APPENDIX D

SOUTHERN PALM BEACH ISLAND COMPREHENSIVE

SHORELINE STABILIZATION PROJECT

2013 HABITAT CHARACTERIZATION REPORT

(CB&I, 2014)

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SOUTHERN PALM BEACH ISLAND
COMPREHENSIVE SHORELINE STABILIZATION PROJECT
2013 HABITAT CHARACTERIZATION REPORT

Prepared for:

Town of Palm Beach and Palm Beach County

Prepared by:

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July 2014

SOUTHERN PALM BEACH ISLAND
COMPREHENSIVE SHORELINE STABILIZATION PROJECT
2013 HABITAT CHARACTERIZATION REPORT

EXECUTIVE SUMMARY

Palm Beach County is located on Florida's east coast approximately 60 miles north of Miami. There are 38 incorporated municipalities within Palm Beach County including four (4) located within the Study Area. These include the Towns of Palm Beach, South Palm Beach, Lantana and Manalapan. The Project Area for the Southern Palm Beach Island Comprehensive Shoreline Stabilization Project comprises approximately 3.3 km (2.1 mi) of shoreline and nearshore environment extending from R-129-210 (south of Lake Worth Municipal Beach located within the Town of Palm Beach) southward to R-138+551 (the Eau Palm Beach Resort & Spa in Manalapan).

The purpose of this report was to assess the existing conditions of the beach and nearshore hardbottom resources within and adjacent to the Project Area (including areas immediately to the north and south). The assessment included the nearshore resources between R-127 and R-141 for a total length of approximately 4.8 km (3.0 mi), herein referred to as the Study Area. The most recent aerial images were provided by Palm Beach County's Department of Environmental Resources Management (PBC-ERM) and delineated in GIS by CB&I Coastal Planning & Engineering, Inc. (CB&I). This resulted in a total area of 14.96 ha (36.96 ac) of nearshore hardbottom adjacent to the Study Area at the time the aerials were flown (March 2013). Originally, fifteen (15) transects were planned for benthic characterization. However, no hardbottom resources were located north and immediately south of the Lake Worth pier; therefore, only twelve (12) shore-perpendicular transects were sampled between R-130 and R-141 on October 21 and 23, 2013. Previous surveys within this area were conducted in May and July 2006. In this report, the 2006 dataset was analyzed for comparison to the current hardbottom habitat conditions. Additionally, a survey was conducted in April 2009 and April 2010 to collect hardbottom relief data in support of the South Palm Beach/Lantana Segmented Breakwater Project. Overall, the benthic hardbottom habitat adjacent to the Study Area is very dynamic and ephemeral in nature. The constant burial and reexposure of hardbottom in this area facilitates the development of an opportunistic community dominated by turf and macroalgae species that recruit quickly when substrate is available.

In order to ensure that the two federally listed threatened *Acropora* coral species (*A. cervicornis* and *A. palmata*) were not present on the hardbottom resources adjacent to the project area, PBC-ERM conducted an *Acropora* spp. survey on October 22, 2013. No colonies of *Acropora* or any of the seven (7) coral species proposed for listing under the Endangered Species Act (ESA) were observed.

A dune vegetation assessment was also conducted within the Study Area on November 15, 2013 to document the species present. The Study Area was first analyzed using aerial images to determine areas of extensive vegetation for ground-truthing. The areas characterized by seawalls were not investigated *in situ.* Seagrape was the dominant dune vegetation recorded throughout the surveyed area. The endangered dune plant beach jacquemontia (*Jacquemontia reclinata*) was not observed.

SOUTHERN PALM BEACH ISLAND
COMPREHENSIVE SHORELINE STABILIZATION PROJECT
2013 HABITAT CHARACTERIZATION REPORT

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Video Files from Shore-Perpendicular Transects

1.0. INTRODUCTION

1.1. PROJECT LOCATION

Palm Beach County is located on Florida's east coast approximately 60 miles north of Miami. Palm Beach County and the Town of Palm Beach have both proposed shoreline stabilization projects that are adjacent to one another. The two projects, combined, include four Palm Beach County municipalities - the Towns of Palm Beach, South Palm Beach, Lantana and Manalapan (Figure 1). The U.S. Army Corps of Engineers (USACE) determined that the proposed projects are connected actions, and is therefore evaluating the environmental effects of these projects together. The comprehensive project includes beach and dune restoration, as well as construction of seven (7) low-profile groins, and has been named the Southern Palm Beach Island Comprehensive Shoreline Stabilization Project (the Project). The Project comprises approximately 3.33 km (2.07 mi) of shoreline and nearshore environment from Florida Department of Environmental Protection (FDEP) monuments R-129-210 (south of Lake Worth Municipal Beach located within the Town of Palm Beach) to R-138+551 (the Eau Palm Beach Resort & Spa in Manalapan). The USACE is preparing an Environmental Impact Statement (EIS) in compliance with the National Environmental Policy Act (NEPA) to identify and assess the environmental effects of the Project and its alternatives. Since a biological investigation of the Project Area had not been conducted since 2006 in the southern portion of the Project Area and since 2008 in the northern portion of the Project Area, an updated characterization of the beach and nearshore habitat was conducted in October 2013 to supplement the EIS.

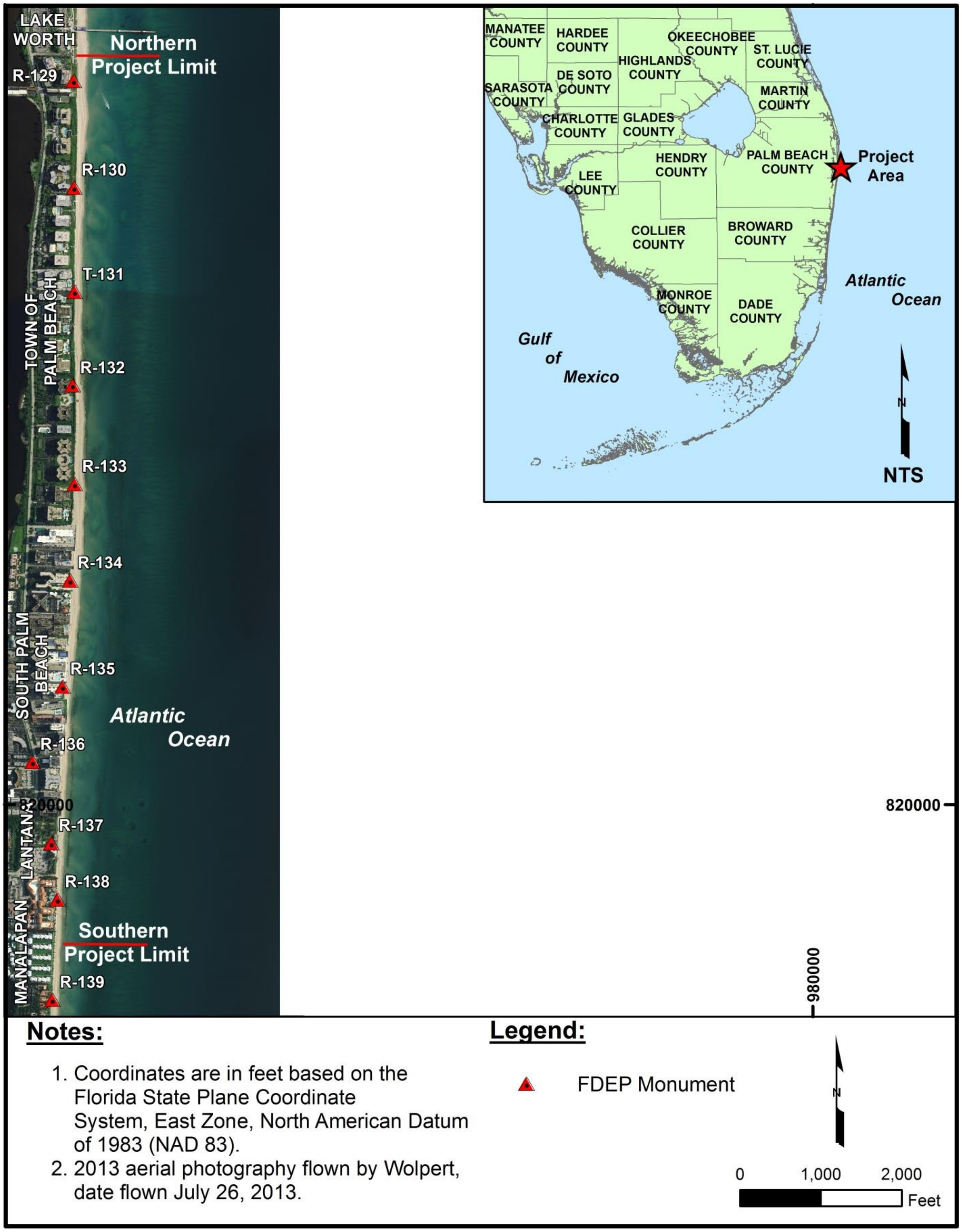

Figure 1. Location map of the Southern Palm Beach Island Comprehensive Shoreline Stabilization Project.

1.2. PROJECT HISTORY

Biological assessments have been conducted in the nearshore marine habitat adjacent to the proposed Project Area within the past several years. Within the Town of Palm Beach, the FDEP Hurricane Recovery Dune Restoration Project was constructed in April and May of 2006 in response to erosion caused by the hurricanes during 2004 and 2005. The project spanned Reaches 7 and 8 in the Town of Palm Beach and was constructed using offshore sand truck-hauled from the Reach 7 Phipps Ocean Park Beach Restoration Project. The biological monitoring program for the 2006 project included shore-perpendicular transects that spanned the width of the nearshore hardbottom resources between R-128 and R-134 (conducted in May 2006). South of the dune project, quantitative assessments were conducted in July 2006 along shore-perpendicular transects between R-134 and R-142 in association with the South Palm Beach/Lantana Erosion Control Study. Within the same project area (R-134 to R-142) and timeframe (September 2006) a dune vegetation survey was conducted to map species coverage and document species location. The data from these surveys will be referenced and used for comparison to the data generated from the 2013 surveys reported herein. The October 2013 biological characterization provides an updated and comprehensive assessment of the Study Area, which includes dune and nearshore resources within and adjacent to the Project Area.

1.3. PROPOSED PROJECT

The Project proposes to use beach fill placement and coastal protection structures to enhance the existing beach and dune system for storm protection to upland property and to improve recreation and enhance the habitat. The Project would place approximately 150,000 cubic yards (cy) of fill along the shorelines of the Town of Palm Beach, South Palm Beach, Lantana and Manalapan from R-129-210 to R-138+551. This project also includes the construction of seven (7) low-profile groins placed perpendicular to the shoreline extending from the existing seawalls to the post-construction (beach fill) waterline in South Palm Beach, Lantana and Manalapan (R-134+113 to R-138+551). Construction of these structures will help stabilize the shoreline by disrupting a portion of the sand flowing south along the beach and encouraging sediment deposition on the updrift (northern) side of the structures. From north to south, the project would place dune fill only from R-129-210 to R-129+150, dune and beach fill from R-129+150 to R-131, dune fill only from R-131 to R-134+113 (Town of Palm Beach southern limit), and beach fill with low-profile groins from R-134+113 to R-138+551. It is anticipated that the mechanism for fill placement would involve use of a truck-haul approach. The sand source would be a combination of stockpiled dredge material from the Reach 7 Phipps Ocean Park Beach Restoration Project (Phipps) or the Mid-Town Beach Restoration Project (Mid-Town) for placement within the Town of Palm Beach project limits (R-129-210 to R-134+113) and upland sand for placement within the project limits in South Palm Beach, Lantana and Manalapan (R-134+113 to R-138+551) (Figure 2).

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Notes:

1. Coordinates are in feet based on the Florida State Plane Coordinate System, East Zone, North American Datum of 1983 (NAD 83).
2. Aerial photography flown by Woolpert, Inc. on July 25-26, 2013.
3. 2013 hardbottom delineated by CB&I. 2006 digitized hardbottom provided by FAU.

Legend:

- 2013 Hardbottom
- 2006 Hardbottom

Dominant Dune Vegetation

- *Coccoloba uvifera*
- *Panicum amarum*
- *Uniola paniculata*

- Buried Seawall
- Seawall
- Applicants' Preferred Project Design
- Proposed Groin
- Transects
- FDEP Monuments

N

Feet
0 100 200

TITLE:

Southern Palm Beach Island Comprehensive Shoreline Stabilization Project Nearshore Hardbottom and Dune Resources

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2481 N. W. Boca Raton Boulevard
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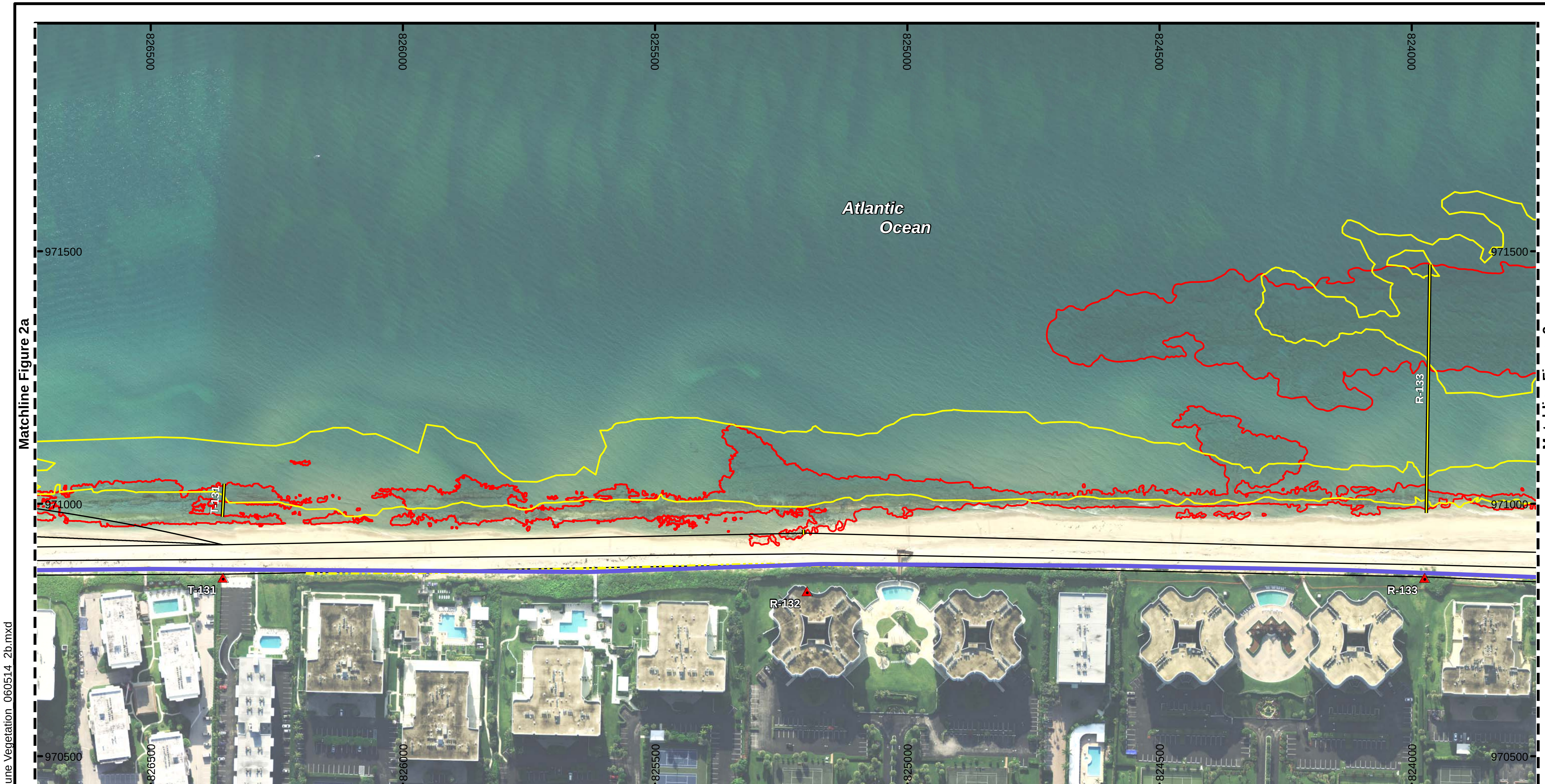
Ph. (561) 391-8102
Fax (561) 391-9116

Date: 06/05/14	By: ALS	Comm No. : 150814	Figure No. 2a



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Matchline Figure 2b

Matchline Figure 2d

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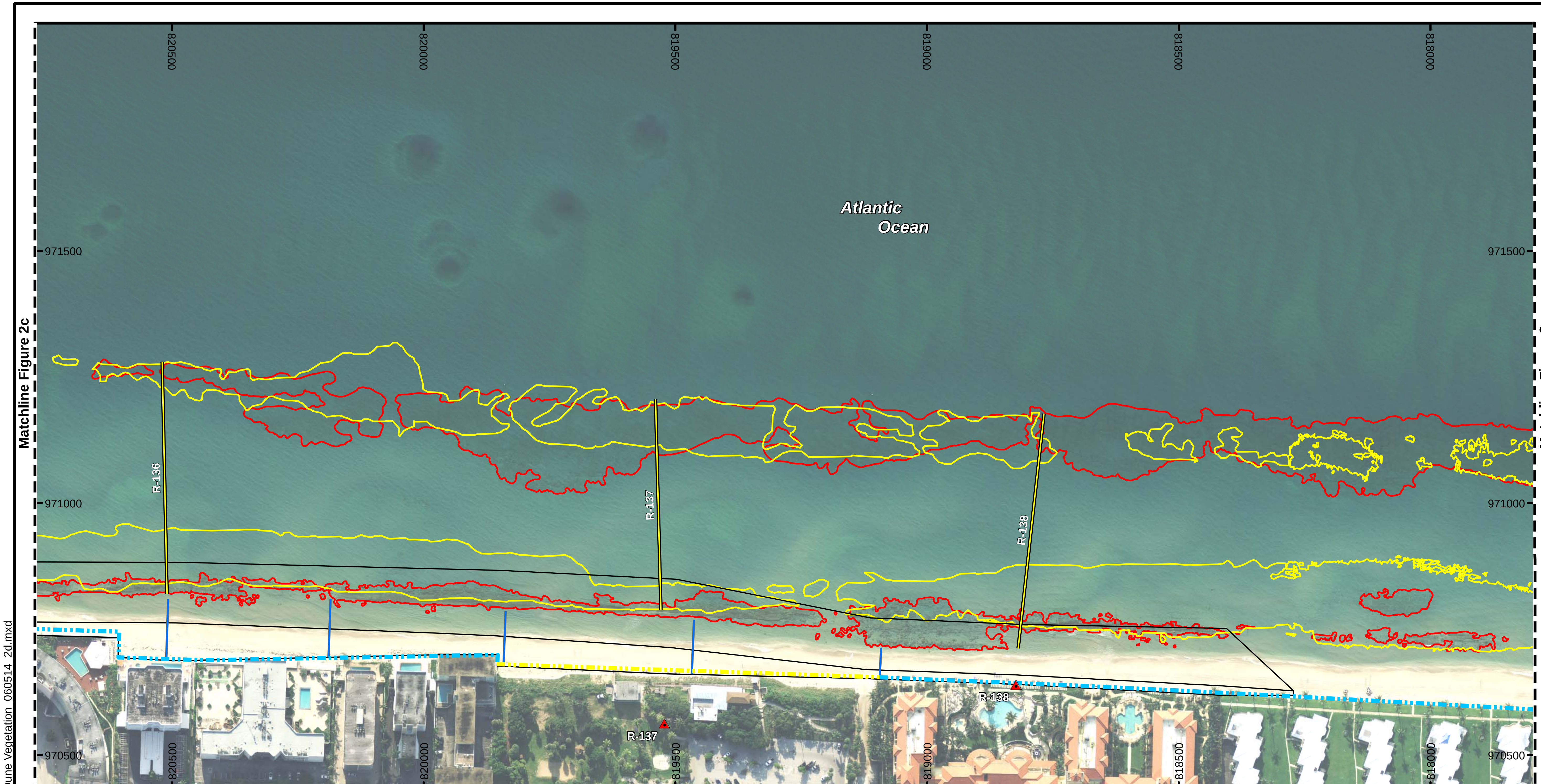

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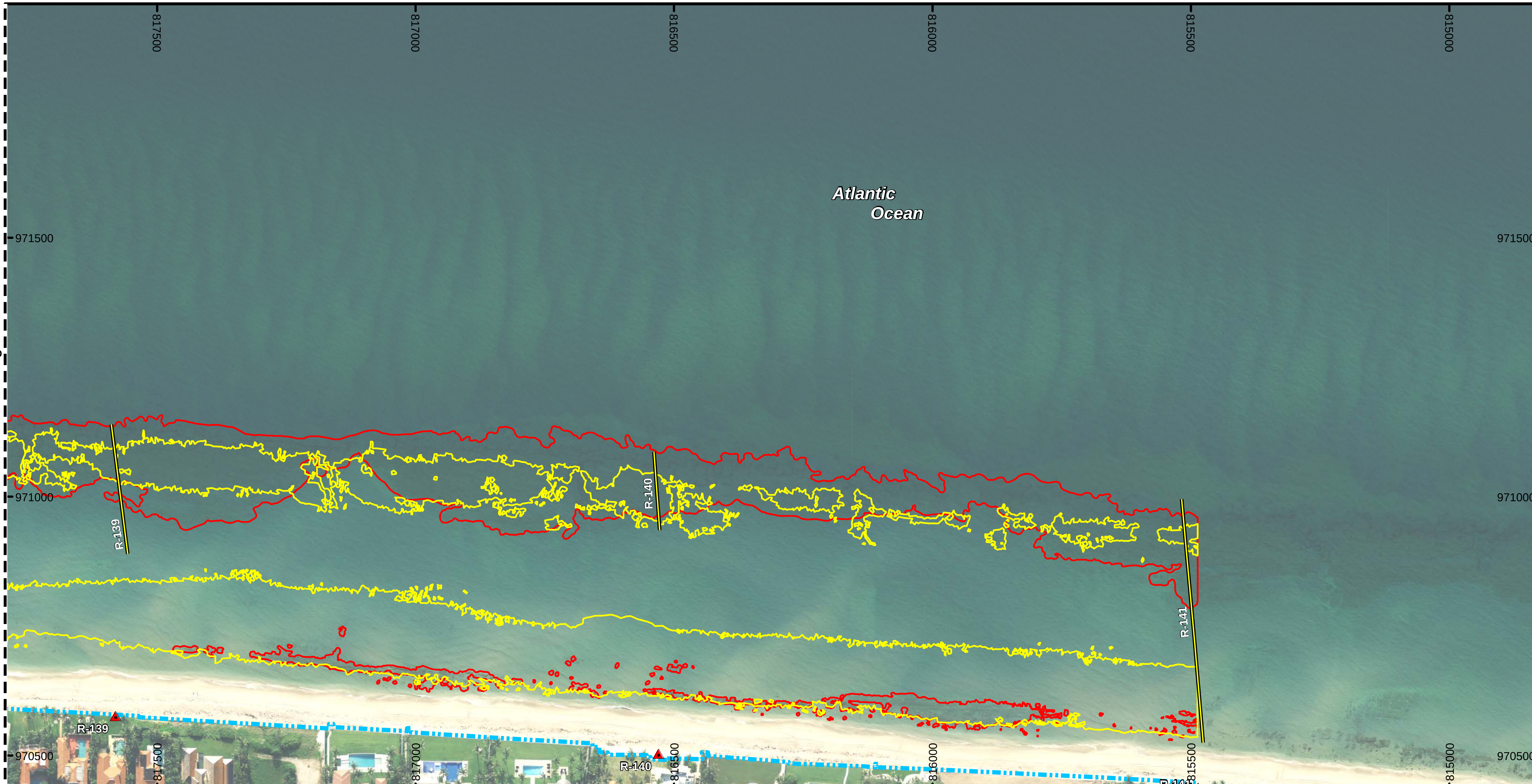
Matchline Figure 2d



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2.0. METHODS

A biological characterization of the dune and nearshore hardbottom habitat was conducted to provide an updated dataset of the environmental conditions within and adjacent to the Project Area (including areas immediately to the north and south). The dune and nearshore hardbottom assessment area included the shoreline between R-127 and R-141 for a total length of approximately 4.8 km (3.0 mi), herein referred to as the Study Area.

2.1. AERIAL DELINEATION OF NEARSHORE HARDBOTTOM RESOURCES

The 2013 rectified aerials were provided by Palm Beach County's Department of Environmental Resources Management. The clear and shallow waters of the Study Area allowed the hardbottom resources to be easily delineated. A marine biologist and GIS specialist delineated the hardbottom resources (Figure 2). A shapefile of the 2013 nearshore hardbottom delineation is also provided on the enclosed CD.

2.2. *IN SITU* ASSESSMENT OF NEARSHORE HARDBOTTOM RESOURCES

Originally, fifteen (15) transects were planned for benthic characterization in the Study Area. However, no hardbottom resources were observed between R-127 and R-129; therefore, twelve (12) shore-perpendicular transects were surveyed between R-130 and R-141. Each transect extended from the landward (western) edge of the hardbottom to the seaward (eastern) extent of the hardbottom or 150 m (whichever was less). The seaward limit of 150 m was determined based on current monitoring requirements regulated by FDEP that are commonly applied in south Florida and supported by examination of 2013 aerial images of the Study Area, which showed that a width of 150 m encompassed the majority of nearshore hardbottom resources in the area. Transect details including the start (west) and end (east) locations, transect length and the number of quadrats sampled in the Study Area are provided in Table 1. The 150-m threshold captured all hardbottom resources along each transect (Figure 2).

Table 1. Study Area transect start (west) and end (east) locations, transect length (m) and the number of quadrats sampled per transect during the October 2013 hardbottom characterization. Transect length and number of quadrats sampled were based on hardbottom resources exposed at the time of the survey.

Transect	Start		End		Transect Length (m)	No. of Quadrats
	Latitude	Longitude	Latitude	Longitude		
R-130	26.607331	-80.036497	26.607304	-80.036347	15.2	13
R-131	26.603851	-80.036585	26.603839	-80.036385	20.3	12
R-132	26.600682	-80.036719	26.600683	-80.036691	2.8	5
R-133	26.597285	-80.036617	26.597255	-80.035112	149.8	12
R-134	26.593934	-80.036092	26.594019	-80.035166	89.4	16
R-135	26.590368	-80.035784	26.590393	-80.035222	54.9	13
R-136	26.587768	-80.037194	26.587785	-80.035784	140.0	12
R-137	26.585090	-80.036035	26.585069	-80.037314	127.5	13
R-138	26.583119	-80.037562	26.582968	-80.036140	148.1	12
R-139	26.579644	-80.037046	26.579725	-80.036281	78.1	14
R-140	26.576811	-80.036931	26.576838	-80.036468	44.6	12
R-141	26.573969	-80.037610	26.574032	-80.036771	145.5	15

The 2013 transect locations were based on previously sampled transects surveyed in 2006; the same size quadrats (0.25 m^2) were utilized in order to generate an easily comparable dataset. Transect length was determined *in situ* based upon the extent of exposed nearshore hardbottom within 150 m of the nearshore hardbottom edge. Quadrat placement was biased to hardbottom in order to avoid sampling sand patches. A total of 147 quadrats and 12 transects were sampled during the 2013 characterization. Along each transect, the quadrat-based Benthic Ecological Assessment for Marginal Reefs (BEAMR) methodology (Lybolt and Baron, 2006) was utilized, along with video documentation, line-intercept for sediment, and interval sediment depth measurements. Representative photographs were taken along each transect and GPS coordinates were recorded at the start and end of each transect when water depth allowed boat access. When the boat could not access the start (inshore) point of a transect due to shallow water depth, divers recorded the distance from the start point of the transect to the closest GPS coordinate that could be collected in order to determine the transect start point coordinates.

2.2.1. BENTHIC ECOLOGICAL ASSESSMENT

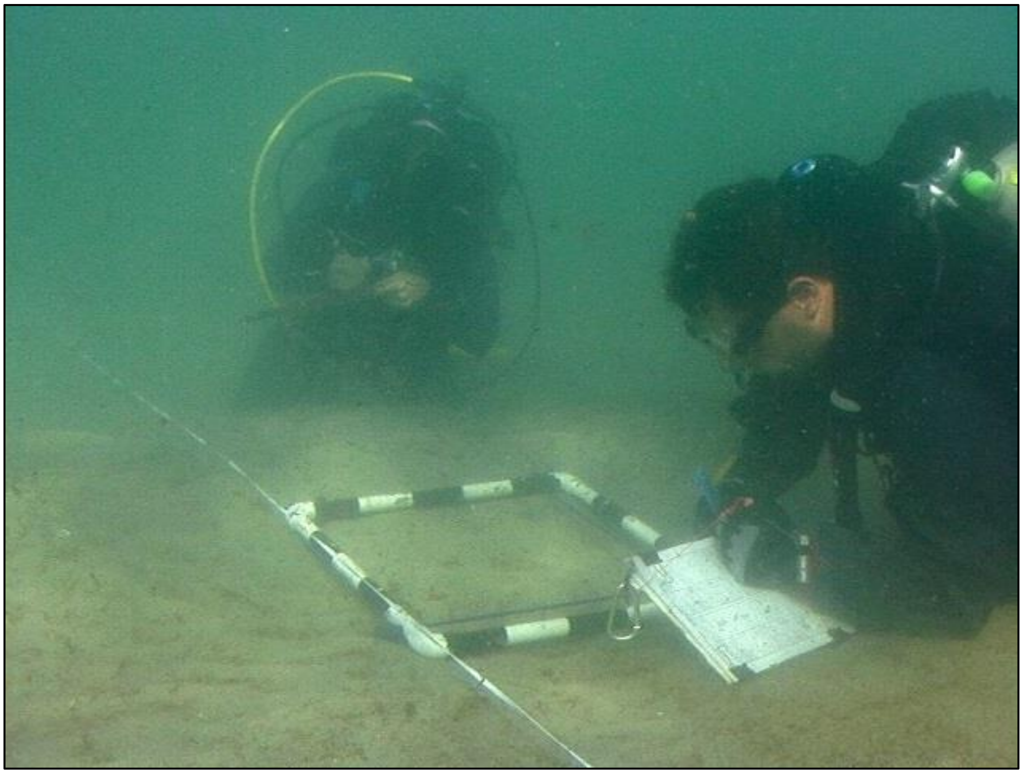
The BEAMR methodology (Lybolt and Baron, 2006) was used for *in situ* sampling to evaluate the benthic cover of the nearshore hardbottom (Photograph 1). It is a quadrat-based methodology that samples three characteristics of the benthos: physical structure, planar percent cover of sessile benthos, and coral/octocoral density. As with all non-consumptive surveys, BEAMR is necessarily constrained to visually conspicuous organisms with well-defined, discriminating characteristics for identification.

Physical characteristics recorded from quadrats include the maximum topographic relief (cm) and the maximum sediment depth (cm). Maximum relief was measured from the lowest to the highest point of attached hard substratum in the quadrat, inclusive of organisms with stony skeletons (i.e., relief measurements do not include octocorals, tunicates, macroalgae, etc.).

Sediment depth measurements were taken within each quadrat and sediment depths greater than 1 cm were recorded. The length of the ruler determined the maximum detectable sediment depth at a given point (e.g., for a 30-cm ruler, the value 30 denotes sediment ≥ 30 cm deep).

Estimates of the planar percent cover of all sessile benthos are pooled to 19 major functional groups that include: sediment, macroalgae, turf algae, encrusting red algae, sponge, hydroid, octocoral, scleractinian coral, tunicate, bare hard substrate, anemone, barnacle, bryozoan, bivalve, *Millepora* spp., seagrass, sessile annelid, wormrock and zoanthid. Additionally, the breakdown of macroalgae genera and bioeroding sponge species percent cover that occupied at least 1% cover were recorded.

Coral density was estimated by individual colony count. The maximum diameter (cm) and species of each scleractinian (stony) coral, and the maximum height (cm) and genus of each octocoral were recorded. Encrusting octocorals were measured by their maximum diameter (cm), similar to stony corals.



Photograph 1. Divers conducting the Benthic Ecological Assessment for Marginal Reefs (BEAMR) methodology during the 2013 characterization survey.

2.2.2. VIDEO DOCUMENTATION

Video was recorded using a digital video camera in an underwater housing along each shore-perpendicular transect to provide a record of the conditions of each transect at the time of the survey. The speed of the video did not exceed 5 m per minute and the camera was held at a height of 40 cm above the substrate.

2.2.3. SEDIMENT COVER

The line-intercept methodology used to document sediment cover and the location of physical transitions in the nearshore habitat along the shore-perpendicular transects. The location of hardbottom boundaries interrupted by sand patches larger than 0.5 m in length was documented using two substrate designations: nearshore hardbottom and sand. Nearshore hardbottom was clearly exposed consolidated substrate with the potential for recruitment of benthic organisms, and sand was defined as areas of uninterrupted sediment at least 0.5 m in length with a depth greater than 1.0 cm with no emerging biota. Areas where biota emerged through sand were considered hardbottom regardless of sand depth in the line-intercept survey. The line-intercept data provide a ratio of hardbottom to sand for the area along each transect.

2.2.4. SEDIMENT DEPTH

Sediment depth data were collected at 1.0-m intervals along each shore-perpendicular transect. Sediment depth data provide a snapshot of the shore-perpendicular sand distribution across and between the nearshore hardbottom patches at each sampling event.

2.2.4. FISH OBSERVATIONS

Transect-counts were utilized for visually assessing the fish assemblage structure along the hardbottom located in the Study Area during the 2006 survey. While a formal quantitative fish survey was not required for the 2013 protocol, all fish taxa encountered during the 2013 benthic survey were recorded.

2.3. DUNE VEGETATION SURVEY

Following an examination of aerial photography to determine specific areas of interest along the Study Area which may support dune vegetation, CB&I biologists ground-truthed the extent of vegetation using a Differential Global Positioning System (DGPS) on November 15, 2013. Biologists started the survey south of Lake Worth Pier and continued south until the dune habitat ended and extensive seawalls began at approximately R-133+500. Dominant species were identified and photographs were collected throughout the survey area. Particular effort was made to identify and document the presence of the endangered plant species beach jacquemontia (*Jacquemontia reclinata*).

2.4. STATISTICAL ANALYSIS

Benthic data were entered into a Microsoft Access database for data management. Vertical relief data were exported to Microsoft Excel for comparisons and statistical testing while benthic data were exported to PRIMER v6 (Clark and Gorley, 2006; Clark and Warwick, 2001) for statistical testing. Data analyses consisted of non-parametric univariate and multivariate statistical tests. Statistical significance was determined at $\alpha = 0.05$ (95% confidence interval) and all reference to "significance" has been determined through statistical analysis. Variations of each analytical application are specified in the appropriate results section, *i.e.,* standardization, transformation, *etc.*

Univariate Statistics

Hartley's F_{max} test was used to compare variances of the intertidal and subtidal relief for each year, and to compare 2006 data to 2013 data. As these data were homoscedastic but failed to meet the normality assumption, the non-parametric Mann-Whitney U test (which is essentially the Kruskal-Wallis test applied to two samples), was used to determine significant differences in relief.

Multivariate Statistics

Non-parametric multivariate statistical analyses were conducted using PRIMER v6 (Clark and Gorley, 2006; Clark and Warwick, 2001). Below is a brief description of the tools and analyses applied to the dataset.

Data Pre-Treatment. Data transformation was applied to downweight the contributions of quantitatively dominant species to the similarities calculated between samples. It is particularly important for the Bray-Curtis similarity, which does not incorporate any form of scaling of each taxon by its total or maximum across all samples. The more severe the transformation, the more strength is given to the less abundant taxa.

Resemblance. A definition of resemblance between every pair of samples is fundamental to the operation of any multivariate analysis. Within PRIMER, the term ‘resemblance’ covers the three concepts of similarity, dissimilarity and distance. Similarity ranges between 0 (completely different) to 100 (perfect similarity), dissimilarity is the complement of similarity (100-similarity), and distance ranges from 0 to infinity. The most commonly used similarity coefficient for biological community analysis is the Bray-Curtis similarity because it obeys many of the ‘natural’ biological axioms that most other coefficients do not.

Analysis of Similarity (ANOSIM). ANOSIM is an approximate analogue of the standard univariate 1- and 2-way analysis of variance test and results in a test statistic (R-statistic) and a level of significance (*p*-value) under the null hypothesis that no differences exist between samples being compared. The R-value varies between 0 (no differences) and 1 (differences) – R will be near 0 when differences do not exist and closer to 1 when differences do exist. The *p*-value determines significant differences based on the pre-determined alpha ($\alpha = 0.05$).

Similarity Percentages (SIMPER). When differences between groups of samples have been shown to exist (from ANOSIM), the SIMPER routine was applied to determine which taxa (functional group, genus, species, *etc.*) contributed to the average dissimilarity ($\bar{\delta}$) between the groups. A lower dissimilarity does not mean that the two groups being compared have similar communities (as ANOSIM indicates), but merely indicates when the average dissimilarity increases and decreases and which taxa are contributing to that dissimilarity.

Cluster Analysis with Similarity Profile (SIMPROF). PRIMER carries out simple agglomerative, hierarchical clustering from a resemblance matrix. The output is a dendrogram which displays the grouping of samples into successively smaller numbers of clusters. The SIMPROF test is a series of permutation tests which looks for statistically significant evidence of genuine clusters in samples which are *a priori* unstructured. When the SIMPROF analysis is undertaken, tests are performed at every node of the completed dendrogram and significant differences between samples are indicated.

3.0. RESULTS

Electronic copies of Appendices A through F are included on the enclosed CD. The logbook field notes and raw datasheets are included in Appendices A and B, respectively. Appendix C includes an Excel spreadsheet with 2013 BEAMR, line-intercept and sediment depth data, and Appendix D includes the 2013 hardbottom delineation and dune vegetation shapefiles. The South Palm Beach/Lantana Breakwaters Feasibility Study, Hardbottom Relief Observation Report (CPE, 2010) is provided as Appendix E and results of the PBC-ERM 2013 *Acropora* Reconnaissance Survey are provided in Appendix F. Transect videos documenting the shore-perpendicular transects are included on the enclosed DVDs.

3.1. AERIAL DELINEATION OF HARDBOTTOM RESOURCES

The nearshore hardbottom resources in the Study Area are defined by two shore-parallel ridges that are considered ephemeral. When described separately herein, these are referred to as the intertidal and subtidal hardbottom ridges. Aerial delineations conducted between 2003 and 2013 have shown that both, one or neither of these ridges may be exposed at any given time. The 2013 aerial delineation resulted in 36.96 ac of exposed hardbottom between R-127 and R-141, compared to 48.78 ac of hardbottom in 2006 (Figure 2). The location of the hardbottom resources exposed in 2006 and 2013 are similar; however, when several additional years of hardbottom delineation are presented, the ephemeral nature of these hardbottom resources is apparent. Figure 3 shows the changes observed between 2003, 2007, 2011 and 2013. Not only does the actual location of exposed hardbottom change but the total area of exposure has also varied drastically over time (Table 2). The least amount of exposed hardbottom occurred in 2009 (2.71 ac) and the greatest amount was present in 2006 (48.78 ac) (Figure 4).

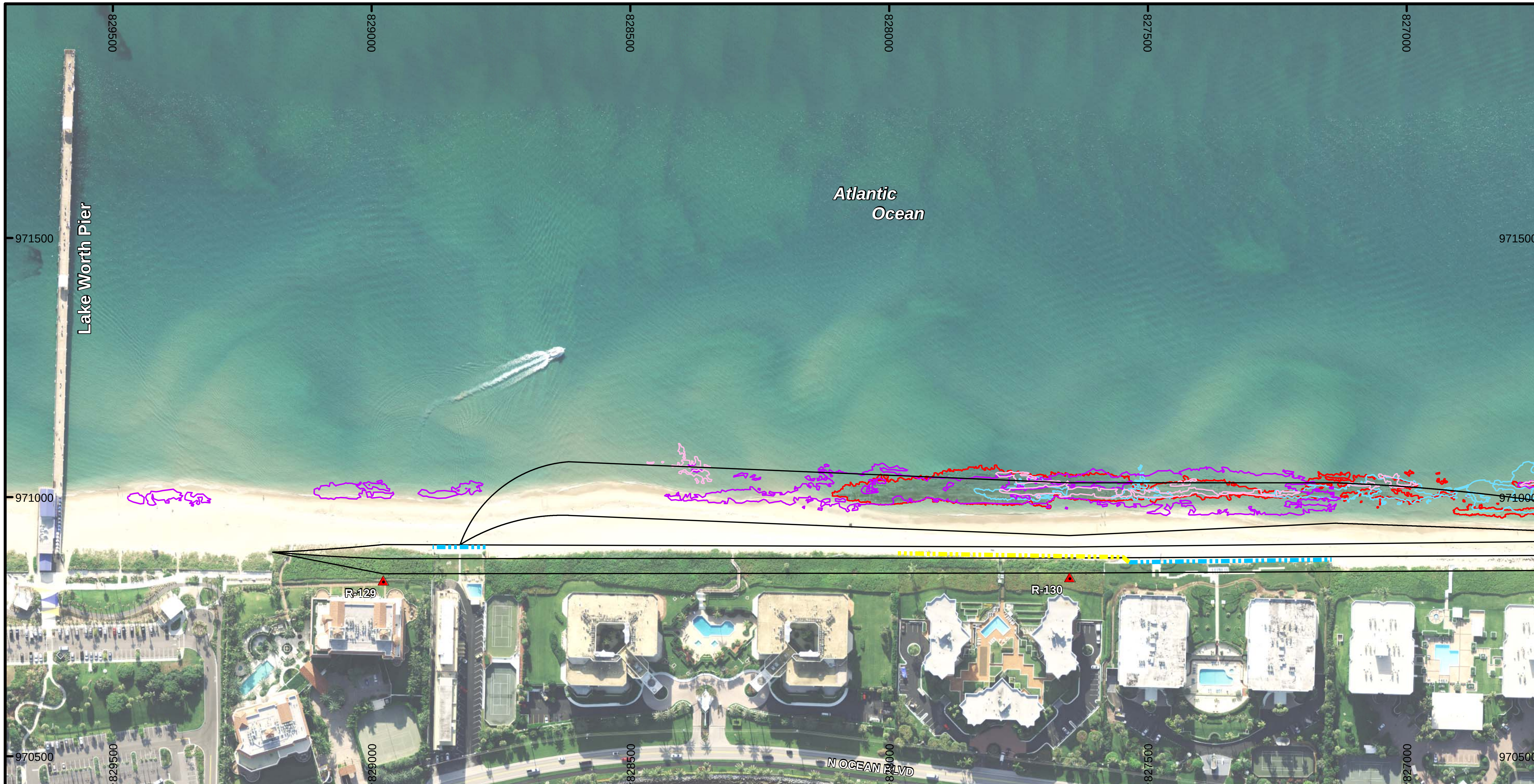
In order to determine the amount of persistent hardbottom exposure, an analysis was conducted in GIS to determine the area and location of hardbottom that was exposed during all aerial delineations between 2003 and 2013. This resulted in a very small area

(0.000392 ac) of hardbottom located on the intertidal hardbottom about 350 ft north of R-133 (Figure 4), supporting the overall designation of hardbottom habitat in the Study Area as ephemeral.

Due to the dynamic nature of sand movement in this area, the hardbottom is constantly exposed to burial and scouring resulting in an opportunistic benthic community dominated by turf and macroalgae and supporting small coral colonies. A survey conducted in 2009 and 2010 to collect hardbottom relief data in support of the South Palm Beach/Lantana Segmented Breakwaters Project (Appendix E) also noted a significant change in exposed hardbottom from year to year. Although quantitative benthic data were not collected for these surveys, various macroalgae species were observed in 2009; however, the hardbottom appeared mostly either buried or well scoured during the 2010 investigation and no macroalgae was noted. Although this habitat is very dynamic, it provides food resources and refuge for benthic and fish species.

Table 2. Exposed hardbottom acreage delineated from aerial imagery between 2003 and 2013 in the Study Area (R-127 to R-141).

Year of Delineation	Area (ac)
2003	4.57
2004	25.03
2005	35.59
2006	48.78
2007	38.94
2008	27.61
2009	2.71
2010 (June)	16.70
2010 (October)	8.02
2011	15.19
2012	16.13
2013	36.96



G:\Enterprise\Palm Beach\150814\Mxd\Dune Vegetation All HB 060514 3a.mxd

Notes:

1. Coordinates are in feet based on the Florida State Plane Coordinate System, East Zone, North American Datum of 1983 (NAD 83).
2. Aerial photography flown by Woolpert, Inc. on July 25-26, 2013.
3. 2013 hardbottom delineated by CB&I.
   2011 hardbottom provided by Tetra Tech.
   2007 digitized hardbottom provided by FAU.
   2003 digitized hardbottom provided by PBC-ERM.

Legend:

- 2013 Hardbottom
- 2011 Hardbottom
- 2007 Hardbottom
- 2003 Hardbottom
- Buried Seawall
- Seawall
- Applicants' Preferred Project Design
- Proposed Groin
- FDEP Monuments

N

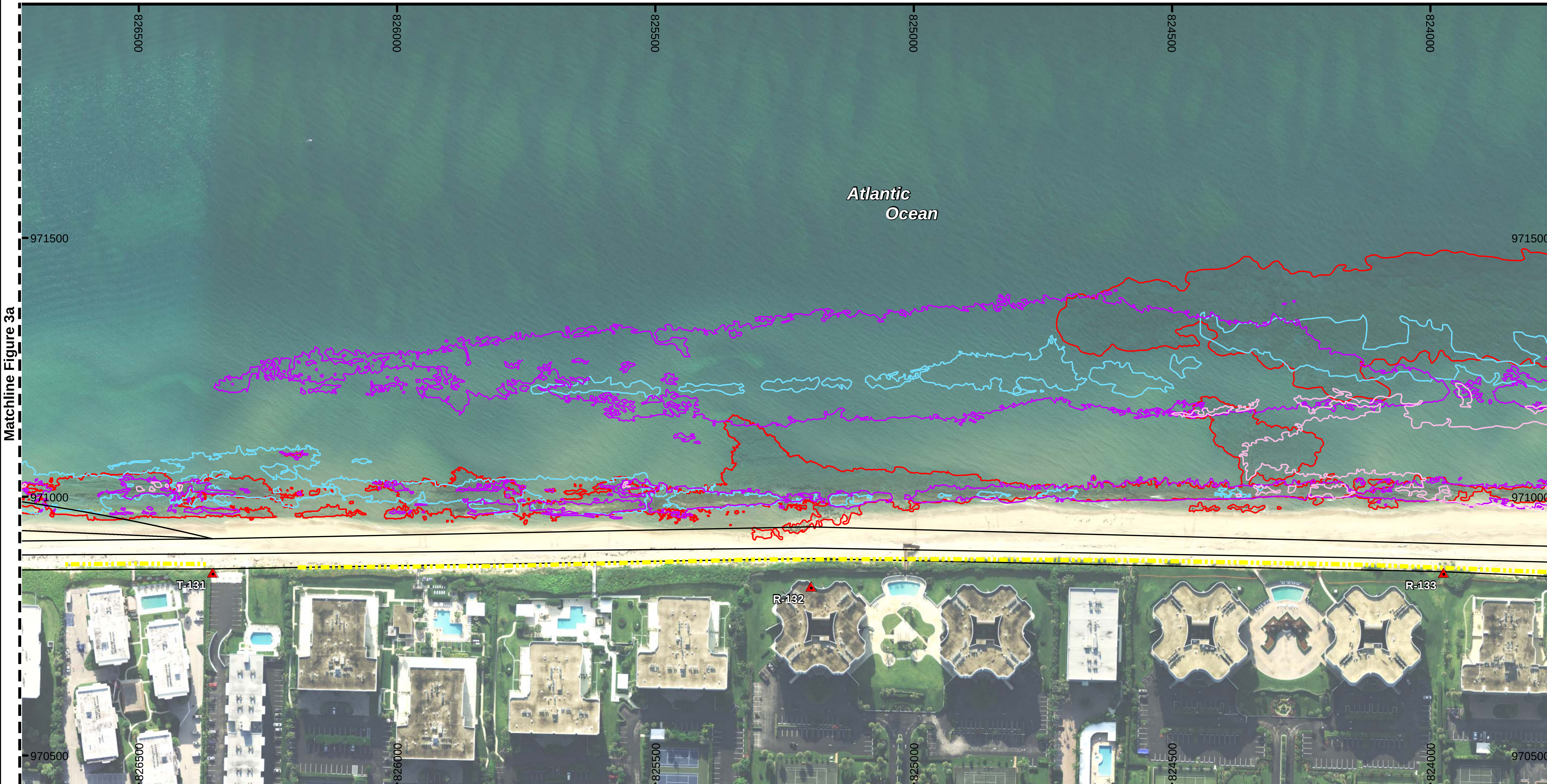
0 100 200 Feet

TITLE:

Southern Palm Beach Island Comprehensive Shoreline Stabilization Project Nearshore Hardbottom Resources (2003-2013)

CB&I
Coastal Planning & Engineering, Inc.
2481 N. W. Boca Raton Boulevard
Boca Raton, FL 33431
Ph. (561) 391-8102
Fax (561) 391-9116

Date: 06/05/14	By: ALS	Comm No. : 150814	Figure No. 3a



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Notes:

1. Coordinates are in feet based on the Florida State Plane Coordinate System, East Zone, North American Datum of 1983 (NAD 83).
2. Aerial photography flown by Woolpert, Inc. on July 25-26, 2013.
3. 2013 hardbottom delineated by CB&I. 2011 hardbottom provided by Tetra Tech. 2007 digitized hardbottom provided by FAU. 2003 digitized hardbottom provided by PBC-ERM.

Legend:

- 2013 Hardbottom
- 2011 Hardbottom
- 2007 Hardbottom
- 2003 Hardbottom
- Buried Seawall
- Seawall
- Applicants' Preferred Project Design
- Proposed Groin
- FDEP Monuments

N

Feet
0 100 200

TITLE:

Southern Palm Beach Island Comprehensive Shoreline Stabilization Project Nearshore Hardbottom Resources (2003-2013)

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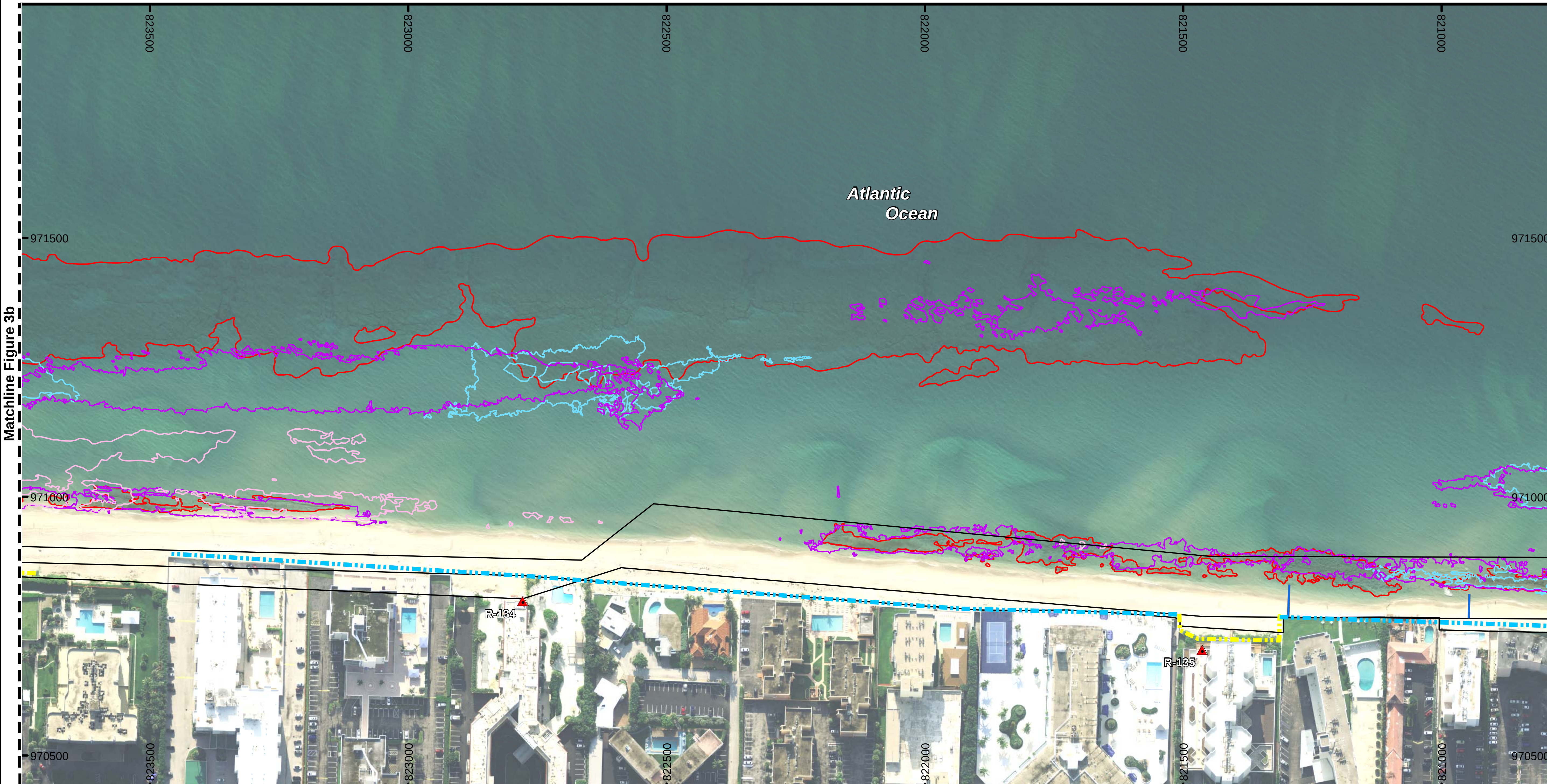
Date: 06/05/14	By: ALS	Comm No. : 150814	Figure No. 3b



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Notes:

1. Coordinates are in feet based on the Florida State Plane Coordinate System, East Zone, North American Datum of 1983 (NAD 83).
2. Aerial photography flown by Woolpert, Inc. on July 25-26, 2013.
3. 2013 hardbottom delineated by CB&I.
   2011 hardbottom provided by Tetra Tech.
   2007 digitized hardbottom provided by FAU.
   2003 digitized hardbottom provided by PBC-ERM.

Legend:

- 2013 Hardbottom
- 2011 Hardbottom
- 2007 Hardbottom
- 2003 Hardbottom
- Buried Seawall
- Seawall
- Applicants' Preferred Project Design
- Proposed Groin
- FDEP Monuments

Feet
0 100 200

TITLE:

Southern Palm Beach Island Comprehensive Shoreline Stabilization Project Nearshore Hardbottom Resources (2003-2013)

CB&I
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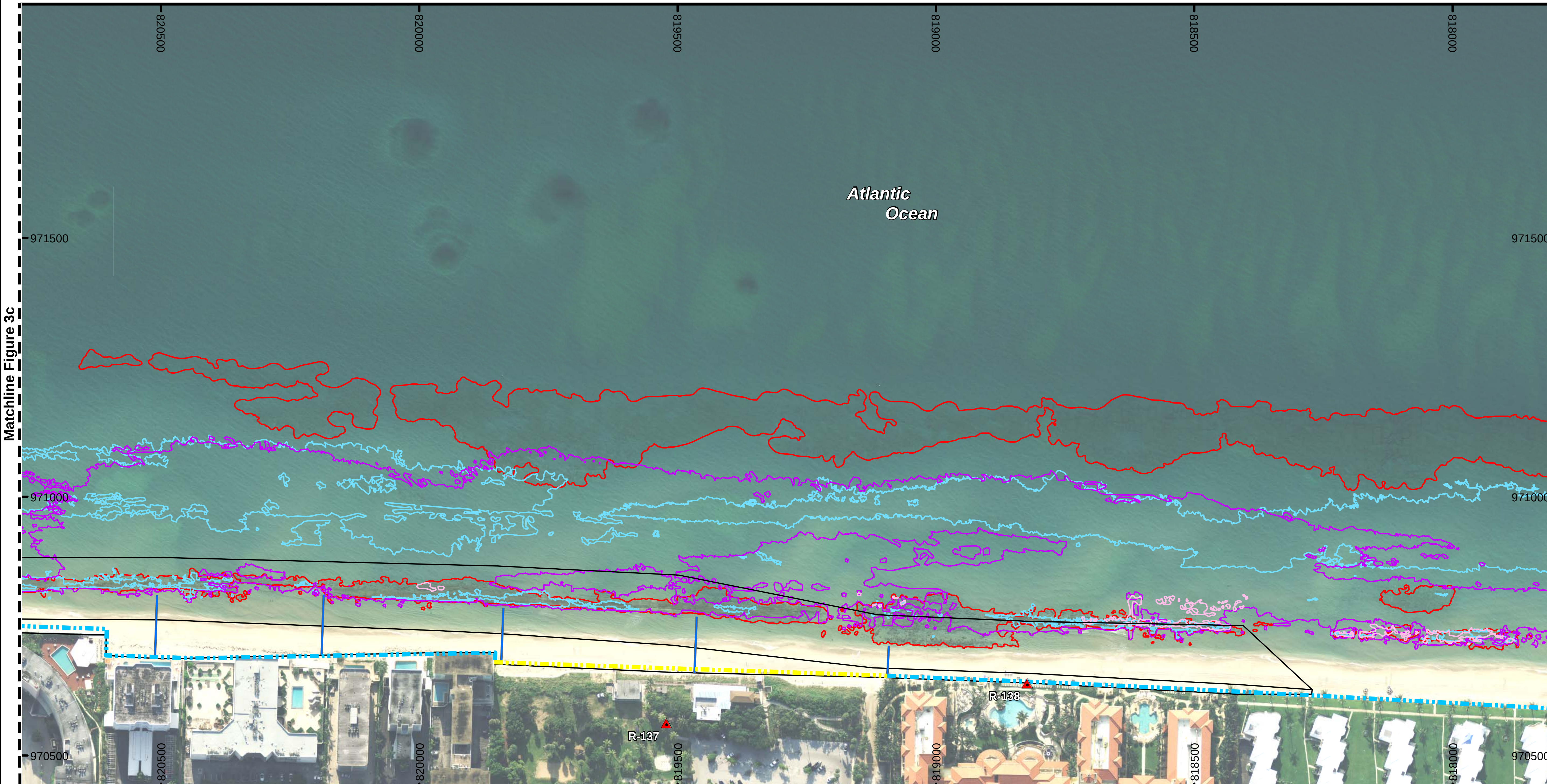
Date: 06/05/14	By: ALS	Comm No. : 150814	Figure No. 3c



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Notes:

1. Coordinates are in feet based on the Florida State Plane Coordinate System, East Zone, North American Datum of 1983 (NAD 83).
2. Aerial photography flown by Woolpert, Inc. on July 25-26, 2013.
3. 2013 hardbottom delineated by CB&I.
   2011 hardbottom provided by Tetra Tech.
   2007 digitized hardbottom provided by FAU.
   2003 digitized hardbottom provided by PBC-ERM.

Legend:

- 2013 Hardbottom
- 2011 Hardbottom
- 2007 Hardbottom
- 2003 Hardbottom
- Buried Seawall
- Seawall
- Applicants' Preferred Project Design
- Proposed Groin
- FDEP Monuments

N

Feet
0 100 200

TITLE:

Southern Palm Beach Island Comprehensive Shoreline Stabilization Project Nearshore Hardbottom Resources (2003-2013)

CB&I
Coastal Planning & Engineering, Inc.
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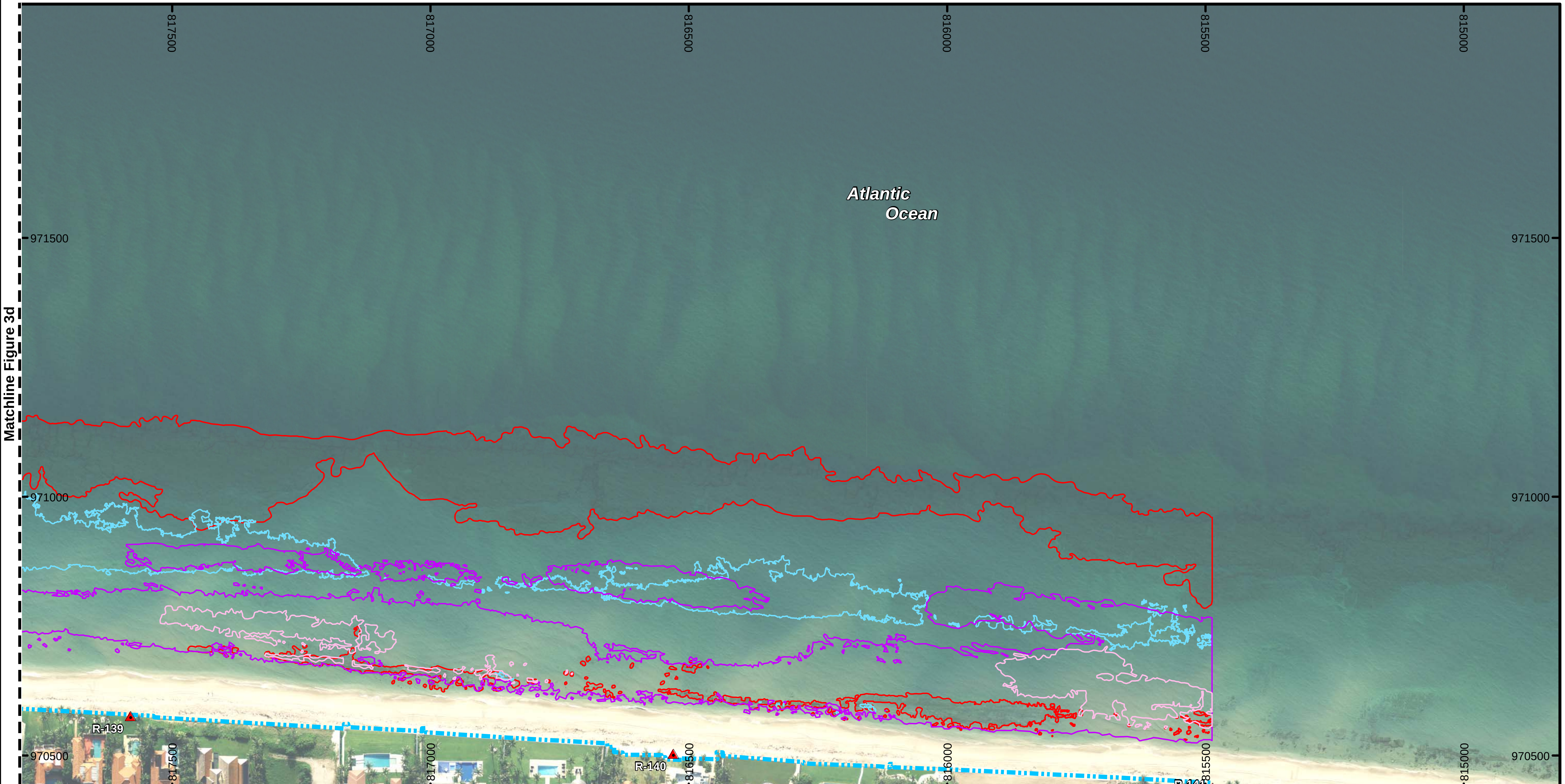
Boca Raton, FL 33431
Ph. (561) 391-8102
Fax (561) 391-9116

Date: 06/05/14	By: ALS	Comm No. : 150814	Figure No. 3d

Matchline Figure 3d



Notes:

1. Coordinates are in feet based on the Florida State Plane Coordinate System, East Zone, North American Datum of 1983 (NAD 83).
2. Aerial photography flown by Woolpert, Inc. on July 25-26, 2013.
3. 2013 hardbottom delineated by CB&I. 2011 hardbottom provided by Tetra Tech. 2007 digitized hardbottom provided by FAU. 2003 digitized hardbottom provided by PBC-ERM.

Legend:

- 2013 Hardbottom
- 2011 Hardbottom
- 2007 Hardbottom
- 2003 Hardbottom
- Buried Seawall
- Seawall
- Applicants' Preferred Project Design
- Proposed Groin
- FDEP Monuments

N

0 100 200 Feet

TITLE:

Southern Palm Beach Island Comprehensive Shoreline Stabilization Project Nearshore Hardbottom Resources (2003-2013)

CB&I
Coastal Planning & Engineering, Inc.
2481 N. W. Boca Raton Boulevard
Boca Raton, FL 33431
Ph. (561) 391-8102
Fax (561) 391-9116

Date: 06/05/14	By: ALS	Comm No. : 150814	Figure No. 3e

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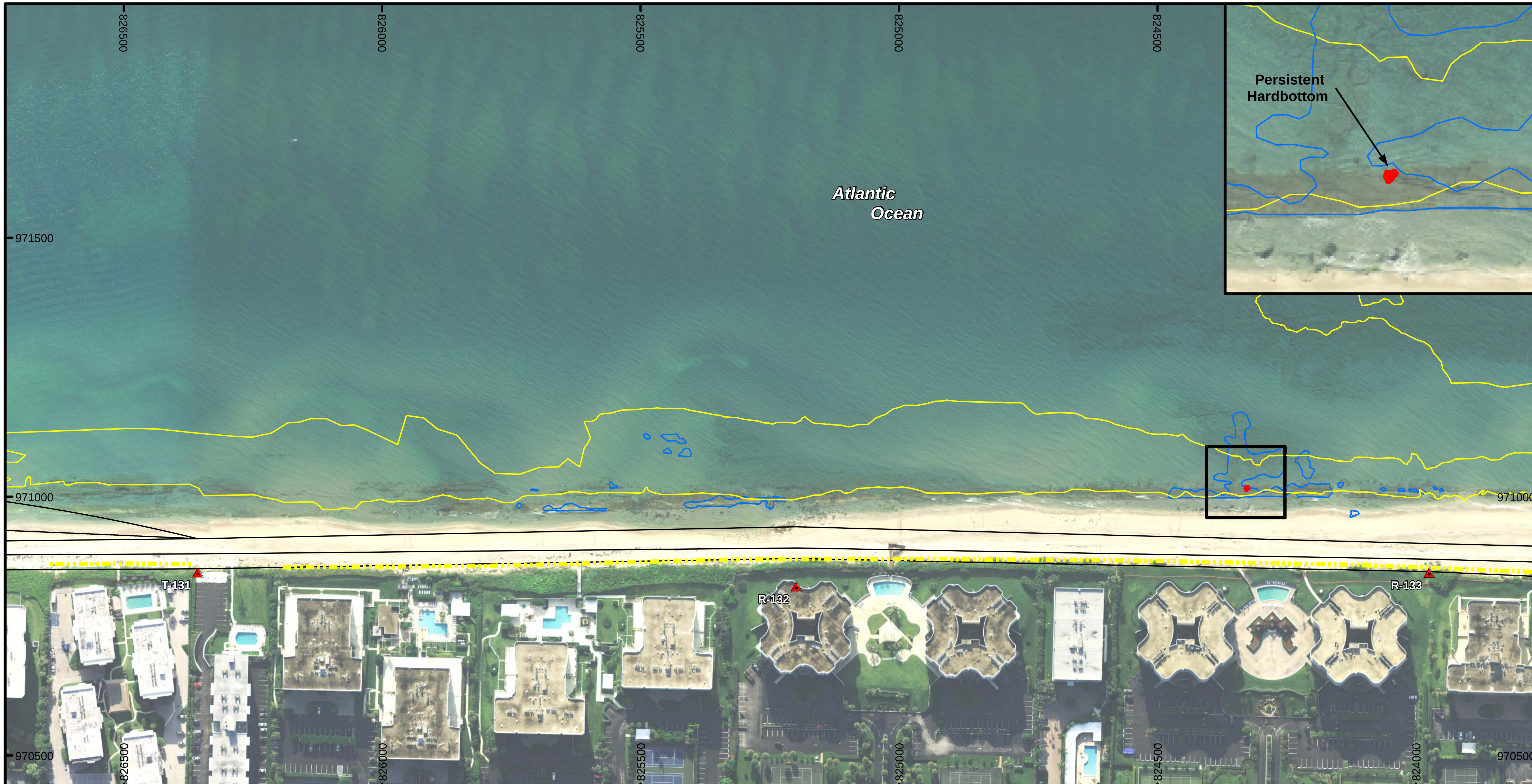

Notes:

1. Coordinates are in feet based on the Florida State Plane Coordinate System, East Zone, North American Datum of 1983 (NAD 83).
2. Aerial photography flown by Woolpert, Inc. on July 25-26, 2013.
3. 2006 and 2009 digitized hardbottom provided by FAU.

Legend:

- Persistent Hardbottom (2003 - 2013)
- 2009 Hardbottom
- 2006 Hardbottom
- Buried Seawall
- Applicants' Preferred Project Design
- FDEP Monuments

N

Feet
0 100 200

TITLE:

Southern Palm Beach Island Comprehensive Shoreline Stabilization Project Persistent Hardbottom Resources (2003-2013)

CB&I
Coastal Planning & Engineering, Inc.
2481 N. W. Boca Raton Boulevard
Boca Raton, FL 33431
Ph. (561) 391-8102
Fax (561) 391-9116

Date: 02/04/14	By: HMV	Comm No. : 150814	Figure No. 4

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3.2. SEDIMENT DYNAMICS

Line-intercept for sediment and sediment depth measurements were collected along all twelve (12) transects in 2013; however, line-intercept was collected along only eight (8) transects in 2006 (R-134 to R-141) and sediment depth was not collected at all. Available data are presented.

3.2.1. LINE-INTERCEPT FOR SEDIMENT

Each transect measured a different length based on the width of exposed hardbottom at each sampling location. For presentation in Figures 5 and 6, each transect length was standardized to the longest transect length from both surveys (2006 and 2013), which was R-135 in 2006 measuring 187 m in length. Since the sampled transects captured all hardbottom present in the subtidal and intertidal areas, it was safe to include the additional transect length (inshore and/or offshore) as sand cover. Similarly, the average cover for sand and hardbottom was calculated based on a transect length of 187 m. When intertidal hardbottom was not present (2013 transects R-134, R-135, R-139 and R-140), an inshore transect start point (0 m) was determined in GIS by drawing a straight line between the start points of the transects to the north and south that did document intertidal hardbottom. The length of sand from the new start point was then measured eastward to the field-verified start point (westernmost interface) of subtidal hardbottom. This distance is presented in Figures 5 and 6 and accounts for sand cover in Table 3. Transects R-130 to R-133 in 2006 were not extended to a length of 187 m and did not contribute to the calculated average cover because line-intercept was not collected on these transects, i.e., the location and length of sand patches within the hardbottom width was not recorded. The line-intercept data were used to provide a visual presentation of the hardbottom patchiness along each transect during 2006 and 2013, as well as to determine an overall percent cover of hardbottom and sand in the Study Area (Table 3).

2006. Line-intercept data were not collected on transects R-130 to R-133 (for the FDEP Hurricane Recovery Dune Restoration Project), but the maximum width of intertidal hardbottom resources was documented. Based on 2006 aerial imagery, only intertidal hardbottom was exposed along R-130 to R-132. Areas of intertidal and subtidal hardbottom were exposed along transect R-133, although the width of the subtidal hardbottom was not recorded during the May 2006 survey. The intertidal hardbottom width data for transects R-130 to R-133 and the line-intercept data for transects R-134 to R-141 (data collection for the South Palm Beach/Lantana Erosion Control Study) are presented in Figure 5. A distinct sand trough was present between the intertidal and subtidal hardbottom formations in 2006. The intertidal ridge was generally less than 50 m wide and the trough varied in width between 52 m (R-139 and R-140) and 154 m (R-135). Average benthic cover between R-134 and R-141 was 29% hardbottom and 71% sand based on the line-intercept data in 2006.

2013. A distinct sand trough was again present between the intertidal and subtidal hardbottom ridges in 2013 (Figure 2). Similar to 2006, transects R-130 to R-132 revealed only intertidal hardbottom resources; however, unlike 2006, the 2013 survey revealed several areas where only subtidal hardbottom resources were exposed. Average cover from the 2013 line-intercept data was 24% hardbottom and 76% sand using all twelve transects (R-130 to R-141). However, when considering the same eight transects with line-intercept data from 2006 (transects R-134 through R-141), the data revealed an average of 28% hardbottom and 72% sand cover, which was almost the same as in 2006 (Table 3).

Table 3. Mean percent cover of hardbottom and sand based on line-intercept data during the 2006 and 2013 benthic characterization surveys.

Transect	2006		2013	
	% Hardbottom	% Sand	% Hardbottom	% Sand
R-130	--	--	7%	93%
R-131	--	--	5%	95%
R-132	--	--	1%	99%
R-133	--	--	50%	50%
R-134	31%	69%	46%	54%
R-135	18%	82%	19%	81%
R-136	31%	69%	9%	91%
R-137	28%	72%	27%	73%
R-138	25%	75%	25%	75%
R-139	34%	66%	32%	68%
R-140	35%	65%	22%	78%
R-141	29%	71%	42%	58%
Mean	**29%**	**71%**	**24%**	**76%**

Note: Line-intercept was not conducted on R-130 to R-133 during the 2006 survey; the mean for 2006 represents R-134 to R-141 only. Using R-134 through R-141 data only for 2013 resulted in a mean hardbottom cover of 28% and sand cover of 72%.

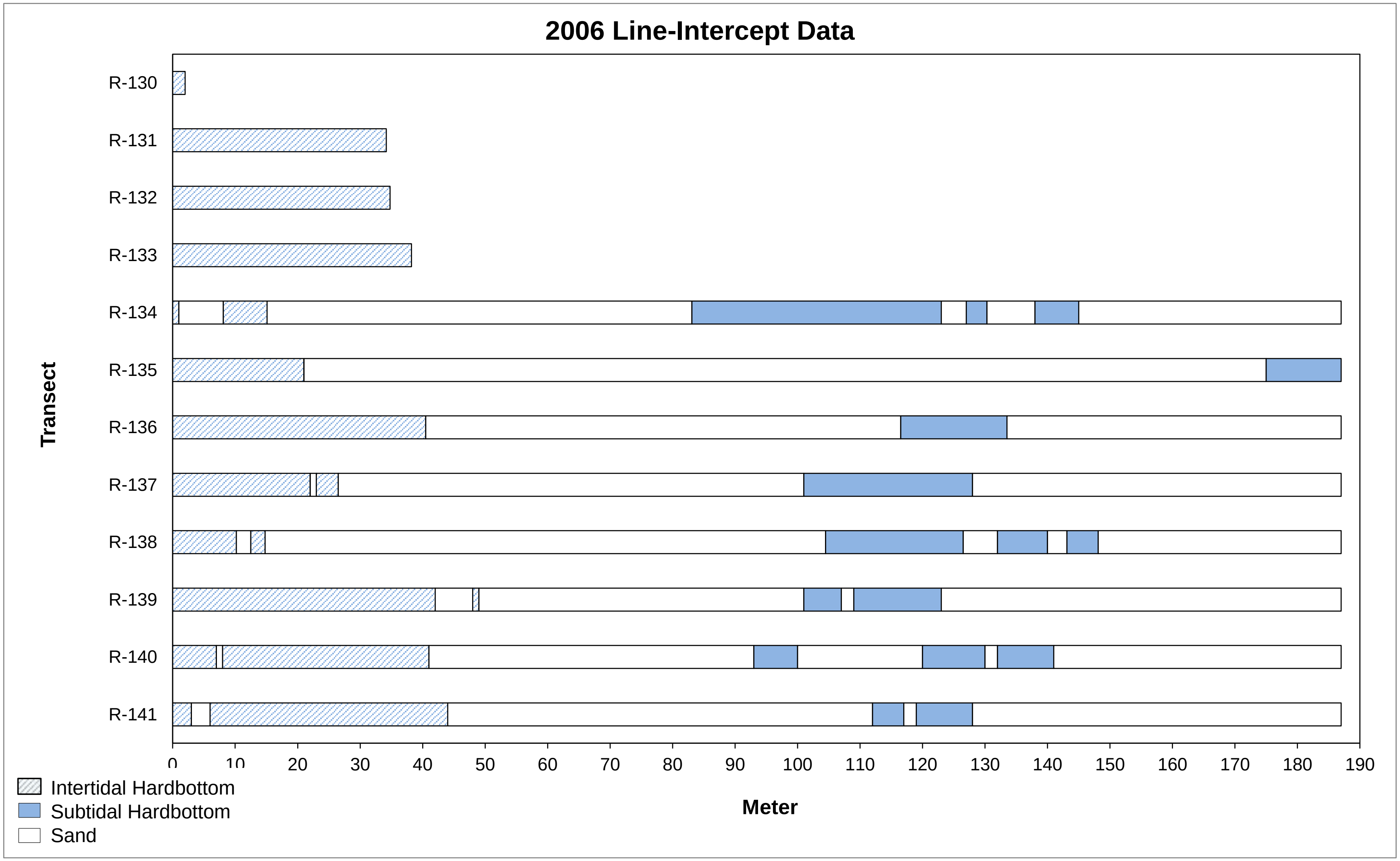

Figure 5. Line-intercept data showing intertidal hardbottom, subtidal hardbottom and sand transitions along transects in the Study Area during the 2006 benthic characterization. Line-intercept data were not collected on Transects R-130 to R-133 (the location and length of sand patches within the hardbottom width was not recorded); therefore, the maximum width of intertidal hardbottom only is presented.

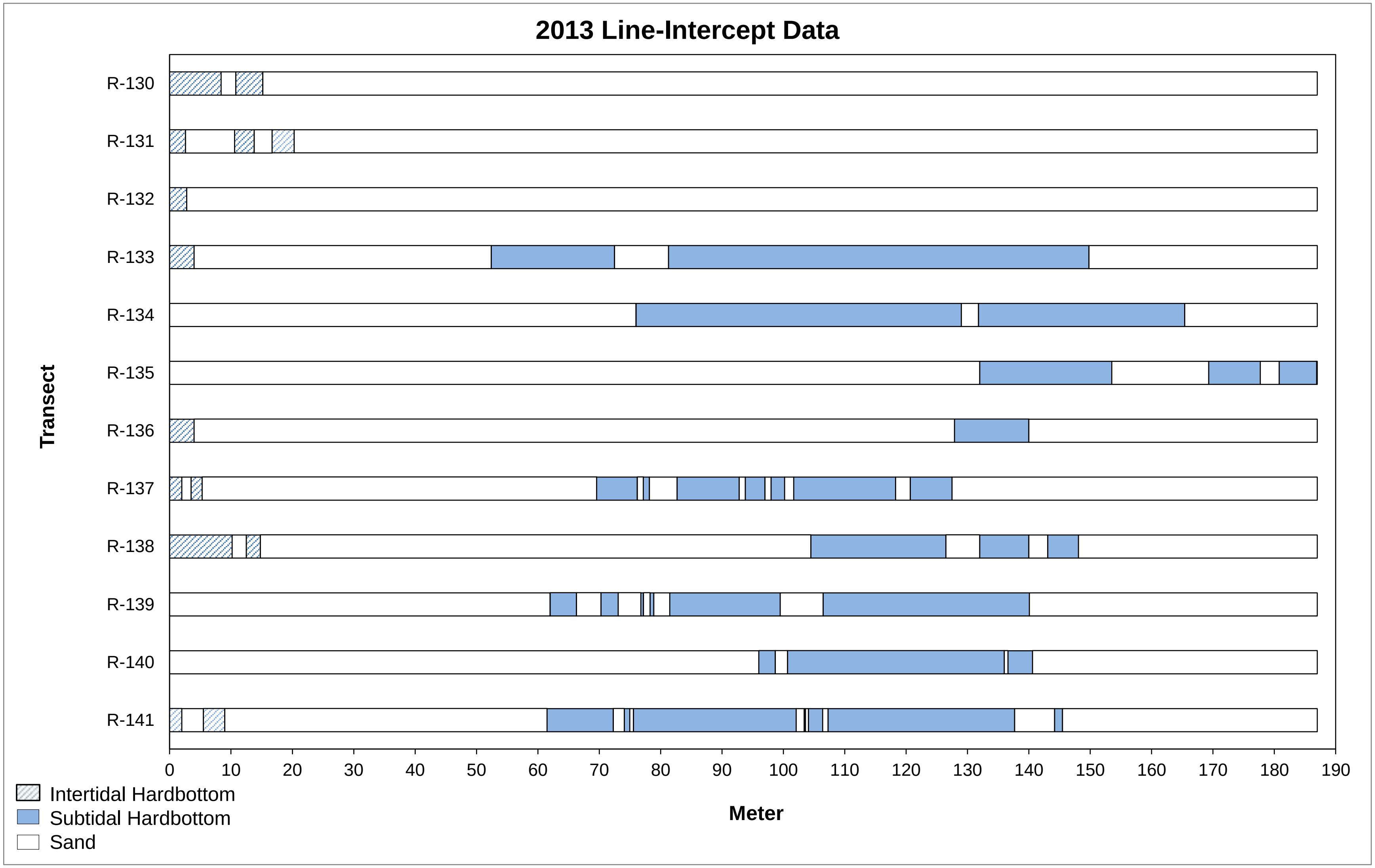

Figure 6. Line-intercept data showing subtidal hardbottom, intertidal hardbottom and sand transitions along transects in the Study Area during the 2013 benthic characterization.

3.2.2. SEDIMENT DEPTH

Sediment depth was measured at every meter along each transect during the 2013 characterization survey but was only collected in the intertidal and subtidal areas when hardbottom was present in both areas, e.g., sediment depth was not collected across the sand trough or subtidal area on transects R-130 to R-132 since subtidal hardbottom was not exposed on these transects. Sediment depths in the intertidal and subtidal zones were dependent on the patchiness of the hardbottom; wider sand patches within the hardbottom boundaries resulted in higher sediment depth as seen in the intertidal on R-131 and the subtidal on R-135 (Table 4). The sediment depth in the sand trough averaged greater than 20 cm on all areas where it was measured.

Table 4. Mean sediment depth measurements (cm) (± Standard Deviation [SD]) along each transect during the 2013 benthic characterization.

Transect	Mean Sediment Depth (cm)		
	Intertidal	Sand Trough	Subtidal
R-130	0.3 ± 1.7	--	--
R-131	8.8 ± 9.6	--	--
R-132	0.3 ± 0.6	--	--
R-133	0.2 ± 0.4	23.7 ± 5.2	0.7 ± 2.1
R-134	--	--	0.5 ± 2.3
R-135	--	--	7.3 ± 10.8
R-136	0.3 ± 0.3	24.2 ± 7.1	1.4 ± 1.8
R-137	2.6 ± 5.4	20.3 ± 5.8	4.1 ± 6.4
R-138	2.0 ± 5.0	26.8 ± 6.3	3.2 ± 5.3
R-139	--	--	3.2 ± 5.8
R-140	--	--	1.9 ± 6.0
R-141	--	--	2.0 ± 4.5

Note: Rough seas prevented complete data collection for the intertidal and sand trough portions of Transect R-141.

3.3. BEAMR QUADRAT SAMPLES

A total of 164 quadrats were sampled during the May and July 2006 characterizations and 147 quadrats were sampled during the October 2013 characterization. As mentioned in the Project History, the 2006 data were collected as part of two separate projects – the FDEP Hurricane Recovery Dune Restoration Project within the Town of Palm Beach (R-130 to R-134) and the South Palm Beach/Lantana Erosion Control Study (R-134 to R-141). The data collected from the South Palm Beach/Lantana

Erosion Control Study was used for Transect R-134 since it was more comprehensive (included line-intercept and division of benthic characterization by intertidal and subtidal hardbottom resources). Table 5 presents the location of hardbottom exposure (intertidal and subtidal) for each transect at the time of sampling in 2006 and 2013.

Overall benthic communities at the functional group, macroalgae and coral levels were compared between the two surveys based on BEAMR quadrat sampling. Additional comparisons were conducted to determine if the benthic communities on the intertidal and subtidal habitats varied significantly over time and space. Both habitats were compared between 2006 and 2013 and then the habitats were compared to each other during each survey.

Table 5. Location of benthic habitat data collected during the characterization surveys of 2006 and 2013 within the Study Area.

Transect	2006		2013	
	Intertidal	Subtidal	Intertidal	Subtidal
R-130	X		X	
R-131	X		X	
R-132	X		X	
R-133	X	X*	X	X
R-134	X	X		X
R-135	X	X		X
R-136	X	X	X	X
R-137	X	X	X	X
R-138	X	X	X	X
R-139	X	X		X
R-140	X	X		X
R-141	X	X	X	X

*Subtidal hardbottom was exposed on R-133 during the 2006 survey but data was not collected beyond the intertidal ridge.

3.3.1. RELIEF

Maximum relief was measured within each quadrat during BEAMR sampling in 2006 and 2013. These data were averaged to determine if any pattern of relief was apparent in a cross-shore or longshore pattern. Hartley's F_{max} test for assessing homoscedasticity was conducted on the maximum vertical relief data to compare variances of the intertidal and subtidal areas for each year, and to compare 2006 data to 2013 data. As the relief data were homoscedastic but non normal, the non-parametric Mann-Whitney

U test (which is essentially the Kruskal-Wallis test applied to two samples), was used to determine any significant differences in relief. Table 6 and Figure 7 summarize the 2006 and 2013 relief data.

2006. In 2006 the mean maximum vertical relief of the intertidal area was 7.8 cm (SD 11.7) and the mean maximum vertical relief for the subtidal area was 11.6 cm (SD 9.2); the difference between intertidal and subtidal relief was significant (H = 12.2, 1 d.f., p = 0.001).

2013. In 2013 the mean maximum vertical relief of the intertidal area was 7.0 cm (SD 10.5) and the mean maximum vertical relief for the subtidal area was 9.3 cm (SD 8.8); again, the difference between intertidal and subtidal relief was significant (H = 9.4, 1 d.f., p = 0.002).

Table 6. Average maximum vertical relief (cm) collected during the characterization surveys of 2006 and 2013 within the Study Area.

Transect	2006			2013		
	Intertidal	Subtidal	Overall	Intertidal	Subtidal	Overall
R-130	10.0	-	10.0	4.0	-	4.0
R-131	12.7	-	12.7	3.8	-	3.8
R-132	5.6	-	5.6	1.0	-	1.0
R-133	8.8	-	8.8	2.5	9.1	8.0
R-134	5.6	14.3	7.6	-	8.3	8.3
R-135	19.2	11.1	14.1	-	9.8	9.8
R-136	3.5	12.2	10.0	17.0	2.8	6.3
R-137	5.6	6.6	6.1	20.0	7.1	8.1
R-138	6.9	10.6	8.9	32.7	5.6	12.3
R-139	6.3	10.8	9.3	-	11.1	11.1
R-140	5.7	14.0	10.3	-	15.9	15.9
R-141	4.6	14.0	10.4	5.0	11.6	11.1
Mean	**7.8**	**11.6**	**9.5**	**7.0**	**9.3**	**8.7**
SD	**11.7**	**9.2**	**10.8**	**10.5**	**8.8**	**9.3**

Intertidal and Subtidal Habitats. No statistically significant differences were observed when comparing overall relief, or subtidal and intertidal relief, between 2006 and 2013. The overall 2006 mean maximum vertical relief was 9.5 cm (SD 10.8) and the 2013 mean maximum vertical relief was 8.7 cm (SD 9.3); there was no statistically significant difference between 2006 and 2013 (H = 1.0, 1 d.f., p = 0.32). The intertidal relief was statistically indistinguishable between 2006 (7.8 cm SD 11.7) and 2013 (7.0 cm SD 10.5) (H = 2.9, 1 d.f., p = 0.09), and subtidal relief was also statistically indistinguishable between 2006 (11.6 cm SD 9.2) and 2013 (9.3 cm SD 8.8) (H = 4.0, 1 d.f., p = 0.05).

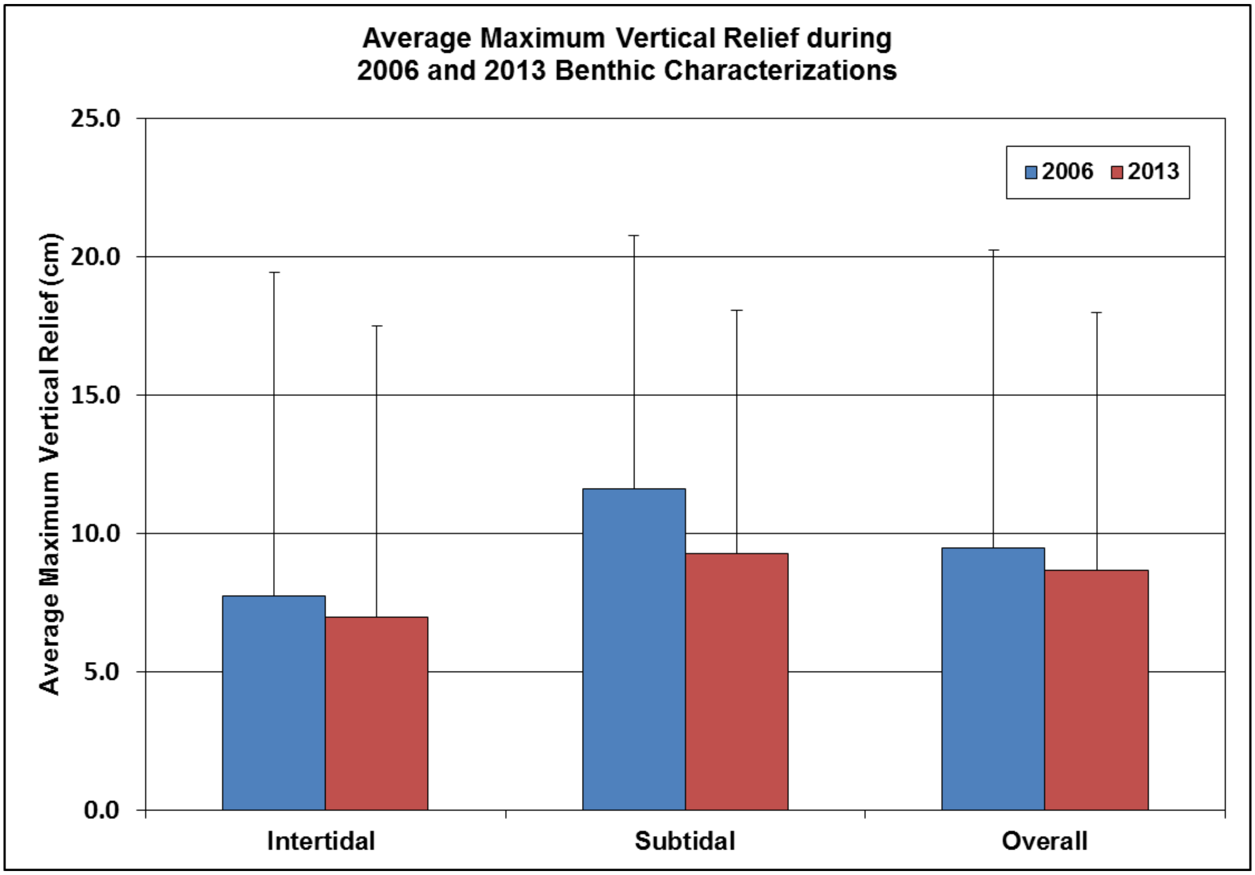

Figure 7. Average maximum vertical relief (+ SD) along the intertidal and subtidal portions, and overall combined area, of the transects during the benthic characterization surveys in 2006 and 2013.

Additionally, hardbottom relief was measured in 2009 and 2010 to provide data in support of the South Palm Beach/Lantana Segmented Breakwaters Project. Relief measurements were taken on the inshore (westernmost interface) and offshore (easternmost interface) hardbottom edges every 50 ft between R-130 and R-141. The average relief measurement was 15.6 cm on the inshore edge and 15.7 cm on the offshore edge. The observation report and maps of these data are provided in Appendix E.

3.3.2. FUNCTIONAL GROUPS

2006. Table 7 presents the mean percent cover of all functional groups recorded on the nearshore hardbottom habitat during the 2006 biological investigations. Turf algae (58.2% SD 30.4) and sediment (22.5% SD 31.8) dominated the cover classes throughout the samples followed by bare hard substrate (8.9% SD 13.4) and macroalgae (7.1% SD 12.5). The high standard deviation indicates that the data are spread out over a large range of values. Therefore, the median is also reported in Table 7 to provide an additional measure of central tendency that is less influenced by outliers. The order of dominant cover remained the same as reported by the median, however, only turf algae remained on the same order of magnitude as reported by the mean. Sediment, macroalgae and bare hard substrate had lower measures of central tendency as reported by the median values.

2013. Table 8 presents the mean percent cover of all functional groups for nearshore hardbottom habitat recorded during the 2013 biological investigations. Turf algae (60.9% SD 2.4) and sediment (21.9% SD 29.5) dominated the cover classes throughout the samples followed by macroalgae (10.4% SD 12.8) and encrusting red algae (2.3% SD 7.2). Similar to the 2006 data, high standard deviations were reported, indicating a large range of values among the quadrats, therefore the median is also reported in Table 8. Based on the median, turf algae remained the dominant cover but sediment and macroalgae had notably lower coverage than reported by the mean.

Table 7. Mean percent cover of all BEAMR functional groups by transect, as well as the overall mean and median cover (with standard deviation) recorded during the 2006 biological investigations. Red, dark pink and light pink indicate the highest, second highest and third highest mean percent cover, respectively, within each transect and overall.

Transect	Date Sampled	Number of Quadrats	Sed	MA	Turf Algae	Coralline Algae	Sponge	Hydroid	Octo	Stony Coral	Tuni	BHS	Anem	Barn	Bivalve	Bryoz	Millepora	Sessile Worm	Wormrock	Zoanthid
R-130	5/18/2006	2	20.5	5.5	31.5	1.5	0.5	0.5	0.0	0.5	1.5	32.5	0.0	0.0	0.0	1.0	0.0	1.0	3.5	0.0
R-131	5/18/2006	10	17.1	11.3	47.4	0.5	1.5	0.0	0.0	0.3	0.0	21.5	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
R-132	5/18/2006	10	31.0	9.5	30.6	0.3	0.4	0.1	0.0	0.0	0.0	27.9	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0
R-133	5/18/2006	10	25.9	7.4	44.2	0.2	0.3	0.0	0.0	0.8	0.1	20.9	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
R-134	7/17/2006	17	27.8	2.0	59.6	1.1	0.5	0.2	0.0	0.2	0.1	6.9	0.0	0.0	0.0	0.4	0.0	0.1	1.2	0.0
R-135	7/17/2006	16	29.6	1.8	59.1	0.4	0.8	0.7	0.0	0.0	0.1	6.2	0.0	0.0	0.0	0.9	0.0	0.2	0.1	0.0
R-136	7/18/2006	16	15.6	12.6	62.9	0.4	0.2	0.6	0.0	0.3	0.1	5.8	0.0	0.0	0.0	0.6	0.0	0.1	1.0	0.0
R-137	7/18/2006	16	15.2	3.1	70.8	0.9	0.4	0.3	0.0	0.0	0.1	8.8	0.0	0.0	0.0	0.4	0.0	0.2	0.0	0.0
R-138	7/18/2006	15	18.1	5.5	66.0	0.8	0.6	0.7	0.0	0.1	0.1	3.3	0.0	0.0	0.0	0.3	0.0	0.1	4.3	0.0
R-139	7/18/2006	18	23.8	18.2	52.7	0.4	0.7	0.5	0.0	0.1	0.1	2.6	0.0	0.0	0.0	0.7	0.0	0.2	0.0	0.0
R-140	7/18/2006	20	21.8	4.6	66.6	0.4	0.4	1.0	0.0	0.2	0.0	4.5	0.0	0.0	0.0	0.5	0.0	0.1	0.2	0.0
R-141	7/19/2006	13	24.2	3.4	64.2	0.4	0.3	0.5	0.0	0.1	0.2	3.2	0.0	0.0	0.0	0.2	0.0	0.3	3.2	0.0
Mean			**22.5**	**7.1**	**58.2**	**0.6**	**0.5**	**0.5**	**0.0**	**0.2**	**0.1**	**8.9**	**0.0**	**0.0**	**0.0**	**0.5**	**0.0**	**0.1**	**1.0**	**0.0**
Median			**5.0**	**2.0**	**64.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**3.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Standard Deviation			31.8	12.5	30.4	0.9	1.0	0.9	0.0	0.5	0.3	13.4	0.0	0.0	0.0	0.8	0.0	0.3	6.1	0.0

Table 8. Mean percent cover of all BEAMR functional groups by transect, as well as the overall mean and median cover (with standard deviation) recorded during the 2013 biological investigations. Red, dark pink and light pink indicate the highest, second highest and third highest mean percent cover, respectively, within each transect and overall.

Transect	Date Sampled	Number of Quadrats	Sed	MA	Turf Algae	Coralline Algae	Sponge	Hydroid	Octo	Stony Coral	Tuni	BHS	Anem	Barn	Bivalve	Bryoz	Millepora	Sessile Worm	Wormrock	Zoanthid
R-130	10/21/2013	13	26.8	6.2	64.1	0.8	0.1	0.1	0.0	0.7	0.0	0.9	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0
R-131	10/23/2013	12	12.0	6.0	74.8	0.6	0.2	0.0	0.0	0.0	0.0	4.6	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0
R-132	10/21/2013	5	5.5	12.3	76.8	0.8	0.0	0.7	0.2	0.1	0.0	2.1	0.0	0.0	0.0	0.9	0.0	0.5	0.0	0.0
R-133	10/23/2013	12	44.2	8.2	43.5	2.2	0.0	1.3	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
R-134	10/21/2013	15	9.1	14.9	70.3	2.4	0.2	0.9	0.7	0.1	0.0	0.6	0.0	0.1	0.0	0.4	0.0	0.2	0.0	0.0
R-135	10/23/2013	13	22.6	18.2	48.4	5.7	0.4	1.4	0.5	0.0	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.1	0.0	0.0
R-136	10/23/2013	12	29.5	8.7	45.0	5.2	0.2	0.0	0.0	0.2	7.1	4.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
R-137	10/21/2013	13	41.5	7.1	47.6	0.2	0.3	0.5	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.3	0.0	0.0
R-138	10/23/2013	12	21.8	10.6	62.0	1.0	0.1	3.3	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.3	0.0	0.5	0.0	0.0
R-139	10/21/2013	14	29.8	2.2	63.0	1.3	0.3	1.5	0.2	0.2	0.2	0.6	0.0	0.0	0.0	0.3	0.0	0.6	0.0	0.0
R-140	10/23/2013	12	5.8	16.8	64.8	6.2	0.2	1.3	2.0	0.3	0.0	1.2	0.0	0.0	0.0	0.8	0.0	0.6	0.0	0.1
R-141	10/21/2013	14	10.7	8.9	77.3	0.4	0.0	1.7	0.0	0.0	0.0	0.3	0.0	0.0	0.2	0.4	0.0	0.2	0.0	0.1
Mean			**21.9**	**10.4**	**60.9**	**2.3**	**0.2**	**1.1**	**0.5**	**0.1**	**0.6**	**1.1**	**0.0**	**0.0**	**0.0**	**0.6**	**0.0**	**0.3**	**0.1**	**0.0**
Median			**5.0**	**5.0**	**71.0**	**1.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Standard Deviation			29.5	12.8	28.6	7.2	0.5	2.0	1.2	0.4	7.0	3.7	0.0	0.2	0.1	2.2	0.0	0.4	0.7	0.1

Figure 8 provides a graphical representation of the distribution of benthic cover documented during the 2006 and 2013 surveys. These data were input into PRIMER-E v6 to determine if significant differences existed between the two monitoring surveys. A CLUSTER analysis did not detect significant differences; however, it is obvious that the benthic community at functional group-level does display some distinction between the 2006 and 2013 surveys based on the dendrogram output (Figure 9).

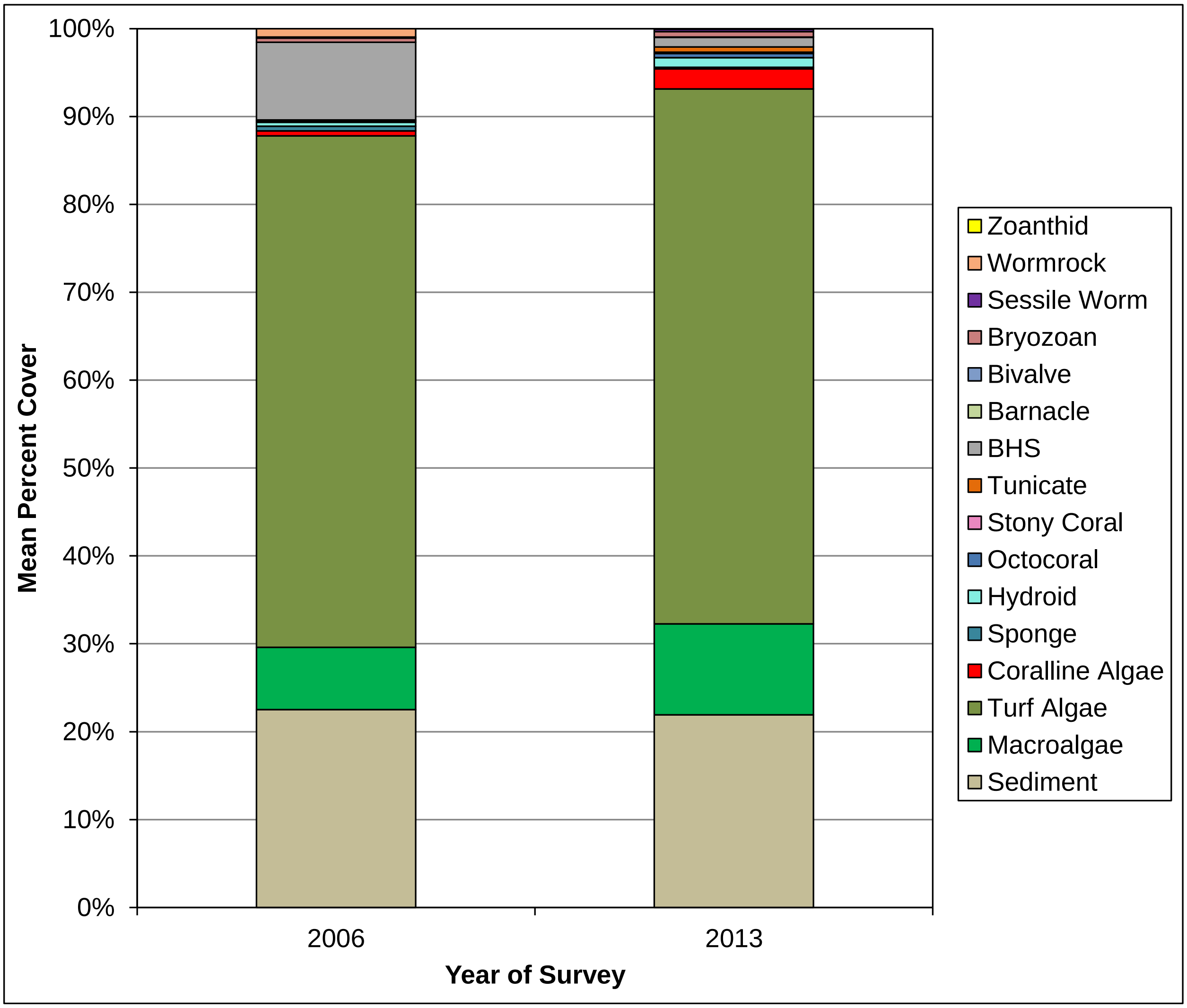

Figure 8. Mean percent cover of functional groups in the Study Area documented during the 2006 and 2013 benthic surveys.

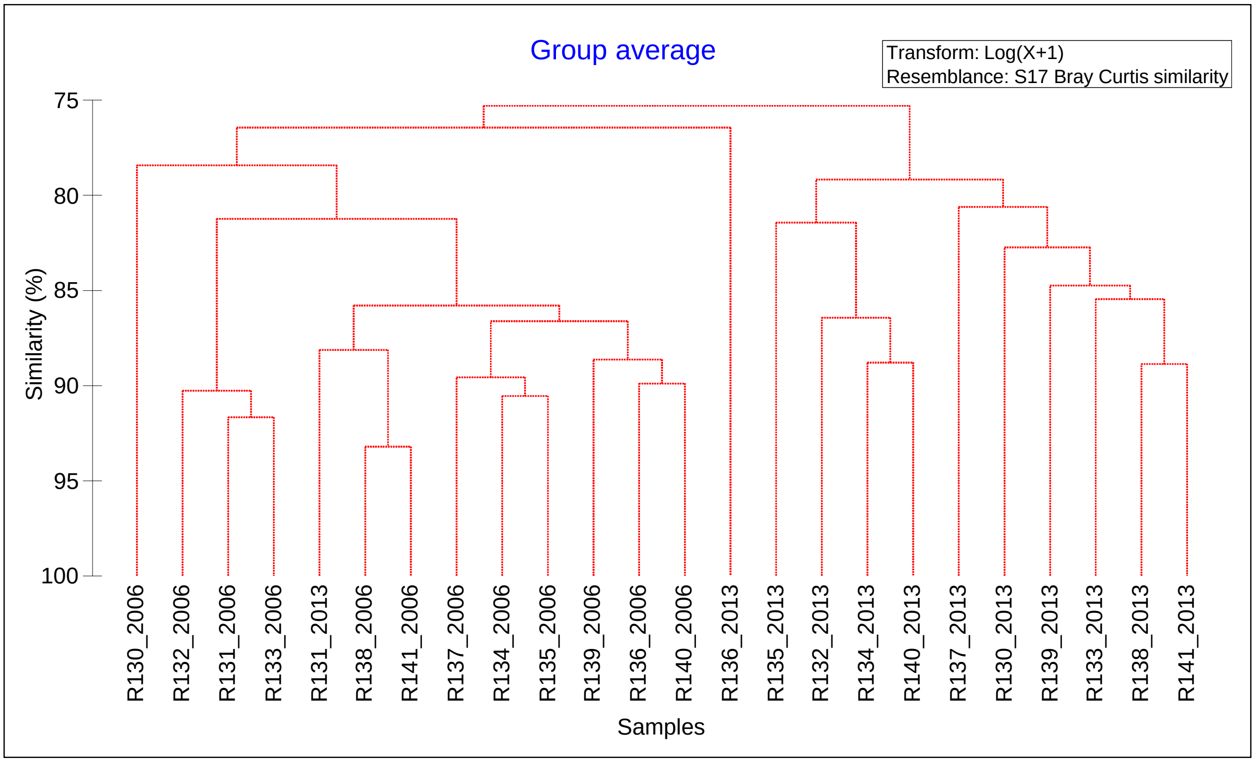

Figure 9. Dendrogram presenting the similarity clusters between transects sampled in 2006 and 2013 based on benthic community functional group percent cover. Red bars indicate no significant differences between samples.

Intertidal and Subtidal Habitats. Additional comparisons were conducted to determine if the intertidal and subtidal habitats varied significantly over time and space at the functional group level. Both habitats were compared between 2006 and 2013 and then the habitats were compared to each other during each survey. All comparisons revealed no significant differences, with one exception. In the intertidal area, the 2013 transects R-133 and R-141 clustered significantly away from all other intertidal transects regardless of year sampled based on a CLUSTER analysis (p = 0.001). Further examination revealed that the intertidal hardbottom along these two transects was defined by a thin ridge with low diversity of functional groups – both transects were characterized by high turf algae cover with low macroalgae and minimal sediment cover. The intertidal habitat on other transects was characterized by several additional functional groups such as sponges, encrusting red algae and tunicates. The ephemeral nature of the nearshore hardbottom habitat and the thin width of exposed hardbottom adjacent to these transects (R-133 and R-141) indicates that substrate may have been exposed for less time than the other samples, thus resulting in a less complex benthic habitat. If the hardbottom in these locations remains exposed, it will likely come to closely resemble the intertidal hardbottom throughout the Study Area.

3.3.3. MACROALGAE

Particular attention was paid to macroalgae genera that were known to be preferred food for juvenile green sea turtles (*Chelonia mydas*). Makowski et al. (2006) identified 11 genera of macroalgae as common food for juvenile green sea turtles (*C. mydas*) in the nearshore waters of Palm Beach, Florida by examining lavage samples. These included: *Gracilaria, Acanthophora, Dictyota, Dictyopteris, Siphonocladus, Jania, Dasycladus, Cladophora, Bryothamnion, Rhizoclonium,* and *Enteromorpha* (now *Ulva* (Hayden et al., 2003))*. Hypnea, Bryothamnion,* and *Gracilaria* were also noted by Wershoven and Wershoven (1988; 1992) to be preferred food items of *C. mydas* at John U. Lloyd Beach State Park in Broward County, Florida, bringing the total preferred macroalgae genera to 12. The genera that dominated macroalgae cover during the 2006 and 2013 benthic characterization surveys (the five most abundant genera in each year) are presented in Figure 10. Macroalgae mean and median percent cover (with standard deviation), as well as frequency of occurrence are presented in Table 9. The mean percent cover represents all quadrats sampled whereas the median percent cover represents only those quads with macroalgae cover greater than 1%; the median value using all quads sampled was 0% for both years.

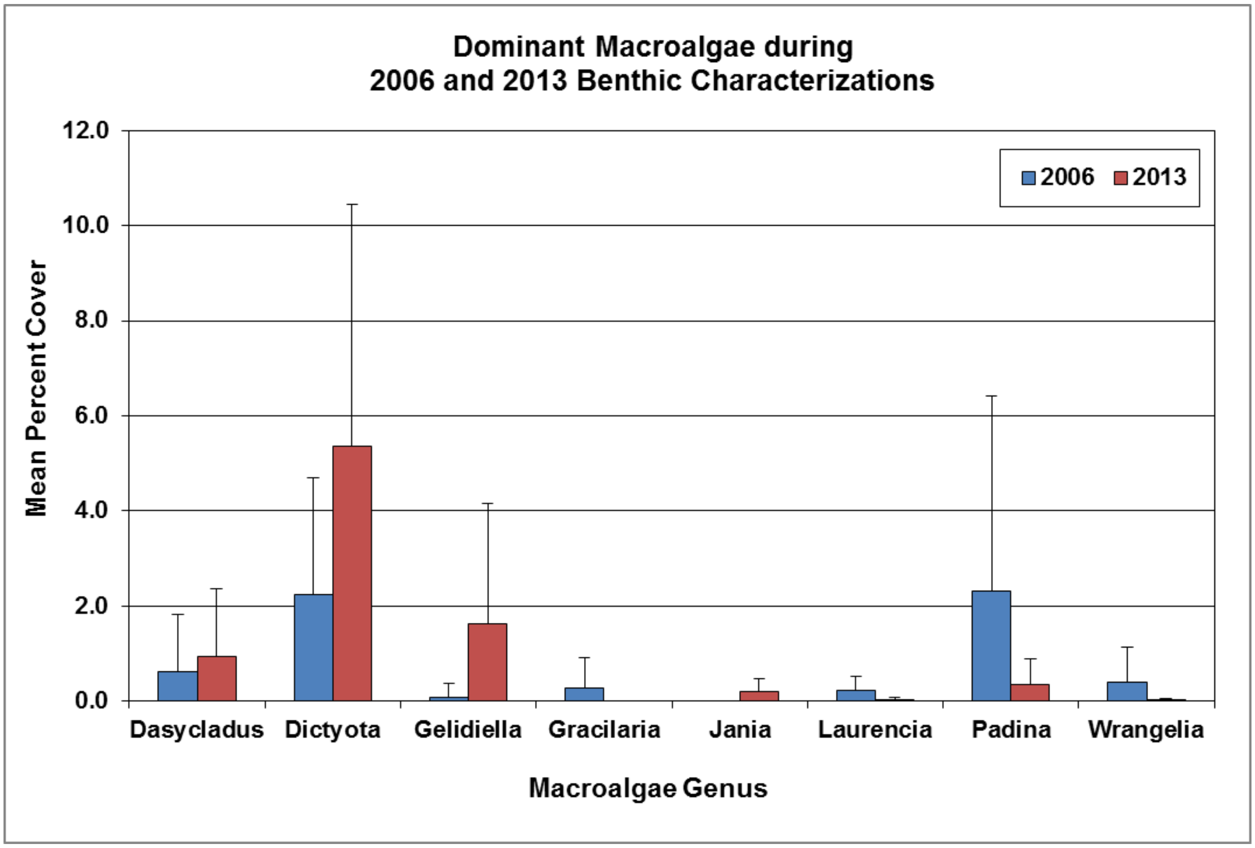

Figure 10. Average percent cover (+ SD) of the dominant macroalgae genera during the benthic characterization surveys in 2006 and 2013.

2006. A total of 13 macroalgae genera were identified during the 2006 characterization survey. Of the 12 genera known to be preferred food items of *C. mydas*, four were identified during the 2006 characterization survey on the nearshore hardbottom habitat, including: *Dasycladus, Dictyota, Gracilaria,* and *Hypnea.* Of all macroalgae genera recorded during the 2006 survey, *Padina* (2.31% SD 4.11), *Dictyota* (2.25% SD 2.44) and *Dasycladus* (0.62% SD 1.20) were the dominant macroalgae cover and the most frequently occurring genera.

2013. A total of 14 macroalgae genera were identified during the 2013 characterization survey, five of which are known to be preferred food items of *C. mydas*. These included *Dictyota, Dictyopteris, Bryothamnion, Dasycladus,* and *Jania.* Of all macroalgae genera recorded, *Dictyota* (5.36% SD 5.08), *Gelidiella* (1.62% SD 2.54) and *Dasycladus* (0.93% SD 1.43) dominated the macroalgae cover in the Study Area and were also the most frequently occurring genera.

Table 9. Macroalgae genera with greater than 1% documented in Study Area during the 2006 and 2013 characterization surveys. Genera with the highest, second highest and third highest mean percent cover are highlighted in red, dark pink and light pink, respectively for each survey event.

Year	Transect	Bryotham*	Caulerpa	Cymopolia	Dasya	Dasycladus*	Dictyopteris*	Dictyota*	Gelidiella	Gelidium	Gracilaria*	Halimeda	Hypnea*	Jania*	Laurencia	Liagora	Padina	Wrangelia
2006	R-130		1.50						1.00		1.00	2.00						
	R-131		0.10					7.50									0.90	2.30
	R-132		0.20			0.30		6.10			2.10					0.10	0.10	0.30
	R-133		0.30					4.30			0.20	0.10	0.20			0.10	0.10	1.50
	R-134					0.94		0.18				0.12			0.06			0.18
	R-135							1.13							0.25			0.25
	R-136				0.13			1.88				0.06			0.25		9.69	
	R-137		0.13			0.13		1.88							0.06		0.38	
	R-138		0.07					2.20							0.13		2.47	0.07
	R-139		0.06	0.44	0.17	3.78		0.56				0.17			0.44		12.11	
	R-140			0.2		2.30		0.45				0.10			0.35		0.85	
	R-141							0.85							1.08		1.08	0.08
2013	R-130					0.08		0.38	2.15	1.69				0.38			0.08	
	R-131		0.17						7.67	0.50								
	R-132								5.40									
	R-133					0.25		5.83						0.33			1.83	
	R-134	0.20				0.67		8.80				0.27		0.07			0.87	
	R-135							5.38						0.92	0.08			
	R-136		0.08	0.17	0.83	0.08		7.58	0.5					0.25				
	R-137		0.23	0.08		1.69	0.38	0.31	3.08								0.62	
	R-138					0		0.17	0.67						0.17			0.17
	R-139					1.79		11.14						0.14			0.21	
	R-140					1.83		12.92						0.08			0.42	
	R-141		0.86			4.79		11.79						0.14				
2006	**Mean**		0.20	0.05	0.02	0.62		2.25	0.08		0.28	0.21	0.02		0.22	0.02	2.31	0.39
	Median		1	4	2	1.5		1	2		1.5	1	2		1	1	3	1
	Mean SD		0.42	0.14	0.06	1.20		2.44	0.29		0.64	0.57	0.06		0.31	0.04	4.11	0.73
	Frequency		0.06	0.02	0.02	0.11		0.32	0.01		0.04	0.06	0.01		0.13	0.01	0.24	0.10
2013	**Mean**	0.02	0.11	0.02	0.07	0.93	0.03	5.36	1.62	0.18		0.02		0.19	0.02		0.34	0.01
	Median	3	2.5	1.5	2	3	5	10	5	4.5		1		1.5	1.5		2	2
	Mean SD	0.06	0.25	0.05	0.24	1.43	0.11	5.08	2.54	0.50		0.08		0.27	0.05		0.55	0.05
	Frequency	0.01	0.03	0.01	0.03	0.18	0.01	0.41	0.16	0.04		0.02		0.10	0.01		0.13	0.01

*Indicates macroalgae genera known to be *C. mydas* preferred food resource.

Intertidal and Subtidal Habitats. The macroalgae communities on the intertidal and subtidal habitats were compared between 2006 and 2013 and the two habitats were also compared to each other within each survey. No significant differences were found when the intertidal habitat was compared between 2006 and 2013; however, significant differences were detected on the subtidal macroalgae habitat over time and between the intertidal and subtidal habitats during each survey event.

Of the 12 transects surveyed in 2006, all had exposed hardbottom in the intertidal zone and nine had exposed hardbottom in the subtidal zone (Figure 5, Table 5). The subtidal macroalgae community clustered together in similarity; however, ANOSIM revealed several of the intertidal transects showed significant differences compared to the subtidal area (intertidal vs. subtidal R = 0.336, p = 0.008). These differences appear to be driven by the presence and abundance of *Dictyota* and *Padina,* which occurred in much higher abundance on the subtidal portions of transects. It should be noted that the relatively low R-value of 0.336 indicates that although the macroalgae community between the intertidal and subtidal areas is not exactly the same, it is highly overlapping.

In 2013, eight transects had exposed hardbottom in the intertidal zone and nine had exposed hardbottom in the subtidal zone (Figure 6, Table 5). The macroalgae community was clearly distinct between the two hardbottom ridges (R = 0.698, p = 0.001). The significant differences appear to be driven by presence and abundance of *Dictyota* and *Gelidiella. Dictyota* had a much higher abundance on the subtidal portions of transects, whereas *Gelidiella* dominated the intertidal macroalgae community but was not observed in the subtidal area.

Differences were also detected over time on the subtidal macroalgae community between 2006 and 2013 (R = 0.343, p = 0.002). These differences were attributed to the higher overall coverage of macroalgae as well as higher genus abundance in 2013. *Wrangelia* was the only genus to occur in 2006 that was not observed in 2013. Once again, the relatively low R-value of 0.343 indicates that although the macroalgae community in the subtidal habitat was not exactly the same between surveys, it is highly overlapping.

3.3.4. CORAL

The nearshore hardbottom habitat within the Study Area is not coral-dominated. The habitat supports small corals, primarily *Siderastrea* spp. Every coral and octocoral colony observed in the BEAMR quadrats was documented by species and maximum diameter (cm) or height (cm). These data were used to determine the average size and density of coral species in the nearshore hardbottom habitat adjacent to the proposed Project Area during the 2006 and 2013 surveys. Due to the low abundance of scleractinian and octocoral colonies documented in the Study Area, only descriptive comparisons were made. Tables 10 and 11 present scleractinian and octocoral density and average size, respectively. Each transect where corals were documented is presented with a breakdown based on the intertidal and subtidal areas as well as the coral community along the entire transect.

Table 10. Scleractinian density (colonies m^{-2}) and average size (cm) during the 2006 and 2013 characterization surveys. Only transects with stony coral presence are presented.

Year	Transect	Density (colonies m^{-2})			Average Size (cm)		
		Intertidal	Subtidal	Overall	Intertidal	Subtidal	Overall
2006	R-130	2.0	0	2.0	2.0	--	2.0
	R-131	2.0	0	2.0	2.0	--	2.0
	R-133	7.6	0	7.6	3.0	--	3.0
	R-134	0.6	4.0	0.6	1.0	2.3	1.6
	R-136	1.0	1.0	1.0	1.0	2.3	1.7
	R-138	1.7	0.5	1.7	1.0	1.0	1.0
	R-139	2.7	0	2.7	1.3	--	1.0
	R-140	0.4	0.4	0.4	1.0	1.0	1.0
	R-141	0	1.0	1.0	--	2.0	2.0
	Mean	**1.5**	**0.6**	**1.1**	**1.7**	**1.7**	**1.7**
2013	R-130	1.8	0	1.8	5.3	--	5.3
	R-131	0.7	0	0.7	3.5	--	3.5
	R-134	0	0.3	0.3	--	3.0	3.0
	R-138	0	1.8	1.8	--	3.0	3.0
	R-139	0	0.9	0.9	--	1.5	1.5
	R-140	0	1.3	1.3	--	1.5	1.5
	Mean	**0.8**	**0.7**	**0.5**	**4.4**	**2.1**	**2.6**

Table 11. Octocoral density (colonies m^{-2}) and average size (cm) during the 2006 and 2013 characterization surveys. Only transects with octocoral presence are presented.

Year	Transect	Density (colonies m^{-2})			Average Size (cm)		
		Intertidal	Subtidal	Overall	Intertidal	Subtidal	Overall
2006	**ALL**	**0**	**0**	**0**	**--**	**--**	**--**
2013	R-134	0	1.6	1.6	--	4.5	4.5
	R-135	0	23.1	23.1	--	5.2	5.2
	R-138	0	2.2	1.7	--	6.3	6.3
	R-139	0	8.0	8.0	--	3.5	3.5
	R-140	0	31.3	31.3	--	5.9	5.9
	R-141	0	5.2	4.9	--	6.0	6.0
	Mean	**0**	**8.4**	**6.1**	**--**	**5.3**	**5.3**

2006. During the 2006 survey, a total of 45 scleractinian colonies (1.1 colonies m^{-2}) and zero octocoral colonies were observed on the 12 transects. *Siderastrea* spp. made up 76% of the scleractinian colonies and the only other species observed was *Solenastrea bournoni*, of which 11 colonies were observed on the intertidal hardbottom of R-133. Average size of all observed scleractinian corals was 1.7 cm.

2013. In 2013, 20 scleractinian colonies (0.5 colonies m^{-2}) and 225 octocoral colonies (6.1 colonies m^{-2}) were documented on the same 12 transects. *Oculina diffusa* added to the scleractinian species diversity in 2013; however, only one 1-cm colony of this species was observed on R-139. The octocoral community was made up of four genera (*Eunicea, Muricea, Pseudopterogorgia* and *Pterogorgia*), all of which occurred in the subtidal portion of the sampling area (Photograph 2). Average size was 2.6 cm for all observed scleractinian corals and 5.3 cm for all observed octocoral corals.

Intertidal and Subtidal Habitats. The main difference between the intertidal and subtidal coral communities was the lack of octocorals on the intertidal habitat during both surveys. In 2006, stony corals had a higher density on the intertidal habitat but the same average size compared to the subtidal habitat. In 2013, however, the density was nearly the same in both areas but the average size was twice as large in the intertidal area.

Photograph 2. Benthic community dominated by octocorals observed on Transect R-135 during the 2013 characterization survey.

3.3.5. FISH OBSERVATIONS

2006. Transect-counts were utilized for visually assessing the fish assemblage structure along the hardbottom located in the Study Area during the 2006 survey. The natural nearshore hardbottom transect-counts yielded a total of 608 individual fishes representing 31 species. Fish surveys documented that 40.6% of the total number of fish were juveniles (<5.0 cm). Mean abundance was 122 fish per transect, with the mean number of species calculated at 16 species per transect. Of the 18 families observed, five families contributed to the majority of individuals recorded and included Labridae (Wrasses) 32.7%, Pomacentridae (Damselfishes) 32.7%, Haemulidae (Grunts) 15.1%, Lutjanidae (Snappers) 4.9%, and Gerreidae (Mojarras) 4.8%. The remaining 13 families contributed less than 2.0% each to the overall abundance.

2013. While a formal quantitative fish survey was not required for the 2013 protocol, all fish taxa encountered during the 2013 benthic survey were recorded to compile a general taxonomic list for the Study Area (Table 12). A total of 56 taxa from 29 families were recorded along the natural hardbottom during this survey (Photographs 3 and 4). The natural hardbottom yielded 18 predatory species and 11 species of the snapper/grouper management complex.

Table 12. Fish taxa recorded during the 2013 characterization survey.

Common Name	Scientific Name	Common Name	Scientific Name
Sergeant Major	*Abudefduf saxatilis*	Slippery Dick	*Halichoeres bivittatus*
Ocean Surgeonfish	*Acanthurus bahianus*	Pudding Wife	*Halichoeres radiatus*
Doctorfish	*Acanthurus chirurgus*	Rock Beauty	*Holacanthus tricolor*
Blue Tang	*Acanthurus coeruleus*	Chub	*Kyphosus sectatrix*
Porkfish	*Anisotremus virginicus*	Hairy Blenny	*Labrisomus nuchipinnis*
Gray Triggerfish	*Balistes capriscus*	Mutton Snapper	*Lutjanus analis*
Spanish Hogfish	*Bodianus rufus*	Mahogony Snapper	*Lutjanus mahogoni*
Saucereye Porgy	*Calamus calamus*	Lane Snapper	*Lutjanus synagris*
Sheepshead Porgy	*Calamus penna*	Banded Jawfish	*Opistognathus macrognathus*
Orange-spotted Filefish	*Cantherhines pullus*	Seaweed Blenny	*Parablennius marmoreus*
Sharpnose Puffer	*Canthigaster rostrata*	Highhat	*Pareques acuminatus*
Yellow Jack	*Carangoides bartholomaei*	French Angelfish	*Pomacanthus paru*
Blue Runner	*Caranx crysos*	Spotted Goatfish	*Pseudupeneus maculatus*
Bar Jack	*Caranx ruber*	Blue Goby	*Ptereleotris calliurus*
Black Seabass	*Centropristis striata*	Lionfish	*Pterois volitans*
Foureye Butterflyfish	*Chaetodon capistratus*	Bandtail Puffer	*Sphoeroides spengleri*
Spotfin Butterflyfish	*Chaetodon ocellatus*	Dusky Damselfish	*Stegastes adustus*
Atlantic Bumper	*Chloroscombrus chrysurus*	Longfin Damselfish	*Stegastes diencaeus*
Sand Perch	*Diplectrum formosum*	Beaugregory	*Stegastes leucostictus*
Spottail Pinfish	*Diplodus holbrookii*	Bicolor Damselfish	*Stegastes partitus*
Neon Goby	*Elacatinus oceanops*	Cocoa Damsel	*Stegastes variabilis*
Silver Jenny	*Eucinostomus gula*	Needlefish	*Strongylura marina*
Nurse Shark	*Ginglymostoma cirratum*	Channel Flounder	*Syacium micrurum*
Green Moray	*Gymnothorax funebris*	Sand Diver	*Synodus intermedius*
Tomtate	*Haemulon aurolineatum*	Bluehead Wrasse	*Thalassoma bifasciatum*
French Grunt	*Haemulon flavolineatum*	Great Pompano	*Trachinotus goodei*
Cottonwick Grunt	*Haemulon melanurum*	Yellow Stingray	*Urobatis jamaicensis*
Sailor's Choice	*Haemulon parra*	Green Razorfish	*Xyrichtys splendens*

Photograph 3. Porkfish observed on Transect R-133 during the 2013 characterization survey.

Photograph 4. Yellow stingray observed on Transect R-139 during the 2013 characterization survey.

3.4. ACROPORA SPP. SURVEY

In order to ensure that the two federally listed threatened *Acropora* coral species (*A. cervicornis* and *A. palmata*) were not present on the hardbottom resources adjacent to the project area, PBC-ERM conducted an *Acropora* spp. survey on October 22, 2013. The survey was conducted using the 2008 NMFS recommended protocol. No colonies of *Acropora* spp. or any of the seven coral species proposed for listing under the Endangered Species Act (ESA) were observed. The survey results and map are provided in Appendix F. It was also noted that no colonies of *Acropora* spp. were observed during the 2009 and 2010 surveys conducted to collect hardbottom relief measurements (Appendix E) or the benthic characterization survey.

3.5. DUNE VEGETATION SURVEY

On November 15, 2013 CB&I biologists ground-truthed the extent of dune vegetation using DGPS (Figure 2). Prior to field verification, aerial images were analyzed to determine specific areas of interest (i.e. areas void of seawalls with vegetation present) for investigation. The dune survey took place between the Lake Worth Pier and R-133+500, at which point seawalls continued to the south and dunes were absent. The dune located immediately south of Lake Worth Pier (R-128+700) was dominated by sea oats (*Uniola paniculata*) (Photograph 5) while the dune located immediately north of the seawall at R-129 was dominated by bitter panic grass (*Panicum amarum*) (Photograph 6). Seagrapes (*Coccoloba uvifera*) with dense cover were the dominant dune vegetation identified throughout the remainder of the survey area (Photographs 7 and 8), which ended near R-133+500 where dune habitat ended and upland properties were bordered by seawalls. One exception, near R-133, was observed where dune vegetation was sparse (Photograph 9). The endangered plant species beach jacquemontia (*Jacquemontia reclinata*) was not observed within the Study Area.

Photograph 5. Dense sea oats (*Uniola paniculata*) were the dominant dune vegetation in the area immediately south of Lake Worth Pier.

Photograph 6. Dense bitter panic grass (*Panicum amarum*) was the dominant dune vegetation in the area immediately north of the seawall at R-129.

Photograph 7. Seagrapes (*Coccoloba uvifera*) were the dominant dune vegetation throughout the survey area.

Photograph 8. Seagrapes (*Coccoloba uvifera*) were the dominant dune vegetation throughout the survey area.

Photograph 9. Steeply scarped dune with sparse vegetation near R-133.

4.0. CONCLUSIONS

The following observations highlight the results from the 2006 and 2013 characterization surveys for the Southern Palm Beach Island Comprehensive Shoreline Stabilization Project 2013.

Aerial Delineation and Sediment Dynamics

Not all transects included both intertidal and subtidal hardbottom formations, but those that did generally crossed a substantial sand patch between the two formations. As a result, the transects that extended between the two formations generally had higher sand cover and longer segments of continuous sand compared to the transects located exclusively in the intertidal or subtidal areas. The area of exposed hardbottom in the Study Area was 48.78 ac in 2006 and 36.96 ac in 2013. Based on line-intercept data, percent cover of exposed hardbottom also decreased slightly from 2006 to 2013.

Sediment depth measurements were not collected during the 2006 survey, so a comparison could not be made over time.

Benthic Characterization

Turf algae and sediment dominated the overall benthic cover classes during both the 2006 and 2013 characterization surveys. Bare hard substrate and macroalgae also had higher cover compared to other functional groups. Overall, the benthic community at the functional group level was similar over time and space.

The macroalgae community was significantly different between the intertidal and subtidal habitats during both surveys of the hardbottom. These differences were driven by the presence and abundance of *Gelidiella* in the intertidal and *Dictyota* and *Padina* in the subtidal. The macroalgae community on the intertidal habitat remained similar between surveys, which is likely due to the highly dynamic nature of this habitat. Constant sand scour and burial facilitates an opportunistic macroalgae community that remains at the pioneer stage of development. The subtidal habitat exhibited significant changes in the macroalgae assemblage between surveys where the 2013 survey had a higher mean coverage and genus abundance. This area is also exposed to fluctuating sand dynamics, but provides a slightly more stable environment for the macroalgae community to develop compared to the intertidal habitat. Differences over time are likely associated with the length of time the hardbottom has been exposed. The 2013 macroalgae cover and genus abundance was higher, indicating a more established community.

Siderastrea spp. dominated the scleractinian coral community in the intertidal and subtidal habitat. This genus is often found in highly disturbed locations and not only has high resistance to stressful environments but exhibits a remarkable resilience to stress (Lirman et al., 2002). These characteristics enable this genus to occupy this habitat and thrive in such a dynamic habitat.

Octocorals were not present on the hardbottom in the 2006 survey but were documented on the subtidal hardbottom in 2013. Based on a study by Yoshioka and

Yoshioka (1991) which found octocoral growth rates in Puerto Rico ranging from 1.36 cm yr^{-1} (SD 1.86) for *Eunicea succinea* and up to 4.48 cm yr^{-1} (SD 2.82) for *Pseudopterogorgia americana*, the average octocoral colony size of 5.3 cm documented during the 2013 benthic characterization indicates an octocoral community that has not been established for very long (2-4 years). This corresponds with the nature of such an ephemeral system as indicated by the aerial analysis of the Study Area.

No colonies of the threatened coral species *Acropora* spp. or any of the seven coral species proposed for listing under the ESA were observed in the Study Area during the benthic characterization or the *Acropora* survey.

Fish

A total of 56 fish taxa from 29 families were recorded along the natural hardbottom during 2013 survey. The natural hardbottom yielded 18 predatory fish species and 11 species of the snapper/grouper management complex.

Dune Survey

The dune vegetation survey indicated a habitat dominated by seagrapes. The endangered plant species beach jacquemontia (*Jacquemontia reclinata*) was not observed within the survey area.

Summary

The benthic hardbottom habitat adjacent to the Study Area is very dynamic and ephemeral in nature. The constant burial and exposure of hardbottom in this area facilitates an opportunistic community dominated by turf and macroalgae species that recruit quickly when substrate is available. Stony corals and octocorals can be observed when hardbottom remains exposed long enough to support their recruitment and growth. Although the hardbottom adjacent to the proposed project area remains low in benthic complexity due to relatively short exposure time, studies have shown that nearshore hardbottom habitat has nursery value for juvenile fish species (Baron et al., 2004; Lindeman and Snyder, 1999), and provides a source of food and refuge for both benthic and fish species.

The dune habitat in the Study Area, established where seawalls are not present, is dominated by common native dune species such as seagrape and sea oats, with no beach jacquemontia present.

5.0. LITERATURE CITED

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