by the second (50.08 ± 9.11 mg/cm^2/day), and third reefs (12.18 ± 2.33 mg/cm^2/day) (Gilliam et al. 2005).

Beach nourishment construction activities began in May 2005 (Gilliam et al. 2006). Results from the 6th annual monitoring report (May 2005-February 2006) revealed a mean coral density of 2.44 ± 1.26 colonies/m^2 and a mean live coral cover of 4.20% ± 7.69, with no significant change in coral density or coral cover between 2001 and 2006 (during nourishment activities) (Gilliam et al. 2006). Pooled data from December 2004 and October 2005 again revealed highest sedimentation rates on the first reef (Gilliam et al. 2006). The highest sedimentation rate was recorded in October 2005 and may have been associated with Hurricane Wilma Seven yearly monitoring sites located in close proximity to sediment borrow areas all revealed increased sedimentation rates during construction activities compared to pre-construction surveys, but there was no apparent effect on coral cover (Gilliam et al. 2006). The 2006/2007 post-construction monitoring report is currently under review.

CSA International was retained by the U.S. Navy to document potential impacts to reef communities due to increased turbidity and sedimentation associated with the Key West Harbor Dredging project. A pre-dredging survey conducted in February 2004 revealed 6.8% mean live stony coral cover, compared to the post-dredging survey completed in May 2006, which reported 5.6% mean live stony coral cover, this was not a significant decrease (CSA 2007). Sediment trap bottles yielded the lowest sedimentation rates in spring and early summer. Daily sedimentation rates ranged widely from 11.1 mg/cm^2/day in June 2004 to 1297.6 mg/cm^2/day in July 2005 (coincident with Hurricane Dennis). Average daily sedimentation rates fluctuated across all monitoring sites, and were higher during winter storms and associated rough seas. For the first 2 months of the project sedimentation rates were slightly elevated at monitoring sites which may have been due to hopper dredge operation, while sedimentation rates showed no increase associated with back hoe dredge operation (CSA 2007).

Pollutants

Concerns regarding the release of pollutants into the water column from dredge and fill activities are typically associated with maintenance dredging of port facilities and inland waterways. It is in these areas that one is more apt to encounter nutrients, heavy metals, organic compounds and pesticides. During dredging these pollutants may be introduced to marine environments. Nutrients bind to sediments and the re-suspension of these sediments can release nutrients into the surrounding water, potentially resulting in long-term disturbance to coral reefs. It has been reported that increased levels of dissolved inorganic nutrients can reduce coral calcification and reproductive success, and support macroalgal growth (Fabricius 2005). Scientific studies have revealed that nutrient threshold values exist for coral reefs and if exceeded, will lead to macroalgal blooms and the loss of coral-dominated reefs (Bell 1992; Lapointe 1997). Lapointe et al. (1990; Lapointe et al. 1993) argued that nutrient levels were elevated along the Florida reef tract as a result of anthropogenic inputs, namely sewage contamination of the groundwater and phosphate mining in west Florida. Nutrients also enter marine ecosystems via runoff and other human-related activities.

Various amounts of heavy metals are found in aquatic environments. These metals exist as dissolved ions or they may precipitate out of the water column onto benthic sediments (Trnka et al. 2006). Marine disposal of untreated sewage results in elevated concentrations of metals (specifically chromium, copper, nickel, lead, silver, zinc, and iron) and other pollutants on the ocean floor (Zdanowicz et al. 1991; Zdanowicz et al. 1995). Metals also enter marine coastal environments via stormwater runoff, inputs from surface water and groundwater, and atmospheric dust (Klein and Goldberg 1970; Huntzicker et al. 1975; Forstner and Wittmann 1979; Burnett and Schaeffer 1980; Finney and Huh 1989; Huh et al. 1992). Several heavy metals are vital to coral reefs; however, metals, in elevated concentrations, can become toxic (GBRMA 2007). High concentrations of metals have a negative impact on coral fecundity (Negri and Heyward 2001; Reichelt-Brushett and Michalek-Wagner 2005; Reichelt-Brushett and Harrison 2005; Victor and Richmond 2005), reproductive success, and larval settlement (Reichelt-Brushett and Harrison 2000; Reichelt-Brushett and Michalek-Wagner 2005; Reichelt-Brushett and Harrison 2005). Heavy metals can also interfere with reef building processes. Gilbert and Guzman (2001) discovered that elevated heavy metal concentrations decreased the activity of carbonic anhydrase (an enzyme thought to be important in coral calcification) in coral colonies (Goreau 1959; Isa and Yamazato 1984; Tambutte et al. 1996). Howard and Brown (1987) observed reduced growth rates in colonies of *Pocillopora damicornis* adjacent to a tin smelter. They suggested that increased metal concentrations inhibit chitin synthetase, an essential enzyme in coral calcification.

Persistent organic pollutants (POPs) are organic compounds that linger in the environment, travel through the food web, and pose risks to human health and the environment (UNEP 1999). Organic hydrocarbons, including petroleum products, are examples of POPs. Exposure to POPs can cause tissue atrophy, degeneration, mortality, and reduced fecundity in some coral species (Peters et al. 1981; Dodge et al. 1985; Peters et al. 1997). POPS are most commonly introduced to marine systems via discharged sewage and stormwater effluent, terrestrial runoff, and oil spills (Peters et al. 1997). Reduced coral calcification rates and pronounced signs of coral stress were observed when Dodge et al. (1985) briefly exposed coral colonies to an oil spill. In particular, *Manicina areolata* colonies continued to show symptoms of hydrocarbon contamination after being transported to a clean environment for two weeks.

Pesticides introduce contaminants through their active ingredients and additives as well as through their degradation products (Ongley 1996). Pesticides are commonly used and they are introduced to marine systems via run-off (Olafson 1978) and antifouling paints (Connelly et al. 2001). Pesticides, as well as their chemical constituents, can be very harmful to corals. Tributyl tin (TBT) can cause devastating damage to coral reefs. According to Goldberg (1986) and Maguire (1987), TBT is the most toxic substance introduced to the environment. In an attempt to decrease TBT levels, copper-based antifouling paints, such as Irgarol 1051, were created (Dahl and Blanck 1996). According to Dahl and Blanck (1996), brief exposure to Irgarol 1051 reduced photosynthetic ability of periphyton while continued exposure produced changes in community structure. According to Peters et al. (1997), there are elevated levels of pesticides in nearly all corals off the Florida Keys. There is a need for additional research on the impacts of these contaminants on coral and hardbottom communities within the SEFCRI Region.

The Miami River dredging project is an example of maintenance dredging within the SEFCRI region. The Miami River was first dredged in the mid 1930's and as the city developed, the Miami River became the primary outlet for untreated sewage and stormwater (Weston Solutions Inc. 2007). This untreated sewage and stormwater, in addition to numerous other pollutants, contributed to the contamination of the water column and the benthic sediments of Miami River. These contaminated sediments posed several problems for the Miami River dredging project and, as a result, several environmental studies were performed. According to environmental studies conducted by the National Oceanic and Atmospheric Administration (NOAA), the U.S. Army Corps of Engineers (USACE) and the FDEP, the sediments of the Miami River are highly contaminated and pose a serious threat to the future viability of the river (Miami River Marine Group 2007). Sediment analyses also indicated the dispersal of contaminated sediments to Biscayne Bay (Miami River Marine Group. 2007. Quality Action Team). Presently, the biggest source of pollution to the Miami River is stormwater runoff. The river serves as drainage for approximately 69 square miles of land (Miami River Marine Group. 2007. Quality Action Team). As the stormwater travels to the Miami River, it accumulates industrial waste, pesticides, oils, and chemicals (Miami River Marine Group. 2007. Quality Action Team). These pollutants quickly settle into the sediments and are re-suspended into the water column when disturbed by vessels navigating up and down the river. Additional information concerning the Miami River O&M dredging project can be found at: http://planning.saj.usace.army.mil/envdocs/envdocsb.htm#Dade-County

Thermal Effluent

The biological consequence of discharging waters used to cool electricity-generating plants has received considerable attention over the past few decades. *In vitro* experiments have established that temperatures of 4-5°C above ambient result in coral mortality (Clausen 1971; Jones and Randall 1973; Clausen and Roth 1975). Thus, thermal discharges (e.g., power plant cooling waters) can have negative impacts on coral reef communities. Though the temperature disturbance is typically considered the most significant hazard associated with thermal discharges, thermal effluents may also contain hazards to aquatic organisms such as residual chlorine, increased suspended solids, decreased chlorophyll a, dissolved oxygen, etc. (Perkins 1974). While motile organisms are able to escape the unfavorably warm discharges, sessile benthic organisms are invariably impacted. Several scientific studies have documented the negative impacts that thermal effluents can have on coral reef communities. For example, Jokiel and Coles (1974) conducted a study on the shallow-water corals at Kahe Point, Oahu, Hawaii, which experienced an increase in power plant thermal discharge. Coral bleaching was observed where water temperatures increased 2-4°C above ambient temperatures and coral mortality was documented with water temperatures of 4-5°C above ambient. Neudecker (1981) documented the effects of the thermal effluent from power plants in Guam on the growth rates and survival of scleractinian corals. This study showed that the thermal effluent impeded coral growth rates and resulted in coral mortality.

Hydrofracture

The term hydrofracture, also known as a 'frac-out', refers to an accident during horizontal directional drilling where drilling fluid encounters a patch of unconsolidated sediments or a fault or crack in the geology above a boring and breaks out at the surface.

Typical directional drilling lubricant consists of water mixed with bentonite clay. Bentonite is naturally occurring clay, mined in the Western United States, weathered from glassy volcanic ash and is an alumina phyllosilicate. If it contains more than 2% of sodium, calcium, or magnesium it is called by the name of the associated primary ion. Sodium bentonite is highly expansive in water, while calcium bentonite, also known as Fuller's earth, is non-swelling. Sodium bentonite is most commonly used as drilling mud since its expansive and binding properties help to stabilize the sides of the drill hole in sandy substrates.

A 6% solution of sodium bentonite in water has a pH of 9.5, which is much higher than that of seawater. If released in seawater, the sodium bentonite could bond with ions in seawater altering local water chemistry. Additionally, the reaction of sodium bentonite with seawater has the potential to precipitate solid from solution thereby increasing local turbidity.

Commercial Vessel Operations and Navigation Impacts

Watercraft and vessel traffic through shallow water and nearshore areas can suspend bottom sediments and erode shorelines, and increase turbidity in the water column. Turbidity blocks the penetration of sunlight to underwater plants and animals (e.g. corals) that need light for survival, and it reduces visibility for fish that rely on sight to catch their prey. Vessel propellers may also churn up harmful chemicals that had been trapped in the sediments. Vessel hulls and propellers in close proximity with shallow hardbottom areas may result in propeller scarring and groundings.

Vessels that utilize ballast water have the potential to introduce non-native species into receiving waters. Ballast water, which contains microscopic marine organisms, is taken on to stabilize unladen vessels. Lack of food and light kill many of the organisms within the ships hold, but some survive. Once the vessel has arrived at the foreign port (in a different ocean perhaps) where it may pick up cargo, the ballast water is released into the surrounding water, with its content of non-native aquatic organisms. When the non-native species are released into the water column with fresh food resources and no natural predators, their populations may grow unchecked.

On southeast Florida reefs and in the Indian River Lagoon, the non-native marine algae *Caulerpa brachypus* has been documented, and is thought to have originated in ballast water from the Pacific Ocean (FDEP 2005a). *C. brachypus* grows abundantly atop the reef, overgrowing organisms, smothering corals, other invertebrates and native algae. Non-native species such as *C. brachypus* pose a real threat to the native organisms of southeast Florida's reefs and waterways.

2.0 Coastal Construction

Overview of Coastal Construction Practices

Coastal construction activities in southeast Florida vary widely. On the inland waterways, construction can include the creation and maintenance of port facilities, navigation channel maintenance, and construction of docks and bridges. On the barrier islands, coastal construction can include activities ranging from the building of beachfront homes, hotels, condominiums and commercial retail business facilities to public infrastructure, fishing piers, seawalls, as well as dune restoration and beach nourishment projects. In the nearshore and offshore waters, construction activities may include activities such as dredging, filling, installation of pipelines, laying utility cables, construction of artificial reefs and installation of navigational aids. The following section provides an overview of coastal construction activities and their intended objectives.

Coastal Construction Methods and Objectives

Inlets

Inlets contribute substantial economic benefits to neighboring communities by providing passageways between the ocean, ports and inland waterways for both recreational and commercial users. Inlets are also the means by which tidal flushing of the lagoons and estuaries takes place, providing input of seawater, nutrients and sediment which are important factors in the ecological health of these water bodies. Coastal inlets are also identified as Essential Fish Habitat by the South Atlantic Fishery Management Council for penaeid shrimp, red drum, and various species of the snapper grouper complex (SAFMC 1996). However, the creation and maintenance of navigation inlets affect the stability of adjacent shorelines and alters sediment transport in the vicinity of the inlet, often to the detriment of adjacent shorelines and upland properties (NOAA Coastal Services Center 2007).

Figure 4: Lake Worth Inlet, Palm Beach County. Source: FDEP

> "*Currently, over 409 miles (approximately 50%) of Florida's beaches are experiencing some level of erosion. At present, about 299 of the state's 825 miles of sandy beaches are experiencing "critical erosion," a level of erosion which threatens substantial development, recreational, cultural, or environmental interests. While some of this erosion is due to natural forces and imprudent coastal development, a significant amount of coastal erosion in Florida is directly attributable to the construction and maintenance of navigation inlets*" (FDEP 2007).

Most east coast inlets have been "hardened" with jetty structures (Figure 4) to maintain the position of the navigation channel and prevent sand from filling into the channels. However, the jetties and inlet channels interrupt the natural process of sediment transport along the beach resulting in an accumulation of sand at the jetty on the updrift side of the inlet and erosion of sand from the beaches on the downdrift side of the inlet (FDEP 2007). In the SEFCRI Region, the net sediment transport is from north to south. The updrift shoreline is the shoreline north of the inlet and the downdrift shoreline is to the south of the inlet.

Inlets at major ports, such as Port Everglades or Port of Miami intend to meet the economic, commercial, and social needs of the southeast Florida population. The use of ships to import and export goods supports the economic and cultural growth of each port's region (FSTED 2007). Use of local ports offsets the need to transport goods via other transportation alternatives such as trucking. With the planned expansion of the Panama Canal to accommodate larger vessels, there will be increased pressure for other ports to consider inlet expansions.

Inlet Maintenance Dredging

Maintenance dredging of inlets occurs on a regular and frequent basis throughout the SEFCRI Region. The intended objective of inlet maintenance dredging is to ensure the inlets and associated navigation channels are of sufficient depth for safe vessel navigation to and from ports and inland waterways. In the case of federally maintained inlets, including the Port of Miami, Port Everglades and the Port of Pam Beach, the federal government has jurisdiction and is charged with maintaining operational channel depths. In the case of most non-federal inlets, such as South Lake Worth Inlet, local governments are responsible for inlet maintenance. In some cases, such as Jupiter Inlet, a special inlet taxing district is formed and the resulting 'inlet district' is the local entity responsible for maintenance of the inlet.

Many Florida inlets have an Inlet Management Plan (IMP) that has been approved and adopted by the state of Florida. The purpose of the IMP is to examine the impacts of the inlet on the local sediment budget and neighboring shorelines and provide for management activities to mitigate those physical shoreline impacts. The IMPs typically define regularly occurring maintenance dredging cycles and associated volumes of material identified for placement on the downdrift shoreline as mitigation for inlet impacts. Sand trapped in the updrift fillet or in the channel is the preferred material for beach placement. This material is part of the sand supply within the coastal littoral system and should be the source first considered when there is a need to nourish beaches because of erosion. In the Department's Strategic Beach Management Plan, the FDEP's Bureau of Beaches and Coastal Systems (BBCS) has included management strategies for those inlets without a defined IMP.

The inlets in the SEFCRI region from north to south are listed in Table 1 below and those that are federally authorized and maintained by the USACE are noted. If an Inlet Management Plan (IMP) has been adopted by the State of Florida, a link to the IMP document is provided.

Table 1: Inlets in the SEFCRI Region.

Inlet	County	Management Authority	Adopted Inlet Management Plan (IMP)
St. Lucie Inlet	Martin	US Army Corps of Engineers	http://bcs.dep.state.fl.us/bchmngmt/st-lucie.pdf
Jupiter Inlet	Palm Beach	Jupiter Inlet District	http://bcs.dep.state.fl.us/bchmngmt/jupiter.pdf
Lake Worth Inlet (Port of PB)	Palm Beach	US Army Corps of Engineers	http://bcs.dep.state.fl.us/bchmngmt/lk_worth.pdf
South Lake Worth Inlet (Boynton Inlet)	Palm Beach	Palm Beach County	http://bcs.dep.state.fl.us/bchmngmt/slkworth.pdf
Boca Raton Inlet	Palm Beach	City of Boca Raton	http://bcs.dep.state.fl.us/bchmngmt/boca_rtn.pdf
Hillsboro Inlet	Broward	Hillsboro Inlet District	http://bcs.dep.state.fl.us/bchmngmt/hillsbor.pdf
Port Everglades Inlet	Broward	Broward County US Army Corps of Engineers	http://www.dep.state.fl.us/beaches/publications/pdf/Port%20Everglades%20Inlet%20Mgmt.%20Study%20Imp.%20Plan.pdf
Bakers Haulover Inlet	Miami-Dade	US Army Corps of Engineers	http://bcs.dep.state.fl.us/bchmngmt/bkr_hlvr.pdf
Government Cut Inlet	Miami-Dade	US Army Corps of Engineers	No Adopted IMP
Norris Cut Inlet	Miami-Dade	Natural Inlet Not Maintained	No Adopted IMP
Bear Cut Inlet	Miami-Dade	Natural Inlet Not Maintained	No Adopted IMP

Inlet management plans are typically based on comprehensive studies that examine and document the physical and environmental condition that affect each inlet. Prior to being adopted by the state, these plans are provided for public review and comment. It is the goal of these plans to outline management issues, techniques, and philosophy to best mitigate all of the negative impacts created by the presence of the inlet.

Dredging Sand Traps

A sand trap, also known as a sediment impoundment basin, is a term typically associated with inlet maintenance. A sand trap is a man made ‘catch basin’ typically constructed just outside the navigation channel, either on the ebb or flood side of the inlet. The purpose of the sand trap is to allow for the natural accumulation of littoral material in the sand trap and reduce the amount that is deposited directly into the channel, thereby reducing the frequency of channel dredging required to maintain navigation depths. The sand trap is dredged when filled and beach quality sand is placed on the downdrift beaches to mitigate the erosional impacts of the inlet and jetties.

Sand Bypassing

Sand bypassing (aka sand transfer) is another technique associated with inlet maintenance. Bypassing describes the transfer of beach quality sand from the fillet updrift at an inlet to the downdrift shoreline.

The transfer of sand from the updrift to the downdrift beach may be implemented by traditional dredging methods or a fixed permanent sand bypassing plant. Two sand bypassing plants are located in Palm Beach County that employ mechanical bypassing (Figure 5) of sand around the Palm Beach Inlet and the South Lake Worth Inlet.

Figure 5: South Lake Worth Inlet Sand Transfer Plant (above left) and discharge pipe (above right). Source: Palm Beach County

Dredged Material Nearshore Placement

Dredged material resulting from inlet maintenance dredging is often placed in the nearshore area rather than directly on the beach. This activity may be employed when material encountered does not meet the criteria for direct beach placement due to an increased percentage of finely graded material (fines), if the proposed placement beach lacks the necessary capacity to absorb the sand into the template or if sand placement must take place during the marine turtle nesting season. Dredged material from navigation channels often contains a very large fraction (over 80%) of beach quality material, a resource which is becoming increasingly difficult to identify and must be considered as a source of beach nourishment material. Dredged material that contains both beach quality sand and elevated fines may be placed in the nearshore if it meets the standards set forth in 62B-41.007(2)(k) of the Florida Administrative Code (F.A.C.). This rule describes material qualifying for nearshore placement as follows:

(k) Pursuant to subsection 62B-41.005(15), F.A.C., sandy sediment derived from the maintenance of coastal navigation channels shall be deemed suitable for beach placement with up to 10% fine material passing the #230 sieve, provided that it meets the criteria contained in (j)2. through 5. above and water quality standards. If this material contains between 10% and 20% fine material passing the #230 sieve by weight, and it meets all other sediment and water quality standards, it shall be considered suitable for placement in the nearshore portion of the beach.

The direct placement of sediment with high percentage of fines may be detrimental to the beach habitat and resources that utilize nearshore reefs, such as the reef-building worms, *Phragmatopoma lapidosa* and early life stages of the snapper-grouper complex. The South Atlantic Fishery Management Council has designated nearshore reefs and worm reefs as Essential Fish Habitat – Habitat Areas of Particular Concern. The introduction of fine material has the potential to result in densely packed sand that tends to harden and this interferes with the ability of sea turtles to dig nests as well as creating difficult conditions for the egg clutch once buried. Compacted beaches also create a more difficult environment for the variety of animals in the swash zone affecting shorebird and fish populations that depend on this habitat.

The placement of inlet-dredged material in the nearshore region allows the energy of the nearshore waters to sort out the sand and redistribute it in a natural fashion. Fines are carried away from the beach system while the coarse beach quality sand is deposited on the beach allowing the eroded beach to now accrete.

Blasting

Blasting involves the detonation of explosives underwater in order to break up consolidated substrate (rock) for removal (Figure 6). In coastal construction, blasting is a method typically associated with the widening and deepening of navigation channels in association with port facilities, as well as demolition of structures like bridge abutments and bulkheads. Sometimes limestone rock or other consolidated substrates cannot be excavated by mechanical methods alone and blasting is used to "pre-treat" (fracture the substrate) before removal by a dredge. Blasting was employed between June and August 2005 to deepen the Federal channel in Miami Harbor.

Figure 6: Blasting in Miami Harbor. Source: USACE

Beach Restoration/Beach Nourishment/Dredge and Fill

The FDEP's BBCS is charged with the management of activities affecting the beaches and coastal systems and sovereign submerged lands. According to the BBCS, beach nourishment is the preferred way to add sand to a coastal system which has been sand starved due to the existence of inlets. The building of eroded beaches with nourishment provides a significant level of storm protection for upland properties and back-bay marshes (FDEP 2007).

The BBCS developed a statewide strategic beach management plan (SBMP) as the basic planning tool for maintaining beaches. The SBMP is broken down into sub regions chosen for their coastal uniqueness and continuity. The BBCS recently completed a draft update to the SBMP where a summary of recent activities and an outlook on continued implementation of beach and inlet management practices and projects are presented.

A series of public workshops for the update to the SBMP are underway and the draft plan may be reviewed by accessing the BBCS website at:
http://www.dep.state.fl.us/beaches/programs/bcherosn.htm#Statewide_Strategic_Beach_Management_Plan

The primary method of restoring eroded beaches is through beach nourishment (FDEP 2007). In a typical beach nourishment project, material is dredged from an offshore site and is transported to the beach by pipeline (Figure 7). A slurry of sediment and water discharges from the pipe on the beach where the excess water drains into the nearshore waters while the sand that falls out of suspension accumulates alongshore leaving behind sand to build the beach. Bulldozers move and shape the sand on the beach until the beach matches the designed beach profile (FDEP 2007).

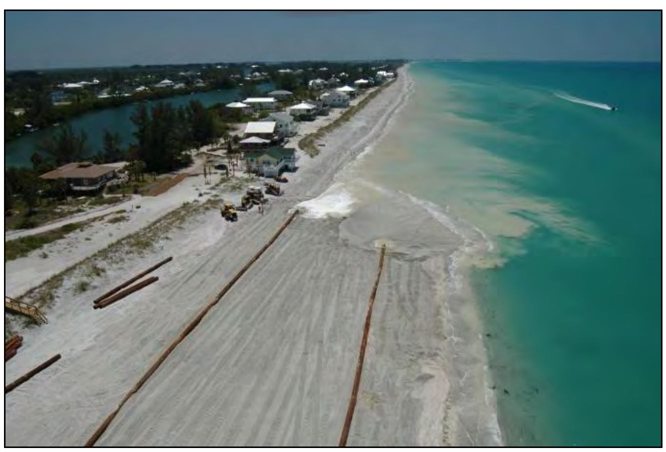


Figure 7: Beach Nourishment Project. Source: PBS&J

A beach design template is initially constructed and once completed wind, wave action and tides begin the process of 'equilibration'. Some of the sand disappears beneath the water line, but not all is lost. The bulk of material is retained within the active littoral system contributing to the sand bars that naturally shift closer to and further from shore with the change of seasons. The sand continues to be transported in the shore perpendicular and shore parallel directions. This is taken into account during the beach nourishment design process and the volume of sand eventually sited for placement includes the volume necessary to both restore the beach and reach equilibrium. However, it is this very process of equilibration that concerns resource managers as the distance over which the sand equilibrates into the nearshore may reach submerged resources resulting in sedimentation and/or burial of hardbottom and coral communities.

Dune Restoration and Enhancement

Dune restoration or enhancement projects may be constructed in conjunction with a beach nourishment project or alone. Sand supplied either from an offshore or upland source is placed on the back beach on top of the beach berm where it is mechanically formed and shaped. When a dune feature is constructed it should be followed by the planting of native dune vegetation (Figure 8) across the dune for stabilization. Salt tolerant plants, such as sea oats, provide stabilization of the dune through their root systems and the plant matter above grade aids in further building the dune by capturing and retaining wind-blown sand.

Figure 8: Dune planting. Source: PBS&J

Wind-blown sand captured in dunes provides increased protection to the coastal infrastructure as well as estuarine resources behind the dunes. Dune restoration and enhancement is frequently employed following a significant erosion event such as the passage of a hurricane.

Borrow Area Dredging

Beach restoration and nourishment activities require a very large volume of sandy material with characteristics as similar to that of the existing beach as possible. The intended objectives of offshore and/or nearshore dredging for beach nourishment projects are the mining and transportation of a sufficient quantity of beach quality material for shoreline placement to restore eroding beaches. The areas in which such sources of sandy material can be found are termed ‘borrow areas’ and can be located in nearshore or offshore waters. In southeast Florida, borrow areas have been known to be located adjacent to or between the reef tracts. Extensive environmental, physical and geotechnical assessment, including public comment, is required before any particular source may be authorized for use.

Pipeline Placement

During the dredging process, sand is mixed into slurry with seawater, pumped from the dredge through a pipeline and discharged along the shore. The water flows back into the nearshore waters while the sand that falls out of suspension accumulates alongshore building the beach. The pipelines utilized for the transport of slurry traverse a significant distance and may cross submerged biological resources to reach the shore. Therefore, pipeline corridors should be identified during the project planning process to avoid impacts to marine resources. The corridors should be surveyed once pipelines are installed to document the level of impact on hard bottom resources. The pipelines should also be monitored regularly to ensure that any leaks are immediately detected and repaired.

Booster pumps may be utilized along the path of the pipeline to provide the power necessary to transport the slurry over the required distance.

Beach Placement

Figure 9: Sand dike construction. Source: PBS&J

When dredging occurs for beach restoration, nourishment, the dredged material is placed along the edge of the shore to expand the width of the beach. Depending on the grain size distribution, composition, and density of the material, a sand dike may first be created (Figure 9) at the seaward end of the beach template with the remainder of material pumped onshore landward of the dike. The purpose of the dike is to create a greater distance over which the slurry water must travel before discharging into nearshore waters. The idea is to provide a greater distance over which the return water has to travel in order to provide the maximum time for material to fall out of suspension. This results in more material on the beach and less suspended material in the return water. This method helps to reduce short-term turbidity in the nearshore waters and reduce potential for sedimentation impacts to submerged resources, but only delays the release of fine sediments as the new beach erodes.

Truck Haul

Beach nourishment and dune enhancement projects are sometimes carried out using an upland source of material for beach placement. As with submerged borrow area sources of sand, upland sand sources must also go through a thorough analysis and approval process prior to receiving authorization to use on the beaches. Transport of sand from upland mines is by truck. A typical dump truck has a capacity on the order of 15 to 20 cubic yards (18 cubic yards on average) of material. A large number of truckloads are often required to deliver the appropriate volume of material. For example, a recent dune restoration project along three miles of shoreline called for the placement of approximately 160,000 cubic yards of material. This project was accomplished by truck haul operations. If each truck is assumed to have a 20 cubic yard capacity, it would take 8,000 truck loads to provide the required material to the site. Since this was only a dune project, the 160,000 cubic yards of material is not representative of the volume of material required for a typical beach nourishment project. To completely nourish a three-mile segment of shoreline may take on the order of one million cubic yards or more of material. Clearly truck haul operations are only feasible for projects requiring relatively small volumes of material. Furthermore, careful consideration and planning of truck routes, access points and hours of operation is necessary. Additionally, an assessment of the road infrastructure and its ability to support the added pressures of this type of operation may also be required.

Truck haul operations are extremely expensive in economic, environmental, and social impacts. In southeast Florida, borrow areas are limited. Upland sand must be mined and the affect on the environment at the mine location should be considered. Large trucks also affect the traffic and damage local roads as well as interfere with local commerce. Truck hauled sand is often 10 times the cost of dredged material especially on large volume projects (for smaller projects the cost of dredge mobilization offsets the higher trucking costs). Truck haul operations are often used for small projects like 'erosional hot spot' mitigation between beach nourishment intervals.

Sand Backpassing

Sand backpassing is a term used to describe the transfer of sand from an accreted shoreline to an eroded shoreline. The transfer of sand is generally in the opposite direction of natural littoral transport. For example, the south end of Miami Beach terminates at the north jetty of Government Cut. This is essentially the end point of sand transport along the east coast of Florida. The north jetty of Government Cut is designed such that very little sand travels through or around the jetty into the channel or to the downdrift barrier islands. As such, there is a great accumulation of sand along South Beach and Lumus Park where the shoreline is not only wide and stable, but shows trends of accretion over time. Further north, however, areas of chronic erosion called 'hot spots' exist due to change in shoreline orientation which tends to focus wave energy and exacerbate erosion. Backpassing has been employed here in order to dredge the accreted material from South Beach and transport it north, against the direction of littoral transport, to nourish the hot spots. In the past truck hauls have been used, however, the affect of these trucks on tourists and commerce has caused local government to rethink this approach.

Dredged Material Disposal

Ocean Dredged Material Disposal Sites (ODMDS)

When maintenance dredging of inlets or inland waterways produces material that is not suitable for beach placement, an offshore disposal area called an Ocean Dredged Material Disposal Site (ODMDS) may be utilized for material disposal. Material is transported by barge or hopper dredge to the ODMDS and is released into the water column and allowed to settle to the ocean floor.

Designation of an ODMDS within state waters (up to 3 miles from the coast in the SEFCRI Region) must be approved by the state of Florida and the US Environmental Protection Agency (EPA) under Section 102 or Section 103 of the Marine Protection, Research, and Sanctuaries Act (MPRSA). If the ODMDS is sited outside of state waters, approval must be obtained solely from EPA. Federal approval in the SEFCRI region requires the development of an Environmental Impact Statement (EIS) under the National Environmental Policy Act that addresses impacts to resources that would be impacted by the disposal process. There are currently three designated ODMDS in the SEFCRI Region (from north to south): Palm Beach Harbor; Port Everglades Harbor and Miami.

Dredged Material Disposal – Upland Disposal

Upland sites are often sited for dredged material disposal, especially for dredged material from ports and inland waterways that are not suitable for either beach placement or offshore disposal, or offshore disposal is too costly. During the authorization process to place material in an ODMDS under Section 103 of MPRSA, the applicant must be able to show that all potential upland disposal and beneficial use options are not viable. After material is dredged from the project site it is placed in an upland containment area designed for dewatering, if necessary. The containment area allows for the dredged material to settle and the remaining water is discharged. Discharge water is routed from the disposal area; often back into the waters of the state. Once dried, the dredged material can be removed from the containment site to allow capacity for the next dredging event. Numerous studies have been conducted and continue to be conducted to examine alternatives for the beneficial use of dredged material.

Spoil Islands

The creation of spoil islands is no longer common practice, but upon initial construction of port facilities including entrance channels, berthing areas and navigable waterways, the practice of creating 'spoil islands' with dredged material was widely accepted. Initial dredging of port facilities or channels creates a large volume of dredged material. Subsequent maintenance dredging of these facilities also results in large volumes of material that require disposal. Managers of inland waterways and port facilities are faced with many issues surrounding the management of dredged material disposal.

Many spoil islands have become vegetated and stabilized and today are frequently utilized for wildlife protection areas. Some spoil islands, for example Peanut Island and Munyon Island in Lake Worth Lagoon, have recently been restored to increase habitat and recreation values. Shorebirds and migrating birds utilize these areas so frequently that many spoil islands are protected against further disturbance to maintain habitat value.

Coastal Structures

Seawalls

Seawalls are vertical armoring structures that are meant to prevent overtopping and flooding from storm surge and waves on the landward side of the structure. Seawalls are often shore parallel structures that become a part of the coastal profile (Figure 10), and are used to protect homes, roads and other infrastructure. However, seawalls can accelerate erosion of the beach or seafloor on the seaward side of the structure due to increased wave reflection caused by the structure. If toe (base of seawall) scour protection features are not included in the design and installation of a seawall, or if the piling is not driven into rock substrate, the structure may become unstable.

Figure 10: Seawalls fronting coastal development, Broward County. Source: PBS&J

Bulkheads

Bulkhead is a term that describes a vertical soil retaining structure with the primary purpose of maintaining the land behind the structure and preventing sliding or sloughing at the land-sea interface. Common applications for bulkheads are the construction of port and marina berthing facilities in harbors where wave action is minimized. Often in literature, there is no distinction made between bulkheads and seawalls (USACE 2002).

Revetments

Revetments are shoreline protection structures (Figure 11) intended to provide protection from wave action or to retain *in situ* earth material. Vertical structures are classified as either seawalls or bulkheads, while protective structural materials that lay on slopes are called revetments (USACE 1995). Revetments are typically constructed using rubble, stone or other armoring material and are placed on the shoreline over the existing slope. A revetment is typically constructed on the shoreline, following the slope of the shoreline and provides protection to any upland buildings or infrastructure.

Figure 11: Revetment at Marineland. Source: PBS&J

Jetties

Jetties are the term given to the structures that are employed to stabilize an inlet. This structure is typically a rubble mound structure; a jetty may have at its core a vertical sheet pile or other stabilizing structure. Most of the inlets in the SEFCRI Region have constructed jetties and so the construction of additional jetties is highly unlikely. However, required periodic maintenance of the structures can be expected to occur. Jetty improvements may include sand tightening, elevating existing structures, expansion of the seaward or landward extent of the structures and adding features of accessibility to the structures.

Groins

Groins are shoreline stabilization structures constructed perpendicular to the shoreline and are usually attached to the shoreline (Figure 12). Groins are typically constructed with stone and/or rubble, with or without a sheet pile component, and some are designed with a T or other geometric feature on the seaward end to increase protection and sand retention. The intended objective of groin construction is to stabilize natural or nourished beaches. Often a series of groins are constructed forming a 'groin field', in order to stabilize a long stretch of shoreline. Sometimes sand is placed behind and over groin structures following

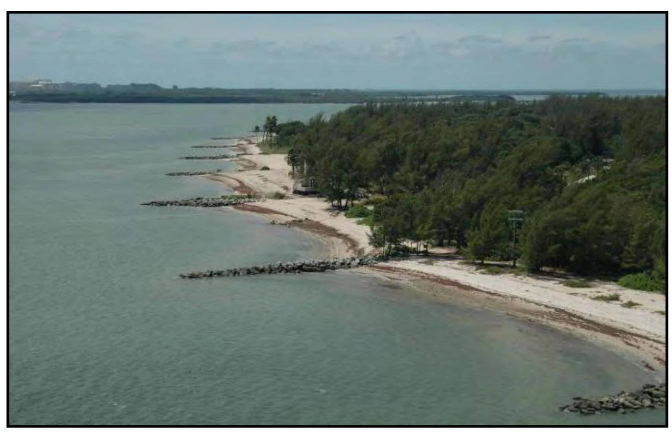


Figure 12: Virginia Key groin field. Source: PBS&J

construction to facilitate infilling and sand retention. However, the downdrift shoreline impacts observed as a result of inlet jetty structures are also observed at groin structures. Like jetties, groins interrupt the longshore sediment transport accreting sand on the updrift side with a tendency for erosion on the downdrift side.

Breakwaters

Breakwaters are shore parallel structures often constructed of rubble, located some distance offshore and can be emergent (Figure 13) or submerged depending on the use and level of protection. Breakwaters ideally act to reduce the wave energy that reaches the shoreline and therefore reduce erosion caused by waves. Breakwaters act like a natural reef reducing wave energy and providing shoreline protection in the lee of the structure. Their texture and structure often allow the breakwater to serve as an artificial reef, providing hard substrate for attachment of corals and other species, as well as providing crevices and shelter for fishes. Care must be taken so as to not impede turtle nesting activities.

Figure 13: Sub-aerial breakwaters, Key West. Source: PBS&J

Sometimes breakwaters are constructed in or around harbors and can be attached to the shoreline in order to create a harbor. The purpose of these attached harbor breakwaters is to enhance the protection from waves and currents afforded by the harbor.

Figure 14: Pier under construction. Source: PBS&J

Piers

Piers are elevated structures attached to shore that extend out over water (Figure 14). Fishing is a popular pier activity, but piers are utilized by others as well. Piers are designed to endure in the marine environment and withstand the forces of currents, storm surge, waves, and wind.

Construction of piers involves the installation of large pilings to a significant depth with an overlay of decking for access. In Florida, the FDEP encourages decking that is designed to breakaway in a 20-year design storm event.

Docks

In comparison to fishing piers, docks are relatively small over the water structures that typically provide access to inland waterways for fishing, boating and other recreational uses. Docks may be fixed or floating, and may be constructed of wood, metal, fiberglass, concrete or even recycled plastic materials. Construction of docks usually involves installation of some type of pile support system with a walking deck elevated above the water or floating on the water. Appropriate actions should be taken to ensure that impacts to biological communities (e.g. corals and seagrasses) from dock construction are avoided and/or minimized and any unavoidable impacts should be offset. See link to BMP document previously developed by the National Marine Fisheries Service (NMFS) and USACE in Section 9.

Permanent Pipelines and Cables

Pipelines permanently installed in the coastal zone are typically used for outlet of treated sewage, transport of oil and gas from offshore fields, and water supply between islands/mainlands and across inlets. Pipelines may be buried or placed directly on the seafloor. Those pipelines that lay on the seafloor may also have an overlay of stone or matting for protection of the pipeline structure from currents and waves in order to keep them stationary. When the pipeline approaches the nearshore, it is common practice to bury the pipelines to protect them from nearshore wave and current action (CEM).

Like pipelines, cables are also permanently installed within the coastal zone for other utility applications, such as telecommunication or fiber optic cables. Cable conduits are often utilized and may be able to transmit multiple cables through an environmentally sensitive area once installed.

Directional Drilling

Horizontal directional drilling (HDD) may be associated with coastal construction as a trenchless method of crossing a water body. Typically, HDD is used to install cables or pipelines for gas, water, telecommunications, fiber optics, power, sewer, oil and water lines underneath a water body. HDD is preferable to open trenching and isolated crossings because the cable or pipeline is drilled underneath the substrate with very little disturbance to the seafloor or banks. HDD is also preferred over traditional trenching because it minimizes the potential for impacts to fishes and fish habitat (Dillon Consulting Limited 2005).

HDD involves drilling a pilot bore-hole underneath the waterbody towards a surface target on the opposite side and pulling the pipe or cable through the hole as the drill is retracted back. This process typically uses a water and mud system to transport drilled spoil, reduce friction and stabilize the drill hole. The mud system is typically composed of a mixture of water as the base with bentonite (clay-based drilling lubricant) and sometimes synthetic polymers (UDI 2006).

One of the risks associated with HDD is the escape of drilling mud into the environment as a result of a spill, collapse of the drill hole or the rupture of mud to the surface, which is commonly known as a “frac-out”. A frac-out is caused when excessive drilling pressure results in drilling mud leaching vertically toward the surface. The risk of a frac-out can be reduced through sound geotechnical assessment practices and prudent drill planning and execution. The extent of a frac-out can be limited by careful monitoring of pressure and having the appropriate response equipment and contingency plans ready in the event that a frac-out occurs (UDI 2006).

While these measures and good practices are useful in reducing and limiting frac-out occurrences, a method of direct measure of borehole pressure would allow for a more reasonable assurance against a frac-out incident. Such devices are currently in development but until a reliable method of direct measure is developed, other methods are needed to predict borehole pressure. Stauber et al. (2003) presents a method of predicting borehole pressure by means of a demand-capacity analysis. The capacity of the soil to resist deformation and hydraulic fracturing is calculated based on site specific soil parameters. Pressure demand is evaluated by determining hydraulic loss of drilling returns based on the Bingham plastic fluid model. With a calculated maximum allowable borehole pressure curve for a given HDD bore profile, specifications could require borehole pressure be maintained below the maximum allowable value or maintain rheologic properties within specified limits. A geotechnical engineer should ensure that these specifications and requirements are reasonable (Stauber et al. 2003).

Stormwater Outfalls

Stormwater discharge pipes are sometimes constructed on the beach to prevent upland flooding and provide an outlet for upland stormwater runoff. Often, stormwater discharge pipes are buried below the beach and discharge directly into the nearshore waters. More often, the pipes are buried below the dune but surface on the face of the beach where stormwater is discharged. Protective structures are frequently constructed to protect the stormwater discharge pipe from shifting. At peak flows, the stormwater discharge may cause localized erosion. Stormwater outfalls also deliver large quantities of nutrients to the coastal system.

Ocean Outfalls

There are six wastewater effluent ocean outfalls within the SEFCRI region: two each in Miami-Dade, Broward, and Palm Beach Counties. Combined, these six outfalls discharge approximately 400 million gallons per day of secondary-treated wastewater directly into the offshore environment (Bloetscher and Gokgoz 2001). The discharge points lie between 0.94 to 3.56 miles from shore at depths of 27.3 to 29.0 meters. The effluent is discharged into the western portion of the Florida Current, which moves north along the coast (EPA 2001).

Navigation Aids

Navigation aids provide boaters with the same information that street signs, road barriers and traffic lights provide to drivers. Navigation aids themselves may be considered a best management practice as they map the 'roadway', or channels for safe navigation to and from ports and inland waterways. By keeping vessels operating within the channel limits, shipping lanes or intended pathways, inadvertent contact with submerged resources may be avoided.

Installation of navigation aids is a minor coastal construction activity. In the case of most channel markers, a relatively small piling structure is installed into the substrate and signage is affixed to the above water portion of the structure. Navigation aids also come in the form of floating buoys which are anchored to the seafloor. Installation of these types of structures can involve the driving or jetting of the pile structure or even drilling into hardbottom to permanently fix the structure to the seafloor.

Anchorages

U.S. Coast Guard designated anchorages are located offshore of the Port of Palm Beach, Port Everglades, and the Port of Miami in southeast Florida. These anchorages are used by ships in transit between ports of call, or awaiting berthing space and entry direction from the Ports. These anchorages are located in close proximity to coral reefs/hardbottom communities and therefore pose a significant threat to the reefs from anchor/chain impacts and ship groundings. In fact, many groundings have occurred from vessels using these anchorages (Collier et al. 2007). Maps of the anchorages off of the Port of Miami, Port Everglades and Port of Palm Beach and their proximity to resources are provided in Appendix 2. The U.S. Coast Guard is currently working on modifying the configuration and locations of some of these anchorages in order to reduce the potential for adverse resource impacts from shipping activities.

Artificial Reefs

In the early 1970's in an effort to create an artificial underwater reef habitat, deployment of tires, old vessels, and other products no longer of use were sunk in near and offshore waters. Over time, and particularly following large storm events, the tires washed ashore, or shifted underwater often impacting the very habitat they intended to create. Beginning in 2007, Broward County and the Navy have begun removing the tire reef as a result of these problems. Construction of artificial reefs has improved greatly since the lessons learned from simply 'dumping' unusable waste products into the ocean, but still has many challenges.

Today, a more careful consideration is given to the creation of artificial reefs. Reef compatible materials such as limestone boulders, concrete rubble, or specifically designed structures are required. As guidance for the selection of artificial reef materials, the Atlantic and Gulf States Marine Fisheries Commissions have produced a document entitled '*Guidelines for Marine Artificial Reef Materials, Second Edition'*. For the use of retired vessels as artificial reefs, the U.S. EPA and the U.S. Maritime Administration have created a guidance document entitled "*National Guidance: Best Management Practices for Preparing Vessels Intended to Create Artificial Reefs*", and NOAA has published the "*National Artificial Reef Plan*". A link to these documents is provided in Section 9.

The FDEP, BBCS has received specifically appropriated funding to further investigate the creation of artificial reef habitat as mitigation for nearshore hardbottom impacts. The proviso language states that the FDEP may spend up to $500,000 conducting a study or studies to assist applicants in the appropriate design and siting of hard bottom or reef mitigation, and to assist in resolving technical differences between hard bottom or reef mitigation requirements of the State and the USACE.

3.0 Summary of MICCI Project 3 Innovative Technologies Workshop

The MICCI project 3 was undertaken "to identify and evaluate existing and emerging technologies in coastal construction practices and procedures that could minimize or eliminate impacts to coral reefs, hard or live bottoms and associated coral reef resources in southeast Florida" (MICCI Project 3 Workshop Proceedings). A workshop was held on May 24-25, 2006 where innovative and emerging technologies were presented by coastal construction professionals, engineers, and other stakeholders. After the presentations, participants broke out into small group sessions where topics were discussed in detail. Breakout group topics addressed the following objectives:

1. Identify existing coastal construction practices known to affect coral reefs and their associated impact on coral reefs;
2. Identify innovative technologies that have recently been implemented and shown to minimize or eliminate impacts to resources;
3. Review emerging technologies for shoreline stabilization, erosion/beach stabilization, and beach nourishment; and
4. Review permit conditions and study designs for mitigation in innovative or advanced coastal construction activities.

Through discussion of the above objectives, seven areas became evident where resource protection could be enhanced, both during and after coastal construction activities. A brief review of these items follows. A more in-depth discussion can be found in the MICCI Project 3 Workshop Proceedings.

For dredging projects, the consensus was that ADCP/acoustic backscatter and fluorometry could be used to monitor for increased levels of turbidity and/or sedimentation during a project to minimize and/or prevent impacts to the resources. Specific technologies put forward relating to dredging included modifications to allow pumping up slurry density or pushing sand, increased dredge efficiency through borrow area design, recycling of "skim" water, use of designated corridors in reef gaps, and refined work areas. The application of as many advanced technologies as possible in a single project would provide the maximum project performance as well as maximum resource protection.

Improvements to water quality were suggested and specific recommendations included creating water treatment master plans for each county. A master plan would address impacts resulting from sewer, septic, deep well injection, stormwater, landfills, and ocean outfalls. It was noted that such a plan was under development in Miami-Dade County. Other recommendations included retrofitting stormwater and discharge structures, the development of advanced water treatment practices, and the development of alternatives to wastewater ocean outfalls and deep water injection wells.

The consensus from workshop participants was that the need for beach nourishment projects should be reduced as much as possible. Given that the maintenance of beaches is vital for the economics of the area, structures including wave breakwaters and multi-purpose reefs were identified as underwater nearshore technologies that could prevent the erosion of nourished beaches, however, it was recognized that placement of these structures in the nearshore in the SEFCRI Region would also result in impacts to resources. Participants emphasized the need for sand of quality comparable to existing sand beaches for nourishment projects. Sand backpassing and bypassing were named technologies to address erosion and move sand to erosional hot spots. Another concern was the identification of alternative sources of sand and more stringent criteria for the evaluation of borrow areas. Improvements are needed in the enforcement of State regulations on discharge prohibitions across beaches, and the development of county level prohibitions was recommended.

Resource management and permitting were areas that could be addressed to reduce impacts to reef communities. In particular, several technologies were identified that could aid regulators. LADS/LIDAR technology would be useful in the planning stages of projects, where maps could be used to avoid high relief reef resources. Other technologies, including the USACE Silent Inspector and the USCG Hawkeye/LVTS/GPS, provide regulators with tools to protect and manage reef resources during construction activities, if access to these technologies can be granted to regulators. Through the permitting process, participants recommended regular communication between regulators and project sponsors using pre-, during- and post-project meetings to determine appropriate methods, review lessons learned, and troubleshoot issues that may ultimately help to protect the environment throughout the course of a project. Additional recommendations included the addition of pre-, during- and post-project monitoring, and the use of adaptive management to address the needs of specific species.

Biological monitoring is necessary to document the effects of construction projects on natural resources. Monitoring activities must be hypothesis driven, time sensitive, have good statistical design, be thorough and complete, and be peer reviewed prior to execution. Monitoring data should be in a standard format and be archived for use by other investigators after the project is complete. If reef resources are impacted and mitigation is necessary, mitigation should be compensatory for the level of impact sustained by the resource. Mitigation projects should include adaptive management and address spatial, temporal, water quality, and organismal changes.

Participants recommended the modification or removal of existing large ship anchorages to address vessel groundings and other direct vessel-related impacts. Other suggestions included the installation of perimeter buoys or beacons to demarcate large vessel anchorages and mooring areas. Educational efforts for vessel operators were also suggested as a way to ameliorate the problem of vessel groundings on reef resources.

In reference to the placement of pipelines and cables, the consensus was that the use of LADS/LIDAR data would be useful in identifying potential corridors where pipelines and cables could be placed to avoid reefs and minimize environmental impacts. Horizontal directional drilling (HDD) and tunneling were alternative technologies identified to avoid laying pipelines or cable directly onto reef resources.

With these recommendations in mind, the MICCI Project 6 was created to explore and develop Best Management Practices (BMPs). The BMPs are created for use in coastal construction activities in the SEFCRI region and are based on existing technologies, as well as innovative and emerging technologies identified in MICCI Project 3.

4.0 Permits for Coastal Construction Activities

All of coastal construction activities discussed in this report will likely require one or more permits from federal, state and/or local agencies. This section describes the main types of permits that are typically required for authorization of coastal construction activities. Section 9 of this report provides links to the websites associated with permitting discussed below where additional information, application forms and associated rules and regulations can be found. Table 2 presents a summary of possible permits required for coastal construction projects and is found at the end of this section.

The permitting process with each of the federal, state and local agencies leads to each agency consulting with their environmental counterpart for the protection of wildlife and habitat. For example, application to the USACE for a federal dredge and fill permit initiates a federally internal consultation between the USACE and the U.S. Fish and Wildlife Service (USFWS) and the NMFS for the protection of threatened and endangered species. The same type of consultation occurs between the FDEP and the FWC. These consultations are very important and result in permit conditions for the protection of threatened and endangered species and their habitats.

Coastal Construction Control Line Permit

The FDEP has regulatory authority over coastal construction activities seaward of the Coastal Construction Control Line (CCCL) under Chapter 161, Florida Statutes (F.S.). The FDEP adopted a coastal construction control line to establish an area of jurisdiction in which special siting and design criteria are applied for construction and related activities. These criteria may be more stringent than that already in place in the rest of the coastal building zone because of the greater forces expected to occur in the more seaward zone of the beach during a storm event.

Chapter 62B-33 of the F.A.C. provides these special design and siting requirements. Anyone seeking to construct seaward of the CCCL, but landward of the mean high water (MHW) line, must obtain authorization for construction via a CCCL permit.

Joint Coastal Permit

The FDEP has regulatory authority over activities occurring in waters in the State of Florida under Chapter 373 F.S. In 1995, the FDEP implemented section 161.055, of the Florida Statutes (F.S.), initiating concurrent processing of applications for coastal construction permits, environmental resource permits, wetland resource (dredge and fill) permits, and sovereign submerged lands authorizations. These permits and authorizations which were previously issued separately and by different state agencies have been consolidated into a Joint Coastal Permit (JCP). The consolidation of these programs and the assignment of responsibility to a single bureau (BBCS) has eliminated the potential for conflict between permitting agencies and helped ensure that reviews are conducted in a timely manner. A copy of the permit application is forwarded to the USACE for separate processing of a federal dredge and fill permit (FDEP 2007).

A JCP is required for activities that meet ***all*** of the following criteria:

- Located on Florida's natural sandy beaches facing the Atlantic Ocean, the Gulf of Mexico, the Straits of Florida or associated inlets;
- Activities that extend seaward of the mean high water line;
- Activities that extend into sovereign submerged lands; and
- Activities likely to affect the distribution of sand along the beach.

Activities that require a JCP include beach restoration or nourishment; construction of erosion control structures such as groins and breakwaters; public fishing piers; maintenance of inlets and inlet-related structures; and dredging of navigation channels that include disposal of dredged material onto the beach or in the nearshore area (FDEP 2007).

Environmental Resource Permit

When coastal construction activities are not sited for the sandy coast of Florida as defined by the above JCP criteria but are still proposed to occur on or over state waters and/or sovereign submerged lands of the state, the FDEP's Office of Submerged Lands and Environmental Resources regulates the activity. An Environmental Resource Permit (ERP) is required for any construction on or use of sovereign submerged lands of the state. Concurrent processing of proprietary authorization for use of sovereign submerged lands and the federal dredge and fill permit, if required, is also included in the ERP process.

Activities that require an ERP include, but are not limited to, coastal construction activities such as dredging and filling; construction of docks, piers or seawalls; directional drilling; installation of submerged cables; installation of navigation aids and mooring fields.

ERP State Programmatic General Permits (SPGP)

On September 24, 1997, the Jacksonville District of the USACE issued an expanded State Programmatic General Permit (SPGP III). The purpose of the SPGP III was to avoid duplication of permitting between the USACE and the Florida Department of Environmental

Protection (DEP) for minor work located in waters of the United States, including navigable waters. Thus, the need for separate approval from the USACE would be mostly eliminated. SPGP III extended geographic coverage throughout the entire State of Florida, excluding Miami-Dade and Monroe County and those counties within the jurisdiction of the Northwest Florida Water Management District. The results of the SPGP III implementation demonstrated that environmental protection continued while increasing the service to the public. In the short time since the SPGP III was issued, we have seen a need to clarify, update, and reformat it. This SPGP (SPGP IV) now reflects the culmination of those actions, and will simplify the SPGP process and further increase the efficiency of both State and Federal staff in serving the public.

Statutory Time Clock

The State of Florida has a specified timeframe for processing permit applications which falls under the same rules as those for applications of licenses under Chapter 120.60 Florida Statutes (F.S.) as follows:

> *"Upon receipt of an application… an agency shall examine the application and, within 30 days after such receipt, notify the applicant of any apparent errors or omissions and request any additional information the agency is permitted by law to require. An agency shall not deny a (permit) for failure to correct an error or omission or to supply additional information unless the agency timely notified the applicant within this 30-day period. An application shall be considered complete upon receipt of all requested information and correction of any error or omission for which the applicant was timely notified or when the time for such notification has expired. Every application for a (permit) shall be approved or denied within 90 days after receipt of a completed application unless a shorter period of time for agency action is provided by law."*

The process of receiving an application and requesting additional information and the associated time frames for permit processors is summarized in Figure 15. There is no comparable timeclock for federal agencies.

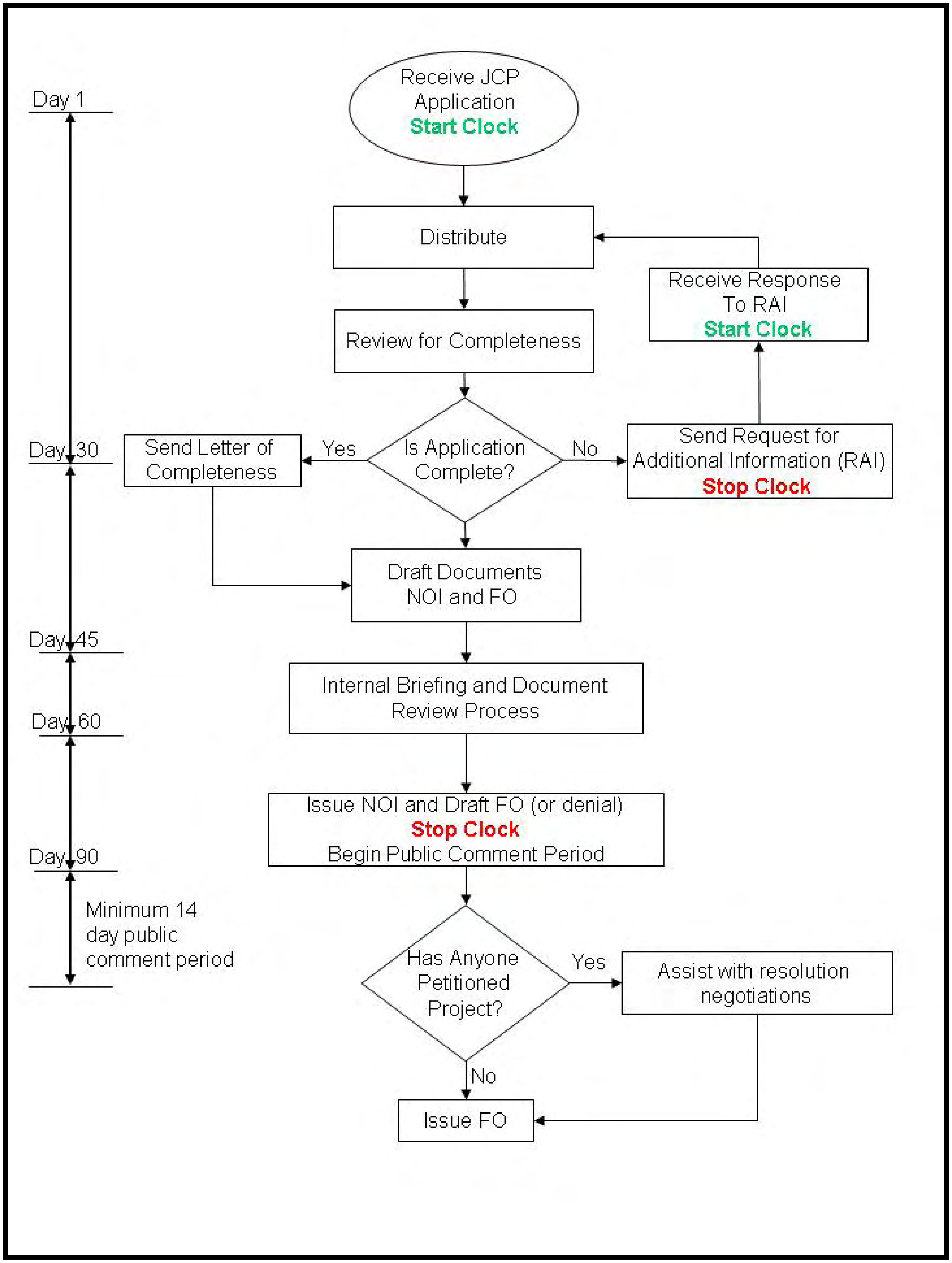


Figure 15: State Permit Processing 'Timeclock' Illustration. Source: PBS&J

Coastal Zone Management Act (CZMA)

In 1972 Congress passed the Coastal Zone Management Act (CZMA) to assist coastal states with the development of state coastal management programs, and comprehensively manage and balance competing uses and impacts to coastal resources. Federal CZMA consistency is required for any federal activity affecting any land or water use, or natural resource of the coastal zone to ensure the activities are consistent with the enforceable policies of the state's federally approved coastal management program (FDEP 2007). With issuance of a JCP or ERP permit from the State of Florida comes a coastal zone consistency determination for federal activities.

Federal Authorizations

Under Section 10 of the Rivers and Harbors Act of 1899 (33 USC 403), the USACE has regulatory jurisdiction over all work and structures in navigable waters of the United States.

> *'That the creation of any obstruction not affirmatively authorized by Congress, to the navigable capacity of any of the waters of the United States is hereby prohibited; and it shall not be lawful to build or commence the building of any wharf, pier, dolphin, boom, weir, breakwater, bulkhead, jetty, or other structures in any port, roadstead, haven, harbor, canal, navigable river, or other water of the United States, outside established harbor lines, or where no harbor lines have been established, except on plans recommended by the Chief of Engineers and authorized by the Secretary of War; and it shall not be lawful to excavate or fill, or in any manner to alter or modify the course, location, condition, or capacity of, any port, roadstead, haven, harbor, canal, lake, harbor of refuge, or inclosure within the limits of any breakwater, or of the channel of any navigable water of the United States, unless the work has been recommended by the Chief of Engineers and authorized by the Secretary of War prior to beginning the same.'*

Under Section 404 of the Clean Water Act (33 USC 1344), the USACE has regulatory jurisdiction over the deposition of dredged or fill material in all waters of the United States. After notice and opportunity for public hearings, the USACE is authorized to issue permits for the discharge of dredged or fill material into waters of the United States at specified disposal sites. The selection of these disposal sites must be in accordance with guidelines developed by the Environmental Protection Agency (EPA) in conjunction with the Secretary of the Army; these guidelines are known as the 404(b)(1) Guidelines (USACE 2007b.).

Under these authorizations the USACE has the authority to issue permits on a statewide basis for the following specific categories of work. These federal authorizations involve many consultations within the federal government for the protection of resources.

The Endangered Species Act (ESA) provides for the protection of threatened or endangered species and the ecosystems on which they depend throughout all or a significant portion of their range. NOAA's National Marine Fisheries (NMFS) and the FWS share the responsibility for implementing the ESA with the FWS managing land and fresh water species while the NMFS manages marine and andromous species. The NMFS reviews coastal construction activities that may impact essential fish habitat (EFH). EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity(Magnuson-Stevens Act, 16 U.S.C. 1801 et seq).

Federal Dredge and Fill Permit

The State of Florida's process for application for authorization of coastal construction activities described above, also initiates the process of application for a federal dredge and fill permit, if required. No separate application is required to apply for a federal dredge and fill permit. Once an application has been submitted to the State of Florida, the State forwards the application to the USACE. Once the JCP or ERP application is filed, the State and the USACE individually correspond with the applicant in order to ensure all the required information to properly evaluate the project is received. The USACE will consult with the USFWS and the NMFS on matters of impacts to threatened and endangered species as it pertains to the Endangered Species Act (ESA) and Essential Fish Habitat (EFH).

Nationwide Permits

An integral part of the USACE regulatory program is the concept of nationwide permits for minor activities. Nationwide permits (NWPs) are activity specific, and are designed to relieve some of the administrative burdens associated with permit processing for both the applicant and the federal government. The USACE regulatory website contains a list of all of the minor activities that may be authorized under a nationwide permit.

The National Environmental Policy Act (NEPA) Process

"The National Environmental Policy Act (NEPA) requires federal agencies to integrate environmental values into their decision making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions. To meet this requirement, federal agencies prepare a detailed statement known as an Environmental Impact Statement (EIS). EPA reviews and comments on EISs prepared by other federal agencies, maintains a national filing system for all EISs, and assures that its own actions comply with NEPA" (EPA 2007a).

The NEPA process consists of an evaluation of the environmental effects of federal projects including all of the identified alternatives. There are three levels of analysis depending on whether or not a project could significantly affect the human environment. These three levels include: categorical exclusion determination; preparation of an environmental assessment/finding of no significant impact (EA/FONSI); and preparation of an environmental impact statement (EIS) (EPA 2007b).

At the first level, a project may be categorically excluded from a detailed environmental analysis if it meets criteria previously determined by a federal agency as having no significant environmental impact. All categorical exclusions must be published in the Federal Register by each agency and undergo a public review and comment process before being finally implemented by the federal agency (EPA 2007b).

At the second level of analysis, a written environmental assessment (EA) is prepared by a federal agency to determine whether or not the proposed federal project would significantly affect the environment. If the determination concludes that the project would not significantly affect the environment, the agency will issue a finding of no significant impact (FONSI). The FONSI may contain additional measures which an agency will take to reduce (mitigate) potentially significant impacts (EPA 2007b). A draft of the EA may undergo public comment and review at the discretion of the federal agency, but the FONSI must be made available to the public after signature.

If the determination of the EA concludes that the environmental consequences of a proposed federal project may be significant, the agency will prepare an EIS. An EIS is a more detailed evaluation of the proposed project and the identified alternatives. The public, other federal, state, and local agencies and outside parties, such as non-governmental organizations, may provide input into the preparation of an EIS and also comment on the draft EIS once completed. A federal agency may choose to prepare an EIS without first preparing an EA if it anticipates that the project may cause significant environmental impacts (EPA 2007b).

Once the EIS is finalized, the federal agency will prepare a public record of its decision addressing how the findings of the EIS, including all of the identified alternatives, were incorporated into the agency's decision-making process (EPA 2007b).

The public has an important role in the NEPA process and has the opportunity to provide input on the issues that should be addressed, particularly during the scoping process. Public hearings or meetings are all open for public participation and the lead federal agency must take into consideration all comments received by the public during the comment period (EPA 2007b).

Table 2: Coastal Construction Activities and Potential Permit Types Required.

Coastal Construction Activity Description	Permit Types: State JCP	State NGP	State ERP	ERP SPGP	Federal Dredge & Fill	Federal Nationwide	County*	Local Municipality*
Inlets								
Inlet Maintenance Dredging	√				√	√	√	√
Dredging Sand Traps	√				√		√	√
Sand Bypassing	√				√		√	√
Dredged Material Nearshore Placement	√				√		√	√
Maintenance Dredging on Interior Waterways		√	√	√	√	√	√	√
Blasting	√		√		√		√	√
Beach Restoration and Nourishment								
Dune Restoration and Enhancement	√				√		√	√
Borrow Area Dredging	√		√		√		√	√
Pipeline Placement	√	√	√		√		√	√
Beach Placement	√				√		√	√
Truck Haul							√	√
Sand Backpassing	√				√		√	√
Dredged Material Disposal								
Ocean Dredged Material Disposal	√		√		√		√	√
Dredged Material Disposal - Upland Disposal			√		√		√	√
Spoil Islands			√		√		√	√
Coastal Structures								
Seawalls	√		√	√	√		√	√
Bulkheads	√		√		√		√	√
Revetments	√		√		√		√	√
Jetties	√		√		√		√	√
Groins	√		√		√		√	√
Breakwaters	√		√		√		√	√
Piers	√	√	√	√	√	√	√	√
Docks	√	√	√	√	√	√	√	√
Permanent Pipelines and Cables	√	√	√	√	√	√	√	√
Stormwater Outfalls	√	√	√	√	√	√	√	√
Ocean Outfalls	√	√	√	√	√	√	√	√
Navigation Aids	√	√	√	√	√	√	√	√
Anchorages	√	√	√	√	√	√	√	√
Artificial Reefs	√	√	√	√	√	√	√	√

* Applicant should always check with the local government entities to determine whether or not the proposed activity will require a local permit.

5.0 Implementation of Innovative Technologies for Coastal Construction

Beach restoration and nourishment have been the primary methods of managing coastal erosion and maintaining beach habitat. However, the FDEP also evaluates innovative technologies that may be more effective, less costly and less likely to cause adverse impacts. Applicants that wish to test a new technology (as an experimental JCP) are encouraged to schedule a pre-application consultation with the FDEP to see if similar methods have already been tested, consider adverse impacts and discuss the theoretical potential to solve an erosion problem. Experimental shore protection projects require a reliable experimental test plan to determine the success or failure of the technology (FDEP 2005b).

The FDEP considers new and innovative shore protection technologies as applied science, intended to solve an erosion problem, and about which the FDEP staff and professional engineering community have insufficient information to predict project performance and reliability, and potential impacts to the beach dune system (FDEP 2007).

In 1989, the Florida Legislature enacted a law (161.082, F.S.) that allows the FDEP to encourage the development of new and innovative methods for dealing with the coastal erosion problems along the state's shorelines. The law provides the FDEP the ability to authorize the construction of pilot projects utilizing alternative erosion control methods, upon receipt of an application from a riparian property owner or governmental entity, and upon consideration of the facts and circumstances surrounding the application. Additional guidance for the regulatory approval of new/innovative shore protection technologies is provided in Chapter 62B-41.075, F.A.C.

Other innovative technologies

The BBCS hosted a workshop on innovative shore protection technologies in Tallahassee, on February 22-23, 2006. The workshop offered designers and vendors of new and innovative shore protection technologies an opportunity to showcase their products and ideas. A link to the workshop materials is provided in section 8. Innovative or experimental coastal construction technologies recently tested or currently being tested in Florida are described in the following section.

Recent and Current Innovative projects

Experimental Net Groins, Naples, Okaloosa and Walton Counties

The concept of removable porous groins using netting material was first introduced to Florida during the 1999 to 2000 time frame. The hypothesis was that the net groins would accumulate sand on the dry portion of the beach by intercepting cross-shore transport without significantly restricting long-shore transport. In order to test this hypothesis, and determine whether or not such installations had the potential to cause adverse impacts to the coastal ecosystem, these projects were classified as "experimental coastal construction".

Figure 16: Net groins at Eglin Air Force Base. Source: PBS&J

To date, there have been two private companies with patented porous net groin systems that have partnered with governmental entities in Florida in order to test the porous (net) groin technology for its effectiveness as a solution to beach erosion problems. Parker Beach Restoration, Inc. patented their "Sand Web System" (Figure 16) and partnered with the City of Naples in Collier County to conduct a test of their system. Benedict Engineering Company, Inc (BEC) patented their net groin system, now called the NuShore Beach Reclamation System, and partnered with the Eglin Air Force Base, Okaloosa County to test their porous groin system. According to the BBCS, neither of these systems showed net positive benefits and results were considered inconclusive. Therefore, a third test of porous groin technology was approved and installed at Inlet Beach in Walton County in an attempt to obtain conclusive results. However, in 2004 during the testing phase, Hurricane Ivan impacted the project area interrupting the testing of the product and causing erosion to such a degree that continuation of the project at that location was no longer feasible.

Some of the main environmental concerns associated with the project include wildlife entanglement and entrapment, biofouling, fish congregation and increased predation and bird congregation. Other concerns include maintenance of the system ensuring the nets are kept tightly stretched and interruption to alongshore beach access. To date, evaluation of net groin technology remains inconclusive.

Low Profile, Submerged Geotextile Tube Groin Field at Stump Pass Beach State Park

Beach Restoration, Inc. partnered with Charlotte County and proposed an innovative project that is currently installed and in the testing phase at Stump Pass Beach State Park. The system consists of a submerged groin field comprised of sand filled, low-profile, geotextile tubes of varying lengths positioned perpendicular to shore, tied into the shoreline and extending into the nearshore. The intended objectives of this experiment are to determine if these structures will 1) hold fill placed on the updrift Stump Pass Beach State Park shoreline and 2) reduce sediment infilling into the Stump Pass navigation channel without causing adverse impacts to the adjacent shoreline.

The main concern regarding the submerged groin field is localized erosion to the downdrift shoreline. The testing phase should be completed by the end of 2007 or early 2008 which will be followed by a report based on the data collection as required by the experimental test plan.

Experimental Reefball Breakwater Project (Section 227)

In 2003, the USACE submitted an experimental JCP application to the BBCS for a project in Dade County. The application proposes installation of a nearshore breakwater system composed of Reefball® units integrated onto articulating concrete mats. The breakwater design indicates the structure will be 1,800 feet long and 40 feet wide and is sited for the nearshore waters off of 63rd Street which is an area of chronic erosion, or hot spot.

The project is a USACE Section 227 National Erosion Control Development and Demonstration Project. The USACE Section 227 program is similar to the BBCS experimental projects program; both are meant to encourage new and innovative methods for erosion control.

The purpose of the proposed breakwater project is to reduce the wave energy that reaches the shore in the area of chronic erosion. As an added benefit, the proposed submerged breakwater will also serve as an artificial reef structure providing hard bottom substrate for the attachment of corals and providing crevices and sheltering spaces for fish. The breakwater design consists of Reefball® units that are specifically designed to act as a breakwater and support marine life. To date, the application for this experimental project remains incomplete. The USACE is waiting for Congressional authorization under the Water Resources Development Act for funding to be able to complete the project application and move forward with construction.

Pressure Equalized Modules (PEM) System

In September of 2006, the Town of Hillsboro Beach in Broward County submitted an application to the Department of Environmental Protection and the USACE of Engineers for an experimental Joint Coastal Permit to install Pressure Equalized Modules (PEM) on a one-mile stretch of beach south of the Deerfield Beach groin field.

A PEM is a hollow PVC tube (6 ft. long, 2.5 inches in diameter), which has been constructed to have slits cut into the walls of the tube. The slits are very close together and are so small that only water can enter. The theory being tested is that the PEM acts as a method to improve beach drainage by connecting the layers of sediment hydraulically and reducing ground water pressure within the beach. The manufacturer claims that reducing ground water increases inter-granular friction and shear stress within the beach allowing sand to accrete. The project design consists of rows of PEM units with a spacing of 50 meters between the rows and 10 meters between the PEM units within the row. Monitoring of the beach profiles is proposed for every 4 months. Monitoring is also proposed for water levels as wells as factors such as temperature, moisture, and gas content which may affect nesting turtles. Because the PEM system works gradually to accrete sand without dredging and large equipment, the system is being tested in Florida as an alternative to beach restoration.

6.0 Managerial BMPs for Coastal Construction

Planning and regulation in coastal construction activities encourage or require certain management practices as a method to eliminate or reduce adverse environmental impacts. For example, a beach nourishment project that proposes direct burial of nearshore hardbottom may be scaled back in beach width and volume of sand proposed for placement during the permitting process. Plans for water quality, biological and physical monitoring should be submitted to the appropriate agencies for review, comment and approval, as appropriate. This process also gives opportunity to the public to participate in the decision-making process regarding coastal construction and beach management activities within their area. Existing federal, state and local requirements provide the basis for building regulatory programs (Peluso and Marshall 2002). A table of Managerial BMPs and Structural BMPs is listed at the end of Section 7 in Table 4.

Nonstructural operational and maintenance procedures can also be used to prevent or reduce environmental impacts and even reduce the need for more costly structural controls. To ensure the proper operation of dredging or other construction equipment, continual oversight and periodic maintenance is required. The successful coastal construction project performed without environmental incident depends in part on the proper upkeep of all BMP components. Nonstructural operations may consist of real-time GPS integrated dredge controls, hopper barge without overflow and use of vessel ingress and egress corridors to name a few. The following section discusses specific managerial BMPs in greater detail.

Design, Siting, Impact Avoidance and Minimization

Design and siting of coastal construction projects should take into consideration all coastal resources that have the potential to be adversely impacted. In many cases, unavoidable impacts are presented as part of the project proposal with the understanding that avoiding these impacts may render the project ineffective.

Coastal construction projects are typically brought to a 50% or greater design level at the time a permit for the activity is sought. This is both advantageous and disadvantageous as the permitting authorities require a high level of detail about the proposed activity in order to provide a thorough review of potential impacts. The applicant however, may hesitate to invest a high level of detail in the design with the understanding that the approving authorities may require the applicant to scale back and re-design the project proposal in order to avoid or minimize potential impacts. It is recommended that the applicant initiate discussions with resource and permitting agencies early in the design phase to discuss options for resource impact avoidance, minimization, and mitigation.

Surveying

To aid in the design and siting of coastal construction projects, surveying techniques have seen significant advancement in recent years with the advancement of digital technology. Advances in high-definition surveying technology and 3-D laser scanning technology focuses on "faster, cheaper, and easier" plus there are significant gains related to the level of detailed information acquired (McGray 2005). Benefits of survey advancements include greater confidence in survey data, reduced need to return to a site to double check or acquire additional data, shorter time in the field leads to faster delivery of completed survey, the richness and quality of the survey is improved and high-defintion and 3-D laser scanning surveying methods cost the same or in some cases less than traditional survey methods.

One such advancement is Laser Airborne Depth Sounder (LADS) technology that utilizes light detection and ranging (LIDAR) for topographic and bathymetric surveying. The advantage to the coastal community is that this technology may be used to survey in water up to 70 meters in depth (Tenix LADS Corporation 2007). This technology has been utilized with success in a few coastal construction projects in southeast Florida. This type of surveying is particularly useful in identifying high relief hardbottom areas which allows for improvements in design, siting and impact minimization. This technology is not as well suited for low-relief hardbottom areas. LIDAR technology, however, remains quite costly compared to ground surveying techniques and should not be relied upon to clearly identify low relief hardbottom.

Borrow Area Siting

Proper selection of a borrow area for beach projects ensures that the material placed on the beach is similar in nature to the native or existing material. To ensure borrow areas meet the criteria for sand quality, 62B-41.008(1)(k)4. of the F.A.C. requires submittal of the following information to the BBCS for review and approval:

> *4. Permit applications for inlet excavation, beach restoration, or nourishment shall include:*
>
> > *a. An analysis of the native sediment and the sediment at the proposed borrow site(s). The analysis shall demonstrate the nature of the material, quantities available, and its compatibility with the naturally occurring beach sediment pursuant to paragraph 62B-41.007(2)(j), F.A.C. The sediment analysis and volume calculations shall be performed using established industry standards and be certified by a Professional Engineer or a Professional Geologist registered in the State of Florida. Certification shall verify that a quantity of material sufficient to construct the project is available at the borrow site(s) which meets the standard in paragraph 62B-41.007(2)(j), F.A.C., and*
> >
> > *b. Quality control/assurance plan that will ensure that the sediment from the borrow sites to be used in the project will meet the standard in paragraph 62B-41.007(2)(j), F.A.C.*

The following recommendations should be considered when designing an offshore borrow site.

1. The borrow site should be in 40 to 60 feet of water. When the borrow site is too shallow the dredge will run a ground before it is full of sand. This causes the dredge to have to light load which reduces the dredge's productivity.

2. The borrow site should be 2 miles square with flat sides to minimize the number of turns the dredge has to make to get a load of sand. Turns are not productive; they take time that the dredge is not digging.

   a. Large and wide borrow sites allow the dredge to dredge in any direction which minimize trenches made by the draghead. Trenches cause the draghead to track away or under the dredge causing the drag tender to have to raise the draghead off the bottom and reset it next to the dredge. The more times the draghead is raised and lowered the greater the odds of taking a turtle and the less productive the dredging.

   b. Large and wide borrow sites allows the dredge to dredge in any direction, reducing crabbing. Crabbing is when the dredge has to steer across a current or the wind causing the dredge to move sideways. Crabbing requires the drag tender to have to raise the dragheads off the bottom more often because the dragheads want to tack under or away from the dredge. Large and wide borrow sites reduce crabbing by allowing the dredge to dredge into the constantly changing currents or wind.

   c. Dredging becomes less efficient when the dredge has to turn or raise the draghead off the bottom. The less efficient the dredging, the longer the project takes and the more stress on the coral, sea turtles and other natural resources in the area. The maximum production is obtained when a hopper dredge shortens its cycle time (time the dredge takes to dig a full load, sail to the beach and pump the sand out and return to the dredge site).

3. Borrow site should have more sand than needed to complete the project. A hopper dredge does not dig corners well so sand in the corners of the borrow site can not be dug efficiently with a hopper dredge. Hopper dredges like to dredge flat, thin, long layers of sand.

a. Stepping the bottom of a borrow site may cause the hopper dredge to have to raise and lower the draghead. This reduces productivity and sand in the corners and sides of each step can not be dug efficiently with a hopper dredge.

4. The dredging cost is a large cost of a project so spending more money in the location and design of a borrow site is paid back in reduced dredging cost. Costly dredging delays due to sea turtle takes or coral impacts can be reduced by proper borrow site location and design.

5. There are many limitations to borrow site location and design but the above criteria should be part of the Best Management Practice to protect coral and sea turtles by maximizing dredging production and reducing project cost.

Sand Quality

Beach and dune quality sand have particular characteristics in terms of size, color, composition, and source. The quality of material can be categorized by the size of particles, from coarse to fine. If the percent of fines is low and similar to that of the native beach then the movement of fines to the open water should be similar to that of the natural sorting taking place and result in little to no impacts.

The following are taken from Chapter 62B-41 of the F.A.C. that contains definitions, requirements, and criteria for material identified for beach placement and requirements for information to be contained in permit applications.

> *62B-41.007 Design, Siting and Other Requirements*
>
> *To protect the environmental functions of Florida's beaches, only beach compatible fill shall be placed on the beach or in any associated dune system. Beach compatible fill is material that maintains the general character and functionality of the material occurring on the beach and in the adjacent dune and coastal system. Such material shall be predominately of carbonate, quartz or similar material with a particle size distribution ranging between 0.062mm (4.0ϕ) and 4.76mm (-2.25ϕ) (classified as sand by either the Unified Soils or the Wentworth classification), shall be similar in color and grain size distribution (sand grain frequency, mean and median grain size and sorting coefficient) to the material in the existing coastal system at the disposal site and shall not contain:*
>
> 1. *Greater than 5 percent, by weight, silt, clay or colloids passing the #230 sieve (4.0ϕ);*
> 2. *Greater than 5 percent, by weight, fine gravel retained on the #4 sieve (-2.25ϕ);*

3. Coarse gravel, cobbles or material retained on the 3/4 inch sieve in a percentage or size greater than found on the native beach;
4. Construction debris, toxic material or other foreign matter; and
5. Not result in cementation of the beach.

If rocks or other non-specified materials appear on the surface of the filled beach in excess of 50% of background in any 10,000 square foot area, then surface rock should be removed from those areas. These areas shall also be tested for subsurface rock percentage and remediated as required. If the natural beach exceeds any of the limiting parameters listed above, then the fill material shall not exceed the naturally occurring level for that parameter.

62B-41.008 Permit Application and Requirements and Procedures

(1)(k)4. Permit applications for inlet excavation, beach restoration, or nourishment shall include:

a. An analysis of the native sediment and the sediment at the proposed borrow site(s). The analysis shall demonstrate the nature of the material, quantities available, and its compatibility with the naturally occurring beach sediment pursuant to paragraph 62B-41.007(2)(j), F.A.C. The sediment analysis and volume calculations shall be performed using established industry standards and be certified by a Professional Engineer or a Professional Geologist registered in the State of Florida. Certification shall verify that a quantity of material sufficient to construct the project is available at the borrow site(s) which meets the standard in paragraph 62B-41.007(2)(j), F.A.C., and

b. Quality control/assurance plan that will ensure that the sediment from the borrow sites to be used in the project will meet the standard in paragraph 62B-41.007(2)(j), F.A.C.

Recent research suggests that in addition to the above criteria, that durability of material also be considered in selecting material for beach projects (Wanless and Maier 2007).

Mitigation

Only after adverse impacts have been avoided and minimized to the maximum extent practicable is mitigation considered. Mitigation offsets unavoidable impacts by creating, restoring, enhancing, or preserving comparable habitats. Frequently, artificial reef construction is proposed as mitigation for hardbottom/coral community impacts. Artificial reef construction should mimic the impacted habitat to the extent possible. For very nearshore hardbottom as found in the energetic surf zone, replication of the habitat by artificial reef has proven to be challenging. Artificial reefs are more easily constructed and more readily replicate habitat in water depths exceeding 15 feet or more. A frequent additional requirement of artificial reef construction in navigable waters is the provision of sufficient depth above the structure for safe navigation.

If direct and/or secondary impacts to resources are unavoidable, a compensatory mitigation plan should also be proposed and submitted to the appropriate authorities/agencies for review. The agency will determine if the proposed mitigation plan provides sufficient quantity and quality of mitigation habitat to compensate for proposed direct and /or secondary impacts. A biological monitoring plan should accompany the mitigation proposal. Monitoring of the mitigation site is necessary to confirm whether or not the mitigation proposed is/becomes functionally equivalent to the impacted habitat.

- **In-Kind Mitigation**: A type of compensatory mitigation in which the adverse impacts to one habitat type are mitigated through the creation, restoration, or enhancement of the same habitat type.
- **On-Site Mitigation:** A mitigation project at or near the adversely affected site.
- **Out-of-Kind Mitigation:** A type of compensatory mitigation in which the adverse impacts to one habitat type are mitigated through the creation, restoration, or enhancement of another habitat type.
- **Off-Site Mitigation:** A mitigation project located away from the adversely affected site.

To the extent possible and appropriate, a mitigation project should be "on-site" and "in-kind." In some instances, contribution to a mitigation bank may be considered in lieu of mitigation construction.

Buffer Zones

Buffer zones are a defined area surrounding a site to allow a minimum distance between construction activities and marine resources. After identifying the location of hardbottom and corals near a project site, buffer zones should be established during the planning or permitting phases of a project. For example, a buffer zone may be established between hardbottom and borrow areas for beach nourishment. According to Goldberg (1989), the accepted standard distance between a borrow area and hard bottom community in the SEFCRI region is 400 feet. This is a minimum buffer zone between hardbottom and the borrow area, which may be adjusted according to the specific situation and environmental conditions. Buffer zones may also be used as exclusion areas around hardbottom/corals.

Submerged Pipeline Corridors, Reef Gaps, and Operational Boxes

Areas proposed for pipeline corridors should be surveyed for submerged resources. The path between the borrow area and discharge area should be selected based on the resource survey avoiding direct impacts to the maximum extent possible. If resources are found within the path of minimum impact, then relocation of corals greater than 10 cm should be relocated. Also, if threatened coral species (elkhorn and/or staghorn coral) occur within the path of minimum impact, these colonies should either be avoided or re-located if avoidance is not possible. If elkhorn and/or staghorn coral colonies cannot be avoided and must be re-located, a section 7 consultation with NMFS is required. Prior to pipeline placement, the selected corridor may be marked with buoys to provide surface visual guidance to the contractor laying the pipeline segments precisely within the chosen path. Pipeline pedestals and their appropriate spacing along the pipeline to avoid resource impacts should also be considered

The corridor for pipeline placement should be surveyed before installation for presence of benthic organisms. Depending on the project and situation corals may be removed from the pipeline corridor before pipeline placement. Pipelines that are used for sand transport should be monitored on a regular basis throughout the project. Monitoring should be conducted immediately following placement of the pipeline periodically throughout construction to ensure the pipeline is in good working order, that there is no leakage and no unanticipated resource impacts and that the pipeline has not moved. Resource impacts should be reported immediately. Monitoring for direct contact with resources and pipe leaks is recommended at least weekly; preferably two or three times per week. If evidence of direct contact or leakage is detected, use of the pipeline should be ceased and appropriate action must be taken to remedy the situation. If pumping is not occurring when the evidence of leakage or direct contact is noted, then pumping should not resume until repairs and/or remedial action has been taken. Upon completion of pipeline usage, the pipeline should be removed as soon as is feasible. If possible, pipelines should be removed before any major tropical storm or hurricane. Once the pipeline is removed monitoring should be conducted to measure the level of impacts, if any. Additional mitigation should be required for impacts greater than that originally anticipated/expected.

For hopper dredge operations, the pumpout terminus of the pipeline should be located in an operational box sited in a resource-free area where the dredge can place a mooring anchor. The box should be big enough to ensure that the anchoring system is in sand and that the moored dredge does not swing over shallow reef areas.

Pipelines that are used for transferring sand from offshore to the beach should be monitored for leaks at least weekly; preferably two or three times per week. The monitoring should involve diving the length of the pipe and visually inspected for signs of sand leakage. If evidence of leakage is detected, pumping of sand should immediately cease and the pipe must be patched. If pumping is not occurring when the evidence of leakage is noted, then pumping should not resume until repairs are made and the pipe is sound.

Florida Administrative Code (F.A.C) 18-21.004(2) (l)5. lists five “reef gaps” suitable for the transmission of telecommunication lines. Four reef gaps are offshore of Palm Beach County and one is offshore of Broward County. The location of these reef gaps may also be useful in the identification of pipeline corridors.

Vessel Ingress/Egress Corridors

Vessel ingress and egress corridors are sometimes identified for impact avoidance from the movement of vessels to and from a coastal construction site. After documenting the extent of the hardbottom and corals located in the vicinity of and near a project area, corridors for vessels to access the coastal construction site should be identified. The water depth of the hardbottom and corals should be known as well as the maximum draft for vessels that may access the site. A minimum distance of 6 feet as recommended by the U.S. Coast Guard should be maintained at all times between the bottom of the vessels and the top of any hardbottom or coral features. During construction the location of the vessel corridors should be adequately identified via GIS maps, GPS locations, buoys or channel markers.

Considerations when planning the location of the vessel corridors include, but are not limited to:

- The mean tidal range.
- The difference in draft between a fully loaded and empty vessel.
- The width of the vessels and the appropriate width of the corridor necessary to protect adjacent hardbottom and corals.
- Turning radius for vessels.

- The need for real time tracking.

Vessel groundings are unlikely to be completely avoided; however, prompt and careful removal of the vessel and evaluation of impacts followed by implementation of remedial actions can significantly reduce damage and enhance the ability of coral and reef species to survive the grounding incident (NOAA and U.S. Coral Reef Task Force 2002).

Water Quality Monitoring

Water quality monitoring is required for coastal construction activities permitted by the state. The FDEP has standard language for water quality monitoring with the frequency and depths of sampling adjusted on a case-by-case basis (e.g. adjacent to hardbottom resources). Though turbidity is typically monitored during dredging projects, additional parameters may be applicable for testing depending on the nature of the project and the potential for introduction of contaminants to the surrounding waters. A water quality monitoring plan should detail how to properly conduct water quality monitoring appropriate for the particular project. All water quality monitoring plans should present a scientifically valid and defensible method for monitoring and should show how the applicant plans to demonstrate that the measured values are representative, and how any uncertainty in reported results will be addressed.

The following subjects are typically included in a water quality monitoring plan.

- Detailed description of construction projects occurring in the vicinity
- Detailed description and consideration of proximity to other sources of land based pollution
- Adverse weather conditions and contingency monitoring plan
- Establishing pre-construction background values
- Selection of monitoring stations based on location of corals/hardbottom within the influence of dredge/fill activities
- Monitoring schedule
- Monitoring protocol
- Current direction and flow data
- Light attenuation
- Clearly stated QA/QC protocol
- Deliverables\Reports
- Location and description of resources that may be impacted
- Turbidity monitoring

Biological Monitoring

Biological monitoring is required for any project that is proposed for construction in the vicinity of hardbottom communities. Monitoring is necessary to determine any direct or indirect biological impacts to the ecosystem caused by physical and/or chemical changes to the environment as a result of the project. Biological monitoring should be conducted using the scientific method. Specifically, the biological monitoring should: (1) identify the purpose/potential threats/areas of concern (2) document the environmental background conditions (3) provide detailed, scientifically valid methods for data collection and analysis (4) state anticipated outcomes with “success/acceptance” criteria (5) include a peer/independent review and (6) provide references of typical methods for different habitats. The level of detail of the biological monitoring plan should be equivalent to the anticipated environmental impact. The monitoring should also be conducted by a qualified scientist who is free of any conflict of interests.

Organisms to be monitored may include, but are not limited to, hard and soft corals, sponges and fish. The following subjects are typically included in a biological monitoring plan for a beach nourishment project.

- Adverse Weather Conditions and Contingency Monitoring Plan
- Availability of Data From Previous Studies
- Monitoring Schedule
- Control/Reference Sites
- Baseline Survey
- Permanent Biological Monitoring Transects
- Video Transects
- *In situ* Quadrats, Macrobenthic, and Quadrat Photography
- Sediment Accumulation Measurements
- Hardbottom Edge Mapping and Monitoring
- Aerial Photography (physical monitoring)
- Availability of Raw Data
- Interpretation of Results
- Clearly Stated QA/QC Protocol
- Deliverables/Reports
- Coral Stress Assessments (See Vargas-Ángel 2005)

Personnel Qualifications

Qualifications of personnel that will be responsible for monitoring activities may be evaluated prior to construction to ensure that qualified persons occupy these positions. Personnel qualifications may be requested for activities such as water quality monitoring, biological monitoring, sea turtle monitoring and manatee monitoring. Additional areas of training could include coral sensitivity training.

Construction Windows (protected species, coral spawning, etc.)

Construction windows are a management tool to map out the times of year during which coastal construction may be limited due to the presence of threatened or endangered species or other sensitive marine life. Construction windows may consider wildlife activity such as coral spawning, coral bleaching, manatee congregation or movement to warm waters, sea turtle nesting, incubation, hatching and emergence, shorebird nesting, and migratory bird movement. During the times of year identified by shading in Table 3 below, construction activities may be restricted or require additional monitoring to ensure the protection of the species.

The U.S. Fish and Wildlife Service (federal), the National Marine Fisheries Service (federal), and the Florida Fish and Wildlife Conservation Commission (state) are the agencies charged with evaluating potential effects on threatened and endangered species as it pertains to coastal and marine construction projects. Through the environmental permitting processes, these agencies provide guidance, requirements and restrictions to the lead permitting agencies for inclusion in permits. Wildlife usage of a project area should be carefully considered during project design and proposed construction in areas of high usage by threatened and endangered species should be avoided to the maximum extent possible. For additional time of year info, see Diaz et al. (2004).

Table 3: Potential Construction Restrictions in SEFCRI Region based on Threatened and Endangered Species Activity.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Coral Spawning												
Coral Bleaching												
Manatees												
Sea Turtle Nesting/Emergence			Early Season								Late Season	
Shorebird/ Migratory Birds												

Adaptive Management

Adaptive management allows for the flexibility to change construction operations in response to particular events (Murray and Marmorek 2003). The concept of adaptive management can be applied to many topics concerning coastal construction and the protection of resources. The permit that authorized the dredging of the main ship channel into Key West harbor is often sited for the adaptive management techniques employed. Because maintenance dredging took place within the Florida Keys National Marine Sanctuary (FKNMS), much stricter criteria for water quality and the protection of resources was required. For example, dredging within the harbor was restricted to work on the slack or outgoing tide due to relatively poor flushing in the harbor and the presence of corals along the harbor structures. The water quality monitoring criteria defined triggers that when reached called for increased frequency of monitoring and operation shutdown at predefined turbidity thresholds. The biological monitoring plan called for weekly monitoring of corals including deployment of sediment collection pans to monitor sedimentation on neighboring corals and defining threshold limits and adjustment of operational criteria based on monitoring results. These are just a few of the examples of the adaptive management approach that were employed during the Key West project.

While these adaptive management solutions seem attractive to resource mangers, it should be noted that the planning and development of these techniques took an incredible amount of time and resources. The working group formed for this project was composed of representatives from the FDEP, FKNMS, U.S. Navy, USACE, NOAA, City of Key West and contractors, many of whom worked on the project in a full-time capacity. Working group meetings were attended by approximately 35 to 40 people representing these agencies in attempt to gain consensus on each management technique. Utilizing as many of the techniques already developed during this process are recommended for adoption to other projects as the site conditions allow. However, further development of adaptive management techniques and adjustment to site conditions is required.

Physical Monitoring

The collection of physical coastal data is required to determine the performance characteristics of beach restoration and nourishment projects and overall monitoring of the coastal system. Physical monitoring data often compliment biological monitoring programs by providing supplemental information on sand volumes and sand transport within the littoral system.

For erosion control projects in which the state of Florida participates as a cost share partner, the collection of physical monitoring data is required. In addition to project monitoring, in 2001 the state initiated a comprehensive Regional Coastal Monitoring program that supports detailed monitoring over one quarter of the state annually. All of the data collected must meet the technical specifications and standards as developed by the FDEP BBCS. All of the monitoring data collected by the state or project monitoring data submitted to the state is made publicly available.

The following are components typically included in a physical monitoring plan for a beach nourishment project:

- Beach Profile Topographic Surveys
- Offshore Profile Surveys
- Borrow Area, Shoal and Other Bathymetric Surveys
- Aerial Photography

Artificial Reefs

Creation of artificial reefs is a common way to provide compensatory mitigation for impacts to hardbottom/coral habitat from coastal construction activities. Selection of appropriate materials for artificial reef construction is important and depends on the impacted habitat. Artificial reef geometry is also important and reef design should include an analysis of structural stability and potential for structural settlement. Artificial reef placement should be considered before placement of materials and include a pre-placement site assessment.

Recruitment of hard and soft corals, sponges and algae will differ based on the texture of the surface provided for attachment. Guidance manuals for the selection of artificial reef materials are included in section 9 of the report. Other important factors to consider include the depth of water in which the reefs are to be built, the extent of relief that should be provided and the availability of crevice space for shelter. Artificial reefs should be monitored following deployment and periodically thereafter to determine success regarding its intended objective.

7.0 Structural BMPs for Coastal Construction

Turbidity Curtains

Turbidity curtains allow suspended sediment to settle out of the water column in a controlled area, thus minimizing the sediment transport from the area of disturbance. Turbidity curtains are floating impermeable barriers that are constructed of flexible reinforced thermoplastic material with an upper hem containing floatation material and a lower hem that is weighted. *Turbidity screens* are similar in construction but are constructed of permeable geosynthetic fabric and thus allow for some water to flow through. Turbidity curtains are one of the primary methods for controlling turbidly generated from coastal construction activities.
Turbidity barriers are highly specialized and designed for temporary use. There are various types of barriers available (e.g., floating and hanging, solid diversion baffles, impermeable curtains vs. permeable screens, etc.). Turbidity barriers should be selected for use with strict evaluation of the project site conditions. Relevant site conditions include hydrodynamics, water depth, slopes, and debris. The industry standard for the upper limit of effectiveness for turbidity barrier use is a current velocity greater than 0.5 to 0.8 m/s (~1.0 to 1.5 knots), with exceptions on a case-by-case basis (USACE 2005). Turbidity barriers should not be used in current velocities of greater than 1.5 to 2.6 m/s (~3.0 to 5.0 knots). Turbidity barriers may be used in tidal and non-tidal areas; however, they should not be installed across channel flows, as they are not designed to stop water movement. Furthermore, turbidity barriers are less effective in project locations with high winds (especially areas with long fetch) or excessive wave heights (including ship wakes). The effective depth of the turbidity barrier must be calculated based on the conditions at each site.

Several other variables determine the effectiveness of turbidity barriers, including the type of construction activity occurring; the quantity and type of material being retained by the barrier; the characteristics, construction and condition of the barrier; the configuration of the area enclosed by the barrier; and the method of deployment and attachment.

There are multiple options available for placement of the barriers. Examples include open-ended barriers along channel edges, enclosed barriers for dredging, staged barriers for small, enclosed areas, and box curtains for low-flow areas. Turbidity barrier bottoms shall be sufficiently anchored with weights or connected to sandy substrate via anchors. Positioning of the turbidity barrier to capture sediment-laden water is critical to success. Barriers must remain in place and operational throughout construction.

Turbidity barriers should be inspected after deployment and all necessary repairs should be made immediately. Removal of the turbidity barriers and the related components is vital once the project activities are complete. Failure to do so can cause the barrier to come loose from its anchors and entangle benthic and other marine organisms.

Pipeline Pedestals

Pipeline pedestals, also known as pipeline collars, are support structures that elevate pipelines over hardbottom communities in order to avoid direct contact. They can be designed in a variety of ways and constructed using a number of natural or man-made materials.

Pipeline elevation may be constrained by the pipe specifications, duration of operation, vibration, current, wave, wind and storm activity during operation. Pedestal design is critical for the stability of the structure and pipeline. Placement and material choices for the pedestals are important considerations. Pedestal materials could include calcium carbonate blocks, cement or other inert materials.

Placement requires a survey of the area proposed for the pipeline and proper design to minimize impacts from the pedestals. Surface pipeline should be placed high enough above the hardbottom to avoid contact with the reef corridor over which it passes. Careful design may allow materials to remain underwater as reef material if properly constructed. Non-natural materials such as tires utilized for collars will require removal.

Floating Pipeline

Floating pipelines are pipelines supported in the water column or on the water surface over hardbottom communities. The floating mechanism can be designed in a variety of ways and constructed using a number of materials. This method is often required when submerged resources are in the vicinity of the pipeline corridor.

Floating pipelines may be constrained by the pipe specifications, duration of operation, vibration, current, wave, wind and storm activity during operation. Vessel traffic in the waters in which floating pipelines are considered may also affect the viability of the use of floating pipelines. Floating pipelines may be supported by floating pontoons, buoys, or other flotation devices sturdy enough to handle the pipelines.

Placement requires pre-survey and design to minimize impacts on the hardbottom and reef communities. The pipeline should be placed high enough above the hardbottom to avoid contact with the reef corridor over which it passes. Buoys should be placed to mark the location of the floating pipelines. Sections of the floating pipelines should also be submerged sufficiently below the water surface such that vessels may cross over the floating pipelines. The areas over which vessels may pass should be marked with buoys. Mariners should be notified of the scheme to mark the floating pipeline and the location of safe passage over the floating pipeline.

Floating pipelines should be visually inspected at least weekly, and preferably two or three times per week, to see that floating mechanisms remain properly attached to the pipeline and to detect leaks. If sand leaks are noted, pumping must cease and the the pipe must be repaired prior to resuming production.

Sand Dike

Sand dikes are constructed with earth-moving equipment and run parallel with the existing beach. Typically, a sand dike is constructed from the existing beach sand and runs several hundred feet in front of the sand discharge location. The sand dike allows a space where the discharged slurry will have space to allow settling of heavy and finer particles, allowing the water discharging into the open waters to be less sediment-laden than without the sand dike.

The length of a sand dike may be restricted due to the volume of sand available onsite. If the beach is heavily eroded or in the vicinity of a structure, the amount of sand available and space in which to construct the dike may limit the length of the dike.

Construction requires sufficient sand to construct a shore-parallel dike that is tall enough to not be overtopped by incoming waves and maintain structural integrity during the discharging of sand onto the beach.

The sand dike will need to be built ahead of the project. Extensions to the sand dike will need to be made depending on the pumping capacity and movement down the length of shoreline sited for the beach project. If a sand dike begins to erode or fails in a section, earth-moving equipment can be used to easily repair the dike. Ultimately, the sand dike becomes the seaward edge of construction and is integrated into the final beach; thus, no removal of a sand dike is necessary.

GPS/GIS Guidance Systems

An integrated Global Positioning Systems (GPS) and Geographic Information Systems (GIS) system provides real-time and archive data for a variety of dredge-related activities, including dredge head position and dredge production status. Dredge heads or pipelines associated with the dredging project can be positioned vertically and horizontally in space and time on the seafloor. In addition, GPS/GIS guidance systems provide facts for dispute resolution.

A GPS hardware and software system must be installed and maintained on a dredge to perform GPS guided systems function. Currently, on USACE projects, the USACE is responsible for maintaining the software portion of the system, while the contractor is required to maintain the hardware portion. Once these systems are installed they are maintained in an “always on” mode, continuously recording data. Removal of GPS guided systems is not recommended because of associated costs.

Currently, these systems are required for operation of hopper dredges and scows. The use of GPS/GIS guided pipeline dredging is currently under development. For hopper dredges, the following data can be recorded: horizontal positioning, ship speed, and heading; draft; displacement; tide level; hopper status (open/closed); hopper volume; draghead depth and position, and material recovery and minimum pump effort.

For pipeline dredges, GPS guidance systems can record the cutterhead’s horizontal and vertical position, the slurry velocity and density, tide level, and dredge heading. Already in use on smaller dredges (e.g. Dredgepack, etc.), testing for implementation of GPS guided systems for pipeline dredges is currently underway.

GPS guided systems can be used to enhance environmental monitoring by providing real-time alarms and archival recording of dredge head position and depth outside of prescribed boundaries and depths.

The USACE has taken the concept of integrated GPS and real-time reporting and incorporated it into a system known as the Silent Inspector. The following description and detailed information about the Silent Inspector is taken from the USACE (USACE 2007a).

> *'The Silent Inspector (SI) is an automated dredge contract monitoring system comprised of both hardware and software developed by the Army Corps of Engineers (the Corps). The Corps developed the SI as a low cost, repeatable, impartial system for automated dredge monitoring.*

The hopper dredge and scow SI systems integrate various automated systems to record digital dredging and disposal activities for both government-owned and contract dredges. Both SI systems collect and record measurements from shipboard sensors, calculate the dredging activities, and display this information using standard reports and graphical displays. The SI systems have three major computer components: the Dredge Specific System (DSS), the Ship Server and the Shore System. These components and their functions are described as follows:

Dredging contractors use computer-based systems for positioning and control of their dredge. These systems comprise the SI DSS. The DSS collects various dredge sensor data, and formats and displays these data to the dredge crew to provide quality control of the dredging project.

The DSS sends data in near real-time to the Ship Server (in a standard format), which another computer on the dredge loaded with USACE SI software. The Ship Server then performs tasks that include automated review of data for quality assurance, data archival, report generation, and graphical displays of data. The Ship Server system is not used for scow implementations.

The Shore System provides the same functionality as the Ship Server, but has greater data storage and data reporting capabilities. Data (which may include daily reports) are taken from dredges either by wireless data link or magnetic media and are archived on the Shore System.

The DSS and all shipboard sensors are the property of the contractor, who is required to maintain them. The contractor purchases the Ship Server computer hardware for the USACE, and the USACE installs SI software on the Ship Server computer. The Shore System consists of USACE supplied hardware and software. The USACE SI software on the Ship Server is similar for both hopper and pipeline SI systems. Both hopper and pipeline dredge SI systems monitor dredge position and dredge state, and report and manage these data for USACE dredging contracts. However, each system collects data and computes measurements specific to each dredging type. Additionally, the hopper dredge SI system computes Tons Dry Solids (TDS).

Silent Inspector Capabilities:

- *Monitors and documents where and when different dredging operations take place*
- *24/7 coverage of operations*
- *Reduces paperwork and contractor reporting duties*
- *Creates detailed production reports*
- *Allows for fast responses to public or environmental concerns*
- *Allows for flexible scheduling of human inspectors*
- *Improves government estimates and planning*
- *Improves project management*
- *Standardizes data collection and reporting*
- *Creates a standard base for dispute resolution and avoidance'*

Dredge Operational Controls

Hopper Dredges and Barges Operational Controls

There are three controls possible with Hopper dredges and barges (USACE 2001)

Eliminate or reduce hopper overflow. Eliminating or reducing hopper overflow reduces the volume of fine material which flows from the hopper in the overflow. However, this control may significantly reduce project production for hopper dredges or when hydraulic dredging into a barge.

Lower hopper fill level. Lowering the hopper fill level in rough sea conditions can prevent material loss during transport.

Recirculation system. Water from the hopper overflow can be re-circulated to the draghead and is used to transport more material into the hopper. Further research and development is required to enable implementation of recirculation systems.

Hydraulic Dredge Operational Controls

There are three fundamental controls possible with hydraulic dredges (USACE 2001):

Reduce cutterhead rotation speed. Reducing cutterhead rotation speed reduces the potential for side casting the excavated sediment away from the suction entrance and resuspending sediment. This measure is typically effective only on maintenance or relatively loose, fine grain sediment.

Reduce swing speed. Reducing the swing speed ensures that the dredge head does not move through the cut faster than it can hydraulically pump the sediment. Reducing swing speed reduces the volume of resuspended sediment. The goal is to swing the dredge head at a speed that allows as much of the disturbed sediment as possible to be removed with the hydraulic flow. Typical swing speeds are 5-30 feet/minute.

Eliminate bank undercutting. Dredgers should remove the sediment in maximum lifts equal to 80% or less of the cutterhead diameter.

Mechanical Dredge Operational Controls

There are three fundamental controls possible with mechanical dredges (USACE 2001):

Increase cycle time. Longer cycle time reduces the velocity of the ascending loaded bucket through the water column, which reduces potential to wash sediment from the bucket. However, limiting the velocity of the descending bucket reduces the volume of sediment that is picked up and requires more total bites to remove the project material. The majority of the sediment resuspension, for a clamshell dredge, occurs when the bucket hits the bottom.

Eliminate multiple bites. When the clamshell bucket hits the bottom, an impact wave of suspended sediment travels along the bottom away from the dredge bucket. When the clamshell bucket takes multiple bites, the bucket loses sediment as it is reopened for subsequent bites. Sediment is also released higher in the water column, as the bucket is raised, opened, and lowered.

Eliminate bottom stockpiling. Bottom stockpiling of the dredged sediment in silty sediment has a similar effect as multiple bite dredging; an increased volume of sediment is released into the water column from the operation.

Cofferdam/Sheet Piling

Sheet Piling is a reusable, water-tight barrier made of steel, vinyl, plastic, wood, recast concrete, or fiberglass. Types of sheet piling include Z type (used for intermediate to deep wall construction), arch shaped/light weight type (used for shallow wall construction), Larson type, and flat/straight type. Interlocks between sheets form tight connections and allow minimum shift. Sheet Piles are costly and less adaptable to hard driving conditions, particularly where irregular rock surfaces occur.

Cofferdams are temporary barriers commonly made of wood, steel, or concrete sheet piling. A braced cofferdam is primarily used for bridge/pier construction in shallow water. It is constructed from a single wall of sheet piling that is driven into the ground and surrounds the excavation site. The cofferdam is braced on the inside for structural support and dewatered.

The advantages associated with using cofferdams during coastal construction projects include easy installation and removal of the sheet piles, and the potential reuse of materials on future projects. Cofferdam disadvantages include the requirement of special equipment; expensive, time consuming and tedious process; the sheets can be driven out if rushed; and in high current locations, log jams may occur, putting stress on the structure.

Horizontal Directional Drilling

Horizontal Directional Drilling (HDD) is a trenchless method for installation of underground utilities. A pilot hole is drilled at an angle into the ground and levels off horizontally at a specified depth. Once the proper depth has been reached, the pilot bore is horizontally advanced to a point where it is redirected at an upward angle to exit the ground. Once the drill exits, the drill head is removed and replaced with a back reamer that is also attached to the product to be installed (e.g. conduit, pipe, cable, etc.). The reamer is pulled back through the pilot bore along with the utility. This method is distance and depth limited, depending on the project and location.

A stabilizing/lubricating agent, typically bentonite clay, is used to create a slurry (drill mud) that helps to lubricate the drill and prevent collapse of the bore hole. There is the potential for vertical fractures (frac-outs) to occur in the substrate during drilling where drilling fluid may leach out of the bore hole.

Monitoring should be conducted regularly throughout construction drilling to ensure there are no leaks or if leaks are detected they are caught early enough to avoid impacts from drill mud.

HDD will typically commence from an upland site with the drill reaching depths on the order of 25-30 feet below the surface. The termination point occurs at a predetermined location where a

4.6-m (~15ft) diameter punch-out hole can be excavated without damage to resource (Vince, 2006). Monitoring allows for the recognition of potential fractures and possible losses of the material.

The volume of drill mud in the drill string and the drill pressure should be monitored constantly during drill operation. In submerged applications in the coastal environment, seawater should be used in place of drill mud for the last 9.1-15.2m (~30-50ft) of the directional bore to prevent drill mud from entering the water (Vince, 2006). Monitoring borehole pressure can aid in frac-out avoidance (Stauber et al. 2003). Free flowing slurry at the upland site during pull back and drilling should be properly contained and disposed of from the upland site.

Manatee Signage/ Observer

The West Indian manatee is a federally endangered species and all construction personnel must be educated regarding manatee protection. Manatee observers/spotters are to monitor waterways for manatee presence. Personnel involved in the project operations will be notified of the potential presence of manatees in the area, manatee speed zones, and the need to avoid collisions with manatees. Temporary manatee signs that have been approved by the FWC will be posted prior to project commencement and during project operations in a location visible to construction crews. All on-site personnel are responsible for manatee observation and at least one designated manatee spotter may be required for each vessel. Vessels must proceed with caution, allowing the manatee spotter sufficient time to look for manatees. If manatees are observed, the captain will be contacted immediately and reduce speed or alter the course. All operations must cease if manatees are observed within 15.2m (~50ft) of the construction activity. Any collisions or injuries to manatees must be reported immediately to the FWC Hotline and the USFWS. Turbidity barriers used during the project must be constructed of appropriate material to prevent manatee entanglement and the barriers will be properly secured and routinely monitored for manatee entrapment. Turbidity barriers will not impede manatee movement or block manatee transit to/from an essential habitat (FWC 2005; FDEP 2006).

For rock cutting/blasting projects, an effective watch program will be employed so that detonation is delayed until all manatees are outside of the impact area. The safety radius will be calculated based on the size of the explosive charge to determine the minimum impact area. Blasting operations will cease if manatees are observed within this safety zone. The blasting event will be suspended if manatees are observed within 91.4m (~300ft) of the safety zone. Prior to and during blasting activities, a minimum of four manatee observers/spotters are positioned on boats, bridges, or land. Manatee spotting will begin at least one hour before the first scheduled blast and will continue until at least 30 minutes after all detonations are complete. A continuous aerial survey will be conducted during the same time period. Any manatee injuries/deaths must be reported immediately to the FWC Hotline and the USFWS (USFWS 2004).

Sea Turtle and Smalltooth Sawfish Construction Conditions

There are six species of sea turtles that are known to inhabit the nearshore waters of the SEFCRI region. These species are the Loggerhead, Green, Leatherback, Hawksbill, Kemp’s Ridley and Olive Ridley. With the exception of the Loggerhead (listed as threatened), sea turtle species within the SEFCRI region are listed as endangered. In addition, the smalltooth sawfish is federally listed as endangered and occurs within nearshore and offshore waters of the SEFCRI region. To avoid or reduce the potential for vessel collisions and/or injury to sea turtles and smalltooth sawfish, the NMFS has developed construction conditions for coastal construction projects in nearshore waters where sea turtles and smalltooth sawfish are known to occur. These conditions include the use of siltation barriers that must be properly secured and regularly monitored to avoid protected species entrapment. Barriers may not block sea turtle or smalltooth sawfish entry to or exit from designated critical habitat without prior agreement from the NMFS's Protected Resources Division, St. Petersburg, Florida.

All vessels associated with the construction project shall operate at "no wake/idle" speeds at all times while in the construction area and while in water depths where the draft of the vessel provides less than a four-foot clearance from the bottom. All vessels will preferentially follow deep-water routes (e.g., marked channels) whenever possible. If a sea turtle or smalltooth sawfish is seen within 100 yards of the active daily construction/dredging operation or vessel movement, all appropriate precautions shall be implemented to ensure its protection. These precautions shall include cessation of operation of any moving equipment closer than 50 feet of a sea turtle or smalltooth sawfish. Operation of any mechanical construction equipment shall cease immediately if a sea turtle or smalltooth sawfish is seen within a 50-ft radius of the equipment. Activities may not resume until the protected species has departed the project area of its own volition. Any collision with and/or injury to a sea turtle or smalltooth sawfish shall be reported immediately to the NMFS's Protected Resources Division and the local authorized sea turtle stranding/rescue organization.

Turtle Deflectors

To prevent sea turtle mortality, sea turtle deflectors are utilized to ward off any sea turtles in or near the path of the draghead during hopper dredging activities. A turtle deflector is a rigid adjustable attachment installed on the draghead that deflects any sea turtles that may be in or near the path of the draghead during dredging activities. The V-shaped deflector has an included angle of less than 90 degrees and internal reinforcement to prevent structural failure of the device. The leading edge of the deflector is designed to have a plowing effect of greater than or equal to 0.15m (~6.0in) depth when the draghead is in operation.

Appropriate instrumentation will be installed on the drag head to ensure that the appropriate approach angle is being used. The openings of the hopper inflow will have baskets or screens installed with less than 0.1m x 0.1m (~4.0in x 4.0in) openings. This will provide 100% screening of the hopper inflow(s) and will remain in place throughout the dredging operations. Floodlights will be installed for illumination of the baskets or screening to allow the observer to monitor for turtles, turtle parts, or damage at night or during low-light conditions.

Turtle deflectors are required during all hopper dredge activities and are only successful when the draghead is completely engaged with the seafloor. When it is necessary to move the draghead off of the seafloor operators must decrease the flow velocity in the draghead, to avoid sucking up turtles and before clearing the dredge material from the dragheads, dragpipes and dredge pumps the draghead should be at or above keel depth to avoid impacting turtles in the water column (Biological Opinion NMFS).

Turtle Trawling

To minimize turtle takes during coastal construction, turtle trawling may be employed when authorized by the appropriate wildlife agencies. Relocation trawling is performed during the dredging activity if certain take criteria are met during that project under a protocol developed between NMFS and the USACE, to collect and relocate turtles away from a dredging operation. The relocation trawler runs as close as safety allows in front of the dredge or it continuously trawls in the vicinity of the dredge. Captured turtles are identified, measured, photographed, scanned for overall health, tagged, and released 4.8-8.0km (~3.0-5.0mi) from the project site (Bargo et al. 2005).

Trawlers will tow two 18.3m (~60ft) trawl nets constructed in accordance with the USACE net specifications in the vicinity of the dredge. Tow time is limited to 30-40 minute intervals to prevent turtle drowning, and trawling will occur on a 12 or 24-hour schedule (Bargo et al. 2005). The nets are designed with a 0.2m (~8.0in) mesh which allows most bycatch to pass through the net. Personnel required for 24-hour trawling projects include two qualified vessel operators, each limited to 12 hrs/day, 2-3 deckhands, one NMFS-approved trawl supervisor, and one NMFS-approved observer.

Trawlers 19.8-30.1m (~65-99ft) are limited in their ability to operate in open water conditions. Small trawlers can operate when waves are less than 1.2-1.5m (~4-5ft) and when wind speeds are under 12.9m/s (~25 knots). If both dredging and trawling operations are suspended, trawling will begin 2-3 hours before dredging resumes.

Rarely, relocation trawling results in turtle mortality from drowning or direct trauma. The equipment required to spread the trawl nets underwater (trawl doors) is heavy and moves through the water with great force. Other problems associated with relocation trawling include: 1) trawl nets may be bogged down by trenches or ditches created by dredging activities, creating a safety hazard for trawling vessels; 2) operation schedules may be disrupted because trawling vessels must yield to larger inbound/outbound ships; 3) debris collected in trawl nets must be removed before the next trawling period; and 4) debris can destroy expensive trawling nets.

Floating Tow Lines

The use of floating towlines may be required to prevent dragging of heavy tow lines and cables on the seafloor and avoid direct contact with submerged resources. Tow lines are a necessary component for ships and dredges during construction activities. They are used to tow other vessels or equipment. Tow lines may be made of steel or synthetic fibers such as nylon or polypropelene. All lines are manufactured with a breaking strength. Certain lines are made of a material that floats. Polypropelene line floats and as such if the line breaks, it will not sink to or be dragged along the seafloor. While being dragged along the seafloor, hardbottom and coral habitats could be damaged or even destroyed.

Table 4: Coastal Construction Activities and Relevant BMPs.

Coastal Construction Activity Description	Managerial BMPS										Structural BMPs											
	Design, Siting, Impact Avoidance and Minimization	Mitigation	Buffer Zones	Pipeline Corridors	Vessel Ingress/ Egress Corridors	Water Quality Monitoring Plan	Biological Monitoring Plan	Personnel Qualification	Construction Windows	Adaptive Management	Turbidity Curtains	Pipeline Collars	Floating Pipeline	Sand Dike	Integrated GPS	Dredge Operational Controls	Cofferdam/Sheet Piling	Horizontal Directional Drilling	Manatee Signage/Observer	Turtle Deflector	Turtle Trawling	Floating Tow Lines
Inlets																						
Inlet/Channel Maintenance Dredging	√	√				√		√	√	√					√	√			√	√	√	√
Dredging Sand Traps	√					√		√	√	√					√	√				√	√	
Sand Bypassing	√							√		√												
Dredged Material Nearshore Placement	√		√		√	√		√	√	√					√	√			√	√	√	
Blasting	√	√				√	√	√			√								√			
Beach Restoration and Nourishment																						
Dune Restoration and Enhancement	√				√			√	√	√												
Borrow Area Dredging	√		√		√	√	√	√	√	√					√	√			√	√	√	
Pipeline Placement	√	√	√	√	√		√	√	√	√		√	√		√	√		√	√			√
Beach Placement	√	√	√			√		√	√	√				√	√							
Truck Haul	√		√					√	√	√					√							
Sand Backpassing	√		√					√	√	√				√	√					√		
Dredged Material Disposal																						
Ocean Dredged Material Disposal	√		√		√	√	√	√	√	√					√	√			√			
Dredged Material Disposal - Upland Disposal	√		√	√	√			√	√	√					√	√						
Spoil Islands	√		√	√		√		√	√	√	√			√	√	√						
Coastal Structures																						
Seawalls	√				√			√		√					√		√		√			
Bulkheads	√				√			√		√					√		√		√			
Revetments	√				√	√		√		√					√		√		√			
Jetties	√				√	√		√		√					√				√			
Groins	√				√	√		√		√					√				√			
Breakwaters	√				√	√		√		√					√				√			
Piers	√	√			√			√		√					√				√			
Docks	√		√					√	√	√	√				√				√			
Permanent Pipelines and Cables	√	√	√	√	√	√	√	√	√	√		√	√		√			√				√
Stormwater Outfalls	√		√		√	√	√	√	√	√		√	√		√							√
Ocean Outfalls	√		√	√		√	√	√	√	√		√	√		√							√
Navigation Aids	√	√	√		√			√	√	√					√							
Anchorages	√	√	√		√			√	√	√					√							
Artificial Reefs	√		√		√	√	√	√	√	√					√							

8.0 BMP Summary Plates

Design, Siting, Minimization & Avoidance

Best Management Practices
Plate 1

SUMMARY : The design of coastal construction projects should avoid and minimize direct and secondary adverse resource impacts to the maximum extent possible.

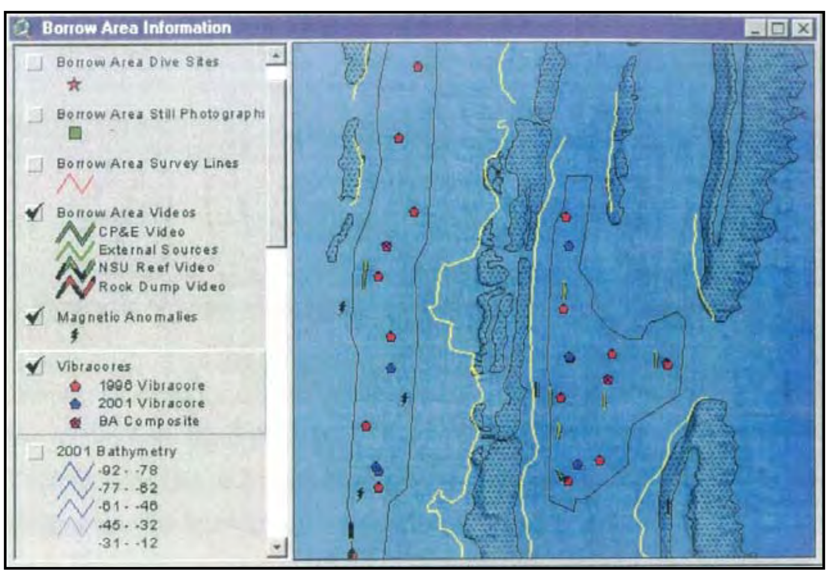
PURPOSE: Avoid and minimize adverse environmental impacts through project design and siting of individual project components.

ENVIRONMENTAL ISSUES ADDRESSED: Avoidance or minimization of adverse environmental impacts.

DESCRIPTION:
Design and siting of coastal construction projects should take into consideration all coastal resources that have the potential to be adversely impacted as a result of the activity. In many cases, unavoidable impacts are authorized in order for the activity to proceed to construction.

Coastal construction projects are typically brought to a 50% or greater design level at time of permit application. This is both advantageous and disadvantageous as the permitting authorities require a high level of detail about the proposed activity in order to provide a thorough review of potential impacts. The applicant however, may hesitate to invest a high level of detail in the design with the understanding that the approving authorities may require the applicant to scale back and redesign the project in order to avoid or minimize potential impacts.

Pre-application meetings with regulatory agencies are highly recommended for coastal projects, particularly when direct resource impacts are proposed. This allows an opportunity for both the applicant and the regulatory agencies to discuss potential impacts and recommendations to avoid or minimize such impacts.



Borrow Area Design and Resource Avoidance GIS database for the Broward County Shore Protection Project. Source: CP&E and Olsen Associates, JV

APPLICATIONS:
All coastal construction projects.

Surveying

Best Management Practices
Plate 2

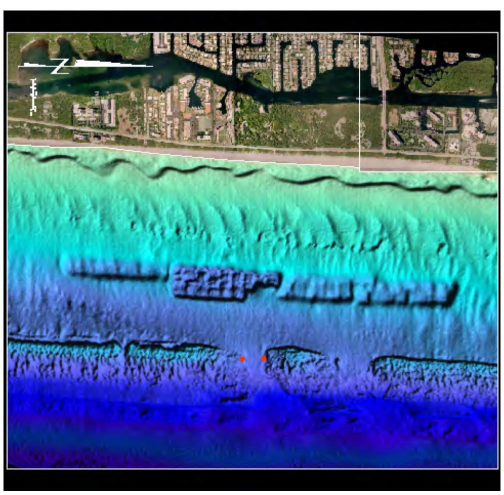
SUMMARY : Utilization of available survey methods to assess, locate and avoid resources in the design of coastal construction projects.

PURPOSE: Avoid and minimize adverse environmental impacts through project design and siting of individual project components.

ENVIRONMENTAL ISSUES ADDRESSED: Avoidance or minimization of adverse environmental impacts.

DESCRIPTION:
To aid in the design and siting of coastal construction projects, surveying techniques have seen significant advancement in recent years with the advancement of digital technology. Advances in high-definition surveying technology and 3-D laser scanning technology focuses on "faster, cheaper, and easier" plus there are significant gains related to the level of detailed information acquired (PSM 2005). Benefits of survey advancements include greater confidence in survey data, reduced need to return to a site to double check or acquire additional data, shorter time in the field leads to faster delivery of completed survey, the richness and quality of the survey is improved and high-defintion and 3-D laser scanning surveying methods cost the same or in some cases less than traditional survey methods.

One such advancement is Laser Airborne Depth Sounder (LADS) technology that utilizes light detection and ranging (LIDAR) for topographic and bathymetric surveying. The advantage to the coastal community is that this technology may be used to survey in water up to 70 meters in depth (Tenix LADS Corporation 2007). This technology has been utilized with success in a few coastal construction projects in southeast Florida. This type of surveying is particularly useful in identifying the seafloor topography and hence location of hardbottom areas which allows for improvements in design, siting and impact minimization. However, LIDAR should not be relied upon for detailing low relief hardbottom areas. LIDAR surveying remains quite costly compared to ground surveying techniques.



LIDAR showing borrow areas and 'Sea Turtle Gap'
Source: Palm Beach DERM.

Leica *Scanstation* high-definition, 3-D surveyor
Source: Leica website.

APPLICATIONS:
All coastal construction projects

Borrow Area Siting

Best Management Practices
Plate 3

SUMMARY : Borrow area siting is necessary for the acquisition of appropriate quality material and resource protection.

PURPOSE: To provide for the selection of beach compatible fill material while avoiding adverse environmental impacts.

ENVIRONMENTAL ISSUES ADDRESSED: Beach quality material placement, sedimentation, minimization of turbidity, protection of water quality, marine turtle nesting habitat and shorebird habitat.

DESCRIPTION:
Proper selection of a borrow area(s), either submerged or an upland mine, ensures that the material applied to the beach is similar in nature to the native or existing material. . Submerged borrow areas should be sited such that the sands contained within the borrow area are compatible with the existing sands and not contrary to the components of 62B-41 F.A.C. Borrow areas should also be sited with a sufficient buffer distance between hardbottom/coral resources and the perimeter of the borrow area to avoid adverse environmental impacts. Resource and regulatory managers can recommend more stringent criteria (e.g. durability, heavy metals, viruses and bacterial) for sand quality for projects adjacent to hardbottom/coral resources
The following borrow site design criteria should be considered.

1. The borrow site should be in 40 to 60 feet of water. When the borrow site is too shallow the dredge will run a ground before it is full of sand. This causes the dredge to have to light load which reduces the dredge's productivity.
2. The borrow site should be 2 miles square with flat sides to minimize the number of turns the dredge has to make to get a load of sand. Turns are not productive; they take time that the dredge is not digging.
- *a. Large and wide borrow sites allow the dredge to dredge in any direction which minimize trenches made by the draghead. Trenches cause the draghead to track away or under the dredge causing the drag tender to have to raise the draghead off the bottom and reset it next to the dredge. The more times the draghead is raised and lowered the greater the odds of taking a turtle and the less productive the dredging.*
- *b. Large and wide borrow sites allows the dredge to dredge in any direction, reducing crabbing. Crabbing is when the dredge has to steer across a current or the wind causing the dredge to move sideways. Crabbing requires the drag tender to have to raise the dragheads off the bottom more often because the dragheads want to tack under or away from the dredge. Large and wide borrow sites reduce crabbing by allowing the dredge to dredge into the constantly changing currents or wind.*
- *c. Dredging becomes less efficient when the dredge has to turn or raise the draghead off the bottom. The less efficient the dredging, the longer the project takes and the more stress on the coral, sea turtles and other natural resources in the area. The maximum production is obtained when a hopper dredge shortens its cycle time (time the dredge takes to dig a full load, sail to the beach and pump the sand out and return to the dredge site).*

3. Borrow site should have more sand than needed to complete the project. A hopper dredge does not dig corners well so sand in the corners of the borrow site can not be dug efficiently with a hopper dredge. Hopper dredges like to dredge flat, thin, long layers of sand.
- *a. Stepping the bottom of a borrow site may cause the hopper dredge to have to raise and lower the draghead. This reduces productivity and sand in the corners and sides of each step can not be dug efficiently with a hopper dredge.*

4. The dredging cost is a large cost of a project so spending more money in the location and design of a borrow site is paid back in reduced dredging cost. Costly dredging delays due to sea turtle takes or coral impacts can be reduced by proper borrow site location and design.
5. There are many limitations to borrow site location and design but the above criteria should be part of the Best Management Practice to protect coral and sea turtles by maximizing dredging production and reducing project cost.

APPLICATIONS:
Beach restoration project, beach nourishment projects and dune restoration projects.

Sand Quality

Best Management Practices
Plate 4

SUMMARY : Any beach and/or dune restoration/nourishment project requires careful consideration of sand quality, including grain size, color, composition and source.

PURPOSE: To ensure selection of the best possible material for beach and dune projects and avoid adverse impacts to environmental resources.

ENVIRONMENTAL ISSUES ADDRESSED: Sedimentation, elevated turbidity, water quality and light attenuation impacts to hardbottom/coral communities and marine turtle habitat.

DESCRIPTION:
Beach and dune quality sand have particular characteristics in terms of size, color, composition, and source. The quality of material can be categorized by the size of particles, from coarse to fine.

62B-41.007 Design, Siting and Other Requirements

> *To protect the environmental functions of Florida's beaches, only beach compatible fill shall be placed on the beach or in any associated dune system. Beach compatible fill is material that maintains the general character and functionality of the material occurring on the beach and in the adjacent dune and coastal system. Such material shall be predominately of carbonate, quartz or similar material with a particle size distribution ranging between 0.062mm (4.0ϕ) and 4.76mm (-2.25ϕ) (classified as sand by either the Unified Soils or the Wentworth classification), shall be similar in color and grain size distribution (sand grain frequency, mean and median grain size and sorting coefficient) to the material in the existing coastal system at the disposal site and shall not contain:*
>
> 1. *Greater than 5 percent, by weight, silt, clay or colloids passing the #230 sieve (4.0ϕ);*
> 2. *Greater than 5 percent, by weight, fine gravel retained on the #4 sieve (-2.25ϕ);*
> 3. *Coarse gravel, cobbles or material retained on the 3/4 inch sieve in a percentage or size greater than found on the native beach;*
> 4. *Construction debris, toxic material or other foreign matter; and*
> 5. *Not result in cementation of the beach.*
>
> *If rocks or other non-specified materials appear on the surface of the filled beach in excess of 50% of background in any 10,000 square foot area, then surface rock should be removed from those areas. These areas shall also be tested for subsurface rock percentage and remediated as required. If the natural beach exceeds any of the limiting parameters listed above, then the fill material shall not exceed the naturally occurring level for that parameter.*

62B-41.008 Permit Application and Requirements and Procedures

> *(1)(k)4. Permit applications for inlet excavation, beach restoration, or nourishment shall include:*
>
> *a. An analysis of the native sediment and the sediment at the proposed borrow site(s). The analysis shall demonstrate the nature of the material, quantities available, and its compatibility with the naturally occurring beach sediment pursuant to paragraph 62B-41.007(2)(j), F.A.C. The sediment analysis and volume calculations shall be performed using established industry standards and be certified by a Professional Engineer or a Professional Geologist registered in the State of Florida. Certification shall verify that a quantity of material sufficient to construct the project is available at the borrow site(s) which meets the standard in paragraph 62B-41.007(2)(j), F.A.C., and*
>
> *b. Quality control/assurance plan that will ensure that the sediment from the borrow sites to be used in the project will meet the standard in paragraph 62B-41.007(2)(j), F.A.C.*

Sands that do not meet the criteria above may contain undesirable material that during dredging, beach placement, and equilibration of the beach may affect nesting marine turtles or corals through direct contact or sedimentation.

APPLICATIONS: Beach nourishment and dune restoration projects.

Mitigation

Best Management Practices
Plate 5

SUMMARY : Mitigation is performed in the event that impacts to resources are unavoidable. Mitigation can create, restore, enhance or preserve habitats comparable to those that were impacted.

PURPOSE: To offset impacts to hardbottom and corals.

ENVIRONMENTAL ISSUES ADDRESSED: Direct and secondary impacts to hardbottom and corals.

DESCRIPTION:
Mitigation is applicable after impacts have been avoided and minimized to the maximum extent practicable. Mitigation offsets unavoidable impacts by creating, restoring, enhancing, or preserving comparable habitats. If direct and/or secondary impacts to resources are unavoidable, a compensatory mitigation plan should also be proposed and submitted to the appropriate authorities/agencies for review. The agency will determine if the proposed mitigation plan provides sufficient quantity and quality of mitigation habitat to compensate for proposed direct and /or secondary impacts. A biological monitoring plan should accompany the mitigation proposal. Monitoring of the mitigation site is necessary to confirm whether or not the mitigation proposed is/becomes functionally equivalent to the impacted habitat.

- **In-Kind Mitigation**: A type of compensatory mitigation in which the adverse impacts to one habitat type are mitigated through the creation, restoration, or enhancement of the same habitat type.
- **On-Site Mitigation:** A mitigation project at or near the adversely affected site.
- **Out-of-Kind Mitigation:** A type of compensatory mitigation in which the adverse impacts to one habitat type are mitigated through the creation, restoration, or enhancement of another habitat type.
- **Off-Site Mitigation:** A mitigation project located away from the adversely affected site.

To the extent possible and appropriate, a mitigation project should be “on-site” and “in-kind.” In some instances, contribution to a mitigation bank may be considered in lieu of mitigation construction.

APPLICATIONS:
Coastal construction projects with unavoidable and/or unanticipated adverse impacts to resources.

Artificial reef units replicating hardbottom habitat in an offshore environment, Miami Dade County.
Source: PBS&J.

Barge and crane employed to construct mitigation in very nearshore habitat, Miami Dade County.
Source: FDEP.

Buffer Zones

Best Management Practices
Plate 6

SUMMARY : A buffer zone is identified to establish a minimum distance between coastal construction activities and neighboring resources.

PURPOSE: To minimize impacts to hardbottom/ coral communities during coastal construction.

ENVIRONMENTAL ISSUES ADDRESSED: Direct and secondary impacts to submerged biological resources, in particular hardbottom and coral communities.

DESCRIPTION:
Buffer zones are a defined area surrounding a site to allow a certain minimum distance between construction activities and neighboring biological resources (hardbottom and coral habitat). After identifying the location of hardbottom and corals near a project site, buffer zones should be established during planning and permitting. A minimum distance of 400 feet from resources is recommended, however local current conditions and construction turbidity levels should be considered when establishing buffer zone distances. Buffer zones are frequently established between hardbottom/coral communities and submerged sand borrow areas that are identified for beach nourishment. Determination of the minimum buffer zone distance between resources and a borrow area may result in a reduction in the amount and quality of sand available in the borrow area and should be carefully considered in the design process. Early coordination with environmental agencies is encouraged to maximize borrow area volume whenever neighboring submerged resources have been identified. Buffer zones may also be used as exclusion areas around hardbottoms or corals. It is important, particularly with respect to hopper dredges, that borrow areas be designed with buffer zones such that the borrow areas are as large and simple in shape as possible, avoiding sharp changes in direction. The ideal borrow area is a long straight rectangle.

Prior to and during construction, it is recommended that the limits of the edge of hardbottom and the limits of the buffer zone be marked with buoys to provide visual guidance to construction operators.

APPLICATIONS:
Any coastal construction activities neighboring submerged biological resources.

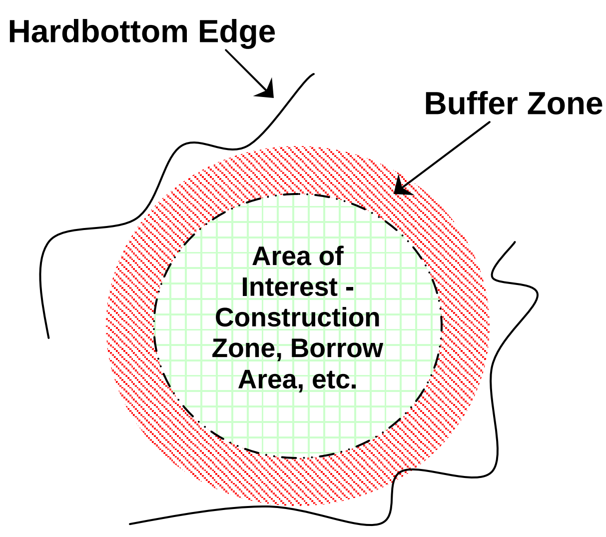
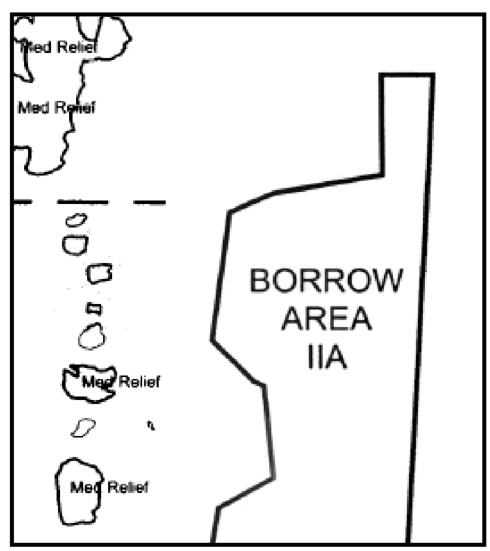


Illustration of buffer zone between construction or borrow area and neighboring resources. Source: PBS&J



Borrow area buffer zone for the City of Boca Raton Central Beach Nourishment Project, Palm Beach County. Source: FDEP permit 0192068-001-JC.

Submerged Pipeline Corridors, Reef Gaps, and Operational Boxes

Best Management Practices
Plate 7

SUMMARY : Pipeline corridors should be specified when construction pipeline is required to traverse through or adjacent to coral/hardbottom habitat. The path of no/minimal impact should be sought.

PURPOSE: To avoid impacts to hardbottom and corals during construction operations.

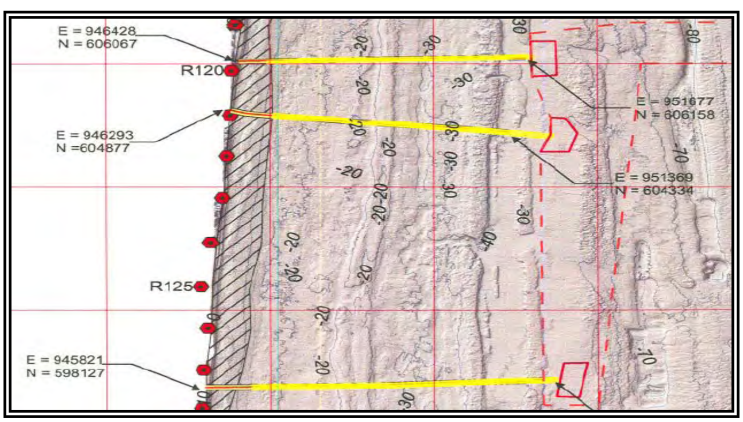
ENVIRONMENTAL ISSUES ADDRESSED: Direct impacts to coral/hardbottom habitat.

DESCRIPTION:
Areas proposed for pipeline corridors and operational boxes should be surveyed for submerged resources. The path between the borrow and discharge areas should be selected based on the resource survey avoiding direct impacts to the maximum extent possible. The operational boxes should be completely free of hardbottom and benthic growth, and corridors should be through areas of minimal resources if possible. There should be several alternative corridor and box options to allow for differing size and pumping capability of particular dredges. If resources are found within the path of minimum impact, then relocation of corals greater than 10 cm should be relocated. Also, if threatened coral species (elkhorn and/or staghorn coral) occur within the path of minimum impact, these colonies should either be avoided or re-located if avoidance is not possible. If elkhorn and/or staghorn coral colonies cannot be avoided and must be re-located, a section 7 consultation with NMFS is required. Prior to pipeline placement, the selected corridor should be marked with buoys to provide surface visual guidance to the contractor laying the pipeline segments precisely within the chosen path. Pipeline pedestals and their appropriate spacing along the pipeline to avoid resource impacts should also be considered.

Monitoring should be conducted immediately following placement of the pipeline and periodically throughout construction to ensure the pipeline is in good working order, that there is no leakage and no unanticipated resource impacts and that the pipeline has not moved. Resource impacts should be reported immediately. Upon completion of pipeline usage, the pipeline should be removed as soon as is feasible. If possible, pipelines should be removed before any major tropical storm or hurricane. The corridor should be surveyed before installation and after the pipeline is removed to confirm the anticipated level of impacts. Additional mitigation should be required for impacts greater than originally anticipated/expected.

Florida Administrative Code 18-21.004(2) (l)5. lists five "reef gaps" suitable for the transmission of telecommunication lines. Four reef gaps are offshore of Palm Beach County and one is offshore of Broward County. The location of these reef gaps may also be useful in the identification of pipeline corridors.

APPLICATIONS:
Any project employing pipelines, cables and/or operational boxes through hardbottom/coral habitat.



Ingress, Egress and Pipeline Corridors - Broward County Nourishment Project (Yellow lines are pipeline corridors, while red line is center line of corridor.) Source: FDEP permit #0163435-011-EM.

Vessel Ingress/Egress Corridors

Best Management Practices
Plate 8

SUMMARY : Vessel ingress/egress corridors may be defined for projects that require vessel access and work areas in the vicinity of hardbottom/coral habitat.

PURPOSE: To avoid impacts to hardbottom and corals from the movement of vessels to and from a site during coastal construction.

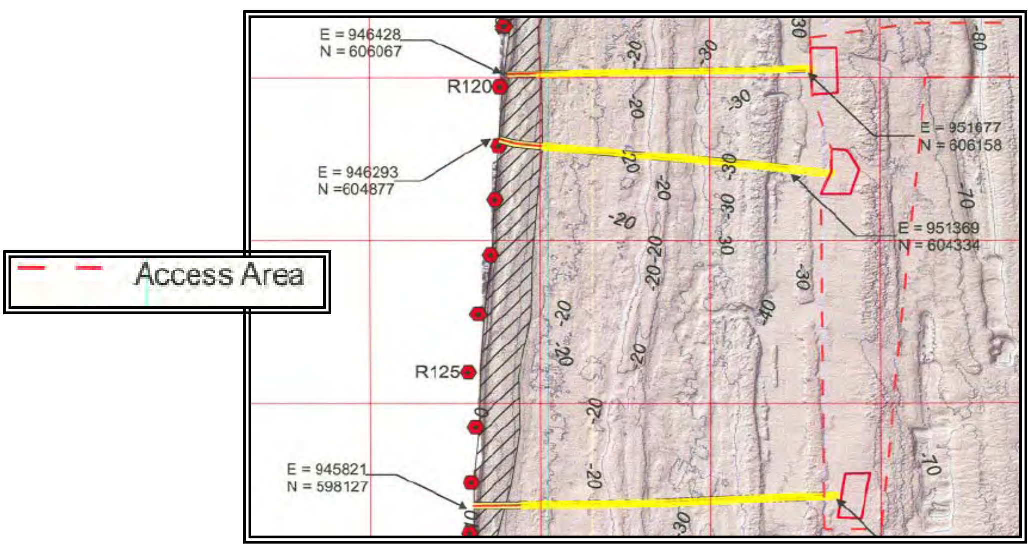
ENVIRONMENTAL ISSUES ADDRESSED: Direct impacts to hardbottom/coral communities.

DESCRIPTION:
After identifying the extent of the hardbottom and corals located in the vicinity of a project area, corridors for vessels access to the coastal construction site should be identified. The water depth, tidal and current conditions and relief of the hardbottom and coral communities should be documented. Detailed knowledge of the working vessels(s), such as length, beam, fully loaded draft and turning radius, are all useful in deciding upon a corridor. A minimum distance should be maintained at all times between the bottom of the vessels and the top of any hardbottom or coral features and should include buffer to allow for unforeseen circumstances. During construction the location of the vessel corridors should be adequately identified via GIS maps, GPS locations, buoys or channel markers.

Considerations when planning the location of the vessel corridors include, but are not limited to:

- The mean tidal range
- The difference in draft between a fully loaded and empty vessel.
- The width of the vessels and the appropriate width of the corridor necessary to protect adjacent hardbottom and corals.
- Turning radius for vessels.
- The need for real-time tracking.

APPLICATIONS:
Any project where construction equipment must traverse hardbottom/coral habitat.



Access and pipeline corridors established for the Broward County Nourishment Project. Source: FDEP permit #0163435-011-EM.

Water Quality Monitoring

Best Management Practices
Plate 9

SUMMARY : There are two concepts associated with water quality monitoring: (1) the state water quality and (2) resource protection. Water quality monitoring is implemented when coastal construction activities may introduce environmental pollution.

PURPOSE: To ensure the protection of water quality and the protection of biological resources.

ENVIRONMENTAL ISSUES ADDRESSED: Direct and secondary impacts to water quality and biological resources associated with sedimentation, decreased light attenuation (associated with elevated turbidity), and other environmental contaminants.

DESCRIPTION:
Water quality monitoring is required for coastal construction projects and necessary for monitoring the effects on water quality and can assist in monitoring for effects on biological resources. Construction activities may result in introducing environmental contaminants, such as excess turbidity, to the surrounding waters. Though turbidity is typically monitored during dredging projects, additional parameters (such as concentrations of metals, nutrients, etc.) may be applicable for testing depending on the nature of the project and the potential for introduction of contaminants to the surrounding waters (Florida Statutes Chapter 62-302). Current direction and flow should be measured when obtaining water samples. All water quality monitoring should present scientifically valid and defensible methods for monitoring.

Note: The Atlantic States Marine Fisheries Commission concluded that appropriate turbidity monitoring standards must be set based on the "organisms present in the coastal areas, with some areas requiring more stringent standards" and that the current Florida standard of 29 NTU's "may not be conservative enough and state agencies may want to reexamine their turbidity standards" (Greene 2002).

Water-quality monitoring typically includes, but is not limited to, the following:

- Detailed description of construction projects occurring in the vicinity
- Detailed description and consideration of proximity to other sources of land based pollution
- Adverse weather conditions and contingency monitoring plan
- Establishing pre-construction background values
- Selection of monitoring stations based on location of corals/hardbottom within the influence of dredge/fill activities
- Monitoring schedule
- Monitoring protocol
- Current direction and flow data
- Light attenuation
- Clearly stated QA/QC protocols
- Deliverables\Reports
- Location and description of resources that may be impacted
- Turbidity monitoring

APPLICATIONS:
Construction projects that may affect water quality by introducing environmental contaminants to the surrounding waters, including but not limited to, turbidity, sedimentation, nutrients and heavy metals.

Biological Monitoring

Best Management Practices
Plate 10

SUMMARY: Monitor the effects of coastal construction on biological resources.

PURPOSE: To document the condition of biological resources before, during, and after coastal construction activities.

ENVIRONMENTAL ISSUES ADDRESSED: Direct and indirect biological impacts to the ecosystem caused by physical and/or chemical changes to the environment as a result of the project.

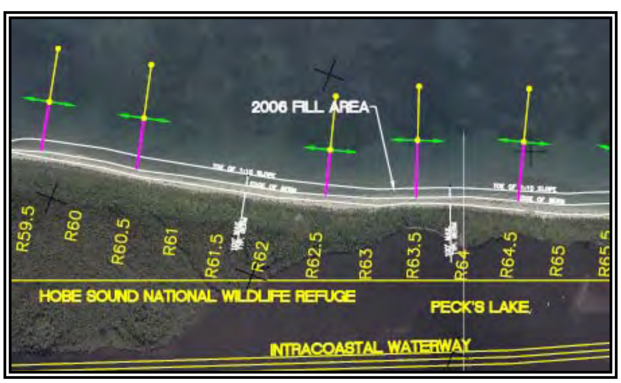
DESCRIPTION:
Biological monitoring should be conducted using the scientific method. Monitoring is necessary to determine any direct or indirect biological impacts as a result of the project. Specifically, the biological monitoring should: (1) identify the purpose/potential threats/areas of concern (2) document the environmental background conditions (3) provide detailed, scientifically valid methods for data collection and analysis (4) state anticipated outcomes with "success/acceptance" criteria (5) include a peer/independent review and (6) provide references of typical methods for different habitats. The level of detail of the biological monitoring plan should be equivalent to the anticipated environmental impact.

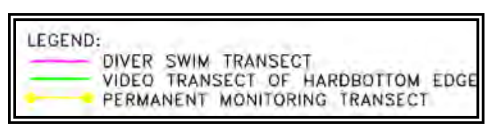
Biological monitoring may be required for any coastal construction project proposed to take place in the vicinity of seagrass, hardbottom and/or coral communities. A biological monitoring plan should be a concise document that details the proposed components of the biological monitoring effort and should include (at *minimum*) the following components: a classification and quantitative characterization of resources including species diversity and abundance of key species (by life history stage); estimated area of direct and secondary impacts (if applicable); monitoring frequency; proposed statistically valid methods of data analysis and a framework and schedule for reporting. Monitoring should be conducted by a qualified scientist who is free of any conflict of interests. Whenever possible, biological monitoring should be coordinated with physical and water quality monitoring.

The following elements are typically included in a biological monitoring plan for a beach nourishment project.

- Adverse Weather Conditions and Contingency Monitoring Plan
- Availability of Data From Previous Studies
- Monitoring Schedule
- Control/Reference Sites
- Baseline Survey
- Permanent Biological Monitoring Transects
- Video Transects
- *In situ* Quadrats, Macrobenthic, and Quadrat Photography
- Sediment Accumulation Measurements
- Hardbottom Edge Mapping and Monitoring
- Aerial Photography (physical monitoring)
- Availability of Raw Data
- Interpretation of Results
- Clearly Stated QA/QC Protocol
- Deliverables\Report
- Coral Stress Assessments (See Vargas-Ángel 2005)

APPLICATIONS:
Any project with anticipated impacts and/or potential for impacts to biological resources.





Biological Monitoring Transects for the St. Lucie Inlet Federal Navigation Maintenance Project. Source: FDEP permit # 43-294982-9.

Personnel Qualifications

Best Management Practices
Plate 11

SUMMARY: Personnel qualifications are usually required by government agencies during the permitting phase of coastal construction projects to assure quality performance during monitoring associated with coastal construction activities. Qualifications are usually required for individuals performing environmental monitoring tasks, such as water quality monitoring, biological monitoring, and manatee observation.

PURPOSE: To minimize adverse impacts to biological resources, including threatened and endangered species, during coastal construction projects by involving high quality, informed personnel in monitoring tasks.

ENVIRONMENTAL ISSUES ADDRESSED: Protection of animal and plant species of concern, including threatened and endangered species.

DESCRIPTION:
Personnel qualifications are usually required by government agencies during the permitting phase of coastal construction projects to assure quality performance during monitoring associated with coastal construction activities. All personnel involved in biological and water quality monitoring must be trained and skilled with the tasks to be conducted, specifically the individuals involved in data collection. The individual approved during the permitting phase should train all people involved in the data collection process. Additional training should be considered for personnel working in the SEFCRI region and may include coral sensitivity training. In order to assure quality performance and results, governmental agencies should ask for previous, related experience as an indicator of the individual's experience level. If resources are present within the project area, monitoring should be conducted by an independent third party to minimize any possible conflicts of interest.

APPLICATIONS:
All monitoring requires individuals with specific professional expertise and experience. Examples include, but are not limited to, water quality monitoring, biological/resource monitoring, physical monitoring, marine turtle monitoring, manatee monitoring.

Nesting Loggerhead.
Source: Florida Fish and Wildlife Conservation Commission

Scientists monitoring coral in Broward County. Source: Dave Gillam, National Coral Reef Institute

Construction Windows

Best Management Practices
Plate 12

SUMMARY : Construction windows consider the time frame for threatened and endangered species utilizing the coastal area for critical life cycle activities and balance construction timing and sequencing to avoid these activities or minimize disturbance when listed species are thought to be present.

PURPOSE: Identify times during which construction activities may be restricted due to the presence of threatened and endangered species in the coastal zone and nearshore waters.

ENVIRONMENTAL ISSUES ADDRESSED: Direct and secondary impacts to protected species.

DESCRIPTION:
Construction windows are a management tool identifying times of year during which coastal construction may be limited due to wildlife activity. Wildlife considerations include coral spawning, coral bleaching, manatee congregation or movement to warm waters, sea turtle nesting, incubation, hatching, and emergence, shorebird nesting, and migratory bird movement. The table below identifies times of the year during which construction activities may be restricted or require additional monitoring to ensure protection of coastal wildlife (Table 1). For additional time of year info, see Diaz et al. (2004).

The U.S. Fish and Wildlife Service (federal), the National Marine Fisheries Service (federal), and the Florida Fish and Wildlife Conservation Commission (state) are the agencies charged with evaluating potential effects on threatened and endangered species as it pertains to coastal and marine construction projects. Through the environmental permitting processes, these agencies provide guidance, requirements and restrictions to the lead permitting agencies for inclusion in permits. Wildlife usage of a project area should be carefully considered during project design and proposed construction in areas of high usage by threatened and endangered species should be avoided to the maximum extent possible.

Table 1: Display of sensitive time periods for various organisms in the SEFCRI region indicated in gray.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Coral Spawning												
Coral Bleaching												
Manatees												
Sea Turtle Nesting/Emergence			Early Season								Late Season	
Shorebird/ Migratory Birds												

APPLICATIONS:
Coastal construction projects that have the potential to interfere with coastal wildlife activities, particularly that of threatened and endangered species.

Adaptive Management

Best Management Practices
Plate 13

SUMMARY: Adaptive management employs science and monitoring to determine effectiveness and continually improve natural resource management. Adaptive management uses monitoring results to modify a course of action for the purpose of resource protection.

PURPOSE: To further refine methods of resource protection by allowing flexibility to make decisions and change methodology in response to monitoring results, particular events or changing environmental conditions.

ENVIRONMENTAL ISSUES ADDRESSED: Any resource impacts detectable by environmental monitoring. For example, during beach nourishment projects if turbidity exceed allowable levels, dredging is temporarily stopped until turbidity returns to an acceptable measurement.

DESCRIPTION:
Adaptive management is the process of using science and monitoring to improve natural resource management. Adaptive management allows decision makers to change the direction of a project based on new knowledge or monitoring results (Murray and Marmorek 2003).

In the planning stage, adaptive management is used to assess predictive modeling and current knowledge. During the decision making process, alternative management plans are considered and implemented. As new knowledge is gained through the implementation of the project, the models are updated and the management plans are changed accordingly. Due to the dynamic variability of the natural environment, the best possible protective measures may result from decisions made based upon the assessment of monitoring data and/or field observations. Allowing flexibility to modify project operations in the field is key to successful resource protection through adaptive management.

APPLICATIONS:
The concept of adaptive management should be applied to coastal construction and the protection of natural resources. The goal of adaptive management is to apply lessons learned to existing and future coastal construction projects to improve resource protection. Adaptive management techniques were employed during the operations and maintenance dredging of the main ship channel into Key West and Truman Harbor. Dredging activities took place within the Florida Keys National Marine Sanctuary (FKNMS) and required adherence to strict water quality and resource protection standards. Dredging within the harbor was restricted to the slack or outgoing tide, due to the relatively poor flushing in the harbor and the presence of corals along the harbor walls. An adaptive management approach was utilized in defining the water quality monitoring criteria in the environmental permits. Defined triggers and thresholds were set that when reached called for adjustment, specifically increased frequency of monitoring and/or operation shutdown at predefined turbidity thresholds. Adaptive management was written into the resource monitoring plan as well. The biological monitoring plan called for frequent monitoring of resources throughout construction including deployment of sediment collection pans to monitor sedimentation on neighboring corals. Threshold limits were defined triggering a series of actions and adjustment of operational criteria based on monitoring results. Resource agencies were updated on a weekly basis via e–mail re: turbidity exceedances and results of resource health/sedimentation monitoring.

Physical Monitoring

Best Management Practices
Plate 14

SUMMARY: Monitor the performance of beach restoration and nourishment projects.

PURPOSE: Collect physical coastal data to determine the performance characteristics of beach restoration and nourishment projects and overall monitoring of the coastal system. Physical monitoring data often compliments biological monitoring programs by providing supplemental information on sand volumes and sand transport within the littoral system.

ENVIRONMENTAL ISSUES ADDRESSED: Direct and indirect biological impacts to the ecosystem caused by physical and/or chemical changes to the environment as a result of the project.

DESCRIPTION:
For erosion control projects in which the state of Florida participates as a cost share partner, the collection of physical monitoring data is required. In addition to project monitoring, in 2001 the state initiated a comprehensive Regional Coastal Monitoring program (http://www.dep.state.fl.us/beaches/publications/pdf/monplan.pdf) that supports detailed monitoring over one quarter of the state annually. All of the data collected must meet the technical specifications and standards (http://www.dep.state.fl.us/beaches/publications/pdf/standard.pdf) as developed by the FDEP Bureau of Beaches and Coastal Systems. All of the monitoring data collected by the state or project monitoring data submitted to the state is made publicly available.

The following are components typically included in a physical monitoring plan for a beach nourishment project.

- Beach profile topographic surveys
- Offshore profile surveys
- Borrow area, shoal and other bathymetric surveys
- Aerial photography

APPLICATIONS:
Beach restoration and nourishment projects.

Vertical aerial photography.
Source: FDEP

Artificial Reefs

Best Management Practices
Plate 15

SUMMARY : Artificial reefs are frequently constructed as mitigation for adverse impacts to hardbottom communities. In addition to mitigation, artificial reefs are often created to enhance habitat for benthic communities and recreational opportunities such as snorkeling, diving and fishing.

PURPOSE: Provide mitigation habitat for hardbottom/coral impacts, provide habitat enhancement for benthic resources and increase recreational opportunities.

ENVIRONMENTAL ISSUES ADDRESSED: Provide compensatory mitigation for unavoidable impacts to hardbottom/coral communities. Provide habitat and recreational enhancement.

DESCRIPTION:
Creation of artificial reefs is a common way to provide compensatory mitigation for impacts to hardbottom/coral habitat from coastal construction activities. Selection of appropriate materials for artificial reef construction is important and depends on the habitat that is to be replicated. Artificial reef geometry is also important and reef design should include an analysis of structural stability and potential for structural settlement. Additionally, pre-placement site assessment(s) should be carried out to ensure success.

Recruitment of hard and soft corals, sponges and algae will differ based on the texture of the surface provided for attachment. Other important factors to consider include the depth of water in which the reefs are to be built, the extent of relief that should be provided and the availability of crevice space for shelter. Artificial reefs should be monitored following deployment and periodically thereafter to determine success regarding its intended objective.

As guidance for the selection of artificial reef materials, the Atlantic and Gulf States Marine Fisheries Commissions have produced a document entitled '*Guidelines for Marine Artificial Reef Materials, Second Edition*'. For the use of retired vessels as artificial reefs, the U.S. EPA and the U.S. Maritime Administration have created a guidance document entitled "*National Guidance: Best Management Practices for Preparing Vessels Intended to Create Artificial Reefs*", and NOAA has published the "*National Artificial Reef Plan*". A link to these documents is provided in Section 9.

APPLICATION:
Artificial reef construction as compensatory mitigation or for habitat creation.

Artificial reef units before (above) and after (right) deployment. Source: PBS&J

Turbidity Curtains

Best Management Practices
Plate 16

SUMMARY: Turbidity curtains are vertical, semi-permeable or impermeable barriers with floatation along the top of the curtain and weights or anchors at the bottom to allow the curtain to remain vertical in the water column.

PURPOSE: Aid in the control of turbidity, sediments, and/or contaminants confined within an area surrounding the dredging/construction site.

ENVIRONMENTAL ISSUES ADDRESSED: Turbidity, light attenuation, smothering/burial, sediment-associated contaminants/nutrients.

DESCRIPTION:
Turbidity curtains are vertical barriers that are constructed of flexible, reinforced thermoplastic material with an upper hem containing floatation material and a lower hem that is weighted. *Turbidity screens* are similar, but are constructed of permeable geosynthetic fabric allowing water flow-through. Turbidity curtains should not be used as the only means by which to control turbidity. Care should be taken in considering turbidity curtains as a means by which to protect resources and it is noted that they have the potential to impact the very resources under consideration. If curtains are employed, daily inspections should be conducted to check for wildlife entanglement (e.g. manatee).

APPLICATIONS:
Dredging or marine construction in inland and protected waters. Turbidity screens and curtains are not practical for use in the open ocean environment.

Use of a turbidity barrier for a small-scale project.
Source: http://www.dawginc.com/secondary-spill-containment/turbidity-barrier-curtain.php

Use of a turbidity barrier for a large-scale project.
Source: http://www.geomembranes.com/images/path_product/Ocean1-3.jpg

OPERATIONAL CRITERIA:
Condition Restrictions. Turbidity barriers are highly specialized devices made for temporary use. There are various types available (e.g., floating and hanging, solid diversion baffles, impermeable curtains vs. permeable screens, etc.). Turbidity barriers should be selected with strict evaluation of sediment quality and site conditions. Relevant site conditions include hydrodynamics, water depth, slopes, and debris. The industry standard for the upper limit of effectiveness is a current velocity greater than 0.5 to 0.8 m/s (~1.0 to 1.5 knots) (USACE, 2005). Turbidity barriers should not be used in current velocities greater than 1.5 to 2.6 m/s (~3.0 to 5.0 knots). Turbidity barriers may be used in tidal and non-tidal areas; but should not be installed across channel flows as they are not designed to stop water movement. Turbidity barriers are less effective in high winds (especially areas of long fetch) and excessive wave heights (including ship wakes). The effective depth of the turbidity barrier must be calculated based on site conditions. In areas of seagrass the curtain should be elevated vertically at least one foot from the bottom and horizontally 25 feet from resources.

Installation. There are multiple options available for barrier placement. Examples include open-ended barriers, enclosed barriers for dredging, staged barriers for small enclosed areas, and box curtains for low-flow areas. Barrier bottoms should be weighted or anchored. Positioning of the turbidity barrier is critical to success. Barriers must remain in place and operational throughout construction.

Maintenance and Removal. Turbidity barriers should be inspected after deployment and all necessary repairs should be made immediately. Turbidity barriers should be removed as soon as possible after activities are complete.

Pipeline Pedestals

Best Management Practices
Plate 17

SUMMARY: Pipeline pedestals are support structures that elevate pipelines over hardbottom communities. These structures may be used during beach renourishment and outfall installation projects. The placement of pipeline pedestals requires pre-survey and design to minimize impacts to underlying hardbottom communities. Proper design may allow pedestal materials to remain underwater as artificial reef structures if properly constructed.

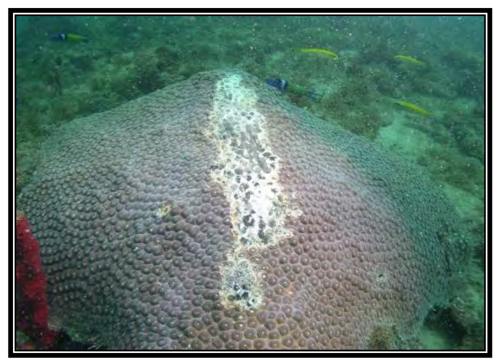
PURPOSE: To elevate pipelines above the benthic community.

ENVIRONMENTAL ISSUES ADDRESSED: Direct contact with benthic organisms; decrease shading effects on benthic organisms.

DESCRIPTION:
Pipeline pedestals are supporting structures that elevate pipelines over hardbottom communities. Typically, very large rubber tires are used to elevate pipelines over sensitive habitat with limited effectiveness. Pipeline pedestals are a good candidate for innovation as improvement of this technology is required in order to achieve greater level of resource protection.

APPLICATIONS:
Beach nourishment and outfall installation projects.

Pipeline elevation above hardbottom community. Source: PBS&J



Damage to a *Montastraea cavernosa* colony from direct contact with a pipeline. Source: PBS&J

OPERATIONAL CRITERIA:

- *Condition Restriction*. Pipeline elevation may be constrained by the pipe specifications, duration of operation, vibration, current, wave, wind and storm activity during operation. Pedestal design is critical for the stability of the structure and pipeline. Placement and material choices for the pedestals are important considerations.

- *Installation*. Placement requires pre-survey and design to minimize impacts from the pedestals on the hardbottom and reef communities. The pipeline should be placed high enough above the hardbottom to avoid contact with the reef corridor over which it passes. Prior to deployment, the pipeline corridor may be marked with buoys to provide surface visual reference. Pedestals are deployed and removed pre-attached to the pipeline and are spaced at variable intervals along the pipeline. Pedestal spacing no less than every 50 feet is recommended. Connecting and deploying long pipeline segments is less impacting to resources than attempting to connect and deploy shorter segments of pipeline.

- *Maintenance and Removal*. The pipeline should be periodically inspected during construction to ensure proper placement and resource protection. All pipeline and associated materials should be removed as soon as possible following completion of construction. An inclement weather plan should be developed. Post removal surveys should be conducted to confirm whether or not resource impacts occurred.

Floating Pipelines

Best Management Practices
Plate 18

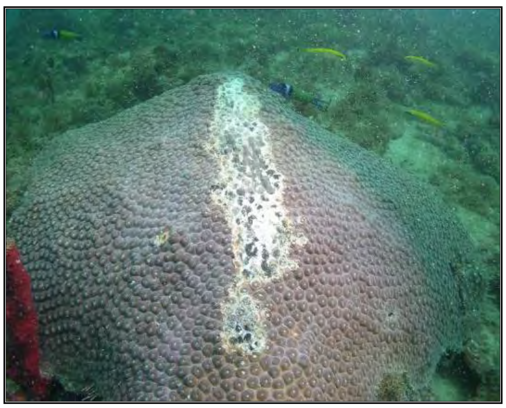
SUMMARY: Floating pipelines are pipelines supported in the water column by buoyant material or pipeline constructed of buoyant material. Application of floating pipelines is limited to inland waterways and protected waters and is not feasible in the open ocean environment.

PURPOSE: To float pipelines so they are not in direct contact with coral and other sensitive benthic resources.

ENVIRONMENTAL ISSUES ADDRESSED: Avoid direct contact with submerged resources.

DESCRIPTION:
Floating pipelines are pipelines supported in the water column or on the water surface over hardbottom communities. The floating mechanism can be designed in a variety of ways and constructed using a number of materials.

APPLICATIONS:
Temporary pipelines for coastal construction.



Damage to a *Montastraea cavernosa* colony from direct contact with a pipeline. Source: PBS&J

OPERATIONAL CRITERIA:
Condition Restriction. Floating pipelines may be constrained by the pipe specifications, duration of operation, vibration, current, wave, wind, and storm activity during operation. Vessel traffic in the waters in which floating pipelines are considered may also affect the viability of the use of floating pipelines. Floating pipelines may be supported by floating pontoons, buoys, or other flotation devices sturdy enough to support the pipelines.

Installation. Placement requires pre-survey and design to minimize resource impacts. The pipeline should be placed high enough above resources to avoid contact. Buoys should be placed to mark the location of the floating pipelines. The areas over which vessels may pass should be marked with buoys. Mariners should be notified of the scheme to mark the floating pipeline and the location of safe passage over the floating pipeline.

Monitoring. Floating pipelines should be visually inspected at least weekly, and preferably two or three times per week, to see that floating mechanisms remain properly attached to the pipeline and to detected leaks. If sand leaks are noted, pumping must cease and the pipe must be repaired prior to resuming production.

Maintenance and Removal. Floating pipelines should be periodically checked to ensure the floating mechanisms remain property attached to the pipeline. An inclement weather plan should be developed. Post-removal surveys should be conducted to confirm whether or not impacts to resources resulted from the presence and operation of the pipeline.

Sand Dike

Best Management Practices
Plate 19

SUMMARY: During a beach nourishment project, dikes are typically employed to assist in sand retention on the beach and reduce turbidity in return water flow.

PURPOSE: To allow time for sand particles to settle out of fluid suspension (slurry) and reduce turbidity of discharge water.

ENVIRONMENTAL ISSUES ADDRESSED: Turbidity and sedimentation impacts
.

DESCRIPTION:
Sand dikes are constructed to align parallel to shore extending some distance ahead of the discharge. Sand slurry is pumped behind the sand dike and the return water runs along the dike before entering the nearshore waters. The sand dike allows a space behind which the discharged slurry flows offering time for sand particles to settle out of suspension. Sand dikes are beneficial not only in the reduction of turbidity in return water, but also in maximizing the amount of sand captured for beach placement. Employment of a sand dike may be dependent on the quality/character of sandy material and ability to control turbidity.

For beach nourishment projects, utilizing a dike during construction is beneficial to the contractor who gets paid based upon the volume of sand placed. For inlet maintenance dredging projects, contractors are paid based on the volume of material removed. If sand from maintenance dredging is to be placed on the beach, use of a sand dike should be specified.

APPLICATIONS:
Beach restoration and nourishment projects.

Sand Dike being constructing during slurry discharge at John U. Lloyd Park in Broward County, FL. Source: FDEP

Sand Dike being constructing during beach nourishment. Source: PBS&J

GPS/GIS Guidance System

Best Management Practices
Plate 20

SUMMARY: Global Positioning Systems (GPS) and Geographic Information Systems (GIS) provide real-time and archive data for a variety of coastal construction activities, including dredging, offloading sediments, and rock cutting/blasting. Both systems are required for operation of hopper dredges and scows in the form of proprietary software from USACE or EPA, depending on which equipment is being used and how it is being used. GPS guided systems can enhance environmental monitoring by providing real-time alarms and archival recording of dredge head position and depth outside of prescribed boundaries.

PURPOSE: To monitor dredge position, cutterhead location, scow position and dredge production status.

ENVIRONMENTAL ISSUES ADDRESSED: Direct contact, threatened and endangered species, sedimentation, turbidity, smothering/burial.

DESCRIPTION: An integrated Global Positioning Systems (GPS) and Geographic Information Systems (GIS) system provides real-time and archived data for a variety of dredge related activities, including dredge head position and dredge production status. Dredge heads or pipelines associated with the dredging project can be positioned precisely in both vertical and horizontal orientation and time on the seafloor. In addition, GPS/GIS guidance systems provide a project record for a multitude of uses including dispute resolution.

APPLICATIONS: Dredging, offloading sediments, placement of rock for artificial reef, rock cutting/blasting.

OPERATIONAL CRITERIA:
Installation and Maintenance: A GPS hardware and software system is installed and maintained on a dredge to perform GPS guided systems function. Currently, the USACE operates a similar system where the USACE maintains the software portion of the system, while the contractor is required to maintain the hardware portion (Silent Inspector). Once these systems are installed they are maintained in an “always on” mode, continuously recording data.

Currently, these systems are placed on hopper dredges and scows. The use of GPS/GIS guided pipeline dredging is currently under development. For hopper dredges, the following data can be recorded: horizontal positioning, ship speed, and heading; draft; displacement; tide level; hopper status (open/closed); hopper volume; draghead depth and position, and material recovery and minimum pump effort.

For pipeline dredges, GPS guidance systems can record the cutterhead’s horizontal and vertical position, the slurry velocity and density, tide level, and dredge heading. Testing for implementation of GPS guided systems for pipeline dredges is currently underway.

GPS guided systems can be used to enhance environmental monitoring by providing real-time alarms and archival recording of dredge head position and depth outside of prescribed boundaries and depths.

USACE Hopper Dredge *Wheeler*. Source: USACE

GIS data layers in the SEFCRI region.
Source: SEFCRI: http://ocean.floridamarine.org/sefcri

Dredge Operational Controls

Best Management Practices
Plate 21

SUMMARY: Dredge operational controls can be used to aid in the minimization and avoidance of adverse impacts to resources, particularly as it relates to controlling impacts due to turbidity and sedimentation and maximizing the transport of material.

PURPOSE: To minimize turbidity and sedimentation impacts while maximizing sediment transport.

ENVIRONMENTAL ISSUES ADDRESSED: Turbidity and sedimentation.

DESCRIPTION:
Turbidity levels around dredging operations can be reduced by managing the operations systems. Dredge operational controls can be used to minimize turbidity and sedimentation impacts.

Hopper Dredges and Barges Operational Controls
There are three controls possible with Hopper dredges and barges (USACE 2001)

Eliminate or reduce hopper overflow. Eliminating or reducing hopper overflow reduces the volume of fine material which flows from the hopper in the overflow. One caution is that this control may significantly reduce project production for hopper dredges or when hydraulic dredging into a barge.

Lower hopper fill level. Lowering the hopper fill level in rough sea conditions can prevent material loss during transport.

Re-circulation system. Water from the hopper overflow can be re-circulated to the draghead and is used to transport more material into the hopper. Further research and development is required to enable implementation of recirculation systems.

Hydraulic Dredge Operational Controls
There are three fundamental controls possible with hydraulic dredges (USACE 2001):

Reduce cutterhead rotation speed. Reducing cutterhead rotation speed reduces the potential for side casting the excavated sediment away from the suction entrance and re-suspending sediment. This measure is typically effective only on maintenance or relatively loose, fine grain sediment.

Reduce swing speed. Reducing the swing speed ensures that the dredge head does not move through the cut faster than it can hydraulically pump the sediment. Reducing swing speed reduces the volume of re-suspended sediment. The goal is to swing the dredge head at a speed that allows as much of the disturbed sediment as possible to be removed with the hydraulic flow. Typical swing speeds are 5-30 feet/minute.

Eliminate bank undercutting. Dredgers should remove the sediment in maximum lifts equal to 80% or less of the cutterhead diameter.

Mechanical Dredge Operational Controls
There are three fundamental controls possible with mechanical dredges (USACE 2001):

Increase cycle time. Longer cycle time reduces the velocity of the ascending loaded bucket through the water column, which reduces potential to wash sediment from the bucket. However, limiting the velocity of the descending bucket reduces the volume of sediment that is picked up and requires more total bites to remove the project material. The majority of the sediment resuspension, for a clamshell dredge, occurs when the bucket hits the bottom.

Eliminate multiple bites. When the clamshell bucket hits the bottom, an impact wave of suspended sediment travels along the bottom away from the dredge bucket. When the clamshell bucket takes multiple bites, the bucket loses sediment as it is reopened for subsequent bites. Sediment is also released higher in the water column, as the bucket is raised, opened, and lowered.

Eliminate bottom stockpiling. Bottom stockpiling of the dredged sediment in silty sediment has a similar effect as multiple bite dredging; an increased volume of sediment is released into the water column from the operation.

APPLICATIONS: Dredging projects.

Cofferdam/Sheet Piling

Best Management Practices
Plate 22

SUMMARY: Cofferdams and sheet piling are temporary structures used to exclude water and/or sediment from an area that is normally submerged. Sheet piling is a temporary, reusable, water tight barrier and the main component in cofferdam construction. These barriers have limited application and may be used in the construction of marine structures in inland waterways and protected harbors. Use of these barriers is not feasible in the coastal and open ocean environment

PURPOSE: To exclude water and/or sediment from an area that is normally submerged and to protect against sediments leaving an area.

ENVIRONMENTAL ISSUES ADDRESSED: Light attenuation, smothering/burial sediment-associated contaminants/nutrients

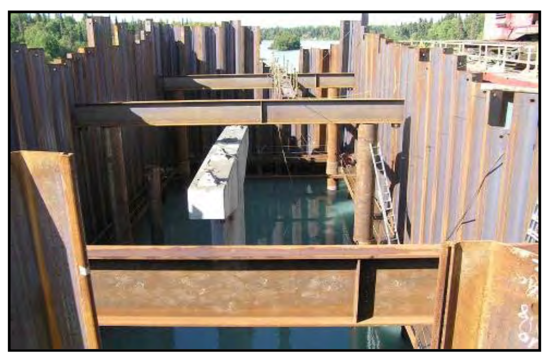
DESCRIPTION:
Sheet Piling is a reusable, water-tight barrier made of steel, vinyl, plastic, wood, recast concrete, or fiberglass. Types of sheet piling include Z type (used for intermediate to deep wall construction), arch shaped/light weight type (used for shallow wall construction), Larson type, and flat/straight type. Interlocks between sheets form tight connections and allow minimum shift.

Cofferdams are temporary barriers commonly made of wood, steel, or concrete sheet piling. A braced cofferdam is primarily used for bridge/pier construction in shallow water. It is constructed from a single wall of sheet piling that is driven into the ground and surrounds the excavation site. The cofferdam is braced on the inside for structural support and dewatered.

Use of either sheet piling or cofferdams in the marine environment should include regularly scheduled inspections for the presence of threatened and endangered species.

APPLICATIONS:
Limited application for the construction of marine structures in protected waters.

Typical Steel Piling
Source: USACE 2005



Internally Supported Cofferdam.
Source: www. Kenairiverbridge.com

OPERATIONAL CRITERIA:
Sheet Piles are costly and less adaptable to hard driving conditions, particularly where irregular rock surfaces occur.

The advantages associated with using c*offerdams* during construction projects include easy installation and removal of the sheet piles, and the potential reuse of materials on future projects. Cofferdam disadvantages include the requirement of special equipment; expensive, time consuming and tedious process; the sheets can be driven out if rushed; and in high current locations, log jams may occur, putting stress on the structure.

Horizontal Directional Drilling

Best Management Practices
Plate 23

SUMMARY: Horizontal Directional Drilling (HDD) is a trenchless method for the installation of underground utilities.

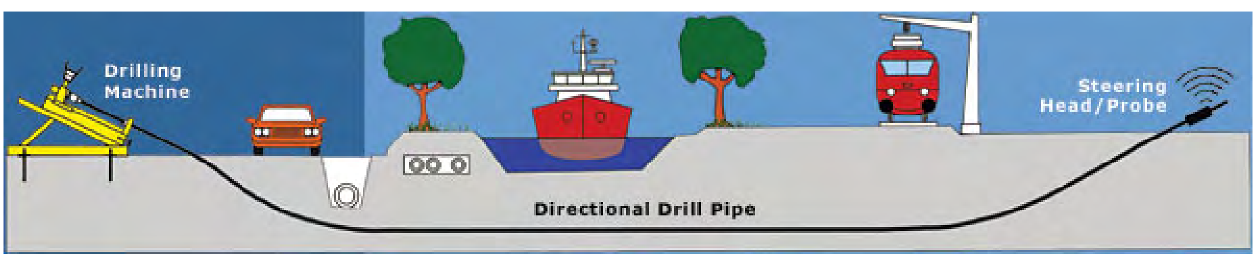
PURPOSE: In coastal construction applications, HDD has been used to install utilities across barrier islands exiting beyond the active surf zone. Additional applications have been considered for the installation of submerged utilities to cross through environmentally sensitive areas in the nearshore.

ENVIRONMENTAL ISSUES ADDRESSED: Frac-outs associated with HDD in the marine environment.

DESCRIPTION:
Horizontal Directional Drilling (HDD) is a trenchless method for installation of underground utilities. A pilot hole is drilled at an angle into the ground and levels off horizontally at a specified depth. Once the proper depth has been reached, the pilot bore is horizontally advanced to a point where it is redirected at an upward angle to exit the ground. Once the drill exits, the drill head is removed and replaced with a back reamer that is also attached to the product to be installed (e.g. conduit, pipe, cable, etc.). The reamer is pulled back through the pilot bore along with the utility. This method is distance and depth limited, depending on the project and location.

A stabilizing/lubricating agent, typically bentonite clay, is used to create a slurry (drill mud) that helps to lubricate the drill and prevent collapse of the bore hole. There is the potential for vertical fractures (Frac-outs) to occur in the substrate during drilling where drilling fluid may leach out of the bore hole. Monitoring borehole pressure can aid in frac-out avoidance (Stauber et al. 2003). Monitoring should be conducted regularly throughout construction drilling to ensure there are no leaks or if leaks are detected they are caught early enough to avoid and/or mitigate for impacts.

APPLICATIONS:
Pipeline, cable, and outfall installation.



Horizontal Directional Drilling Illustration. Source: http://www.perforator.net/hdd.html

OPERATIONAL CRITERIA:
HDD will typically commence from an upland site with the drill reaching depths on the order of 25-30 feet below the surface. The termination point occurs at a predetermined location where a 4.6-m (~15ft) diameter punch-out hole can be excavated without damage to resource (Vince, 2006). Monitoring allows for the recognition of potential fractures and possible losses of the material.

The volume of drill mud in the drill string and the drill pressure should be monitored constantly during drill operation. In submerged applications in the coastal environment, seawater should be used in place of drill mud for the last 9.1-15.2m (~30-50ft) of the directional bore to prevent drill mud from entering the water (Vince, 2006). Free flowing slurry at the upland site during pull back and drilling should be properly contained and disposed of from the upland site.

Manatee Signage/Observer

Best Management Practices
Plate 24

SUMMARY: Manatee observers monitor waterways for manatees during coastal construction projects to prevent manatee injury or mortality. The West Indian manatee is a federally endangered species and all construction personnel must be educated regarding manatee protection. All operations must cease if manatees are observed within ~ 15 meters of construction activities. All efforts are taken to avoid manatee impacts and any manatee injuries/deaths are reported to the FWC and the USFWS.

PURPOSE: To prevent manatee injury, harassment, and mortality during coastal construction operations.

ENVIRONMENTAL ISSUES ADDRESSED: Impacts to manatees.

DESCRIPTION: The West Indian manatee is a federally endangered species. Construction personnel must be educated regarding manatee protection. Manatee observers/spotters are to monitor waterways for manatee presence.

APPLICATIONS:
Dredging and disposal, rock cutting/blasting, coastal construction, vessel operations for coastal construction.

Manatee Caution Sign
Source: FWC

OPERATIONAL CRITERIA: Manatee signage and spotting is important for project operations with the potential presence of manatees in an area, manatee speed zones, or other manatee protection zones designating the need to avoid collisions with manatees. Temporary manatee signs that have been approved by the Florida Fish and Wildlife Conservation Commission (FWC) will be posted prior to project commencement and during project operations in a location visible to construction crews. All on-site personnel are responsible for manatee observation and at least one designated manatee spotter may be required for each vessel. Vessels entering or working within the designated zones must proceed with caution, allowing the manatee spotter sufficient time to look for manatees. If manatees are observed, the captain will be contacted immediately to reduce speed or alter the course. All operations must cease if manatees are observed within 15.2m (~50ft) of the construction activity. Collisions or injuries to manatees must be reported immediately to the FWC Hotline and the United States Fish and Wildlife Service (USFWS). Turbidity barriers used on a project must be constructed of appropriate material to prevent manatee entanglement. The barriers will be properly secured and routinely monitored for manatee entrapment. Turbidity barriers will not impede manatee movement or block manatee transit to/from an essential habitat (FWC, 2005; FDEP, 2006).

During rock cutting/blasting projects, an effective watch program is to be employed to monitor the presence of manatees. Detonation is always delayed until all manatees are outside of the impact area. The safety radius to determine the minimum impact area is calculated based on the size of the explosive charge. Blasting operations must cease if manatees are observed within this safety zone. Prior to and during blasting activities, a minimum of four manatee observers/spotters are positioned on boats, bridges, or land. Manatee spotting begins at least one hour before the first scheduled blast and continues until at least 30 minutes after all detonations are complete. A continuous aerial survey will be conducted during the same time period. Any manatee injuries/deaths must be reported immediately to the FWC Hotline (1-888-404-FWCC) and the USFWS (FWS 2004).

Turtle Deflectors

Best Management Practices
Plate 25

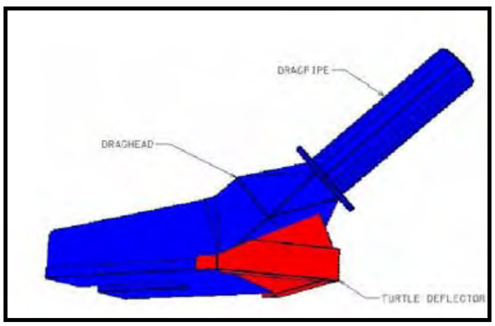
SUMMARY: Turtle deflectors are installed on hopper dredges to deflect sea turtles away from the draghead during dredging activities. These devices are required during all hopper dredge activities and are only successful when the dredge is completely engaged with the seafloor. Appropriate instrumentation, including baskets or screens, are installed with the deflector to ensure that the appropriate approach angle is used at all times. Screens are constantly monitored for turtles, turtle parts, or damage.

PURPOSE: To prevent sea turtle mortality by deflecting sea turtles in or near the path of the draghead during dredging activities.

ENVIRONMENTAL ISSUES ADDRESSED: Impacts to sea turtles.

DESCRIPTION:
A turtle deflector is a rigid adjustable attachment installed on the hopper dredge draghead that deflects any sea turtles that may be in or near the path of the draghead during dredging activities.

APPLICATIONS:
Dredging activities that involve hopper dredges.



Hopper dredge draghead (blue) with attached turtle deflector (red). Source: USACE 2003

Photo of a turtle deflector attached to a hopper dredge draghead. Source: USACE 2003

OPERATIONAL CRITERIA:
The deflector is usually V-shaped with an included angle of less than 90 degrees and internal reinforcement to prevent structural failure of the device. The leading edge of the deflector is designed to have a plowing effect of $\geq$ 0.15m (~6.0in) depth when the draghead is in operation. The openings of the hopper inflow will have baskets or screens installed with less than 0.1m x 0.1m (~4.0in x 4.0in) openings. This will provide 100% screening of the hopper inflow(s) and will remain in place throughout the dredging operations. Floodlights will be installed for illumination of the baskets or screening to allow the observer to monitor for turtles, turtle parts, or damage at night or during low-light conditions. Appropriate instrumentation will be installed on the drag head to ensure that the appropriate approach angle is being used. For more detailed information on specifications for turtle deflectors, see http://www.saj.usace.army.mil/pd/turtle.htm.

Turtle deflectors are required during all hopper dredge activities and are only successful when the draghead is completely engaged with the seafloor. When it is necessary to move the draghead off of the seafloor operators must decrease the flow velocity in the draghead, to avoid sucking up turtles and before clearing the dredge material from the dragheads, pipes and dredge pumps the draghead should be at or above keel depth to avoid impacting turtles in the water column (Biological Opinion NMFS 1997).

Turtle Trawling

Best Management Practices
Plate 26

SUMMARY: Turtle trawling is a mitigation technique utilized in association with hopper dredge projects to minimize turtle takes by hopper dredges.

PURPOSE: To minimize turtle takes by trawling for turtles before and during dredging projects.

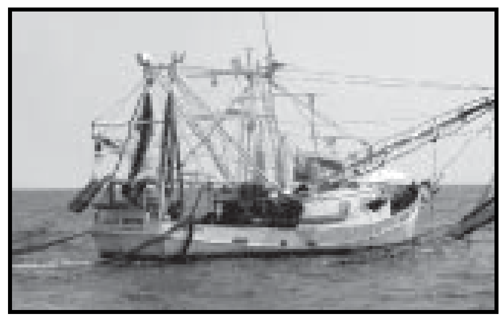
ENVIRONMENTAL ISSUES ADDRESSED: Impacts to sea turtles.

DESCRIPTION:
Turtle trawling is a mitigation technique for hopper dredging projects to reduce the likelihood of turtle takes. Trawling should only be employed within the borrow area and never in hardbottom areas (NMFS 2003).

Relocation trawling is performed to collect and relocate turtles away from a dredging operation. The relocation trawler trawls continuously as close to the vicinity of the dredge as safe vessel operations allow. Captured turtles are identified, measured, photographed, genetically sampled, scanned for overall health, tagged, and released 4.8-8.0km (~3.0-5.0mi) from the project site (Bargo et al. 2005).

APPLICATIONS:
Dredging activities, to date not used in the SEFCRI region.

A 110 lb loggerhead turtle being relocated, onboard a trawler. Source: USACE 2003



Shrimp boats (with special nets) trawl in front of hopper dredges, relocating sea turtles to a safer location. Source: USACE 2003

OPERATIONAL CRITERIA:
Trawlers will tow two 18.3m (~60ft) trawl nets constructed in accordance with the USACE net specifications in the vicinity of the dredge. Tow time is limited to 30-40 minute intervals to prevent turtle drowning, and trawling will occur on a 12 or 24-hour schedule (Bargo et al. 2005). The nets are designed with a 0.2m (~8.0in) mesh which allows most bycatch to pass through. Personnel required for 24-hour trawling projects include two qualified vessel operators limited to 12 hrs/day, 2-3 deckhands, one trawl supervisor from the National Marine Fisheries Service (NMFS), and one observer approved by NMFS. It is important for turtles to be relocated in similar habitat and depth.

Trawlers used as part of a dredging operation are required to be as seaworthy as the dredge itself so that they can trawl during the dredging operation, otherwise dredging operations must cease if the trawler is not functional.

Rarely, relocation trawling may result in turtle mortality from drowning or direct trauma. The equipment required to spread the trawl nets underwater (trawl doors) is heavy and moves through the water with great force. Other problems associated with relocation trawling include: 1) trawl nets bogged down by trenches or ditches created by dredging activities, creating a safety hazard for trawling vessels; 2) operation schedules disrupted because trawling vessels must yield to larger inbound/outbound ships; 3) debris collected in trawl nets must be removed before the next trawling period; and 4) debris can destroy expensive trawling nets.

Floating Tow Lines

Best Management Practices
Plate 27

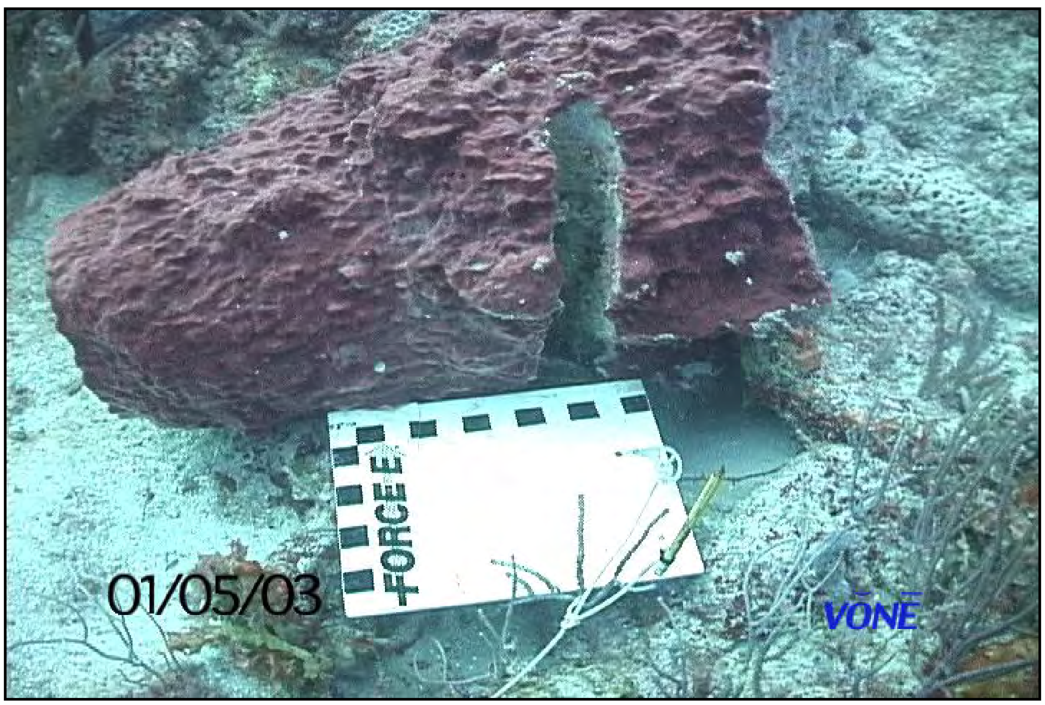
SUMMARY: Floating tow lines are used to tow other vessels or equipment during coastal construction activities.

PURPOSE: To insure that excess line or line that goes slack does not fall to seafloor over sensitive resources.

ENVIRONMENTAL ISSUES ADDRESSED: Direct impacts to hardbottom/coral communities and other benthic resources.

DESCRIPTION:
Tow lines are necessary equipment for ships and dredges. They are used to tow other vessels or equipment. They also include buoy lines and anchor lines. Lines may be floated by securing floats to the line or by using line material which does not sink.

APPLICATIONS:
Any vessel operation using tow lines in the vicinity of sensitive marine resources.



Damage to a sponge as a result of steel towlines that dragged across reef resources during the dredging of the Hillsboro Inlet in Broward County, FL. Source: Vone Research

OPERATIONAL CONDITIONS:
Tow lines may be made of steel or synthetic fibers such as nylon or polypropelene. All lines are manufactured with a breaking strength. Certain lines are made of a material that floats. Polypropelene line floats and as such if the line breaks, it will not sink to or be dragged along the seafloor.

9.0 Additional Readings and Other Sources of Information

Related BMP Documents

Environmental and Aesthetic Impacts of Small Docks and Piers
http://www.nccos.noaa.gov/documents/dockpier.pdf

Preparation of Vessels for Artificial Reefs
http://www.epa.gov/owow/oceans/habitat/artificialreefs/documents/0605finalreefguidance.pdf

Guideline for Marine Artificial Reef Material, Second Edition
http://www.gsmfc.org/pubs/SFRP/Guidelines_for_Marine_Artificial_Reef_Materials_January_2004.pdf

BMPs for Southeast Florida Urban Stormwater Management Systems
https://my.sfwmd.gov/pls/portal/docs/PAGE/PG_GRP_SFWMD_ENVIROREG/PORTLET_REGUIDANCE/TAB383509/BMP_MANUAL.PDF

Office of Agricultural Water Policy BMP forms, documents and manuals
http://www.floridaagwaterpolicy.com/BestManagementPractices.html

NOAA National Artificial Reef Plan
http://www.nmfs.noaa.gov/sfa/PartnershipsCommunications/recfish/NARPREVISION_3_07_07_FINAL.pdf

USACE Silent Inspector
http://si.usace.army.mil/

BMPs for Dock Construction
http://www.saj.usace.army.mil/regulatory/what/species/dockGuide.htm

National Marine Fisheries Service Dock & Pier Guidelines
http://sero.nmfs.noaa.gov/dhc/habitat/pnc/dockhome.htm

Florida Department of Environmental Protection Office of Coastal and Aquatic Managed Areas
http://www.dep.state.fl.us/coastal/

Southeast Florida Coral Reef Initiative
http://www.southeastfloridareefs.net/

SEFCRI Counties

Martin County
http://www.martin.fl.us/

Palm Beach County
http://www.co.palm-beach.fl.us/

Broward County
http://www.broward.org/

Miami-Dade County
http://miamidade.gov/

Florida Department of Environmental Protection Bureau of Beaches and Coastal Systems

FDEP Erosion Control Program
http://www.dep.state.fl.us/beaches/programs/bcherosn.htm

FDEP Strategic Beach Management Plan
http://www.dep.state.fl.us/beaches/publications/gen-pub.htm#Strategic_Management_Plan

FDEP Inlet Management Plans http://www.dep.state.fl.us/beaches/publications/gen-pub.htm#Inlet_Management

FDEP Workshop on Innovative Shore Protection Technology
http://www.dep.state.fl.us/beaches/workshop.htm

FDEP Critical Erosion Report
http://bcs.dep.state.fl.us/reports/crit_ero.pdf

FDEP Report to the Governor's Coastal High Hazard Study Committee on Chapter 161, Florida Statutes
http://bcs.dep.state.fl.us/news/dep_rpt.pdf

Publications on coastal dune vegetation and protection
http://www.dep.state.fl.us/beaches/publications/gen-pub.htm#Coastal_Vegetation

Assessment of alternative design template for beach nourishment (turtle friendly design)
http://www.dep.state.fl.us/beaches/publications/gen-pub.htm#Turtle_Friendly_Alternative_Construction

Florida Department of Environmental Protection Environmental Resource Permitting

Environmental Resource Permitting Program
http://www.dep.state.fl.us/water/wetlands/erp/index.htm

ERP State Programmatic General Permit
http://www.dep.state.fl.us/water/wetlands/erp/spgp.htm

Florida Administrative Code (F.A.C.)

Biscayne Bay Aquatic Preserve – Chapter 18-18 F.A.C.
https://www.flrules.org/gateway/ChapterHome.asp?Chapter=18-18

Florida Aquatic Preserves – Chapter 18-20 F.A.C.
https://www.flrules.org/gateway/ChapterHome.asp?Chapter=18-20

Sovereignty Submerged Lands Management – Chapter 18-21 F.A.C.
https://www.flrules.org/gateway/ChapterHome.asp?Chapter=18-21

Coastal Construction – Chapter 62B-41 F.A.C.
https://www.flrules.org/gateway/ChapterHome.asp?Chapter=62B-41

Joint Coastal Permitting and Concurrent Processing of Proprietary Authorization – Chapter 62B-49 F.A.C.
https://www.flrules.org/gateway/ChapterHome.asp?Chapter=62B-49

FDEP Permits – Chapter 62-4 F.A.C.
https://www.flrules.org/gateway/ChapterHome.asp?Chapter=62-4

FDEP Delegations – Chapter 62-113 F.A.C.
https://www.flrules.org/gateway/ChapterHome.asp?Chapter=62-113

Surface Waters of the State – Chapter 62-301 F.A.C.
https://www.flrules.org/gateway/ChapterHome.asp?Chapter=62-301

Surface Water Quality Standards – Chapter 62-302 F.A.C.
https://www.flrules.org/gateway/ChapterHome.asp?Chapter=62-302

Environmental Resource Permitting – Chapter 62-330 F.A.C.
https://www.flrules.org/gateway/ChapterHome.asp?Chapter=62-330

Delineation of Landward Extent of Wetland and Surface Waters – Chapter 62-340 F.A.C.
https://www.flrules.org/gateway/ChapterHome.asp?Chapter=62-340

Notice General Environmental Resource Permits – Chapter 62-341 F.A.C.
https://www.flrules.org/gateway/ChapterHome.asp?Chapter=62-341

Mitigation Banks – Chapter 62-342 F.A.C.
https://www.flrules.org/gateway/ChapterHome.asp?Chapter=62-342

ERP Procedures – Chapter 62-343 F.A.C.
https://www.flrules.org/gateway/ChapterHome.asp?Chapter=62-343

Delegation of ERP Program to Local Governments – Chapter 62-344 F.A.C.
https://www.flrules.org/gateway/ChapterHome.asp?Chapter=62-344

Uniform Wetland Mitigation Assessment Method (UMAM) – Chapter 62-345 F.A.C.
https://www.flrules.org/gateway/ChapterHome.asp?Chapter=62-345

Florida Statutes (F.S.)

Florida Beach and Shore Preservation – Chapter 161 F.S.
http://www.leg.state.fl.us/Statutes/index.cfm?App_mode=Display_Statute&URL=Ch0161/titl0161.htm&StatuteYear=2003&Title=%2D%3E2003%2D%3EChapter%20161

Coastal Construction - Chapter 161 F.S.
http://www.leg.state.fl.us/Statutes/index.cfm?App_mode=Display_Statute&URL=Ch0161/titl0161.htm&StatuteYear=2004&Title=%2D%3E2004%2D%3EChapter%20161

Sovereign Submerged Lands - Chapter 253 F.S.
http://www.leg.state.fl.us/Statutes/index.cfm?App_mode=Display_Statute&URL=Ch0253/titl0253.htm&StatuteYear=2004&Title=%2D%3E2004%2D%3EChapter%20253

Aquatic Preserves - Chapter 258 F.S.
http://www.leg.state.fl.us/Statutes/index.cfm?App_mode=Display_Statute&URL=Ch0258/titl0258.htm&StatuteYear=2004&Title=%2D%3E2004%2D%3EChapter%20258

Environmental Resource Permitting (ERP) and Wetland Resource Permitting (ERP) – Chapter 373 F.S.
http://www.leg.state.fl.us/Statutes/index.cfm?App_mode=Display_Statute&URL=Ch0373/titl0373.htm&StatuteYear=2004&Title=%2D%3E2004%2D%3EChapter%20373

Atlantic States Marine Fisheries Commission (ASMFC)
Beach Nourishment: *A Review of the Biological and Physical Impacts:*
http://www.asmfc.org/publications/habitat/beachNourishment.pdf

The Florida Fish and Wildlife Conservation Commission
http://myfwc.com/

The Florida Building Code
http://www.floridabuilding.org/

National Environmental Policy Act (NEPA)
http://www.epa.gov/compliance/nepa/index.html
http://ceq.eh.doe.gov/nepa/regs/nepa/nepaeqia.htm

The U.S. Environmental Protection Agency
Clean Water Act, Section 404
http://www.epa.gov/OWOW/wetlands/regs/sec404.html

USACE, Jacksonville District
http://www.saj.usace.army.mil/

The U.S. Fish and Wildlife Service
http://www.fws.gov/southeast/

The Endangered Species Act
http://www.fws.gov/endangered/ESA/content.html

South Atlantic Fishery Management Council

Habitat Plan:
http://www.safmc.net/Default.aspx?tabid=80]

Policies for the Protection and Restoration of Essential Fish Habitats from Beach Dredging and Filling and Large-Scale Coastal Engineering:
http://www.safmc.net/Portals/0/HabitatPolicies/BeachPolicy.pdf

10.0 References

Anthony, K. R. N. 1999. A tank system for studying benthic aquatic organisms at predictable levels of turbidity and sedimentation: Case study examining coral growth. Limnology and Oceanography 44: 1415-1422.

Babcock, R. and P. Davies. 1991. Effects of sedimentation on settlement of *Acropora millepora*. Coral Reefs 9: 205-208.

Bargo, T., J. Glass, T. Fitzpatrick and D. Ouellette. 2005. Sea Turtle Relocation Trawling: Is it Effective? Proceedings of the National Conference on Beach Conservation Technology. Destin, FL.

Bell, P. R. F. 1992. Eutrophication and coral reefs -- some examples in the Great Barrier Reef lagoon. Water Research 26: 553-568.

Bloetscher, F. and S. Gokgoz. 2001. Comparison of water quality parameters from south Florida wastewater treatment plants versus potential receiving waters. Florida Water Resources Journal: 37-45.

Burnett, W. C. and O. A. Schaeffer. 1980. Effect of ocean dumping on 13C/12C ratios in marine sediments from the New York Bight. Estuarine and Coastal Marine Science 11: 605-611.

Christensen, N.L., A.M. Bartuska, J.H. Brown, S. Carpenter, C. D'Antonio, R. Francis, J.F. Franklin, J.A. MacMahon, R.F. Noss, D.J. Parsons, C.H. Peterson, M.G. Turner, and R.G. Woodmansee. The Report of the Ecological Society of America Committee on the Scientific Basis for Ecosystem Management. Ecological Applications 6: 665-691.

Clausen, C. 1971. Effects of temperature on the rate of 45 calcium uptake by *Pocillopora damicornis*. Marine Biology 33: 93-100.

Clausen, C. and A. A. Roth. 1975. Estimation of coral growth-rates from laboratory and 45 calcium incorporation rates. Marine Biology 33: 85-91.

Collier C, R. Dodge, D. Gilliam, K. Gracie, L. Gregg, W. Jaap, M. Mastry, N. Poulos. 2007. Rapid Response and Restoration for Coral Reef Injuries in Southeast Florida: Guidelines and Recommendations Southeast Florida Coral Reef Initiative pp 57. Internet website: http://www.dep.state.fl.us/coastal/programs/coral/reports/MICCI/MICCI_Project2_Guidelines.pdf

Connelly, D., J. Readman, A. Knaps and J. Davies. 2001. Contamination of the coastal waters of Bermuda by organotins and the Triazine herbicide Irgarol 1051. Marine Pollution Bulletin 42: 409-414.

Continental Shelf Associates (CSA) International. 2007. Post-Dredging Resource Impact Assessment Monitoring Survey Final Report for the Key West Harbor Dredging Project. Jupiter, FL. 221 pp.

Cortes, J. and M. J. Risk. 1985. A reef under siltation stress: Cahuita, Costa Rica. Bulletin of Marine Science 36: 339-356.

Dahl, B. and H. Blanck. 1996. Toxic effects of the antifouling agent Irgarol 1051 on periphyton communities in coastal water microcosms. Marine Pollution Bulletin 32: 342-350.

Diaz, R.J., G.R. Cutter Jr., and C.H. Hobbs, III. 2004. Potential impacts of sand mining offshore of Maryland and Delaware: Part 2 – biological considerations. Journal of Coastal Research 20(1): 61-69.

Dillon Consulting Limited. 2005. City of Winnipeg: Best Management Practices Handbook for Activities in and Around the City's Waterways and Watercourses.

Dodge, R. E., R. C. Aller and J. Thomson. 1974. Coral growth related to resuspension of bottom sediments. Nature 247: 574-577.

Dodge, R. E., A. Knap, S. Wyers, H. Frith, T. Sleeter and S. Smith. 1985. The effect of dispersed oil on the calcification rate of the reef-building coral *Diploria strigosa*. Proceedings of the 5th International Coral Reef Congress, 453-457.

Ecosystem Management Research Institute. 2007. What is ecosystem management? Internet website: http://www.emri.org/what_is_ecosystem_management.htm.

Environmental Protection Agency (EPA). 2001. Ocean Outfalls. Internet website: http://www.epa.gov/region4/water/uic/downloads/ra/06-ocean.pdf.

---. 2007a. Environmental Impact Statement (EIS) Database. Internet website: http://www.epa.gov/compliance/nepa/eisdata.html.

---. 2007b. National Environmental Policy Act (NEPA). Internet website: http://www.epa.gov/compliance/nepa/index.html.

Erlingsson, U. In prep. Monitoring sediment pollution. 14pp.

Fabricius, K. E. 2005. Effects of terrestrial runoff on the ecology of corals and coral reefs: review and synthesis. Marine Pollution Bulletin 50: 125-146.

Fabricius, K. E. and E. Wolanski. 2000. Rapid smothering of coral reef organisms by muddy marine snow. Estuarine, Coastal and Shelf Science 50: 115-120.

Finney, B. B. and C. A. Huh. 1989. History of metal pollution in the Southern California Bight: an update. Environmental Science & Technology 23: 294-303.

Flagler Museum. 2006. Florida East Coast Railway (FECR). Internet website: http://flaglermuseum.us/html/fec.html.

Florida Department of Environmental Protection (FDEP). 2004. Southeast Florida Coral Reef Initiative: A Local Action Strategy. Office of Coastal and Aquatic Managed Areas, Miami, Florida. Internet website: http://www.dep.state.fl.us/coastal/programs/coral/documents/2005/SEFCRI_LAS_FINAL_20May05.pdf

---. 2005a. Invasive Marine Algae Alert. Internet website: http://www.dep.state.fl.us/southeast/hottopics/caulerpa/cbrachypusalertbulletin.pdf.

---. 2005b. Report for the Governor's Coastal High Hazard Study on Chapter 161, Florida Statutes. Internet website: http://bcs.dep.state.fl.us/news/dep_rpt.pdf.

---. 2006. Palm Beach Harbor Maintenance Dredging Permit Modification. Internet website: http://bcs.dep.state.fl.us/env-prmt/palm_bch/issued/0216012_Palm_Beach_Harbor/008-EM/Permit%20Modification%20(09-14-06).pdf.

---. 2007. Beaches and Coastal Systems. Internet website: http://www.dep.state.fl.us/beaches/.

Florida Fish and Wildlife Conservation Commission (FWC). 2005. Standard Manatee Conditions for In-Water Work. Internet website: http://myfwc.com/manatee/permits/StandardCondIn-waterWork.pdf.

Florida Seaport Transportation and Economic Development Council (FSTED). 2001. Internet website: http://www.flaports.org/fsted.htm.

Forstner, U. and G. T. W. Wittmann. 1979. Metal Pollution in the Aquatic Environment. Berlin, Springer.

Gilbert, A. and H. Guzman. 2001. Bioindication potential of carbonic anhydrase activity in anenomes and corals. Marine Pollution Bulletin 42: 742-744.

Gilliam, D. S., R. E. Dodge, R. E. Spieler, L. K. B. Jordan and J. A. Monty. 2005. Technical Report EPD 05-02. Marine Biological Monitoring in Broward County Florida: Year 5 Annual Report. Nova Southeastern University. Dania, FL. 92pp.

Gilliam, D. S., R. E. Dodge, R. E. Spieler, L. K. B. Jordan and J. Walczak. 2006. Technical Report EPD 05-XX. Marine Biological Monitoring in Broward County Florida: Year 6 Annual Report. Nova Southeastern University. Dania, FL. 97pp.

Gilliam, D.S., R.E. Dodge, R.E. Spieler, S.T. Thornton and L.K.B. Jordan. 2001. Marine Biological Monitoring in Broward County, Florida: Year 1 Annual Report. Technical Report 01-08. Prepared for the Broward County Board of Commissioners, Broward County Department of Natural Resource Protection, Biological Resources Division. 67 pp.

Gilmour, J. 1999. Experimental investigation into the effects of suspended sediment on fertilization, larval survival and settlement in a scleractinian coral. Marine Biology 135: 451-462.

Goldberg, E. 1986. TBT: An environmental dilemma. Environment ENTVAR 28: 17-20, 42-44.

Goldberg, W. M. 1989. Biological effects of beach restoration in south Florida: the good, the bad, and the ugly. In Proc. 1988 National Conf. Beach Preserv. Technol. FL. Shore and Beach Preserv. Assoc., Tallahassee, FL p. 19-27.

Goreau, T. F. 1959. The ecology of Jamaican Coral Reefs I: Species composition and zonation. Ecology 40: 67-90.

Great Barrier Reef Marine Park Authority (GBRMPA). 2007. Principal water quality influences on Great Barrier Reef ecosystems. Internet website: http://www.gbrmpa.gov.au/corp_site/key_issues/water_quality/principal_influences.html#metals.

Greene, K. 2002. Beach Nourishment: A Review of the Biological and Physical Impacts. Atlantic States Marine Fisheries Commission. Internet website: http://www.asmfc.org/publications/habitat/beachNourishment.pdf

Helms, D. 2007. Natural Resources Conservation Service Brief History. Natural Resources Conservation Service. Internet website: http://www.nrcs.usda.gov/about/history/articles/briefhistory.html

Hodgson, G. 1990. Sediment and the settlement of larvae of the reef coral *Pocillopora damicornis*. Coral Reefs 9: 41-43.

Howard, L. and B. Brown. 1987. Metals in *Pocillopora damicornis* exposed to tin smelter effluent. Marine Pollution Bulletin 18: 451-454.

Huh, C. A., B. P. Finney and J. K. Stull. 1992. Anthropogenic inputs of several heavy metals to nearshore basins off Los Angeles. Progress & Oceanography 30: 335-351.

Hunte, W. and M. Wittenberg. 1992. Effects of eutrophication and sedimentation on juvenile corals. Marine Biology 114: 625-631.

Huntzicker, J. J., S. K. Friedlander and C. I. Davidson. 1975. Material balance for automobile-emitted lead in Los Angeles Basin. Environmental Science Technology 9: 448-457.

International Navigation Association Environmental Commission - EnviCom Working Group 15. 2005. Environmental Aspects of Dredging and Port Construction Around Coral Reefs and Cold Water Hard Bottom Benthic Communities. International Coral Reef Initiative General Meeting, Palau, 2.

Isa, Y. and K. Yamazato. 1984. The distribution of carbonic anhydrase in a staghorn coral *Acropora hebes* (Dana). Galaxea 3: 25-36.

Jokiel, P. L. and S. L. Coles. 1974. Effects of Heated Effluent on Hermatypic Corals at Kahe Point, Oahu. Pacific Science 28: 1-18.

Jones, R. S. and R. H. Randall. 1973. A study of biological impact caused by natural and man-induced changes on a tropical reef. University of Guam Marine Lab., Tech. Rept. No. 7. : 182p.

Klein, H. H. and E. D. Goldberg. 1970. Mercury in the marine environment. Environmental Science Technology 4: 765-768.

Lapointe, B. E. 1997. Nutrient thresholds for bottom-up control of macroalgal blooms on coral reefs in Jamaica and southeast Florida. Limnology and Oceanography 42: 1119-1131.

Lapointe, B. E., W. R. Matzie and M. W. Clark. 1993. Phosphorus inputs and eutrophication on the Florida reef tract. In: Proceedings of the Colloquium on Global Aspects of Coral Reefs: Health, Hazards, History. R. N. Ginsburg: Univ. of Miami. 106-112.

Lapointe, B. E., J. D. O'Connell and G. S. Garret. 1990. Nutrient couplings between on-site sewage disposal systems, groundwaters, and nearshore surface waters of the Florida Keys. Biogeochemistry 10: 289-308.

Loya, Y. 1976. Effects of water turbidity and sedimentation on the community structure of Puerto Rican corals. Bulletin of Marine Science 26: 450-466.

Maguire, R. 1987. Environmental aspects of tributyltin. Applied Organometallic Chemistry 1: 475-498.

Marszalek, D. S. 1981. Impact of dredging on a subtropical reef community, southeast Florida, U.S.A. Proceedings of the Fourth International Coral Reef Symposium, Manila, 147-153.

Miami River Marine Group. 2007. Quality Action Team. Internet website: http://www.miamirivermarinegroup.com/qat97/protection.html.

Murray, C. and D.R. Marmorek**.** 2003. Adaptive Management and Ecological Restoration. *In:* P. Friederici (ed.). Ecological Restoration of Southwestern Ponderosa Pine Forests. Ecological Restoration Institute, Flagstaff, AZ. pp. 417-428.

National Marine Fisheries Service (NMFS). 1997. Regional Biological Opinion for Hopper Dredging of Channels and Beach Nourishment Activities in the Southeastern United States from North Carolina through Florida East Coast. NOAA, NMFS, Southeast Regional Office, Protected Resources Division, St. Petersburg, FL.

National Oceanographic and Atmospheric Administration (NOAA) Coastal Services Center. 2007. Effects of Navigation Channel Construction and Maintenance on Coastal Processes. Internet website: http://www.csc.noaa.gov/beachnourishment/html/geo/channels.htm.

National Oceanographic and Atmospheric Administration (NOAA) and U.S. Coral Reef Task Force. 2002. A National Coral Reef Action Strategy. Internet website: http://www.coris.noaa.gov/activities/actionstrategy/.

Negri, A. and A. Heyward. 2001. Inhibition of coral fertilization and larval metamorphosis by tributyltin and copper. Marine Environmental Research 51: 17-27.

Neudecker, S. 1981. Growth and survival of scleractinian corals exposed to thermal effluents at Guam. Proceedings of the 4th International Coral Reef Symposium, Manila, 173-180.

Nugues, M. M. and C. M. Roberts. 2003. Coral mortality and interaction with algae in relation to sedimentation. Coral Reefs 22: 507-516.

Olafson, R. W. 1978. Effect of agricultural activity on levels of organochlorine pesticides in hard corals, fish and molluscs from the Great Barrier Reef. Marine Environmental Research 1: 87-107.

Ongley, E. D. 1996. Control of water pollution from agriculture. Food and Agriculture Organization of the United Nations 55: 68 pp.

Peluso, V. F. and A. Marshall. 2002. Technical Publication Reg-004: Best Management Practices for South Florida Urban Stormwater Management Systems

Perkins, E. J. 1974. The Biology of Estuaries and Coastal Waters. London, Academic Press Inc.

Peters, E. C., N. J. Gassman, J. C. Firman, R. H. Richmond and E. A. Power. 1997. Ecotoxicology of tropical marine ecosystems. Environmental Toxicology and Chemistry 16: 12-40.

Peters, E. C., P. Meyers, P. Yevich and N. Blake. 1981. Bioaccumulation and histopathological effects of oil on a stony coral. Marine Pollution Bulletin 12: 333-339.

Philipp, E. and K. E. Fabricius. 2003. Photophysiological stress in scleractinian corals in response to short-term sedimentation. Journal of Experimental Biology and Ecology 287: 57-78.

Professional Surveyor Magazine. 2005. High Definition Scanning: Standard Twenty-foot Cross Sections? No problem! Volume 25 Number 9. Internet website: http://www.profsurv.com/archive.php?issue=104&article=1465.

Reichelt-Brushett, A. and P. Harrison. 2000. The effect of copper on the settlement success of larvae from the scleractinian coral *Acropora tenuis*. Marine Pollution Bulletin 41: 385-391.

Reichelt-Brushett, A. and K. Michalek-Wagner. 2005. Effects of copper on the fertilization success of the soft coral *Lobophytum compactum*. Aquatic Toxicology 74: 280-284.

Reichelt-Brushett, A. J. and P. Harrison. 2005. The effect of selected trace metals on the fertilization success of several scleractinian coral species. Coral Reefs 24: 524-534.

Riegl, B. 1995. Effects of sand deposition on scleractinian and alcyonacean corals. Marine Biology 121: 517-526.

Riegl, B. and G. M. Branch. 1995. Effects of sediment on the energy budgets of four scleractinian (Bourne 1900) and five alcyonacean (Lamouroux 1816) corals. Journal of Experimental Biology and Ecology 186: 259-275.

Rogers, C. S. 1990. Responses of coral reefs and reef organisms to sedimentation. Marine Ecology Progress Series 62: 185-202.

South Atlantic Fishery Management Council (SAFMC). 1998 Final habitat plan for the south Atlantic region: essential fish habitat requirements for fishery management plans of the South Atlantic Fishery Management Council. Charleston, South Carolina. 639 p. Internet website: http://www.safmc.net/Default.aspx?tabid=80.

Stafford-Smith, M. G. 1993. Sediment-rejection efficiency of 22 species of Australian scleractinian corals. Marine Biology 115: 229-243.

Stauber, R. M., Bell, J., Bennett, R. D. 2003. A Rational Method for Evaluating the Risk of Hydraulic Fracturing in Soil During Horizontal Directional Drilling. Proceedings of North American Society of Trenchless Technology and International Society of Trenchless Technology International Conference (a.k.a. NoDig 2003), Las Vegas, Nevada, March 31, 2003.

Tambutte, E., D. Allemand, E. Mueller and J. Jaubert. 1996. A compartmental approach to the mechanism of calcification in hermatypic corals. Journal of Experimental Biology and Ecology 199: 1029-1041.

Telesnicki, G. J. and W. M. Goldberg. 1995a. Effects of turbidity on the photosynthesis and respiration of two south Florida reef coral species. Bulletin of Marine Science 57: 527-539.

---. 1995b. Comparison of turbidity measurement by nephelometry and transmissiometry and its relevance to water quality standards. Bulletin of Marine Science 57(2): 540-547.

Tenix LADS Corporation. 2007. Internet website: http://www.tenix.com/Main.asp?ID=30.

Trnka, M., K. Logan and P. Krauss. 2006. Land-based Sources of Pollution: Local Action Stategy Combined Projects 1&2.

United Nations Environment Programme (UNEP). 1999. Inventory of information sources on chemicals: Persistent organic pollutants.

United States Army Corps of Engineers (USACE). 1989. Engineering and Design: Environmental Engineering for Coastal Shore Protection. EM 1110-2-1204.

---. 1995. Design of Coastal Revetments, Seawalls and Bulkheads. EM 1110-2-1614.

---. 2001. Long Term Management Strategy for the Placement of Dredged Material in the San Francisco Bay Region: Management Plan 2001.

---. 2002. Coastal Engineering Manual. EM 1110-2-1100.

---. 2005. Silt Curtains as a Dredging Project Management Practice. Technical Note ERDC TN-DOER-E21.

---. 2007. Silent Inspector Primer, A Guide for the Implementation of the Silent Inspector Version 1. Internet website: http://si.usace.army.mil/.

United States Coral Reef Task Force (USCRTF). 2000. The National Action Plan to Conserve Coral Reefs. Washington D.C. 41pp.

United States Fish and Wildlife Service (USFWS). 2004a. Draft Interagency Manatee Task Force protocols. Internet website: http://www.fws.gov/verobeach/CERP/AppendixD-Manatee_Task_Force_documents.pdf.

---. 2004b. Investigations of Mitigation for Coral Reef Impacts in the U.S. Atlantic: South Florida and the Caribbean Final Report. 97 pages. Internet website: www.southeast.fws.gov/es

United States Geological Survey (USGS). 2007. Turbidity. Internet website: http://water.usgs.gov/owq/FieldManual/Chapter6/6.7_contents.html

Vargas-Ángel B, Halter H, Hodel E, Riegl B, Dodge RE, Gilliam DS, Fisher L (2005) A histopathological index as an indicator for sedimentation stress on scleractinian corals. Proc. 10th Int. Coral Reef Symp Okinawa, Japan June 28-July 2, 2004

Victor, S. and R. Richmond. 2005. Effect of copper on fertilization success in the reef coral *Acropora surculosa*. Marine Pollution Bulletin. 50: 1433-1456.

Vince, G. A. 2006. Means of Avoidance and Minimization of Coral Reef Impacts During Offshore Coastal Construction Projects. FDEP PowerPoint Presentation, presented May 25, 2006 at the Southeast Florida Coral Reef Initiative's Workshop on the study to identify innovative technologies, construction practices and procedures that minimize or eliminate coral reef impacts.

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

Weston Solutions Inc. 2007. Miami River Maintenance Dredging, Miami FL. Internet website: http://www.westonsolutions.com/projects/project_miamiriver.htm.

Yentsch, C. S., C. M. Yentsch, J. J. Cullen, B. Lapointe, D. A. Phinney and S. W. Yentsch. 2002. Sunlight and water transparency: Cornerstones in coral research. Journal of Experimental Biology and Ecology 268: 171-183.

Zdanowicz, V., S. L. Cunneff and T. W. Finneran. 1995. Reductions in sediment metal contamination in the New York Bight Apex with the cessation of sewage sludge dumping. NOAA Technical Report NMFS 124.

Zdanowicz, V., S. Leftwich, T. Finneran and E. Leimburg. 1991. Sediment trace metals. NOAA Technical Memorandum NMFSF/NEC-82.

Appendix 1 - Stakeholders

SEFCRI PARTNERS

- Biscayne National Park
- Broward County Audubon Society
- Broward County Environmental Protection Department
- Broward County Extension Education/University of Florida IFAS
- CCI Consulting Engineers Inc.
- Coastal Planning and Engineering Inc.
- Coastal Systems International
- College of Charleston
- Cry of the Water
- Environmental Defense
- Florida Department of Environmental Protection
- Florida Fish and Wildlife Conservation Commission
- Florida Keys National Marine Sanctuary
- Florida International University
- Florida Outdoor Writers Association
- Florida Sea Grant
- Florida Sportsman Magazine
- Greater Fort Lauderdale Diving Association
- Harbor Branch Oceanographic Institute
- International Game Fish Association
- Lighthouse Point Saltwater Sportsman Association
- Marine Industries Association of Florida
- Martin County
- Miami-Dade County Environmental Resources Management
- McMaster University
- National Coral Reef Institute at Nova Southeastern University
- National Oceanic & Atmospheric Administration
- Ocean Engineering
- Ocean Watch Foundation
- Palm Beach County Department of Environmental Resources Management
- PADI Project Aware
- Port Everglades
- Port of Miami
- Port of Palm Beach
- Smithsonian Institute Marine Station
- South Florida Diving Headquarters
- South Florida Water Management District
- Tetra Tech
- The Nature Conservancy
- The Ocean Conservancy
- Tropical Audubon Society
- University of Georgia
- University of Miami
- University of North Carolina, Wilmington
- University of South Florida
- U.S. Army Corps of Engineers
- U.S. Coast Guard/Marine Safety Office
- U.S. Department of Agriculture/Natural Resources Conservation Service
- U.S. Environmental Protection Agency
- U.S. Geological Survey
- Vone Research

COASTAL ENGINEERING FIRMS

Applied Technology & Management
400 S. Australian Avenue, Suite 855
West Palm Beach, FL 33401-5045
Phone: (561) 659-0041
Fax: (561) 659-3733
Contact: Michael Jenkins, P.E.
mjenkins@appliedtm.com

Charles C. Isiminger and Stubbs Engineering, Inc.
P.O. Box 14702
North Palm Beach, Fl 33408
Phone: (561) 881-0003
Fax: (561) 881-8123
Contact: Darwin Stubbs
darwins@fdn.com

Coast & Harbor Engineering
745 US Hwy One, Suite 204
North Palm Beach, FL 33408
Phone: (561) 863-0514
Fax: (561) 828-5877
Contact: Scott Hicks
scotthicks@coastharboreng.com

Coastal Planning & Engineering, Inc.
2481 N.W. Boca Raton Blvd.
Boca Raton, FL 33431
Phone: (561) 391-8102
Fax: (561)391-9116
Contact: Tom Campbell, P.E., President
tcampbell@coastalplanning.net

Coastal Engineering Consultants, Inc.
3106 South Horseshoe Drive
Naples, Florida 34104
Phone: (239) 643-2324
Fax: (239) 643-1143
Contact: Michael Stephen, Ph.D., P.G.
mstephen@cecifl.com

Coastal Systems International, Inc.
464 South Dixie Highway
Coral Gables, Florida 33146
United States
Phone: (305) 661-3655
Fax: (305) 661-1914
Contact: Timothy Blankenship, P.E.
tblankenship@coastalsystemsint.com

Coastal Technology Corporation
3625 20th Street
Vero Beach, FL 32960
Phone: (772) 562-8580
Fax: (772) 562-8432
Contact: Michael Walther, P.E.
mwalther@coastaltechcorp.com

Cunningham & Durrance Consulting Engineers
400 Executive Center Drive Suite 108
West Palm Beach, FL 33401
Phone: (561) 689-5455
Fax: (561) 640-7815
Contact: Dallas H. Durrance P.E.
cdconeng@aol.com

Emerald Ocean Engineering, LLC
107 Ariola Drive.
Pensacola Beach, FL 32561
Phone: (850) 932-9111
Contact: David McGhee
bigwave@emeraldoe.com

Erickson Consulting Engineers, Inc.
7201 Delainey Court
Sarasota, Florida 34240
Phone: (941) 373-6460
Fax: (941) 373-6480
Contact: Karyn Erickson, P.E., President
karyn@ericksonconsultingengineers.com
http://www.ericksonconsultingengineers.com/

Gahagan & Bryant Associates, Inc.
3802 West Bay to Bay Boulevard
Suite B-22
Tampa, FL 33629-6826
Phone: (813) 831-4408
Fax: (813) 831-4216
Contact: Clay Bryant
cmbryant@gba-inc.com

HPA, Inc.
4010 Boy Scout Boulevard, Suite 580
Tampa, FL 33607
Phone:(813) 876-6800
Fax:(813) 876-6700
Contact: Todd Stockberger
tstockberger@hpa.com

Humiston & Moore Engineers
805 East Hillsboro, # 103
Deerfield Beach, FL 33441
Phone: (954) 428-2550
Fax: (954) 428-4733
Contact: Ken Humiston
kh@humistonandmoore.com

Moffat and Nichol
1025 Greenwood Blvd, Suite 371
Lake Mary, FL 32746
Phone: (407) 562-2030
Fax: (407) 562-2031
Contact: James N. Marino (Vice President)
jmarino@moffatnichol.com

MRD Associates, Inc.
543 Harbor Blvd., Suite 204
Destin, FL 32541
Phone: (850) 654-1555
Fax: (850) 654-3918
Contact: Michael Dombrowski, P.E.
m.dombrowski@mrd-associates.com

Olsen Associates, Inc.
4438 Herschel Street
Jacksonville, FL 32210
Phone: (904) 387-6114
Fax: (904) 384-7368
Contact: Erik J. Olsen, P.E., President
eolsen@olsen-associates.com

Taylor Engineering, Inc.
1665 Palm Beach Lakes Blvd., Suite 803
West Palm Beach, Florida 33401
Phone: (561) 640-7310
Fax: (561) 640-7805
Contact: Ken Craig (Director)
kcraig@taylorengineering.com

COASTAL CONSULTING FIRMS

Coastal Eco-Group
808 East Las Olas Blvd
Fort Lauderdale Fl 33301
Phone: (954) 591-1219
Fax: (954) 358-2441
Contact: Cheryl Miller
cmiller@coastaleco-group.com
http://www.coastaleco-group.com

Continental Shelf Associates
759 Parkway
Jupiter, FL , 33477-4505
Phone: (561) 746-7946
Fax: (561) 747-2954
Contact: Kevin Peterson (President & CEO)
csa@conshelf.com
http://www.conshelf.com

Dial Cordy
490 Osceola Avenue
Jacksonville Beach, FL 32250
Phone: (904) 241-8821
Fax: (904) 241-8885
Contact: Steve Dial, President
sdial@dialcordy.com
http://www.dialcordy.com/

Ecological Associates, Inc.
Post Office Box 405
Jensen Beach, Florida 34958-0405
Phone: (772) 334-3729
Fax: (772) 334-4925
Contact: Robert G. Ernest, President
bob_ernest@bellsouth.net
http://ecological-associates.com/index.html

Sandra Walters Consulting
6410 Fifth Street , Suite 3
Key West, FL 33040
Miami, FL 33179
Phone: (305) 294-1238
Fax: (305) 651-5732
Contact: Sandra Walters, Principal
sandy@swcinc.net
http://www.swcinc.net/index.html

Seabyte, Inc.
P.O. Box 14069
Bradenton, FL 34209
Phone: (941) 798-9500
Contact: Dick Shaul, President
seabyte@att.net

Tetra Tech
759 S. Federal Hwy, Suite 100
Stuart, FL 34994
Phone: (772) 781-3400
Contact: Lisa Canty
Lisa.canty@tteci.com
Contact: Annette Carter
annette.carter@tteci.com
http://www.tetratech.com/

DREDGING/MARINE CONTRACTORS

Associated Builders and Contractors of Florida, Inc.
Florida East Coast Chapter
(Brevard to Key West)
3730 Coconut Creek Parkway, Suite 200
Coconut Creek, Florida 33066
Phone: (954) 984.0075
Fax: (954) 984.4905
Contact: Dan Shaw - President & CEO
dshaw@abceastflorida.com
www.abceastflorida.com
http://www.abcflorida.com/

Bean Dredging, L.L.C.
1055 St. Charles Ave.
Suite 500
New Orleans, LA 70130
Phone: (504) 587-8600
http://www.cfbean.com/beandred/defaultcon t.htm

Bellingham Marine
1813 Dennis St
Jacksonville, FL 32204
Phone: (904) 358-3362
Fax: (904) 354-4818
Contact: Mr. Steve Ryder
sryder@bellingham-marine.com
http://www.bellingham-marine.com
Counties we serve: Duval; Statewide

Boca Dock & Seawall
4500 Oak Cir Ste B3
Boca Raton, FL 33431-4212
Phone: (561) 750-4255
Fax: (561) 750-4201
Contact: Mr. Ken Wells
kengatorw@aol.com
http://www.bocadockandseawall.com/
Counties we serve: Palm Beach, Broward

Construction Technology, Inc.
POB 16576
West Palm Beach, FL 33416-6576
Phone: (561) 683-7495
Fax: (561) 683-7522
Contact: Mr. Scott Groomes
contech@bellsouth.net
Counties we serve: Palm Beach

Coral Marine Construction
10610 7th Avenue Gulf
Marathon, FL 33050
Phone: (305) 743-0907
Fax: (305) 743-0900
Contact: Mr George Steinmetz
FWCCCPT@aol.com
http://www.coralmarineconstruction.com
Counties we serve: Monroe

Custom Built Marine
PO Box 3016
Stuart, FL 34995
Phone: (772) 288-4254
Fax: (772) 288-2802
Contact: Mr. David Corrigan Sr
cbmarine@bellsouth.net
Counties we serve: Martin

Dolphin Marine Construction, Inc.
312 Hibiscus St
Jupiter, FL 33458
Phone: (561) 746-4963
Fax: (561) 746-0218
Contact: Mr Tim Wehage
jaw708@aol.com
Counties we serve: Palm Beach, Martin

Dredging Contractors of America
503 D Street, NW - Suite 150
Washington, DC 20001
Phone: (202) 737-2674
Fax: (202) 737-2677
Contact: Mr. Barry Holiday
barryholiday@dredgingcontractors.org

Florida Marine Contractors Association
(FMCA)
PO Box 542111
Merritt Island, FL 32954-2111
Phone: (321) 453-3051
Fax: (321) 406-0579
info@fmca.us
http://fmca.us/

Great Lakes Dock and Dredge
2122 York Road
Oak Brook, IL 02523
Phone: (630) 574-3000
Fax: (630) 574-2909
Contact: Doug Mackie (President and CEO)
dbmackie@gldd.com
Contact: Bill Hanson
whhanson@gldd.com
http://www.gldd.com

IMCA - The International Marine
Contractors Association
5 Lower Belgrave Street
London
SW1W 0NR
United Kingdom
Phone: +44 (0) 20 7824 5520
Fax: +44 (0) 20 7824 5521
imca@imca-int.com
http://www.imca-int.com/

Key's Grading & Paving Inc.
POB 504316
Marathon, FL 33050
Phone: (305) 289-9393
Fax: (305) 289-9394
Contact: Ms. Vivian Culmer
mdocks@bellsouth.net
Counties we serve: Monroe

Lifetime Dock & Lumber Inc.
24536 Overseas Hwy
Summerland Key, FL 33042
Phone: (305) 745-2840
Fax: (305) 745-9111
Contact: Mr. Murray Shatt
lifetime@bellsouth.net
Counties we serve: Monroe

Lucas Marine Division
3130 SE Slater St
Stuart, FL 34997
Phone: (772) 286-5094
Fax: (772) 286-1139
Contact: Mr Todd Marsteller
tm@LMCLLC.net
http://www.lucasmarine.fdn.com
Counties we serve: All Florida

Manson Dredging
PO Box 24067
Seattle, WA 98124
Phone: (206) 762-0850
Fax: (206) 764-8590
http://www.mansonconstruction.com/

Marathon Seawalls and Docks
POB 504316
Marathon, FL 33050
Phone: (305) 289-9393
Fax: (305) 289-9394
Contact: Ms. Vivian Culmer
mdocks@bellsouth.net
Counties we serve: Monroe

Marine Construction Inc.
2001 Bomar Dr. Ste 3
N. Palm Beach, FL 33408
Phone: (561) 627-1555
Fax: (561) 627-2350
Contact: Mr. Daniel Coston
mcidocks@yahoo.com
Counties we serve: Palm Beach

Marine Engineering & Construction
130 SW 24th Ave
Boynton Beach, FL 33435
Phone: (561) 752-3800
Fax: (561) 752-3880
Contact: Mr Jason Bator
race2091@aol.com
Counties we serve: Palm Beach

Morrison Builders Inc.
2765 S.W. 36th St
Dania Beach, FL 33312
Phone: (954) 583-8500
Fax: (954) 583-4212
Contact: Mr. Michael Morrison
mmorrison@morrisonbuilders.com
Counties we serve: Broward

Muddobbers Inc.
30750 Watson Blvd.
Big Pine Key, FL 33043
Phone: (305) 872-2052
Fax: (305) 872-2924
Contact: Mr. Russell Moore
Counties we serve: Monroe

Palm Beach Marine Construction, Inc.
1410 Forsythe Rd
West Palm Beach, FL 33405
Phone: (561) 588-7690
Fax: (561) 697-3238
Contact: Mr. Javier Quevedo
info@pbmcinc.com
http://www.pbmcinc.com
Counties we serve: Palm Beach, Martin, St. Lucie, Indian River

Perini Marine Construction
10420 159th Court N
Jupiter, FL 33478
Phone: (561) 747-2555
Fax: (561) 575-9553
Contact: Mr Allen Mcmullin
perinimarine@aol.com
Counties we serve: Palm Beach, Martin, Broward

Upper Keys Marine Construction
PO Box 2790
Key Largo, FL 33070
Phone: (305) 853-2644
Fax: (305) 853-2645
Contact: Mr. Johnny Debrule
JTD3UKMC@aol.com
Counties we serve: Monroe

Vogell Marine Inc.
1320 S. Killian Dr.
Lake Park, FL 33403
Phone: (561) 625-9203
Fax: (561) 841-8426
Contact: Mr. Frederick Vogell
vmivip@msn.com
http://www.vogellmarine.com
Counties we serve: Palm Beach

Weeks Marine, Inc.
4 Commerce Drive
Cranford, NJ 07016-3598
Phone: (908) 272-4010
Fax: (908) 272-4740
http://www.weeksmarine.com/

Wilco Construction Inc.
28 N. Causeway Dr - Unit #1
Fort Pierce, FL 34946
Phone: (772) 460-6928
Fax: (772) 460-6929
Contact: Mr. Robert Williams
Counties we serve: St. Lucie

GOVERNMENT AGENCIES

Division of Longshore and Harbor Workers' District Office, Jacksonville
Jacksonville Longshore District Office
Region IV
400 West Bay Street
Suite 63A, Box 25
Jacksonville, Fl 32202
Phone: (904) 357-4788
Contact: Charles Lee, District Director
http://www.dol.gov/esa/contacts/owcp/jac/6lsframe.htm

ERDC Dredging Operations Technical Support Program
3909 Halls Ferry Road
Vicksburg, MS 39180
Phone: (601) 634-3770
Fax: (601) 634-3528
Contact: Dr. Doug Clarke
Douglas.G.Clarke@erdc.usace.army.mil

FDEP Bureau of Beaches & Coastal Systems
3900 Commonwealth Boulevard M.S. 300
Tallahassee, Florida 32399
Phone: (850) 488-7708
Fax: (850) 488-5257
Contact: Michael R. Barnett (Bureau Chief)
Michael.Barnett@dep.state.fl.us
Contact: Jackie Larson
Jackie.Larson@dep.state.fl.us
Contact: Martin Seeling (Environmental Administrator)
Martin.Seeling@dep.state.fl.us
Contact: Dr. Vladimir Kosmynin (Environmental Consultant)
Vladimir.Kosmynin@dep.state.fl.us
Contact: Stephanie Gudeman (ESIII)
Stephanie.Gudeman@dep.state.fl.us
Contact: Paden Woodruff (Environmental Administrator)
Paden.Woodruff@dep.state.fl.us
Contact: Roxane Dow
Roxane.Dow@dep.state.fl.us

FDEP District Office (Southeast)
400 North Congress Avenue,
Suite 200
West Palm Beach, FL 33401
Phone: (561) 681-6600
Fax: (561) 681-6755
Contact: Tim Rach (Acting Director)
Timothy.Rach@dep.state.fl.us

FDEP Office of Coastal & Aquatic Managed Areas
3900 Commonwealth Boulevard, M.S. 235
Tallahassee, Florida 32399
Phone: (850) 245-2094
Fax: (850) 245-2110
Contact: Stephanie Bailenson (Director)
Stephanie.Bailenson@dep.state.fl.us
Coral Reef Conservation Program
Phone: (305) 795-1208
Contact: Chantal Collier (Manager)
Chantal.Collier@dep.state.fl.us
http://www.dep.state.fl.us/coastal/

Florida Keys National Marine Sanctuary
33 East Quay Road
Key West, FL 33040
Phone: (305) 809-4670
Fax: (305) 293-5011
Contact: Dave Score
dave.a.score@noaa.gov
http://floridakeys.noaa.gov/

Florida Inland Navigation District
1314 Marcinski Road
Jupiter, FL 33477-9498
Phone: (561) 627-3386
Fax: (561) 624-6480
Contact: David K. Roach, Executive Director
Email: droach@aicw.org
http://www.aicw.org/

FWC FWRI
100 Eighth Avenue SE
St. Petersburg, FL 33701
Phone: (727) 896-8626
Fax: (727) 823-0166

FWC Tallahassee
620 S. Meridian Street
Tallahassee, FL 32399
Phone: (850) 922-4330
Fax: (850) 921-6988
Contact: Robbin Trindell
Robbin.Trindell@MyFWC.com

NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML)
4301 Rickenbacker Causeway
Miami, FL 33149
Phone: (305) 361.4450
Contact: Dr. John Proni
John.Proni@noaa.gov

NOAA National Centers for Coastal Ocean Science
1305 East-West Highway
Silver Spring, Maryland 20910
Phone: (301) 713-3020
Fax: (301) 713-4353
Contact: Dr. Gary Matlock, Director
https://coastaloceanscience.nos.noaa.gov

NOAA National Marine Fisheries
Habitat Conservation Division
263 13th Avenue South
Saint Petersburg, Florida 33701
Phone: (727) 824-5317

OSHA
Fort Lauderdale Area Office
8040 Peters Road, Building H-100
Fort Lauderdale, Florida 33324
Phone: (954) 424-0242
Fax: (954) 424-3073
http://www.osha.gov/

US Army Corps of Engineers
Jacksonville District
Mail Address:
P.O. Box 4970
Jacksonville, FL 32232-0019
Office Location:
701 San Marco Blvd.
Jacksonville, FL 32207-8175
Phone: (904) 232-2241
Fax: (904) 232-2200
http://www.saj.usace.army.mil/

USGS Coastal and Marine Geology Program
USGS Center for Coastal & Watershed Studies
600 Fourth Street South
St. Petersburg, FL 33701-4846
Phone: (727) 803-8747 ext. 3018
Fax: (727) 803-2032
Contact: Jack Kindinger –
Assoc. Dir. for Science/St. Petersburg - Oceanographer
jkindinger@usgs.gov
http://coastal.er.usgs.gov/

U.S. EPA
Environmental Protection Agency
Atlanta Federal Center
61 Forsyth Street, SW
Atlanta, GA 30303-3104
Phone: (404) 562-9900
Fax: (404) 562-8174
Toll free: (800) 241-1754
http://www.epa.gov/region04/

ENVIRONMENTAL ORGANIZATIONS

Caribbean Conservation Corporation and Sea Turtle Survival League
4424 NW 13th Street, Suite 1-A
Gainesville, FL 32609
Phone: (352) 373-6441
Contact: Gary Appelson
gary@cccturtle.org
www.cccturtle.org

Citizens for Florida's Waterways
PO Box 541712
Merritt Island, FL
32954-1712
Phone: (321) 722-4137
Contact: CFFW Board
info@cffw.org
http://www.cffw.org/

Coastal Conservation Association of Florida
4061 Forrestal Ave, Suite 8
Orlando, FL 32806
P.O. Box 568886
Orlando, FL 32856
Phone: (407) 854-7002
Fax: (407) 854-1766
Contact: Marcia Dunfee
mdunfee@ccaflorida.org
http://www.ccaflorida.org/

Cry of the Water
P.O. Box 8143
Coral Springs, FL 33075
Phone: (954) 753-9737
reefteam2@yahoo.com
http://www.cryofthewater.org/

Palm Beach County Reef Rescue
PO Box 207
Boynton Beach, FL 33425
Phone: (561) 699-8559
Contact: Ed Tichenor, Director
info@reef-rescue.org
http://www.reef-rescue.org/

Standing Watch
Executive Director, Standing Watch
Phone: (239) 825.4247
Contact: Chad Holland
chad.holland@standing-watch.org
http://www.standing-watch.org/

Surfrider Foundation
PO Box 683
Jensen Beach, FL 34957
Local Contact: Ericka D'Avanzo
edavanzo@surfrider.org
Contact: Tom Warnke-Chair P. Bch. Co.
twarnke@bellsouth.net
http://www.surfrider.org/
http://www.surfriderpbc.org/

Vone Research
640 SE 6 Terrace
Pompano Beach, FL 33060
Phone: (954) 249-9195
Contact: Stephen Attis
YAttis@Bellsouth.net
http://voneresearch.org/

COUNTIES

Broward County
Beach Erosion Administrator
Broward County DNRP
1 North University Drive
Plantation, FL 33324
Phone: (954) 519-1265
Fax: (954) 519-1412
Contact: Steve Higgins
shiggins@co.broward.fl.us

Dade County
Special Projects Administrator
Miami-Dade County DERM
33 SW 2nd Avenue, Ste. 1100
Miami, FL 33128
Phone: (305) 372-6850
Fax: (305) 372-6542 Fax
Conatct: Brian Flynn
flynnb@miamidade.gov
www.miamidade.gov\derm

Martin County
County Engineer
2401 SE Monterey Road
Stuart, FL 34996
Phone: (561) 288 5927
Fax: (772) 288-5955
Contact: Kathy Fitzpatrick
kfitzpat@martin.fl.us
www.martin.fl.us/

Palm Beach County
Environmental Program Supervisor
3323 Belvedere Rd, Bldg. 502
West Palm Beach, FL 33406-1548
Phone: (561) 233-2434
Fax: (561) 233-2414
Contact: Daniel Bates
dbates@co.palm-beach.fl.us www.co.palm-beach.fl.us/

MUNICIPALITIES

Deerfield Beach
City Manager
150 N.E. Second Ave.
Deerfield Beach, FL 33441
Phone: (954) 480-4263
Fax: (954) 480-4268
Contact: Mr. Larry R. Deetjen
tere@deerfield-beach.com
www.deerfield-beach.com

Delray Beach
Director of Planning and Zoning
100 NW 1st Avenue
Delray Beach, FL 33444
Phone: (561) 243 7043
Fax: (561) 243-7221
Contact: Mr. Paul Dorling
dorling@mydelraybeach.com
www.mydelraybeach.com

Fort Lauderdale
Redevelopment Services and Marine Facilities Management
100 N. Andrews Avenue
Ft. Lauderdale, FL 33301
Phone: (954) 828-5000
Contact: Mr. Charles Adams, II
cadams@fortlauderdale.gov
www.fortlauderdale.gov

Hallandale Beach
Director of Public Works/Utilities/Eng.
630 N. W. 2nd Street
Hallandale Beach, FL 33009
Phone: (954) 457-1623
Fax: (954) 457-1624
Contact: Ms. Jenny Cheretis
jcheretis@hallandalebeachfl.gov
www.hallandalebeachfl.gov

Hillsboro Beach
1210 Hillsboro Mile
Hillsboro Beach, FL 33062
Contact: The Honorable Howard Sussman
Phone: (954) 427-4011
Fax: (954) 941-1947
bigchuck@chucksussman.com

Hollywood
Office of Planning
P.O. Box 229045
Hollywood, FL 33022-9045
Phone: (954) 921-3471
Fax: (954) 921-3347
Contact: Mr. Jaye Epstein
jepstein@hollywoodfl.org
www.hollywood.fl.org

Juno Beach
340 Ocean Drive
Juno Beach, FL 33408
Phone: (561) 626-1122
Fax: (561) 775-0812
Contact: Ms. Gail Nelson (Town Manager)
gnelson@juno-beach.fl.us
www.juno-beach.fl.us

Jupiter
Dept. of Parks and Recreation
210 Military Trail
Jupiter, FL 33458
Phone: (561) 746-5134
Fax: (561) 745-2559
Contact: Mr. Russell Ruskay (Director)
russr@jupiter.fl.us
www.jupiter.fl.us

Jupiter Island
P.O. Box 7
Hobe Sound, FL 33475
Phone: (772) 545-0100
Fax: (772) 545-0188
Contact: Mr. James R. Spurgeon (Town Manager)
jrstji@attglobal.net

Key Biscayne
85 West McIntyre St.
Key Biscayne, FL 33149
Phone: (305) 365-5514
Fax: (305) 365-8936
Contact: Ms. Jacqueline R. Menendez (Village Manager)
info@vkb.key-biscayne.fl.us
www.keybiscayne.fl.gov

Key West
P.O. Box 1409
Key West, FL 33041
Phone: (305) 296-0232
Fax: (305) 292-8278
Contact: Janet Muccino (Project Development Coordinator)
jmuccino@keywestcity.com
www.keywestcity.com

Manalapan
600 S. Ocean Blvd.
Manalapan, FL 33462
Phone: (561) 585-9477
Fax: (561) 585-9498
Contact: Gregory L. Dunham (Town Manager)
townhall@manalapan.org
www.manalpan.org

Surfside
9293 Harding Ave.
Surfside, FL 33154
Phone: (305) 993-1052
Fax: (305) 993-5097
Contact: Mr. Eduardo Rodriguez
tclerk@town.surfside.fl.us

Miami Beach
Environmental Resources Management
Miami Beach City Hall,
1700 Convention Center Drive
Miami Beach, FL 33139
Phone: (305) 673-7080
Fax: (305) 673-7028
Contact: Jordanna Rubin (Director)
jordannarubin@miami-beach.fl.gov

Ocean Ridge
6450 N. Ocean Blvd.
Ocean Ridge, FL 33435
Phone: (561) 732-2635
Fax: (561) 737-8359
Contact: Bill Mathis (Interim Town Manager)
oceanridgetm@adlephia.net

Palm Beach
P.O. Box 2029
Palm Beach, FL 33480
Phone: (561) 838-5440
Fax: (561) 835-4691
Contact: Sandy Tate (Coastal Management Coordinator)
state@townofpalmbeach.com
www.townofpalmbeach.com

Palm Beach Shores
247 Edwards Lane
Palm Beach Shores, FL 33404
Phone: (561) 844-3457
Fax: (561) 863-1350
Contact: William V. Hayes (Vice Mayor)
pbstwnhall@adelphia.net

Riviera Beach
600 West Blue Heron Blvd.
Riviera Beach, FL 33404
Phone: (561) 845-4090
Fax: (561) 840-3353
Contact: William Wilkins (City Manager)
wewilkin@rivierabch.com
www.rivierabch.com

PORT/INLET AUTHORITIES

Port of Miami
Port of Miami-Dade
Administrative Offices
1015 N. America Way
2nd Floor
Miami, FL 33132
Phone: (305) 347- 4844
Fax: (305) 347-4843
Contact: Bill Johnson (Seaport Director)
bj4@miamidade.gov
http://www.miamidade.gov/portofmiami/

Port Everglades
Port Everglades Administration
1850 Eller Drive
Fort Lauderdale, FL 33316
Phone: (954) 468-3516
Fax: (954) 523-8713
Contact: Phillip C. Allen (Port Director)
http://www.broward.org/port/

Hillsboro Inlet District
901 Hillsboro Mile
Hillsboro Beach, FL 33062
Phone: (954) 785-3926
Contact: Jack Holland (Chairman)
papajacksbc@aol.com

Jupiter Inlet District
400 N. Delaware Blvd.
Jupiter, FL 33458
Phone: (561) 746-2223
Fax: (561) 744-2440
Contact: Michael Grella
mgrella@jupiterinletdistrict.org

Port of Palm Beach
One East 11th Street, Ste. 400
Riviera Beach, FL 33404
Phone: (561) 383-4100
Fax: (561) 842-4240
Contact: Lori Baer (Executive Director)
LBaer@portofpalmbeach.com
http://www.portofpalmbeach.com/

ACADEMIA

Nova Southeastern University
Oceanographic Center
8000 North Ocean Drive
Dania Beach, FL 33004
Phone: (954) 262-3600
www.nova.edu/ocean/

University of Miami
Rosenstiel School of Marine and Atmospheric Science
4600 Rickenbacker Causeway
Miami, FL 33149-1098
Phone: (305) 421-4000
http://www.rsmas.miami.edu/

Florida Atlantic University
Department of Ocean Engineering
777 Glades Road
Boca Raton, Florida 33431
Phone: (561) 297-3430
Fax: (561) 297-3885
www.oe.fau.edu

Florida International University
Department of Environmental Studies
11200 SW 8th Street
Miami, Florida 33199
Phone: (305) 348-1930
Fax: (305)348-6137
envstud@fiu.edu
www.fiu.edu/~envstud

Florida Institute of Technology
Marine and Environmental Systems
150 University Blvd
Melbourne, FL 32901
Phone: (321) 674-8096
Fax: (321) 674-7212
dmes@marine.fit.edu
www.coe.fit.edu

University of South Florida
College of Marine Science
140 7th Avenue South
St. Petersburg, FL 33701
Phone: (727) 553-1130
www.marine.usf.edu

University of Florida
Coastal Engineering Program
575 Weil Hall
University of Florida
Gainesville, FL 32611-6590
Phone: (352) 392.9537
Fax: (352) 392.3394
www.ce.ufl.edu

RECREATIONAL INTERESTS

Florida Sportsman
2700 S. Kanner Highway, Stuart, FL, 34994
Phone: 772-219-7400
Fax: (772) 219-6900
Contact: Blair Wickstrom (Publisher)
blair@floridasportsman.com
http://www.floridasportsman.com/

Florida Water Access Coalition
Southwest Florida Marine Industries Assoc.
1314 B N. Tamiami Trail
Mail: P.O. Box 1510
N. Ft. Myers, FL 33902
Phone: (239) 656-7083/7084
Fax: (239) 656-7068
Contact: Mr. Ken Stead (President)
ken@swfmia.com
http://www.water-access.com/

Greater Fort Lauderdale Diving Association
http://www.diveftlauderdale.com/

Horizon Divers – Key Largo
100 Ocean Drive, Building #1
Key Largo, FL 33037
Phone: (800) 984-DIVE
Fax: (305) 453-3535
Contact: Dan Dawson (Owner)
dan@horizondivers.com
http://www.horizondivers.com/

The Coral Reef Alliance
417 Montgomery Street, Suite 205
San Francisco, CA, USA,
Phone (415) 834-0900
http://www.coralreefalliance.org/

Organization for Artificial Reefs (OAR)
2545 Blairstone Pines Drive
Tallahassee, FL 32301
Phone: (850) 656-2114
http://www.oar-reefs.org/

South Florida Diving Headquarters
101 N Riverside Dr. #106
Pompano Beach, Fl 33062
Phone:(954) 783-2299
Fax: (954) 942-2933
Contact: Jeff Torode, President
sfdhjeff@aol.com
http://www.southfloridadiving.com

The International Game Fish Association
300 Gulf Stream Way
Dania Beach , Florida 33004 U.S.A.
Phone: (954) 927-2628
Fax: (954) 924-4299
Contact: Rob Kramer (President)
hq@igfa.org
http://www.igfa.org/

Pro Dive International
429 Seabreeze Blvd
Fort Lauderdale
Florida 33316, USA
Phone: (954) 776-3483
Fax: (954) 761-8624
Contact: Frank Gernert (Chief Executive Officer)
info@prodiveusa.com
http://www.prodiveusa.com/

Recreational Fishing Alliance
The Recreational Fishing Alliance Headquarters
P.O. Box 3080
New Gretna, New Jersey 08224
Phone: (888) 564-6732
Fax: (609) 404-1968
The Recreational Fishing Alliance Legislative Office
P.O. Box 98263
Washington, DC 20090
Phone: (202) 463-6557
Fax: (703) 847-2478
Contact: Jim Donofrio (Executive Director)
http://www.joinrfa.com/

INNOVATIVE PROJECTS

ASR Ltd.
Marine Consulting and Research
1 Wainui Road
PO Box 67
Raglan
New Zealand
Phone: +64 7 825 0380
Fax: +64 7 825 0386
Contact: Dr. Kerry Black
k.black@asrltd.co.nz
http://www.asrltd.co.nz/

Benedict Engineering Co LLC
P.O. Box 4229
Tallahassee, Fl 32315
3660 Hartsfield Rd
Tallahassee, FL , 32303-1163
Phone: (850) 576-1176
Fax: (850) 575-8454

Catch Basin
7826 Kavanagh Ct.
Sarasota, FL 34240
Phone: (941) 377-9725
Contact: Calvin LeBuffe
papacaddy@comcast.net

Coast & Harbor Engineering
Ocean Shores Protection Project
Edmonds, WA 98020
Phone: (425) 778-6733
Contact: Vladimir Shepsis
vladimir@coastharboreng.com
http://www.coastharboreng.com/

EcoShore Internationl, Inc.
2255 Glades Road, Suite 324A
Boca Raton, FL 33431
Phone: (239) 567-9753
Fax: (801) 740-7654
Cell: (239) 298-6563
Contact: Kenneth Christensen (President)
kwc@ecoshore.com
http://www.ecoshore.com/

Flow & Erosion Control 'FEC' System
121 Crystal Cove Drive
Palatka, FL 32177
Phone: (904) 536-3413
Contact: Sandy Rubin
rubinsandra@bellsouth.net

Jetspray
1331 W. Central Blvd
Orlando, FL 32802
Phone: (407) 849-6420
Contact: Troy Deal
Aztecd1331W@aol.com

Low Profile Stabilization System
601 Church St.
Franklin, TN 37064
Phone: (615) 790-0895
Contact: Kelly Rankin
tengle@beachrestorations.com

Moveable Seawall
4 Oceans W. Blvd., Unit 405 C
Daytona Beach Shores, FL 32118
Phone: (386) 761-3458
Contact: Herb Ackerman

Progressive Innovations, LLC
21081 Co. Hwy 61
Pine City, MN 55063
Phone: (800) 536-6268
Contact(s): Will Hagfors
Roger Sweningson
probagger12@earthlink.net

ProtecTube & Sand Dune Restoration System
2733 Ross Clark Circle
Dothan, AL 36303
Phone: (334) 333-5854
Contact: Rande Kessler
Randek@lbaproperties.com

Reef Mitigation Garden
207 Surf Road
Melbourne, FL 32951
Phone: (321) 733-2296
Contact: William Dally
wdally@surfbreakengineering.com

Sand Saver
1600 Made Ind. Dr.
Middletown, OH 45044
Phone: (513) 424-1955
Contact: Jim Cravens
jcravens@grangerplastics.com

Seaboxes
8267 Lighthouse Lane
King George, VA 22485
Phone: (540) 775-2651
Contact: SE 'Ed' Veazey
SEVeazey@aol.com

Seadozer
205 East Terminal Blvd
Atlantic Beach, NC 28512
Phone: (252) 727-0998
Contact: Dennison Breese
seadozer@starfishnet.com

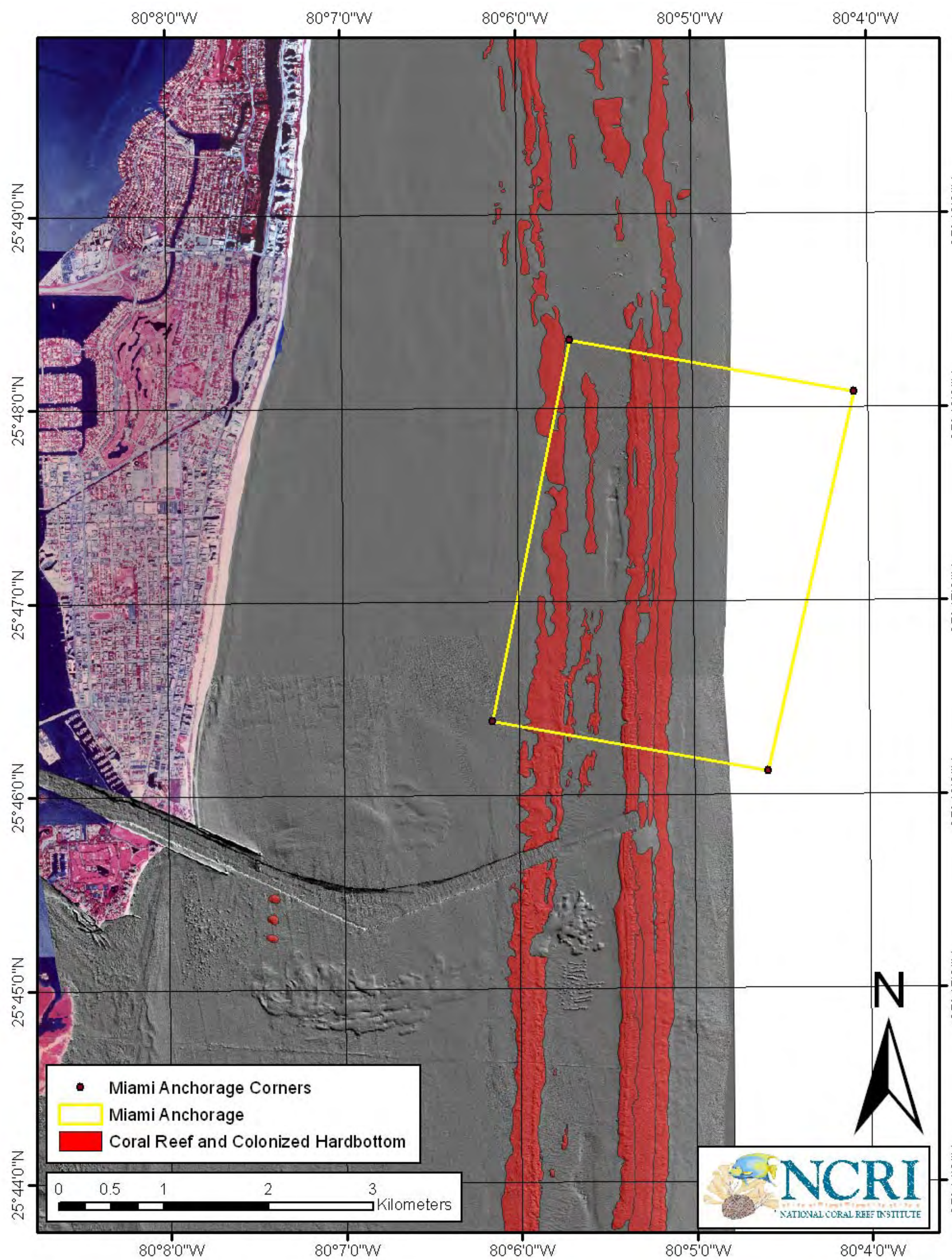
Sediment Reclaim
97 Greenpoint Ave.
Brooklyn, NY 11222
Contact: Michal Ciechorski
michalciechorski@hotmail.com

Submerged Artificial Reef Breakwaters
150 W. University Blvd, DMES
Melbourne, FL 32901
Phone: (321) 674-8096 x7273
Contact: Lee Harris
lharris@fit.edu

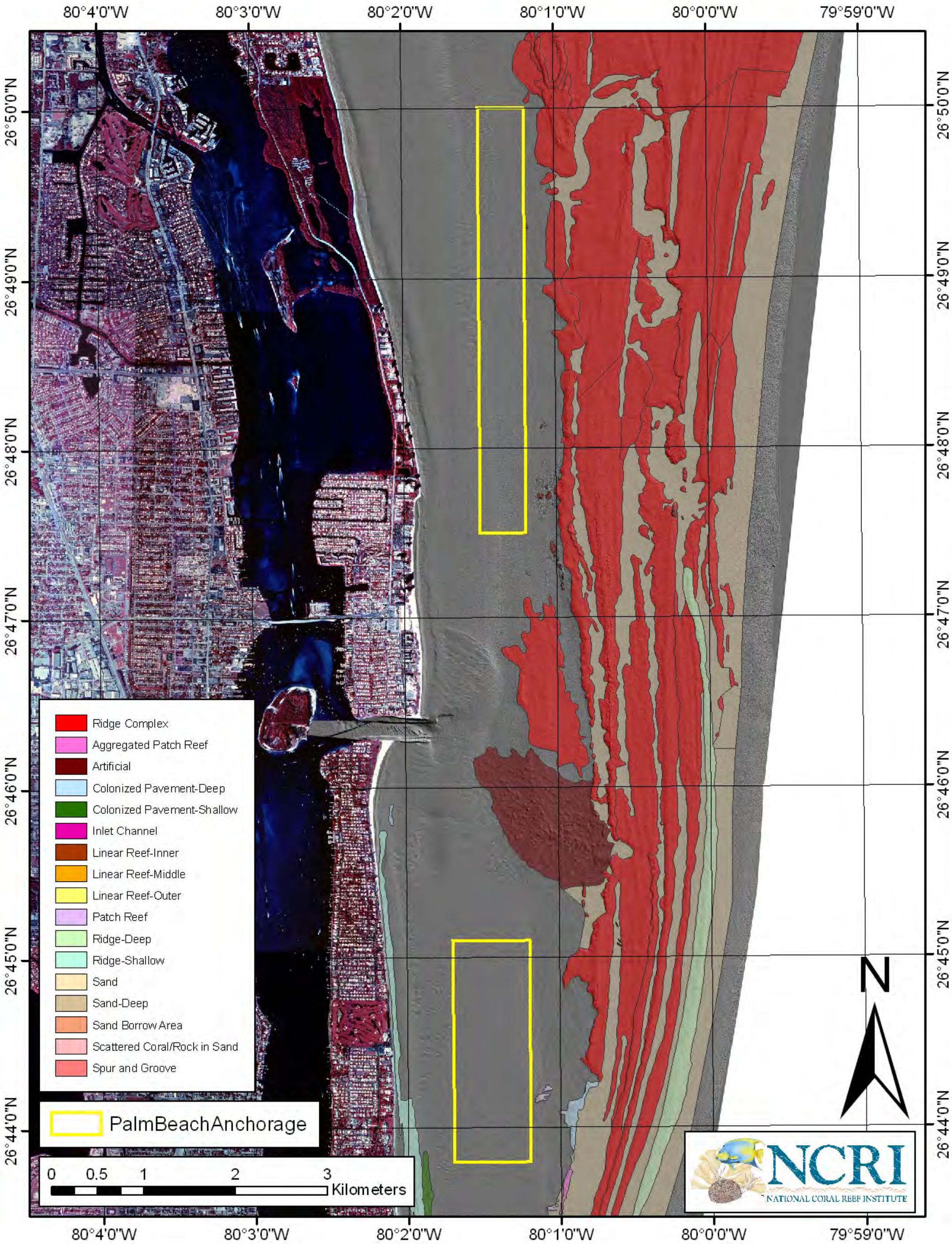
Total Beach Management
3660 Hartsfield Road
Tallahassee, FL 32303
Phone: (850) 576-1176
Contact: Jay Tiedeberg
jtiedeberg@beceng.com

Appendix 2 - Anchorage Maps

Port of Miami Anchorage Map



Port of Palm Beach Anchorage Map



Port Everglades Anchorage Map