APPENDIX I

DRAFT BIOLOGICAL MONITORING PLAN

St. Lucie County
South County Beach & Dune Restoration Project
Draft Biological Monitoring Plan




September 21, 2010

COASTAL TECH
COASTAL TECHNOLOGY CORPORATION

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Front Cover Photo Credits (clockwise from top left):
South Beach, St. Lucie County, Florida (Coastal Tech 2009)
Nearshore hardbottom, St. Lucie County, Florida (CSA 2010)
Green Turtle, North Shore O'ahu, Hawaii (Colstad 2007)
Terns, Anna Maria Island, Florida (Coastal Tech 2010)

1.0 INTRODUCTION

The south St. Lucie County Beach and Dune Restoration Project (Project), FDEP File Number 0154626-001-JC, proposes to restore beach and dune between DEP reference monuments R-87.7 to R-90.3 and R-98 southward to the St. Lucie/Martin County line (Figure 1) in order to: a) offset sediment deficit, b) restore and maintain the recreational beach, c) restore and maintain habitat for marine turtle nesting, marine life and shorebirds, and d) provide storm damage protection for property and infrastructure. As currently designed, the Project may result in a maximum potential hardbottom impact of 7.94 acres based on FDEP methodology (see Section 3.1 of the Draft Mitigation Plan, dated September 21, 2010).

The objectives of the Biological Monitoring Plan are to provide characterization of the post-construction impacts as well as biotic response to the project via monitoring of nearshore hardbottom, marine turtles (nesting and in-water), benthic infauna (if offshore borrow area is used), shorebirds, and dune plantings. This document outlines the protocols for the Project Biological Monitoring Plan. Implementation of this Plan is subject to FDEP and County approval and funding.

2.0 NEARSHORE BIOLOGICAL MONITORING

Nearshore biological monitoring constitutes surveys that will occur in the nearshore region within the influence of the predicted Equilibrated Toe of Fill (ETOF) of the Project and vicinity.

2.1 Nearshore Hardbottom Monitoring

Nearshore hardbottom monitoring will follow protocol set forth during pre-construction baseline monitoring, which was evaluated and approved by Department staff during the scoping process. In general, weather and tide conditions will be monitored for an appropriate window of opportunity (acceptable water clarity and visibility) for performance of the fieldwork, and a daily log of weather and tide conditions will be maintained at minimum from May 1 to September 30 of each monitoring year. When an appropriate window occurs, personnel and equipment shall be mobilized to conduct the fieldwork which includes monitoring/control transects, *in situ* quadrats, diver survey of permitted pipeline corridors if an offshore borrow area is used, and mapping of nearshore hardbottom edge, as described below.

2.1.1 Aerial Interpretation of Hardbottom Extent

Using aerial images obtained under the Physical Monitoring Plan, analyses of the aerial images will be conducted, including classification of the spectral bands of the images followed by ground-truth verification within the Project area. A GIS-based habitat map (ESRI shape files) will be generated that will identify the different hardbottom types and extent within the nearshore area of the area identified in the photography. Aerial image processing methodology will be consistent with that of the pre-construction baseline hardbottom mapping efforts (Appendix A).

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2.1.2 Permanent Cross-Shore Transects and in situ Quadrats

Transects to be monitored in the Project area include those previously established during the summers of 2008 and 2009 for baseline monitoring (CSA 2010a). Twelve 150-meter transects were established within the Project area (Figure 2, Table 1), with an additional 2 transects

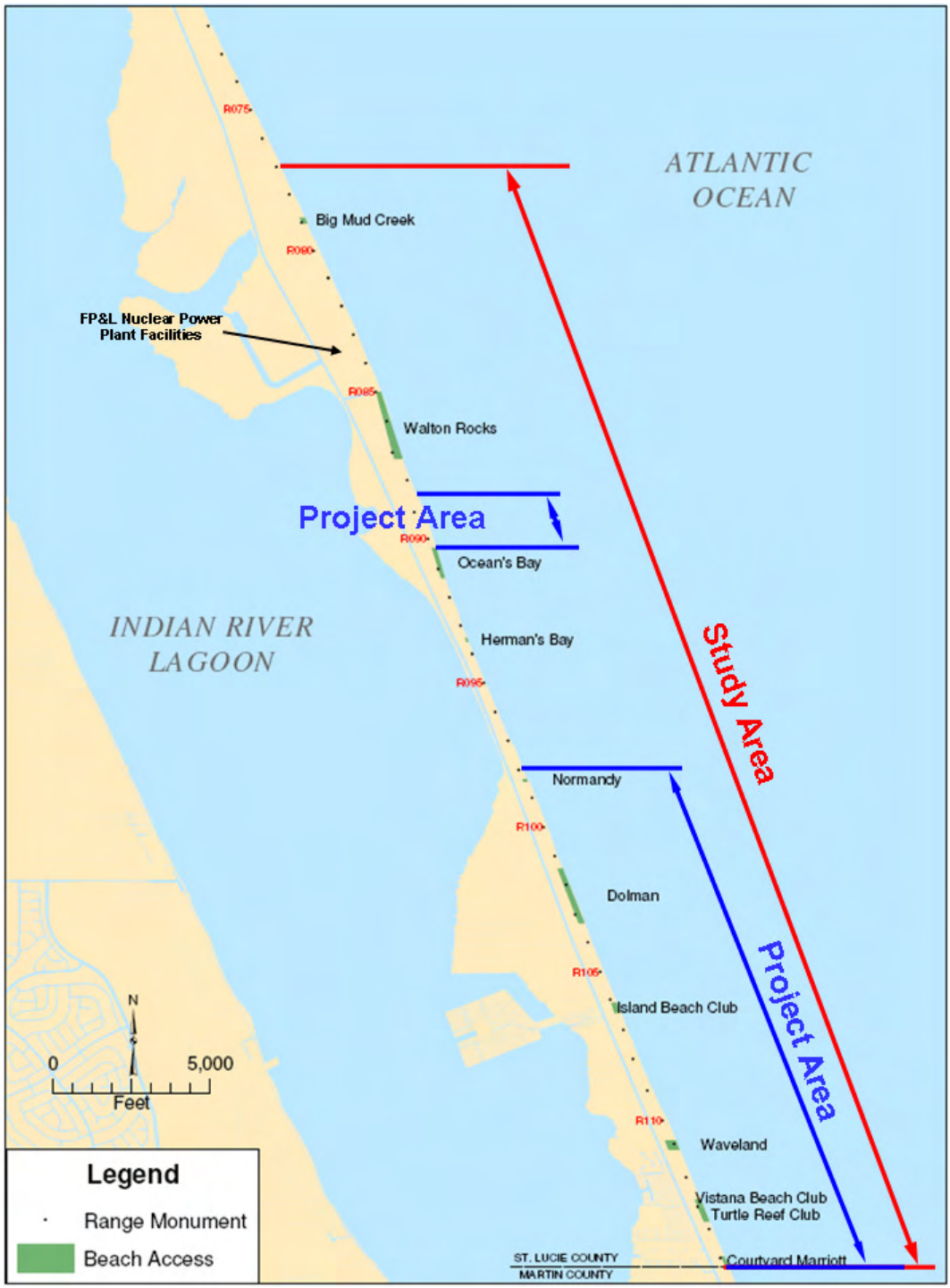

Figure 1: South St. Lucie County Project Area (in blue): DEP reference monuments R-87.7 to R-90.3 and R-98 to the St. Lucie/Martin County line.

Figure 2: Nearshore hardbottom monitoring transects established within the South St. Lucie County Project Area (from CSA 2010a).

Table 1: Locations of established hardbottom monitoring transects within the Project area and downdrift (from CSA 2010a).

Transect	0-m Transect Marker			
	Easting (X)	Northing (Y)	Latitude (N)	Longitude (W)
R-88.7	906142.2	1090484.1	27°19'53.7301"	80°13'48.1873"
R-90.4	906684.8	1088989.9	27°19'38.9011"	80°13'42.2737"
R-92	907205.0	1087442.2	27°19'23.5436"	80°13'36.6126"
R-93.5	907766.6	1086243.6	27°19'11.6404"	80°13'30.4688"
R-100	910109.7	1080392.5	27°18'13.5571"	80°13'04.8989"
R-101	910630.2	1079201.0	27°18'01.7263"	80°12'59.2122"
R-102	911037.4	1078145.5	27°17'51.2493"	80°12'54.7721"
R-103.2	911413.8	1077202.6	27°17'41.8891"	80°12'50.6659"
R-104.5	911874.6	1076062.0	27°17'30.5659"	80°12'45.6381"
R-105.9	912309.7	1074945.5	27°17'19.4829"	80°12'40.8938"
R-109.2	914211.7	1071569.9	27°16'45.9378"	80°12'20.0515"
R-110	914591.5	1070932.7	27°16'39.6042"	80°12'15.8874"
R-110.5	914880.2	1070365.7	27°16'33.9715"	80°12'12.7281"
R-112	915205.7	1069546.7	27°16'25.8411"	80°12'09.1788"
R-1	916285.0	1065615.7	27°15'46.8472"	80°11'57.4974"
R-3	916975.2	1063904.8	27°15'29.8618"	80°11'49.9713"

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downdrift of the northern segment (R-87.7 to R-90.3) and 2 downdrift of the southern segment (R-98 to St. Lucie/Martin County line), for a total of 16 monitoring transects. Single video transects will also be surveyed along the length of each of the permitted pipeline corridors, if an offshore borrow area is used.

The 150-meter transects shall be sampled using digital video in progressive scan mode, and survey date and location coordinates will be superimposed on the final deliverable. The diver shall swim at a speed of approximately 20 meters/6 minutes (~3.5 meters/minute) with a constant camera distance of 25 cm above bottom during the portions of the transect to be quantitatively analyzed. For the remainder of the 150-meter transect, the diver shall swim at a speed of 20 meters/5 minutes (~4-5 meters/minute) with a constant camera distance of 25 cm. If the diver is moved off the transect by surge, the diver shall return to the point where he/she was disturbed by the wave action, and resume filming at that point. The video transects shall be reviewed during the course of the survey to ensure that there are no gaps in the data due to diver error and that the quality of the video is acceptable for video analysis. Any missing video transect data or poor quality video shall be re-filmed during the course of the event.

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

photographs shall be obtained using the digital video camera or digital still camera at all quadrat locations, vertical ledges, large *Oculina* spp. colonies or *Siderastrea siderea* colonies along the transect or adjacent to transect (within underwater visibility during transect establishment), and changes in benthic landscape along the transect. Voucher sampling of macroalgae shall be conducted as needed to assist with video identification of macroalgae genera.

During each survey, a 0.25 square meter (0.5 m by 0.5 m) gridded quadrat will be sampled by the diver/biologist at several point-intercept locations along the 150-meter long transects – with approximately 12 quadrats along each transect. The first quadrat will be located at the nearshore hardbottom edge. If the hardbottom edge consists of a vertical ledge, one quadrat will be located along the vertical/sub-vertical face, a second quadrat will be located at the top of the ledge along at the horizontal face of the ledge, and the third quadrat shall be placed at the 5-meter mark along the transect. Additional quadrat sampling shall occur along each transect to capture changes in benthic landscape (physical relief, species dominance/abundance, presence of stony corals/octocorals along or immediate adjacent to the transect). If the transect crosses a sand gap (i.e. trough), a quadrat shall be sampled at the seaward edge of the exposed hardbottom, and at the west edge of hardbottom east of the sand gap (i.e. on the horizontal face of the crest of the next ledge). The distance across the sand gap shall be noted and is included within the 150-meter length of the transect. Quadrats shall not be placed in the sand gaps between hardbottom ridges. Each 150-meter transect shall have approximately 12 quadrats within the first 125 meters of the transect. A list of the locations of the quadrats along each transect with a description of the quadrat location/benthic community shall be provided to the Department after transect establishment. Within each quadrat, visual estimate of percent cover and genus/species identification shall be performed *in situ* for the following functional groups:

- macroalgae (identification & % cover of two dominant species within quadrat),
- microalgae/cyanobacteria,
- encrusting calcareous algae, sponges (genus level), with a separate assessment of percent cover of boring sponge (*Cliona* spp),
- tunicates (with identification of dominant genera),
- zoanthids (genus level), hydroids,
- wormrock (*Phragmatopoma lapidosa*),
- octocorals (genus level), and
- scleractinian corals (species level).

Individual counts shall be conducted for all octocorals, scleractinian corals, sponges (not including *Cliona* spp. which shall be assessed for percent cover), solitary tunicates, urchins, and holothuroids within the quadrat.

Scleractinian corals and octocorals shall also be assessed for size class distribution:

- size class 1: < 5 cm diameter of scleractinian/height of octocoral;
- size class 2: 5 cm to 15 cm diameter of scleractinian/height of octocoral;
- size class 3: 15 to 25 cm diameter of scleractinian/height of octocoral; and
- size class 4: >25 cm diameter of scleractinian/height of octocoral).

Maximum and average algal height of the two dominant macroalgal species shall also be recorded. Average algal height shall be estimated by five measurements.

Percent cover of substrate, unconsolidated substrate (rubble, shell hash, rhodoliths), sand and sediment over hardbottom shall be recorded. The maximum physical relief of hardbottom from the lowest point to highest point in the quadrat, shall be measured to the nearest centimeter.
Sediment accumulation measurements will be performed within all quadrats located on the flat (horizontal) surface of hardbottom along each transect. Five random measurements of sediment thickness will be performed within each quadrat using a ruler to measure to the nearest cm. Continuous layers of sediment less than 1 cm covering the hardbottom surface and benthos shall be recorded. Sediment accumulation measurements shall also be recorded at each rod/eyebolt along the transect and at 1-meter west of each rod/eyebolt using a ruler to measure to the nearest cm. If a ledge exists at the nearshore hardbottom edge (0-mark) or subsequent exposed hardbottom ridges, sediment accumulation shall be estimated by measuring the distance from the pin on the crest of the ledge to the foot of the ledge (sand).

2.1.3 Nearshore Hardbottom Edge Mapping

In concert with the above monitoring efforts, the nearshore hardbottom edge shall be mapped within the Project extent and 2000' downdrift (i.e., R-87 to R-2 in Martin County) for comparison to the pre-construction survey. The method for mapping shall be dependent upon underwater visibility conditions. The preferred method is by diver swimming the hardbottom edge with a DGPS antenna. Upon completion of the diver-mapped hardbottom edge, a towed-diver system with DGPS-integrated video may be utilized to document the conditions, including presence of trash/debris to document mitigation efforts, and benthic communities along the nearshore hardbottom edge if water depths and underwater visibility allow safe boat operation and safe diving conditions. The final deliverable video will also include survey date and location coordinates superimposed. If visibility conditions do not allow for a diver-mapped hard bottom interface the County shall coordinate with the Department for approval to utilize alternative methods for mapping the nearshore hard bottom edge, which may include the collection of 20-meter shore-parallel video transects at 150-m (500 ft) intervals with DGPS positioning of the hard bottom edge/video transect locations, ten measurements of vertical relief of the nearshore hard bottom edge along each transect, video documentation of the dominant benthos, and identification and canopy height measurements of the two dominant macroalgal species along each transect (five measurements per species).

2.1.4 Video Transect Analysis

Two, 20-meter long segments of the video transect shall be quantitatively analyzed using PointCount'99 or a comparable software package based upon the random point count method for estimation of percent cover from digitally frame-grabbed underwater video images. The first 20-meter segment shall correspond to the first 20 meters of hardbottom (commence at the 0 point at the exposed nearshore hardbottom edge and continue to the 20-meter mark). The second 20-meter segment shall cross hardbottom between 40 and 80 meters along each transect. The exact location of the second 20-meter segment shall be determined at the time of transect establishment based upon the benthic landscape and location of hardbottom ridges along the transect, and shall be referenced to the nearest pin along the transect for repeated occupation of the same stretch of transect for video analysis. DGPS positioning will be obtained for the start point of the second 20-meter segment along each transect.

Each 20-meter segment shall result in approximately 100 non-overlapping frame-grabbed images. A unique set of 20 random points shall be generated at the time of frame-grabbing and stored with each set of images so that the same points are assessed during each monitoring event. This also ensures that each person examining a particular image will view the same points, thereby allowing for double-blind counting for quality assurance and control purposes. Ten percent (10%) of the images shall be counted by two scorers to assess inter-observer variability.

An estimate of percent cover (projected to the surface) will be performed for each image according to the following functional groups/categories: scleractinian corals (to the genus level), octocorals, macroalgae (to the genus level if possible, if not, then according to the following breakdown: calcareous red, calcareous green, fleshy brown, fleshy red, fleshy green), microalgae/cyanobacteria, sponges, tunicates, hydroids, wormrock, zoanthids, urchins, holothuroids, and substrate. Substrate shall be broken down into the following categories: unconsolidated substrate (rubble/shell hash, rhodoliths), sediment over hardbottom, sediment over benthos (where the underlying fauna cannot be identified due to the sediment cover), and sand.

The remainder of the 180-meter video transect shall be reviewed for qualitative changes in benthic community cover/composition in comparison to the pre-construction surveys, previous annual surveys, and the reference sites. If the qualitative review of the video transect suggests sedimentation impacts or cross-shore transport of sediments over the benthic community along the remaining portions of the transect, and the results of the sedimentation monitoring and quadrat assessments indicate burial of hardbottom communities, additional quantitative analysis of the video transects shall be required as directed by the Department to determine the extent of the project-related impacts.

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2.2 Nearshore Fish Census and Sampling

Consistent with pre-construction baseline monitoring (CSA 2010b), fishes will be censused along each of the 12 established hardbottom monitoring transects within the Project area using quantitative strip transects (if conditions allow) and qualitative timed swims censused by a diver/ichthyologist. The two approaches provide complementary information on the extant fish assemblage. Strip transects provide density data by species and life stage and timed swims ensure that an adequate assessment of overall diversity and life stage composition for each survey transect is made.

At each survey transect, 2 strip transects will be sampled perpendicular to the cross-shelf axis of the survey transect. Two transects will be positioned randomly within each of three cross shelf strata (inner, center, and offshore) strata of the hardbottom feature traversed by the survey transect. The exact position of the cross-shelf strata will depend upon the nature of hardbottom along individual transects. Random placement of the strip transects will be determined prior to each survey using the survey transect as a baseline. The strip transects will be 15 x 2 m and the observational corridor will extend from surface to bottom and 2 m in front of the diver/ichthyologist. Fishes will be counted in the following size (total length) categories: 0-20 mm, 21-40 mm, 41-60 mm, 61-80 mm, 81-100 mm, 100-200 mm, 200-300 mm, 300-400, and > 400 mm. Lengths of all fishes will be estimated using a hand-held ruler affixed to 1 m plastic

pole. Identification of newly settled taxa (20 mm or less) will be recorded at the lowest practicable taxonomic level. All data will be recorded on standardized sheets.

Qualitative timed swims will consist of modified roving census where the diver/ichthyologist will swim about haphazardly for 5 min recording all fishes observed around the survey transect within each of three cross-shelf strata. During a timed swim, the diver is free to look under ledges, in crevices, and overhead in the water column. All data will be recorded *in situ* on pre-prepared waterproof data sheets. Data will be entered into a database for storage and analyzed using standard multivariate and univariate techniques.

2.3 In-water Sea Turtle Monitoring

Monitoring will occur for 1 year post-construction, consisting of 4 total quarterly monitoring events: winter, spring, summer, and fall. Surveys will be conducted from a boat equipped with an elevated observation platform and a GPS navigational system to allow constant monitoring of speed and location. Surveys will only be conducted during periods of calm seas (2.5 feet or less), with no whitecaps or breaking waves, other than wave break on the beach. The boat will traverse pre-established shore-parallel transects of fixed length (Figure 3, EAI 2009) at slow speed (4.0 knots or less). Two observers will be positioned on the platform and will make observations at an eye level of approximately 12 feet above the water; one will monitor the port side and the other the starboard side. Two passes will be made along each transect with observers changing sides between the first and second passes.

When a turtle is sighted, the position of the vessel at the time of the sighting will be recorded by GPS. The position of the turtle will be mapped based on the position of the boat and the observer's estimate of the distance and bearing to the turtle. In addition to recording the position of the turtle, the observer will also record the time the turtle was first observed, the species, its relative size, and whether it was at the surface or submerged.

Of the two passes made along each transect during each monitoring event, the pass with the highest number of sea turtle sightings will be used for estimating density of turtles along that transect. A belt extending 50 meters to either side of the survey vessel over the length of each transect will be used for estimating density. Baseline density data will be used for documenting natural spatial and temporal variability of turtles within the Study Area and will be used in comparison with post-construction monitoring data to assess project effects.

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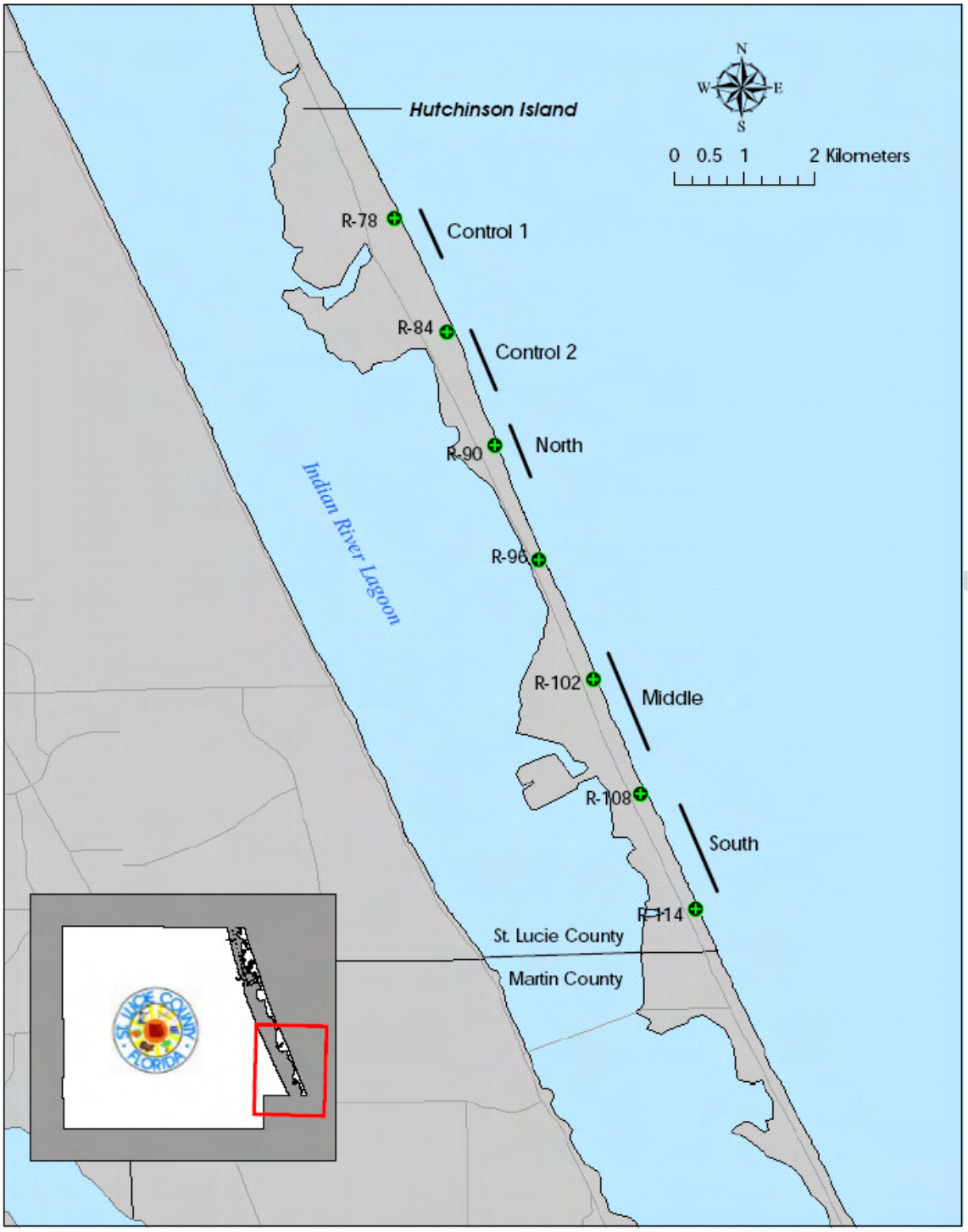

Figure 1. Location of the five transects monitored for sea turtles, St. Lucie County South Beach Project, December 2008 - August 2009.

EAI ECOLOGICAL ASSOCIATES, INC.
www.ecological-associates.com

Figure 3: Location of in-water sea turtle monitoring transects, as established by Ecological Associates, Inc. (EAI) in 2008 and 2009 (from EAI 2009).

3.0 OFFSHORE BORROW AREA MONITORING

Offshore borrow area monitoring consists of surveys that will occur within the footprint of the Project offshore borrow area and vicinity, if an offshore borrow area is used.

3.1 Benthic Infauna Monitoring

If an offshore borrow area (Figure 4) is utilized for the Project, monitoring of benthic infauna within that borrow area will be performed. To conduct pre- and post-construction infaunal biomass surveys for secondary productivity, approximately 15 sample sites will be established within and proximal to the borrow area: 5 within the refuge patch, 5 in the area to be dredged, and 5 outside the borrow area. At each of the sampling sites, 3 replicate core samples will be collected by divers using 12.5 cm by 12.5 cm by 15 cm deep stainless steel corers. The top of each corer is covered with 0.5 mm mesh screen to prevent the loss of organisms. Samples at the borrow site will be placed in cotton bags in the water, the bag tied shut, and then brought to the surface for sample processing.

Samples will be individually placed within a 0.5 mm mesh sieve bucket and gently sieved to remove fine sediments. The material remaining in the bucket will be placed in 1-l labeled plastic jars and preserved using 10% buffered formalin with rose bengal stain. A total of 30 samples will be collected at the borrow area during both the pre-construction and the post-construction surveys.

Following the collection and preservation of the infaunal samples the specimens will be sorted to five major taxonomic groupings including annelids, crustaceans, mollusks, echinoderms, and miscellaneous. Counts will be made of the number of individuals within each grouping. Ash-free dry weights will be determined for each group within each sample and an electronic spreadsheet will be created with a breakdown by group and sample for each of the infaunal samples.

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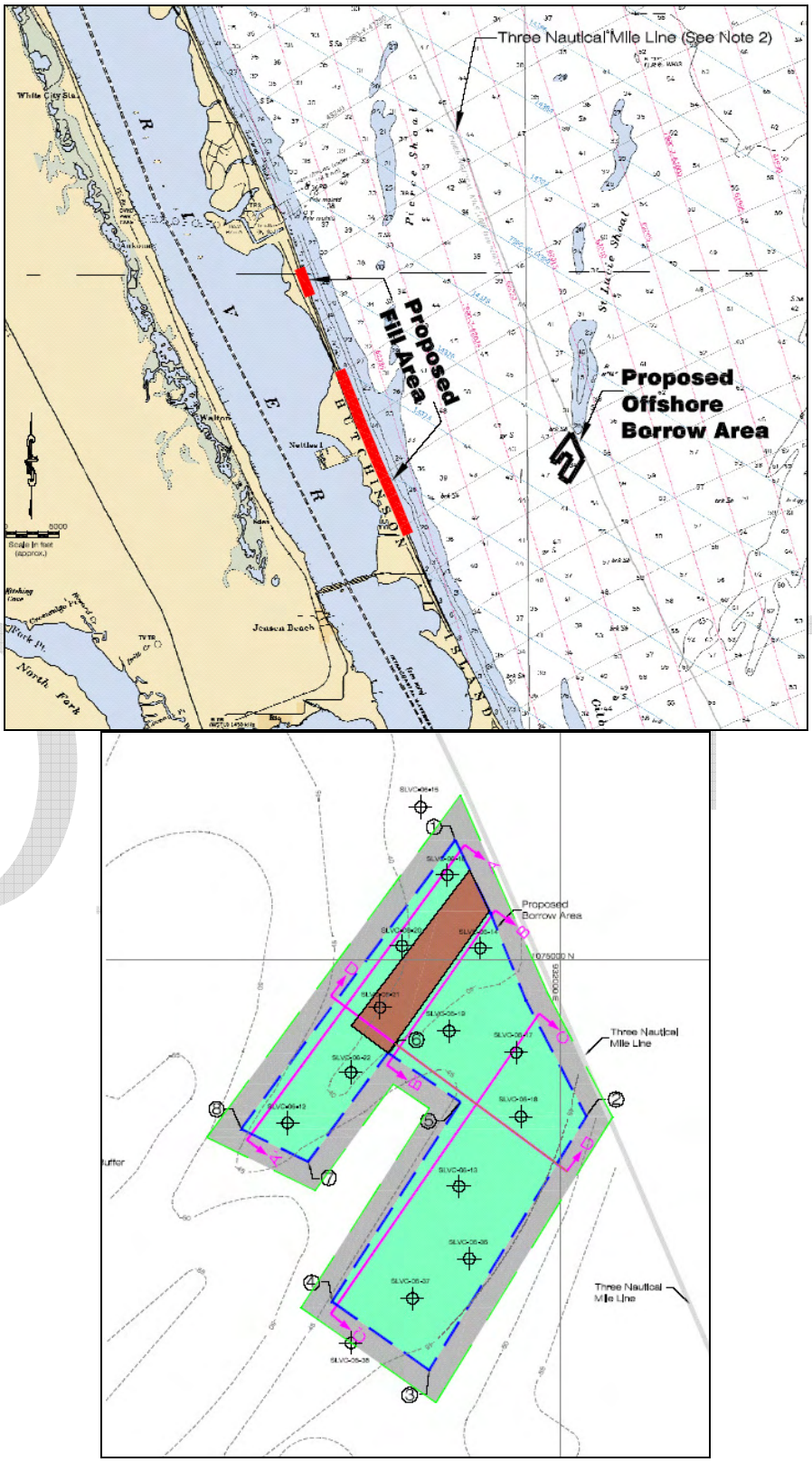

Figure 4: Location of proposed offshore borrow area (top) and dredge plan of proposed offshore borrow area (bottom). Brown polygon represents a "refuge patch", an area to be left undisturbed to facilitate recolonization of benthic infauna post-construction.

4.0 BEACH AND DUNE MONITORING

Beach and dune monitoring consists of surveys that will occur on the beach and dune system within the Project fill area, landward of the Mean High Water Line.

4.1 Beach Infauna

In order to evaluate changes in infaunal assemblages, 8 transects with 3 stations each will be positioned across the Project fill area. Methodology for sampling and analysis will be consistent with that described in section 3.1.

4.2 Sea Turtle Monitoring

Consistent with requirements put forth by both U.S. Fish & Wildlife Service (USFWS) and Florida Fish & Wildlife Conservation Commission (FFWCC) in the typical JCP, the following monitoring will be conducted for nesting sea turtles during construction activities, the nesting season immediately post-construction, and three nesting seasons thereafter.

4.2.1 Sea Turtle Nest Monitoring

Daily early morning surveys for sea turtles will be required if any portion of the sand placement construction occurs during the period from March 1 through April 30, or November 1 through November 30. Nesting surveys must be initiated 65 days prior to construction activities, or by March 1, whichever is later. Nesting surveys must continue through the end of the project or through September 30, whichever is earlier. In addition, nighttime surveys for leatherback sea turtles must be conducted from March 1 through April 30 or until completion of the project (whichever is earliest). Nighttime nesting surveys must be conducted from 9 p.m. until 6 a.m. The project area must be surveyed at 1- hour intervals (since leatherbacks require at least 1.5 hours to complete nesting, this will ensure all nesting leatherbacks are encountered). If nests are constructed in areas where they may be affected by construction activities, eggs must be relocated per the following requirements:

1) Nesting surveys and egg relocations will only be conducted by personnel with prior experience and training in nesting survey and egg relocation procedures. Surveyors must have a valid FFWCC Permit issued pursuant to Florida Administrative Code Rule 68E-1. Nesting surveys must be conducted daily between sunrise and 9 a.m. The contractor must not initiate work until daily notice has been received from the sea turtle permit holder that the morning survey has been completed. Surveys must be performed in such a manner so as to ensure that construction activities do not occur in any location prior to completion of the necessary sea turtle protection measures.

2) Only those nests that may be affected by construction activities will be relocated. Nests requiring relocation must be moved no later than 9 a.m. the morning following deposition to a nearby self-release beach site in a secure setting where artificial lighting will not interfere with hatchling orientation. Nest relocations in association with construction activities must cease when construction activities no longer threaten nests.

3) Nests deposited within areas where construction activities have ceased or will not occur for 65 days must be marked and left *in situ* unless other factors threaten the success of the nest. The sea turtle permit holder must install an on-beach marker at the nest site and a secondary marker at a point landward as possible to assure the future location of the nest will be possible should the on-beach marker be lost. A series of stakes and highly visible survey ribbon or string must be installed to establish a 10-foot radius around the nest. No activity will occur within this area nor will any activity occur which could result in impacts to the nest. Nest sites must be inspected daily to assure nest markers remain in place and that the nest has not been disturbed by the nourishment activity.

Post-construction nesting surveys shall occur daily and continue through October 31, as outlined above and in Table 2 below. Post-construction monitoring shall occur for a minimum of three (3) additional nesting seasons thereafter.

Table 2: FFWCC-required sea turtle monitoring parameters for JCP projects.

Characteristic	Parameter	Measurement	Variable
Nesting Success	False crawls - number	Visual assessment of all false crawls	Number and location of false crawls in project and control areas with respect to the different types of fill sand: any interaction of the turtle with obstructions, such as groins, seawalls, or scarps, should be noted.
	False crawl - type	Categorization of the stage at which nesting was abandoned	Number in each of the following categories: emergence-no digging, preliminary body pit, abandoned egg chamber.
	Nests	Number	The number of marine turtle nests in the project and adjacent areas in project and control areas should be noted with respect to the different types of fill sand. Nest location along the profile, including the distance from the waterline and the landward structure, shall be recorded using sub-meter GPS. Any abnormal cavity morphologies should be reported as well as whether turtle touched groins, seawalls, or scarps during nest excavation
		Lost Nests	The number of nests lost to inundation, erosion depredated, vandalized, or the number with lost markers that could not be found.
	Lighting Impacts	Disoriented sea turtles	The number of disoriented hatchlings and adults shall be documented and reported in accordance with existing FWC protocol for disorientation events.
Reproductive Success	Emergence & hatching success	Standard survey protocol	Numbers of the following: unhatched eggs, depredated nests and eggs, live pipped eggs, dead pipped eggs, live hatchlings in nest, dead hatchlings in nest, hatchlings emerged, disoriented hatchlings, depredated hatchlings

4.2.2 Compaction Testing

Immediately after completion of the project (April 30) and prior to March 1 for three subsequent years, sand compaction must be monitored in the area of sand placement in accordance with a

protocol agreed to by the USFWS, Department, and the County. At a minimum, the protocol provided below may be followed, if post-construction tilling does not occur prior to sea turtle nesting season.

Compaction sampling stations must be located at 500 foot intervals along the project area. One station must be at the seaward edge of the dune per bulkhead line (when material is placed in this area), and one station must be midway between the dune line and the high water line (normal wrack line). At each station, the cone penetrometer will be pushed to a depth of 6, 12, and 18 inches three times (three replicates). Material may be removed from the hole if necessary to ensure accurate readings of successive levels of sediment. The penetrometer may need to be reset between pushes, especially if sediment layering exists. Layers of highly compact material may lie over less compact layers. Replicates will be located as close to each other as possible, without interacting with the previous hole or disturbed sediments.

4.2.3 Escarpment Monitoring

Visual surveys for escarpments along the action area must be made immediately after completion of the project and prior to March 1 for three subsequent years if post-construction tilling does not occur prior to sea turtle nesting season. In addition, weekly surveys of the project area shall be conducted during the three nesting seasons following completion of sand placement as follows:

The number of escarpments and their location relative to DEP reference monuments shall be recorded during each weekly survey and reported relative to the length of the beach survey (e.g., 50 percent escarpments). Notations on the height of these escarpments shall be included (0 to 2 feet, 2 to 4, and 4 feet or higher) as well as the maximum height of all escarpments.

4.2.4 Lighting Surveys

Lighting surveys shall be conducted in accordance with the St. Lucie County lighting ordinance, U.S. Fish & Wildlife Service Biological Opinion, and JCP specific permit conditions, and will document all artificial lighting visible from the nourished beach, using standard techniques.

4.3 Shorebird Monitoring

Shorebird monitoring will be conducted consistent with FFWCC requirements typical for beach restoration projects. Shorebird surveys will be conducted by trained, dedicated individuals with proven shorebird identification skills and avian survey experience. Nesting season surveys will encompass all potential beach-nesting bird habitats within the Project area that may be impacted by construction activities during the nesting season. Portions of the Project area in which there is no potential for Project-related activity during the nesting season may be excluded. Surveys for detecting new nesting activity shall be completed on a daily basis prior to movement of equipment, operation of vehicles, or other activities that could potentially disrupt nesting behavior or cause harm to the birds or their eggs or young. Surveys shall also document the presence of any piping plovers, or other federally-listed shorebirds, within or adjacent to the fill site.

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4.4 Planted Dune Vegetation Monitoring

Post-construction dune vegetation planting will be conducted immediately after installation and shall be completed within 30 days of ending beach fill activities. Within 30 days of planting completion, an as-built report shall be submitted to the Department documenting the number and type of plants installed. At least one annual post-construction dune vegetation monitoring event will also be required until at least 80% survivorship of planted vegetation is achieved. Monitoring shall be conducted using any standard method for assessing total areal plant cover; however the simple *Flat Vegetative Cover Test Method* is recommended.

5.0 MONITORING SCHEDULE

In general, monitoring will follow the schedule outlined in Table 3, below. Details for each monitoring component are contained within the following sub-sections.

Table 3: **Biological monitoring schedule for either upland or offshore sand source.**

Monitoring Requirement	Pre-Construction	Post-Construction			
		Immediate	Year 1	Year 2	Year 3
Nearshore Hardbottom & Fish Census	Complete	X	X	X	X
In-Water Sea Turtle(1)	Complete	X	X		
Offshore Benthic Infauna(2)	Needed(2)	X	X	X	X
Sea Turtle Nesting	Complete	X	X	X	X
Compaction Testing		X	X	X	X
Escarpment		X	X	X	X
Lighting Survey	Needed	X			
Shorebirds		X			
Planted Dune Vegetation(3)		X	X		

Note: (1) A total of 6 monitoring events will occur throughout the first year post-construction
(2) Infaunal Biomass Monitoring will only be performed if an offshore borrow area is used.
(3) If 80% survivorship is not achieved after Year 1, monitoring will occur until it is.

5.1 Nearshore Hardbottom Monitoring

Monitoring events shall consist of an immediate post-construction survey conducted during the summer after project completion (May 1 through September 30), and three subsequent annual post-construction monitoring events conducted during the summer months (May 1 through September 30). A pre-construction survey was conducted during the summers of 2008 and 2009.

During the course of each survey, the County or its designated consultant shall submit weekly progress reports via email to the Department. The weekly progress reports shall consist of a brief narrative describing the progress of work during the week and predicted schedule for the following week. If adverse weather conditions are encountered which do not allow for field operations, the biological consultant shall maintain a log of all attempts to conduct the survey and weather/visibility conditions which prevented collection of the required data. If, while in the field, the biological monitoring team encounters poor visibility conditions that prevent collection of data, conditions shall be documented with digital video at the site.

After demonstration of diligence and repeated failed attempts by the consultant to collect the monitoring data according to the permitted protocol, if the required monitoring is less than 50% complete by August 15th due to the persistently adverse visibility conditions, the County or its designated consultant shall coordinate with Department staff to schedule a Department site visit during the second half of August. The consultant shall continue to monitor weather conditions and attempt to collect the required data until the Department site visit. After the site visit, Department staff may make recommendations/revisions to the monitoring protocol to expedite the collection of the data. After coordination and approval by Department staff, if the required monitoring is less than 50% complete by August 31st, the County shall implement the approved contingency monitoring plan (Appendix B).

5.2 Nearshore Fish Census and Sampling

The fish census and sampling will be conducted in association with the nearshore hardbottom monitoring, as outlined in section 5.1.

5.3 In-Water Sea Turtle Monitoring

Monitoring will be conducted monthly during the summer (June through August) when sea conditions are ideal for performing surveys. Throughout the remainder of the year, monitoring will be conducted quarterly. This will yield a total of 6 monitoring events during the first year post-construction.

5.4 Offshore Borrow Area Benthic Infauna and Beach Infauna Monitoring

A review of pertinent literature indicates that infaunal assemblages in offshore sand shoals and beach recipient sites recover approximately 2-3 years post-dredging and post-fill, respectively; therefore monitoring of the infaunal biomass will occur for 3 years post-construction if an offshore borrow area is used.

5.5 Sea Turtle Monitoring, Compaction, Escarpment, Lighting Surveys

Monitoring of sea turtle nesting, compaction, and escarpments shall occur in the initial nesting season post-construction and for three (3) nesting seasons thereafter, for a total of four (4) nesting seasons. A pre-construction lighting survey shall be conducted, followed by monthly post-construction lighting surveys conducted by May 15, June 15, July 15, August 15, and September 15.

5.6 Shorebird Monitoring

Daily shorebird surveys shall begin April 1 or ten (10) days prior to project commencement, whichever is later, and continue throughout the construction period within the Project area or through August 31, whichever is later. Weekly surveys of the project site shall continue through August or through fledging or loss of identified nests or hatchlings, whichever is later.

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6.0 REPORTING

Reports summarizing the results of the biological monitoring will be submitted to the Department, FFWCC, U.S. Army Corps of Engineers (USACE), and/or USFWS as follows.

6.1 Nearshore Hardbottom Monitoring

All data deliverables shall be provided within 90 days after completion of the survey and will include the following data on CD:

- all digital video transects and frame-grabbed images from all transects
- PointCount files and associated data (i.e. PTS files, MGR files, cd.dat files)
- Excel spreadsheets of PointCount data (raw data and summary files)
- Excel spreadsheets of *in-situ* quadrat data.
- Spatial GIS shapefiles of transects and hardbottom maps.

A report summarizing the survey (permanent transects, quadrats, hardbottom edge mapping) and analyses will be prepared. The report shall include appropriate graphics/tables, statistical analysis of the collected data, and assessment of Project-related impacts to the hardbottom communities, shall be provided within 90 days after completion of the survey. The report shall be provided in both hard copy and digital format.

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6.2 Nearshore Fish Census and Sampling

Within 90 days of the census/sampling event, a report summarizing the results of the nearshore fish census and sampling will be prepared. In addition to standard report sections (introduction, methodology, conditions, etc) the report results will include:

- Density of species by size class
- Species composition
- Species richness
- Spatial comparison of species present along transects
- Associate fish assemblages with habitat type/characteristics as developed from the quadrat data
- Temporal comparison of assemblages, if data allows.

6.3 In-Water Sea Turtle Monitoring

A brief letter report describing survey and analysis methods and reporting the results will be prepared and submitted 90 days following each survey.

6.4 Offshore Borrow Area and Beach Infauna

A brief letter report describing survey and analysis methods and reporting the results will be prepared and submitted 90 days following each survey. The study should provide information to assist in understanding impacts, including changes and recovery rates, to infaunal communities at offshore borrow sites and beach fill sites.

6.5 Sea Turtle Monitoring, Compaction Testing, Escarpment Monitoring, Lighting Surveys

Reports on all nesting activity, compaction, and escarpment monitoring shall be provided. Reports submitted shall include daily report sheets noting all activity, nesting success rates, hatching success of all relocated nests, hatching success of a representative sampling of nests left in place (if any), dates of construction and names of all personnel involved in nest surveys and relocation activities. The three replicate compaction values for each depth will be averaged to produce final values for each depth at each station. Reports will include all 18 values for each transect line, and the final six averaged compaction values. Summaries of nesting activity shall be submitted in electronic format (Excel spreadsheets). All reports shall be submitted by January 15 of the following year.

A report summarizing lighting survey results and documenting compliance with the St. Lucie County beach lighting ordinance and enforcement action shall be submitted to the USFWS and FFWCC by the first of the month following each lighting survey (i.e., May 1 for the April 15 survey, June 1 for the May 15 survey, etc.) and a final summary report provided by December 15 of that year.

6.6 Shorebirds

A summary of all shorebird activity, including daily logs, will be submitted after monitoring has been completed. All breeding activity shall be reported to the FFWCC Beach-Nesting Bird website within one week of data collection. Observations of non-breeding shorebirds shall be reported to the FFWCC Shorebird-Seabird Occurrence Database and the FFWCC Regional Nongame Biologist.

6.7 Planted Dune Vegetation

A summary report of planted dune vegetation monitoring activities will be provided within 60 days of the monitoring event. The report will include a calculation of the percent survivorship of all planted vegetation.

7.0 REFERENCES

CSA International, Inc. 2010a. Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. 50pp. + appendices.

CSA International, Inc. 2010b. St. Lucie County South Beach Project: Characterization of Hard Bottom Fish Assemblages. 29pp.

Ecological Associates, Inc. 2009. St. Lucie County South Beach Project: Annual Report of Boat-Based Sea Turtle Surveys December 2008-August 2009. 16pp.

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Appendix A:
Aerial Hardbottom Interpretation Methodology

(CSA International, Inc. 2008)

IMAGERY PROCESSING

Processing Software

Leica ERDAS Imagine v9.3, a remote sensing software program, and ESRI ArcGIS v9.3 were utilized to perform hard bottom delineation. The Iterative Self-Organizing Data Analysis Technique Algorithm (ISODATA) used in the classification process is a sophisticated algorithm that allows the number of clusters to be automatically adjusted during iteration by merging similar clusters and splitting clusters with large standard deviations. The application of this automated technique to the source imagery emphasizes intensive clustering to sort pixels into spectrally separable categories. No reflectance values were collected in conjunction with the provided imagery.

Pre-processing Techniques

The initial step involved mosaicing the image tiles from the study area. Following standard remote sensing protocols, various enhancement techniques were then applied to the imagery data to better distinguish hard bottom features. Spectral and spatial enhancement were tested on each imagery class to determine which techniques, if any, were applicable.

Spatial Enhancement (Focal Analysis/Spatial Filtering)
Convolution Filtering was applied to the data set. Filtering is a broad term that refers to the altering of spatial features for image enhancement. Convolution filtering is the process of averaging small sets of pixels across an image and is used to change the spatial frequency characteristics of an image (Jensen, 1996).

For this analysis, 3x3, 5x5, and 7x7 kernels were applied to various locations for each imagery class within the study area. A convolution kernel is a matrix of numbers that averages the value of each pixel with the values of surrounding pixels. The numbers in the matrix provided a weight-average towards particular pixels. This filtering process produced few discernible improvements over the spatial resolution of the source imagery.

Habitat boundaries were not noticeably improved through spatial filtering.

Spectral Enhancement
Histogram Equalization (HEQ) was applied to all imagery classes in an attempt to "standardize" habitat classification. HEQ is a nonlinear stretch that redistributes pixel values within a range, which approximates a flat histogram. Contrast is therefore increased at the peaks of the histogram and lessened at the tails. HEQ can also separate pixels into distinct groups if there are few output values over a wide range. Even with significant manual manipulation, HEQ did not effectively enhance habitat classification primarily due to the loss of spectral signature definition and was not applied to the final data set.

Principal Components Analysis (PCA) was applied to the imagery classes to compress redundant data values into fewer bands. The bands of PCA data are noncorrelated and independent and are often more interpretable than the source data (Jensen, 1996; Faust, 1989). Preliminary ISODATA classifications were run in pairs on tiles of the original source imagery and on the same tiles to which PCA had been applied. When checked for accuracy, features classifications of PCA tiles showed no increase in accuracy over classifications of the original data.

Processing

Given only limited *a priori* information for this study site, only an unsupervised classification could be conducted rather than the preferred supervised classification method. Unsupervised classification techniques are computer-automated techniques and emphasize intensive clustering algorithms to sort pixels into spectrally separable categories. The method uses less *a priori* information than supervised training, which requires real-time ground truthing of upwelling spectral radiance from specific points within the study area.

The following ISODATA parameters were tested and established as the best suitable method for imagery analysis:

- Number of Classes: 64;
- Initializing Options – Principal Axis, Standard Deviations: 1.00;
- Maximum Iterations: 6;
- Convergence Threshold: 0.95; and
- Do not classify zeros.

These parameter values were tested against multiple series of parameter values for each image mosaic and yielded the most appropriate result for the habitats mapped. Image mosaics for each class were then processed and classified. Three techniques were used to associate classified values with habitats:

- Image Alarm, which highlights pixel values of the class the user determines in the signature editor to help analyze the data and sort out pixel values that are similar for comparison;
- Flicker, which quickly flips between the top and bottom layers of the viewer when the classified image is overlaid on the preprocessed mosaic images; and
- Swipe, which enables comparison of layers in the viewer using a vertical and horizontal swipe line.

Utilizing these techniques, classified values were visually interpreted from the imagery. The analysis incorporated hard bottom delineation/mapping. Although these features have different spectral characteristics and can be separable as homogenous pixels, in reality, there can be a significant amount of intermixing between these features, even at high spatial resolutions. Specific problems such as complex benthic combinations (e.g., sandy areas with variable amounts of algal cover; variation in color, texture, size) and error in depth estimation can also have a considerable impact on the classification results.

Feature Analysis

A pixel growing technique was used to identify and delineate the boundaries of remaining distinguishable hard bottom that was not classified in the unsupervised classification. Given that each of the features has an approximate spectral "boundary" that provides separation from surrounding features, contiguous pixels were sequentially clumped into a polygon using a threshold "homogeneity" criterion. This technique offers the advantage of rapid, contiguous zonal delineation combined with analytical interpretation of image contrast. Spectral Euclidean distance (difference) of four band composite (r,g,b,nir) values between each surrounding pixel versus a "seed" pixel were calculated and used to determine membership in the delineated Area of Interest (AOI) polygon in an image overlay if the difference was less than a specified threshold.

Threshold values were iteratively applied until the AOI boundary visually matched the strong gradient in landscape reflectance at the edges of the target feature (hard bottom edge). Each polygon file was converted from ERDAS IMAGINE AOI format to ESRI's ArcGIS polyline shapefile format.

Post-processing Techniques

Five primary post-processing techniques were applied to the process dataset:

- Binary Recode;
- Dice;
- Clump;
- Sieve; and
- Raster-to-Vector.

Binary Recode is a manual process that was used to separate the classified imagery into thematic layers consisting of only two classes: a single "target" feature type and all other classes.

Dice was used to subset the larger mosaic into new smaller images at specified dimensions. Dicing was utilized on the mosaic images to make the size of the image tiles more manageable for exporting to vector format. Dice resulted in forming subsequent subsets of classified imagery.

Clump was used to identify clumps, which are contiguous groups of pixels in one GIS class, and group them together and save them into a new image file. This technique was utilized to group pixel values of similar classes together.

Sieve was used following the application of Clump. Sieve eliminated clumps smaller than the minimum size specified. Sieve creates a new image file that assigns attribute values of 0 (zero) to clumps smaller than the minimum size and assigns a value of 1 to values greater than or equal to the specified size.

Raster-to-Vector was used to convert the raster-interpreted information into coverage format. Coverage files were then converted to shapefile format.

Vector files from both classification methods (unsupervised and region grow) were merged to create the final delineated hard bottom shapefile deliverable.

SOURCES

Faust, N.L. 1989. Image Enhancement. Volume 20, Supplement 5 of Encyclopedia of Computer Science and Technology. Eds. A. Kent and J.G. Williams. Marcel Dekker, Inc., NY.

Jensen, J.R. 1996. Introductory Digital Image Processing: A Remote Sensing Perspective. 2nd ed. Prentice-Hall, Englewood Cliffs, NJ.

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Appendix B:
Contingency Hardbottom Monitoring Plan

If the required hardbottom monitoring is less than 50% complete by August 15th due to persistently adverse visibility conditions, the County or its designated consultant shall coordinate with Department staff to schedule a Department site visit during the second half of August. The consultant shall continue to monitor weather conditions and attempt to collect the required *in situ* quadrat and video transect data according to the monitoring plan parameters until the Department site visit. After the site visit, Department staff may make recommendations/revisions to the monitoring protocol to expedite the collection of the data. After coordination and approval by Department staff, if the required monitoring is less than 50% complete by August 31st, the County shall implement and satisfy the conditions of this contingency monitoring plan for Sector 3 for completion of the survey by September 30 of each year. Coordination between the County, its consultant, and Department staff to resolve contingency monitoring methodology will take into consideration funding constraints in today's economic climate.

Sediment accumulation measurements will be performed within all quadrats located on the flat (horizontal) surface of hardbottom along each transect. Five random measurements of sediment thickness will be performed within each quadrat using a ruler to measure to the nearest cm. Continuous layers of sediment less than 1 cm covering the hardbottom surface and benthos shall be recorded. Sediment accumulation measurements shall also be recorded at each pin along the transect and at 1 meter west of hardbottom edge (0-mark) or subsequent exposed hardbottom ridges; sediment accumulation shall be estimated by measuring the distance from the pin on the crest of the ledge to the foot of the ledge (sand).

At a minimum, during each post-construction monitoring event, eight of the twelve 150-meter monitoring transects and the four reference/control transects shall be sampled using digital video in progressive scan mode according to the requirements of the monitoring plan. Landscape panoramic views shall be recorded with the digital video camera at the start and end of each transect, and at each interruption of the transect by a sand gap/recommencement at the next hardbottom ridge. DGPS positioning will be obtained for the landward edge (0 mark) and seaward edge of the first nearshore hardbottom ridge, and for all subsequent hardbottom ridges/exposed hardbottom located seaward along the 180-meter transect. Close-up digital still video/photographs shall be obtained of representative benthos along the transect to aid in identification during video analysis.

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At a minimum, the two 20-meter digital video segments for quantitative analysis shall be collected and analyzed according to the requirements of the hardbottom monitoring plan along the eight cross-shore transects as sampled above. Estimate of percent cover (projected to the surface) will be performed for each image to the lowest taxonomic level possible according to the quality of the digital video data. At a minimum, the following functional groups shall be identified: scleractinian corals, octocorals, macroalgae (to the genus level if possible, if not, then according to the following breakdown: calcareous red, calcareous green, fleshy brown, fleshy red, fleshy green), microalgae/cyanobacteria, sponges, tunicates hydroids, wormrock, zoanthids, urchins, holothuroids, and substrate. Substrate shall be broken down into the following categories: unconsolidated substrate (rubble/shell hash, rhodoliths), sediment over hardbottom, sediment over benthos (where the underlying fauna cannot be identified due to the sediment cover), and sand.

The nearshore hardbottom edge between R-77 and R-3 in Martin County was mapped during pre-construction monitoring event during the summers of 2008 and 2009. All subsequent post-construction monitoring events, a towed-diver system with DGPS-integrated video will be utilized to document conditions along the previously mapped nearshore hardbottom edge between R-87 and R-3 (Project extent and 3000' downdrift), for comparison to the pre-construction survey. This method is employed by diver swimming the hardbottom edge with a DGPS antenna, and DGPS-integrated video will be utilized to document the conditions and benthic communities along the nearshore hardbottom edge. If visibility conditions do not allow for a diver-mapped hardbottom interface during post-construction surveys, the

County shall coordinate with the Department to obtain additional biological information (vertical relief, community type, dominant benthos) during the shore-perpendicular beach profiles at 250-foot intervals.

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