Appendix K

Environmental Documentation

Integrated General Reevaluation Report
and
Supplemental Environmental Impact Statement

Brevard County, Florida
Hurricane and Storm Damage Reduction Project
Mid-Reach Segment

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APPENDIX SEIS-A

Abundance and foraging activity of marine turtles using nearshore rock resources along the Mid Reach of Brevard County, Florida.

FINAL REPORT

Abundance and Foraging Activity of Marine Turtles Using Nearshore Rock Resources along the Mid Reach of Brevard County, Florida

Contract No:
OLS 02022005

October 18, 2005

Submitted to:

Olsen Associates, Inc.
4438 Herschel Street
Jacksonville, FL 32210

Prepared by:

DYNAMAC CORPORATION

100 Spaceport Way
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ABUNDANCE AND FORAGING ACTIVITY OF MARINE TURTLES USING NEARSHORE ROCK RESOURCES ALONG THE MID REACH OF BREVARD COUNTY, FLORIDA

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Introduction

The nearshore hardbottom habitat in Brevard County, Florida is composed of worm rock, coquina and limestone outcroppings. Within the County, the hardbottom habitat is most conspicuous along the shoreline from the south end of Patrick Air Force Base (PAFB) to the city of Indialantic (Figure 1). The history of mapping and assessments of these rock outcroppings is described by Olsen (2003). The reef parallels the shoreline and is partially exposed in many areas at mean low tide. The reef structures exist predominantly in waters 0-4 m deep. The water conditions over the structures are highly dynamic throughout the year; turbulent with high wave energy and normally poor visibility. Portions of the reef have been described as ephemeral; being covered and uncovered by shifting sands during typical surf and extreme tide and storm events. Sections of the nearshore reef in Brevard County are composed of "worm rock". The rock structures are formed by the reef-building sabellariid worm, *Phragmatapoma lapidosa*; originally described by Kirtley and Tanner (1968). Similar hardbottom habitats studied in Indian River and Martin Counties revealed that more than 300 invertebrates, 192 fish species, and over 100 marine algae species utilize the reefs and associated resources for development and survival (Nelson and Demetriades, 1992; Juett et al., 1976; Nelson, 1989). In addition to these taxa, marine turtles have also been found to utilize the rock resources (Ehrhart, 1992).

While the nesting population of marine turtles in Brevard County has been extensively studied since the 1980's (Ehrhart et al., 2002), the juvenile marine turtle population utilizing the nearshore hardbottom in Brevard County was not studied until 2003

(Holloway-Adkins, 2005). In Florida, the use of nearshore reefs as developmental habitat by juvenile loggerhead and green turtles has been recognized and studied in Indian River County (Ehrhart, 1992; Ehrhart et al., 2001); Port St Lucie County (Bresette et al., 1998; Quantum Resources, 2000); Palm Beach County (Makowski, 2004; Makowski et al., 2002) and Broward County (Wershoven and Wershoven, 1989). The purpose of this study is to provide baseline information for the Supplemental Environmental Impact Statement (SEIS) document that will augment the Final EIS Brevard County Shore Protection Study conducted in 1996 (USACE, 1996). That study included plans for several alternatives to provide beach nourishment and shoreline protection in Brevard County. While the original EIS evaluated several shore protection options, planners could not adequately address the potential impacts to the 7.6 mile section of nearshore hardbottom referred to as the "Mid Reach". Based on this lack of sufficient information for the Mid Reach, the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) coordinated with Brevard County and the USACE (United States Army Corps of Engineers) which resulted in shore protection only for the areas north and south of the Mid Reach. The agencies determined that a more intensive investigation of the environment and potential impacts to the nearshore hardbottom and associated flora and fauna would be required before proposed options would be considered. The data from the current (2005) study will provide the SEIS with: 1) a more detailed description of the affected environment, as it relates to the ecology of juvenile marine turtles, and 2) an evaluation of the environmental consequences of proposed shore protection options for the Mid Reach area.

The specific objectives of the 2005 study were to (1) collect data concerning the relative abundance and distribution of marine turtles using the nearshore hardbottom along the Mid

Reach, (2) assess the size class structure and condition of the turtles, (3) determine the foraging and movement habits of the turtles, and (4) compare the data with similar juvenile marine turtle studies on the east coast of Florida. A separate marine turtle study conducted within the Mid Reach area during 2003-2004 (Holloway-Adkins, 2005) will be used in this report. While the goals of the 2003-2004 (hereafter referred to as the 2004 study) were not designed to address the full extent of the Mid Reach, the applicable data are incorporated into this report to increase the sample size and temporal component of this assessment.

METHODS

Study Area---The Mid Reach is located along the Brevard County coast from latitude 28^o 13.8 N, longitude 80^o 35.9 W to latitude 28^o 6.18 N, longitude 80^o 34.06 W which correspond to the designated state monuments R-75.4 and R-118.3, respectively (Figure 1). There are some dense reef structures north of R-75. Transect data were periodically recorded from section R-68 to R-75 for comparison with the Mid-Reach data. The county, state, and USACE use R-monument numbers to describe and track specific subsections of beach for biological and engineering purposes. The average distance between R-monuments is approximately 1000 ft. The USACE grouped R-monuments to form six segments of unequal lengths along the beach for evaluation purposes. These segments will be referred to as Corp Segments throughout the remainder of this document. The study's northern landmark is the Officers Club at PAFB, approximately 2.0 km (1.2 mi) north of State Road (SR) 518 or Pineda Causeway. The southern landmark is the intersection of Fluge Ave. and Highway A1A, approximately 1.0 km (0.6 mi) north of SR 192.

Several methods were used to accomplish the study goals and included (1) visual transect surveys to identify the relative abundance and distribution of turtles, (2) tangle net and

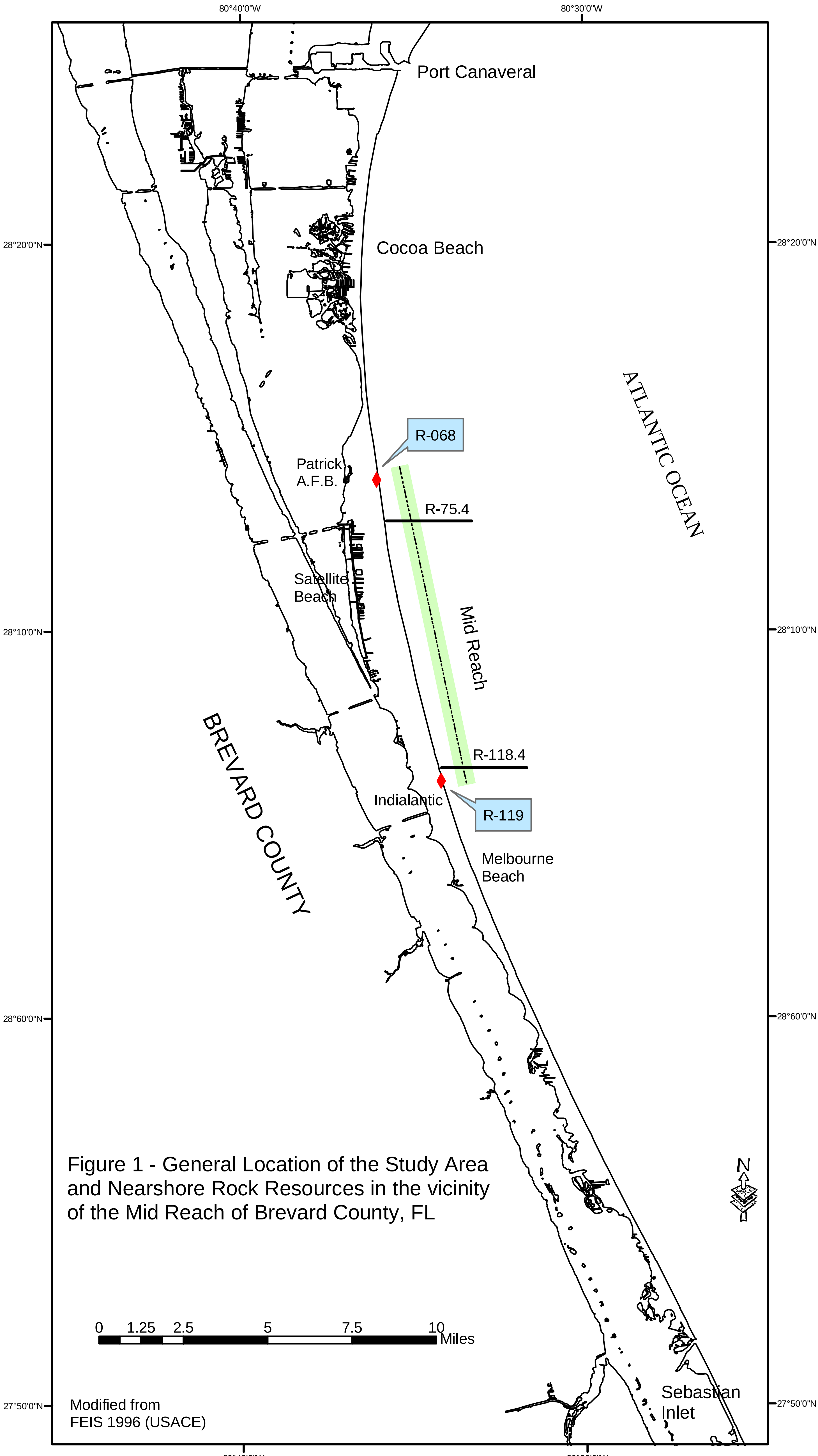

Figure 1 - General Location of the Study Area and Nearshore Rock Resources in the vicinity of the Mid Reach of Brevard County, FL

hand captures to provide data on the size class and condition of turtles, (3) flushing the esophagus of turtles to identify what they were eating, and (4) attaching acoustic tracking devices to several green turtles to study their movement and behavior over the nearshore hardbottom area.

Visual Transect Surveys---Systematic visual surveys were conducted from spring of 2003 through summer 2005. The 2003-2004 surveys were designed for a separate study and covered a 7 km (4.2 mi) linear distance between R-74 and R-99, or Corp Segments 4, 5, and 6 (Figures 2 and 3). The 2005 surveys followed a transect that covered the linear distance of the Mid Reach which began at the northern boundary of the study area (R-68) and terminated south at R-119. The transect length was 14.2 km (8.5 mi) and extended across all six Corps Segments and into southern PAFB (Figures 2 and 3). Surveys were conducted from a 7.3 m (24 ft) Carolina Skiff with a captain and two turtle observers. One observer was positioned midship and the other at the bow. The vessel was maneuvered parallel to the shoreline at approximately 7 mph. (11.2 km/h). The distance from shore was determined by the ocean conditions, water depth and activities present along the shoreline (i.e., people fishing, swimming, or surfing). The vessel platform elevated the observer's "height of eye" to approximately 2.5 m (8 ft) above the waterline. The observation swath was approximately 180^o with a bias across the bow and landward side of the vessel**.** When an observer positively sighted a turtle, the captain immediately marked a waypoint on the GPS (Garmin 72), and then recorded the turtle species, time of day and waypoint number on a datasheet or waterproof dive slate. The water temperature, water clarity, sea state, and weather conditions were also recorded for the survey.

Netting --- Marine turtles were captured using tangle net methods described by Ehrhart and Ogren (1999). Captured animals provided a subsample of the size, distribution and condition of turtles using the nearshore hardbottom. Tangle nets were set at various locations along the Mid Reach (Figure 3). Netting sites were selected based on where: 1) turtles were spotted during visual transect surveys, 2) nets could be safely deployed and monitored depending on water depth, visibility and surf conditions, and 3) a safe distance could be maintained from human activities. The tangle net was 180 m long x 3 m deep, constructed of 18-gauge nylon twine with a knot-to-knot stretch diameter of 30 cm. The top line of the net was constructed of braided polypropylene and the bottom line was 12 lb. (5.4 kg) lead core. The net was deployed over the bow of a 7.3 m (24‘) Carolina Skiff in 1.5 to 2.0 m (6.5’) water depth. The net was set over the sand bottom adjacent to the reef and parallel with the shoreline (Figure 4). It was secured to the bottom with a 24 lb.

Figure 4. Tangle net being set to capture marine turtles along the Mid Reach study area.

(10.8 kg) anchor attached at either end. Bullet-shaped buoys were attached with clips along the top line at 7-10 m (24- 32.5’) intervals. The net was continually monitored to avoid drowning turtles or injuring other marine organisms captured in the net. When visibility permitted, researchers would snorkel the net looking for entangled turtles. When a turtle was sighted, the boat was signaled and the snorkeler retrieved the turtle from the net and delivered it to the nearby waiting boat. When the visibility was poor the net was monitored from the bow of the boat by pulling hand-over-hand along the top line. The net was monitored every 20 minutes or less. When a turtle was located in the net, a large dip net was placed underneath it to prevent it from getting free before it was on the boat. The deployment and retrieval times were recorded for every net set. Catch-Per-Unit-Effort (CPUE) was calculated based on the number of turtles captured per 1,000 m (1 km) of net soak time.

Total turtles / [net length (km) X soak time (hrs)].

Elasmobranchs (sharks and rays) are often captured in tangle nets set in the shallow nearshore environment. When sharks were caught, if they could be landed, their total straight length was measured with forestry calipers. The wing-tip to wing-tip measurement was recorded for rays and most of the animals were photographed. The species, measurement, time and location of captures were recorded and the animals were safely released some distance away from the netting site.

Turtles were kept cool with a damp towel and placed on a foam pad in the shade. Their flippers were scanned for internal tags and examined for signs of external tags or tags scars. If no tags were found, the turtle received an external flipper tag on one or both front flippers and an internal tag on the right front flipper. All tagging sites were prepped with

Provodine (or Betadine). The external front flipper tags were Inconel tags by National Band and Tag Company. These were applied to the 2nd scale from proximal trailing edge of each front flipper. The internal P.I.T. (or passive integrated transponder) tags manufactured by Destron-Fearing were inserted above the second proximal scale of the trailing edge of the right front flipper. Before the P.I.T. tag was inserted, an application of Neosporin (triple antibiotic ointment) was applied to the tip of the applicator needle. The P.I.T. tag was injected just below the surface of the skin and angled toward the turtle's wrist. The internal tag area was scanned before the turtle was released to verify the transponder was working properly.

Turtles were weighed and measured. They were thoroughly checked for any evidence of fibropapillomatosis (FP) tumors in their mouth, eyes or other parts of their body. Their condition was assessed (i.e., barnacle load, leeches, carapace and flipper damage). Dorsal, ventral and head profiles were photographed, as well as, anything that appeared unusual.

Lavage----An esophageal flushing technique called lavage was used to collect a sample of what turtles ingested. The process is a modified veterinary stomach pump procedure where ocean water is used to gently flush out the contents of the esophagus (Balazs, 1980; Forbes and Limpus, 1993). The contents of the lavage sample were strained and placed in a glass jar in a 5% formalin/seawater mix to preserve the plant material. In the laboratory, samples were strained through a 0.7 mm filter. Stereoscopy and light microscopy were used to identify the sample contents. Many of the content particles were less than 1 cm in length with few identifying structural features. Most representatives of algae had to be cross-sectioned to utilize the cell size and structure for identification. Every effort was made to identify samples to the species level. After sample contents were identified, the sample was quantified using a petri dish with 16-cell grid (4x 4) and a cell size of 1.5 $cm^{2.}$ The sample was spread over the grid to form a thin layer across the cells. A Bausch and Lomb stereoscope, fitted with a 100 (10 x10) square grid micrometer in the eyepiece, was used to segregate the sample and make counts. The scope was adjusted so the micrometer fit neatly inside one of the 1.5 cm^2 grids of the petri dish. The items that fell on the top left intercept of the even numbered squares of the micrometer were counted, yielding a total potential of an 800-item count per sample.

Acoustic Tracking---- Tracking devices were placed on a subset of turtles to establish the spatial movements of green turtles using the Mid Reach rock resources. A tag was attached to the turtle's carapace on the lower portion of the posterior costals using non-toxic marine epoxy. The tag application area was first cleaned with a scrub pad, then dried and lightly sanded with fine sandpaper. Alcohol (70% Isopropyl) on a lint-free marine cloth was used to wipe away oil or sanding residue. The epoxy was formed to wrap around the length of the tag and then gently pressed onto the carapace. The epoxy hardened in one hour. Two types of acoustic tags were used, the CHP-87 and the AST 05 (Sonotronics Inc., Tucson, Arizona). The CHP-87 tags transmitted every 6 seconds, each with a specific frequency (69.0-71.0 kHz). The AST-05 tags were designed to transmit at other frequencies (73.0 kHz and 76.0 kHz), log time and depth data. The AST-05's were also designed to transmit real-time depth during manual tracking. A USR-96 receiver, connected to a directional hydrophone (DH-4) was placed at mid-water depth and used to detect the presence of tagged animals in the tracking area. Monitoring sessions for turtles with acoustic tags were typically conducted for an hour and within a 500-meter area north and south of the location where turtles were originally released. Tracking was generally attempted at high tide to reduce background wave impact noise.

Sampling Augmentation: At the conclusion of the planned sampling for this study, shoreline observations were implemented to supplement data for those areas along the Mid Reach where transect data resulted in not a single turtle sighting and where netting did not occur due to safety and effort constraints. The shoreline observations were conducted for 15 minutes from each of seven crossovers. The crossovers were approximately 10’ above the top of the dune. The observer’s visual coverage of the water extended approximately 300’ to the north and south and east about 150’ out from the shoreline. If a turtle was sighted at the surface breathing, a time was recorded to prevent counting the same turtle more than once. Previous observations indicate juvenile green turtles in this nearshore environment breathe approximately every two minutes.

Treatment of data and analyses---All data (visual transects, CPUE, foraging, etc.) were entered into spreadsheets for basic summary statistics. The visual transect surveys were ranked with a condition code (poor, fair, and good) based on water clarity and sea conditions prevalent at the time of the survey. A survey would be considered poor if the visibility was impacted by large swells and/or choppy water. Surveys ranked as poor were not included in the summary statistics.

Results were spatially evaluated based on R-monument numbers and the Corps Segments (1-6) that were provided in SEIS team meetings on 17 August 2005. The visual transect data were weighted based on the total length (km) of the surveys for comparison between years (with differing transect lengths) and to compare spatial trends. Similar weighting was performed for data analyzed based on Corp Segments (segments varied in length from 1.1 to 2.85 km). The GPS waypoint positions recorded for the visual transect surveys, net set locations and tracking points were converted to NAD27 using ESRI-GIS tools (ArcView and ArcGIS version 8.2). The points were super-imposed on aerial geo-rectified maps of the Mid Reach. The measuring tool provided linear distances for tracking data. The percentage of items ingested was calculated for each lavage sample using the item count divided by the total sample count. The population percentage and frequency of occurrence of ingested items among all turtles was also calculated.

RESULTS

Visual Transect Surveys— All of the turtles sighted during the transect surveys were juveniles, with green turtles (*Chelonia mydas*) being the most common and making up 99% of the sightings. The only other turtle species sighted was the loggerhead (*Caretta caretta*). Eleven surveys were performed in 2005 along the entire Mid Reach with nine surveys meeting the condition criteria for inclusion in the analyses. Sixty-five turtles (64 green turtles and 1 loggerhead) were observed for an average of 7.2 turtles per survey or 0.41 turtles per km (Appendix, Table A-1). In 2004, 15 of the 17 surveys met the condition criteria, but surveys did not extend into Segments 1-3. The average number of turtles observed per survey was 5.2 or 0.74 per km (Appendix, Table A-2). The distribution of sightings varied with each survey, however, no turtles were sighted south of R-109 or within Segment 1 (Figures 5, 6, 7, and 8). For the areas where surveys overlap for both years (Segments 4, 5, and 6), the distribution of marine turtles was skewed towards Segments 5 and 6 (Figure 8). Using the data solely from 2005, the mean number of turtles sighted per Segment indicates a relatively even distribution of turtles across Segments 3, 4, 5, and 6 with values ranging from 0.62 to 0.85. Those Segments had values twice as high as Segment 2 (Figure 8).

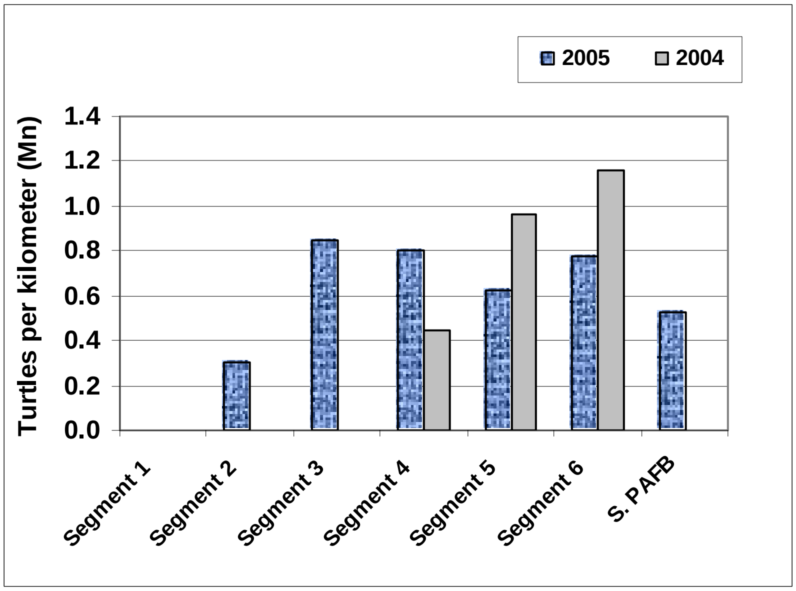

Figure 8. Spatial distribution of marine turtles sighted across Corp Segments during visual transect surveys conducted in 2004 and 2005. Segments 1 through 3 were not surveyed in the 2004 study. Observations were calculated based on sightings per kilometer and applied to Segments. S. PAFB is the area just north of Segment 6 at the southern end of Patrick Air Force Base.

Netting and Hand Capturing Turtles--- The spatial distribution of netting was non-uniformly distributed across the Mid Reach (Figure 3). Nets were set at locations where turtles were most frequently observed and where the aforementioned safety criteria could be met. Netting in 2005 extended from R-77 to R-105 and the 2004 efforts extended from R-77 to R-98. The combined efforts of tangle netting in 2004 and 2005 resulted in 54 total net sets or 11.7 net kilometer hours (Table 1). In 2005, nine juvenile green turtles were captured in tangle net sets and two turtles were captured by hand (Appendix, Table B-1). In 2004, netting effort resulted in 20 captures (Appendix, Table B-2). While the netting effort was similar, in terms of net kilometer hours, the CPUE in 2004 exceeded the 2005 CPUE (Table 1).

Table 1. Netting effort and CPUE for green turtles captured adjacent to the nearshore rock resources along the Mid Reach in 2004 and 2005.

	Effort Net Hours	Net-KM Hours	Logger-head Captures	Green Captures	Logger-head CPUE	Green CPUE	Total CPUE
2004	28.29	5.09	0	20	0	3.52	3.52
2005	36.81	6.62	0	9	0	1.25	1.25
TOTAL	65.1	11.71	0	29	0	2.47	2.47

High CPUE rates corresponded to net sets within R-monuments R-77, R-95 and R-96 in 2005, while in 2004 high CPUE rates were within R- 85, R-94 and R-96 (Tables 2 and 3). Over 60% of the 2005 effort occurred in these high CPUE R-monuments. For 2004, the high CPUE R-monuments received only 37% of the effort.

Table 2. Net locations and Catch-Per-Unit-Effort (CPUE) for marine turtles within R-monuments in 2005.

R-monument	Soak Hours	Net km/hrs	Effort	Mean CPUE	Cm captures	# Net Sets	Segment
R-77	3.75	0.684	10.33%	1.59	1	3	6
R-81	0.9	0.57	8.61%	0	0	1	6
R-83	2.32	0.62	9.33%	0	0	2	5
R-85	3.43	0.33	5.03%	0	0	1	5
R-95	15.64	2.56	38.68%	1.8	7	11	4
R-96	7.89	0.98	14.86%	1.85	1	6	4
R-97	1.42	0.23	3.47%	0	0	1	4
R-105	1.47	0.64	9.69%	0	0	2	2
TOTAL	36.82	6.62	100.00%		9	27	

Table 3. Net locations and Catch-Per-Unit-Effort (CPUE) for marine turtles within R-monuments in 2004.

R-monument	Soak Hours	Net km/hrs	%Effort	Mean CPUE	Cm captures	# Net Sets	Segment
R-77	3.34	0.60	11.76%	0.00	0	2	6
R-79	1.13	0.20	3.92%	0.00	0	1	6
R-80	2.58	0.48	9.41%	0.00	0	3	6
R-81	0.45	0.08	1.57%	0.00	0	1	6
R-83	0.75	0.14	2.75%	0.00	0	1	5
R-84	0.55	0.10	1.96%	0.00	0	1	5
R-85	5.17	0.93	18.24%	11.37	11	6	5
R-86	2.22	0.40	7.84%	0.00	0	1	5
R-87	1.87	0.34	6.67%	0.00	0	2	5
R-90	2.5	0.45	8.82%	1.55	1	2	5
R-91	0.92	0.17	3.33%	0.00	0	1	5
R-94	2.13	0.38	7.45%	5.65	2	2	4
R-96	3.4	0.63	12.35%	8.00	6	3	4
R-98	1.08	0.20	3.92%	0.00	0	1	4
TOTAL	28.09	5.10	100.00%		20	27	

Net efforts in 2004 and 2005 did not include Segment 1. Additionally Segments 2 and 3 were not sampled in 2004. When the data are superimposed on Corp Segments, CPUE rates were highest in Segments 4 and 6 in 2005 and Segments 4 and 5 in 2004 (Tables 4 and 5).

Table 4. Net locations and Catch-Per-Unit-Effort (CPUE) for marine turtles in relation to Corp Segments in 2005.

Segment	Net km/hrs	%Effort	Mean CPUE	Cm captures	# Net Sets
6	1.25	18.94	0.80	1	4
5	0.95	14.36	0.00	0	3
4	3.78	57.03	2.12	8	18
3	0.00	0.00	0.00	0	0
2	0.64	9.67	0.00	0	2
1	0.00	0.00	0.00	0	0
TOTAL	6.62	100.00		9	27

Table 5. Net locations and Catch-Per-Unit-Effort (CPUE) for marine turtles in relation to Corp Segments in 2004.

Segment	Net km/hrs	Effort	Mean CPUE	Cm captures	# Net Sets
6	1.36	26.67%	0.00	0	7
5	2.53	49.61%	1.08	12	14
4	1.21	23.73%	1.71	8	6
3	0.00	0.00%	n/a	n/a	0
2	0.00	0.00%	n/a	n/a	0
1	0.00	0.00%	n/a	n/a	0
TOTAL	5.10	100.00%		20	27

Shoreline observations conducted on August 23, 2005 were used to supplement netting efforts and reassess the absence of boat transect sightings in Segment 1 and the results are found in the Appendix, Table C. Seven shoreline observation surveys extended from Segment 2 through Segment 1, including R-109.2 and R-118.8. Three green turtles were recorded at R-109.2. No other green turtles were observed south of R-109.2.

In addition to marine turtles, four shark species and two ray species were caught during net sets. Species included *Carcharinus leucas, C. brevipinna, Ginglystoma cirratum, Aetobatus narinari*, *Rhinoptera bonasus*, *Sphyrna tiburo* and *Remora* spp. (Appendix, Table D). Eagle rays (*Aetobatus narinari*) were the most frequently captured species; representing 46.4% of the total elasmobranchs captured. All of these animals were released alive within the vicinity of their capture.

Size distribution

Only juvenile green turtles were captured during both study periods. The size distribution based on Straight Carapace Length (SCL) ranged from 26.4 cm to 64.6 cm (Appendix, Tables E-1 and E-2). The average SCL was 35.6 cm (std. ± 8.1) and 94.0 % percent of green turtles were less than 44 cm SCL. Two turtles were considerably larger than the rest of the sample (56.1 and 64.6 SCL cm), however, all of the captured turtles fell within the juvenile size class range (Hirth, 1997). The majority of turtles ranged towards the smaller juvenile size class (Figure 9).

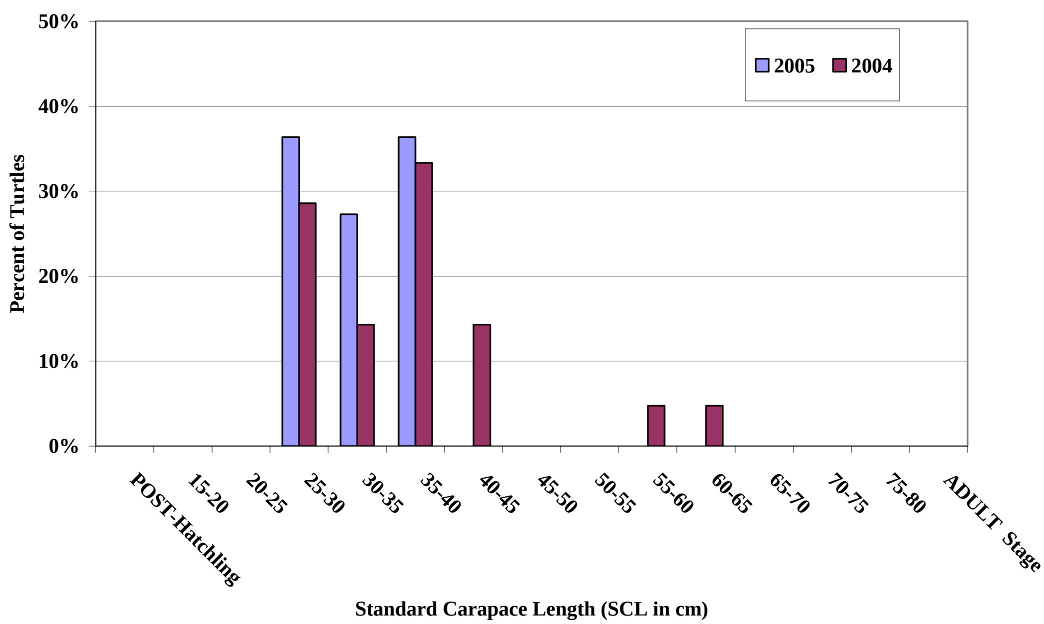

Figure 9. Size class distribution of green turtles captured along the nearshore rock resources in the Mid Reach, (N=32).

Condition

The condition of the turtles observed and captured in 2004 and 2005 was generally healthy and free of external parasites. None of the 32 captured turtles showed signs of fibropapillomatosis (FP). Some turtles had small barnacles on their shells or fleshy parts. Seven turtles had some kind of minor flipper damage and many turtles had cuts or abrasions on the plastron or carapace.

Food Habits

Lavage samples for 21 green turtles captured in the 2004 study and 11 green turtles captured in 2005 were analyzed (Appendix, Table F). The results indicate turtles were foraging on a wide variety and large number of different items on the reef (Table 6). The lavage samples contained 44 different items from 6 major categories; the bulk of which were in the red algae category. There was an average of 8 different items found in each lavage samples.

Table 6. Items found in lavage samples from green turtles captured adjacent to nearshore rock resources along the Mid Reach.

RED ALGAE	**GREEN ALGAE**	**BROWN ALGAE**
Bryocladia cuspidata	*Chaetomorpha* spp.	*Padina* spp.
Gelidium spp.	*Chaetomorpha linum*	
Gelidium americanum	*Cladaphora* spp.	
Gelidium pussillum	*Ulva* spp.	
Ceramium sp.	*Ulva lactuca*	
Centroceras clavulatum	*Caulerpa prolifera*	
Gracilaria spp.		
G. mammillaris		
Hypnea spp.		
Hypnea valentiae		
Chondria spp.		
Chondria dasyphylla		
Agardhiella subulata		
Dudresyna crassa		
Laurencia spp.		
Jania adhaerens		
Chondrocanthus acicularis		
ANIMAL	**PLANT**	**INORGANIC**
Bugula	Unknown plant (unk orange)	Rock
Tube worm	Mush (decomposing matter)	Shell
Shrimp-like	Seed	Sand
Caprellid	Bark	
Jellyfish		
Star jellies		
Barnacle		
Snail with body		
Insect		
Tubeworm-casing		
Hydroid		
Fish scales		
Gelatinous mass		

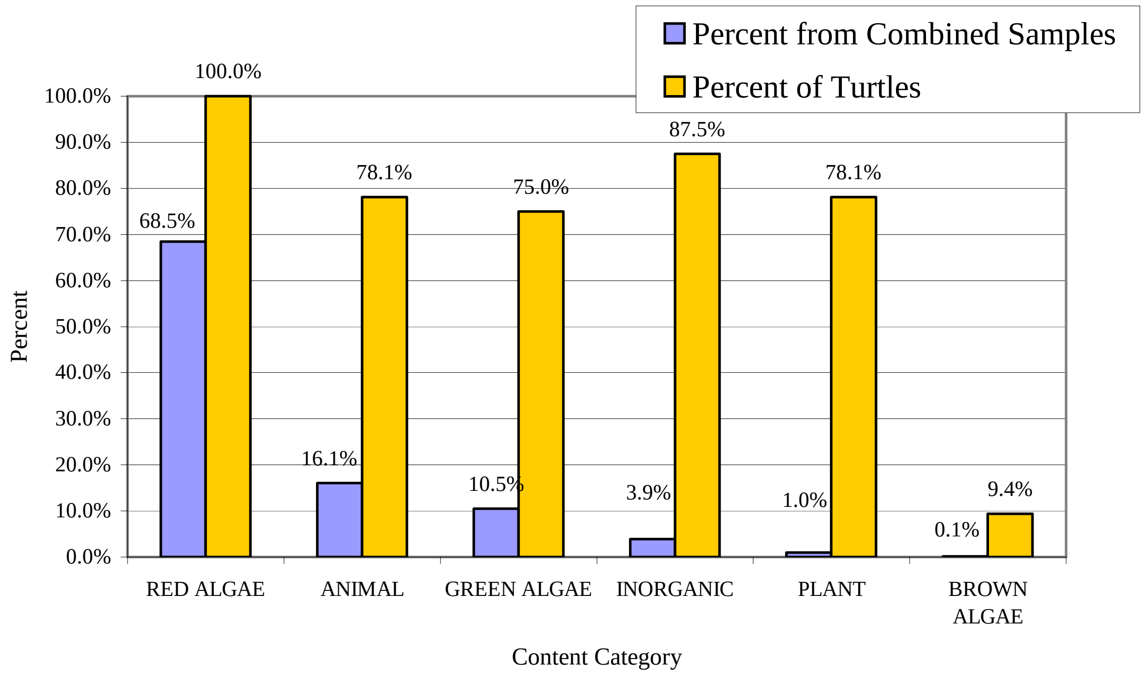

Figure 10. Categories of items ingested by green turtles captured adjacent to nearshore rock resources along the Mid Reach. Blue bars indicate the percentage of items ingested, according to category, from combined lavage sample results. Yellow bars indicate frequency of occurrence, of each category, among the lavage samples.

Red algae were consumed in the greatest quantity and the most frequently (Figure 10). All of the turtles (100%) ingested red algae and when all samples were pooled, it represented 68.5% of the contents. In terms of specific species or genera found within the samples, the dominant red algae groups were *Gelidium* spp., *Gracilaria* spp. and *Bryocladia cuspidata* (Figure 11).

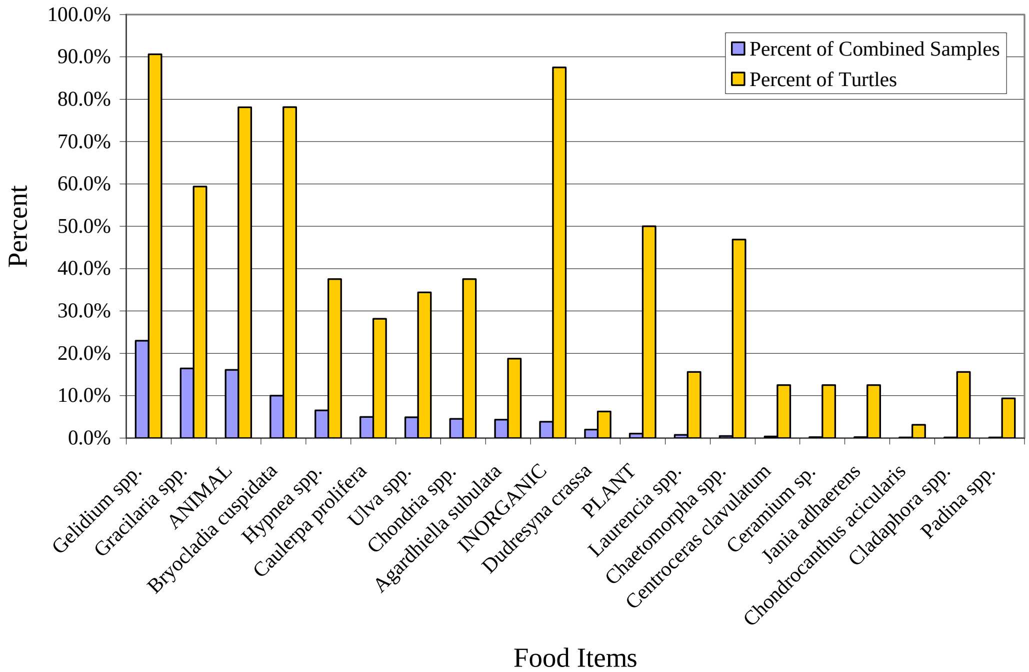

Figure 11. Items ingested by green turtles captured adjacent to nearshore rock resources along the Mid Reach. Blue bars indicate the overall percentage of the ingested item among combined samples. Yellow bars indicate the frequency of occurrence among the lavage samples.

Acoustic tracking---During the 2005 study period, five juvenile green turtles were fitted with acoustic transmitter devices; four CHP-87's and one AST-05 tag. Four of the five turtles were captured over the nearshore hardbottom in the vicinity of R-95 & R-96 (Corp Segment 4) and one was captured in the vicinity of R-77 (Corp Segment 6). Monitoring attempts were made on 28 separate days for a total of 69 hours (Table 7 and Appendix, Table G). One green turtle (Sharky) was released and monitored on June 17. This turtle was detected on 6 different days and covered a linear distance of 681 m (Figure 12). The furthest point away from the original capture/release location was south for 515 m. Underwater photography and video were recorded where Sharky was captured and spent several hours. The hardbottom habitat was patchy there, with large expanses of sand between the main reefs. Another turtle (Boomer) was monitored for approximately 1.5

hours after released. During that time, Boomer's sonic transmission indicated that he (or she) was on the bottom next to a large ledge. GPS points recorded during the tracking show Boomer moving 89 linear meters from the original release location (Figure 13). When monitoring was resumed later the same day; however, Boomer could not be detected in the area and consequently was not detected again for the remainder of the study period.

Table 7. Juvenile green turtles tagged with acoustic transmitters: size, tag numbers, R-monuments and total hours spent on the water monitoring each turtle.

Turtle Name	Sonic Tag ID (kHz)	Capture Site (R-monument)	Size SCL cm	Capture Date	Days Attempted	Days Detected
Van	69.0	R-96	28.1	May 12	25	0
Sharky	70.0	R-77	36.0	June 16	12	6
Boomerang	71.0	R-95	37.9	July 1	10	1
Hawk	73.0	R-95	39.8	July 1	10	0
Sally	72.0	R-95	32.9	July 6	7	0

DISCUSSION

The separate and combined results of the 2004 and 2005 studies clearly identify the nearshore rock resources along the Mid Reach of Brevard County as marine turtle habitat. More specifically, the data convey the area as important juvenile green turtle habitat. The visual transects, capture and tracking data indicate green turtles were frequently observed, captured and tracked within the northern, dense, nearshore hardbottom. The most consistent and continuous zone with no turtle sightings along the Mid Reach was between monuments R109-R119. This is the zone referred to by the Corps as proposed nourishment Segment 1. It had the lowest concentration and aerial extent of rock reef in the Mid Reach based on our observations and earlier rock classification mapping conducted by Dial Cordy in 2001 (Olsen Associates, 2003). Results of the 2001 mapping reported 1.2 acres of rock resource in Segment 1 (Figure 14).

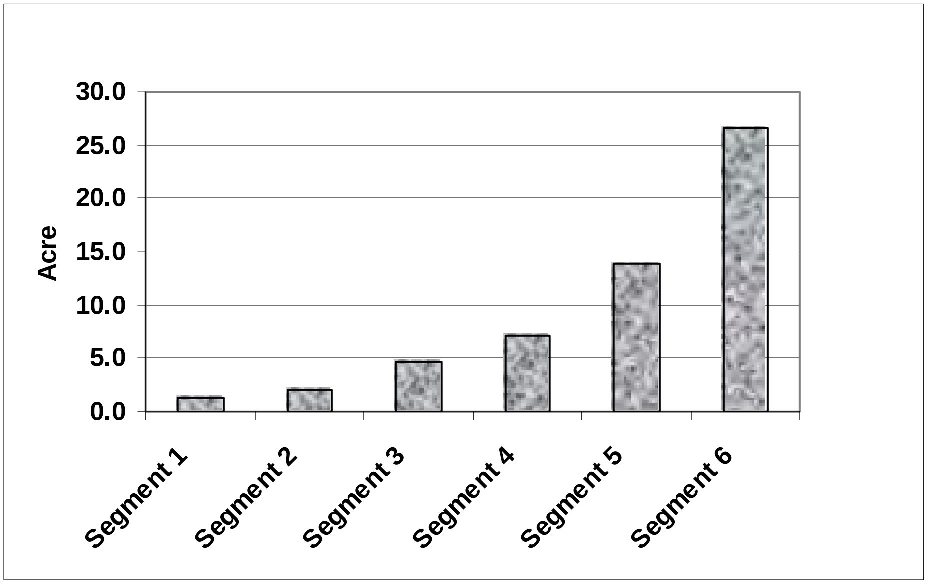

Figure 14. The distribution of rock resources within each Segment along the Mid Reach Study Area.

The negative correlation in turtle sightings in Segment 1 is likely no coincidence since turtles seek substrates with abundant macroalgae cover and refuge, both of which are relatively limited in Segment 1.

Working close to shore was dangerous and unpredictable, forcing netting and boating events to areas where they could be safely and efficiently conducted. At the same time, nets that were set away from the nearshore reefs or in deep water - did not capture turtles. Netting effort was concentrated in areas where turtles were observed. As aforementioned, marine turtles were not observed in Corp Segment 1; hence there are no CPUE data available for that area. The rock resource habitat in Segment 1 is patchy, discontinuous and confined very close to shore; also meaning nets could not be efficiently utilized in this area.

However, the supplemental (post hoc) observations conducted in late August found green turtles in the waters on the north end of Segment 1. In addition, Continental Shelf Associates, Inc. observed green turtles in areas within Segment 1 during fish surveys on August 22, 2005 (Snyder, D., pers. comm.). We have to assume that turtles utilize the resources in Segment 1 but apparently in relative low numbers.

Most research on juvenile sea turtle developmental habitat has been limited to protected estuaries, lagoons and sounds (Ehrhart, 1992; Ehrhart et al., 2001; Bresette et al., 1998; Bresette et al., 2000; Provancha et al., 1998) that are not as directed and limited by ocean and weather conditions. There have been 6 juvenile green turtle population studies conducted in nearshore oceanic habitats on the east coast of Florida (Table 8). Turtles captured along the Mid Reach in Brevard County exhibit a size class distribution similar to the worm reef study in Indian River County but an overall mean that is most similar to turtles captured at the FPL Power Plant in Hutchinson Island, Florida.

Table 8. Mean Straight Carapace Length (SCL) in cm and size class distribution of green turtles captured adjacent to nearshore oceanic habitats on the east coast of Florida.

Location	**Method**	**Measurement**	**Size**	**Range**	**N**
Trident Basin, Cape Canaveral AFS, FL	Tangle Net & Dip Net	SCL	31.4 cm	22.9 - 48.1cm	126
Shipping Channel, Cape Canaveral, FL	Trawl	TCL	33.8 cm	23.6 - 67.0 cm	19
Worm Reefs, Indian River County, FL	Tangle Net *	SCL	41.1 cm	25.1 - 67.0 cm	190
FPL Power Plant, Hutchinson Island, FL	Intake **	SMCL	38.7 cm	20.0 - 108.0 cm	2,417
Limestone Reefs, Broward County, FL	SCUBA	n/a	n/a	26.4 - 67.0 cm	105
Nearshore Reefs, Brevard County, FL	Tangle Net & Hand Capture	SCL	35.6 cm	26.4 - 64.6 cm	32

This table (in part) was re-created from L.M. Ehrhart and W.E. Redfoot (1998); * Data from L.M. Ehrhart, W.E. Redfoot and D.A. Bagley (1996); ** Data from Ecological Associates, Inc. (2000).

Currently, there are only two studies of juvenile green turtles using nearshore oceanic habitats where tangle nets are used and a comparison between CPUEs can be made (Table 9). The CPUE during the Mid Reach 2005 study was most similar to the Trident Basin; however, the 2004 CPUE results were over twice as large and closer to the average CPUE for Indian River County worm reefs. Ehrhart (2001) suggested the outcome of CPUE may be a result of changes in surf condition and water clarity from year to year and fluctuation in available food resources, rather than any radical changes in green turtle population density over the reef.

Table 9. Comparisons of CPUEs for marine turtle studies conducted over nearshore hardbottom areas in Florida.

Location	CPUE	Year	N
Trident Basin, Cape Canaveral AFS, FL	1.32	1996-1997	39
Worm Reefs, Indian River County, FL **	6.28	1989-1995	190
Nearshore Reefs, Brevard County, FL	3.52	2003-2004	20
Nearshore Reefs, Brevard County, FL	1.25	2005	9

Data from L.M. Ehrhart, D.A. Bagley, W.E. Redfoot, S.A. Kubis and S. Hirama (2001); ** Data from L.M. Ehrhart, W.E. Redfoot and D.A. Bagley (1996).

The most informative data from the netting effort is the assessment of size and condition of turtles in this habitat. While turtles were in apparent good condition, abrasions were found on the plastron of many and may be indicative of their behavior amongst the rocks in the nearshore environment. Turtles were observed foraging and swimming in very shallow water (< 0.6 m or 2 ft) at low tide even on days when the surf was rough. Turtles were also observed wedging themselves under small ledges. The first turtle captured in 2005 was found resting beneath a 0.15 m (6 in.) ledge, located approximately 0.6 m (2ft) from the shoreline in 0.2 m (8 in.) of water.

All of the turtles that were captured appeared to be healthy, free from parasites and did not exhibit signs of fibropapillomatosis disease (FP). The disease normally manifests as tumors on the eyes and fleshy parts of the skin. It can impair the turtles' abilities to forage and/or evade predators (Herbst and Klein, 1995). Remarkably, this population is one of only two locations on the east coast of Florida where green turtles have been found without FP.

Juvenile green turtles using nearshore oceanic habitats predominantly forage on macroalgae (Redfoot, 1997; Holloway-Adkins, 2001; Ehrhart et al., 1996). The availability of macroalgae is dependent on hard substrates upon which it can attach and grow.

Temperature, light, nutrients and grazing competition are other important factors that control the growth, diversity and production of marine macroalgae. The photosynthetic pigments in red algae allow it to grow in deeper depths and more light limited areas than green or brown algae. Preliminary studies along the Mid Reach and nearby Indian River County worm reefs indicate red algae are the most abundant and diverse (Juett et al., 1976; Holloway-Adkins, 2001; Ehrhart et al., 1996). Foraging studies conducted at the Trident Basin in Cape Canaveral and the worm reefs in Indian River County indicate green turtles ingest red algae more frequently and in larger quantities than other available food resources (Figure 15). Jellyfish dominated only two of the lavage Mid Reach turtle samples but were in a large enough quantity to skew the overall combined sample results. Jellyfish did not represent an item frequently ingested within the rest of the samples. There was a commonality present in the ingested contents of the lavage samples from the Mid Reach, Trident Basin and Indian River County worm reefs for several items including *Gelidium* spp., *Hypnea* spp. and *Gracilaria* spp. Available food resources fluctuate seasonally and annually. After Hurricane Frances and Jeanne in 2004, the rocks in the mean low tide zone were scoured bare. However, turtles were observed on visual transects conducted two months post- hurricanes (November and December 2004) and it could be assumed they were foraging in deeper waters on what was available.

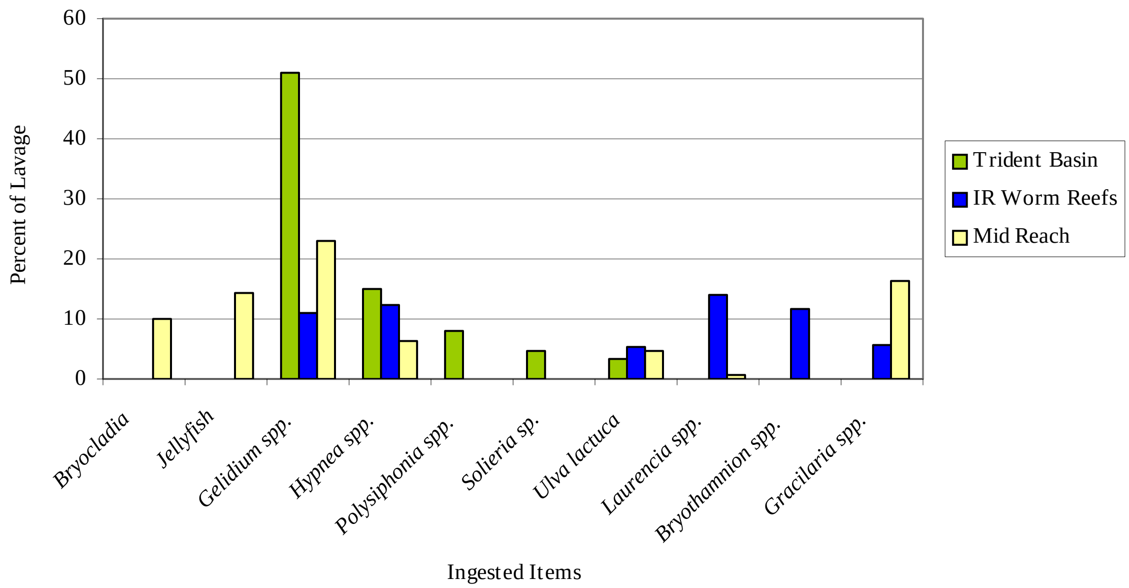

Figure 15. A comparison of items frequently ingested by juvenile green turtles at the Trident Basin in Cape Canaveral, Florida, the Worm Reefs in Indian River County, Florida and along the Mid Reach in Brevard County, Florida.

Interestingly, few herbivorous fish and invertebrate grazers were found in this study area (Snyder, D. pers comm. and pers. observ.). Sea urchins frequently out-compete other grazers on the reef and can keep an area void of macroalgae. The absence of urchins may be due to an inability to attach to the reef in high-energy wave conditions of these shallow waters (Witherington, B.E. pers. comm.).

The recovery criteria for the U.S. population of loggerheads and green turtles includes determining the distribution and seasonal movements for all life stages in the marine environment (NMFS, 1991b; NMFS, 1991a). This project provides a baseline of the marine turtles utilizing the nearshore reefs in central Brevard County as developmental habitat. Burial of nearshore hardbottom, as can occur in association with beach nourishment operations, could potentially reduce food availability both by removing potential food items and altering the benthic habitat (USACE, 1996). Future beach nourishment may impact this and other nearshore habitats. It is important to monitor nearshore areas for environmental changes that alter the fish, invertebrate and macroalgae composition, which in turn may affect green turtle and loggerhead populations.

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APPENDIX

Table A-1. Results of the transect surveys for 2005 extending along the entire Mid Reach. The gray rows highlight the dates that were not used in the summary statistics due to condition code (poor).

DATE	*C. caretta*	*C. mydas*	Condition	R118-109 S-1	108-105 S-2	104-99 S-3	98-93 S-4	92-83 S-5	82-75.4 S-6	75.4-68 S. PAFB
22-Apr-05	0	3	Fair	0	0	1	0	0	2	n/a
12-May-05	0	0	Poor	0	0	0	0	0	0	n/a
23-May-05	0	0	Poor	0	0	0	0	0	0	n/a
24-May-05	0	2	Good	0	1	0	1	0	0	n/a
30-May-05	0	6	Good	0	0	1	1	2	2	n/a
16-Jun-05	0	0	Good	0	0	0	0	0	0	n/a
19-Jun-05	0	14	Good	0	0	2	3	6	3	0
7-Jul-05	0	9	Good	0	0	1	3	0	5	0
17-Jul-05	0	6	Fair	0	0	2	1	2	0	1
24-Jul-05	0	14	Good	0	1	4	3	3	1	2
6-Aug-05	1	10	Good	0	1	4	1	3	1	1
TOTAL	**1**	**64**		**0**	**3**	**15**	**13**	**16**	**14**	**4**
MEAN				**0**	**0.33**	**1.67**	**1.44**	**1.78**	**1.56**	**1.00**
#/Segment Length (km)				**0.00**	**2.73**	**7.65**	**7.26**	**5.61**	**6.97**	**2.09**
Mn # /Segment Length (km)				**0.00**	**0.30**	**0.85**	**0.81**	**0.62**	**0.77**	**0.52**

Table A-2. Results of the transect surveys for 2004 extending along the Mid Reach. The gray rows highlight the dates that were not used in the summary statistics due to condition code (poor). The gray columns highlight Corps Segments in 2004 that were not surveyed.

				R118-109	108-105	104-99	98-93	92-83	82-75.4
DATE	***C. caretta***	***C. mydas***	**Condition**	**S-1**	**S-2**	**S-3**	**S-4**	**S-5**	**S-6**
22-Jun-03		8	Fair	n/a	n/a	n/a	1	3	3
13-Jul-04		6	Fair	n/a	n/a	n/a	0	3	1
24-Aug-03		9	Good	n/a	n/a	n/a	0	6	2
1-Jan-04		4	Fair	n/a	n/a	n/a	0	2	1
25-Jan-04		9	Good	n/a	n/a	n/a	0	0	9
10-Apr-04		20	Good	n/a	n/a	n/a	0	9	11
29-May-04		1	Fair	n/a	n/a	n/a	0	0	1
31-May-04		7	Fair	n/a	n/a	n/a	0	5	2
6-Jun-04		8	Fair	n/a	n/a	n/a	2	5	1
20-Jun-04		2	Fair	n/a	n/a	n/a	1	1	0
26-Jun-04		4	Fair	n/a	n/a	n/a	1	1	0
2-Jul-04		3	Fair	n/a	n/a	n/a	3	0	0
10-Jul-04		8	Fair	n/a	n/a	n/a	3	4	1
21-Aug-04		2	Poor	n/a	n/a	n/a	1	0	1
21-Nov-04		2	Poor	n/a	n/a	n/a	1	1	0
8-Dec-04		0	Good	n/a	n/a	n/a	0	0	0
8-Dec-04		6	Good	n/a	n/a	n/a	1	2	3
TOTAL	**0**	**98**		**n/a**	**n/a**	**n/a**	**12**	**41**	**35**
MEAN				**n/a**	**n/a**	**n/a**	**0.8**	**2.73**	**2.33**
# / Segment Length (km)							**6.70**	**14.39**	**17.41**
Mn /Segment Length							**0.45**	**0.96**	**1.16**

Table B-1. Catch per unit effort in km-hrs for net-captured marine turtles along nearshore rock resources in Brevard County, Florida, from April 2005 to July 2005.

Date	Soak Hours	Net km/hr Effort	Loggerhead Captures	Green Turtle Captures	Loggerhead CPUE	Green Turtle CPUE	Total CPUE	R-Monument
22-Apr-05	1.27	0.23	0	0	0.00	0.00	0.00	96
22-Apr-05	0.90	0.16	0	0	0.00	0.00	0.00	81
24-May-05	0.58	0.11	0	0	0.00	0.00	0.00	95
24-May-05	1.35	0.24	0	0	0.00	0.00	0.00	95
24-May-05	0.77	0.14	0	0	0.00	0.00	0.00	95
29-May-05	0.85	0.15	0	0	0.00	0.00	0.00	105
29-May-05	1.02	0.18	0	0	0.00	0.00	0.00	83
30-May-05	0.57	0.10	0	0	0.00	0.00	0.00	95
30-May-05	1.30	0.23	0	0	0.00	0.00	0.00	83
16-Jun-05	0.90	0.16	0	0	0.00	0.00	0.00	96
16-Jun-05	1.17	0.21	0	1	0.00	4.76	4.76	77
18-Jun-05	1.32	0.24	0	0	0.00	0.00	0.00	96
18-Jun-05	0.50	0.09	0	1	0.00	11.11	11.11	96
19-Jun-05	2.67	0.48	0	1	0.00	2.08	2.08	95
19-Jun-05	1.35	0.24	0	0	0.00	0.00	0.00	77
1-Jul-05	1.77	0.32	0	1	0.00	3.14	3.14	95
1-Jul-05	2.70	0.49	0	3	0.00	6.17	6.17	95
3-Jul-05	0.95	0.17	0	0	0.00	0.00	0.00	96
3-Jul-05	0.90	0.16	0	0	0.00	0.00	0.00	95
5-Jul-05	1.10	0.20	0	0	0.00	0.00	0.00	85
5-Jul-05	2.33	0.42	0	0	0.00	0.00	0.00	95
6-Jul-05	3.18	0.57	0	1	0.00	1.75	1.75	95
6-Jul-05	1.42	0.26	0	0	0.00	0.00	0.00	97
7-Jul-05	1.15	0.21	0	1	0.00	4.83	4.83	95
7-Jul-05	1.23	0.22	0	0	0.00	0.00	0.00	77
17-Jul-05	0.62	0.11	0	0	0.00	0.00	0.00	105
24-Jul-05	2.95	0.53	0	0	0.00	0.00	0.00	96
14 days	36.81	6.62	0	9	0.00	1.25	1.25	

<u>NOTE:</u> these calculations do not include a hand-captured green turtle May 12 and a fisherman green captured turtle May 30, 2005.

	Total Net Hours	Total Km-hrs	Loggerhead Captures	Green Captures	Loggerhead CPUE	Green CPUE	Total CPUE
2005	36.81	6.62	0	9	0	1.25	1.25

Table B-2. Catch per unit effort in km-hrs for net-captured marine turtles along nearshore rock resources in Brevard County, Florida, from August 2003 to December 2004.

Date	Hours	NET KM HRS EFFORT	Loggerhead Captures	Green Captures	Loggerhead CPUE	Green CPUE	Total CPUE	R-Monuments
24-Aug-03	2.22	0.40	0	0	0.00	0.00	0.00	86
24-Aug-03	0.52	0.09	0	0	0.00	0.00	0.00	80
16-Jan-04	0.92	0.17	0	0	0.00	0.00	0.00	91
25-Jan-04	1.62	0.29	0	0	0.00	0.00	0.00	77
10-Apr-04	0.98	0.18	0	0	0.00	0.00	0.00	80
10-Apr-04	0.45	0.08	0	0	0.00	0.00	0.00	81
29-May-04	1.00	0.18	0	0	0.00	0.00	0.00	87
29-May-04	0.87	0.16	0	0	0.00	0.00	0.00	87
31-May-04	1.18	0.21	0	0	0.00	0.00	0.00	80
31-May-04	1.13	0.20	0	0	0.00	0.00	0.00	79
20-Jun-04	0.90	0.16	0	1	0.00	6.17	6.17	85
2-Jul-04	1.35	0.24	0	1	0.00	4.12	4.12	94
10-Jul-04	1.80	0.32	0	1	0.00	3.09	3.09	90
16-Jul-04	0.78	0.14	0	1	0.00	7.09	7.09	85
16-Jul-04	0.37	0.07	0	0	0.00	0.00	0.00	85
16-Jul-04	1.47	0.26	0	7	0.00	26.52	26.52	85
25-Jul-04	1.08	0.20	0	0	0.00	0.00	0.00	98
25-Jul-04	2.05	0.37	0	3	0.00	8.13	8.13	96
25-Jul-04	0.65	0.12	0	2	0.00	17.09	17.09	85
18-Aug-04	1.00	0.18	0	0	0.00	0.00	0.00	85
18-Aug-04	1.05	0.19	0	3	0.00	15.87	15.87	96
18-Aug-04	0.40	0.07	0	0	0.00	0.00	0.00	96
21-Aug-04	0.78	0.14	0	1	0.00	7.09	7.09	94
21-Aug-04	0.70	0.13	0	0	0.00	0.00	0.00	90
21-Aug-04	0.55	0.10	0	0	0.00	0.00	0.00	84
21-Nov-04	0.75	0.14	0	0	0.00	0.00	0.00	83
8-Dec-04	1.72	0.31	0	0	0.00	0.00	0.00	77
15 days	28.29	5.09	0	20	0.00	3.52	3.52	

NOTE: does not include dip-netted turtle on June 6, 2004

2004	Total Net Hours	Total Effort	Loggerhead Captures	Green Captures	Loggerhead CPUE	Green CPUE	Total CPUE
	28.29	5.09	0	20	0	3.52	3.52

Table C. Shoreline observations of marine turtles were conducted on August 23, 2005. Observation periods were 15 minutes long at each location.

R-monument	Location	Segment	Start Time	End Time	TIME Turtle seen	OBSERVE Duration	Observations	Conditions
107.7	Coral Way crossover	2	1151	1206	1203	15	small cm 1.5 to 2 minutes breathing, 50-75' from shore	east wind
109.2	Stairs S of Holiday Inn	1	1217	1231	1217	15	very small cm @ surface 30' to 50' from shore	east wind
					1222			shorebreak
					1225		OBSERVED 3 Different turtles	
					1225		Seen at surface at same time	
					1226			
					1230			
111.35	Paradise Beach	1	1241	1256	n/a	15		
	Southernmost stairs							
112.3	across from condo	1	1303	1422	n/a	19		
	south of SeaView condo							
114.0	Across from SeaSide	1	1510	1525	n/a	15		
	community							
115.5	Stairs S of Quality Suites	1	1533	1548	n/a	15		
117.35	Stairs S of Dune Condo	1	1555	1610	n/a	15		
118.80	Stairs N of Blueberry	1	1615	1630	n/a			
	Muffin							

Table D. Captures of non-target species collected in the tangle nets set along the Mid Reach in 2004 and 2005.

DATE	BULL SHARK	SPINNER SHARK	NURSE SHARK	EAGLE RAY	COWNOSE RAY	BONNETHEAD	Remora	R-monument
08/24/03			166.0 cm					86
05/31/04				44.0 cm F				80
06/20/04						90.0 cm M		85
07/02/04				60.0 cm				94
07/02/04				66.0 cm				94
07/10/04				75.0 cm		78.8 cm		90
07/10/04				not measured				90
07/10/04				not measured				90
07/16/04					not measured			85
07/16/04			F - not measured					85
07/16/04			170.0 M					85
07/25/04				77.6 cm				96
07/25/04				not measured				96
04/22/05	145 cm							81
05/29/05				70.0 cm * F				83
06/16/05			134.0 cm M					77
06/16/05			172.0 cm F					77
06/18/05					70.5 cm M			96
06/18/05				*		102.1 cm F		96
06/19/05				55.3 cm M				95
06/19/05				65.4 cm F				77
07/01/05					*		on turtle	95
07/03/05					63.0 cm		20.0 cm	96
07/05/05				64.0 cm F				85
07/05/05		128.0 cm F						95
07/06/05						52.0 cm F		97

tbo = to be obatined from last year's report
Shark measurements are total straight length (snout to tip) measured.
Ray measurements are wing-tip to wing-tip.
* indicates estimate (animal not completely landed)
M = male, F= female
All measurements were taken using forestry calipers

BULL SHARK *Carcharinus leucas*
SPINNER SHARK *C. brevipinna*
NURSE SHARK *Ginglymostoma cirratum*
EAGLE RAY *Aetobatus narinari*
COWNOSE RAY *Rhinoptera bonasus*
BONNETHEAD *Sphyrna tiburo*

Table E-1. Sea turtles captured during study period April 2005 through July 2005 along nearshore reefs in Brevard County, Florida

Date	Type	Left Tag	Right Tag	PIT Tag	RECAP?	SCL	NNSL	SCW	Body	Head	Weight	CCL	NNCL	CCW	plastron
12-May-05	CM	RRR038	no	4526044D21	NO	28.1	27.8	22.5	10.3	5.1	2.8	29.6	28.9	24.5	23.7
30-May-05	CM	RRR039	RRR040	4526553C1F	NO	38.9	38.3	31.0	13.9	5.9	7.3	40.8	40.0	34.5	32.6
16-Jun-05	CM	RRR041	RRR042	452678547B	NO	36.0	35.9	28.4	13.2	6.4	6.0	38.2	38.0	32.2	29.9
18-Jun-05	CM	RRR043	no	4523555A73	NO	27.2	26.7	20.8	11.1	5.2	2.8	28.9	28.5	23.7	22.7
19-Jun-05	CM	RRR044	no	4529456908	NO	27.4	27.2	22.0	11.0	5.1	2.6	28.4	28.1	24.3	24.1
1-Jul-05	CM	RRR045	RRR046	44514B7667	NO	37.9	37.7	29.8	15.5	6.7	7.9	40.4	40.2	34.2	32.6
1-Jul-05	CM	RRR047	RRR048	44395A5C4E	NO	31.8	31.4	25.7	12.7	5.7	4.8	34.1	33.9	29.5	26.8
1-Jul-05	CM	RRR050	RRR051	4451405640	NO	34.5	34.3	27.4	14.1	5.9	6.4	36.7	36.5	31.1	29.7
1-Jul-05	CM	RRR052	RRR053	445301290D	NO	39.8	39.5	31.0	16.7	6.4	9.7	43.0	42.7	36.1	34.5
6-Jul-05	CM	RRR054	RRR055	452A127468	NO	32.9	32.3	26.0	12.6	5.7	4.8	34.5	32.0	30.0	28.0
7-Jul-05	CM	RRR056	no	4527591465	NO	27.9	27.5	21.9	9.6	4.8	2.6	29.6	29.0	23.5	23.5

SCL = straight carapace length
NNSL = notch to nuchal carapace length (straight)
SCW = straight carapace width
Body = body depth (straight caliper)
Head = head width (straight caliper)

CCL = curved carapace length
NNCL = notch to nuchal carapace length (curved tape)
plastron = plastron (curved tape)
to tip = length of tail from edge of carapace to tip (curved tape)
to vent = length to vent from edge of carapace (curved tape)

Table E-2. Sea turtles captured during study period August 24, 2003 through August 21, 2004 along nearshore reefs in Brevard County, Florida. *

Date	Type	Left Tag	Right Tag	PIT Tag	RECAP?	SCL	NNSL	SCW	Body	Head	Weight	CCL	NNCL	CCW	plastron
6-Jun-04	CM	no	RRR002	444F18104A	NO	33.7	33.6	27.0	13.3	5.9	5.6	35.4	35.3	31.8	29.2
20-Jun-04	CM	RRR003	RRR004	4438782C5E	NO	33.3	33.3	26.5	12.4	5.9	4.7	34.9	34.7	30.3	28.9
2-Jul-04	CM	RRR005	RRR006	444F3F2671	NO	38.2	38.0	30.8	14.7	6.9	7.8	40.5	40.1	34.7	32.7
10-Jul-04	CM	RRR007	RRR008	44391F290A	NO	44.1	44.0	34.3	17.5	7.4	13.5	46.8	46.7	40.3	38.1
16-Jul-04	CM	RRR009	RRR010	44532D2F6F	NO	35.5	35.3	28.2	13.3	6.4	5.55	37.5	37.4	32.6	29.8
16-Jul-04	CM	RRR011	RRR012	44532F311E	NO	39.8	39.6	30.5	15.3	6.8	8.4	42.2	41.9	36.7	34.2
16-Jul-04	CM	RRR013	RRR014	4439206D3A	NO	36.7	36.5	28.6	14.3	6.5	6.7	38.8	38.6	33.8	31.9
16-Jul-04	CM	RRR015	RRR016	45276B6D18	NO	56.1	56.0	46.0	21.3	9	23.13	59.9	59.4	55.4	47.4
16-Jul-04	CM	RRR017	RRR018	45297E3D4A	NO	35.4	35.3	34.0	16.6	7.2	10.1	43.1	42.7	40.2	35.2
16-Jul-04	CM	RRR019	RRR020	4526144E5A	NO	41.6	41.1	31.8	15.4	6.9	9.07	44.6	43.5	37.1	33.5
16-Jul-04	CM	RRR021	RRR022	45256C3D17	NO	32.2	32.2	25.0	12.2	5.9	5.3	33.9	33.9	28.2	27.3
16-Jul-04	CM	RRR023	no	45240A4136	NO	27.6	27.3	22.1	10.4	5	2.5	28.8	28.3	24.8	22.7
24-Jul-04	CM	RRR029	RRR030	4526556921	NO	38.9	38.8	29.7	14.6	6.5	3	41.4	41.2	34.6	32.7
24-Jul-04	CM	RRR032	RRR031	452676581B	NO	28.1	27.6	21.9	10.4	5.4	2.8	29.6	29.1	24.7	23.6
24-Jul-04	CM	RRR027	RRR028	45266F5917	NO	37.9	37.5	28.7	14.5	6.5	7.3	40	39.6	34.7	31.7
24-Jul-04	CM	RRR025	no	4525707105	NO	27.2	26.8	22.6	10.4	5.4	2.5	28.3	27.8	24.7	22.7
24-Jul-04	CM	RRR024	RRR026	444F18316A	NO	41.9	41.4	32.0	15.9	7	9.9	43.5	43.3	36.8	36.3
18-Aug-04	CM	RRR034	no	4526453A5D	NO	28.5	28.0	22.9	10.6	5.2	2.9	29.6	29.3	25.1	24.7
18-Aug-04	CM	RRR035	no	4523731D7B	NO	26.4	25.9	21.4	9.8	4.8	2.3	27.5	27.2	23.7	23.6
18-Aug-04	CM	RRR033	no	452A486C6D	NO	29.6	28.7	24.0	11	5.1	2.95	30.7	30	26.6	24.6
21-Aug-04	CM	RRR036	RRR037	4436407E60	NO	64.6	64.4	52.9	23.4	9.5	-	68.6	68.5	63.4	54.5

SCL = straight carapace length
NNSL = notch to nuchal carapace length (straight)
SCW = straight carapace width
Body = body depth (straight caliper)
Head = head width (straight caliper)

CCL = curved carapace length
NNCL = notch to nuchal carapace length (curved tape)
plastron = plastron (curved tape)
to tip = length of tail from edge of carapace to tip (curved tape)
to vent = length to vent from edge of carapace (curved tape)

Table F. Items from lavage samples collected from marine turtles captured along the Mid Reach in 2004 and 2005.

Item Ingested	RRR002	RRR003	RRR005	RRR007	RRR009	RRR011	RRR013	RRR015
Bryocladia cuspidata		1.86%	64.34%	12.39%	3.88%		12.1%	32.5%
Gelidium spp.	37.5%	2.52%	8.96%		31.90%	17.65%	12.8%	15.9%
Gelidium americanum				17.95%				
Gelidium pussillum								
Ceramium sp.					1.72%			
Centroceras clavulatum					0.43%		4.3%	3.1%
Gracilaria spp.								
G. mammillaris			13.26%	39.74%			16.8%	
Hypnea spp.				14.53%		5.88%	18.6%	18.3%
Hypnea valentiae								
Chondria spp.			10.04%		15.95%		0.5%	3.5%
Chondria dasyphylla								
Agardhiella subulata								11.1%
Dudresyna crassa								
Laurencia spp.				0.43%				
Jania adhaerens								
Chondrocanthus acicularis								
Chaetomorpha spp.			1.97%	3.42%	0.43%		0.3%	2.1%
Chaetomorpha linum								
Cladaphora spp.					0.86%			0.7%
Ulva spp.			0.72%	0.85%			33.9%	
Ulva lactuca					2.16%			
Caulerpa prolifera					34.48%			5.9%
Padina spp.				2.56%				
Seed			0.18%	1.28%				
Bark-like		0.27%		0.43%		5.88%		3.8%
Mush (decomposed matter)					1.29%			
Hydroid								
Bugula							0.5%	
Tube worm								
Shrimp-like								
Caprellid		0.40%						
Jellyfish		92.96%						
Star jellies								
Barnacle	37.5%	0.93%				5.88%		
Snail with body				2.99%	2.16%	2.94%		
Gelatinous mass								
Fish scales						50.00%		
Insect					0.86%			
Tubeworm casing		0.40%						
Rock								
Shell	12.5%	0.66%		1.28%	2.59%	11.76%	0.3%	2.4%
Sand	12.5%			2.14%	1.29%			0.7%
Unknown plant (orange)			0.54%					
TOTAL	100.0%	100.00%	100.00%	100.00%	100.00%	100.00%	100.0%	100.0%

Item Ingested	RRR017	RRR019	RRR021	RRR023	RRR029	RRR032	RRR027	RRR025
Bryocladia cuspidata	20.4%	10.3%	11.0%		6.9%	12.6%	1.4%	8.3%
Gelidium spp.	14.6%	7.6%	46.2%	65.2%				
Gelidium americanum					6.9%	26.1%		
Gelidium pussillum					4.8%	4.5%		
Ceramium sp.								8.3%
Centroceras clavulatum	0.7%							
Gracilaria spp.							95.6%	41.7%
G. mammillaris	12.6%	21.4%	9.9%	4.3%	2.8%			
Hypnea spp.	8.5%	13.8%				7.2%		
Hypnea valentiae					58.7%			
Chondria spp.	28.6%	36.2%				19.8%		
Chondria dasyphylla								
Agardhiella subulata	0.0%				5.6%			
Dudresyna crassa								
Laurencia spp.					1.7%			
Jania adhaerens					1.3%	1.8%		
Chondrocanthus acicularis								
Chaetomorpha spp.	1.7%	0.4%					0.2%	
Chaetomorpha linum								
Cladaphora spp.		0.9%						
Ulva spp.					4.3%			
Ulva lactuca								
Caulerpa prolifera	0.7%	0.4%	2.2%		1.5%	16.2%		
Padina spp.			2.2%		0.6%			
Seed								
Bark-like	1.4%		2.2%					
Mush (decomposed matter)	2.7%		16.5%	8.7%				
Hydroid								
Bugula	0.3%	0.4%						
Tube worm								
Shrimp-like	0.3%	0.4%						
Caprellid								
Jellyfish								
Star jellies	1.4%	0.9%						
Barnacle			4.4%			3.6%		
Snail with body	0.7%	0.9%		8.7%	0.6%		0.2%	
Gelatinous mass								
Fish scales								25.0%
Insect			3.3%					
Tubeworm casing								
Rock								8.3%
Shell	4.4%	6.3%	2.2%	13.0%	4.1%	8.1%	2.7%	8.3%
Sand	1.0%							
Unknown plant (orange)								
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Item Ingested	RRR024	RRR034	RRR035	RRR033	RRR036	RRR038	RRR039	RRR041
Bryocladia cuspidata	16.4%	3.8%	6.3%	29.3%		1.1%	4.8%	23.5%
Gelidium spp.	47.9%				1.1%	9.1%	22.8%	14.8%
Gelidium americanum		70.5%	15.2%	17.1%				
Gelidium pussillum		10.3%	66.1%	8.5%				
Ceramium sp.			1.3%					
Centroceras clavulatum								
Gracilaria spp.								
G. mammillaris				17.1%			41.1%	
Hypnea spp.		4.3%		15.9%	6.0%			
Hypnea valentiae								
Chondria spp.			5.6%					
Chondria dasyphylla							8.7%	
Agardhiella subulata						34.2%		
Dudresyna crassa						35.8%		
Laurencia spp.					1.7%	4.4%	8.1%	
Jania adhaerens	4.1%							
Chondrocanthus acicularis	19.2%							
Chaetomorpha spp.	1.4%	0.4%	0.3%				0.3%	
Chaetomorpha linum								
Cladaphora spp.				4.9%				
Ulva spp.			0.3%					
Ulva lactuca								28.2%
Caulerpa prolifera	1.4%				83.2%			
Padina spp.								
Seed								
Bark-like		3.0%	1.3%	3.7%				
Mush (decomposed matter)								
Hydroid								
Bugula								
Tube worm							1.2%	
Shrimp-like						0.2%	2.4%	
Caprellid								
Jellyfish								
Star jellies							4.2%	
Barnacle		1.3%						
Snail with body	1.4%		0.3%					1.3%
Gelatinous mass								6.0%
Fish scales								
Insect								
Tubeworm casing								0.7%
Rock					0.9%	0.9%		2.7%
Shell	8.2%	6.4%	3.3%	3.7%	7.1%	13.5%	4.8%	8.7%
Sand			0.3%			0.9%	0.6%	10.7%
Unknown plant (orange)							0.9%	3.4%
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Item Ingested	RRR043	RRR044	RRR046	RRR047	RRR050	RRR052	RRR054	RRR056
Bryocladia cuspidata	1.7%	1.5%			0.2%	2.1%	1.2%	
Gelidium spp.	25.4%	47.8%		56.7%	5.0%	7.2%	97.5%	1.3%
Gelidium americanum								
Gelidium pussillum								
Ceramium sp.								5.3%
Centroceras clavulatum								
Gracilaria spp.	10.4%	14.9%	12.2%		17.0%	33.7%	0.3%	
G. mammillaris						10.2%		24.0%
Hypnea spp.	5.2%							
Hypnea valentiae								
Chondria spp.	15.6%	11.9%						4.0%
Chondria dasyphylla								
Agardhiella subulata		6.0%				15.1%		65.3%
Dudresyna crassa				30.0%				
Laurencia spp.								
Jania adhaerens						1.5%		
Chondrocanthus acicularis								
Chaetomorpha spp.		1.5%			0.2%		0.2%	
Chaetomorpha linum								
Cladaphora spp.						0.3%		
Ulva spp.		4.5%	79.3%					
Ulva lactuca	34.1%					22.6%		
Caulerpa prolifera								
Padina spp.								
Seed								
Bark-like				6.7%				
Mush (decomposed matter)								
Hydroid								
Bugula								
Tube worm	1.2%							
Shrimp-like	1.2%					0.3%	0.2%	
Caprellid								
Jellyfish					77.1%			
Star jellies	5.2%		2.4%		0.2%	3.9%		
Barnacle								
Snail with body						0.3%		
Gelatinous mass							0.2%	
Fish scales								
Insect								
Tubeworm casing							0.5%	
Rock						0.3%		
Shell		6.0%	2.4%	6.7%	0.5%	2.4%		
Sand		6.0%						
Unknown plant (orange)			3.7%					
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table G. Acoustic tracking surveys performed in 2005 along the Mid Reach for five green turtles fitted with sonic tags. Dates and number of hours spent monitoring for each turtle are listed.

Tracking Date	**Start Time**	**Activity**	**Time (Hrs) Monitored**	**Detected**	**Van RRR038**	**Sharky RRR041**	**Boomer RRR045**	**Hawk RRR052**	**Sally RRR054**
5/13/2005	1150	release	1		1				
5/17/2005	1000		1		1				
5/20/2005	1700	eqpmt failed	1		1				
5/23/2005	1500		1		1				
5/24/2005	1500		2		2				
5/25/2005	700		1		1				
5/26/2005	1000		1		1				
5/28/2005	1100		1		1				
5/29/2005	1400		1		1				
5/30/2005	1400		1		1				
6/8/2005	700	test	1		1				
6/16/2005	1300		1		1				
6/17/2005	1330	release	1	Sharky		1			
6/18/2005	900		3	Sharky	1	2			
6/19/2005	1145	video	4	Sharky	2	2			
6/20/2005	1930		1	Sharky		1			
6/23/2005	930		1	Sharky		1			
7/1/2005	915		2		1	1			
7/2/2005	845	release	4	Boomer	1	1	1	1	
7/3/2005	1115		5	Sharky	1	2	1	1	
7/5/2005	1230		4		1	1	1	1	
7/6/2005	1020	release	4		1		1	1	1
7/7/2005	1100		5		1	1	1	1	1
7/16/2005	900		4		1		1	1	1
7/17/2005	1400		2		0.5		0.5	0.5	0.5
7/24/2005	1100		6		3		1	1	1
8/6/2005	1000		5		1	1	1	1	1
8/20/2005	1100		5		1	1	1	1	1
Total hours			69		28.5	15	9.5	9.5	6.5
Total # days	28				25	12	10	10	7

APPENDIX SEIS-B

Results of epibiotic surveys of nearshore rock outcrops in the Mid Reach project area in Brevard County, FL.

Results of Epibiotic Surveys of Nearshore Rock Outcrops in the Mid Reach Project Area in Brevard County, Florida

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INTRODUCTION

Nearshore rock features along the central Brevard County coastline are coquina outcrops, formed from lithified shell fragments, quartz sand, and calcium carbonate. The outcrops parallel the shoreline, extending from Patrick Air Force Base (AFB) south through Indian Harbor Beach, and provide diverse habitat for shallow water marine flora and fauna (Continental Shelf Associates, Inc., 1990). These coquina outcrops extend from the intertidal to subtidal zones and range from wide expanses of tabular ledges with up to 2 to 3 ft of relief at the southern end of Patrick AFB to small isolated rocks in northern Indialantic. In the higher relief areas, the ledges are tipped up toward the beach, exhibiting exposed vertical faces and overhangs along the shoreward edges.

The rock outcrops are colonized by various species of algae, the sabellariid reef-building polychaete *Phragmatopoma caudata* (= *P. lapidosa*), sponges, mollusks, crustaceans, bryozoans, and ascidians (Gore et al., 1978; Zale and Merrifield, 1989). Relatively high densities of the green alga *Caulerpa prolifera* and varying densities of unidentified green filamentous algae have been observed along the crests of these outcrops (Continental Shelf Associates, Inc., 1990). The sabellariid polychaete *P. caudata* is found throughout this area, building scattered mounds on nearshore rock outcrops south to Key Biscayne (Kirtley, 1966; Kirtley and Tanner, 1968; Young, 1975; McCarthy, 2001). The wormreef colonies are typically found in both the low intertidal and subtidal zones and are somewhat ephemeral, being negatively impacted by both storm waves and burial by sediments. The crabs *Menippe nodifrons* and *Pachygraspus transversus* have been noted as having some abundance in wormreef areas north of Melbourne, along with limited occurrence of *Plagusia depressa* (Young, 1975). Van Montfrans (1981) collected eight decapod species on wormreef mounds in the intertidal zone and subtidally off Patrick AFB in Satellite Beach.

The objectives of this study were to further characterize this specific habitat throughout the Mid Reach area and provide additional information for the Supplemental Environmental Impact Statement. This information will then be used to determine potential impacts to the existing hard bottom communities from various beach nourishment alternatives.

METHODS

The Brevard County coastline is a relatively high-energy area, exposed to both winter and tropical storms (Tanner, 1960). The almost constant wave and ocean swell impacts create a nearshore environment with nearly year-round suspended sediments and high turbidity. This combination of rough water and low underwater visibility creates problems in the visual assessment of benthic communities associated with hard bottom.

Continental Shelf Associates, Inc. (CSA) scientific staff were tasked with surveying and characterizing the epibiotic assemblages associated with the nearshore hard bottom in the Mid Reach Project Area along the Brevard County coastline. As previously described, the nearshore area is exposed to nearly continuous wave and/or ocean swell activity with resulting turbidity, yielding less than optimal sampling conditions. Because of these conditions, attempts were made to limit data collection to periods of low tidal levels on days with minimal winds and nearly flat sea states. Even on the few days of optimal conditions, there was still nearshore wave activity and associated surge, causing sediment suspension and less than ideal conditions for video data collection and *in situ* observations. Selected nearshore outcrops were surveyed from the vicinity of Florida Department of Environmental Protection (FDEP) Monument R 78 at Seagull Park, just south of Patrick AFB, to near Monument R 117, near the southern end of the Mid Reach (**Figure 1**).

Field teams collected digital video data from transects along and across the rock outcrops using a Sony DCR-TRV900 digital videocamera within an Amphibico aluminum underwater housing. Video was utilized for data collection because of the great difficulty associated with collecting *in situ* data such as quadrat counts and measurements in this high energy environment. The videocamera can collect continuous data segments under fairly extreme conditions, with the camera being held closer to the substrate if turbid water conditions are encountered. The data may then be used to determine relative abundance of species or taxonomic groups. By using a random point analysis technique, percent biotal cover determinations can be made and data compared between areas.

Transects were established on the rock outcrops and extended generally parallel to the shoreline, with individual video segments taken at random distances along and east or west of the transect centerlines. The transect layouts and distances between video segments became more haphazard than random as wave heights increased and visibility decreased. Video data were collected on outcrops exposed to the air at low tide as well as on hard bottom below the water level. The videocamera was held a fixed distance of 35 cm above the rock surface, with converging lasers used to maintain the distance. In areas of turbid water, the camera-to-rock distance was decreased to approximately 20 cm to allow the collection of acceptable images. Video segments were obtained while holding the camera as motionless as possible at each randomly selected location. Specimens of algae from several of the surveyed sites were collected and preserved for subsequent identification.

Sampling location coordinates within the survey area were recorded with a hand-held Garmin differential global positioning system (DGPS) receiver. For rock outcrops extending less than approximately 100 ft along the shoreline, a single set of coordinates was taken at the estimated center of the rock feature. For larger hard bottom features, coordinates were taken at both the northern and southern extents of sampling locations.

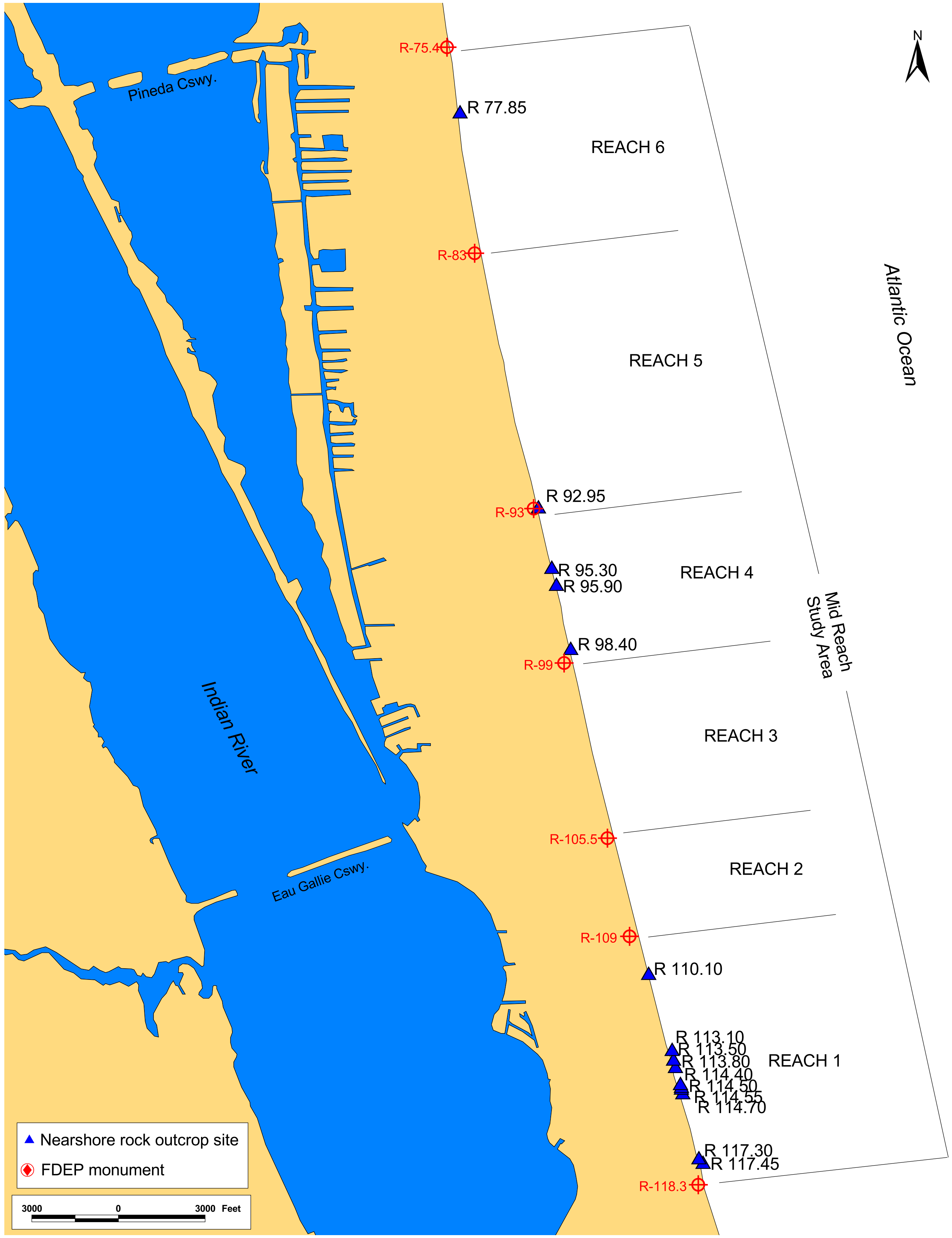

Figure 1. Nearshore rock outcrop sampling sites along the Mid Reach of Brevard County (2005).

The digital video data were reviewed at the office following field data collection to determine the suitability of video frames for analyses. Video segments from each data collection location or point were reviewed, with the acceptable video frames from each location saved as jpeg files for subsequent random point analysis. The selected video images were analyzed using Point Count software, in which random points are placed over each image, then each item (algal species, wormreef, substrate type) beneath a point is identified and counted. The data were entered into a spreadsheet, and percent cover values for biota and substrate were calculated.

RESULTS

Video data and observations were successfully collected on nearshore rock outcrops in the vicinity of Seagull Park, Pelican Park, Sunrise Avenue, Bicentennial Park, Paradise Park, and south of Paradise Park in the period from 2 July through 22 August 2005 (**Table 1**). Several survey attempts also were made at High Tower Park (R 82.5), Millenium Park (R 103.0), and Canova Beach (R 105.0), but turbid water conditions prevented collection of acceptable video data. In most instances the video data were not clear enough to make species-level identifications for algae, aside from certain large-bladed or visually distinct species such as *C. prolifera*, *Caulerpa racemosa*, *Ulva lactuca*, *Bryopsis plumosa*, and *Padina gymnospora*. Several other algal taxa were identifiable to genus-level, but due to the thin blades and small sizes of most of the algae and the somewhat turbid water and effects of wave action on camera steadiness, detailed identifications were problematic. An average of 20 video images underwent percent cover analyses at each of the sampling sites. In the specific site descriptions and characterizations, both the video data analyses and *in situ* observations and specimen collections were utilized.

A total of 22 species of algae, at least two sponge species, a gastropod mollusk, a crab, and unidentified hydroids and ascidians was identified within the project area rock habitat (**Table 2**). Percent cover analyses from the 14 surveyed sites showed total green algal cover ranging from 0.0% to 30.4% (11.4% average), total red algal cover from 4.7% to 47.0% (22.2% average), and total algal cover from 16.3% to 54.5% (39.1% average) at individual locations (**Table 3**). The two most abundant green algae species were *C. prolifera* and *U. lactuca*, which had percent cover values ranging from 0.0% to 24.4% (5.9% average) and 0.0% to 12.5% (2.3% average), respectively. *Bryocladia cuspidata* was the only abundant species of red algae that could be consistently identified from the video data set, and its percent cover at specific sites ranged from 0.0% to 41.6% (6.5% average). At several of the sampling sites, however, turbid water may have resulted in this species being identified only to the level of unidentified red algae, causing an underestimation of its actual percent cover. Wormreef (*P. caudata*) was observed at nine of the sampling locations and had percent cover values ranging from 0.0% to 27.2%, and 5.2% cover for all sites averaged. The following site descriptions were compiled from field observations and video data analysis.

Table 1. Hard bottom sampling locations within the Mid Reach Project Area.

Monument	Latitude	Longitude	Easting	Northing	Description
R 77.85	28°12’22.8”	80°35’44.1”	786419.03	1407936.67	Seagull Park
R 92.95	28°10’07.4”	80°35’14.3”	789131.64	1394271.24	Pelican Park
R 95.30	28°09’46.7”	80°35’09.5”	789568.36	1392182.16	Sunrise Avenue subtidal
R 95.90	28°09’40.9”	80°35’07.5”	789749.36	1391597.01	Sunrise Avenue intertidal
R 98.40	28°09’18.8”	80°35’02.0”	790249.28	1389366.77	Bicentennial Park
R 110.10	28°07’27.5”	80°34’33.0”	792884.28	1378135.32	Paradise Park
R 113.10	28°07’01.4”	80°34’23.4”	793753.07	1375502.44	South of Paradise Park
R 113.50	28°06’58.1”	80°34’22.9”	793799.01	1375169.33	South of Paradise Park
R 113.80	28°06’55.6”	80°34’22.1”	793871.53	1374917.10	South of Paradise Park
R 114.40	28°06’49.7”	80°34’20.2”	794043.75	1374321.84	South of Paradise Park
R 114.50	28°06’48.7”	80°34’19.9”	794070.97	1374220.95	South of Paradise Park
R 114.55	28°06’48.1”	80°34’19.8”	794080.14	1374160.38	South of Paradise Park
R 114.70	28°06’46.5”	80°34’19.3”	794125.48	1373998.95	South of Paradise Park
R 117.30	28°06’24.2”	80°34’11.9”	794796.07	1371749.18	South of Paradise Park
R 117.45	28°06’22.7”	80°34’11.6”	794823.47	1371597.78	South of Paradise Park

Table 2. Benthic taxa in phylogenetic order identified at hard bottom sites within the Mid Reach Project Area in July/August 2005.

ALGAE
- Chlorophyta
  - *Ulva lactuca*
  - *Bryopsis plumosa*
  - *Caulerpa prolifera*
  - *Caulerpa racemosa*
  - *Codium decorticatum*
- Phaeophyta
  - *Dictyota pinnatifida*
  - *Padina gymnospora*
- Rhodophyta
  - *Scinaia complanata*
  - *Gelidiopsis planicaulis*
  - *Dudresnya crassa*
  - *Halymenia floresia*
  - *Gracilaria tikvahiae*
  - *Solieria filiformis*
  - *Agardhiella subulata*
  - *Gelidium pusillum*
  - *Centroceras clavulatum*
  - *Bryocladia cuspidata*
  - *Chondria capillaris*
  - *Chondria dasyphylla curvilineata*
  - *Chondrocanthus acicularis*
  - *Laurencia intricata*
  - *Laurencia poiteaui*

PORIFERA
- *Cliona* sp.
- Unidentified sponge

HYDROZOA
- Unidentified hydroid

ANNELIDA
- *Phragmatopoma caudata*

MOLLUSCA
- *Thais haemastoma floridana*

ARTHROPODA
- *Plagusia depressa*

ASCIDEACEA
- Unidentified ascidians

Table 3. Percent cover results from video data analyses for the 14 sites surveyed along the Mid Reach Project Area.

Taxa	Florida Department of Environmental Protection Monument														Project Area Average
	R 77.85*	R 92.95	R 95.30*/ R 95.90*	R 98.40	R 110.10	R 113.10	R 113.50	R 113.80	R 114.40	R 114.50	R 114.55	R 114.70	R 117.30	R 117.45	
GREEN ALGAE (CHLOROPHYTA)															
Calcareous Green Algae	0.0	0.3	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
Caulerpa prolifera	24.4	0.0	5.4	0.7	16.6	0.0	0.0	0.0	8.6	3.0	0.0	0.0	23.8	0.4	5.9
Caulerpa racemosa	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Codium decorticatum	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ulva lactuca	0.4	2.9	12.5	9.7	0.4	0.0	0.0	0.0	5.9	0.0	0.0	0.0	0.0	0.0	2.3
Filamentous Green	0.0	0.0	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
Unidentified Green	5.6	6.4	2.9	1.2	4.8	12.0	0.0	0.0	2.7	2.7	1.3	0.0	2.9	0.8	3.1
TOTAL GREEN ALGAE	**30.4**	**9.6**	**21.8**	**11.5**	**21.9**	**12.0**	**0.0**	**0.0**	**17.3**	**5.7**	**1.3**	**0.0**	**26.7**	**1.1**	**11.4**
RED ALGAE (RHODOPHYTA)															
Agardhiella subulata	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.3	0.0	0.0	0.0	0.0	0.2	3.0	0.3
Bryocladia cuspidata	0.0	0.0	0.0	0.0	0.0	0.0	41.6	36.8	0.2	0.0	2.3	0.0	3.2	6.4	6.5
Filamentous Red	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Laurencia sp.	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Solieria filiformis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.3	0.0
Red Turf Algae	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unidentified Red	13.1	11.8	9.7	4.5	8.8	34.5	2.1	10.0	21.2	17.1	5.7	38.7	2.1	36.1	15.4
TOTAL RED ALGAE	**13.3**	**12.0**	**10.1**	**4.7**	**8.8**	**35.0**	**43.7**	**47.0**	**21.6**	**17.1**	**8.0**	**38.7**	**5.5**	**45.8**	**22.2**

Table 3. (Continued).

Taxa	Florida Department of Environmental Protection Monument														Project Area Average
	R 77.85*	R 92.95	R 95.30*/ R 95.90*	R 98.40	R 110.10	R 113.10	R 113.50	R 113.80	R 114.40	R 114.50	R 114.55	R 114.70	R 117.30	R 117.45	
BROWN ALGAE (PHAEOPHYTA)															
Dictyota sp.	0.2	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
TOTAL BROWN ALGAE	**0.2**	**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**
Unidentified Algae	2.6	4.6	2.4	0.2	1.5	7.5	0.0	1.3	5.9	12.4	12.7	0.0	20.0	5.6	5.5
TOTAL ALGAE	**46.6**	**26.2**	**34.3**	**16.3**	**32.2**	**54.5**	**43.7**	**48.3**	**44.9**	**35.2**	**22.0**	**38.7**	**52.2**	**52.5**	**39.1**
EPIFAUNA															
Wormreef	9.9	27.2	8.0	5.0	0.0	0.0	0.0	0.0	8.3	3.0	12.0	0.0	0.0	0.0	5.2
TOTAL EPIFAUNA	**9.9**	**27.2**	**8.0**	**5.0**	**0.0**	**0.0**	**0.0**	**0.0**	**8.3**	**3.0**	**12.0**	**0.0**	**0.0**	**0.0**	**5.2**
SUBSTRATE	23.0	18.7	50.1	64.7	59.6	42.5	47.2	47.8	41.3	45.0	58.3	42.7	45.1	43.4	44.9
TOTAL SUBSTRATE	23.0	**18.7**	**50.1**	**64.7**	**59.6**	**42.5**	**47.2**	**47.8**	**41.3**	**45.0**	**58.3**	**42.7**	**45.1**	**43.4**	**44.9**
OTHER															
Other Unidentified Bottom Features**	20.5	27.8	7.5	14.0	8.2	3.0	9.1	4.0	5.5	16.8	7.7	18.7	2.7	4.1	10.8
TOTAL OTHER	**20.5**	**27.8**	**7.5**	**14.0**	**8.2**	**3.0**	**9.1**	**4.0**	**5.5**	**16.8**	**7.7**	**18.7**	**2.7**	**4.1**	**10.8**

* Average percent cover for intertidal and subtidal areas at this site.

** Includes shadows, glare from water, and unidentifiable objects.

R 77.85 (Seagull Park)

The hard bottom at Seagull Park was surveyed on 7 July and 5 August 2005. The survey area extended from the intertidal zone to the eastern edge of hard bottom and approximately 180 ft along the beach. At the outer edge of the rock outcrops, water depths ranged from 4 to 6 ft and the outcrops graded into the sand. Unidentified red algae were the dominant biotal group within the intertidal zone with 23.0% cover. Unidentified green algae, probably a combination of small *B. plumosa* and *U. lactuca*, had an intertidal zone percent cover of 4.7%. The green alga *C. prolifera* also was observed at low densities intertidally with 0.7% cover. Total intertidal percent algal cover was 29.7%. Small colonies of the polychaete *P. caudata* also were noted in the intertidal zone with 14.0% cover. The gastropod mollusk *Thais haemastoma floridana* was associated with the wormreef colonies in several locations.

The green alga *C. prolifera* was the dominant subtidal species at the site, occurring at very high densities on the shallower upper edges of the outcrops and colonizing the rock substrate from the lower intertidal zone out to the eastern edge of hard bottom. This species approached 100% cover in large areas of the site, and analyses of the video imagery yielded a subtidal percent cover of 48.2% for this species. Other algal groups contributing significantly to the percent cover totals within the subtidal area included unidentified green algae (6.6%) and unidentified red algae (3.3%). The unidentified red algae species category from the video data analyses included the species *Chondria capillaris*, *Chondria dasyphylla curvilineata*, *Halymenia floresia*, and *Scinaia complanata*. Green algae included *B. plumosa*, *Codium decorticatum*, and *U. lactuca*, and brown algae consisted of *Dictyota pinnatifida* and *P. gymnospora*. Total subtidal percent algal cover at this site was 63.5%.

The polychaete *P. caudata* also was observed subtidally, attached to the shallower nearshore edges of the subtidal rock ledges. Analyses of the video data showed subtidal wormreef with 5.9% cover at the site. Other epifauna included several species of encrusting ascidians that were observed under overhangs or ledges on the nearshore sides of the outcrops. Several encrusting (*Cliona* sp.) and unidentified low profile sponges also were present under these ledges. The ascidians and sponges were observed only on the nearshore sides of rock ledges and were generally under the overhangs, protected from direct wave impacts. Because of their positions, they were not easily viewed with the videocamera, and percent cover estimates were not obtained.

R 92.95 (Pelican Park)

The hard bottom off Pelican Park was surveyed on 7 July 2005 and included an area extending approximately 400 ft along the beach. Due to turbid water conditions, video data were concentrated in the intertidal and shallow subtidal zones. Dominant algae included unidentified red algae with a total of 12.0% cover, unidentified green algae with 6.4% cover, and *U. lactuca* with 2.9% cover. Much of the unidentified green algae may have been small specimens of *U. lactuca* not identified due to cloudy water.

Total percent algal cover at the site was 26.2%. Colonies of *P. caudata* were relatively common intertidally in this area and had a percent cover of 27.2%.

R 95.30 and R 95.90 (Sunrise Avenue)

This hard bottom area off the east end of Sunrise Avenue was surveyed on 2 July and 5 August 2005. On 2 July, data were collected during a low tide period within a large intertidal and shallow subtidal area extending approximately 640 ft along the shoreline. The surveyed intertidal hard bottom was largely composed of extensive flat outcrops and higher relief boulder-shaped outcrops up to 6-ft diameter by 2-ft height. The flat, tabular outcrops often had western edges that tilted up slightly toward the shoreline, with resulting small ledges. During the 5 August survey, video data were collected approximately 250 ft further to the north on subtidal rock ledge features with a vertical relief of up to 2 ft.

Within the intertidal area, the green algae *U. lactuca* was the dominant species with a biotal cover of 24.7%, with *C. racemosa* also identified with 1.3% cover. Unidentified red algae had 6.8% cover. Total intertidal algae percent cover at this location was 35.0%. Wormreef colonies (*P. caudata*) were relatively abundant at this intertidal site, with some colonies approaching 2-ft diameter and having a percent cover of 12.0%. The grapsoid crab *Plagusia depressa* and the gastropod mollusk *T. h. floridana* also were observed associated with the wormreef colonies at this site.

The slightly deeper subtidal outcrops were dominated by the green alga *C. prolifera* with 10.7% cover. As noted at the Seagull Park site, *C. prolifera* had its highest density at the crests of the western edges of the outcrops and along the upper edges of east-west breaks in the ledges. Unidentified red algae from the video data analyses had 12.6% cover and may have included the species *Agardhiella subulata*, *B. cuspidata*, *Centroceras clavulatum*, *Gelidiopsis planicaulis*, *Laurencia intricata*, and *Solieria filiformis,* which were identified from specimens collected during the survey. *C. decorticatum* (0.6% cover) and *U. lactuca* (0.4% cover) also were noted on the subtidal outcrops. Total subtidal algae percent cover was 33.7%, similar to the algal cover observed in the intertidal area. Wormreef colonies were somewhat smaller than noted intertidally and were represented by 4.0% cover. Other epifauna included at least two species of encrusting ascidians that were observed under ledges on the nearshore sides of the outcrops, along with the encrusting sponge *Cliona* sp.

R 98.40 (Bicentennial Park)

The hard bottom off Bicentennial Park was surveyed on 2 July 2005 and included an intertidal area extending approximately 200 ft along the beach. The bottom was primarily low-relief tabular outcrops with small wormreef colonies. The green alga *U. lactuca* was the most abundant species with 9.7% cover, followed by unidentified red algae (4.5% cover), unidentified green algae (1.2% cover), and *C. prolifera* (0.7% cover). Total algal cover at this intertidal site was 16.3%, lower than that observed at the three locations to the north. Wormreef percent cover was 5.0%. No other epifaunal species were noted at this location.

R 110.10 (Paradise Park)

The subtidal rock features at this location were surveyed on 5 August 2005. The outcrops consisted of tabular ledges tilted up toward the shoreline, with the extensive undercutting and overhangs along the western edges having vertical relief of from 1 to 3 ft. Small colonies of wormreef were observed during the survey, although the species was not detected in the video data set. The most abundant species was the green alga *C. prolifera* with 16.6% cover, followed by unidentified red algae (8.8% cover), unidentified green algae (4.8% cover), and *U. lactuca* (0.4% cover). Other algal species observed included *B. plumosa*, *B. cuspidata*, and *D. pinnatifida*. Total subtidal algal cover at this site was 32.2%. Unidentified encrusting sponges and tunicates were observed along the rock outcrop western faces and under the ledges.

Hard Bottom Sites South of Paradise Park

Subtidal rock features associated with the following monuments were surveyed on 19 and 22 August 2005.

R 113.10

This hard bottom site was a narrow subtidal rock ridge approximately 180 ft in length with about 1 ft of relief on both the inshore and offshore edges. Identifications of algae in the video data were limited primarily to either green or red algae due to minimal water clarity at the site during the survey. Unidentified red algae had 34.5% cover, unidentified green algae had 12.0% cover, and total algal cover was 54.5% at this site. Species of algae visually identified at the site included *U. lactuca*, *B. cuspidata*, and *A. subulata*. No wormreef was observed either in the video data set or during field observations.

R 113.50

This site extended for 130 ft along the beach and consisted of wide low-relief rock slabs grading into the sand in the nearshore and narrower subtidal ledges tilted slightly up toward the shoreline with up to 1 ft of relief. The intertidal rock was partially covered by a thin layer of sand and colonized primarily by the red alga *B. cuspidata.* This species had a percent cover of 41.6% at the site, making it the dominant algae present. Total algal cover at this location was 43.7%. No wormreef was observed either in the video data set or during field observations.

R 113.80

This location was 250 ft south of the previous hard bottom site and was similar in structure and appearance. The rock feature extended for approximately 130 ft along the beach and had low-relief intertidal rock platforms with an intermittent thin sand veneer adjacent to narrower subtidal ledges with up to 1 ft of relief along the east and west sides. The red alga *B. cuspidata* had a percent cover of 36.8%, followed by unidentified red algae with a cover of 10.0%. Total algal cover was 48.3%. No wormreef, sponges, or ascidians were observed during the visual survey of the site.

R 114.40

This hard bottom site had large slabs and tabular ledges covering a length of about 35 ft along the beach and extending up to 25 ft offshore. There were three sections of rock from west to east, with the most seaward section tilted up toward the beach. This eastern outcrop had the highest algal density and richness, including *C. prolifera*, *U. lactuca*, *B. cuspidata*, *S. filiformis*, and red filamentous algae. Unidentified red algae had the highest percent cover at 21.2%, likely primarily *B. cuspidata* that could not be readily identified to species due to turbid water conditions during video data collection. Other algal taxa occurring at relatively high densities included *C. prolifera* with 8.6% cover, *U. lactuca* at 5.9% cover, and unidentified green algae with 2.7% cover. Total algal percent cover was 44.9%. Wormreef also was present at the site with a percent cover of 8.3%. No sponges or ascidians were observed during the visual survey of the site.

R 114.50

This hard bottom feature was 100 ft south of the previous feature and had large tabular ledges tilted up slightly toward the shore. The ledges extended about 25 ft along the beach and 8 ft offshore. Attached algae included *C. prolifera*, *U. lactuca*, *B. cuspidata*, and unidentified red filamentous algae. Analyses of video data showed unidentified red algae with 17.1% cover, unidentified algae at 12.4%, *C. prolifera* at 3.0% cover, and unidentified green algae at 2.7% cover. Total algal percent cover was 35.2%. Wormreef was present at the site with a percent cover of 3.0%. No sponges or ascidians were observed during the visual survey of the site.

R 114.55

This was a small outcrop approximately 10-ft (alongshore) by 4-ft in size with a thin sand veneer. Unidentified algae at 12.7% cover was the dominant biotal group, followed by unidentified red algae (5.7% cover), *B. cuspidata* (2.3% cover), and unidentified green algae (1.3% cover). Total percent algal cover was 22.0%. Wormreef also was present at the site with a percent cover of 12.0%. No sponges or ascidians were observed during the visual survey of the site.

R 114.70

This was a tabular subtidal ledge feature about 160 ft south of the previous site. The red alga *B. cuspidata*, the green alga *U. lactuca*, and other unidentified red algal species were present at this location. Due to the poor water clarity, algae could not be identified to species from the video data, and the percent cover data showed unidentified red algae with a cover of 38.7%, also the percentage for total algal cover. Although several small wormreef colonies were observed at the site, they were not sampled during video data collection, and thus wormreef percent cover was 0.0%. No sponges or ascidians were observed during the visual survey of the site.

R 117.30

This site was located near the southern end of the Mid Reach Project Area, off the beach access south of The Dunes condominium. This was a small subtidal tabular outcrop with about 1 ft of relief. Attached algal species were similar to previous sites with *C. prolifera*, *U. lactuca*, *B. cuspidata*, *A. subulata*, and unidentified red algae observed on the outcrop. The green alga *C. prolifera* was the dominant species with a percent cover of 23.8%, followed by unidentified algae (20.0% cover), *B. cuspidata* (3.2% cover), unidentified green algae (2.9% cover), and unidentified red algae (2.1% cover). Total percent algal cover at the site was 52.2%. No wormreef, sponges, or ascidians were observed during the visual survey of the site.

R 117.45

This site was primarily a subtidal ledge with approximately 1 ft of relief, along with a small amount of barely exposed intertidal rock with a sand veneer. Algal species identified at the site included *C. prolifera*, *U. lactuca*, *B. cuspidata*, *A. subulata,* and *S. filiformis*. Unidentified red algae, with 36.1% cover, was the most abundant taxa at the site, followed by *B. cuspidata* (6.4% cover), unidentified algae (5.6% cover), and *A. subulata* (3.0% cover). Total percent algal cover at the site was 52.5%. No wormreef, sponges, or ascidians were observed during the visual survey of the site.

DISCUSSION

The nearshore rock outcrops in the Mid Reach Project Area of Brevard County provide physical structure for algal communities and a few hardy invertebrate species able to withstand the high-energy wave activity of the area. The hard bottom surveys conducted at 14 sites along the Mid Reach Project Area during the late summer of 2005 identified 22 species of marine algae along with sponges, hydroids, mollusks, crabs, and ascidians. The observed taxa, well-adapted to this habitat, are similar to those reported from nearshore coastal hard bottom communities further to the south in Brevard and Indian River Counties (Clark, 1978; Irlandi, 2001), St. Lucie County (Seabyte Inc., 1994; Continental Shelf Associates, Inc., 1997, 2002, 2004; Dial Cordy and Associates Inc., 2000), and Martin County (Continental Shelf Associates, Inc., 1985).

Monitoring surveys conducted in association with inlet maintenance dredging and sand placement on beaches south of Sebastian Inlet in southern Brevard County assessed adjacent nearshore hard bottom communities (Clark, 1978; Irlandi, 2001). As observed in the Mid Reach Project Area, the nearshore rock outcrops were dominated by species of green, red, and brown macroalgae, along with colonies of *P. caudata* and occasional boring sponges (*Cliona* sp.). During monitoring in 2000 to 2001, total algae percent cover for this area averaged higher than 74% (20.3% for green algae, 22.8% for red algae, and 31.3% for brown algae).

Baseline characterization surveys and monitoring studies associated with beach nourishment activities conducted on nearshore rock outcrops south of the Fort Pierce Inlet in St. Lucie County and along Jupiter Island in Martin County showed similar biotal communities (Continental Shelf Associates, Inc., 1985, 2002, 2004; Seabyte Inc., 1994). Off Fort Pierce, the nearshore hard bottom was dominated by algae, with 20 species identified along 15 survey transects across these features. Percent algal cover along the transects ranged from 7% to 31% in 1994, from 14% to 81% in 2002, and from 1% to 48% in 2004. Wormreef also was associated with the outcrops in several locations with percent cover as high as 24%. Other attached epifauna, including encrusting sponges, hydroids, and ascidians, were observed at low densities. During each of the surveys, the highest species abundance was noted in areas of higher vertical relief.

On Jupiter Island, coquina rock outcrops similar to those in the Mid Reach Project Area were colonized by algal/sponge-dominated communities (Continental Shelf Associates, Inc., 1985). Total algae percent cover values ranged from 26% to 79% along transects in the nearshore zone during a characterization survey conducted in 1985. The sponge *Cliona* sp. also was present, with a percent cover of more than 20% on one of the shallower outcrops. Wormreef, although present in the area, was not detected during sampling along the established transects.

During a nearshore survey of the Mid Reach Project Area in 1989, extensive outcrops emerging 2 to 3 ft above the surrounding bottom were observed between FDEP Monuments R 78 and R 93, with lower relief rock outcropping both to the north and south. Well-defined ledges were noted, with the green alga *C. prolifera* growing in high densities along the crests.

Currently within the Brevard County Mid Reach Project Area, percent cover analyses from the summer 2005 diver video data showed wide variability in algal distribution and density both within and between surveyed outcrops. Along virtually any cross-reef transect extending from the intertidal zone to the offshore edge of rock bottom, algal percent cover could vary from 0% up to nearly 100%, depending on water depth, height of rock surface above the surrounding sand, sand overburden, and rock physical shape and orientation to wave action. For example, large areas of low-relief intertidal rock in the northern segment of the Mid Reach could exhibit minimal algal cover, possibly due to air exposure at low tide, intermittent sand burial, or sand scour, while immediately adjacent higher profile sections of the reef in slightly deeper water could have dense algal cover.

Areas typically exhibiting higher percent algal cover included 1) low-relief platforms in the lower intertidal and upper subtidal zone, where high abundances of red filamentous and branching algae and the green alga *U. lactuca* were noted, and 2) the inshore edges of subtidal rock ledges that were tilted up toward the shoreline and east-west breaks between these longshore ledges, both of which had the highest number of algal species and density within the project area. The green alga *C. prolifera* was very abundant along these subtidal rock edges, in many areas occurring in wide dense bands covering 100% of the bottom. Larger, thin-branching red algae such as *A. subulata* and *S. filiformis* and the brown algae *Dictyota* sp. and *P. gymnospora* also were fairly common along these margins. The red algae *B. cuspidata* was a widely distributed species, occurring on the shallow intertidal platforms as well as on deeper subtidal ledges throughout the length of the Mid Reach Project Area. Along the offshore margins of the tabular outcrops where the rock typically graded into the adjacent sand bottom, the algal density generally declined with increasing amounts of sand overburden.

Total algal percent cover during the 2005 surveys within the Mid Reach Project Area ranged from 16.3% to 54.5% at individual sampling sites, with green algal cover ranging from 0.0% to 30.4% and red algal cover from 4.7% to 47.0%. These algal percent cover ranges and species compositions are similar to those reported during the previously described surveys of nearshore hard bottom in counties immediately south of the project area.

Algae species richness appeared to be higher in the more physically complex subtidal rock areas. Although high percent algal cover was often noted on the large flat rock platforms in the low intertidal zone, there appeared to be fewer species present, and the individual alga thalli were most often smaller in size than for the subtidal specimens. Most of the species observed within the intertidal areas also occurred subtidally, although the reverse was not necessarily evident.

Epifaunal species including sponges, hydroids, and ascidians were primarily distributed along the western margins and under rock ledges with a vertical relief of greater than 1 ft. This provided protection from the direct impact of high-energy waves prevalent throughout much of the year. Wormreef colonies (*P. caudata*) were observed in relatively low abundance at nine of the sampling locations and had percent cover values ranging from 0.0% to 27.2%. Most colonies were less than 2 ft in diameter, and abundance may have declined following hurricane impacts to the shoreline in August and September 2004. Associated with the wormreef colonies were the grapsoid crab *P. depressa* and the gastropod mollusk *T. h. floridana*.

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APPENDIX SEIS-C

Essential Fish Habitat (EFH) Assessment

September 3, 2008

BREVARD COUNTY, FLORIDA
MID REACH SHORE PROTECTION PROJECT
ESSENTIAL FISH HABITAT ASSESSMENT

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1.0 INTRODUCTION

The Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. § 1801-1882) established regional Fishery Management Councils (FMCs) and mandated that Fishery Management Plans (FMPs) be developed to responsibly manage exploited fish and invertebrate species in federal waters of the United States. When Congress re-authorized this act in 1996 as the Sustainable Fisheries Act, several reforms and changes were made. One change was to charge the National Marine Fisheries Service (NMFS) with designating and conserving Essential Fish Habitat (EFH) for species managed under existing FMPs. Charging the NMFS with this responsibility was intended to minimize, to the extent practicable, any adverse effects on habitat caused by fishing or non-fishing activities as well as to identify other actions that encourage the conservation and enhancement of such habitat.

EFH is defined as “those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity” [16 U.S.C. § 1801(10)]. The final rule summarizing EFH regulations (50 CFR Part 600) outlines additional interpretation of the EFH definition. Waters, as previously defined, include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish. Substrate includes “sediment, hard bottom, structures underlying the waters, and associated biological communities.” Necessary is defined as “the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem.” Fish include finfishes, mollusks, crustaceans, and all other forms of marine animal and plant life other than marine mammals and birds, whereas “spawning, breeding, feeding or growth to maturity” cover the complete life cycle of species of interest.

The South Atlantic Fishery Management Council (SAFMC) is the FMC responsible for managing fisheries and habitat in the waters of the project area. SAFMC has produced several FMPs for single and mixed groups of species. All of these FMPs, including those for penaeid shrimps, spiny lobster, red drum, snapper-grouper (reef fishes), and coastal migratory pelagics, were amended in a single document (SAFMC, 1998) to address EFH within the South Atlantic region. In addition to the FMPs prepared by the SAFMC, highly migratory species (e.g., tunas, billfishes, sharks, and swordfish) are managed by the Highly Migratory Species Management Unit, Office of Sustainable Fisheries, NMFS. This office prepared an FMP for highly migratory species that includes descriptions of EFH for sharks, swordfish, and tunas (NMFS, 1999). Some of the species managed by SAFMC and NMFS also are under the jurisdiction of the Atlantic States Marine Fisheries Commission (ASMFC).

Within the EFH designated for various species, particular areas termed Habitat Areas of Particular Concern (HAPC) also are identified. HAPCs either play important roles in the life history (e.g., spawning areas) of federally managed fish species or are especially vulnerable to degradation from fishing or other human activities. SAFMC (1998) designated the nearshore hard bottom along the central east coast of Brevard County, including the Mid Reach project area shoreline, as areas meeting the criteria for EFH-HAPC.

Proposed Action

The proposed action is to stabilize the Mid-Reach shoreline by placing sand on the existing beach. The Mid-Reach encompasses approximately 7.6 mi between Patrick Air Force Base and Indiatlantic (Florida Department of Environmental Protection [FDEP] Monuments R-75.4 to R-118.3) (**Figure 1**). For analysis purposes, the Mid-Reach shoreline is divided into six segments or sub-reaches, Reaches 1 to 6 (from south to north).

The proposed action consists of two similar plans formulated to achieve shoreline protection required at the Mid-Reach. The first plan is the U.S. Army Corps of Engineers (USACE) National Economic Development (NED) Plan and the second is the Locally Preferred Plan (LPP). The spatial extent along the six sub-reaches of the Mid-Reach shoreline of each project plan are illustrated in **Figure 1**.

The nature and scope of various project alternatives to the NED and LPP, including these alternatives' effects upon environmental resources, are described in Section 5 of the GRR/SEIS main text. These alternatives include no-action, shoreline retreat, seawalls and revetments, conventional-scale hydraulic beach fill, coastal structures, larger- and smaller-scale dune- and beach-face fill, and various combinations thereof. Because these alternatives are concluded to have unacceptable adverse impacts to environmental resources and/or do not meet the project objectives, for reasons described in Section 5, their effects upon significant EFH are not specifically considered in this section.

Both the NED Plan and LPP include the following principal project elements:

(a) hydraulic excavation of beach-quality sediment, by hopper dredge, from the Canaveral Shoals I or II offshore borrow areas;
(b) transit of the hopper dredge between the borrow area and Canaveral Harbor;
(c) hydraulic placement of the dredged sediment from the hopper dredge to the Poseidon Dredged Material Management Area (DMMA), via pipeline, to create a temporary upland sand stockpile;
(d) truck-haul transfer of stockpiled sediment from the DMMA to the 7.6-mile long Mid Reach project area shoreline;
(e) mechanical (truck-haul) placement of the sediment as dune and/or beach face fill along the shoreline;
(f) construction of nearshore mitigation reef structures; and
(g) project monitoring.

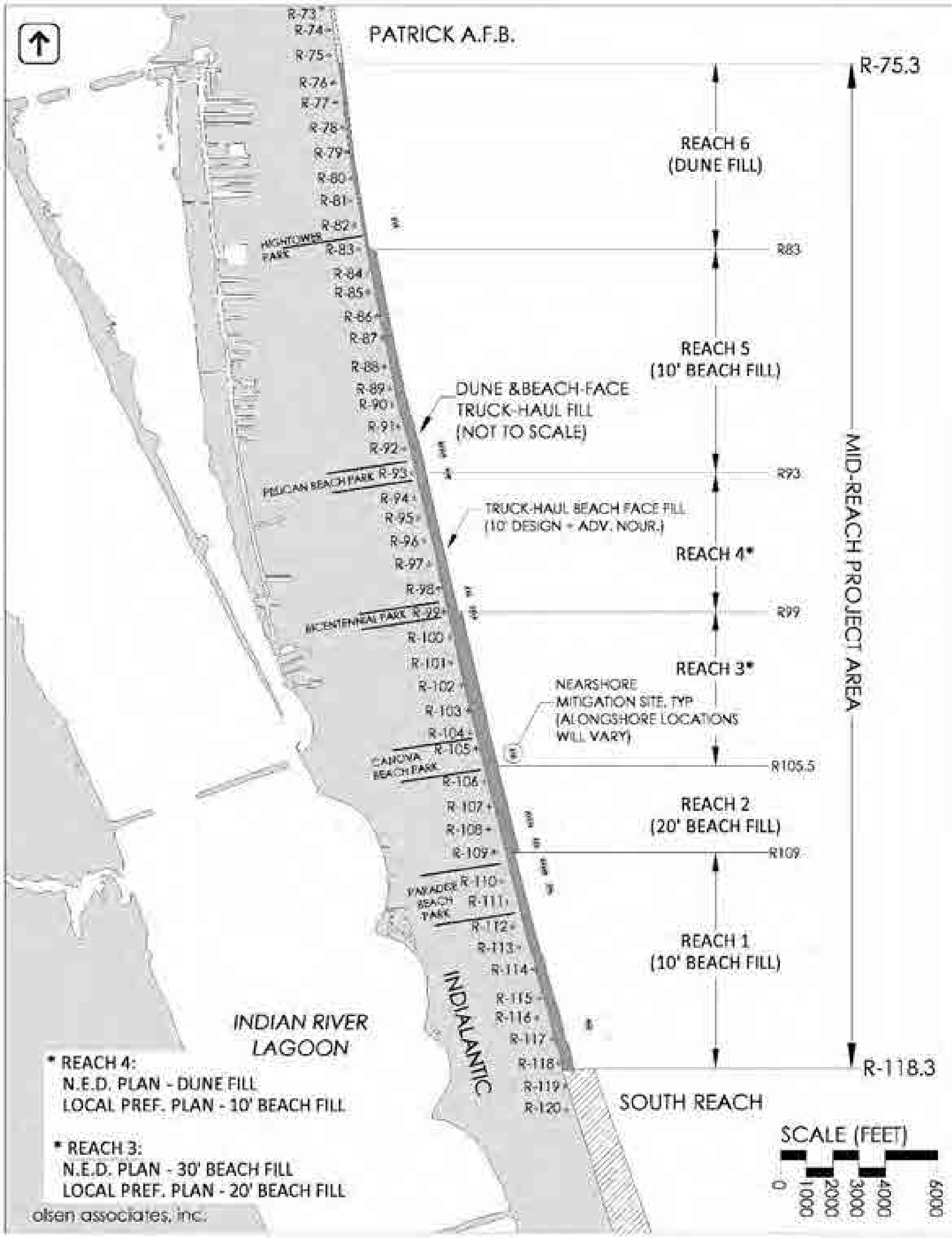

Figure 1. Proposed plan along the Mid Reach project shoreline for the Corps' NED Plan and Locally Preferred Plan. The beach fill plans (not drawn to scale) are identical for the two plans except along Reaches 3 and 4.

The beach fill consists of initial construction and periodic renourishment of limited dune- and/or beach-face sand placement, as summarized below and indicated in **Table 1** and **Figure 1**

NED Plan:
Reach 6: dune-only fill
Reach 5: 10-ft design widening of the beach plus advance nourishment;
Reach 4: dune-only fill;
Reach 3: 30-ft design widening of the beach plus advance nourishment;
Reach 2: 20-ft design widening of the beach plus advance nourishment;
Reach 1: 10-ft design widening of the beach plus advance nourishment.

Locally Preferred Plan.
Reach 6: dune-only fill
Reach 5: 10-ft design widening of the beach plus advance nourishment;
Reach 4: 10-ft design widening of the beach plus advance nourishment;
Reach 3: 20-ft (design widening of the beach plus advance nourishment;
Reach 2: 20-ft design widening of the beach plus advance nourishment;
Reach 1: 10-ft design widening of the beach plus advance nourishment.

Table 1. Summary of beach fill plans and anticipated nearshore rock impacts.

Reach Limits				Dist. to stockpile site (miles)	NED PLAN					
Reach	FDEP Monuments		Length (ft)		Design Fill Template	Initial Nourishment Volume (cy)	Periodic Renourishment Volume (cy)	Impacts to Nearshore Rock (Acres)		
								Design Template	Advance Template	Total*
1	R119 -	R109	**9,599**	**24**	10'	148,000	34,000	0.2	0.2	0.3
2	R109 -	R105.5	**3,406**	**22.7**	20'	84,000	16,000	0.4	0.2	0.5
3	R105.5 -	R99	**6,239**	**21.7**	30'	162,000	28,000	0.8	0.3	1.1
4	R99 -	R93	**5,603**	**20.7**	dune	15,000	15,000	0.1	0.1	0.2
5	R93 -	R83	**9,029**	**19.4**	10'	103,000	43,000	0.3	0.6	0.9
6	R83 -	R75.4	**7,207**	**18**	dune	18,000	18,000	0.0	0.0	0.1
TOTAL	R119 -	R75.4	41,083			**530,000**	**154,000**	**1.8**	**1.2**	**3.0**

Reach Limits				Dist. to stockpile site (miles)	LOCALLY PREFERRED PLAN					
Reach	FDEP Monuments		Length (ft)		Design Fill Template	Initial Nourishment Volume (cy)	Periodic Renourishment Volume (cy)	Impacts to Nearshore Rock (Acres)		
								Design Template	Advance Template	Total*
1	R119 -	R109	**9,599**	**24**	10'	148,000	34,000	0.2	0.2	0.3
2	R109 -	R105.5	**3,406**	**22.7**	20'	84,000	16,000	0.3	0.1	0.4
3	R105.5 -	R99	**6,239**	**21.7**	20'	135,000	28,000	0.5	0.3	0.8
4	R99 -	R93	**5,603**	**20.7**	10'	85,000	25,000	0.3	0.2	0.5
5	R93 -	R83	**9,029**	**19.4**	10'	103,000	43,000	0.3	0.6	0.9
6	R83 -	R75.4	**7,207**	**18**	dune	18,000	18,000	0.0	0.0	0.1
TOTAL	R119 -	R75.4	41,083			**573,000**	**164,000**	**1.6**	**1.4**	**3.0**

* The total predicted impact represents the maximum (seaward extent) of the anticipated toe of beach fill after cross-shore equilibration and alongshore diffusion. For this reason, and likewise due to rounding, the numeric sum of impacts from the design and advance templates are in some cases different from the numeric value of the anticipated total impacts.

Advance nourishment, where indicated, consists of an approximate additional 10-ft widening of the beach beyond the design width. Beach fill placement for the NED and LPP plans is identical except along Reaches 3 and 4.

Beach fill placement and grading will be by truck-haul, excavator, bulldozer and similar mechanical equipment, with placement mostly (but not wholly) above the mean low water line. Initial construction (placing between 530,000 and 573,000 cubic yards of sand) is anticipated to require between 160 and 180 calendar days. Periodic renourishment would be in approximately 3-year cycles, with each event anticipated to place between 154,000 and 164,000 cubic yards and to require between 45 and 60 days for construction.

Hydraulic dredging of the offshore borrow area(s) and replenishment of the DMMA upland stockpile would be in approximate 6-year cycles to correspond with hydraulic-fill renourishment of the North or South Reach portions of the federal shore protection project. Hydraulic dredging and discharge to initially construct and subsequently replenish the DMMA stockpile is anticipated to require between about 60-90 days and 30-40 days, respectively.

The proposed sand source is the Canaveral Shoals offshore borrow areas. Both areas are located east of Port Canaveral along expansive sand shoals in 20- to 50-ft water depths associated with Cape Canaveral. Canaveral Shoals I (CS-I) is located in Florida state waters. Canaveral Shoals II (CS-II) is located in federal (Outer Continental Shelf) waters. In the event that there is insufficient stockpiled material within the DMMA site for project renourishment, then use of beach-compatible sand from alternate upland sources may be used as a temporary, supplemental source of beach fill material. This instance is not anticipated, but it could arise in the event of emergency, post-storm conditions whereby storm erosion requires prompt replenishment of at least a portion of the project's dune and beach-face fill. Use of supplemental upland sand sources would require that the material conforms to all applicable State of Florida standards and that its use is specifically pre-approved by the Florida Department of Environmental Protection.

2.0 MANAGED SPECIES AND EFH IN THE PROJECT AREA

Of the species or species groups managed by the SAFMC and NMFS, the following may be found within the project area:

- Penaeid shrimps;
- Coastal pelagic fishes;
- Red drum;
- Reef fishes; and
- Coastal sharks.

Members of these groups occur in the project area for, at minimum, a portion of their life history. The following accounts briefly describe the EFH for these species and their respective life stages.

2.1 MANAGED SPECIES

The EFH determination is based on species distribution maps and habitat association tables. In offshore areas, EFH consists of those areas depicted as "adult areas," "spawning areas," and/or "nursery areas." The maps for species managed by the SAFMC were reviewed, and potential impacts to the selected species were determined according to the indicated abundance within the project area.

2.1.1 Penaeid Shrimps

Penaeid shrimps managed by the SAFMC and occurring in the project area are brown shrimp (*Farfantepenaeus aztecus*), pink shrimp (*F. duorarum*), and white shrimp (*Litopenaeus setiferus*). Other members of this management unit, including rock shrimp (*Sicyonia brevirostris*), seabob shrimp (*Xiphopenaeus kroyeri*), and royal red shrimp (*Pleoticus robustus*), are found in waters much deeper than the project area.

EFH for penaeid shrimps encompasses the series of habitats used during their life history (SAFMC, 1998). This life history has two basic phases: the adult/juvenile benthic phase and the planktonic larval/post-larval phase. Benthic adults aggregate to spawn in shelf waters over coarse, calcareous sediments. Eggs attached to the females' abdomen hatch into planktonic larvae. These larvae and subsequent post-larval shrimps feed on zooplankton in the water column and make their way into inshore waters. For the inshore phase of the life history, post-larval shrimps settle to the bottom and resume a benthic existence in estuaries that provide rich food sources as well as shelter from predation. Young penaeid shrimps prefer shallow-water habitats with nearby sources of organic detritus such as estuarine emergent vegetated wetlands or mangrove fringe. Young shrimps occur in the Indian River Lagoon from April to June.

2.1.2 Red Drum

Red drum (*Sciaenops ocellata*), a member of the drum family Sciaenidae, occur in the project area. EFH for red drum includes tidal freshwater, estuarine emergent vegetated wetlands (e.g., flooded salt marshes, brackish marsh, and tidal creeks), mangrove shorelines, seagrasses, oyster reefs and shell banks, unconsolidated bottom (e.g., soft sediments), ocean high-salinity surf zones, and artificial reefs (SAFMC, 1998). Red drum EFH particular to the project area includes ocean high-salinity surf zone.

HAPCs for red drum are coastal inlets, state-designated nursery habitats of particular importance to red drum, documented sites of spawning aggregations, and habitats for submerged aquatic vegetation (SAFMC, 1998). In many areas throughout the geographic range of red drum, mature adults migrate offshore into shelf waters to spawn from inshore areas. This appears to be the case offshore east-central Florida; however, in the Indian River and Mosquito Lagoons, Johnson and Funicelli (1991) have documented spawning by red drum. Tagging studies conducted in inshore waters of the area have documented that red drum will migrate to ocean inlets such as Sebastian or Ponce de Leon, presumably to spawn (Stevens and Sulak, 2001; Tremain et al., 2004). Although the portion of the local population spawning in shelf waters off Brevard County is unknown, adult and subadult red drum occur in the nearshore waters of the region during certain times of the year.

Other sciaenids found in the project area include kingfish (*Menticirrhus* spp.), sand drum (*Umbrina coroides*), and striped croaker (*Bairdiella sanctaeluciae*). These species are not managed by the SAFMC, but may serve as prey for other managed species in the project area (e.g., reef fishes and coastal pelagic species). Striped croaker is considered a species of special concern by the State of Florida.

2.1.3 Coastal Pelagic Fishes

The major coastal pelagic families occurring in inshore and coastal waters of the project area are ladyfish, anchovies, herrings, mackerels, jacks, mullets, bluefish, and cobia. Coastal pelagic species migrate over the region’s shelf waters throughout the year. Some species form large schools (e.g., Spanish mackerel), while others travel alone or in smaller groups (e.g., cobia). Many coastal pelagic species inhabit the nearshore environment along beaches and barrier islands of eastern Florida (Gilmore et al., 1981; Peters and Nelson, 1987). Commonly occurring species in the project area include anchovies (*Anchoa* spp.), menhaden (*Brevoortia* spp.), scaled sardine (*Harengula jaguana*), striped mullet (*Mugil cephalus*), hardhead catfish (*Ariopsis felis*), and Florida pompano (*Trachinotus carolinus*). Larger predatory species (particularly bluefish, blue runner, jack crevalle, sharks, and Spanish mackerel) may be attracted to larger concentrations of anchovies, herrings, and mullets that aggregate in nearshore areas. The distribution of most species depends on water temperature and quality, which vary spatially and seasonally.

Coastal pelagic species managed by the SAFMC are cobia (*Rachycentron canadum*), Spanish mackerel (*Scomberomorus maculatus*), king mackerel (*S. cavalla*), and little tunny (*Euthynnus alletteratus*) (SAFMC, 1998). Various life stages of all these species may occur in the project area (**Table 2**).

Table 2. Coastal pelagic fishes and life stages with Essential Fish Habitat identified within the Mid-Reach project area (Adapted from: South Atlantic Fisheries Management Council, 1998; National Marine Fisheries Service, 1999).

Common Name	Species	Eggs and Larvae	Juveniles/Subadults	Adults
Cobia	*Rachycentron canadum*	Shelf waters	Shelf waters; artificial and natural hard bottom; associates with larger nekton (i.e., sharks, rays, sea turtles)	Shelf waters; artificial and natural hard bottom structures; associates with larger nekton (i.e., sharks, rays, sea turtles)
King mackerel	*Scomberomorus cavalla*	Shelf waters	Shelf waters; associates with artificial and natural hard bottom	Shelf waters; associates with artificial and natural hard bottom
Spanish mackerel	*Scomberomorus maculatus*	Shelf waters	Shelf and inshore waters; associates with artificial and natural hard bottom	Shelf and inshore waters; associates with artificial and natural hard bottom
Little tunny	*Euthynnus alletteratus*	Shelf waters	Shelf waters; artificial and natural hard bottom	Shelf waters; artificial and natural hard bottom

EFH for coastal pelagic species includes *Phragmatopoma* reefs (worm reefs) off the central coast of Florida; nearshore hard bottom is south of Cape Canaveral. This EFH also includes sandy shoals of capes and offshore bars as well as high-profile rocky bottom and barrier island ocean-side waters from the surf zone to the shelf break zone from the Gulf Stream shoreward (including *Sargassum)*. Also, all coastal inlets and state-designated nursery habitats of particular importance to coastal migratory pelagics are included as EFH for coastal pelagic species (SAFMC, 1998).

2.1.4 Reef Fishes

The reef fish (snapper-grouper) management unit consists of 73 species from 10 families. Although the fisheries and adult habitat of most of these species exist well offshore of the project area, the young stages of several reef fishes utilize nearshore hard bottom (e.g., Gilmore et al., 1981; SAFMC, 1998; Lindeman and Snyder, 1999; Lindeman et al., 2000). SAFMC (1998) identified the following habitats as EFH for early life stages of reef fishes: attached macroalgae, seagrasses, salt marshes, tidal creeks, mangrove fringe, oyster reefs and shell banks, soft sediments, artificial reefs, coral reefs, and hard/live bottom. The Mid-Reach project area includes soft bottom and hard/live bottom. Nearshore hard bottom has been identified as an important habitat for many of the 73 members of the reef fish management unit (SAFMC, 1998); reef fish species with EFH in the project area are listed in **Table 3**.

Generally, reef fishes spawn offshore, releasing eggs and larvae into the water column. In some species, such as gray snapper (*Lutjanus griseus*) and gag grouper (*Mycteroperca microlepis*), larvae are transported through inlets into estuarine areas where they settle the bottom and occupy seagrass meadows or other structured habitats. As they grow, young gray snappers will move from seagrass areas to more structured areas such as artificial hard bottom, mangrove fringe (prop roots), and near shore hard bottom. Other reef fishes such as lane snapper (*L. synagris*) and grunts (e.g., *Haemulon* spp., *Anisotremus surinamensis*, *A. virginicus*, and *Orthopristis chrysoptera*) have similar life cycles, and their early life stages also could occur in the inshore waters of the area. Nearshore hard bottom is an important connection of the cross-shelf developmental pathways undertaken by many reef species (Lindeman et al., 2000).

Table 3. Species by family from the Reef Fish Management Unit with Essential Fish Habitat presence in the project area (South Atlantic Fishery Management Council, 1998).

Family	Common Name	Species	Spawning	Eggs	Larvae	Juveniles	Adults
Serranidae – sea basses and groupers	Red grouper	*Epinephelus morio*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; hard bottom; inshore and shelf waters	Demersal; hard bottom; shelf waters
	Goliath grouper	*Epinephelus itajara*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; hard bottom; inshore and shelf waters	Demersal; hard bottom; shelf waters
	Gag grouper	*Mycteroperca microlepis*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; hard bottom; inshore and shelf waters	Demersal; hard bottom; shelf waters
	Scamp	*Mycteroperca phenax*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; hard bottom; shelf waters	Demersal; hard bottom; shelf waters
	Black sea bass	*Centropristis striata*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; hard bottom; inshore and shelf waters	Demersal; hard bottom; shelf waters
Carangidae – jacks	Blue runner	*Caranx crysos*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; inshore waters	Demersal; hard bottom; inshore and shelf waters
	Crevalle jack	*Caranx hippos*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; inshore waters	Demersal; hard bottom; inshore and shelf waters
Lutjanidae – snappers	Gray snapper	*Lutjanus griseus*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; inshore waters	Demersal; hard bottom; inshore and shelf waters
	Lane snapper	*Lutjanus synagris*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; inshore and shelf waters	Demersal; hard bottom; inshore and shelf waters
	Vermilion snapper	*Rhomboplites aurorubens*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; shelf waters	Demersal; hard bottom; inshore and shelf waters

Table 3. (Continued).

Family	Common Name	Species	Spawning	Eggs	Larvae	Juveniles	Adults
Haemulidae – grunts	White grunt	*Haemulon plumieri*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; inshore waters	Demersal; hard bottom; inshore and shelf waters
	Porkfish	*Anisotremus virginicus*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; inshore waters	Demersal; hard bottom; inshore and shelf waters
	Black margate	*Anisotremus surinamensis*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; inshore waters	Demersal; hard bottom; inshore and shelf waters
	Sailors choice	*Haemulon parra*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; inshore waters	Demersal; hard bottom; inshore and shelf waters
Sparidae – porgies	Sheepshead	*Archosargus probatocephalus*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; inshore waters	Demersal; hard bottom; inshore and shelf waters
Ephippidae – spadefishes	Atlantic spadefish	*Chaetodipterus faber*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; inshore and shelf waters	Demersal; hard bottom; inshore and shelf waters
Balistidae – triggerfishes	Gray triggerfish	*Balistes capriscus*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; shelf waters	Demersal; hard bottom; inshore and shelf waters

Visual surveys consisting of 10-min swims (a modification of Kimmel's [1985] method) were conducted over nearshore hard bottom along the southern portion of Brevard's Mid-Reach. Locations of these censuses are presented in **Figure 2**. Because these censuses were made when the water clarity was marginal (less than 1 m), the results should be considered underestimates of diversity and species composition. The surveys revealed 19 species (**Table 4**) and generally higher numbers of juveniles than adults, indicating that the habitat provides some nursery function. Species composition is consistent with the results of Gilmore et al. (1981) for nearshore hard bottom in the region. Of the 19 species observed, 6 (i.e., black margate, porkfish, lane snapper [*Lutjanus synagris*], gray snapper, Atlantic spadefish [*Chaetodipterus faber*], and sheepshead [*Archosargus probatocephalus*]) are members of the Reef Fish Management Unit (SAFMC, 1998). Another species, the nurse shark, is managed by the NMFS (1999). Striped croaker (*Bairdiella sanctaeluciae*) is considered a species of special concern by the State of Florida (Gilmore and Snelson, 1992). Many reef fish species not managed by the SAFMC also utilize nearshore hard bottom in the project area. During field surveys, other species such as wrasses (*Halichoeres bivittatus*, *H. poeyi*), clingfish (*Gobiesox strumosus*), sergeant major (*Abudefduf saxatilis*), night sergeant (*Abudefduf taurus*), and hairy blenny (*Labrisomus nuchipinnis*) were observed in shallow tide pools.

2.1.5 Coastal Sharks

Coastal sharks commonly occur during their life stages in inland and nearshore shelf waters. In the project area, several managed shark species have been observed, including blacknose (*Carcharhinus acronotus*), spinner (*C. brevipinna*), bull (*C. leucas*), dusky (*C. obscurus*), sandbar (*C. plumbeus*), tiger (*Gaelocerdo cuvier*), sand tiger (*Carcharias taurus*), bonnethead (*Sphyrna tiburo*), and lemon (*Negaprion brevirostris*). The young of several of these species also utilize the nearby Indian River Lagoon as nursery grounds (Snelson and Williams, 1981; Snelson et al., 1984). EFH identified by NMFS (1999) for coastal shark species is presented in **Table 5**. No HAPCs are available for coastal sharks.

2.2 EFH IN THE PROJECT AREA

In the SAFMC (1998) comprehensive EFH amendment, important habitats of the South Atlantic region were broadly divided into estuarine/inshore and marine/offshore categories, with many subcategories under each heading. Marine/offshore habitats include coastal, open shelf, live/hard bottom, shelf edge, and lower shelf (SAFMC, 1998). Each habitat harbors a distinct assemblage of demersal fishes and invertebrates. The Brevard Mid-Reach project area encompasses only marine/offshore habitats, specifically hard bottom (nearshore hard bottom), soft bottom (open shelf), and the water column. These habitats were previously discussed relative to how they are utilized by managed species. In the following sections, they are discussed in terms of salient characteristics in and relevant to the project area.

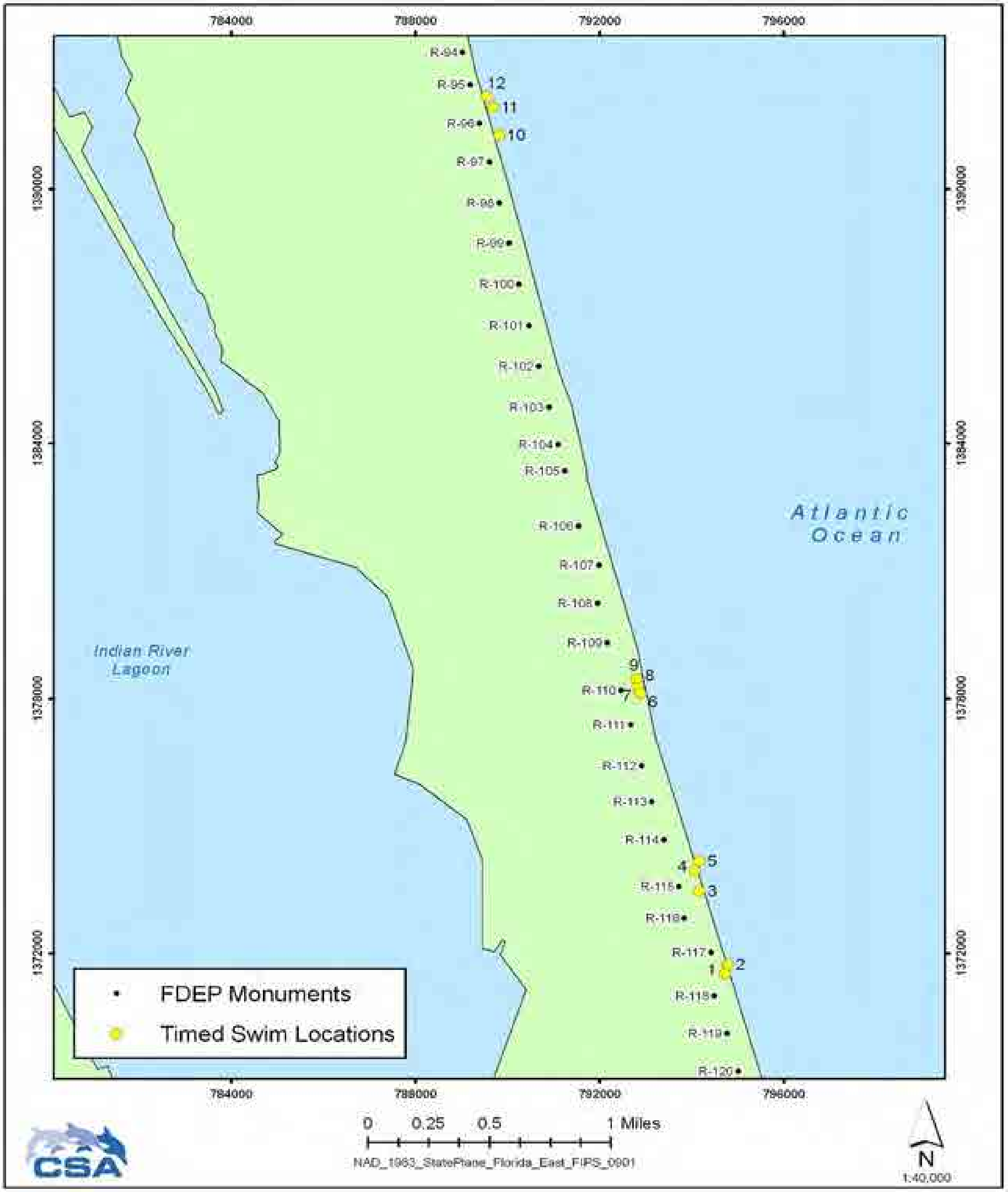

Figure 2. Location of timed swim sites relative to Florida Department of Environmental Protection (FDEP) monuments.

Table 4. Fishes observed during 10-min swims over hard bottom features along the Brevard County Mid-Reach in order of total abundance. Sites are ordered from south to north (see **Figure 2**).

Common Name	Species	Site												
		1	2	3	4	5	6	7	8	9	10	11	12	Total
Black margate	*Anisotremus surinamensis*	3	12		7	13	10	47	57	14	17	30	22	232
Hairy blenny	*Labrisomus nuchipinnis*	6	1	1	2	3	13	6	22	11	17	21	16	119
Silver porgy	*Diplodus argenteus*	7	5				8	4	10	11	8	5	10	68
Sheepshead	*Archosargus probatocephalus*		11			3		4	16	6	1	1	2	44
Atlantic spadefish	*Chaetodipterus faber*	6	9	2		3	5		1				2	28
Gray snapper	*Lutjanus griseus*		3			1				2		2	1	9
Slippery dick	*Halichoeres bivittatus*										1		5	6
Porkfish	*Anisotremus virginicus*				1							1	2	4
Molley miller	*Scartella cristata*										1		3	4
Sergeant major	*Abudefduf saxatilis*							1			1			2
Lane snapper	*Lutjanus synagris*								1		1			2
Striped croaker	*Bairdiella sanctaeluciae*											1		1
Nurse shark	*Ginglymostoma cirratum*					1								1
Blackear wrasse	*Halichoeres poeyi*										1			1
Pigfish	*Orthopristis chrysoptera*							1						1
Gulf flounder	*Paralichthys albigutta*												1	1
High-hat	*Pareques acuminatus*							1						1
Sand drum	*Umbrina coroides*								1					1
Razorfish	*Xyrichtys* sp.										1			1
Total Observed		22	41	3	10	24	36	64	108	44	49	61	64	526
Total Taxa		4	6	2	3	6	4	7	7	5	10	7	10	19

Table 5. Coastal shark species and life stages with Essential Fish Habitat identified within the project area (Adapted from: National Marine Fisheries Service, 1999).

Common Name	Species	Neonate/Early Juveniles	Late Juveniles/Subadults	Adults
Blacknose shark	*Carcharhinus acronotus*	Shallow coastal waters less than 25 m deep from the Georgia/Florida border to Cape Canaveral, Florida	Shallow coastal waters less than 25 m deep from the Georgia/Florida border to Cape Canaveral, Florida	--
Spinner shark	*Carcharhinus brevipinna*	Shallow coastal waters less than 25 m deep from Cape Hatteras, North Carolina to around Florida	Shallow coastal waters less than 200 m deep from the Georgia/Florida border south to Cape Canaveral, Florida (28.5 ºN)	Shallow coastal waters less than 100 m deep from Georgia/Florida border south to Cape Canaveral, Florida (28.5 ºN)
Bull shark	*Carcharhinus leucas*	Shallow coastal waters, inlets, and estuaries in waters less than 25 m deep from just north of Cape Canaveral at 29ºN to just south of Cape Canaveral at 28ºN	Shallow coastal waters, inlets, and estuaries in water depths less than 25 m	n/a
Dusky shark	*Carcharhinus obscurus*	Shallow coastal waters, inlets, and estuaries in waters less than 25 m deep	Shallow coastal waters, inlets, and estuaries in waters less than 25 m deep	n/a
Sandbar shark	*Carcharhinus plumbeus*	Shallow coastal waters, inlets, and estuaries in waters less than 25 m deep from Montauk, New York to Cape Canaveral, Florida (27.5ºN)	Shallow coastal waters, inlets, and estuaries in waters less than 25 m deep from Montauk, New York to Cape Canaveral, Florida (27.5ºN)	n/a
Tiger shark	*Gaelocerdo cuvier*	Shallow coastal waters to the 200-m isobath from Cape Canaveral, Florida (27.5ºN) to Montauk, New York	--	--
Sand tiger shark	*Carcharias taurus*	Shallow coastal waters less than 25 m deep from Barnegat Inlet, New Jersey to Cape Canaveral, Florida (27.5ºN)	--	Shallow coastal waters less than 25 m deep from Barnegat Inlet, New Jersey to Cape Canaveral, Florida (27.5ºN)
Bonnethead shark	*Sphyrna tiburo*	--	Shallow coastal waters, inlets, and estuaries less than 25 m deep from Cape Fear, North Carolina to West Palm Beach, Florida	--
Lemon shark	*Negaprion brevirostris*	Shallow coastal waters, inlets, and estuaries less than 25 m deep from Bulls Bay, South Carolina to West Palm Beach, Florida	Shallow coastal waters, inlets, and estuaries less than 25 m deep from Bulls Bay, South Carolina to West Palm Beach, Florida	--

-- = Life stage does not occur within the project area.
n/a = Information not available.

2.3 NEARSHORE HARD BOTTOM

Nearshore hard bottom is the primary EFH found in the project area. This habitat supports more species than either the soft bottom or water column habitats. Nearshore hard bottom outcrops along the eastern Florida shoreline are composed of beach rock (coquina) of the Anastasia Limestone Formation (Davis, 1997), usually formed as wind-blown sand dunes during the Pleistocene era. These features parallel the current shoreline and are subject to frequent burial and erosion caused by high wave energy of the surf zone. Unless the features have appreciable relief, they will be inundated by sand to varying degrees.

Despite this physically demanding environment, several sessile organisms are well adapted to the prevailing conditions and often cover high portions of the exposed rock. One such organism is the sabellarid polychaete *Phragmatopoma lapidosa*, which forms large gregarious colonies commonly referred to as worm reefs (Kirtley and Tanner, 1968; McCarthy, 2001). The worm reef colonies are composed of sand grains cemented together to form rugose structures that add relief and structural complexity to existing natural and artificial hard bottom. The growth of worm reef depends on a combination of available hard substrate, wave energy, sediment availability, and larval supply (McCarthy et al., 2003). Worm reefs south of Cape Canaveral have been designated as EFH by the SAFMC (1998). In addition to fish species, worm reef supports associated assemblages of organisms, such as decapod crustaceans (Gore et al., 1978). Details of epibiota of the Mid-Reach hard bottom features may be found in the **Appendix SEIS-B.**

Based upon June 2004 mapping, there are approximately 31.3 acres of nearshore hard bottom in a band along the entire Mid-Reach shoreline, exposed in irregularly scattered outcrops near the mean low water shoreline. There is an additional 11.2 acres of exposed nearshore hard bottom along the adjacent mile of shoreline immediately north of the Mid Reach, along Patrick Air Force Base. This band has been quantified by aerial photography, then characterized by field verification of broad substrate categories (Olsen Associates, Inc., 2003, 2005). The areal extent of rock increases with increasing latitude. Mapping in both 2001 and 2004 indicated that over 85% of the exposed rock in the Mid Reach occurred along the northern half of the Mid Reach, along Reaches 4 through 6, between monuments R75.4 and R99. There are subtidal and intertidal portions of hard bottom along the Mid-Reach. The intertidal portions are most prevalent in the vicinity of FDEP Monuments R-90 and R-99. The rock surface supports macroalgae and other epibionts that are important food sources or shelter for fishes of varying life stages. Much of the epibiota is emphemeral and subject to extensive wave scour. Portions of the exposed rock are colonized by the sabellariid worm *Phragmatopoma lapidosa*.

2.3.1 Nearshore Soft Bottom (Surf Zone)

Surf zone is the innermost portion of the open shelf habitat subcategory. Along the Mid-Reach, the surf zone occurs landward of the hard bottom outcrop and the shoreline. The presence of infaunal invertebrates in the surf zone and nearshore soft bottom provides an important prey base for many benthic feeding fishes. Sediment characteristics in the nearshore soft bottom habitat change with latitude. Coarser, shelly material is found in the southern portion of the Mid-Reach. Soft bottom species such as kingfish and sand drum feed extensively on infaunal invertebrates. In the surf zone, mole crab (*Emerita talpoida*) and beach clam (*Donax* sp.) are key invertebrate prey species.

2.3.2 Water Column

The water column of the area overlays the nearshore and surf zone portions of the project area. Important attributes of the water column include hydrodynamics, temperature, salinity, and dissolved oxygen (DO). The hydrodynamic regime is driven mostly by persistent ground swells generated by low pressure systems (i.e., tropical and extra-tropical cyclones). The persistent wave energy resuspends fine sediments into the water column for extended periods. A nearby wave gauge at Melbourne Beach, Florida recorded maximum wave heights for April, May, and June 2005 as 2.31, 1.57 and 1.61 m, respectively. As a result of the persistent waves, the project area’s water column is continually turbid, which prevented complete visual sampling of the Mid-Reach hard bottom as well as aerial photography during spring and summer of 2005.

Salinity data for the project area are not available. However, because coastal inlets are a considerable distance from the Mid-Reach (13.5 mi from Canaveral Inlet to the northern Mid-Reach FDEP Monument R-75.3 and 18.5 mi from Sebastian Inlet to the southern Mid-Reach FDEP Monument R-118.3), the effects of inshore tidal water discharges on salinity are likely minimal during most seasons. With persistent wave energy and constant mixing, DO also is expected to be within normal ranges to support fish assemblages. Temperature should follow a seasonal pattern, with peaks in summer and lows in winter. However, upwellings of cold water during the summer season could cause unseasonable changes in nearshore water temperature.

3.0 ASSESSMENT OF IMPACTS AND MITIGATIVE MEASURES

3.1 IMPACTS TO EFH

Impacts to EFH are expected because of the extent of nearshore hard bottom present along most of the Mid-Reach project area. The primary impact-producing factors for both the NED Plan and the LPP are turbidity and sedimentation.

3.1.1 Turbidity

Turbidity can affect feeding, movements, and respiration in fishes. Many fish species are primarily visual feeders, and the fishes reactive distance decreases when turbidity reduces light penetration (Vinyard and O'Brien, 1976). Light scattering caused by suspended sediment also can affect a visual predator's ability to perceive and capture prey (Benfield and Minello, 1996). Some fishes have demonstrated the ability to capture prey at various turbidity levels, but the density of prey and amount of light penetration are important factors (Grecay and Targett, 1996). Some species will actively avoid and/or be attracted to turbid water. Experiments with pelagic kawakawa (*Euthynnus affinis*) and yellowfin tuna (*Thunnus albacares*) showed that these species would actively avoid experimental turbidity clouds, but that they also would swim directly through them during some trials (Barry, 1978). Gill cavities can be abraded and clogged by suspended sediment, preventing normal respiration and mechanically affecting food gathering in planktivorous species (Bruton, 1985). High suspended sediment levels generated by storms have contributed to the death of nearshore and offshore fishes by clogging gill cavities and eroding gill lamellae (Robins, 1957). High concentrations of fine sediments can coat respiratory surfaces of the gills, preventing gas exchange (Wilber and Clarke, 2001).

Understanding and predicting effects of suspended sediments on fishes requires some information on the range and variation of turbidity levels found at a project site prior to dredging (Wilber and Clarke, 2001). Range and variation of turbidity will depend greatly on the nature of the sediment in the borrow areas to be transported to the DMMA (Wanless and Maier, 2007).

Prior experience with dredging the CS-II borrow area and hydraulic placement of the sand to Brevard County beaches by direct pump-out or via a nearshore rehandling area complied with state and federal laws and regulations, resulting in no violations of state water quality standards. Compliance turbidity levels have averaged less than 4.3 nephelometric turbidity units (NTUs) above background (vs. state allowance of 29 NTU above background). These numbers represent temporary turbidity levels associated with plumes during construction. There were no significant differences in granulometric qualities among samples from the borrow area, hopper dredge (transit), or in place on the beach berm (Olsen, 2002), suggesting that there was not a significant loss in fine-sediments during excavation and transfer of the borrow material that would otherwise indicate substantial turbidity or sedimentation outside the project shoreline area.

As measured by vibracore samples and direct sampling of material placed on the beach, the physical characteristics of the offshore sand source material conform closely to those of the native beach, which is a fine to medium grain sand with variable carbonate and coarse shell content. The typical composite profile median grain size is approximately 0.3 to 0.35 mm, with carbonate fractions ranging from 16% to 54% (about 38% on average).

The median grain size of the CS-I borrow area ranges from about 0.18 to 0.3 mm (about 0.27 mm on composite average), with sieves typically less than 3% finer than #200 and #230. The median grain size of the CS-II borrow area ranges from approximately 0.3 to 0.4 mm (about 0.34 mm on composite average), with average carbonate fraction of about 39%. The fine sediment content of the material is less than 2% to 3% by core-boring and less than 0.5% (finer than #200 sieve) measured in-place on the beach.

Measured turbidity within visible plumes from previous direct hydraulic discharge of the beach fill to Brevard County beaches – along the North Reach, South Reach, and Patrick Air Force Base in 2000 to 2001 and 2005 – has never exceeded state water quality standards. The average compliance values were less than approximately 4.0 NTU above background. After construction, it is not anticipated that fill material will be suspended during wave action and contribute to chronic turbidity across the nearshore rock to any extent greater than the existing beach sediment. Overall, the fill material is generally as coarse or coarser than the native material, with similar carbonate/small-shell content (~40%). The fill material exhibits a fine-sediment content of less than 0.5% (finer than #200 sieve), as measured in place on the beach berm. This is equal to or less than the fine-sediment content of the sampled native beach material, which averaged between 0.47% (berm samples) and 0.99% (composite profile samples).

There is no indication that the fill material will result in increased turbidity across the nearshore profile. In contrast, there are abundant, significant existing data that indicate the placement of the proposed fill material will not increase turbidity across the nearshore profile. Fill material is not reasonably anticipated to be suspended during wave action or to contribute to chronic turbidity over the adjacent reefs to any extent greater than the existing conditions. Analogous activity involving mechanical (truck-haul) placement of sand fill at the dune and upper beach face along the Mid Reach and Patrick AFB shorelines, using sand from the same sources as the proposed activity, resulted in no observed or measured elevation of turbidity relative to natural levels, during or after placement of the material.

During placement and spreading of the beach fill material by mechanical means, periodic visual observation of the nearshore water for turbidity will be made. Visual observation indicating elevations in turbidity relative to natural areas, will require turbidity measurement as follows:

- Measurement at the surface and approximately 1 m above the seabed every 6 hours during daylight hours while activity is occurring;

- Background at minimum 1,640 ft (500 m) upcurrent from the point at which discharged water or sand fill enters surface waters in the opposite direction of the prevailing current flow and clearly outside the influence of any turbid plume;
- Compliance at not more than 500 ft (150 m) downcurrent from the point at which discharged water or sand fill enters surface waters in the densest portion of any visible turbidity plume; and
- Samples collected at the same distance offshore.

Measurements of compliance turbidity levels exceeding 29 NTU above background will require that operations be modified or halted and actions taken to ensure that turbidity levels are less than the 29-NTU limit. Measurements indicating turbidity levels approaching the 29-NTU limit will require that more frequent turbidity measurements be made.

These observations indicate that if the material used for the proposed projects is composed of sand with similar qualities, then turbidity will not adversely affect EFH in the project area.

3.1.2 Sedimentation

Sedimentation caused by the proposed action will be sand placement on the beach that immediately covers the inshore margin of nearshore hard bottom along the entire Mid-Reach project area, resulting in adverse impacts to EFH. Both proposed plans will result in equal levels of habitat burial, but they are discussed separately below.

The dune fill will be placed mostly or wholly above the normal wave zone by truck-haul. Based on the small volume of proposed fill and its placement above the wave zone as well as the monitoring of prior analogous activities, no significant adverse impacts to the nearshore rock are anticipated from this activity.

The initial sand placement by truck-haul during beach fill activities will extend approximately to or just below the MLWL, resulting in some direct (immediate) burial of the landward-most edge of part of the existing exposed nearshore rock during construction. Subsequent equilibration will spread some of the placed fill seaward, resulting in additional burial of landward portions of the nearshore rock along and below the low water shoreline. The thickness of the equilibrated sand-fill across the nominal existing seabed is anticipated to be about 12 in. at the low water line, decreasing to zero thickness in the seaward direction. The vertical relief of the existing rock outcrops varies between about 30 in. and 1 in. (i.e., nearly flush with the seabed); therefore, the degree to which the landward portions of the nearshore rock might be buried by sand will vary.

The anticipated impacts to the existing nearshore rock hard bottom are summarized in **Table 1**. This summary includes the entire Mid-Reach region (Reaches 1 through 6) and describes both the NED Plan and the LPP. Beach profiles illustrating the proposed fill placement, equilibration, and anticipated impacts to nearshore rock for the NED plan and the Locally Preferred (LP) Plan are depicted in **Figure 3** and **Figure 4**, respectively**.**

After initial equilibration of the placed fill, the NED Plan's potential impact to exposed nearshore rock along Reaches 1 through 5 is predicted to be about 3.0 acres, based on June 2004 resource mapping. As the advance fill erodes and the beach width retreats, rock potentially buried by the sand fill placement will become increasingly re-exposed. When the sand fill recedes to the design condition (between 10-ft and 30-ft advance of the high water line along Reaches 1-3 and Reach 5) -- in the interval before renourishment, about 3-years after construction – the anticipated impact to the rock resource is predicted to be approximately 1.8 acres along Reaches 1 through 5. This accounts for alongshore diffusion of the fill and erosion of the advance fill.

The Locally Preferred (LP) Plan's total potential impact to exposed nearshore rock is also predicted to be about 3.0 acres, based on June 2004 resource mapping. When the truck-hauled sand fill recedes to the design condition (between 10-ft and 20-ft advance of the high water line along Reaches 1 through 5 – just before renourishment, about 3 years after construction – the total anticipated impact is predicted to be approximately 1.6 acres. This likewise accounts for alongshore diffusion of the fill and erosion of the advance fill.

Little or no impact to exposed nearshore rock is anticipated along Reach 6 – along the northern 7200-ft of the Mid Reach – in either the NED or LP Plans. Fill placement along this reach is proposed as dune fill only. Monitoring conducted since 2005 pursuant to conservation recommendations of the NMFS has indicated no impacts or burial of nearshore rock associated with prior, equivalent dune fill activities along the Mid Reach or Patrick Air Force Base (Olsen 2007b, 2008; see also Appendix SEIS-I).

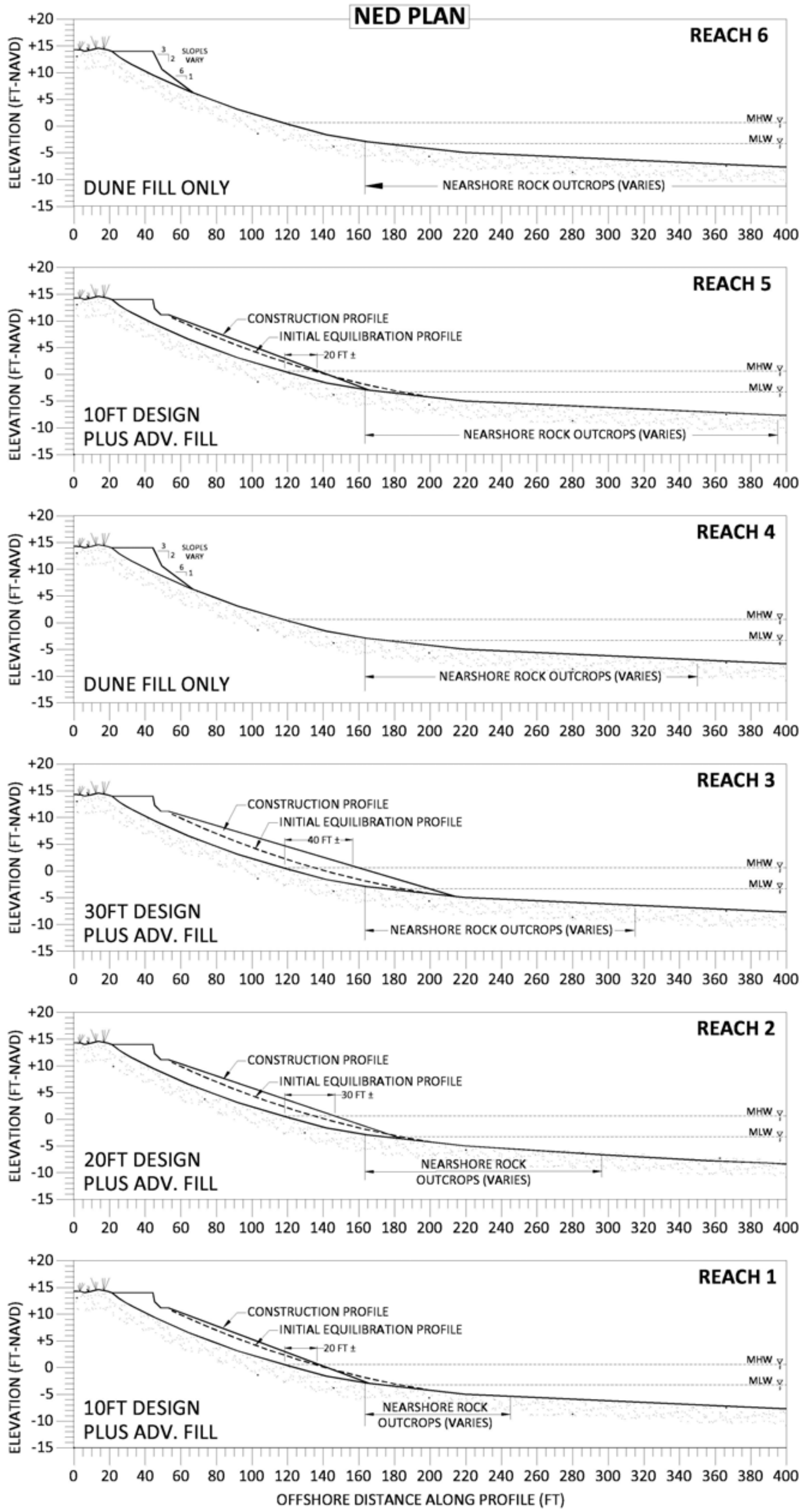

Figure 3. Schematic illustration of typical project beach fill in the NED Plan relative to the existing beach profile and nearshore rock.

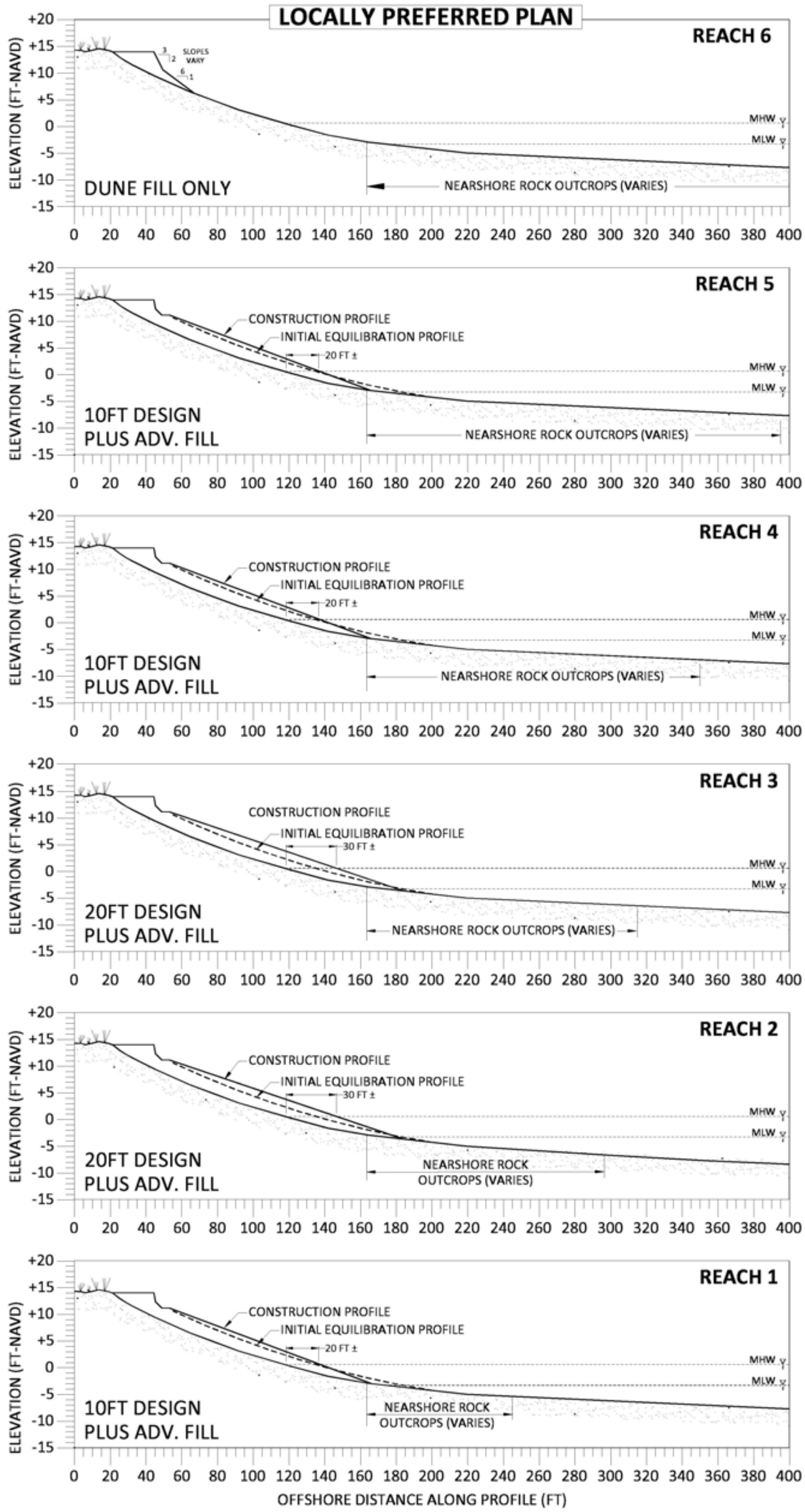

Figure 4 Schematic illustration of typical project beach fill in the Locally Preferred Plan relative to the existing beach profile and nearshore rock.

3.2 PROPOSED MITIGATIVE MEASURES

The NED Plan and Locally Preferred Plan include construction of artificial reef structures in the nearshore waters along the project shoreline to mitigate anticipated adverse environmental impacts to the existing nearshore hard bottom. The proposed reef structure will consist of articulated concrete mats with an integral coquina-rock surface. An example structure, illustrated in **Figure 5**, consists of nine experimental blocks constructed by Brevard County. The mitigation reef is designed to replicate the physical appearance, texture, relief, and function of the existing nearshore rock resource as closely as practical, while respecting aspects of constructability, hydraulic stability, and geotechnical considerations.

Figure 5. Sample portion of an articulated mat reef mitigation structure prototype proposed for the project.

Each articulated reef mat will consist of approximately 18 cable-connected blocks. Each mat would be about 8-ft x 15-ft x 1-ft and comprise about 90 linear ft of valleys (ridges) between blocks and adjacent mats. See **Figure 6.** In total, 42 mats (in 6 rows and 7 offset columns) would be placed adjacently – along with two additional "top-layer" mats along the landward edge to form an overhanging ledge. This would constitute one "set" of 44 mats. Each set of mats would create about 0.15 to 0.16 acres of hard bottom structure. Approximate alongshore locations of reef "sets" are illustrated in **Figure 1**. Final details, dimensions, and alongshore locations of the mitigation reef structures will be determined through the reef structure's final design.

Each set of mats would be placed on the sand seabed at ambient depths between about -14.4 ft and -15.6 ft mean low water (MLW) (i.e., approximately centered along the -15-ft MLW contour and located about 1,000 ft from the MLW shoreline). At 12-in. nominal relief (and 24-in. maximum relief along the landward edge), the coquina surface of the reef units would lay in water depths between -12.4 ft MLW and -14.6 ft MLW.

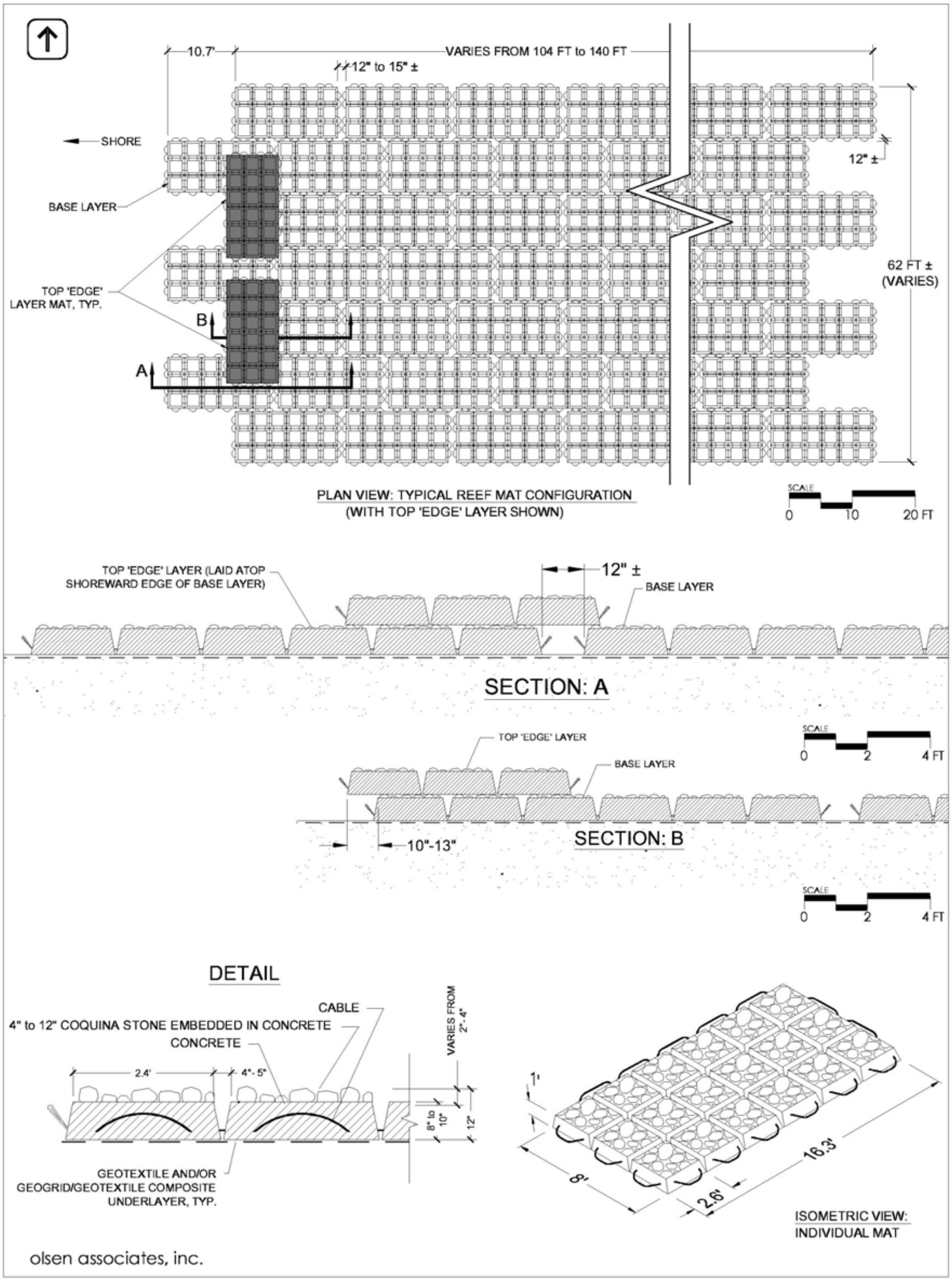

Figure 6. Schematic illustration of individual blocks, articulated mats, and lay-out of mats composing one set of structure in the project's mitigation reef.

Between three and five sets of mats would be spaced 50 to 60 ft apart along the -15-ft contour to form a reef-group. These reef-groups would be spaced on the order of 400 to 9000 feet apart to create the requisite total area of reef mitigation along the shoreline.

The specific geometry of the mats within and between each set will be determined by considerations of marine construction equipment, seabed depth and tides, and the objective of installing the reef as shallow as possible. The geometry and alongshore spacing of reef units considers the natural patch dynamics of nearshore hard bottom. The alongshore spacing is similar to that of the existing hard bottom along the southern Mid-Reach. It is intended to create a corridor of readily traversed (yet semi-isolated) reef patches proximate to the existing non-impacted rock.

Jointly, considerations of hydrodynamic stability, construction access, historical sea conditions, natural seabed profile fluctuation, and potential hazards to public safety indicate that seabed depths of about -14 ft mean low water line (MLWL) or deeper (equating to approximately -17.3 ft North American Vertical Datum) represent the shallowest practical limit of reef construction at this location (Olsen, 2007a). Prior deployment of prototype structures along the Mid-Reach in the same water depths as proposed for the project's mitigation reef indicated the recruitment of *Phragmatopoma lapidosa* (worm rock building polychaete) and establishment of macroalgae in abundance and type generally similar to that observed on the existing nearshore hard bottom along with fish and other invertebrates (Holloway-Adkins and McCarthy, 2007; McCarthy and Holloway-Adkins, 2007).

4.0 CONCLUSIONS

The Brevard Mid-Reach area supports EFH for several federally managed species and species groups. The most important habitat within the project boundaries is the nearshore hard bottom feature that extends along much of the Mid-Reach project area, followed by the water column and level sand bottom. The two proposed actions will impact EFH through turbidity and sedimentation. Effects of turbidity on EFH and managed species (and their life stages) will be adverse, but not significant. This evaluation is based on past experience with the sand from the source area (Canaveral Shoals), its sedimentary characteristics, and general lack of chronic turbidity following placement on the beach suggest only temporary effects. If sedimentary characteristics of the sand were to change, then turbidity effects could be significant.

Sedimentation or direct burial of nearshore hard bottom following the placement, mechanical spreading, and subsequent diffusion of sand will result in an adverse and significant impact. The maximum burial expected is 3.0 acres, approximately 11% of the overall hard bottom feature along the Mid Reach (or about 7% of the overall feature including Patrick AFB), and the extent of the burial will be along the landward edge. The impacts are anticipated to be temporal, decreasing from 3 acres to 1.8 acres or less between the project's renourishment activities in approximate 3-year intervals.

Although the two plans propose to fill 3.0 acres of nearshore hard bottom, the applicants will provide compensatory mitigation in the form of 4.8 acres of artificial reef constructed to mimic the structure and substrate of the natural hard bottom. This was determined through consideration of both Habitat Equivalency Analysis (HEA) and Uniform Mitigation Assessment Method (UMAM), and assuming a perpetual, complete, and constant impact of 3.0 acres to the nearshore hard bottom. Based on pilot studies of algae and invertebrate colonization, epibiota on the artificial reef is expected to recover rapidly. Fishes should colonize the artificial reef rapidly as well. Thus, adverse impacts will be offset by constructing the artificial reef. The success of the mitigation reef is contingent upon engineering stability of the structure as well as inherent biological variability.

Mitigation reefs proposed for this project cannot be assumed to replace all ecological functions for the same suite of species or life stages that exist on natural reefs in shallower water. There are likely species-specific differences in sensory perception to water depth, wave energy, light penetration, turbidity, and other factors that may be different at the proposed mitigation site. In addition to these deterministic factors, there is an element of uncertainty associated with the colonization of newly available substrate by marine organisms that leads to variability and unpredictability. Nevertheless, an estimate of the fraction of the macroalgal, invertebrate, and fish species present at the impact site that will ultimately reside on the mitigation reefs located 300 to 400 m offshore is 75%. Over time, this will lessen the significance of the initial adverse impact affected by direct burial of the landward edge of the hard bottom feature. Detailed discussion of the anticipated functional loss and functional gain associated with the biotic community and habitat at the impacted (nearshore hard bottom) and mitigation reef features is presented in CSA et al. (2006, 2008) and **Appendix K - Subappendix G**.

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APPENDIX SEIS-D

Assessing larval recruitment of the polychaete *Phragmatopoma lapidosa* on subtidally deployed structures off Satellite Beach, Florida

Assessing larval recruitment of the polychaete *Phragmatopoma lapidosa* on subtidally deployed structures off Satellite Beach, Florida

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August 20, 2007

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Assessing larval recruitment of the polychaete *Phragmatopoma lapidosa* on subtidally deployed structures off Satellite Beach, Florida

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OBJECTIVES & HYPOTHESES

The primary objective of this project is to determine whether the polychaete *Phragmatopoma lapidosa (*also known as *P. caudata)* will recruit on deployed sets of settlement plates in ~4.6 m depth off Brevard County, Florida. A secondary objective is to assess whether recruitment varies with height above the sea floor bottom, orientation, or chemical coating of the settlement plates.

Objective 1: To determine whether *P. lapidosa* will recruit to structures deployed at ~4.6 m depth off Brevard County, Florida.

Hypothesis 1A. There will be at least 20% coverage of *P. lapidosa* recruitment on deployed settlement plates.

Objective 2: To determine sources of variation in *P. lapidosa* recruitment.

Hypothesis 2A. Worm recruitment will be highest at the deepest settlement plates.

Hypothesis 2B. Worm recruitment will be highest on the southern facing plates.

Hypothesis 2C. Worm recruitment will be highest on plates coated with Butylated Hydroxytolulene (BHT).

METHODS

To test the stated hypotheses, three 100 cm x 100 cm x 70 cm UV-stabilized white polyethylene PALM (Propagule and Larval Measurement) boxes were deployed in a triangular arrangement on the sandy bottom off Satellite Beach (lat/long = 028° 09.600' N, 080 ° 34.950' W), Florida in ~4.6 m of water. The PALM boxes were designed to provide the structure for the settlement plates. They were constructed of white, UV stabilized, polyethylene material (Seaboard™, Austin Industries, Melbourne, Florida) and measured 59.0

cm high by 91.4 cm wide. The box was secured to a concrete base that raised the boxes off the seafloor another 20.3 cm. Prior to deployment; 122 cm long screw anchors were jet pumped into the sand, by divers on SCUBA, approximately 0.5 m from each side of the future location of the PALM boxes. Two cm diameter nylon line was threaded through u-bolts on the side panels of the boxes and secured to the screw anchors, to further stabilize the units. The boxes were transported to the site by a 24' skiff and hoisted into the water with a davit that was secured to the bow of the boat. The coordinates for the location of each PALM unit were recorded, and a surface float (Styrofoam crab trap buoy) was attached with a line to a screw anchor, to identify the underwater location of each of the PALM boxes.

On each PALM box, fifteen 10 cm x 10 cm x 1.5 cm limestone settlement plates were vertically attached on the North, East, West, and South face of the PALM box. Each plate was secured with a stainless steel screw through the center. In order to examine the importance of chemical cues in affecting recruitment, five of these plates were coated with Butylated Hydroxytolulene (BHT) dissolved in Isooctane (at a concentration high enough to leave ~ $3\mu g/cm^2$ of a BHT residue), five were coated with Isooctane, and five were non-coated (control). On each face of the PALM box three rows of five plates were attached on the outer surface of the box at 0.35, 0.5, and 0.65 m from the sea floor bottom.

The PALM boxes were deployed for two time periods. The first deployment occurred on May 24, 2006, and plates were recovered on July 8, 2006. The second deployment also took place on July 8, 2006 with boxes being recovered on May 5, 2007.

At the end of each time period, plates were recovered from each box and taken back to the JU laboratory where encrusting species were positively identified, and the percentage cover of *P. lapidosa* recruits on each plate was determined by random point analysis of digital photographs of each plate. Treatment means were computed, and for each time period, separate nested ANOVAs were used to compare *P. lapidosa* recruitment with a) chemical treatment (control, Isooctane, Butylated Hydroxytolulene (BHT) dissolved in Isooctane), and b) either Height (3 levels) or c) Plate orientation (4 levels) nested under PALM box (3 levels). Data were arcsine transformed to meet the assumptions necessary to run the ANOVA.

RESULTS AND DISCUSSION

Objective One

During the first plate deployment, comprising 45 days, all three boxes had a fairly high amount of recruitment of the polychaete *Phragmatopoma lapidosa (caudata)* (Fig 1.). Several individual worms were positively identified as *P. lapidosa* using the Kirtley (1994) key. All clusters of worm recruits formed “live” carpet-like encrustations that occupied, on average, greater than 20% of the plates on all boxes (Fig. 1). The worm coverage among the PALM boxes was significantly lower for Box One (x = 24.3%; s.d. = $\pm$ 19.9) than Box Three (x = 43.4%; s.d. = $\pm$ 22.16) (Table 1). Box Two (x = 33.0%; s.d. = $\pm$ 19.7) was statistically equal to both Box One and Two. While only a few worm lengths were measured, individual recruits ranged from 0.8 to 9 mm in size. Such a range of sizes suggests that multiple settlement events occurred during this experiment. Finally, other encrusting species were encountered on the plates, which included 2 bryozoan, 1 polychaete, 1 bivalve, 2 barnacle, and 1 hydrozoan species.

During the second plate deployment, comprising approximately 300 days, a high amount of natural sediment deposition occurred in the area with many of the plates being buried. Sediment had to be physically removed in order to remove the PALM boxes from their stations. Upon examination, a number of the plates were stained black as a result of the anoxic conditions they were likely exposed to. Regardless, we attempted to quantify recruitment of the encrusting organisms on the plates.

There was a relatively low recruitment of the polychaete *P. lapidosa* (Fig 2.). Few live individuals were found although the tubes encountered occupied 1-6 % of the surface area of the plates. The worm coverage among the PALM boxes was generally similar with values being 4.0 % (s.d. = $\pm$ 5.5), 5.7 % (s.d. = $\pm$ 7.9), and 1.5 % coverage (s.d. = $\pm$ 3.1) for Boxes One, Two and Three respectively. Finally, other encrusting species were generally more prevalent during this time period with 3 bryozoan, 1 polychaete, 3 bivalve, 3 barnacle, 3 tunicate, and 1 hydrozoan species being encountered on the plates.

Objective Two

Plate height. There was generally more *P. lapidosa* recruitment on plates recovered in July 2006 than in May 2007 (Figs. 3 & 4). During the first time period, there was a trend that more recruitment occurred on plates closest to the sea floor bottom (Table 1). Recruitment on the top (most shallow) row was 24.1 % (s.d. = ± 18.3) while that on the middle and bottom rows was 32.9% (s.d. = ± 22.2) and 43.7 % (s.d. = ± 25.2), respectively. During the second time period, this trend was less drastic: recruitment on the top row was 2.42 % (s.d. = ± 4.6), while that on the middle and bottom rows was 2.70 % (s.d. = ± 4.45) and 5.9 % (s.d. = ± 6.3), respectively (Table 2).

While the exact reason for higher recruitment occurring near the sea floor bottom is unknown, it may be that turbidity and/or current levels at this height may not be conducive to larval settlement or post-settlement survival. Regardless, this result is logical, since most adult worm mounds are not frequently encountered on the upper edges of high relief hard bottom areas (McCarthy, *pers. observation*). They are much more common either on the tops of low relief areas or on the edges close to the sea floor bottom.

Plate orientation. *Phragmatopoma lapidosa* recruited equally on all sides of each PALM box for both time periods sampled (Figs. 5 & 6). During the first time period, recruitment varied between 20.6 and 57.2 % with no significant differences found for orientation (Table 1). During the second time period, recruitment varied equally among all sides of the PALM boxes (Table 2) with values ranging between 1.07 and 8.8 percent cover.

Chemical treatment. *Phragmatopoma lapidosa* recruited equally on all plates regardless of chemical treatment (Tables 1 & 2). During the first deployment, recruitment occurred equally on BHT, Isooctane and control plates with values of 35.2 % (s.d. = ± 23.5), 33.6 % (s.d. = ± 19.0), and 32.1 % (s.d. = ± 21.0), respectively (Fig. 1). No statistically significant differences in overall chemical treatment were encountered during the second deployment. In this case, recruitment on BHT, Isooctane and control plates was 4.1 % (s.d. = ± 6.3), 3.5 % (s.d. = ± 6.6), and 3.6 % (s.d. = ± 6.1), respectively (Fig. 2).

SUMMARY

We found that *Phragmatopoma lapidosa* recruitment varied considerably for the two time periods sampled. During the May to July 2006 time period *P. lapidosa* was the dominant encrusting organism recruiting in fairly high, yet variable, levels. Most *P. lapidosa* worms encountered on the settlement plates were alive and in a range of sizes indicating multiple cohorts of recruitment. Additionally, encrusting species such as bryozoans, hydrozoans, ascidians and barnacles were also encountered frequently on the settlement plates. During the July 2006 to May 2007 time period, the PALM boxes were partially buried with sediment with high mortality of recruits of various species of encrusting organisms. *Phragmatopoma lapidosa* recruitment was very low, with most of the observed recruits on the plates being bivalves and barnacles. For both time periods, there was a trend that *P. lapidosa* recruitment was lowest on plates at the rows furthest from the sea floor. Otherwise, *P. lapidos*a recruitment occurred equally on plates regardless of chemical treatment and plate orientation.

In conclusion, recruitment of *P. lapidosa* did occur to artificially deployed structures off the Brevard County coast in mean water depths of approximately 4.6 meters (15 ft). The variation in recruitment between sampling periods may be because of: 1) differences in time the plates were deployed, and/or 2) natural seasonal fluctuations in larval availability. The general lack of significance among the experimental treatment means are probably a result of local hydrodynamic and/or turbidity conditions that consistently and dramatically fluctuate. These fluctuations likely are continually creating favorable conditions for the settlement of *P. lapidosa* larvae regardless of the effect of plate orientation, height and chemical treatment.

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Table 1. Nested analyses of variance comparing the July 2006 percent cover of *Phragmatopoma lapidosa* among PALM box plates (BOX) nested under chemical treatments (CHEMICAL), and A) plate orientation (ORIENT), and B) height off the sea floor (HEIGHT). Data were arcsine transformed in order to meet the assumptions of ANOVA.

A)

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
CHEMICAL	0.020	2	0.010	0.178	0.837
BOX (CHEMICAL)	1.689	6	0.281	5.023	0.000
ORIENT (BOX (CHEMICAL)	2.000	26	0.077	1.373	0.124
Error	8.012	143	0.056		

B)

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
CHEMICAL	0.045	2	0.023	0.407	0.666
BOX (CHEMICAL)	1.725	6	0.287	5.151	0.000
HEIGHT (BOX (CHEMICAL)	1.585	18	0.088	1.577	0.072
Error	8.427	151	0.056		

Table 2. Nested analyses of variance comparing the May 2007 percent cover of *Phragmatopoma lapidosa* among PALM box plates (BOX) nested under chemical treatments (CHEMICAL), and A) plate orientation (ORIENT), and B) height off the sea floor (HEIGHT). Data were arcsine transformed in order to meet the assumptions of ANOVA.

A)

Analysis of Variance

Source	**Sum-of-Squares**	**df**	**Mean-Square**	**F-ratio**	**P**
CHEMICAL	0.001	2	0.001	0.133	0.876
BOX (CHEMICAL)	0.067	6	0.011	2.934	0.010
ORIENT(BOX (CHEMICAL)	0.106	27	0.004	1.035	0.427
Error	0.545	143	0.004		

B)

Analysis of Variance

Source	**Sum-of-Squares**	**df**	**Mean-Square**	**F-ratio**	**P**
CHEMICAL	0.001	2	0.001	0.166	0.847
BOX (CHEMICAL)	0.064	6	0.011	2.940	0.010
HEIGHT (BOX (CHEMICAL)	0.095	18	0.005	1.449	0.117
Error	0.556	152	0.004		

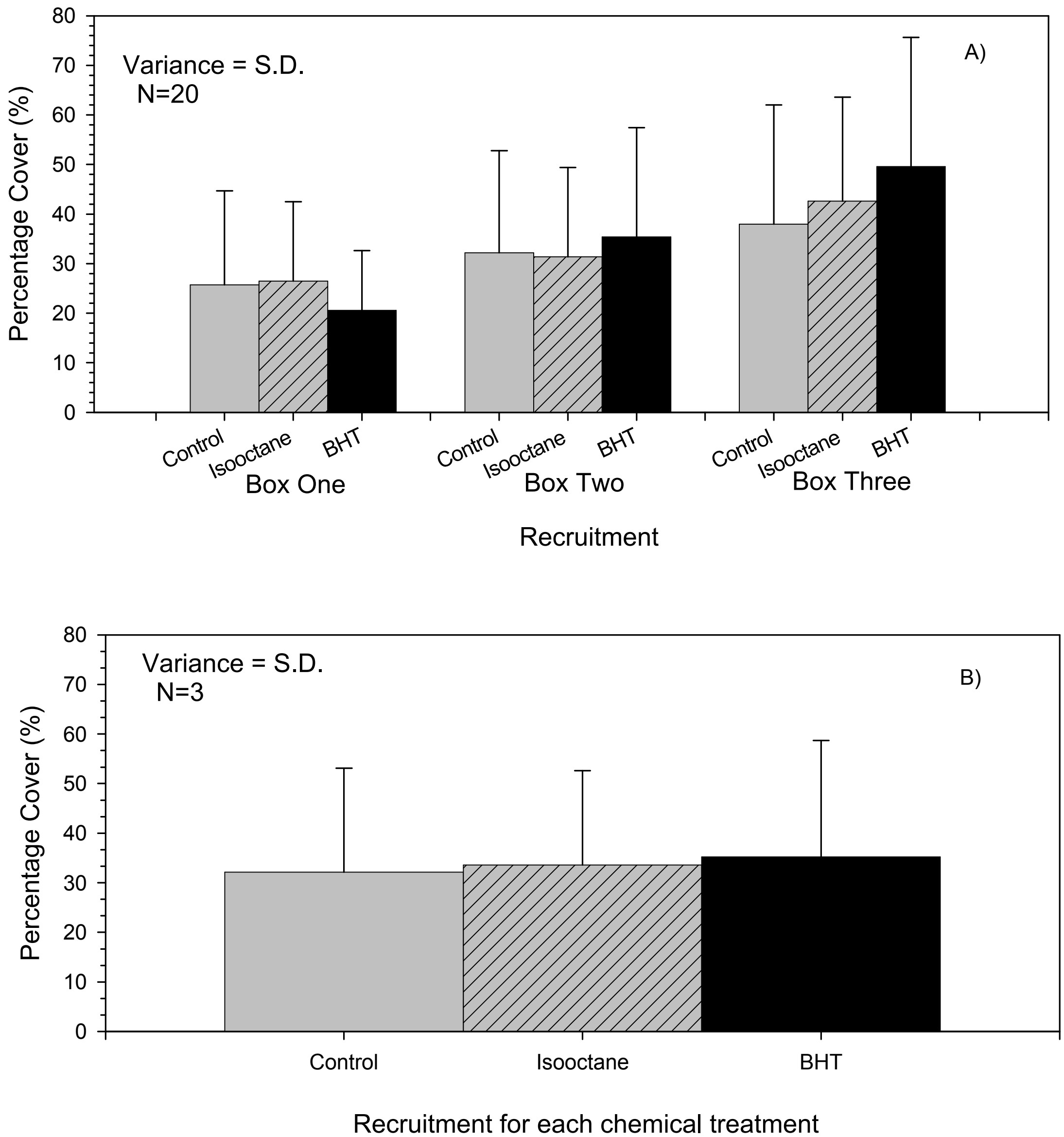


Fig.1. A comparison of mean percent cover of *P. lapidosa*, for the first time period, among A) box and chemical treatment, and B) overall chemical treatment. The BHT treatment on Box 3 was found to be significantly different than the same treatment on Box 1 ($p < 0.001$). Otherwise, there were no significant differences.

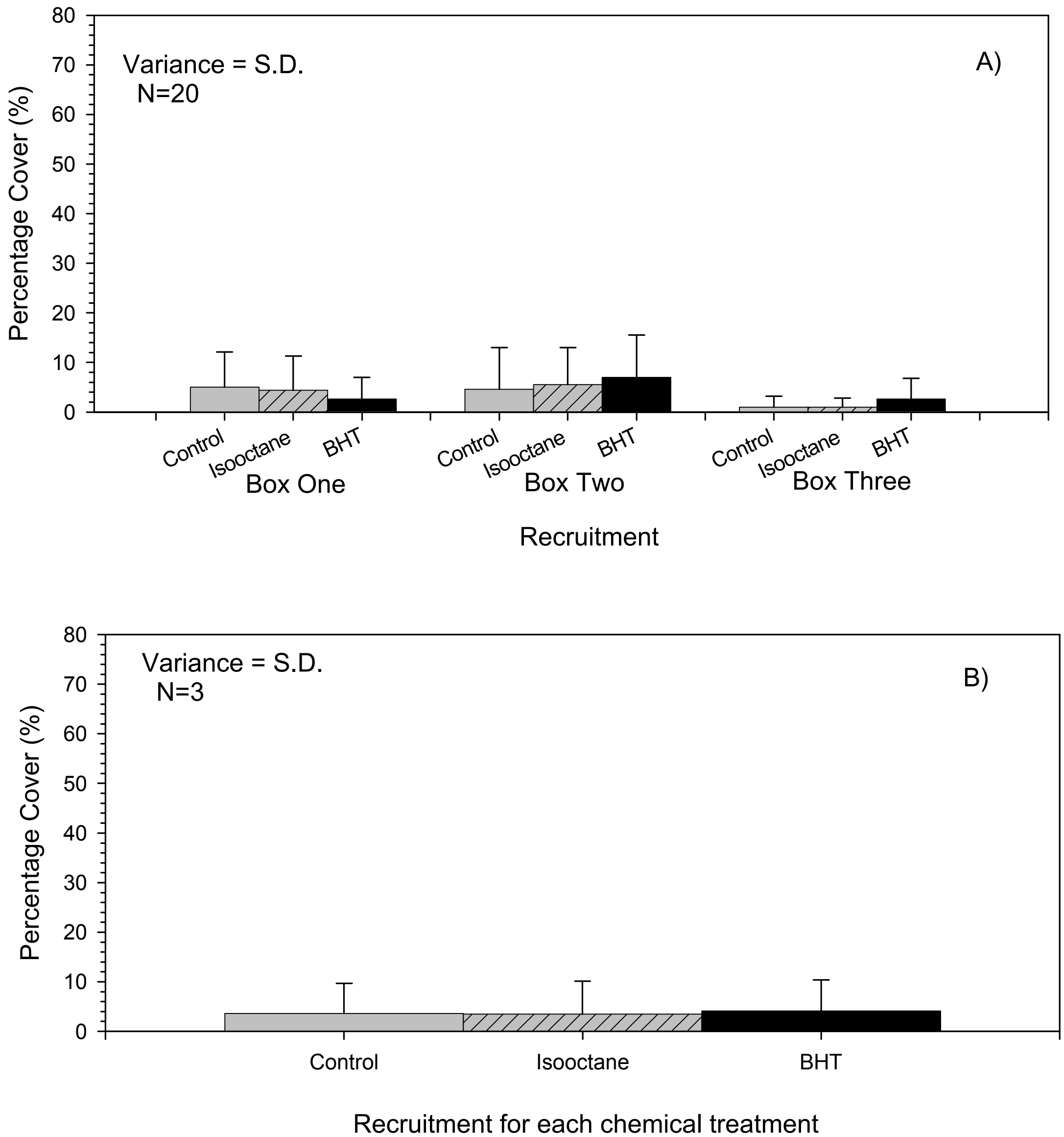


Fig. 2. A comparison of mean percent cover of *P. lapidosa,* for the second time period, among A) box and chemical treatment, and B) overall chemical treatment. There were no significant differences for the three chemical treatments.

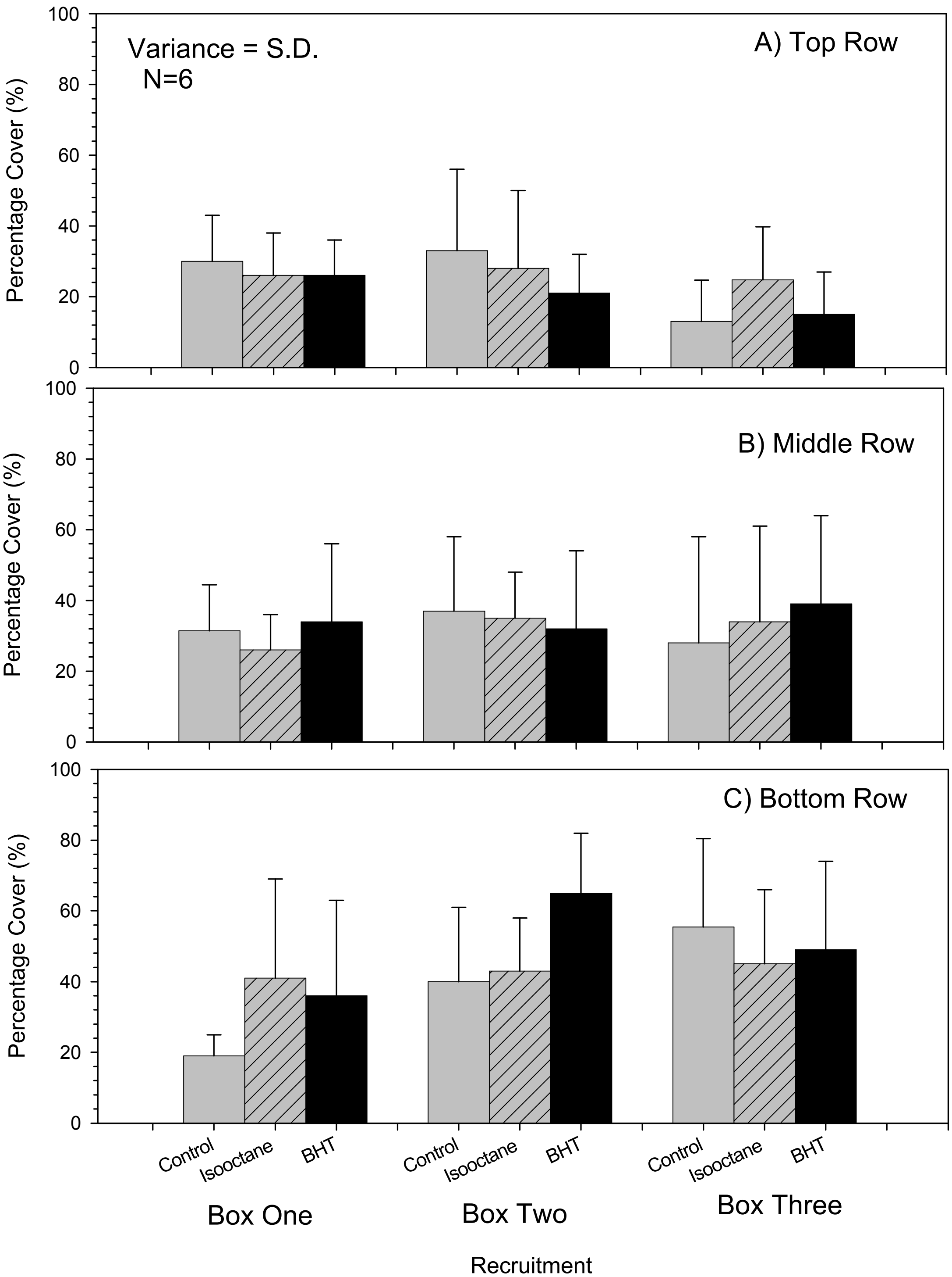


Fig. 3. A comparison of mean percent cover of *P. lapidosa*, for the first time period, among box and chemical treatment for the A) top, B) middle, and C) bottom rows of the PALM boxes. There were no significant differences for height.

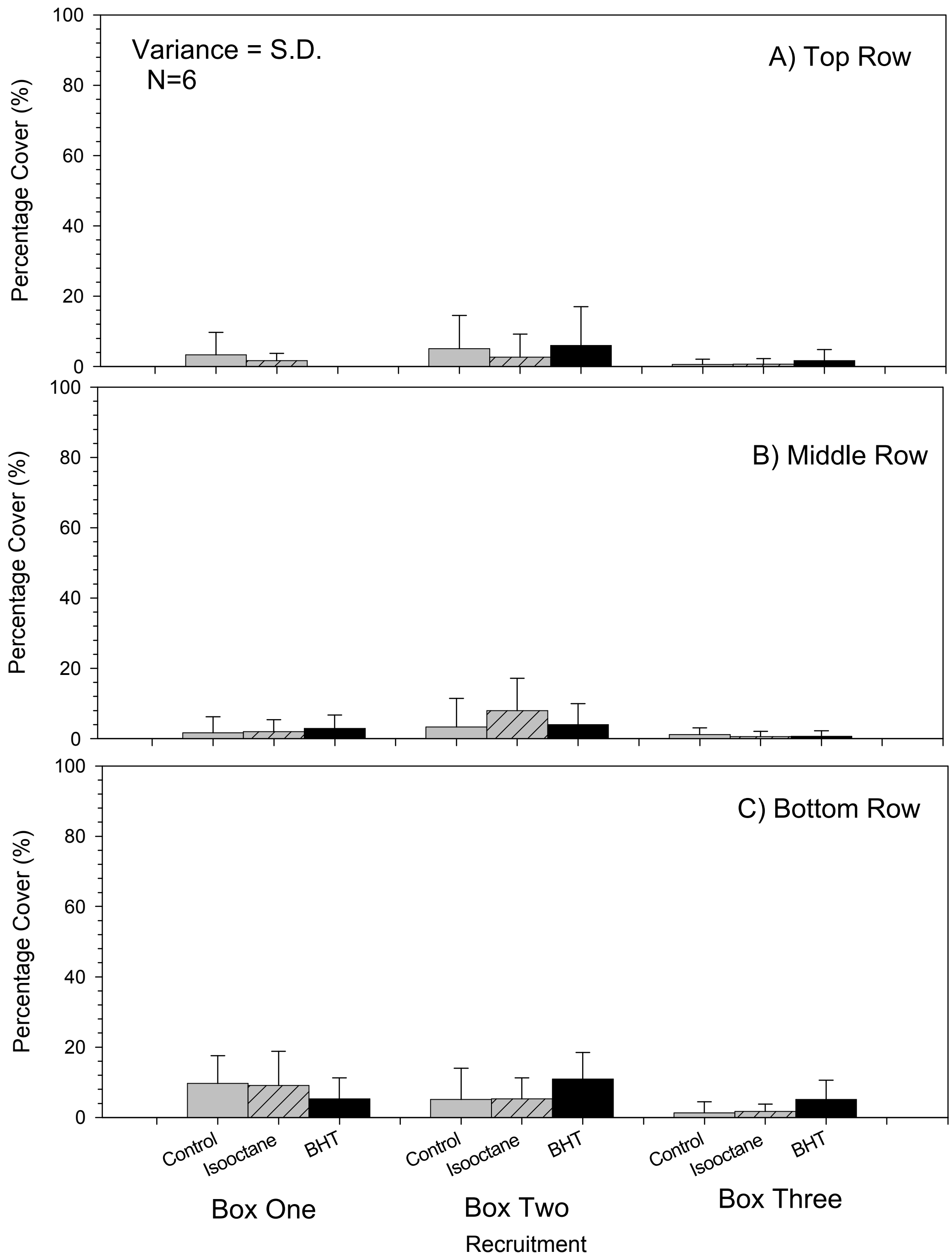


Fig. 4. A comparison of mean percent cover of *P. lapidosa*, for the second time period, among box and chemical treatment for the A) top, B) middle, and C) bottom rows of the PALM boxes. There were no significant differences for height

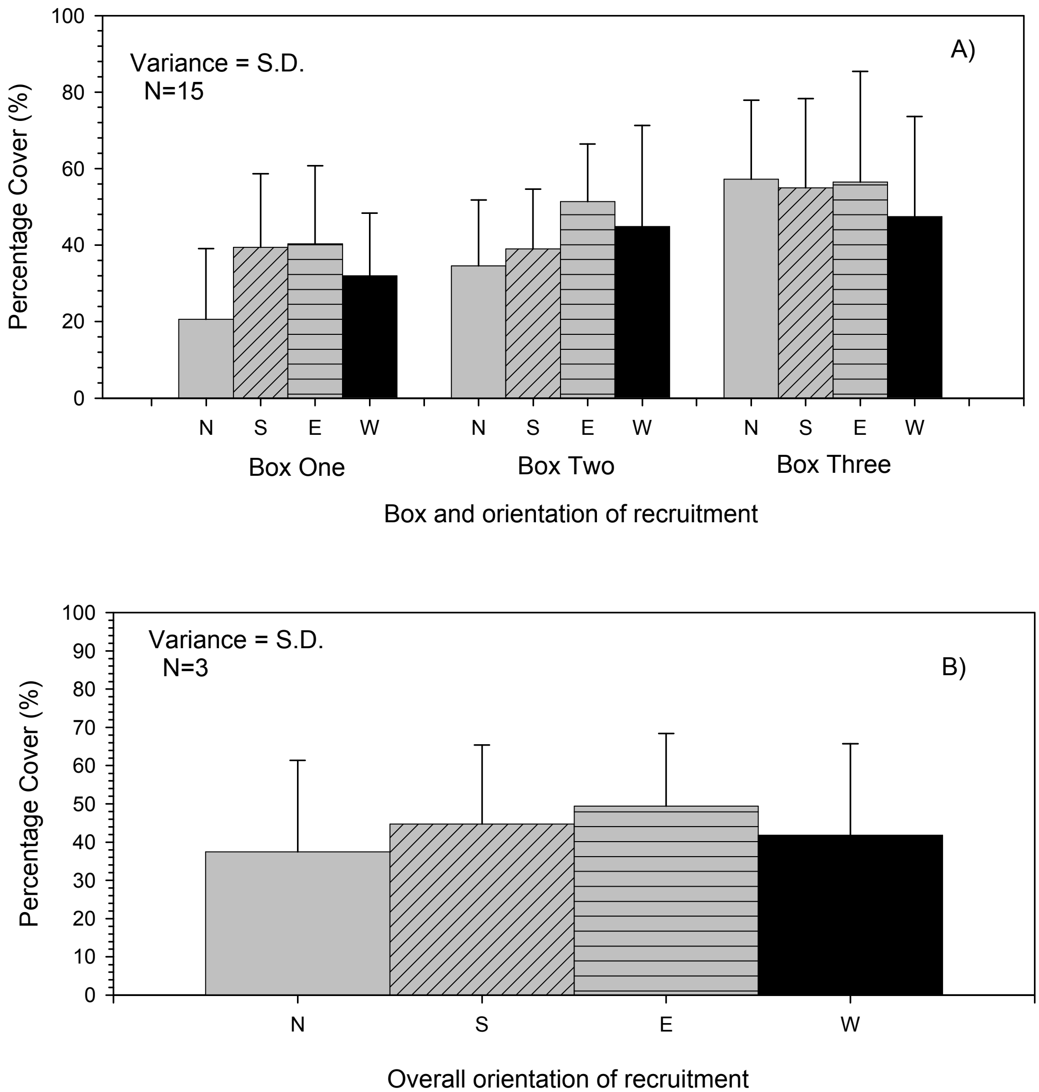
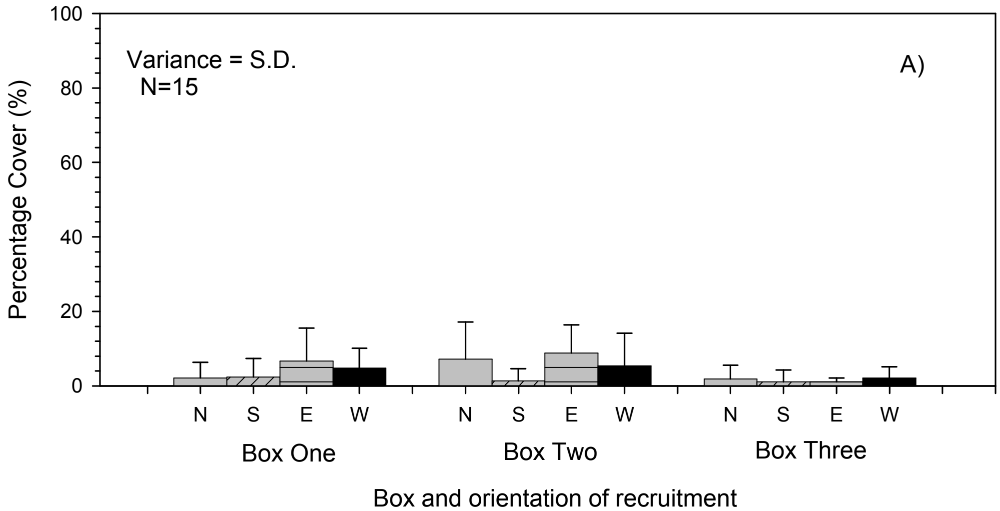


Fig. 5. A comparison of mean percent cover of *P. lapidosa*, for the first time period, among A) box and orientation, and B) overall orientation. There were no significant differences for orientation.



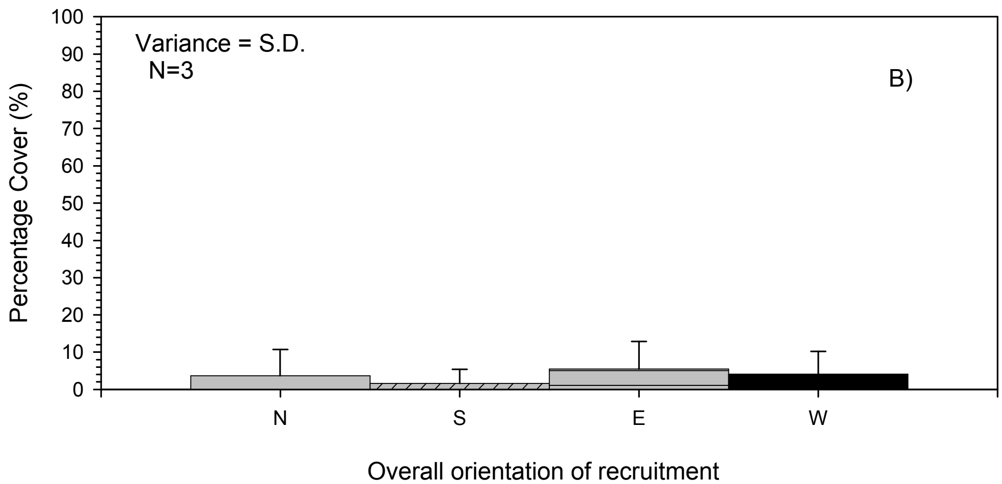


Fig. 6. A comparison of mean percent cover of *P. lapidosa*, for the second time period, among A) box and orientation,and B) overall orientation. There were no significant differences for orientation.

APPENDIX SEIS-E

The recruitment of macroalgae on subtidally deployed structures off the coastal waters of Brevard County, Florida

The Recruitment of Macroalgae on Subtidally Deployed Structures off the Coastal Waters of Brevard County, Florida

August 30, 2007

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The Recruitment of Macroalgae on Subtidally Deployed Structures off the Coastal Waters of Brevard County, Florida

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Introduction

This report presents the results of the deployment of settlement plates for the central purpose of assessing potential recruitment of macroalgal species on deployed structures in the subtidal sand bottom areas off the coast of Brevard County, Florida. Our goal was to determine whether algae would grow in this subtidal sandy bottom area, and if recruitment is influenced by substrate type.

Our specific hypotheses were to determine whether: (a) macroalgae would recruit and grow in 4.6 m (15 feet) of water, and (b) recruitment would vary with substrate-type.

Methods

To test our hypotheses, we deployed replicates of four different types of settlement plates composed of: pure coquina rock, limestone tiles, concrete, and concrete with chunks of coquina pressed into the surface. Plates were approximately 10 cm x 10 cm x 2 cm thick. The limestone plates (LI) were cut from limestone tiles (Showcase Design Marble and Granite, Ft. Pierce, Florida), the pure coquina (PC) originated from an upland source of quarried coquina (Pt. St John, Florida), and the mixed concrete (MC) was crushed coquina added into concrete. The chunk coquina (CC) was concrete that had 1-2 cm sized pieces of coquina partially pressed into the top of the plate before it dried.

These plates were deployed via attachment to pre-constructed boxes that we called PALM (propagule and larval measurement) boxes. Settlement plate types were randomly arranged on the top panel of the PALM boxes and each one was secured with a stainless steel screw through the center. The PALM boxes were designed to provide the structure for the settlement plates. They were constructed of white, UV stabilized, polyethylene material (Seaboard™, Austin Industries, Melbourne, Florida) and measured 59.0 cm high by 91.4 cm wide. The box was secured to a concrete base that raised the boxes off the seafloor another 20.3 cm. Prior to deployment; 122 cm long screw anchors were jet pumped into the sand, by divers on SCUBA, approximately 0.5 m from each side of the future location of the PALM boxes. Two cm diameter nylon line was threaded through u-bolts on the side panels of the boxes and secured to the screw anchors, to further stabilize the units. The boxes were transported to the site by a 24' skiff and hoisted into the water with a davit that was secured to the bow of the boat. The coordinates for the location of each PALM unit were recorded, and a surface float (Styrofoam crab trap buoy) was attached with a line to a screw anchor, to identify the underwater location of each of the PALM boxes.

The PALM boxes were placed approximately 250 m from shore in 4.6 m of water (***Figure 1***). The south PALM unit (box 1) was deployed at latitude 28^{o} 09.586' N and longitude 80^{o} 34.937' W. Box 2, the north box, was deployed at latitude 28^{o} 09.637' N and longitude 80^{o} 34.951' W. Box 3 was placed mid-way between the two and slightly more inshore at 28^{o} 09.612' N and 80^{o} 34.964' W. There was approximately 60 m linear distance between boxes 1 and 3, and between boxes 2 and 3. Boxes 1 and 2 were approximately 100 m apart.

The PALM Boxes were deployed from May 24, 2006 to May 5, 2007 (346 days). Several times during the study, the boxes were examined (via the use of SCUBA) where photographs were taken, and the tips of algal species were collected for identification in the laboratory. Additionally, an attempt was made to determine the conspicuous invertebrate and fish species that were present near the boxes. When the PALM boxes were recovered, the settlement plates were removed and placed in pre-labeled bags and refrigerated until analyzed.

The percent cover of red, green & brown algae was determined for each box and substrate-type combination using grid analysis (Coyer et al., 1999). First, the plates were individually photographed with the box and substrate information. Then, a 100 square grid with 1 cm squares was used to calculate percent cover of encrusting organisms (***Figure 2***). A 10 cm x 10 cm grid was placed over the plate, and the presence of algal, tunicate, bryozoan and hydroid species was recorded for each square (n = 100), using a Bausch and Lomb stereoscope. Algae were identified to the lowest taxonomical level possible. Free-living invertebrates were photographed and preserved for future identification.

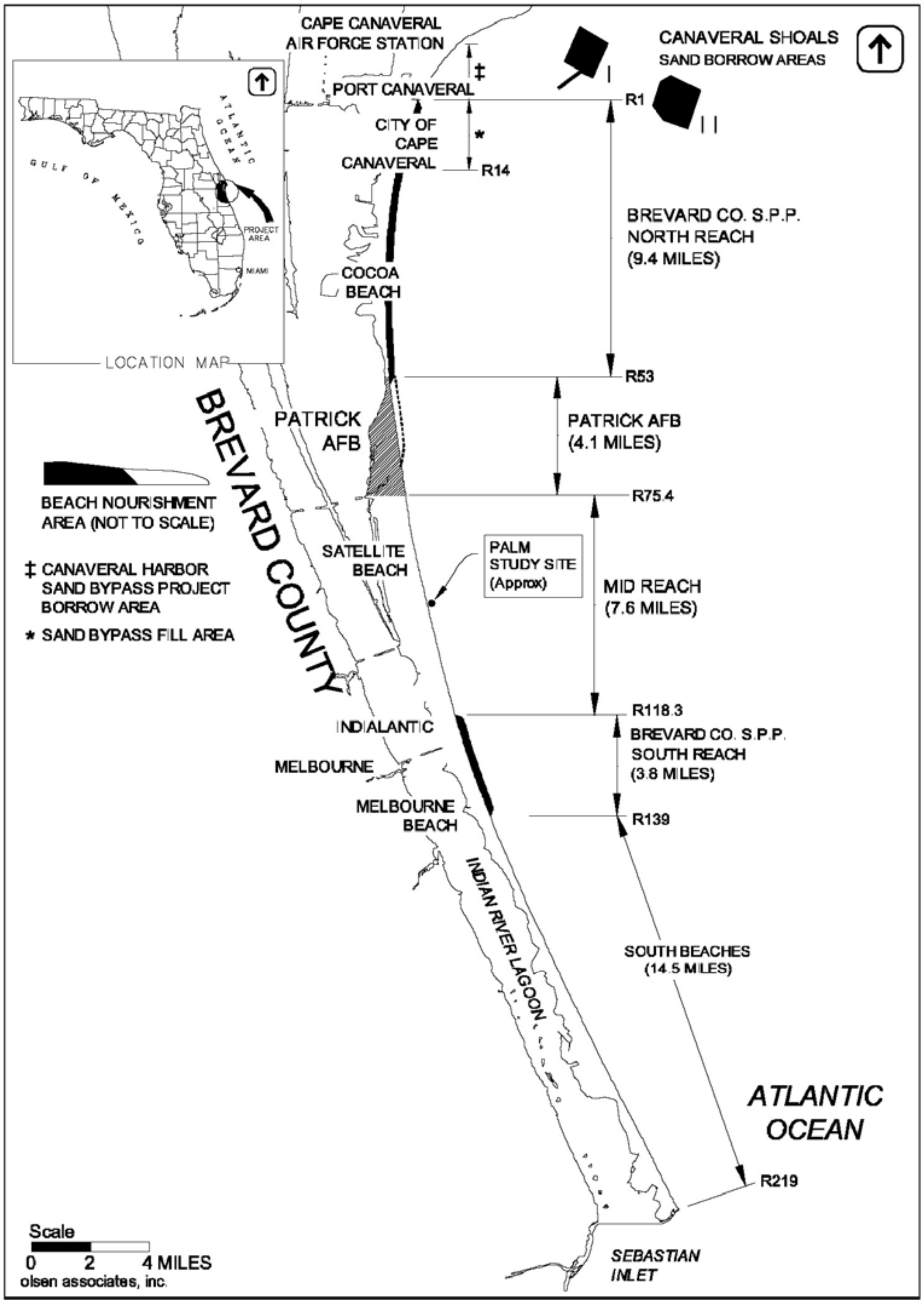


Figure 1. General location of the 3 PALM (propagule and larval measurement) boxes that were deployed approximately 250 m from the shoreline of Satellite Beach in Brevard County, Florida.

Figure 2. Grid overlaid on a limestone settlement plate for percent cover analysis. Species of algae, bryozoans, tunicates and hydroids were identified from a 10 cm^2 area of the grid for each plate.

Total percent cover (TPC) for all algae, percent cover of red and green algae, and species composition of TPC were calculated using the following equations:

$$\text{Total Percent Cover (TPC)} = \frac{\text{total squares with algae}}{\text{total squares (n=100 x number of plates)}} \times 100\%$$

$$\text{Percent Cover of Red (or Green) algae} = \frac{\text{total squares with red (or green) algae}}{\text{total squares (n=100 x number of plates)}} \times 100\%$$

$$\text{Percent cover of a specific species of algae} = \frac{\text{mean of total squares of a species}}{\text{total squares with algae}} \times 100\%$$

Means were computed for each tested factor, and separate one-way analyses of variance were used to test our hypotheses using the dependent variable (percent cover of red and green algae) with substrate (4 levels) nested under PALM box (3 levels), and $p < .05$ being used to assess treatment significance. The multiple comparisons-Bonferroni test was used to determine specific treatment differences Data were transformed to meet the assumptions necessary to run the ANOVA. Specific algal species were analyzed using Kruskal-Wallis and Mann-Whitney tests since data could not meet the assumptions of ANOVA .

Results

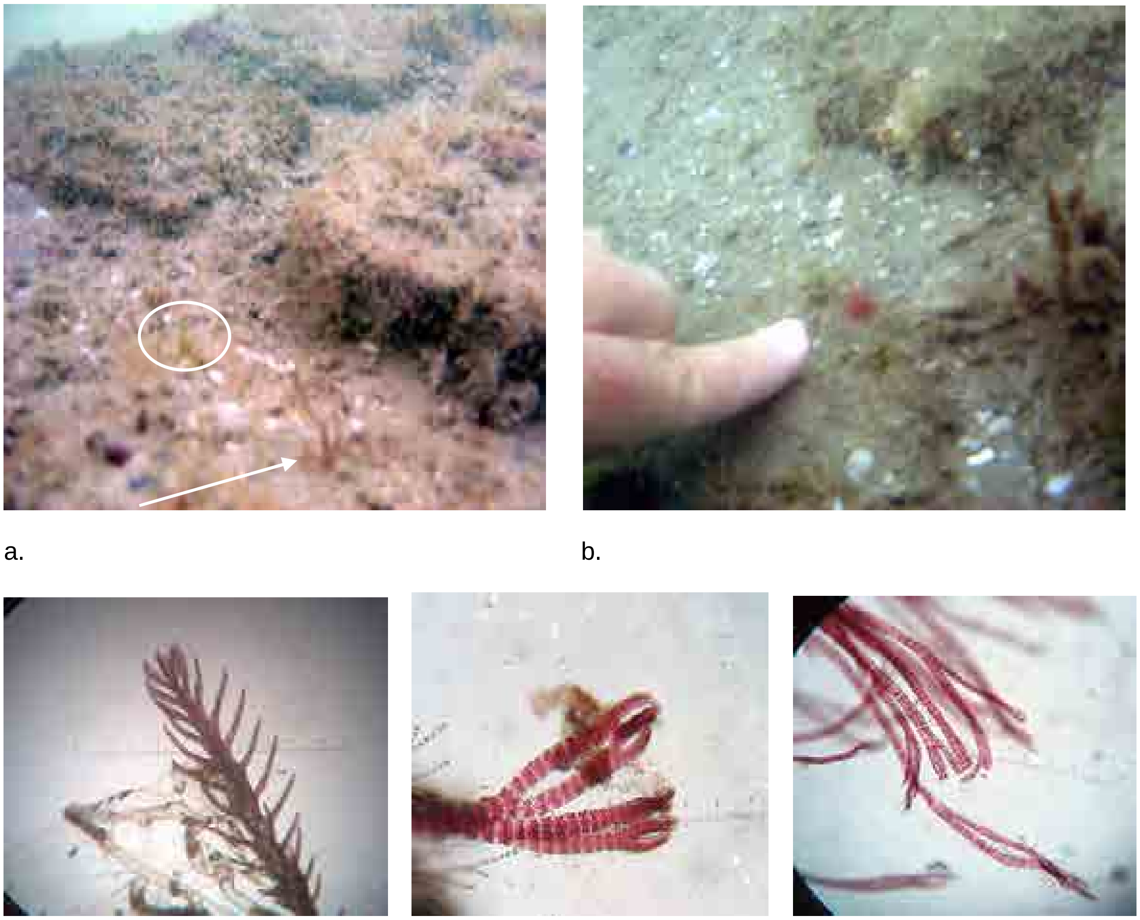
Field Visits of the PALM Boxes

PALM boxes were initially visited 45 days (July 2006) after deployment. During this time, hydroids and bryozoans appeared to dominate the plates. No obvious macroalgae were observed. A number of conspicuous fish and invertebrate species were observed during this visit (***Appendix I***). Some of the more abundant species were Atlantic spadefish (*Chaetodipterus faber*), white grunts (*Haemulon plumieri*), and sea bass (*Serranus* sp.).

PALM boxes were visited 141 days after deployment (Oct 2006). During this visit, we videoed and took still photographs of the boxes. Additionally, we extracted small pieces of attached macroalgae to determine which species were growing on the boxes. However, the most dominant encrusting species at this time appeared to be branched and unbranched hydroids, and the bryozoan, *Bugula neritina.* Conspicuous species of algae observed during the dive were *Caulerpa prolifera* and *Bryocladia cuspidata* (***Figure 3***). After the collected pieces of algae were examined in the laboratory, a total of seven species of algae were positively identified from the PALM boxes (***Table 1***).

Table 1. Species of macroalgae identified growing on settlement plates of the PALM (propagule and larval measurement) boxes in Brevard County, Florida on October 13, 2006 (141 days after initial deployment).

Red Algae (Rhodophyta)	Green Algae (Chlorophyta)
Bryocladia cuspidata	*Bryopsis plumosa*
Ceramium sp.	*Caulerpa prolifera*
Gelidium pusillum	
Spyridia sp.	
Wrangelia sp.	



c. d. e.

Figure 3. Macroalgae found growing on the PALM (propagule and larval measurement) boxes on October 13, 2006; (a) *Bryocladia cuspidate* (arrow) and *Caulerpa prolifera* (in the circle), (b) *Ceramium* or *Polysiphonia* sp.(c) *Bryocladia cuspidata*, (d) *Ceramium* sp., and (e) *Polysiphonia* sp. Images 3a and b were photographed *in situ*. Images 3 c, d, and e were photographed in the lab.

On a third visit (February 2007), we attempted to retrieve the PALM boxes. However, each one of them had undergone significant burial by sediment. The accretion of sand was highest on the eastern face of the boxes where only the top 15 - 20 cm of the boxes remained exposed. While we attempted to extract the boxes using a combination of hand digging, shoveling and a lift bag, these efforts failed.

The boxes remained similarly buried when we returned on May 5, 2007 (346 days after deployment). However, during this visit, we were able to remove the boxes through a combination of jet pumping using a centrifugal pump, and use of a 136 kg (300 lb.) lift bag. All plates and boxes were taken back to the laboratory for processing and analysis.

Percent cover of red and green algae

The total percent cover (TPC) of algae was 24.7% (± 14.3 SD). No species of Phaeophyta (brown algae) were found growing on the plates. The TPC for red and green algae overlapped. For example in some cases, red and green algae were both present in one square of the grid. This resulted in a combined percent cover of 26.7% (± 16.8 SD), red algae percent cover was 17.8% (± 12.2 SD), and green algae percent cover was 8.9% (± 9.9 SD). Seventeen different species of macroalgae, eleven rhodophytes and six chlorophytes, were identified growing on the settlement plates (***Table 2***). *Polysiphonia* sp. (23.7%, ± 23.3 SD), *Bryocladia cuspidata* (17.3%, ± 15.2 SD), and *Chaetomorpha* sp. (13.9%, ± 12.8 SD) were species with the highest percent composition of the TPC (***Table 2***).

Table 2. Species percent composition of the total percent cover (+ one standard deviation) for species of macroalgae identified on settlement plates from the PALM (propagule and larval measurement) boxes (n = 3) Brevard County, Florida on May 5, 2007 (346 days after initial deployment).

Red Algae (Rhodophyta)	Percent Cover	SD +	Green Algae (Chlorophyta)	Percent Cover	SD +
Polysiphonia sp.	23.7%	23.3	*Chaetomorpha* sp.	13.9%	12.8
Bryocladia cuspidata	17.3%	15.2	*Ulva* sp	10.8%	13.0
Centroceras clavulatum	11.2%	12.0	*Cladaphora* sp.	4.7%	8.2
Ceramium sp.	10.8%	19.0	*Enteromorpha flexuosa paradoxa*	2.5%	4.6
Gelidium sp.	1.9%	4.6	*Bryopsis plumosa*	1.4%	3.5
Hypnea sp.	0.9%	2.8	*Caulerpa prolifera*	0.1%	0.9
Jania sp.	0.3%	1.4			
Chondria sp.	0.3%	1.4			
Gracilaria sp.	0.1%	0.5			
Lomentaria baileyana	0.1%	0.8			
Gelidiopsis sp.	0.1%	0.5			

Macroalgal cover among plate types

No significant differences were detected for the total percent cover of algae or for divisions of red or green algae growing on different plate types (α = .05; ***Figures 4 and 5***, and ***Table 3a, b, and c***). The mean percent cover of macroalgae for limestone (LI) plates was 26.4% (+ 18.8 SD), 24.6% (+ 9.8 SD) for pure coquina (PC), 24.0% (+ 12.5 SD) for chunk coquina, and 23.9% (+ 14.4 SD) for mixed concrete (Figure 5).

There was a trend (while not significant) for 5 of the 6 green algal species where the mean percent cover was higher on limestone plates for 5 of the 6 species observed. Red algal species with percent covers < 10.0 % did not show a pattern of greater recruitment to any specific plate type.

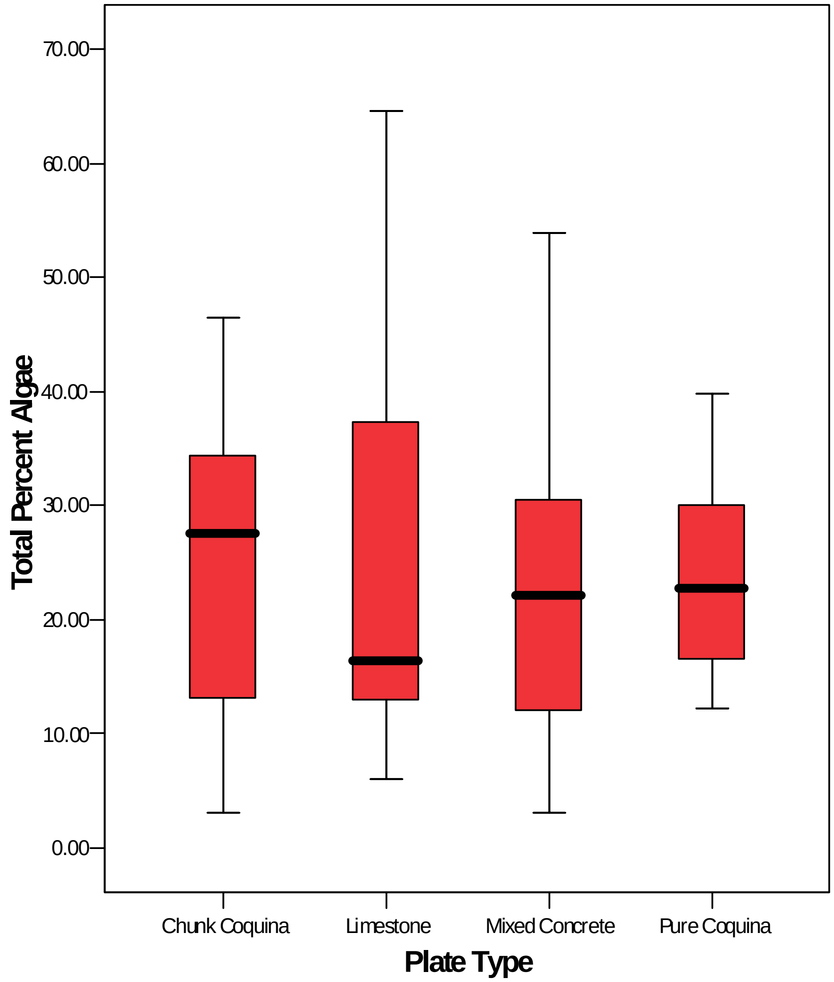


Figure 4. Box plot illustrating quantiles of total percent cover of algae data by settlement plate material (Plate Type). The bold black line indicates the 50^{th} percentile (median), and the red box encompasses 50% of the data, from the 25^{th} to the 75^{th} percentile. The vertical lines extend from the 10^{th} to the 90^{th} percentile. No significant differences were detected at α = .05 level for total percent cover of algae on different plate types.

Table 3. Analysis of variance comparing total percent cover of macroalgae (a.), percent of red algae (b.), and percent green algae (c) for plate type (n = 4) and plate type nested within PALM (propagule and larval measurement) boxes (n = 3) retrieved June 5, 2007 (346 days in situ). Asterik (*) indicates significant differences were detected at α = .05 level.

a.

ANOVA

				Squared multiple R:	
Dep. var. = log TPC	n = 63	Multiple R: 0.505		0.255	
Source	**Sum-of-Squares**	**df**	**Mean-Square**	**F-ratio**	**P**
Plate Type	0.012	3	0.004	0.06	0.981
Box (Plate Type)	1.14	8	0.143	2.135	0.049
Error	3.405	51	0.067		

b.

ANOVA

				Squared multiple R:	
Dep. var. = log red algae	n = 63	Multiple R: 0.669		0.448	
Source	**Sum-of-Squares**	**df**	**Mean-Square**	**F-ratio**	**P**
Plate Type	0.08	3	0.027	0.411	0.746
Box (Plate Type)	2.599	8	0.325	5.027	0.000
Error	3.295	51	0.065		

c.

ANOVA

				Squared multiple R:	
Dep. var. = log green algae	n = 63	Multiple R: 0.423		0.179	
Source	**Sum-of-Squares**	**df**	**Mean-Square**	**F-ratio**	**P**
Plate Type	0.482	3	0.161	1.018	0.392
Box (Plate Type)	1.254	8	0.157	0.994	0.452
Error	8.04	51	0.158		

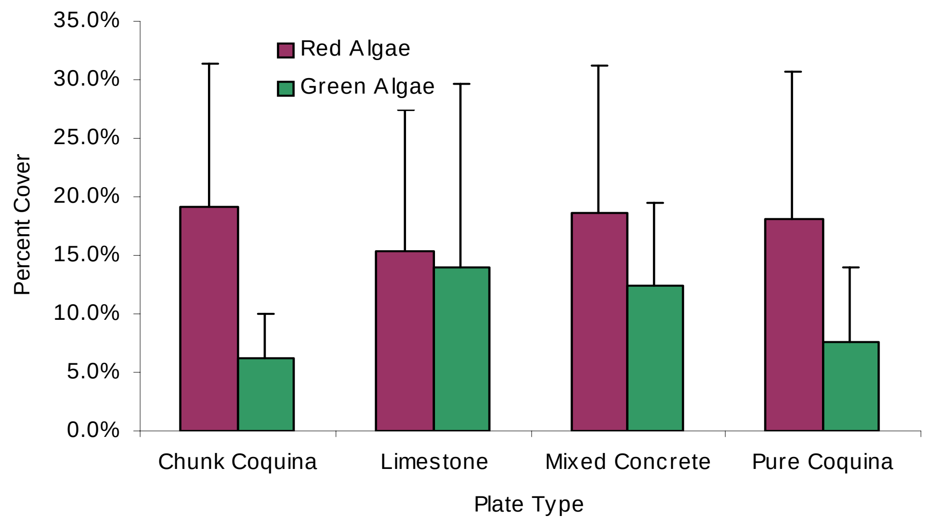


Figure 5. Percent cover of red and green macroalgae on settlement plate types (+ SD). No significant differences for red or green macroalgal cover were detected among plate type at α = .05 level.

Macroalgal cover on plate types among PALM boxes

Significant differences were detected for the TPC of macroalgae on settlement plates among the PALM boxes (***Table 3a***). *Post hoc* Bonferroni analysis revealed that box 3 (34.3 ± 5.1 SD) had significantly higher TPC of macroalgae than boxes 1 (28.8 ± 4.7 SD) and 2 (28.9 ± 7.2 SD). Significant differences were also detected for red algae cover for plate types among the boxes (***Table 3b***). Box 3 had a significantly higher percent cover of red algae (28.5%, ± 2.5 SD) than the other boxes ($F = 22.12$, $p < .0001$). No significant differences were found for green algae at the box (plate type) level (***Table 3c***).

The percent cover of specific algal species varied between the boxes to some degree (***Figure 6***). The dominant species among boxes (i.e., *Polysiphonia* sp., *Ulva* sp., *Chaetomorpha* sp. and *Bryocladia cuspidata*) were similar to the overall percent composition described earlier in Table 2.

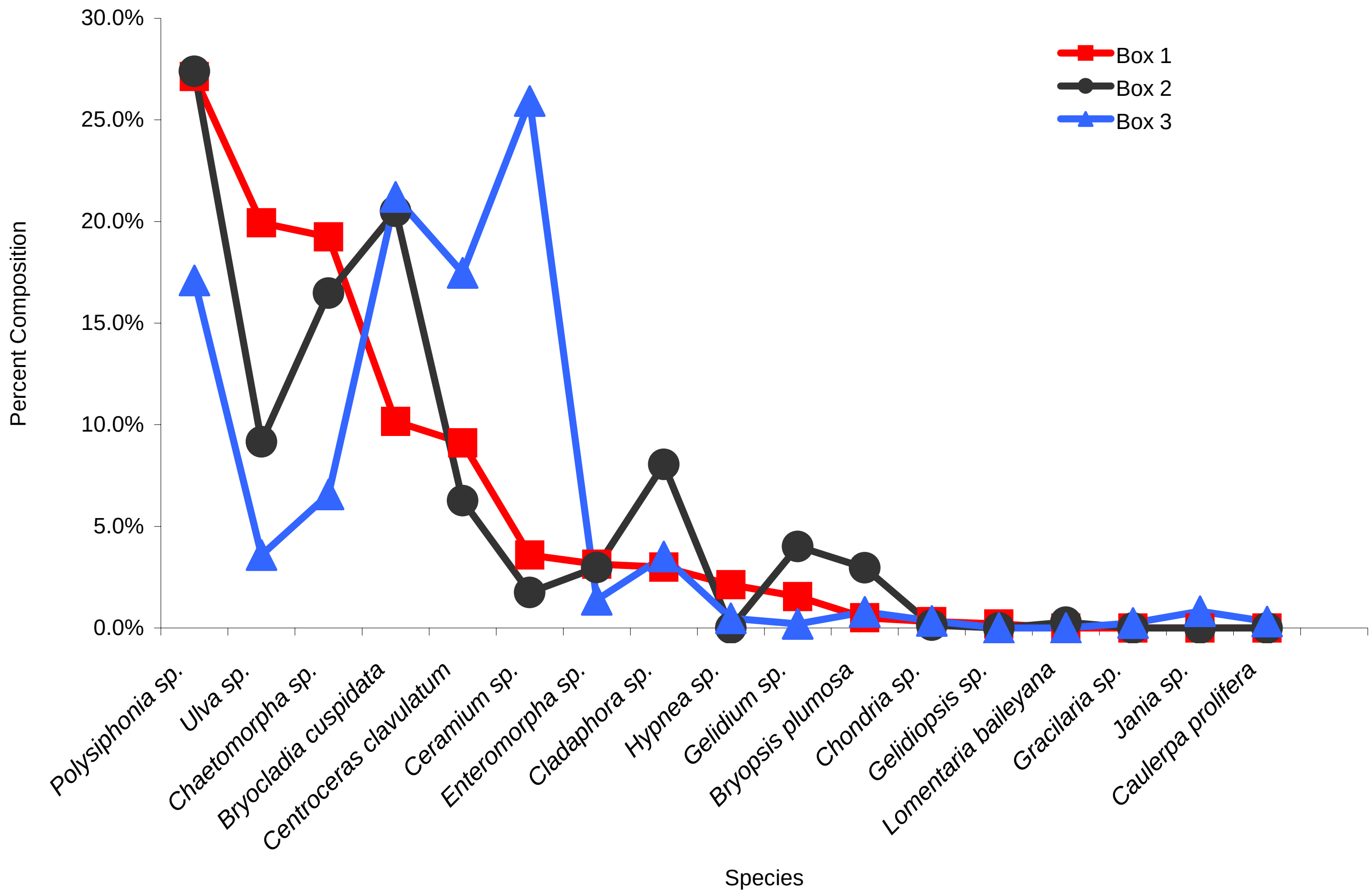


Figure 6. A comparison of percent cover of dominant algal species on settlement plates on each PALM (propagule and larval measurement) boxes after their retrieval on May 5, 2007 (346 days *in situ*).

Twenty-two motile and sessile invertebrate species were found on the settlement plate and box surfaces. They represent eight species of arthropods, two annelids three cnidarians, three bryozoans, and six mollusks (***Appendix II***).

Discussion

Our results indicate that macroalgae can successfully recruit on artificial structures in the sandy subtidal regions off Brevard County, Florida. Our results also indicate that the recruitment of macroalgae is not significantly different on the substrate materials we tested. We found variation in percent cover among the boxes deployed with the total and red algae recruitment being higher on one of the boxes than the other two. These differences are most likely attributable to natural variability of recruitment that is found with marine organisms. Further, no brown algae were observed growing on the plates during the course of this experiment

Macroalgae observed on the settlement plates were generally small in size. The reason for this is unknown. There was no indication that the forms observed were generated by fragmentation of existing plants. The size and condition of most of the macrophytes on the settlement plates indicate they most likely propagated via spore recruitment, which has been experimentally proven to require more time for growth than generation by fragmentation (Dethier et al., 2003). A likely explanation is that the algal recruits were newly settled and may have not had enough time to grow into a large size by the time they were collected. Another possibility is their growth may have been impacted by herbivorous animals (i.e., green turtles, juvenile fish and invertebrates) and/or stunted by sedimentation. During the plate analyses, we photographed examples of what has been previously documented as mechanical damage from grazers (Amsler, 2001) on the margins and thallus of *Hypnea* sp. and *Ulva* sp. (***Appendix III***).

Some of the same macroalgae species observed in the local intertidal and shallow, subtidal zones by Continental Shelf Associates (2005), were also found on the settlement plates during this study (***Appendix IV***). During our plate analysis, we identified six of the fifteen red, and three of the five green algal species found during that study. Common species between our two studies were *Ulva* sp., *Bryocladia cuspidata*, Centroceras sp., *Gelidium pusillium*, and *Gracilaria* sp.

Similarly, some of the same macroalgae species observed in our study were found in a study on green turtle diets conducted during 2004-2005 (Holloway-Adkins and Provancha, 2005; ***Appendix V***). Eleven of the macroalgae and four of the invertebrate species that recruited on the settlement plates were previously identified in the diets of juvenile green turtles captured over the nearshore reef. A conspicuous difference between our study and both of these other studies is that we did not encounter any brown algae on our settlement plates.

In summary, we conclude that a number of species of macroalgae (and some encrusting invertebrates) are capable of recruiting on deployed structures in 4.6 m depth in Brevard County, Florida. We found several species of red, green of macroalgae (no brown algal species were encountered). Considering the time of deployment, many of the encountered species recruited fairly quickly within 141 days. Finally, the percent cover of total, green or red macroalgae remained consistent regardless of the material used yet sometimes varied among the boxes that were deployed.

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APPENDIX I. Fish and Invertebrate Species List for July 8, 2006

Table I-1. Fish species observed on and around the PALM boxes while diving July 8, 2006 (45 days after deployment).

Common Name	**Genus Species**
Sand perch	*Diplectrum formosum*
Sea bass	*Serranus* sp.
Spotted drum (juvenile)	*Equetus* sp.
Molly miller	*Scartella cristata*
Hairy blenny	*Labrisomus nuchipinnis*
Clingfish	*Gobiesox* sp.
Hairy blenny (juvenile)	*Labrisomus nuchipinnis*
Saddled blenny	*Malacoctenus triangulatus*
Atlantic spadefish	*Chaetodipterus faber*
Porkfish (juvenile)	*Anisotremus virginicus*
Leopard sea robin	*Prionotus scitulus*
Clingfish	*G. strumosus*
White grunt	*Haemulon plumieri*
Tomtate	*Haemulon aurolineatum*
Lane snapper	*Lutjanus synagris*

Table I-2. Invertebrate species observed on and around the PALM boxes while diving July 8, 2006 (45 days after deployment).

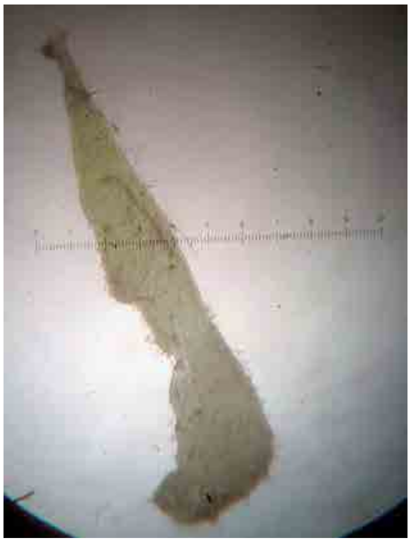
Common Name	Genus Species
ARTHROPODA	
Barnacles	*Balanus* sp.
Peppermint shrimp	*Lysmata wurdmanni*
Mud crabs (including Cuban stone crab)	*Menippe* spp.
ANNELIDA	
Sabella worm	*Sabellaria* sp.
Sabellariid worm	*Phragmatapoma lapidosa*
CNIDARIA	
Hydroid zoanthid	
Unbranched hydroid	
Sun zoanthid	
MOLLUSCA	
Atlantic strawberry cockle	*Americardia media*
BRYOZOA	
Bugula (bryozoan)	*Bugula neritina*

APPENDIX II. Invertebrate Species Found on PALM Settlement Plates from May 5, 2007

Table II-1. Sessile and motile invertebrate species found associated with or growing on settlement plates from PALM boxes retrieved on May 5, 2007 346 days *in situ*).

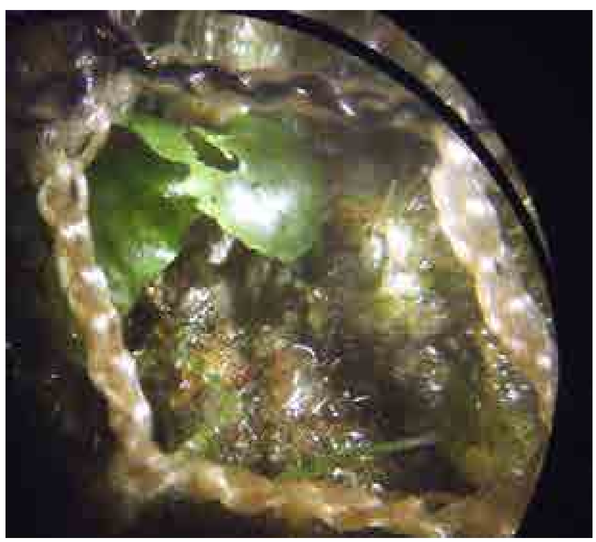
Common Name	**Genus Species**
ARTHROPODA	
Barnacles	*Balanus* sp.
Pink acorn barnacle	*Megabalanus sp.*
Mud crab	*Panopeus herbsti*
Stone crab species	*Menippe* spp.
Bigclaw snapping shrimp	*Alpheus heterochaelis*
Basket stars	Ophiothrix
Skeleton shrimp	*Caprella* sp.
Sea spider	Pycnogonida
ANNELIDA	
Sabella worm	*Sabellaria floridensis*
Sabellariid worm	*Phragmatapoma lapidosa*
CNIDARIA	
Feather hydroid	*Halocordyle sp.*
Hydroid	*Bougainvillia rugosa*
Sea pansy	*Renilla reniformis*
BRYOZOA	
Colonial tunicate	*Didemnum* sp.
White crust bryozoa	*Membranipora tenuis*
Bugula (bryozoan)	*Bugula neritina*
MOLLUSCA	
Cerith shell	Cerithidae
Gem clam	*Gemma gemma*
Coquina clam	*Donax* sp.
Borer clam	*Diplothyra* sp.
Oysters	
Atlantic strawberry cockle	*Americardia media*

APPENDIX III. Evidence of Grazing on Macroalgae from PALM Settlement Plates (photographs from May 5, 2007, 346 days after deployment)



1a.

1b.



1c.

Figure III-1. Evidence of herbivory on macroalgae: (a) *Ulva* sp. with margin chewed, (b), *Hypnea* sp., tips cropped and new growth present on one branch, and (c) *Ulva* sp. signs of grazing on margin and center of thallus.

APPENDIX IV. Species of Macroalgae identified within the Mid Reach Project area in July/August 2005 by CSA (2005)

Table IV-1. Species of macroalgae identified within the Mid Reach project area in July/August 2005 by Continental Shelf Associates (2005) identified from 14 video transects.

Division	Genus species	
Chlorophyta		
	Ulva lactuca	*
	Bryopsis plumosa	*
	Caulerpa prolifera	*
	Caulerpa racemosa	
	Codium decorticatum	
Phaeophyta		
	Dictyota pinnatifida	
	Padina gymnospora	
Rhodophyta		
	Scinaia complanata	
	Gelidiopsis planicaulis	*
	Dudresnya crassa	
	Halymenia floresia	
	Gracilaria tikvahiae	*
	Solieria filiformis	
	Agardhiella subulata	
	Gelidium pusillum	*
	Centroceras clavulatum	*
	Bryocladia cuspidata	*
	Chondria capillaris	*
	Chondria dasyphylla curvilineata	
	Chondrocanthus acicularis	
	Laurencia intricata	
	Laurencia poiteaui	

* indicates this species (or Genus sp.) were found on settlement plates on PALM boxes.

APPENDIX V. Species of Macroalgae identified from lavage samples from green turtles captured adjacent to nearshore rock resources along the Mid Reach 2004-2005 by Dynamac (2005)

Table V-1. Species of algae identified from lavage samples from green turtles captured adjacent to nearshore rock resources along the Mid Reach during 2004-2005 (Dynamac 2005).

Division	**Genus species**	
Chlorophyta		
	Chaetomorpha spp.	*
	Chaetomorpha linum	
	Cladaphora spp.	*
	Ulva spp.	*
	Ulva lactuca	
	Caulerpa prolifera	*
Phaeophyta		
	Padina gymnospora	
Rhodophyta		
	Bryocladia cuspidata	*
	Gelidium spp.	*
	Gelidium pusillum	*
	Ceramium sp.	*
	Centroceras clavulatum	*
	Gracilaria tikvahiae	*
	Gracilaria mammillaris	
	Hypnea spp.	*
	Hypnea valentiae	
	Chondria spp.	*
	Chondria dasyphylla	
	Agardhiella subulata	
	Dudresnya crassa	
	Laurencia spp.	
	Jania adhaerens	*
	Chondrocanthus acicularis	

* indicates this species (or Genus sp.) were found on settlement plates on PALM boxes.

APPENDIX SEIS-F

Practical consideration of depth for the construction of nearshore mitigation along the Mid Reach coastline of Brevard County, Florida

Practical Consideration of Depth for the Construction of Nearshore Mitigation along the Mid Reach Coastline of Brevard County, FL

1.0 Introduction

The following summarizes the principal physical considerations that limit or influence the seabed depths in which artificial rock-reef structures may be practically constructed along the Mid Reach shoreline of Brevard County, Florida. The reef structures are proposed as mitigation for anticipated impacts (sand burial) of portions of existing nearshore rock hardbottom that occur immediately along the shoreline.

The existing rock outcrops are typically exposed at seabed depths of approximately +1 to -4 ft MLW, and generally range from about ~0" to ~18" in vertical relief above the sand seabed. The mitigation reef structures are proposed for construction at existing seabed depths of between -14.5 and -15.5 ft MLW, and are expected to range from about ~6" to ~20" in vertical relief above the sand seabed, more or less. The proposed mitigation is to construct about 4.8 acres of artificial reef, relative to an estimated project impact of about 3 acres.

Principal factors of consideration include the following:

- Geotechnical
- Existing rock locations and gaps
- Hydrodynamic stability and storm impacts
- Effect upon littoral processes
- Construction access
- Seabed (profile) stability
- Public safety and liability

Many of these factors overlap and/or require joint consideration, and are discussed below.

2.0 Geotechnical

Sub-bottom mapping and probing[1] indicate that the existing nearshore rock reef strikes sharply downward in elevation along its seaward, exposed edge. Probings within 70 feet seaward of the exposed rock, at seabed elevations of -3 to -6 ft MLW, exhibited rubble or rock stratum at 3-ft to 6-ft below the sand seabed. But beyond this margin, no firm stratum was found within 10 feet below the seabed. These data indicate that essentially

[1] "Sub-bottom Mapping of Nearshore Rock along the Mid Reach Shoreline of Brevard County, FL" Report prepared by Olsen Associates Inc., Morgan & Eklund Inc., and Sonographics Inc., for Brevard County Nat. Res. Mgt. Office. October 16, 2005. This report was included in the Applicant's response to RAI #1.

any mitigation structure constructed seaward of the existing rock reef will require placement of a stable foundation. To preclude use of a foundation, mitigation structures must be placed immediately along the seaward edge of the existing reef and must be also expected to scour (drop) at least 3 to 6 ft, or more, into the seabed (presuming that the underlying stratum is regular and structurally sound to support any structure). However, as discussed below, construction access to this narrow margin along the the reef, at any significant scale, is not practical.

3.0 Existing Rock Locations and Gaps

Along the proposed truck-haul fill area (where proposed beach fill will not encroach significantly upon the existing exposed rock) there are few or no areas that feature significant alongshore gaps in the nearshore rock reef -- wherein reef structure might be placed in very shallow water -- at least north of about R103 or R105.5. Between this limit and the northern limit of Reach 1 (R109), there are several apparent gaps in the exposed rock that total on the order of 1000 to 1400 lineal feet alongshore, or less. There are longer gaps in the exposed rock along Reach 1, where the overall rock occurrence is least abundant.

Land (beach) based heavy-equipment, working at low tide, might practically reach between 40 and 60 feet from shore at most. So, along a total shoreline length of between 1000 and 1400 feet, a 40- to 60-ft swath equates to a maximum planform area of between 1 and 2 acres at most. Erection of reef mitigation structures across such an area would require that

1) essentially all of the existing sandy ("no rock") subtidal beach area along this mile of shoreline, more or less, would be occupied with rock structures that significantly interfere with wading/recreational access to the surf – and that public/private assent would be given for such work
2) the structures would be stable in these shallow depths but not cause adverse littoral impact, and
3) public safety and liability issues were waived in conjunction with placement of submerged structures in shallow waters used for wading and swimming.

As described below, none of these three considerations are practical.

These same issues practically limit the placement of mitigation structures along the *landward* edge of the existing rock reef. This consideration is additionally complicated in that the predicted impacts from the proposed beach fill activity will occur along the landward edge of the rock reef. Thus, constructing mitigation structures along the landward edge of the existing rock reef would be placing the work within (and subject to) the impacts of the project that are intended to be mitigated.

4.0 Hydrodynamic Stability and Storm Impacts

Assessment of the hydrodynamic stability of the proposed mitigation structures was made using Dean's stream function wave theory and consideration of a design storm event along Brevard County. The predicted stability of any structure in this regard, in any depth range, must consider such storm events and the associated forces.

Conditions for the 'severe' (design) storm event were adapted from wave data collected about 5 miles south of the Mid Reach during Hurricane Jeanne in 2005. Throughout an approximate 18-hr period of peak storm energy on 9/26/07, using a bottom-mounted gauge in normal seabed depths of about 25.6-ft MLLW, Dally & Osiecki[2] measured sustained significant wave heights of about 12.5-ft and 13-second period, with alongshore currents of about 3 ft/second in varying still water depths of about 30.8 feet. Tides and surge averaged about 5-ft above chart datum. Transformed to breaking conditions (by linear theory), this equates to an outer breaking wave height of about 14 feet in 18-ft water depth.

To compute the design stability of a structure, the drag, inertial and lift forces on the structure are computed from stream function for the design wave height, period and steady currents indicated above. The wave kinematics and forces are computed for a range of water depths (e.g., between 30 feet and breaking), as waves pass over the structure by phase angle. For these combined forces, the maximum coefficient of seabed friction – required to resist net dislocation of the structure – is computed. The extent to which the requisite coefficient of friction is *greater* than, or *less* than, that which is theoretically achievable indicates the instability or stability, respectively, of the structure. For concrete structures deployed on a sand seabed, the maximum 'achievable' coefficient of friction is taken as 0.58, based upon the literature and prior experience.

After iterations for optimization of design, the proposed reef mitigation structures consist of articulated concrete-block mats (with surficially exposed coquina rock) with nominal outer dimensions of 16.3-ft by 8-ft by 1-ft height. [3] The weight of each mat is estimated as between 6.4 and 7.2 tons (in air), equating to between 7135 and 8064 pounds (immersed). For the design storm conditions, this configuration yields a requisite coefficient of seabed friction that increases from between 0.21 and 0.25 in 30-ft water depth to between 0.42 and 0.54 at wave breaking in 18-ft water depth. The latter approaches the point of incipient instability, beyond which the hydrodynamics of wave breaking obviate the applicability of the non-linear stream-function wave theory. Computed for a single block within the mat (nominally 1.5' x 1.5' x 1' high), the requisite coefficients of friction, and estimated seabed stability, are similar to that of the

[2] Dally, W. R. and D. A. Osieki, 2005. "Nearshore Wave and Current Measurements During Hurricane Jeanne." *Shore and Beach*. Vol. 73, Number 2-3. pp. 29-33.

[3] Hydrodynamic force coefficients on the structure are estimated as C_d=1.5, C_m=1.09, and C_L=0.5.

total articulated mat. Increasing the dimensions and weight of the blocks and mats, at or beyond the point of wave breaking, increases the corollary forces and does not result in a net increase in stability.

In sum, the practical limit of hydrodynamic stability of the structures occurs at the point of incipient wave breaking of the design storm — which occurs at a still water depth of about 18 feet. As described above, this design case is based upon measured wave conditions from Hurricane Jeanne in 2005, which is variously ascribed as representing a 20- to 25-year event (more or less).[4] Given the site's average tide range of about 4 feet, and without allowance for surge or wave set-down (-0.7 ft) at breaking, a design water depth of 18 feet equates to a design seabed elevation of about -14 ft MLLW -- or, approximately, about -16 ft NGVD -- as the minimum depth limit for stable deployment of reef structure from a standpoint of the hydrodynamic forces.

5.0 Effect Upon Littoral Processes

Clearly, rock mound and similar gravity structures can be built in very shallow water (surf zone) environments. Examples include groins, jetties and breakwaters. But these structures require large units (nominally on the order of at least 5- to 7-ft boulders in the present case (5 to 15 tons)) typically placed in a consolidated sloping mound. Such structures – placed either from the land in very shallow depths (akin to a groin) or in depths of 8- to 14-feet (akin to a semi-submerged breakwater) – would disrupt the wave field and attendant littoral processes.[5] Specifically, the net result to the shoreline would be similar to that of a groin or weak breakwater. This would potentially result in two adverse functions: (1) disrupting the natural alongshore movement of sand along an otherwise mostly uninterrupted strand, and (2) potential formations of impoundments or salients that promote seaward advance of the beach sand and additional burial of nearshore rock. Neither outcome is desired or beneficial in terms of the project or overall resource management.

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[4] This may be a non-conservative estimate. For example, significant wave heights recorded at NOAA buoy 41009 in deep water offshore of Cape Canaveral, exceeded 17 feet during at least 5 events during the last seven years. Offshore wave heights during the recent subtropical storm Andrea, on May 8-9, 2007, reached 18 feet, during which visual estimates of the breaking heights along the Mid Reach exceeded 12 feet height. Thus, the occurrence of 14-ft breaking wave heights, such as measured during H. Jeanne, is probably much more frequent along Brevard County than is represented by a 20- to 25-year return period event.

[5] For example, consider the requirements for a submerged rock mound in 8-ft water depth (MLLW). At high tide, plus 1' surge allowance, the corresponding maximum water depth and breaking wave height are 13 ft and 10.1', respectively. For typical quarried limestone per the Hudson Formula (K_D=1.5 at 1v:2h slope, 140 lbs/cf), and a 15% damage allowance ($H/H_{D=0}$ = 1.17), the requisite boulder size is 9 tons, or about <u>5.8-ft</u> nominal diameter per stone. Deployment of a minimum 2-layer required thickness (2 x 5.8 = 11.6') would create a structure that exceeds the 8' water depth by 3.6-ft at low tide. This would significantly shelter the shoreline from waves. Likewise, the analogous boulder requirement for a submerged mound in 12-ft water depth (MLLW) is 20.6 tons, or <u>7.7-ft</u> diameter per stone. The height of a minimum 2-layer structure would be 15.4 ft, which would similarly broach the water surface.

6.0 Construction Access

From the Beach. Construction of large-scale marine structures by heavy equipment operated from the beach requires that the work be limited to within about 60 feet or less of the low tide shoreline, more or less. As described in Section 3.0, this does not provide means by which to construct the requisite reef structure. To extend beyond this distance from shore practically requires (1) temporary placement of a sand or rock bund, (2) temporary installation of large trestles, or (3) tracking over (and crushing) the existing rock reef. The first two alternatives are often used to provide temporary construction access for heavy equipment into the water. In the present case, the first alternative (bunds) would bury adjacent rock by imported sand or by the alongshore impoundment of existing sand. The second alternative (trestles) would fracture the existing, underlying rock reef by the large-diameter pilings that must be driven into the seabed to support the trestles. A single trestle built from shore can usually reach to less than about 50-ft to either side, thus creating less than 100-ft of alongshore structure. The third alternative (track-over) is generally applicable only up to about 3 to 4-ft water depth where there is mostly calm seas and hard substrate. As noted, it fractures or crushes the substrate below the equipment tracks. Mats decrease the fracture; but in the present case of near constant surf, the physical action of the mats against the rock reefs would damage the rock. In short, construction access from the beach for heavy equipment is not practical in this instance.

From the Sea. Construction access from the sea along the Mid Reach is confounded by the site's distance from safe harbour and the pervasive high surf. The nearest harbour, for construction staging and refuge, is Port Canaveral – located between 15 and 21 miles, one-way, north of the Mid Reach work area. (Sebastian Inlet is equidistant to the south, but is less well suited for staging heavy equipment.) This distance is significant. It requires several hours for transit, mooring etc., to reach or flee the work site as seas dictate. Anticipated equipment would include a derrick/crane barge and storage barge (or the two would be combined), and tugboat or workboat.

The general area – from Cocoa Beach through Satellite Beach and Indialantic -- is well known for its consistent, high swell. It is not coincidental that multi-time world surfing champions Kelly Slater, Lisa Anderson, and others, grew up surfing in this area.

At the Mid Reach site, both the distance to harbour and the intensity of swell set the project distinctly apart from other reef mitigation sites in Florida. Additive to these two problems is the lack of sub-bottom substrate offshore of the Mid Reach coupled with chronically limited, near-zero underwater visibility. The lack of substrate requires that marine foundations be installed. Installation of foundations, particularly in low-visibility water, create a significant additional complication to reef construction because of the additional time, equipment, and precision that is required for the foundations -- versus simple placement of boulders upon the seabed in relatively calm and/or clear waters.

Overall, the constructability of nearshore reef construction projects in south Florida or the Gulf of Mexico is not comparable to the Mid Reach.

Experienced marine and dredging contractors who are familiar with the Mid Reach coastline have each, independently, cited a reasonable minimum working depth of not less than about 14 ft (MLLW) for the scale and mass of the proposed reef construction, with depth of 16 ft or greater preferred. Coupled with the area's 4-ft tide range, this practically allows for the Contractor to work the shallowest areas (14') at mid to high tide and to work the deeper areas (16') at low tide.[6] Even employing a jack-up barge for installation, the reef materials (mats etc.) must be transported and delivered to the site, such that depth and sea considerations are still relevant.

In general, a significant wave height of 2-ft or less is a reasonable proxy for the maximum swell in which a marine contractor would schedule or conduct vessel operations for the present work. Work in 3-ft seas is mostly infeasible. Additionally, it is critical that the low wave heights will dependably span *at least* 2 full days, and preferably several days. Obviously, concurrent winds and wave period are also important – as is the exact nature of the equipment and construction task that is being considered – but the wave height considerations listed above are of initial, fundamental importance. As seas rise, the ability to work in shallow water declines sharply. At issue is not only the wave surge – but also the risk of losing moorings, anchoring or other control of a vessel when in such shallow water. That is, in shallow water, closer to shore, the margin of physical space and water available to maneuver and recover control of a large vessel – before it becomes dangerously and/or intractably lost to the surf – is of paramount concern.

The wave climate along the Mid Reach was considered through fifty years of six-hour hindcast wave data (July 1954-June 2004), developed in water depth of about -20 ft (NGVD)[7], offshore of about R-106, as prepared for the Corps of Engineers. The record included tropical storms and hurricanes. Spectral transformation from deep water across the shelf included consideration of bottom friction dissipation, calibrated by measured wave data[8]. The percent occurrence of significant wave height and peak period is summarized in ***Tables 1 and 2***, following page, as considered by 6-hour intervals.

[6] This depth limitation is consistent with prior experience with nearshore disposal of maintenance dredged material at Canaveral Harbor. In about 1996, at Port Canaveral's request, the Corps of Engineers required their maintenance dredging contractor to place suitable dredged material in nearshore depths of about -16 ft MLLW. Prior nearshore disposal operations had been at about -19 ft MLLW or deeper. Despite best efforts of the contractor, the attempt at shallower water disposal fared badly. Scows and tugs sustained damage, and the ability to retain consistent control of the equipment so near to shore was problematic. The effort was subsequently abandoned by the Corps, and nearshore disposal operations returned to about -19 ft MLLW.

[7] Precisely, -19.4 ft NGVD (-17.5 ft MLLW)

[8] W. Dally – personal communication

Table 1 – Percent occurrence of significant wave height (number of 6-hourly events), by month, in nearshore water depth of -20ft, NGVD (1954-2004).

Wave Height(ft)	January	February	March	April	May	June	July	August	September	October	November	December	TOTAL (%)
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<H<=1	0.4	0.3	0.3	0.3	0.1	0.2	0.1	0.1	0.0	0.0	0.1	0.2	2.2
1<H<=2	1.8	1.6	1.7	1.9	1.9	3.4	3.9	2.7	0.8	0.6	1.0	1.6	22.8
2<H<=3	2.8	2.7	3.0	2.9	3.7	3.2	3.7	4.2	3.3	2.3	2.4	2.7	36.9
3<H<=4	2.1	1.8	2.1	2.0	1.8	1.0	0.6	1.1	2.4	2.6	2.4	2.4	22.3
4<H<=5	1.0	0.7	0.8	0.9	0.7	0.3	0.1	0.3	1.0	1.6	1.3	1.1	9.9
5<H<=6	0.3	0.4	0.3	0.3	0.2	0.1	0.0	0.1	0.4	0.9	0.6	0.4	4.1
6<H<=7	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.2	0.4	0.2	0.1	1.4
7<H<=8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.3
8<H<=9	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
9<H<=10	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
H>10	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
TOTAL (%)	8.5	7.7	8.5	8.2	8.5	8.2	8.5	8.5	8.2	8.5	8.2	8.5	100

Table 2 – Percent occurrence of peak period (number of 6-hourly events), by month, in nearshore water depth of -20ft, NGVD (1954-2004).

Peak Period(s)	January	February	March	April	May	June	July	August	September	October	November	December	TOTAL (%)
T<3	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
3<T<=6	1.2	1.1	1.5	1.7	1.5	1.4	0.9	0.8	0.6	0.6	0.9	1.1	13.4
6<T<=8	3.0	2.7	3.2	3.2	3.9	4.8	5.6	5.0	3.4	3.5	2.9	3.0	44.1
8<T<=10	3.3	3.0	2.8	2.5	2.6	1.8	1.9	2.1	2.7	3.3	3.5	3.3	32.6
10<T<=12	0.7	0.6	0.6	0.5	0.4	0.2	0.1	0.4	0.9	0.9	0.6	0.6	6.3
12<T<=14	0.3	0.3	0.4	0.2	0.1	0.0	0.0	0.2	0.5	0.3	0.2	0.4	2.8
14<T<=16	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.7
T>16	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
TOTAL (%)	8.5	7.7	8.5	8.2	8.5	8.2	8.5	8.5	8.2	8.5	8.2	8.5	100

On annual average, significant wave heights are 2-ft or less only 25% of the year. The three months of June-July-August are the most consistently calm – when, on 50-year average, the significant wave height is 2-ft or less for between 33% and 48% of the month. (See ***Figure 1,*** below.) The marine construction window for a reef construction project of this scale, offshore of the Mid-Reach, is pragmatically limited to between mid-May and mid-September.

Figure 2, following page, summarizes the duration, in days, of those periods during which wave heights are continually less than 2 feet, considered over a 50 year hindcast. Again, the months of June-August, on average, exhibited the longest spans of continuous calm seas: 4 to 5 consecutive days (versus 2½ days for the other months). Of course, some years exhibit few or no periods of calm seas, including June - August. Because the

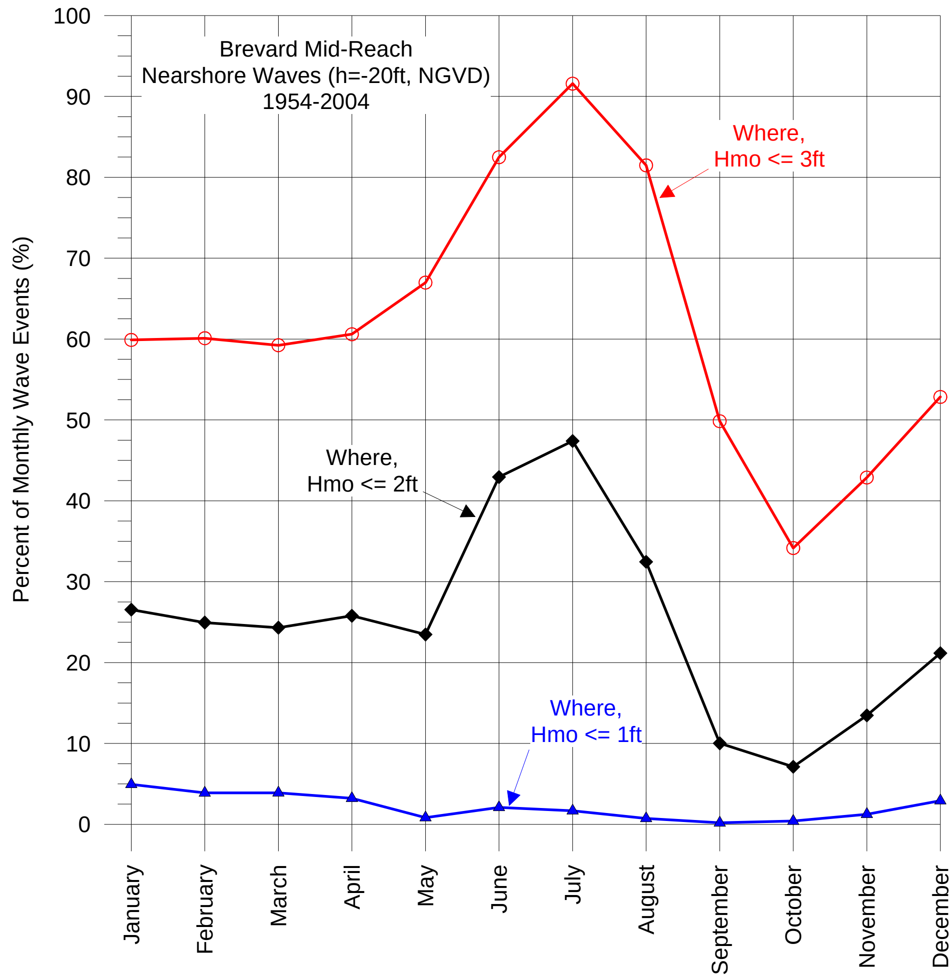

Figure 1: Monthly occurrence of waves less than 3 ft, 2 ft, and 1 ft in height computed from a 50-year hindcast in approximately 18 ft water depth (MLLW) at the Mid-Reach, Brevard County.
(In these figures, the value of Hmo is approximately equivalent to significant wave height.)

work requires many spans of several consecutive days with "calm" seas, the work is pragmatically limited to these few summer months. And even then, from Figure 1, wave heights are 1-ft or smaller for less than 2% of the time, on average. It is only during these near-flat conditions of 1-ft seas that one would consider working in the shallowest waters; and these periods comprise less than 2% of the work window.

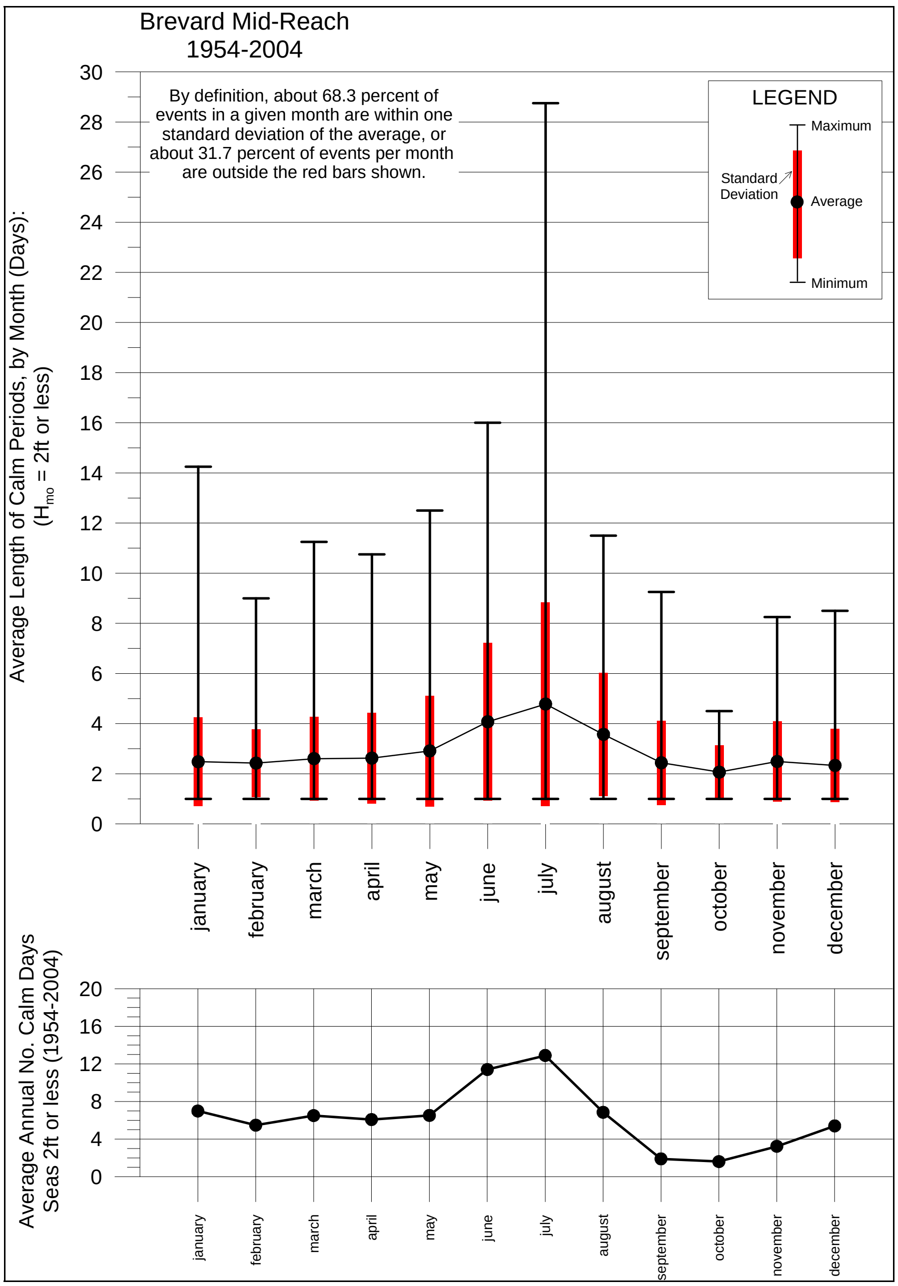

Figure 2: Length and number of "calm periods" when significant wave heights are consistently less than 2 ft along the Mid-Reach.
(Computed in 18-ft MLLW water depth for fifty year hindcast record.)

The hindcast wave climate along the Mid Reach was contrasted with that along West Palm Beach and Fort Lauderdale. For this purpose, coincident 20-year hindcast wave records were available, from 1980-1999. The hindcast for these two south Florida WIS stations (#461 and #467, respectively) were transformed to about -20 ft NGVD water depth and evaluated in 6-hour intervals in order to match that of the Mid Reach wave database, from which the equivalent 1980-99 data were extracted for comparison.

Figure 3 contrasts the average annual significant wave height and peak spectral period for the three hindcast stations. On 20-year average, the Mid-Reach (Brevard) waves are significantly larger in height and longer in period than those of Palm Beach and Broward Counties.

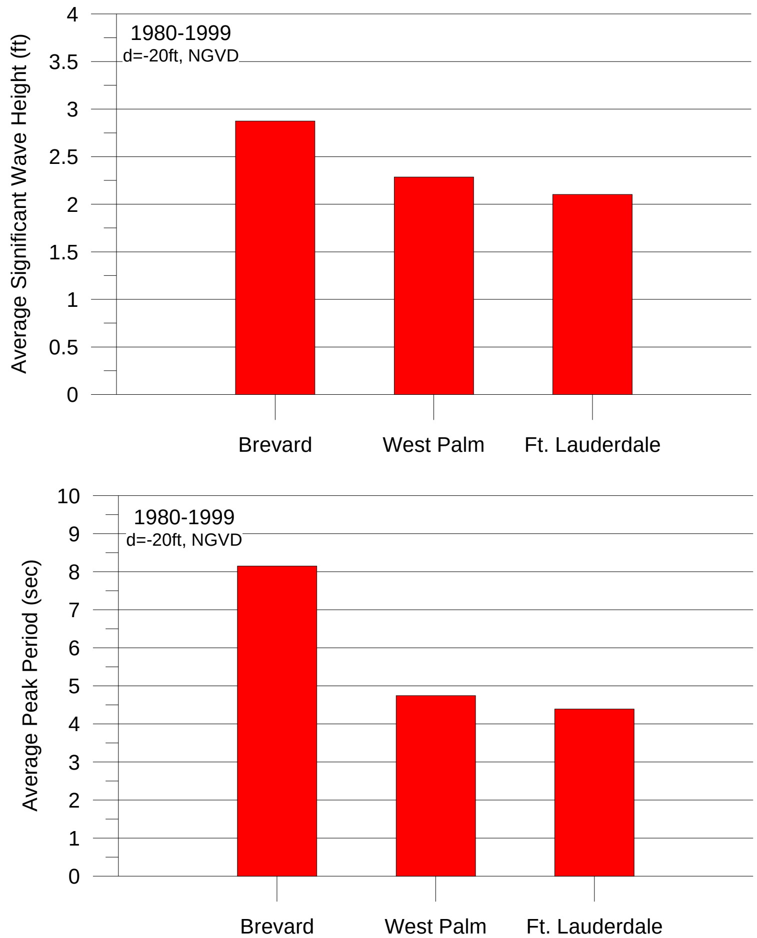

Figure 3: Comparison of average annual significant height and spectral peak period of waves in approximately 20-ft (NGVD) water depth along the Mid-Reach, West Palm Beach and Ft. Lauderdale shorelines.

Figure 4 contrasts the average annual occurrence of waves, by height, among the three locations. Notably:

- Both West Palm and Ft. Lauderdale exhibit about 20% of local waves at 1-ft height or less; but at the Mid-Reach, only 2% of the waves are 1-ft or less. These are the periods when work in very shallow water (say, less than 16 ft) might be undertaken.
- Both West Palm and Ft. Lauderdale exhibit about 32% of the waves at 1- to 2-ft height; but at the Mid-Reach, only 21% are in this class. These are the periods when typical nearshore work would be scheduled or executed.

Overall, these two ranges of wave-heights (2-ft seas or less) – representing "working" conditions -- comprise *over half* of the annual record at West Palm Beach and Ft. Lauderdale, but *less than one-quarter* of the annual record along the Mid Reach.

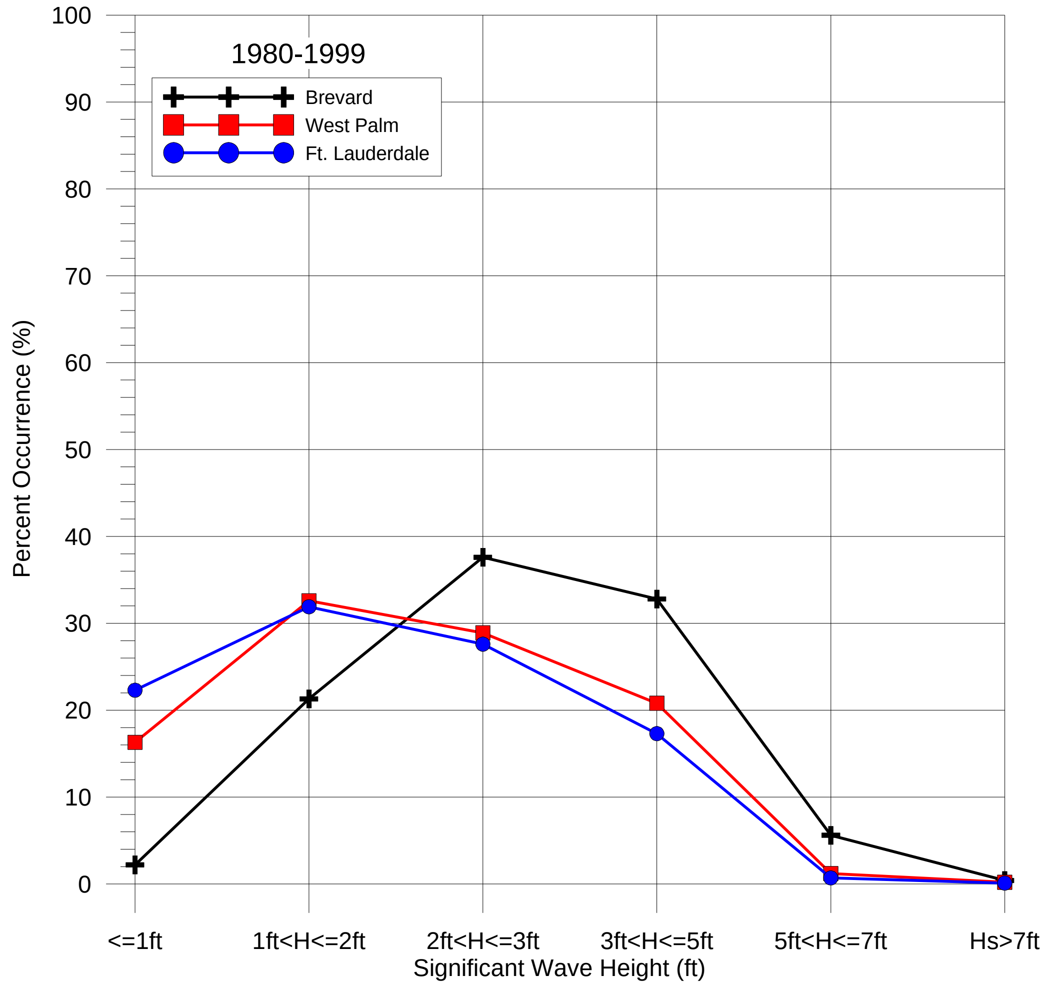

Figure 4: Distribution of wave height occurrence at the Mid-Reach, West Palm Beach, and Fort Lauderdale, in 20-ft (NGVD) water depth from 20-yr hindcast wave data.

Figure 5 contrasts the average annual number of times per year that the wave heights remain at 2-ft or less for at least 4 consecutive days; i.e., ideal conditions for nearshore work. The occurrence of these events at West Palm Beach and Ft. Lauderdale are about 2- and 2-½ times greater than along the Mid Reach.

Likewise, from ***Figure 6***, it is noted that a 4-day long span of calm seas is likely to occur, on 20-yr average, at least *once every month* in Ft. Lauderdale (excepting Novmeber), and almost as often in West Palm Beach. However, at the Mid Reach, a 4-day long span of calm seas occurs at least once per month in only *two* months; viz., June and July.

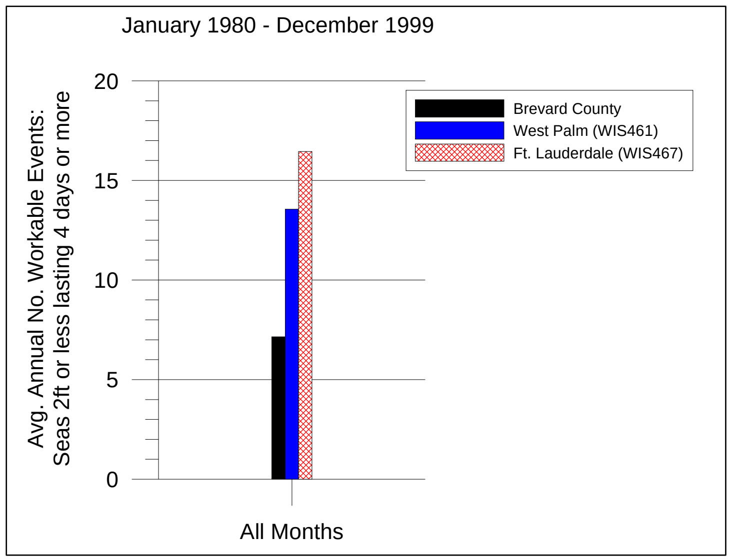

Figure 5.
Average annual number of times per year during which the significant wave height is 2-ft or less for at least 4 consecutive days.

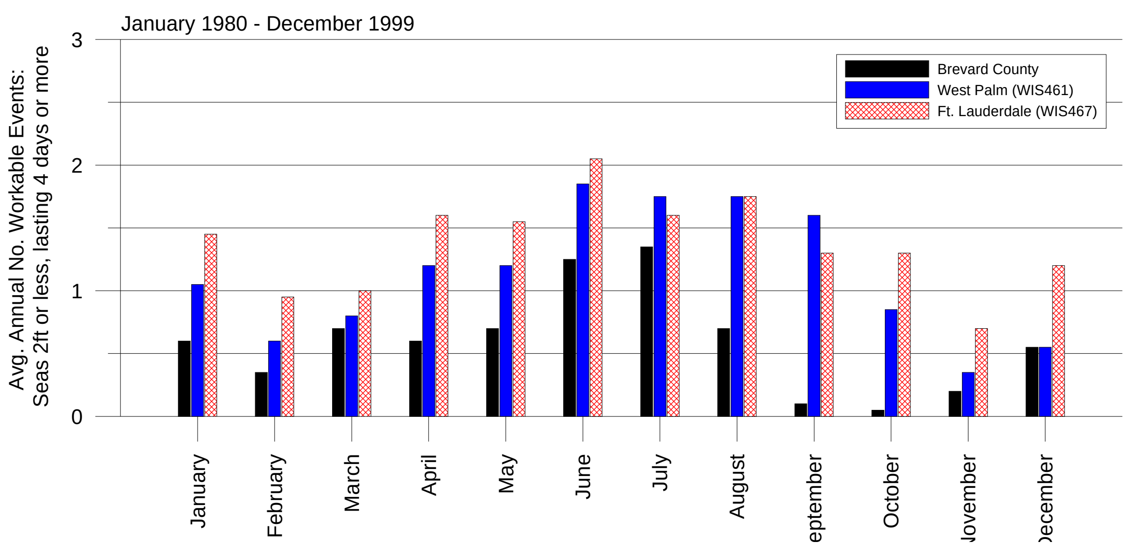

Figure 6: Average annual number of times per month during which the significant wave height is 2-ft or less for at least 4 consecutive days.

In coarse, day-to-day comparison of the hindcast wave heights at the three locations, conducted at 6-hr intervals over a 20-year period, there is no statistically meaningful correlation that is simply described. Broadly, best-fit regression suggests that wave heights along the Mid Reach on any given day are 47% larger than along West Palm Beach and are 69% greater than along Fort Lauderdale; but, again, daily conditions at the Mid Reach are generally not statistically related to those at the south Florida stations.

Overall, a fundamental observation here is that the nearshore sea conditions at Palm Beach and Broward Counties are distinctly different – calmer – than along the Mid Reach. *The construction of mitigation reef structures in shallow water along Palm Beach and Broward Counties is not evidence that such structures can be practically constructed along the Mid Reach.* Particularly in light of the greater distances that separate the Mid Reach site from the nearest port, the generally higher seas, and the less-frequent duration of calm-seas, the ability to safely and reliably work in very shallow nearshore waters is *significantly* more limited along the Mid Reach than in south Florida.

7.0 Seabed Profile Stability

Of additional consideration is the magnitude of the natural fluctuations in the seabed elevation at any proposed mitigation site. It is recognized that the sand seabed amidst the existing nearshore rock reef fluctuates significantly, and that large portions of the reef are alternately exposed or buried. Thus, some fluctuating burial or exposure of the mitigation reef is probably acceptable.

Nonetheless, it is also recognized that placement of the reef structure on seabeds with greater natural fluctuation will increase the possibility of the structures' burial. Most simply, this is because the mitigation reefs (unlike the fixed, natural rock) are gravity structures. Even though they are built upon, or composed of, marine foundations, they are mostly limited to *downward* movement. To the extent that they may *fall* in elevation with an eroding seabed (if at all), they are not likely to *rise* with a subsequent accreting seabed. Thus, in a dynamic environment, the potential for long-term reef burial increases.

To better ensure exposure of the reef structure in shallow water, it is therefore important to place it upon the seabed with the least fluctuation (i.e., greatest apparent stability).

To assess this factor, the profile (seabed) history at three typical locations along the Mid-Reach were considered: at the north end (R76), middle (R97), and south end (R111). At each monument, surveyed profiles were reduced to common datums and digitized at 10-ft horizontal intervals. At each interval, the mean, minimum, maximum, and standard deviation of the seabed elevation were computed for each of the three profiles. (See ***Figures 7a, 7b, 7c***, following pages.) Between 6 and 12 profile-surveys were available, and used, for each monument – spanning 1993 through 2007.

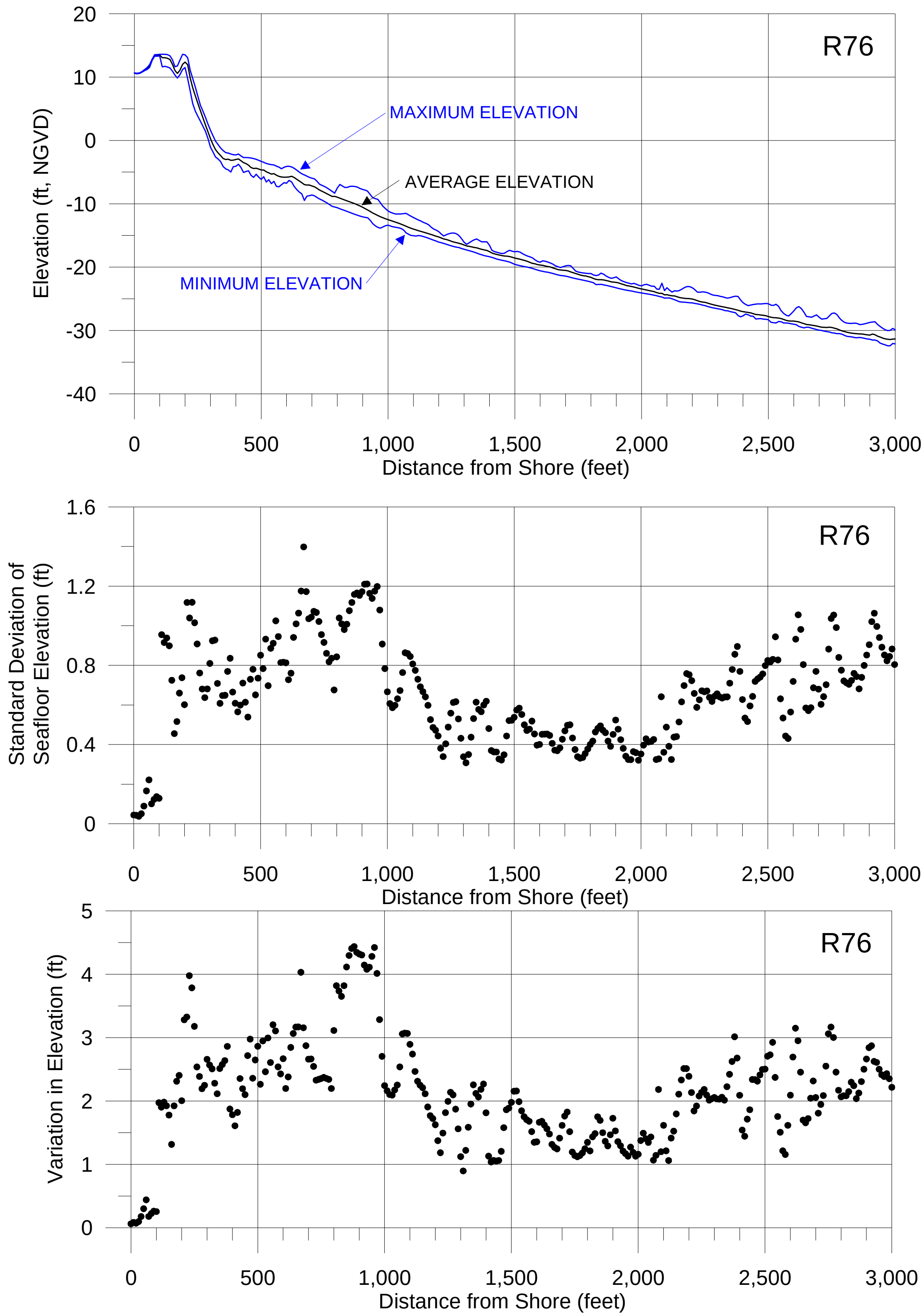

Figure 7a: Mean, minimum, maximum, standard deviation, and total vertical range (variation) of seabed elevation computed at 10-ft horizontal intervals for beach profile surveys at R76 [north end of Mid Reach]; 1993 – 2007.

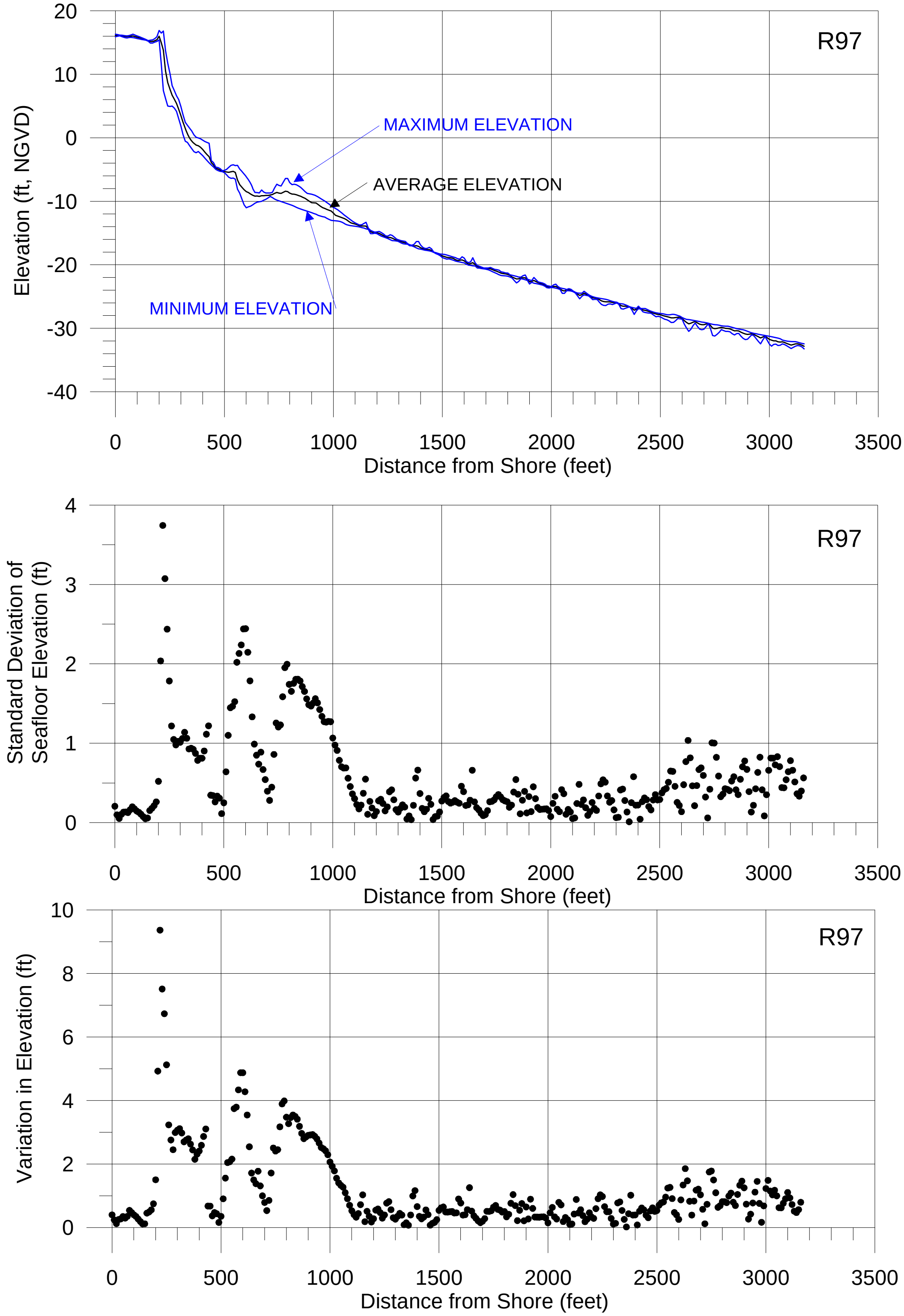

Figure 7b: Mean, minimum, maximum, standard deviation, and total vertical range (variation) of seabed elevation computed at 10-ft horizontal intervals for beach profile surveys at R97 [central Mid Reach]; 1993 – 2007.

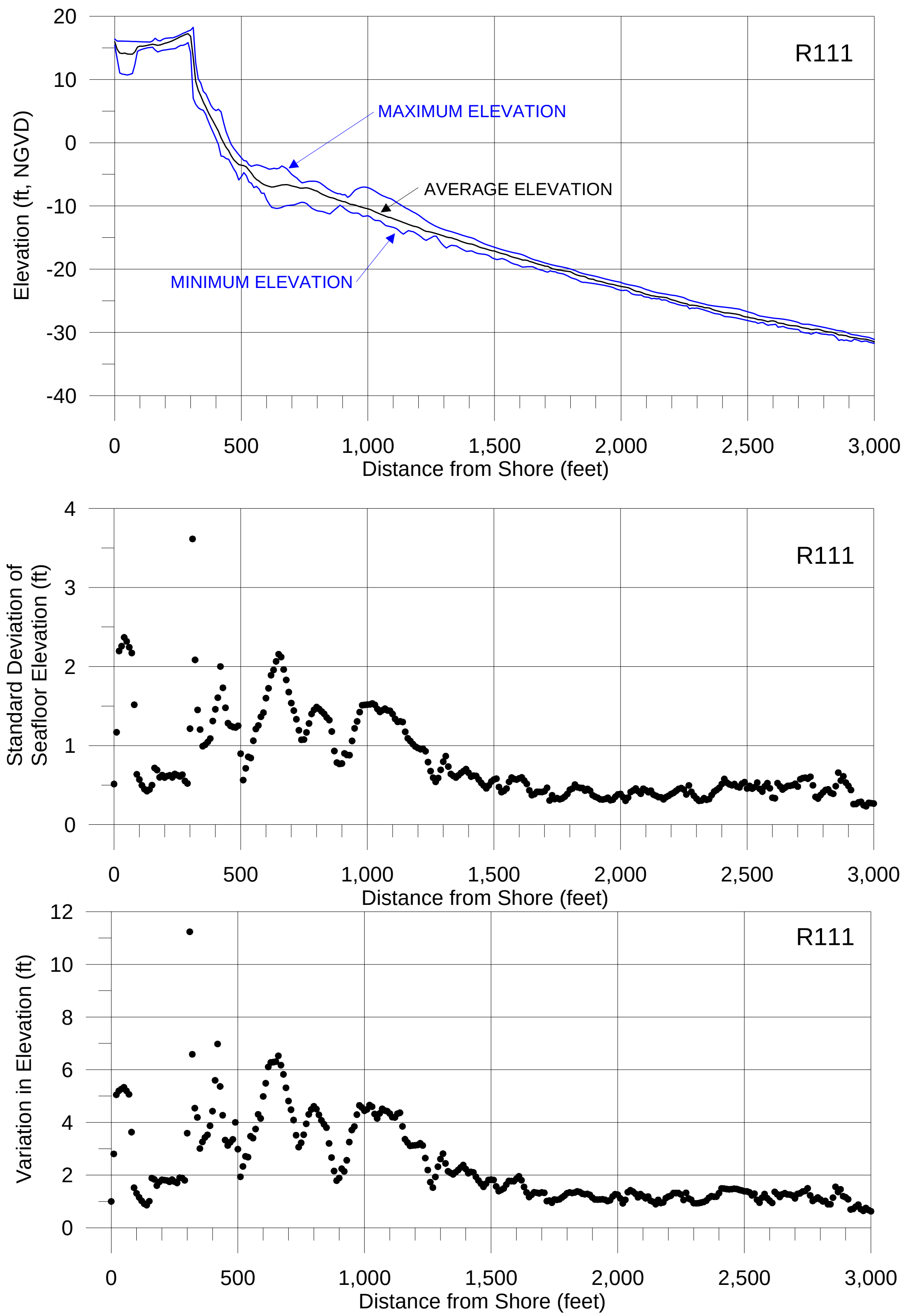

Figure 7c: Mean, minimum, maximum, standard deviation, and total vertical range (variation) of seabed elevation computed at 10-ft horizontal intervals for beach profile surveys at R111 [south end of Mid Reach]; 2002 – 2007.

Figure 8, below, illustrates the standard deviation of the measured seabed elevation as a function of mean seabed depth -- for each of the three Mid Reach profiles.

- The *least* vertical deviation (seabed fluctuation) is consistently observed between about -19.5 and -24 ft NGVD elevation [-17.6 to -22.1 ft MLLW]: about 0.45-ft or less; or, on the general order of typical survey uncertainties.
- The second least seabed fluctuation, in shallower water, is at or deeper than about -16 ft NGVD [-14.1 ft MLLW]: about 0.6 feet or less.
- The seabed fluctuation increases dramatically in depths shallower than about -15 ft NGVD [-13.1 ft MLLW]: quickly approaching and exceeding 1-ft or greater in standard deviation.

These values are consistent with observations from annual beach profile monitoring surveys along Brevard County. These three profiles are not influenced by beach fill.

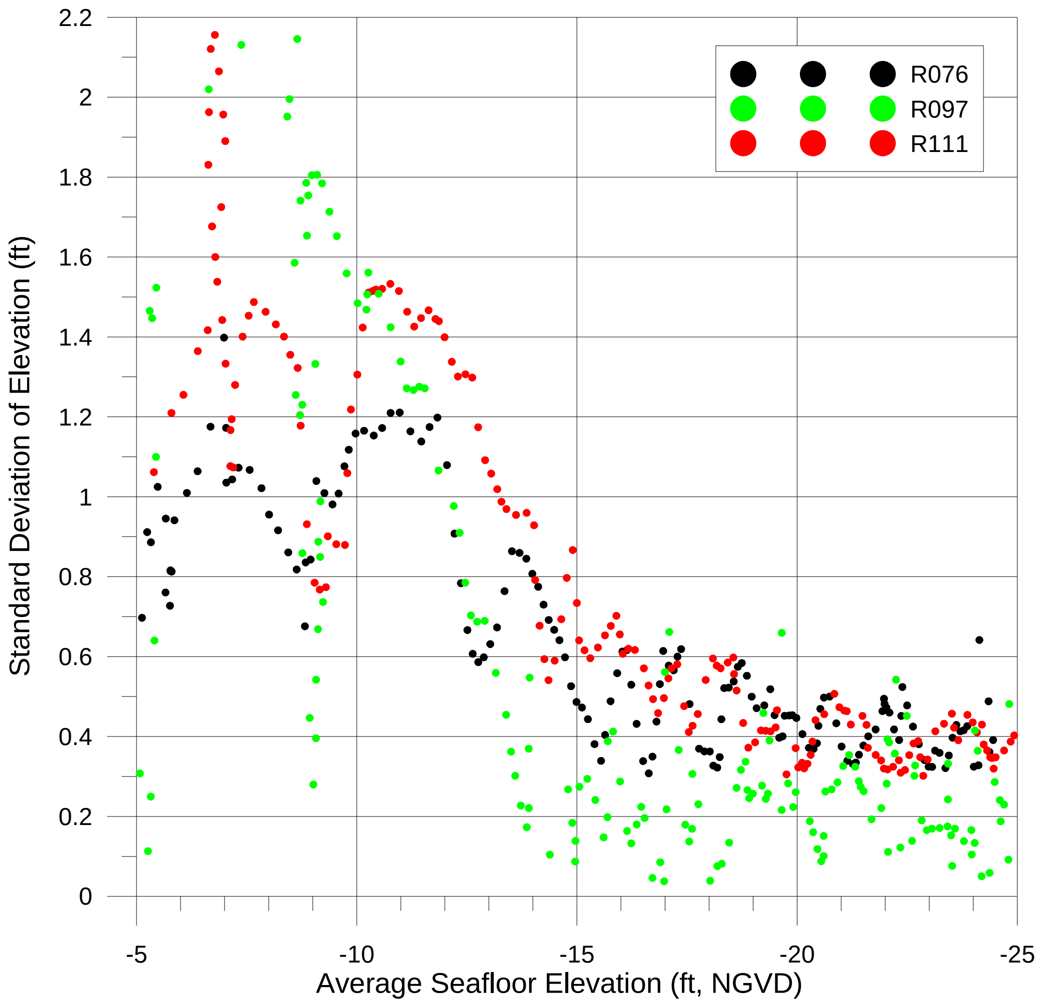

Figure 8: Vertical deviation in seabed elevation as a function of mean seabed depth, computed from historical beach profiles at R76, R97, and R111 between 1993 and 2007.

This analysis would suggest that the most stable, shallowest depths for mitigation reef deployment are at or deeper than about -16 ft NGVD [-14.1' MLLW], more or less. This is also consistent with observations of reef deployments in other locations. In Palm Beach County, for example, it is our understanding that historical performance of reef structures placed in shallower water (-12 to -16 ft) has been poorer than that in slightly deeper water [Dan Bates, personal communication].

Regardless, from Figure 8, vertical seabed fluctuations on the order of at least 0.6 to 1.2 feet can be statistically expected at seabed depths *shallower* than -16 ft NGVD along the Mid Reach. To the extent that these fluctuations could adversely impact exposure of the mitigation reef, deployment in depths near or *deeper* than -16 ft NGVD appears prudent.

8.0 Public Safety and Liability

Purposeful placement of a man-made, irregular, submerged structure in an energetic, turbid environment that is customarily used for wading and swimming by people of all ages raises very significant questions regarding public safety and liability.

The existing, naturally occurring nearshore rock, of itself, poses somewhat of a 'hazard' to swimmers along the beach. Its presence results in unusual currents and turbulence, common (and painful) tripping hazards, and the potential for injury by entrapment or impact via wading, swimming, body or board surfing, etc. However, it is a generally natural feature of the shore; and injuries therefrom might be reasonably attributed to expected environmental hazards of the shore.

Similar injury caused by intentionally-installed, man-made structures cannot be attributed to nature. Nearshore reef mitigation structures are unlike conventional coastal structures (e.g., groins, breakwaters, piers) because they are submerged. In the turbid and energetic waters along the Mid Reach, submerged structures are essentially invisible. Potential injuries associated with the structures could include drowning (due to claims of altered currents & turbulence, or by entrapment) and broken bones, laceration or contusions from brushed or traumatic impact with the structures; et cetera. If erected in locations where the structure was readily accessible from shore, extraordinary levels of above-water signage, exclusion areas, buoys, or the like would be necessary, at minimum, to warn people of the structures' presence. Again, the requisite concerns are far greater for expansive, submerged reef structures (than for a groin or breakwater) because the structures cannot otherwise be seen and are not otherwise expected by a beach user.

In common practice (as for, say, a beach resort), submerged seabed obstructions or other irregular, unexpected seabed features must be limited to areas that are reasonably beyond wading depth from shore. Depending upon the allowance for waves and safety factors, this depth may be at least 6- to 9-feet, at lowest tide. But the Mid Reach shoreline poses an additional complication because of the popularity of surfing.

Surfing, particularly in bigger wave conditions that are common to this area, means that people are accessing deeper water with greater chance of [unintentionally] encountering the seabed. Surfers may be attracted to areas near mitigation reefs because of the perception (or slight possibility) that the broad, low-relief structures enhance the break. A surfer that attempts, and fails, to drop an 8-ft wave, for example, can often be pushed to the bottom, risking impact or entrapment by any structure thereupon. An 8-ft wave will break in about 10-ft water depth. This would suggest that structures should be at least 10 feet below the water surface to allow reasonable clearance for surfers in overhead conditions. Allowing for a structure height of up to 1.5 ft off of the seabed, plus about 0.5 ft of wave set-down (radiation stress), suggests that the structures should be placed in depths of at least 12 feet or greater at low tide, for consideration of 8-ft break. Of course, big wave surfers will ride higher waves that are known to occur on this coastline. There is no established guidance in this specific matter; it is a function of prudent judgement.

The potential hazard posed to the public by submerged reef structures along the turbid, high-energy surfing environment of the Mid Reach poses unique and site specific considerations. Because of this known potential hazard to public safety, the design engineer is ethically bound to discuss this issue and bring it to the forefront of decision making. Any public body involved in this project must be advised that there are specific liabilities associated with the submerged structures, regardless of whether or not beach users are educated as to their hazards. This presents a paramount consideration for the submerged structures to be installed at depths *greater* than those that can be expected to be reasonably encountered by beach users; viz., waders, swimmers, surfers, et al.

9.0 Summary

In summary, the following is concluded in regard to the practical depth limitations at which mitigation reef structures might be constructed along the Mid Reach shoreline:

- consideration of hydrodynamic stability indicate that about -14.1 ft MLLW[9] is the shallowest depth limit for stable deployment
- consideration of construction access suggests that -14 ft MLLW is the shallowest depth for practical constructability (with -16 ft MLLW preferred)
- consideration of seabed profile fluctuations suggest that the shallowest depth for reliable stable reef performance is about -14.1 ft MLLW, and
- consideration of the potential liabilities and hazards to public safety presents a paramount argument for structures to be installed at depths greater than those encountered by beach users; e.g., on the order of -12 ft MLLW or deeper.

[9] Equates to -16.0 ft NGVD

The preceding discussion also demonstrates that the constructability of reefs in shallow depths in south Florida does *not* apply to the Mid Reach of Brevard County. In particular, the Mid Reach exhibits significantly greater wave heights, fewer periods of calm seas, and longer sailing distances to port than at Palm Beach and Broward Counties. Accordingly, the complexity and limitations of nearshore reef construction along the Mid Reach are far greater than along south Florida – where relatively long periods of calm seas and close proximity to port can allow for safe construction in very shallow water.

In sum consideration, it is reasonably concluded that an appropriate *minimum* depth for the deployment of reef mitigation structures along the Mid Reach shoreline is approximately -14.1 ft MLLW (-16 ft NGVD) or deeper. This does not mean that *all* of the reef structure can be placed in -14.1 ft MLLW depth. As shown above, wave conditions along the Mid Reach are usually marginal (not ideal) for construction at best. Practical provision must be made to undertake useful construction (in slightly deeper water) when seas are "workable" but less than ideal.

Additionally, to work practically in the limited weather windows that are available, reef structures must be installed in at least 100-ft to 200+ ft long shore-perpendicular "strips" that can be reached from a single, shore-perpendicular barge set-up. In 14 to 16 ft water depths, the natural seabed slope is about 1:83. Thus, a reef structure that extends 150 feet in east-west length, for example, will span about 1.8-ft in seabed depth. Hence, a 150-ft long structure placed with its landward edge at -14.1 ft MLLW will have its seaward edge at -15.9 ft MLLW, as measured at the natural seabed. On average, this structure would be centered along the -15 ft MLLW contour, more or less.

The presently proposed mitigation plan calls for the construction of 100- to 180-ft long articulated-concrete reef mats centered along the -15 ft MLW contour; or, approximately spanning depths of -14.5 to -15.5 ft MLW. Adjusting for the approximate 0.3-ft difference between MLW and MLLW, this corresponds to reef deployment in seabed depths of between -14.2 and -15.2 ft MLLW – which is consistent with the conclusions of the analysis described above.

This paper has considered only practical engineering aspects of the reef mitigation structures. Biological considerations are addressed in separate analyses[10]. The

[10] McCarthy, D. and K. Holloway-Adkins, 2007. "Assessing larval recruitment of the polychaete *Phragmatopoma lapidosa* on subtidally deployed structures off Satellite Beach, Florida." Report prepared for Brevard County Natural Res. Mgt. Office. August 20, 2007.

Holloway-Adkins, K. and D. A. McCarthy, 2007. "The Recruitment of Macroalgae on Subtidally Deployed Structures off the Coastal Waters of Brevard County, Florida." Report prepared for Brevard County Natural Res. Mgt. Office. August 30, 2007.

Continental Shelf Associates Inc., East Coast Biologists Inc., and Olsen Associates Inc., 2006. "Brevard County Mid Reach Shore Protection Project: Mitigation Assessment Analysis." Report prepared for Brevard County Natural Res. Mgt. Office. 28 August 2006.

engineering requirements for reef construction in water depths of about -14 to -16 ft MLLW may be at least partly supported by recently completed investigations of biotic recruitment in these water depths. Artificial structures deployed in about 15-ft water depths offshore of the Mid Reach (the “PALM” experiments) found significant recruitment of reef-building worms (*Phragmatopoma lapidosa*) with coverage matching or exceeding prior estimates of worm rock occurrence along the existing nearshore rock. Significant recruitment of macroalge was likewise identified, including red and green algae species observed along the existing nearshore rock and identified in the diets of juvenile green turtles that forage along the rock. Fish and invertebrate species were also identified on the structures. Specific details of these investigations, and related analyses, are described in the references listed on the preceding page.

APPENDIX SEIS-G

Brevard County Mid Reach Shore Protection Project:
Mitigation Assessment Analysis

August 2008

BREVARD COUNTY MID REACH SHORE PROTECTION PROJECT: MITIGATION ASSESSMENT ANALYSIS

August 2008

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1.0 INTRODUCTION

This document provides data and information supporting an analysis of impact and corresponding mitigation using the Uniform Mitigation Assessment Method (UMAM) in accordance with Chapter 62-345 Florida Administrative Code (F.A.C.). The impact and mitigation scenarios analyzed are proposed to occur off the Mid Reach segment of coastal Brevard County, Florida (Florida Department of Environmental Protection [FDEP] Monuments R-75.4 to R-118.3). The impact being assessed is the loss of nearshore hard bottom habitat that will be buried during a shoreline protection project involving sand dredged from an offshore location then trucked to the onshore fill site. Much of the background information on the Mid Reach area and potential project scenarios are available in Olsen Associates, Inc. (2003).

Nearshore hard bottom is used by algae, invertebrates (sessile and motile), fishes, and marine turtles and is considered essential fish habitat and a habitat area of particular concern by the National Marine Fisheries Service and the South Atlantic Fishery Management Council (1998). In Florida waters UMAM is currently used as the primary tool for assessing impacts and formulating a restoration or mitigation strategy. UMAM was designed primarily to determine mitigation required for upland situations where projects have caused unavoidable impacts. However, in coastal marine environments the UMAM approach is not as well developed and requires some rationale and support for the essentially subjective scoring procedure used in the analysis. For logistical and engineering purposes, mitigation of nearshore hard bottom impacts must occur in slightly deeper waters than the impacted hard bottom. Therefore, the mitigation sites as well as the impact site must be included in the UMAM analyses to provide an adjusted amount of habitat replacement required to offset losses due to project impacts.

UMAM has three key components that are scored on the basis of reasonable scientific judgment:

- location and landscape support;
- water environment; and
- community structure.

The impact and mitigation sites are evaluated separately for each of these components before and after impact or mitigation, using a scoring system that ranges from 0 to 10. Characteristics of impact and mitigation sites are given below.

*Impact Site – A*s defined in Chapter 62-345 F.A.C., the UMAM applies to wetlands and other surface waters as delineated pursuant to Chapter 62-340 F.A.C. that would be impacted by the project. Uplands shall not be included as part of the impact site. In this case, we define the impact site to mean the intertidal and subtidal nearshore hard bottom that would be impacted by the project. The physical characteristics of the Mid Reach rock resource are described in detail in Olsen Associates, Inc. (2003).

Mitigation Site – Defined as wetlands and other surface waters as delineated pursuant to Chapter 62-340 F.A.C. or uplands that are proposed to be created, restored, enhanced, or preserved by the mitigation project. In this case, the proposed mitigation profile seeks to offset the burial of nearshore rock habitat by constructing “like” replication of hard bottom in a water depth of approximately 4.6 m (mean low water [MLW]). The mitigation reef will be placed in a water depth of approximately 4.6 m (MLW) so that the top of the relief will be at a depth of approximately 4.0 to 4.3 m. The mitigation site will be placed approximately 300 to 400 m from shore on sand bottom.

The proposed mitigation reef has been modified to replicate the physical appearance, texture, relief, and ecological function of the existing nearshore hard bottom as closely as practical – while respecting aspects of constructability, hydraulic stability, and geotechnical considerations. The proposed reef structure will consist of articulated concrete mats with an integral coquina-rock surface. **Photo 1** shows an example of the proposed mitigation reef structure consisting of nine experimental blocks constructed by Brevard County during its development of mitigation-reef alternatives earlier this summer.

Photo 1. Sample portion of a prototype articulated-mat reef mitigation structure proposed for the project. Each block is about 30 in. x 30 in. x 12 in. (76 cm x 76 cm x 30 cm), with integral coquina rock surface. (The cable between the blocks illustrates the cable geometry that would be used in the articulated mat. Cable in the constructed materials would differ.)

Each articulated reef mat would consist of 18 cable-connected blocks. Each mat would be about 8-ft x 15-ft x 1-ft (2-m x 5-m x 0.31-m) high and comprise about 90 lineal ft (27 m) of valleys (ridges) between blocks and adjacent mats. Forty-two mats, in six rows and seven offset columns, would be placed adjacently – along with three additional "top-layer" mats along the landward edge to form an overhanging ledge. This would constitute one "set" of 45 mats. Each set of 45 mats would create about 0.15 acres (0.06 ha) of hard bottom structure (**Figure 1**).

Each set of mats would be placed upon the sand seabed at ambient depths of between about -14.4 and -15.6 ft (4.4 and 4.8 m) MLW; i.e., approximately centered along the -15 ft MLW contour, and located about 300 to 400 m from the MLW shoreline. At 12 in. (30 cm) nominal relief (and 24 in. [61 cm] maximum relief along the landward edge), the coquina surface of the reef units would lay in water depths of between -12.4 and -14.6 ft (4.0 and 4.5 m) MLW.

Between three and five sets of mats would be spaced 50 to 60 ft (15 to 18 m) apart, along the -15 ft contour, to form a reef unit. These reef units would be spaced 400 to 600 ft (122 to 183 m) apart, or more, to create the requisite total area of reef mitigation along the shoreline.

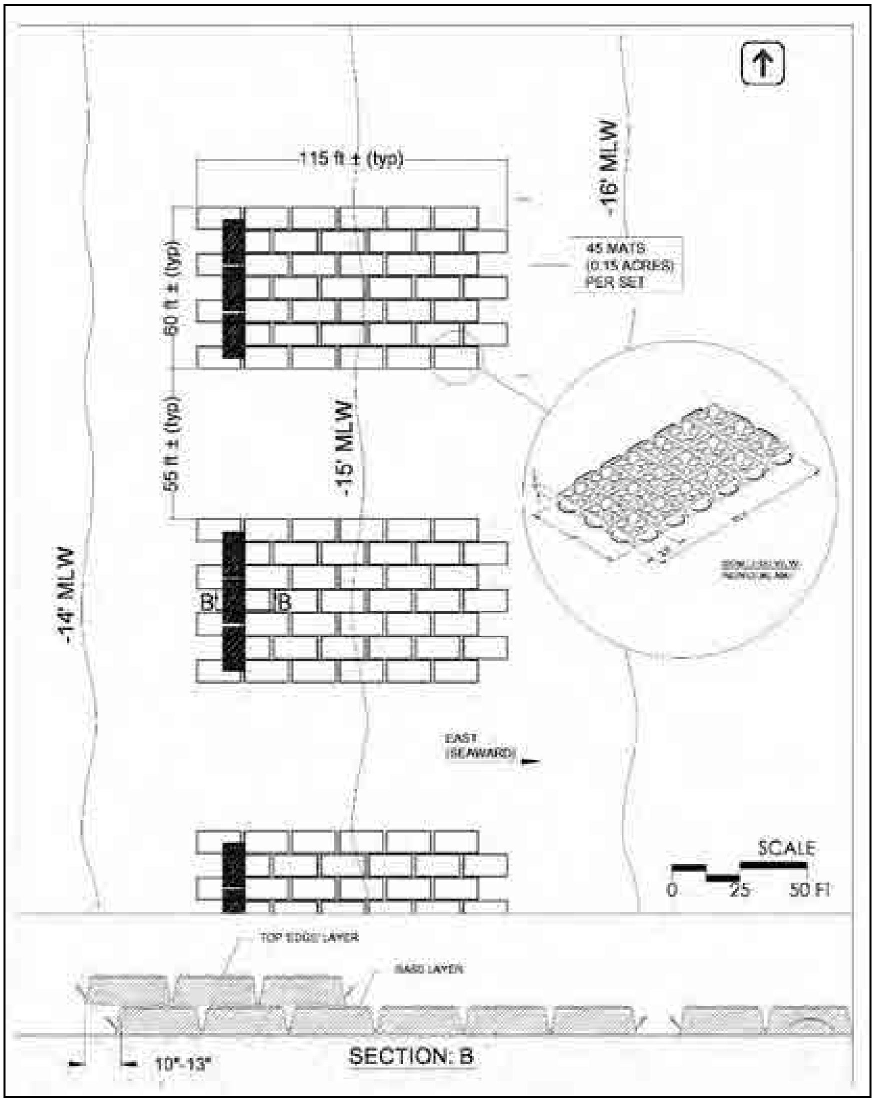

Figure 1. Proposed layout (and typical section) of articulated reef mats within a "set" and reef unit.

The specific geometry of the mats within and between each 0.15-acre (.06-ha) set is determined by considerations of marine construction equipment, seabed depth and tides, and the objective of installing the reef as shallow as possible. The geometry and alongshore spacing of reef units creates a natural patch-structure similar to that of the existing hard bottom along the southern Mid Reach. It is intended to create a corridor of readily traversed (yet semi-isolated) reef patches that are proximate to the existing non-impacted hard bottom. Patchy configuration of artificial reefs has proven effective off Florida's west coast (Frazer and Lindberg, 1994; Lindberg et al., 2006).

The coquina surfaces of the mats' blocks are developed by placing 4- to 12-in. (10 to 30 cm) locally-quarried coquina stone in the top of the concrete forms within a temporary sand matrix. The top surface thus features essentially 100% coquina cover with 1- to 4-in. (2.5 to 10 cm) deep crevices between the coquina stones that emulate the existing nearshore rock. (Attempts to further increase the coquina coverage along the sides of each block ultimately proved to be impracticable.) The valleys between blocks and the overhanging "ledge" on the landward end of a set of units emulate the physical relief of crevices and ledges within the existing reef. In addition, 16-in. gaps between the ends of reef mats would provide resting areas appropriately sized for juvenile green turtles observed to rest and forage in similarly-sized crevices on the existing Mid Reach rock resource. At the same time, the articulated mat (which is fundamental to the reef structure) serves as the requisite foundation for the area's sand bottom. Use of such articulated mats (without the special coquina surface) is a standard marine construction practice employed to establish hydraulically stable structures on sand seabeds prone to scour.

Toward developing the proposed mitigation reef structure, significant efforts were undertaken to research and develop a stable structure that could optimally emulate the impacted resource and be produced and deployed in large scale. The proposed structure represents a novel alternative to the traditional practice of deploying boulders upon the seabed. While other fish attracting devices (such as reefballs, etc.) might be fastened to the surfaces of the articulated reef mats, such additions are considered uncharacteristic of the existing resource and are therefore not proposed for this project.

The goal of the UMAM approach is to evaluate the *relative functional loss* of the impacted habitat and compare that with the *relative functional gain* of the mitigative habitat. The "ratio" of project mitigation-acreage versus impact-acreage is fundamentally computed as follows:

$$\text{Ratio} = \frac{\text{Functional Loss of Impact Area}}{\text{Relative Functional Gain of Mitigation Area}} \times \text{Time Lag Factor} \times \text{Risk Factor}$$

The "functional loss of impact area" considers the net change in ecological function of the impacted hard bottom from existing to post-project conditions. The "functional gain of mitigation area" considers the net change in ecological function of the impacted offshore soft bottom to the project mitigation reef structure.

Two very important factors in the analysis and calculation of the ratio are time lag and risk. Time lag refers to the time required for mitigation to achieve an acceptable level of "functional equivalence" to the impacted habitat, and risk is a subjective measure of the expected outcome given an individual impact/mitigation scenario. In the UMAM context risk addresses the vulnerability of the mitigation to many physical and biological factors and, in the present context, additionally addresses uncertainties in the evaluation not already captured within the estimated loss/gain of ecological function.

This support document is organized into sections based on the three components of the UMAM assessment. Within each chapter, relevant functions for both impact and mitigation sites are discussed with respect to key taxonomic groups. These groups are based on ecological studies conducted at the impact site in the past 3 years (Continental Shelf Associates, Inc., 2005a; Holloway-Adkins and Provancha, 2005). The taxonomic groups are as follows:

- macroalgae;
- invertebrates;
- fishes; and
- marine turtles.

Within each group, various "indicator" taxa of particular ecological or economic importance and/or typical of the site(s) were considered in addition to discussion of the broader taxonomic group. Areas of overlapping topics were identified to avoid multiple-counting or over-weighting of specific ecological functions or taxonomic groups.

The degree to which members of each of the four major taxonomic groups are estimated to be “served” by the existing hard bottom in the impact areas (pre- and post-project conditions) and by the proposed mitigation areas (pre- and post-project conditions) were evaluated and “rated” in terms of each of seven key ecological functions. Results were compared for the impact and mitigation areas (pre- and post-project conditions) and totaled across the taxonomic groups. From this, an assessment was made of the relative loss and relative functional gain of the impact and mitigation sites, respectively.

The evaluation was based upon input from many sources: (1) critical review of existing literature, (2) the investigators’ prior related experience, (3) prior data collection along the existing nearshore hard bottom including transect mapping, netting, controlled boat observation, and related studies documented in reports previously provided as part of this project, (4) diving examination of the nearest adjacent reefs in Indian River County (natural and mitigation reefs), (5) review of the proposed mitigation reef mat system, and (6) preliminary results from an experimental reef platform placed at the same depth and similar location as proposed for the mitigation reef. The latter refers to the Propagule and Larvae Measurement (PALM) instrument/reef platform deployed in late May 2006 for Brevard County (**Photo 2**).

Photo 2. The PALM reef instrument deployed for Brevard County offshore of the Mid Reach is intended to measure *Phragmatopoma caudata* larval recruitment under different current regimes, chemical treatments, and macroalgal growth on four different types of substrates. 2a shows a photo of the Instrument platform being lowered into the water. 2b shows a photo of various substrate panels located on top of the PALM platform (Photos provided by K. Holloway-Adkins).

The intent of this document is to provide an analytical framework and support for what are largely subjective decisions in scoring the UMAM forms. Within the three components (location and landscape support, water environment, and community structure), not all of the identified ecological functions are applicable. The term function has many usages in the field of ecology and, as with most ecological terms, is generally imprecise (Jax, 2005). With UMAM, functions are defined “services” (e.g., substrate for attachment, shelter from predators, access to food resources) provided by the habitat to extant organisms. For the Brevard Mid Reach, the key ecological functions of nearshore hard bottom are provided in **Table 1**. Both relative functional losses and relative functional gains are determined during the scoring process within the three key components. Examples for scoring community structure are given in **Table 2**.

Table 1. Ecological functions and corresponding species groups applicable to nearshore hard bottom along the Brevard County Mid Reach.

Ecological Function	Species Groups
Habitat corridor – connectivity along cross-shelf continuum	Migrating invertebrates, fishes (including managed penaeid shrimps, reef fishes, coastal pelagic fishes, coastal sharks, and red drum), and marine turtles
Water quality – water depth, wave energy, currents and light penetration	Invertebrates, fishes (including listed striped croaker and federally managed species from the reef fishes and coastal sharks), and marine turtles
Substrate – attachment sites	Macroalgae, sponges, hydrozoans, sabellariid polychaetes (*Phragmatopoma caudata*), bryozoans, ascidians, and other sessile organisms
Cover – shelter from predation, waves and currents	Motile invertebrates, fishes (including listed striped croaker and federally managed reef fishes and coastal sharks), and marine turtles
Nesting area – egg deposition sites	Demersal fishes including blennies, damselfishes, and clingfishes
Feeding area – forage base	Macroalgae, invertebrates, fishes (including listed striped croaker and federally managed reef fishes, coastal pelagic fishes, coastal sharks, and red drum), and marine turtles
Nursery area – habitat for young stages	Invertebrates, fishes (including listed striped croaker and federally managed species from the reef fishes and coastal sharks), and marine turtles

To avoid double-counting in this analytical framework, each of the ecological functions is assigned to only one most relevant key component.

Component
- Location and landscape support
- Water environment
- Community structure

Ecological Function
- Habitat corridor
- Water quality
- Substrate
- Cover
- Nesting area
- Feeding area
- Nursery area

Table 2. Functional indicators and scoring based on the Uniform Mitigation Assessment Method in accordance with Chapter 62-345 Florida Administrative Code.

Functional Indicator	Score 10	Score 7	Score 4	Score 0
Location and landscape support	Ideally located and surrounding landscape provides full opportunity for the assessment area to perform beneficial functions at an optimal level.	Compared to the ideal, the location of the assessment area limits its opportunity to perform beneficial functions to 70% of the optimal ecological value.	Compared to the ideal, the assessment location limits its opportunity to perform beneficial functions to 40% of the optimal ecological value.	The location of the assessment area provides no habitat support for wildlife utilizing the assessment area and no opportunity for the assessment area to provide benefits to fish and wildlife outside the assessment area.
Water environment	The hydrology and water quality fully support the functions and provide benefits to fish and wildlife at optimal capacity for the assessment area.	The hydrology and water quality support the functions and provide benefits to fish and wildlife at 70% of optimal capacity for the assessment area.	The hydrology and water quality support the functions and provide benefits to fish and wildlife at 40% of optimal capacity for the assessment area.	The hydrology and water quality does not support the functions and provides no benefits to fish and wildlife.
Community structure	The benthic communities are indicative of conditions that provide optimal support for all of the functions typical of the assessment area and provide optimal benefit to fish and wildlife.	Relative to ideal habitat, the benthic communities of the assessment area provide functions at 70% of the optimal level.	Relative to ideal habitat, the benthic communities of the assessment area provide functions at 40% of the optimal level.	The benthic communities do not support the functions identified and do not provide benefits to fish and wildlife.

2.0 LOCATION AND LANDSCAPE SUPPORT

This component examines the ecological context of the impact site, both before and after project construction, and mitigation site, both before and after deployment of the proposed artificial reefs. The quality of the surrounding habitats and how well surrounding habitats are connected to the impact and mitigation sites is examined for each taxonomic group. Therefore, of the ecological functions listed in **Table 1**, the Habitat Corridor function is relevant under this component.

2.1 IMPACT SITE – HABITAT CORRIDOR

2.1.1 Macroalgae

BEFORE Impact
Nearshore rock provides attachment sites critical to the colonization of macroalgal species (Dawes, 1981; Luning, 1990; Schneider and Searles, 1991). High-energy environment promotes the uptake of nutrients and limits foraging opportunities for many herbivores (Underwood and Jernakoff, 1984; Bustamante et al., 1997; Bellgrave et al., 2004). These environmental characteristics support the growth and abundance of macroalgae at the site. Propagules and vegetative fragments provide a source of local recruitment. However, the viability and limited dispersal distances of macroalgal propagules limits substantial contributions to distant adjacent habitats (Hoffman, 1987; Norton, 1992; Dethier et al., 2003; Bellgrave et al., 2004). The score for the before-impact corridor was 9 (**Table 3**).

Table 3. Location and landscape support scores for individual taxa at impact and mitigation sites along the Brevard County Mid Reach.

Taxa	Location and Landscape Support			
	Habitat Corridor			
	Impact		Mitigation	
	Before	After	Before	After
Macroalgae	9	2	1	6
Invertebrates	9	2	1	6
Juvenile Fishes	9	2	1	2
Adult Fishes	9	8	1	9
Sea Turtles	9	8	1	9
Average	9	4.4	1	6.4

AFTER Impact
Lack of available substrate will greatly reduce or eliminate opportunities for macroalgal attachment and growth. However, project-related activities are not expected to create barriers to the dispersal of planktonic spores; therefore, after-impact corridor was scored as a 2 (**Table 3**).

2.1.2 Invertebrates

BEFORE Impact
Ecological context of the impact site and surrounding habitats for sessile and motile invertebrates depends on physical characteristics of the water column and the substrate as well as biological traits of individual species. The nearshore hard bottom of the Mid Reach supports motile and sessile invertebrates (Continental Shelf Associates, Inc., 2005). Both of these

groups have planktonic larval stages capable of broad dispersal (hundreds of kilometers). Motile forms such as worms, crabs, shrimps, and sea urchins all rely on local and regional larval supply to replenish the existing populations (Sponaugle et al., 2002). With some taxa, immigration by adults or subadults is a possible source of new individuals. Sessile forms rely on colonization from settling larvae as well as some re-growth from existing local colonies.

The delivery of larvae to the relatively isolated impact site depends on current patterns and water column structure at the impact site. These characteristics are driven by local winds and tides and vary with season. Given the existing weather patterns and sea conditions, there is no evidence that the location or surrounding habitats at the impact site would present any impediments to colonization by planktonic larvae or immigrating mature stages of any motile invertebrate taxa. For this reason, the before-impact score for this component was 9 (**Table 3**).

AFTER Impact
The composition of the invertebrate fauna at the impact site will change from an assemblage of hard bottom species to one of soft bottom species. Soft bottom species include epifaunal (motile) and infaunal forms that will colonize the new soft bottom by larval settlement. New soft sand habitat will not interfere with dispersal by planktonic propagules or movements by soft bottom species, however the sandy area will not be conducive to movements of hard bottom species, resulting in an after-impact score of 2 (**Table 3**).

2.1.3 Fishes

BEFORE Impact
From the perspective of a cross-shelf benthic habitat gradient extending from inshore waters to the outer shelf, nearshore hard bottom is important for many species and, in particular, for their early life stages (Lindeman and Snyder, 1999; Lindeman et al., 2000). Many of these species may utilize other habitats along the gradient as adults. Habitats adjacent to the Mid Reach are the barrier island to the west and open sand bottom north, south, and east of the hard bottom formation. The surrounding water column is a continuum without obvious barriers to passive or actively swimming organisms.

Because most marine fishes have a dispersive planktonic stage, there are no obvious barriers to the delivery of larvae capable of colonizing the nearshore hard bottom. Less obvious barriers can be physical and biological. The coupling of physical and biological aspects of the recruitment process provides an explanation of variability in larval settlement patterns (Cowen et al., 2006). Physical barriers include hydrographic or hydrodynamic features that would prevent planktonic young (spawned in either local or regional waters) from arriving and colonizing the habitat. Periodic cold-water upwelling (e.g., Smith, 1983) during times of planktonic advection or settlement could kill or repel temperature sensitive species. Additional water column variables that would impair movement of fishes are dissolved oxygen, turbidity, and salinity. Of these, only turbidity is expected as an impairment in the Mid Reach area. Therefore previous projects using the proposed sand source have not experienced chronic turbidity, the effects of turbidity from the proposed project are expected to be temporary. Biological barriers would include species-specific behavioral characteristics that are influenced by physical factors in the water column. These include planktonic larval duration, swimming ability, visual acuity, and temperature sensitivity.

Nearshore hard bottom of the Mid Reach is located mid-way between two inlets, 40 km from Sebastian Inlet to the south and 26 km from Canaveral Inlet to the north. Because so little is known about the movements of young fishes across the shelf, this aspect of the Mid Reach location and landscape support remains unknown and is therefore evaluated as potentially important. Also, from available information (Ocean Biogeographic Information System [OBIS], 2006), it appears that there is a broad gap along the cross-shelf gradient between the Mid Reach hard bottom and hard bottom of the open shelf (approximately 8 km to the nearest hard bottom habitat). As with the distance from inlets, this suggests that the Mid Reach is isolated from other habitats on a spatial scale that is important to young fishes.

Adult fishes clearly differ in their ability to swim from habitat to habitat both along shore and across the shelf. Coastal migratory pelagic species such as cobia, Spanish mackerel, bluefish, and pompano as well as adult reef fishes should find no barriers to movements to and from the Mid Reach hard bottom. Therefore, based on the unknown capabilities of young fishes to travel to and from the Mid Reach habitat, this site is evaluated as a potentially important habitat corridor for juvenile and adult fishes and given a score of 9 (**Table 3**).

AFTER Impact
Hard bottom species would be displaced following sand burial of the project site. Species composition at the impact site will transform from an assemblage of reef fishes to one of soft bottom fishes. During construction, the primary impediment to connectivity would be project-related turbidity. Although project-related turbidity is expected to be temporary, high levels of suspended material can affect swimming, vision, feeding, and respiration in fishes of all life stages (Robins, 1957; Johnston and Wildish, 1982; Benfield and Minello, 1996; Grecay and Target, 1996; Wilber and Clarke, 2001). Competent or actively swimming larvae would possibly avoid areas of high turbidity. Highly mobile adult species would likely avoid areas of high turbidity, as well. Juvenile reef fishes would likely be negatively affected by the hard bottom void created by sand burial of a portion of the hard bottom; the impact score for this category is 2. Adult fishes are expected to be able to swim across the void with less risk of predation or fatigue, therefore the score for adult fishes is 8 (**Table 3**).

2.1.4 Sea Turtles

BEFORE Impact
The impact area is a corridor to adjacent beaches for adult nesting female loggerhead, green, and leatherback sea turtles. The area is also used in the capacity of a developmental habitat corridor for juvenile green turtles and immature loggerheads. Nearshore reefs are an important component in the early life stages where juvenile green turtles and loggerheads are moving from pelagic to neritic environments. Nearshore reefs provide habitat, especially for juvenile green turtles (Ehrhart, 1992; Wershoven and Wershoven, 1992; Bresette et al., 1998; Holloway-Adkins et al., 2000; Makowski, 2004; Inwater Research Group, 2005). Habitat corridor before impact was scored a 9 (**Table 3**).

AFTER Impact
Sand bottom habitat will not interfere with the nesting corridor for adult turtles using adjacent beaches. Immature loggerhead and juvenile green turtles are infrequently associated with open sand bottoms, however the sand bottom will not impede travel to adjacent sea turtle habitat. The after-impact habitat corridor for sea turtles was scored an 8 (**Table 3**).

2.2 MITIGATION SITE – HABITAT CORRIDOR

2.2.1 Macroalgae

BEFORE Mitigation
With the exception of worm tubes and shell fragments, sand bottom habitat provides very limited opportunities for macroalgal attachment. However, there are no impediments to dispersal within the water column. The corridor at the mitigation site was scored as a 1 (**Table 3**).

AFTER Mitigation
The properties and characteristics of the proposed mitigation reef provide substrate for attachment and growth of macroalgal species found in the subtidal region of the Mid Reach. The addition of free hard bottom substratum promotes the development of fouling assemblages and increases the biomass of an area (Svane and Petersen, 2001). The proposed mitigation is constructed of material with similar composition (coquina) as the existing reef.

Factors that may constrain the ability to replicate species composition are based mostly on the distance from the wave zone and the depth of the proposed site. The water depth, light penetration, and laminar flow will differ from the impact site. The macroalgal species diversity may reflect only 65% to 70% of the existing algal composition at the impact site. This is based on observations at natural and artificial reefs in Indian River County (**Appendix A**) and a literature review (Dawes, 1981; Luning, 1990; Littler and Littler, 2000; Schneider and Searles, 1991) of depth ranges for specific species. During in-water observations, some discrepancies where species were located outside of the ranges specified in the literature were found. The mitigation reef scored a 6 (**Table 3**).

2.2.2 Invertebrates

BEFORE Mitigation
Invertebrate assemblages of the mitigation sites were not directly investigated; however, both infaunal and epifaunal species are expected to be present. Infauna include burrowing organisms such as worms, clams, snails, shrimps, crabs, and sea cucumbers, whereas epifauna consist of shrimps, crabs, gastropods, and sand dollars. Because most infaunal invertebrates have planktonic larvae and motile adults, there are no barriers to movement of organisms to and from the site. However, there is no hard bottom present at the site, thus no hard bottom epifaunal assemblage has developed and connectivity, particularly for sessile forms, will be low. A score of 1 was given to this category (**Table 3**).

AFTER Mitigation
Following deployment of the artificial reef, hard bottom substrate will be available for colonization by habitat-limited sessile invertebrates (Svane and Petersen, 2001). This will provide connections with the local hard bottom epifaunal assemblages that are producing planktonic larvae. Because of restored connections, this category scored a 6 (**Table 3**).

2.2.3 Fishes

BEFORE Mitigation
Along the cross-shelf habitat continuum of the local area, the proposed mitigation sites are best described as inner shelf soft bottom. The bottom-associated or demersal ichthyofauna inhabiting the inner shelf of eastern Florida includes sharks, rays, eels, croakers, drums, porgies, searobins, and flatfishes (Anderson and Gehringer, 1965; Gilmore et al, 1981; Wenner

and Sedberry, 1989). Presently, location and landscape support is not expected to impede movements of planktonic larvae, early juvenile, or larger demersal individuals into or out of the area. Lack of hard bottom indicates that juvenile reef fishes are not expected to be present; adult and planktonic phase reef fishes may traverse the sites but are only responding to the water column and not the seafloor habitat. The before-mitigation score is a 1 (**Table 3**).

AFTER Mitigation
Following the deployment of the artificial reefs, the fish assemblage of the mitigation sites will consist of reef-associated species. Artificial reefs will attract adult and juvenile fishes from surrounding hard bottom areas and provide sites for the settlement of planktonic larvae. The artificial reef should contribute positively to connectivity of the cross-shelf habitat gradient, particularly for reef fish species. This assumes that the reef material is physically stable and persistent over time. For early life stage fishes, the score is a 2 because not all species found at the impact site will settle in the slightly deeper waters of the mitigation sites. Because most adults found on the impact site are likely to occur in the waters of the mitigation sites following the construction of the artificial reef, the score for adult fishes is a 9 (**Table 3**).

2.2.4 Sea Turtles

BEFORE Mitigation
There are no barriers to the nesting beach via the water corridor for adult loggerhead, green, and leatherback sea turtles that are coming ashore to lay eggs. Juvenile loggerhead and green turtles are infrequently associated with bare, sand bottom habitat. This area was scored a 1 (**Table 3**).

AFTER Mitigation
The proposed mitigation reef poses no restriction to the nesting corridor for adult marine turtles in the Mid Reach area. The reef does provide additional habitat and close connectivity to adjacent habitats for immature loggerhead and green sea turtles. The mitigation reef corridor was scored 9 (**Table 3**).

2.3 UMAM SUMMARY EXPLANATION/IMPLICATIONS

2.3.1 UMAM Rating for Habitat Corridor at the Impact Site

BEFORE Impact
As a habitat corridor, the impact site received an average rating of 9 (**Table 3**). While it provides a corridor for sea turtles and fishes that are highly mobile, it is beyond or at the limits for dispersal distances for macroalgal propagules (Dethier et al., 2003; Bellgrave et al., 2004). Recruitment is most likely local and could represent a bottleneck in genetic variability.

AFTER Impact
After the hard bottom is covered by sand, the connections between adjacent hard bottom segments is severed and a sandy void is created. This will reduce local recruitment of macroalgae and invertebrates and present a problem for movement of smaller fishes that will be more susceptible to predation when moving across open sand. Open sand areas will not, however, present barriers to movements for planktonic young or larger adult fishes nor adult juvenile turtles. The average score for habitat corridor after impact is 4.4 (**Table 3**).

Habitat created at the site of impact through fill activities will increase the already abundant resource of soft, sand bottom habitat. Invertebrates associated with soft, sand bottom habitat would be expected to recruit within a reasonably short period of time. Their relative abundance is more likely driven by life cycle characteristics. This was documented immediately south of the Mid Reach area by Lacharmoise et al. (2005).

2.3.2 UMAM Rating for Habitat Corridor at the Mitigation Site

BEFORE Mitigation
Soft bottom does not offer extensive consolidated hard substrate necessary for the settlement, growth, and attachment for macroalgae. Fragmented *Caulerpa prolifera* was the only macroalga found in the mitigation area. It was found growing on the periodic exposure of tubeworm casings. This habitat type is also well represented in the marine environment. Level soft bottom is part of the cross-shelf habitat continuum but does not facilitate movements of reef-associated species (and life stages) across that continuum. The current condition of the mitigation site was rated 1 (**Table 3**).

AFTER Mitigation
The mitigation reef will provide a surface area for the settlement and propagation of macroalgae and will not prevent barriers to nesting turtles. The algal composition may differ to some extent, but many of the same species that utilize the current subtidal areas of the nearshore hard bottom in the Mid Reach will disperse and settle under the distance and conditions offered by the mitigation project. Similarly, invertebrates and fishes that associate with reefs and hard substrate will colonize the artificial reef through immigration and larval settlement. For many species the artificial reefs will provide connections with nearby habitats and therefore maintain developmental pathways. The mitigation site received a habitat corridor rating of 6.4 based on these factors (**Table 3**). Net gain for the mitigation site is actually higher than the net loss, because from the perspective of hard bottom the mitigation site goes from one of no hard bottom to creation of hard bottom where none previously existed. This maintains and extends the cross-shelf habitat gradient and adds hard substratum to the system. The impacted hard bottom is only a part of a larger hard bottom area, so hard bottom is not totally eliminated.

3.0 WATER ENVIRONMENT

This component evaluates the hydrologic conditions and, in this case, more readily pertains to water quality.

3.1 IMPACT SITE – WATER QUALITY

BEFORE Impact
Water quality parameters under the present scenario include turbidity, salinity, dissolved oxygen, leachate from septic tanks, and chemical contamination. Upland runoff including leachates from septic tanks may slightly degrade marine water quality during heavy rains. Persistent waves make high turbidity the norm in the Mid Reach area. Eddies and turbulence around rocks may increase turbidity; nevertheless, there is no reason to expect that the current water environment is anything other than optimal for the extant organisms. In fact, some level of suspended sediment is required by the reef building polychaete *Phragmatopoma caudata*. The before-impact score for all of the biological elements is 9 (**Table 4**).

Table 4. Water environment scores for individual taxa at impact and mitigation sites along the Brevard County Mid Reach.

Taxa	Water Environment			
	Water Quality			
	Impact		Mitigation	
	Before	After	Before	After
Macroalgae	9	9	9	9
Invertebrates	9	9	9	9
Juvenile Fishes	9	9	9	9
Adult Fishes	9	9	9	9
Sea Turtles	9	9	9	9
Average	9	9	9	9

AFTER Impact
A wider beach will provide better filtering for upland run off, and slightly coarser sediment may reduce turbidity. Elevated turbidity can be temporary or chronic, depending on the sedimentary characteristics of the material placed on the beach. The sand source proposed for this project has been utilized previously with no turbidity problems. Based on the assumption that the proposed sand source does not contain higher fractions of fine sediment than the native material, water quality should be the same as pre-construction levels once construction related turbidity recedes. Therefore, the after-impact score is 9 (**Table 4**).

3.2 MITIGATION SITE – WATER QUALITY

BEFORE Mitigation
No data are available on water quality variables from the mitigation site, but we assume that water quality is good and reflects local conditions without conspicuous problems. As with the impact site, a score of 9 is given across all taxa (**Table 4**).

AFTER Mitigation
Placement of the artificial reef will influence the water flow and turbulence around the reef footprint. This should not affect water quality. During and immediately after construction of the artificial reef, there will be elevated turbidity due to propeller wash and placement of the

modules. Construction-generated turbidity should subside rapidly, so the score for all taxa is 9 (**Table 4**).

3.3 UMAM SUMMARY EXPLANATION/IMPLICATIONS

3.3.1 UMAM Rating for Water Quality at Impact Site

BEFORE Impact
Although water quality at the impact site may be slightly impacted by freshwater runoff sources from nearby roadways, groundwater contamination from septic tanks, and condominium water-cooling air conditioner systems, the general parameters of salinity, turbidity, and dissolved oxygen are expected to be typical for coastal waters of the region. The presence of diverse biotic assemblages without any obvious indicators (e.g., “nuisance” algae) of degraded conditions is evidence of good water quality; therefore, the impact site was rated as a 9 (**Table 4**).

AFTER Impact
The primary project-related effect on water quality will be elevated turbidity. High turbidity levels are expected during construction, but these levels should return to background conditions when construction ends. The potential for chronic post-construction turbidity will depend on sand source and characteristics. With the standards of sand grain and composition set forth in the nourishment permitting process and past history of projects using the same local borrow material, it is unlikely that water quality will be diminished. It was rated as a 9 (**Table 4**).

3.3.2 UMAM Rating for Water Quality at the Mitigation Site

BEFORE Mitigation
The mitigation area is deeper and further from shore than the impact site. The water is usually much less turbid than in the intertidal zone during short periods of high-energy wave activity. The mitigation site is located 300 to 400 m from shore and is not highly susceptible to land-based runoff. Existing water quality at the mitigation site was rated as a 9 (**Table 4**).

AFTER Mitigation
The mitigation site is located 300 to 400 m from shore and is not highly susceptible to land-based runoff. Water quality at the mitigation site was rated as a 9 (**Table 4**).

4.0 COMMUNITY STRUCTURE

In this section, community structure components are evaluated for the impact and mitigation assessment areas. The functional indicator for marine systems in the UMAM evaluation process is the hard bottom benthic community. The process attempts to realize that the species composition on coral reefs and live hard bottom is variable and highly dependent on structure and habitat. The functions evaluated for community structure are the ability for the impact and mitigation areas to provide substrate, cover, nesting, feeding, and nursery areas.

4.1 IMPACT SITE – SUBSTRATE

4.1.1 Macroalgae

BEFORE Impact
Anastasia limestone outcroppings, sabellariid worm rock, and compressed coquina rocks form the substrate on which an abundant and diverse number of macroalgae thrive in the intertidal and subtidal areas of the nearshore. Brown, green, and primarily red algae represent the primary producers in this marine community. Approximately 25 different species of macroalgae were identified in the Mid Reach in the macroalgae surveys (Continental Shelf Associates, Inc., 2005; Holloway-Adkins and Provancha, 2005). The impact site was scored 10 (**Table 5**) due to temporally high availability and diversity of macroalgal species.

AFTER Impact
The absence of substrate after impact will eliminate algal growth in the nearshore. Where fragments of *Caulerpa prolifera* grew in deeper water on tubeworm casings, the nearshore environment with high-energy wave action and no hard substrate will not induce macroalgal survival or growth. After impact was rated 0 (**Table 5**).

4.1.2 Invertebrates

BEFORE Impact
Sessile invertebrates including sponges, hydroids, sabellariid worms, and tunicates attach to the coquina limestone substrate provided by the Mid Reach hard bottom (Continental Shelf Associates, Inc., 2005). Sabellariid worms form extensive colonies that can spatially dominate the coquina substrate, providing another layer of complexity to the nearshore hard bottom. These colonies are commonly called worm rock (Kirtley and Tanner, 1968). Substrate use by invertebrates, particularly hard bottom sessile forms, is rated as a 10 (**Table 5**).

AFTER Impact
Direct burial of hard bottom by the proposed project will eliminate hard substrate and its sessile assemblage and replace it with level sand bottom. The new sand substrate will be utilized by infaunal (e.g., polychaete worms, bivalves, and gastropods) and epifaunal invertebrates (e.g., swimming crabs, shrimps, and echinoderms), but with no hard bottom substratum, hard bottom sessile species will not be present. For this reason, invertebrate use of substrate after the impact was scored as a 1 (**Table 5**).

Table 5. Community structure scores for individual taxa at impact and mitigation sites along the Brevard County Mid Reach.

Taxa	Community Structure																			
	Substrate				Cover				Nesting Area				Feeding Area				Nursery Area			
	Impact		Mitigation		Impact		Mitigation		Impact		Mitigation		Impact		Mitigation		Impact		Mitigation	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
Macroalgae	10	0	0	8	9	0	0	8	n/a	n/a	n/a	n/a	9	0	0	7	n/a	n/a	n/a	n/a
Invertebrates	10	1	1	9	9	1	1	8	5	2	2	5	9	2	2	7	9	2	1	7
Juvenile Fishes	n/a	n/a	n/a	n/a	9	1	1	7	n/a	n/a	n/a	n/a	9	2	2	8	9	1	1	7
Adult Fishes	n/a	n/a	n/a	n/a	8	1	1	7	5	1	1	5	9	2	2	7	n/a	n/a	n/a	n/a
Sea Turtles	n/a	n/a	n/a	n/a	8	0	0	7	n/a	n/a	n/a	n/a	9	0	0	7	9	0	0	7
Average	10	0.5	0.5	8.5	8.6	0.6	0.6	7.4	5	1.5	1.5	5	9	1.2	1.2	7.2	9	1.333	0.667	7

n/a = not applicable.

4.1.3 Fishes

BEFORE and AFTER Impact
In the UMAM context, substrate is considered as attachment surfaces for sessile invertebrates and algae. Fishes do not attach to the substrate; see sections on cover and feeding (**Sections 4.2.3** and **4.4.3**, respectively) for details about how fishes utilize substrate.

4.1.4 Sea Turtles

BEFORE and AFTER Impact
Sea turtles are affiliated with substrate, however, they do not attach themselves to it.

4.2 IMPACT SITE – COVER

4.2.1 Macroalgae

BEFORE Impact
The substrate provides for cover (in the form of crevasses) that can produce shade or shelter. Canopy (or fleshy) macroalgal species also provide cover, especially for turf-forming species. There are few studies that focus on specific interactions between turf and canopy macroalgae in the western Atlantic and Caribbean. Baek et al. (2004) found both positive and negative effects between two species similar to those found in the Mid Reach (Genera: *Chondracanthus* and *Pterocladia*). The function for cover was scored a 9 (**Table 5**).

AFTER Impact
The lack of substrate will eliminate any function of cover for turf species by canopy species. The after-impact score was 0 (**Table 5**).

4.2.2 Invertebrates

BEFORE Impact
Motile invertebrates, especially spider, porcelain, and mud crabs, seek cover under ledges in crevasses provided by the hard bottom. In addition, many decapods and stomatopods associate with the structure provided by worm rock (Gore et al., 1978). The Cuban stone crab *Menippe nodifrons*, a smaller relative of the commercially important stone crab (*M. mercenaria*), is commonly observed along the Mid Reach where it inhabits small ledges and is sheltered in small crevices, holes, and ledges. The before-impact status of invertebrate use of cover provided by the nearshore hard bottom yields a score of 9 (**Table 5**).

AFTER Impact
Hard bottom cover will be eliminated within the impact footprint. The sediment placed on the project site will provide cover for a different suite of invertebrates other than those found on hard bottom. Infaunal and epifaunal invertebrates characteristic of soft bottoms will colonize the sand placed over the area. Without hard bottom there will be no hard bottom-associated sessile or motile invertebrates left in the impact site. The score for this category is 1 (**Table 5**).

4.2.3 Fishes

BEFORE Impact
Fishes utilize the hard bottom structure for shelter at several spatial scales. Small solitary individuals (e.g., blennies, gobies, and clingfishes) use small (ca. 1 to 10 cm) holes, cracks, and ledges. Larger reef fishes such as black margate, cubbyu, striped croaker, and gray snapper

seek shelter under ledges (approximately 10 cm to 1 m in relief) and overhangs formed by the tabular outcrops that occur along the Mid Reach hard bottom. It appears that adult and juvenile fishes congregate under ledges and overhangs seeking shelter not only from predators but also from the constant wave surge. The before-impact score for adult fishes is 8 and the score for early life stage fishes is 9 because life stage composition of nearshore hard bottom fish assemblages is generally skewed toward immature individuals (Lindeman and Snyder, 1999) (**Table 5**).

AFTER Impact
Following the impact, hard bottom cover will be lost to the local system, and fishes utilizing the impact area will mostly be soft bottom and coastal pelagic species. Cover provided by level sand bottom is only used by a few burrowing species such as eels, jawfishes, and gobies. There will be few, if any, reef fishes that regularly seek or use cover provided by the hard bottom features remaining in the impact area. Accordingly, a score of 1 is given for both early life and adult stages (**Table 5**).

4.2.4 Sea Turtles

BEFORE Impact
Juvenile green turtles utilize the shallow limestone ledges and relief for resting areas. Tucked away on the inside of ledges, small turtles are able to avoid the pounding surf in the intertidal zone. Many of the ledges are narrow and afford protection from large predators. The function of cover at the impact site was scored an 8 (**Table 5**).

AFTER Impact
No cover function is afforded after impact. The score is a 0 (**Table 5**).

4.3 IMPACT SITE – NESTING AREA

4.3.1 Macroalgae

BEFORE and AFTER Impact
This ecological function does not apply to macroalgae.

4.3.2 Invertebrates

BEFORE Impact
Most of the motile invertebrates (e.g., crabs, shrimps, and sea urchins) inhabiting nearshore reefs brood their fertilized eggs before releasing them into the water column as planktonic larvae. Other invertebrates, such as gastropods and nudibranchs, attach eggs to the substrate in what could be regarded as nests. No nests or egg masses have been observed along the Mid Reach hard bottom, but species known to deposit demersal eggs are present. Thus, a score of 5 is given for this category (**Table 5**).

AFTER Impact
Invertebrates expected to assemble on the soft bottom footprint of the impact site will include some egg laying taxa. However, following the burial of hard bottom there will be no hard surface for depositing eggs by any invertebrates adapted to this reproductive mode. This results in an after-impact score of 2 (**Table 5**).

4.3.3 Fishes

BEFORE Impact
Some fishes, particularly blennies, gobies, damselfishes, triggerfishes, and clingfishes, lay demersal eggs that adhere to the coquina limestone substrate. No nests have been observed at the Mid Reach, but species known to lay demersal eggs are present (Continental Shelf Associates, Inc., 2005). A score of 5 is given for the pre-impact nesting function (**Table 5**).

AFTER Impact
Following burial of the hard bottom, fish species that deposit eggs on hard substrata will be displaced. Most of the soft bottom fishes that will be present following the impact do not nest, but instead release gametes into the water where they are broadcast over broad spatial scales. The post-impact score for this category is 1 (**Table 5**).

4.3.4 Sea Turtles

BEFORE and AFTER Impact
Sea turtles use the adjacent beaches but not the nearshore waters for nesting.

4.4 IMPACT SITE – FEEDING AREA

4.4.1 Macroalgae

BEFORE Impact
On high-energy shorelines, available phosphorous, trace minerals, and carbon are rapidly resuspended in the water column. This activity promotes the growth and productivity of macroalgae (Bustamante et al., 1997; Santelices, 1990, Hurd, 2000). The light and substrate conditions make attachment and photosynthesis processes possible for macroalgae. However, nutrient components (especially available nitrogen and phosphorus) determine growth and production of macroalgae. This function was scored as a 9 (**Table 5**).

AFTER Impact
While wave energy will provide constant nutrient flow, macroalgae will not be present after impact in the absence of substrate. The feeding area score for macroalgae is 0 (**Table 5**).

4.4.2 Invertebrates

BEFORE Impact
Sessile invertebrates are primarily suspension feeders and depend on suspended detrital and particulate organic matter emanating from surrounding waters. Being attached to the elevated hard bottom allows suspension feeders better access to their food. Motile invertebrates such as mollusks, crabs, shrimps, and sea urchins feed on a variety of items including macroalgae, sessile invertebrates, amphipods, isopods, and others small motile invertebrates that associate with hard bottom. Gore et al. (1978) found that some of the most common crabs inhabiting sabellariid reefs fed on the worms that constructed the habitat. Invertebrate feeding opportunities was scored 9 (**Table 5**).

AFTER Impact
After the impact, feeding opportunities for hard bottom species essentially will be eliminated. However, because soft bottom species expected to colonize the impact footprint will possibly serve as prey for motile hard bottom species such as swimming crabs or octopods, a score of 2 is given (**Table 5**).

4.4.3 Fishes

BEFORE Impact
Fish assemblages inhabiting the Mid Reach hard bottom are composed of herbivores, carnivores, planktivores, and omnivores. The relative abundance of these broad feeding types is unknown, but each depends to some extent on some feature of the hard bottom, adjacent soft bottom, or water column to be successful. There are species that graze directly on attached epibiota. Many fishes rely on plankton during their early life stages. The microcirculation patterns created by the hard bottom structure may facilitate planktonic feeding for these individuals. Others will shelter around the hard bottom and then forage, often at night, over the adjacent soft bottom areas. The score for early life and adult stage fishes before the impact is 9 (**Table 5**).

AFTER Impact
After impact the fish assemblage will be a soft bottom assemblage consisting mostly of bottom feeding species and occasional pelagic predators traversing the area. Hard bottom species will find limited foraging over the sandy area. Some species will seek shelter by day around the larger features, then foray out into the sandy plains at night. The score for this category is 2 (**Table 5**).

4.4.4 Sea Turtles

BEFORE Impact
The impact site functions as an important foraging habitat for juvenile green turtles. Macroalgae are diverse, abundant, and temporally available. Green turtles forage mostly on red algae, which are abundant at the impact site (Holloway-Adkins and Provancha, 2005). Feeding was scored 9 for sea turtles (**Table 5**).

AFTER Impact
The macroalgae food resources for juvenile green turtles are eliminated. Immature loggerhead turtles may forage on soft bottom benthic organisms, however, these will be in relatively shallow water. This limits access to foraging for the larger juvenille loggerhead turtles. The feeding function after impact fell between 0 and 1 due to unlikely events of loggerhead turtles moving into this area. Loggerhead sightings were infrequent in the Mid Reach area and were not observed in shallow intertidal waters

4.5 IMPACT SITE – NURSERY AREA

4.5.1 Macroalgae

BEFORE and AFTER Impact
This ecological function does not apply to macroalgae.

4.5.2 Invertebrates

BEFORE and AFTER Impact
This ecological function does not apply to invertebrates.

4.5.3 Fishes

BEFORE Impact
Nearshore hard bottom is considered important habitat for juvenile fishes because of the skewed abundance of early life-stage individuals that characterizes the assemblages (Lindeman and Snyder, 1999). A precise definition of nursery area should consider the relative contribution of the young fishes from a particular habitat to the adult populations and not just abundance (Beck et al., 2001; Dahlgren, et al., 2006). These data are not available for the region, but enough evidence exists on the distribution of fishes across a range of habitats (Gilmore et al., 1981) to identify species that are exclusively using nearshore hard bottom as nursery areas. The nursery function of the nearshore hard bottom in southeastern Florida has been documented (Lindeman and Snyder, 1999). This leads to a score of 9 for early life stage individuals (**Table 5**).

AFTER Impact
Once the nearshore habitat is buried, there will be a transition from the structure afforded by the hard bottom, which is important to young reef species. Following construction, the nursery function of the area for reef fishes is lost, but it is likely that the young of some hard bottom species will utilize the impact area for feeding. Juveniles of soft bottom (e.g., kingfishes, drums, and croaker) and coastal pelagic (e.g., pompano, permit, and mullets) species also will utilize the impact area. The post-impact score for early life-stage fishes is 2 (**Table 5**).

4.5.4 Sea Turtles

BEFORE Impact
Juvenile green turtles recruit to nearshore habitats at approximately 20.0 to 30.0 cm straight carapace length (SCL) (Carr, 1987; Hirth, 1997). Population studies conducted in the Mid Reach indicate juvenile green turtles and immature loggerhead turtles utilize this area as developmental habitat (Holloway-Adkins and Provancha, 2005). Foraging samples from captured green turtles, and tracking data indicate turtles are actively feeding and resting in this habitat. The average size class (35.8 SCL) and size distribution indicate these animals represent a relatively smaller-sized population of juvenile green turtles when compared to other population studies on the east coast of Florida (Bresette et al., 1998; Wershoven and Wershoven, 1992; Ehrhart et al., 2001; Ehrhart et al., 1996). Shallow, nearshore habitats may prove more beneficial to these relatively small juvenile green turtles than to the larger ones (Redfoot, 1997). Accessibility to resources in this nearshore habitat is easier for smaller animals with the ability to maneuver in the shallows, and may provide a competitive advantage over larger animals. The area was scored as a 9 for nursery habitat (**Table 5**).

AFTER Impact
Juvenile green turtles are rarely associated with open, bare sand bottom. These areas lack refugia from predators or rest areas in the form of ledges and crevices. Macroalgal food resources for green turtles do not grow on sand bottoms. Loggerheads may feed on soft bottom invertebrates, but the high wave energy in the shallow waters where food may be found may be inaccessible for the relatively larger juvenile loggerhead turtles. The scoring (0) after-impact reflects a rounding of the potential (1) to the unlikely (0), that this area will provide nursery habitat after impact (**Table 5**).

4.6 MITIGATION SITE – SUBSTRATE

4.6.1 Macroalgae

BEFORE Mitigation
Small fragments of *Caulerpa prolifera* were found attached to tubeworm casings in 3 to 5 m water depths. The lack of substrate prevents macroalgae from flourishing in this area. It was scored as a 0 (**Table 5**).

AFTER Mitigation
The mitigation plan (using locally quarried coquina limestone for the mitigation surface) will provide matching substrate necessary for the attachment and growth of macroalgal species. Enhanced light penetration may exist outside the wave zone, which would enable many of the same species to thrive in the subtidal conditions at the mitigation site. Santelices (1990) noted that wave-exposed rocky intertidal habitats of central Chile exhibited zonation of algal morphologies rather than strict patterns of species zonation. Fleshy red algae were observed at the Indian River County mitigation reefs at 5-m water depths (**Appendix A**, **Table 2**). The substrate function for the mitigation reef was scored as an 8 (**Table 5**).

4.6.2 Invertebrates

BEFORE Mitigation
Invertebrates inhabiting the mitigation sites would either be those that live within the sediments (infauna) or on the seafloor (epifauna). Worms, clams, snails, shrimps, crabs, sea cucumbers, sand dollars, sea biscuits, and other invertebrates either utilize the sediment surface or burrow into the soft bottom. Due to a lack of hard bottom, reef-associated species (sessile and motile) are not present at the mitigation sites. The pre-mitigation score for these sites is 1 (**Table 5**).

AFTER Mitigation
After the deployment of the artificial reef, the soft bottom assemblage will be displaced and hard bottom species will develop. Hard bottom substrate provided by the artificial reef will include native coquina rock that is expected to promote settlement of species found at the impact site. Some taxa will be generalized about the substrate, whereas others will require particular topographic and chemical characteristics. The proposed mitigation reefs were designed to account for the varied substrate preferences by individual species. The score for this category is 9 (**Table 5**).

4.6.3 Fishes

BEFORE and AFTER Mitigation
This ecological function does not apply to fishes.

4.6.4 Sea Turtles

BEFORE and AFTER Mitigation
Sea turtles are found in association with substrate but not attached to it.

4.7 MITIGATION SITE – COVER

4.7.1 Macroalgae

BEFORE Mitigation
Only one species of macroalgae is present in the mitigation area. No provision of cover for turf species can be found. Cover was scored as a 0 (**Table 5**).

AFTER Mitigation
The mitigation reef profile provides similar conditions as the impact site and seeks to mimic the structures and features that enhance macroalgal growth and attract the same epifauna. This will provide similar assemblages with canopy/turf species cover relationships due to the available substrate. It was scored as an 8 (**Table 5**).

4.7.2 Invertebrates

BEFORE Mitigation
The pre-mitigation invertebrate assemblage found at the mitigation sites is expected to include a variety of typical infaunal and epifuanal species. These species take cover by burrowing into the expanse of soft sediment. However, because no hard bottom cover is available for hard bottom invertebrates, the score for this category is 1 (**Table 5**).

AFTER Mitigation
After the artificial reefs are deployed, the amount of cover for hard bottom species will dramatically increase. Crevices, holes, and overhangs will provide crabs, shrimps, and sea urchins sufficient cover from predation, wave energy, and ultraviolet light. The post-mitigation score is 8 (**Table 5**).

4.7.3 Fishes

BEFORE Mitigation
Some demersal fishes such as snake eels, gobies, and jawfishes burrow into soft sediments for cover. Some demersal species such as flounder (*Paralichthys* spp.) and red drum are managed fishery species. Currently, the mitigation sites provide no cover for reef fish species and thus are given a score of 1 for adult and early life stages (**Table 5**).

AFTER Mitigation
After the artificial reefs are deployed the amount of cover will clearly increase. Early life stage and adult reef fishes including snappers, grunts, porgies, and drums will utilize this cover. Because of the increase in cover available for all life stages, a score of 7 is given (**Table 5**). In Palm Beach County the striped croaker, a species of special concern, seeks cover and is more abundant on artificial mitigation reefs than on adjacent natural reefs (Continental Shelf Associates, 2005, 2006). A higher score was not given because species-specific differences in habitat preference will exclude some individuals and species on the deeper artificial reefs.

4.7.4 Sea Turtles

BEFORE Mitigation
No cover at the mitigation site is currently present. Sea turtles are rarely associated with bare, sand bottom habitats. The function of cover at the mitigation site was scored 0 (**Table 5**).

AFTER Mitigation
The physical characteristics of the substrate will provide the same benefits as discussed for the impact site. Substrate placed in deeper waters, however, may influence the size-class distribution of green turtles in this area. Currently, the average SCL of juvenile green turtles captured at the impact site is 35.8 cm. Deeper refugia may attract a larger size class of turtles to utilize the area, possibly negatively impacting space for smaller turtles. The after-mitigation score was a 7 (**Table 5**).

4.8 MITIGATION SITE – NESTING AREA

4.8.1 Macroalgae

BEFORE and AFTER Mitigation
(n/a)

4.8.2 Invertebrates

BEFORE Mitigation
Some invertebrates that deposit demersal eggs may use the soft substrate at the mitigation sites. The absence of hard bottom at the mitigation sites precludes egg laying by reef-associated invertebrates. A score of 2 is given for this category (**Table 5**).

AFTER Mitigation
The artificial reef will provide hard surfaces for the deposition of eggs by invertebrates. The structural design and use of coquina rock in the artificial reef will help simulate conditions found on the hard bottom of the impact site. The difference in water depth between the impact and mitigation sites causes some uncertainty as to what species will actually use the artificial sites for nesting or egg laying. However, because invertebrate species known to deposit demersal eggs occur in the area, a score of 5 is given for this category (**Table 5**).

4.8.3 Fishes

BEFORE Mitigation
As described for invertebrates, some demersal fishes are known to deposit eggs directly on the seafloor. However, most soft bottom species that occur in the region are water column spawners and do not deposit eggs in nests or on the substrate. The score for this category is 1 (**Table 5**).

AFTER Mitigation
After the artificial reef is in place, there will be considerable surfaces that could be used for egg laying by blennies, damselfishes, and clingfishes. Crevices and holes will be more important for clingfishes and blennies, whereas damselfishes will use open areas under ledges. Little is known about demersal egg laying behavior in fishes from the impact site, but because egg laying species are known to occur in the area, the post-mitigation score is 5 (**Table 5**).

4.8.4 Sea Turtles

BEFORE and AFTER Mitigation
(n/a)
While the adjacent beaches are nesting grounds for sea turtles, the nearshore waters are not used in this capacity.

4.9 MITIGATION SITE – FEEDING AREA

4.9.1 Macroalgae

BEFORE Mitigation
The only macroalgae observed in the proposed mitigation area were fragments of *Caulerpa prolifera,* attached to exposed tubeworm casings (personal observation, K. Holloway-Adkins). The lack of substrate in the mitigation area eliminates the opportunity for macroalgal growth. This was scored as a 0 (**Table 5**).

AFTER Mitigation
Light and nutrients are major limiting factors for macroalgal growth. The subtidal zone has adequate light and nutrient availability to promote the growth and production of macroalgae. The resources currently available to macroalgae at the subtidal zone of the impact site should be equivalent at the mitigation site. Benefits of the subtidal zone include the fact that light may become less scattered and penetrate deeper than it does in the intertidal wave zone. Feeding, available nutrients, and light penetration enhance macroalgae growth at the mitigation reef. This function was scored as a 7 (**Table 5**).

4.9.2 Invertebrates

BEFORE Mitigation
The pre-mitigation soft bottom assemblage will be composed of taxa employing various feeding modes. Infaunal species such as worms and bivalves will feed on suspended and deposited material. Motile species such as crabs, shrimps, and gastropods will be predators or scavengers and echinoderms will graze on microbes covering sediment grains. There are, however, no feeding opportunities for hard bottom taxa, and therefore the score is 2 (**Table 5**).

AFTER Mitigation
The artificial reef will provide feeding opportunities for motile and sessile hard bottom species. A trophic web will develop where motile species feed on other motile and sessile biota (Gore et al., 1978). The after-mitigation score is 7.

4.9.3 Fishes

BEFORE Mitigation
Demersal species may feed on infaunal and epifaunal invertebrates that characterize soft bottom habitats. The fish assemblage at the mitigation site should be composed of demersal species (e.g., stingrays, red drum, Atlantic croaker, kingfishes, and flatfishes) that feed on soft bottom invertebrates and coastal pelagic species (e.g., sharks, tarpon, herrings, anchovies, Spanish mackerel, jacks) that feed on water column dwelling plankton, invertebrates, and fishes. Hard bottom species feeding at the mitigation site would be limited to larger, wide ranging species such as grunts and snappers that may venture away from hard bottom to forage. The pre-mitigation score for both juvenile and adult fishes was 2.

AFTER Mitigation
After mitigation, the presence of hard bottom will create feeding opportunities for hard bottom species that graze on attached invertebrates or algae. In addition, many common hard bottom species and especially juvenile stages depend on input of plankton from the surrounding water column for nutrition. The presence of the hard bottom structure will create small scale turbulence that will facilitate plankton feeding by these individuals. Because juveniles are

expected to be represented by more species and individuals than adults, the post-mitigation score for juveniles was 8 and the post-mitigation score for adults was 7.

4.9.4 Sea Turtles

BEFORE Mitigation
Juvenile green turtles would not find forage in this area. Juvenile loggerhead turtles may feed on soft bottom invertebrates. This function was scored 0 before mitigation (**Table 5**).

AFTER Mitigation
The substrate material is of similar composition as the nearshore rock at the impact site. Many of the same macroalgal species present at the subtidal zone of the Mid Reach are expected to grow at the mitigation site. Juvenile green turtles of a larger size class may have access to resources that were previously limited to a very small size class of turtles. This could introduce intraspecies competition for space and resources. This function was scored 7 (**Table 5**) under these predictions.

4.10 MITIGATION SITE – NURSERY AREA

4.10.1 Macroalgae

BEFORE and AFTER Mitigation
(n/a)

4.10.2 Invertebrates

BEFORE Mitigation
Early life stages of soft bottom invertebrates are expected to be present throughout the mitigation site varying in abundances and occurrence with reproductive activity of adults at local and regional spatial scales. This mitigation area may include early stages of managed penaeid shrimp species. Young of hard bottom species at the mitigation site would be limited to cases where planktonic larvae colonized shell fragments, worm tubes, or other fragments of hard substrate present on the otherwise sandy bottom. The pre-mitigation score for this category is 1.

AFTER Mitigation
Once the mitigation reef is in place, hard substratum will be available for use by early life stages of sessile and motile hard bottom species. Colonization by sessile species will follow a successional trajectory that will reflect facilitation, inhibition, and tolerance by various epibiota. Young of motile invertebrates are expected to colonize the smaller spaces and ledges provided by the artificial reef. One motile species likely to colonize the artificial reef is the federally-managed stone crab (*Menippe mercenaria)*. Although colonization by early life stages of both sessile and motile taxa is expected to be rapid, uncertainty remains about how closely the overall composition of the assemblage utilizing the artificial reef as a nursery area will resemble that of the impact site. The post-mitigation score is 7.

4.10.3 Fishes

BEFORE Mitigation
Early life stages of fishes present at the mitigation site are expected to be represented by young of kingfishes, drums, weakfish, flounders, and other demersal species. Juveniles of hard

bottom species are not expected to occur other than by chance at the level bottom mitigation site. The pre-mitigation score is 1.

AFTER Mitigation
Due to species-specific preferences, not all species found at impact site will initially settle at the mitigation sites, but a majority of the regional reef fish species including federally managed snapper, grunts, porgies, and groupers are expected to utilize the artificial reefs. The artificial reefs lying in deeper waters may attract more predators than were found at the shallower impact sites and thus present a greater potential predation pressure to incoming larvae and juveniles. The proposed artificial reef is designed to provide ledges and small spaces for young fishes to hide in and lessen the predation factor. The score for this category is 7 (**Table 5**).

4.10.4 Sea Turtles

BEFORE Mitigation
The current site for the mitigation is not recognized as a nursery or developmental habitat. Green and loggerhead sea turtles are rarely associated with soft sand bottom. This area was scored a 0 for nursery function (**Table 5**).

AFTER Mitigation
The area should function as developmental habitat for juvenile green turtles, however, competition from larger size class turtles may be a result of the mitigation reef resource placement in deeper waters. The structural design of the mitigation reef was planned to create small crevasses specifically for small turtles to hide and rest in (**Figure 1**). The area was scored 7 for after the mitigation reef is in place (**Table 5**).

4.11 UMAM SUMMARY EXPLANATION/IMPLICATIONS

4.11.1 UMAM Rating for the Community Structure at the Impact Site

BEFORE Impact
Community structure at the impact site scored an average of 8.3 for the existing hard bottom without impact (**Table 5**). All of the ecological functions listed were relevant for the associated taxa, and clearly these taxa are adapted to the nearshore hard bottom habitat. The function that scored lowest (5) and brought this average down was the nesting function of the habitat. Nesting is not well known for invertebrates and fishes on the Mid Reach, and the low score for this category is due in part to uncertainty. The other ecological functions related to the impact site score very high.

AFTER Impact
Burial of nearshore hard bottom reduces the substrate required for settlement and growth of macroalgae and sessile invertebrates. Existing macroalgae and sessile invertebrates at the actual site of impact will be smothered and not be able to grow through the sand. Marine turtles, fishes, and motile invertebrates will be displaced to adjacent hard bottom areas. Overall, the community structure of the impact area undergoes a transformation from a hard bottom to a soft bottom assemblage. These assemblage types differ in species composition and trophic structure. Because hard bottom supports protected species as well as managed fishery species and because it represents much less of the regional coastal environment than does soft bottom, the average score for the impact site following the impact is 1 (**Table 5**).

4.11.2 UMAM Rating for the Community Structure at the Mitigation Site

BEFORE Mitigation
Although no samples have been taken, community composition at the mitigation site consists mostly of infaunal and epifaunal invertebrates. Sand dollars, burrowing mollusks, brittle stars, and tubeworms provide foraging for some invertebrates, fishes and loggerhead sea turtles. The availability of this resource, however, is fairly widespread and much lower in diversity when compared to hard bottom habitat. The mitigation site was given an average rating of 0.9 (**Table 5**). The low score was given because of a lack of structured benthic habitat, not because the infauna/epifauna were considered unimportant.

AFTER Mitigation
Some of the impact site functions may not be duplicable at the new site. The mitigation site is not replicating the shallow intertidal conditions that many larval fishes and invertebrates depend on for survival in early developmental stages. Also, macroalgal species could be less diverse and abundant in the subtidal versus intertidal regions based on conditions that promote the photosynthesis processes. The mitigation site was rated as a 7 (**Table 5**).

5.0 TIME LAG

Time lag is incorporated into the gain in ecological value of the proposed mitigation. It is associated with mitigation and means “the period of time between when the functions are lost at the impact site and when those functions are replaced by the mitigation.” The scoring range is incrementally small and ranges from 1.0 (for 1 year or less) to 3.91 (for more than 55 years) (**Table 6**). The evaluation process should consider physical, chemical, and biological factors.

Table 6. Time lag. The Year column represents the number of years between the time the impacts are anticipated to occur and the time when the mitigation is anticipated to fully offset the impacts, based on reasonable scientific judgment of the proposed mitigation activities and site-specific conditions (Source: Chapter 62-345, Florida Administrative Code).

Year	Time Lag
< 1	1
2	1.03
3	1.07
4	1.1
5	1.14
10-6	1.25
15-11	1.46
16-20	1.68
21-25	1.92
26-30	2.18
31-35	2.45
36-40	2.73
41-40	3.03
45-50	3.34
51-55	3.65
>55	3.91

Time lag was estimated at 1 year (T=1.0) based on field observations conducted in Indian River County at the mitigation reef approximately 50 km (30 miles) south of the Mid Reach, other Florida artificial reef assessments, monitoring, and literature. The proposed mitigation is expected to restore ecological functions in a relatively short period of time. Some temporal variability will exist, however, based upon the season of placement and local recruitment.

6.0 RISK FACTOR

The degree of uncertainty that the proposed mitigation will achieve desired results is evaluated under "mitigation risk." During the assessment of risk, several factors that affect the long-term viability of the mitigation project need to be considered. Such factors include, but are not limited to, the potential for invasive species, degradation of water quality, and sustaining primary production. Ratings range from 1.0 (no risk factor) to 3.0 (high risk factor). The scale is increased at increments of 0.25.

Risk associated with the proposed mitigation can be viewed as biological or physical. We will focus on biological risks in this report; however, important physical risks are burial or movement of the proposed structures. Some burial and erosion would actually be desirable in that it would mimic natural disturbance patterns that are important in maintaining species richness and re-setting succession trajectories within patches of hard bottom.

The UMAM guidelines for determining a risk score require the applicant to consider several factors with respect to their likelihood and potential to reduce the ecological value of the mitigation. The following factors are considered in relation to the vulnerability of the mitigation site to:

1) the effect of different hydrologic conditions than those proposed;
2) establishment and long-term viability of plant communities other than those proposed;
3) colonization by invasive exotic or other invasive species;
4) degraded water quality;
5) secondary impacts due to its location; and
6) direct impacts, considering its location.

Factor 1 considers the vulnerability of the mitigation site to the effects of hydrologic conditions different than those proposed. In the context of coastal waters of the Mid Reach hydrologic conditions of ecological importance are water depth, wave energy, sedimentation, turbidity, and light penetration. These conditions are interrelated and differ between the impact and mitigation sites. The uncertainty lies in how individual taxa will respond to different conditions and how this will affect the successional trend towards replicating functions lost at the impact site. However, most app. Thought to occur in the Mid reach have also been documented in water depths similar to the mitigation site.

Factor 2 is related somewhat to the first in that differing physical conditions may promote the development of an ecological assemblage of primary producers that is different from that of the impacted area. In temperate/subtropical waters of the Mid Reach, colonization of artificial reefs by epibiota is expected to occur rapidly (Cummings, 1994; Renaud et al. 1996; Svane and Peterson, 2001); however, composition of the assemblage will depend on timing and availability of propagules. It is a fact that compositional similarity declines with distance between sites even though the sites are colonized by organisms from the same regional species pool (Nekola and White, 1999). For this reason some level of variation should be allowed when comparing mitigation sites to impacts or natural reference sites. If the assemblage that develops on the artificial reefs attracts colonists but conditions for growth and reproduction are suboptimal, then they could become sinks or ecological traps (Crowder et al., 2000). Another contributor to risk in the community context is the potential for higher levels of predation, primarily by fishes at the artificial reefs (Hixon and Beets, 1989; Eklund, 1997). To lessen the chance of building a predation trap, the proposed mitigation reefs are being designed to provide adequate shelter for small fishes and invertebrates.

Factor 3, the vulnerability of the mitigation site to invasion by exotic species, is not expected to be a problem for the Mid Reach. Although exotic reef fishes have been reported from southeastern Florida (Semmens et al., 2004), it is unlikely that these mostly Indo-Pacific species will colonize the shallow waters of the Mid Reach. There is one exception: the red lionfish (*Pterois volitans*). This species is established offshore of North Carolina and the southeastern coast of the U.S. (Whitfield et al., 2002) and has been collected offshore of northeastern Florida (Ruiz-Carusa, 2006). The exotic green alga (*Caulerpa brachypus*, LaPointe, et al., 2005) has been reported from southeastern Florida, but there is no indication of potential problems for Brevard County coastal waters.

Factor 4 is the vulnerability of the mitigation site to degraded water quality. This is not expected to affect the ability of the mitigation reefs to restore ecological functions. Water quality necessary to support locally adapted biotic assemblages is present in Brevard County coastal waters, and there is no indication of that changing in the immediate future.

Factor 5 concerns the vulnerability of the mitigation site to secondary impacts due to location and in relation to changes in land use practices or other regulations that would affect the ability of the mitigation reefs from restoring ecological functions. There are no obvious secondary impacts related to local, state, or federal regulations on land use that would retard the development of the ecological functions of the mitigation reefs.

Factor 6 includes the vulnerability of the mitigation site to direct impacts due to location and in relation to local, state, or federal regulation on land use. Direct physical impact is also an important consideration for high-energy coastal waters such as those in Brevard County. The tendency for mitigation reefs to settle into the sand and completely and permanently disappear has been documented for other areas along the Florida east coast (Continental Shelf Associates, Inc., 2005, 2006). The seabed elevation, materials, and configuration of the proposed mitigation reef were designed to prevent or avoid the problem of settling or direct burial. This design will also prevent reef components from moving or even being washed on shore. With engineering assurances of the stability of the proposed mitigation reefs, this risk factor will be greatly reduced. There are no obvious direct impacts expected from changes in land use practices.

Because most hard bottom organisms associated with the Mid Reach have a dispersive planktonic stage capable of colonizing any hard substrate, there is little risk in the proposed reefs developing epibiotic and fish assemblages relatively rapidly. The risk will be in the nature of the assemblage that develops and what portion of the biota present at the impact sites are not represented on the mitigation reefs. There is not enough information on individual species life histories to predict which species will be most affected in this manner. In the UMAM process risk is considered by evaluating the 6 factors discussed above. We assigned expected scores for each factor then averaged those scores to derive a final risk score (**Table 7**).

Table 7. UMAM risk scores. Scores range from 1 (low risk) to 3 (high risk).

Risk Factor	Score
Different Hydrologic Conditions	2
Different Community Composition	2
Exotic Invasion	1
Degraded Water Quality	1
Secondary impacts	1
Direct Impacts	2
Average Score	1.5

Biological risks revolve around the recruitment and colonization and subsequent assembly of species on the artificial reefs. Recruitment may not be the same in the deeper waters of the mitigation site, which is fragmented from the natural system. Most of the species of concern have been documented in deeper depths at other sites and recruited from a distance of at least as far away or greater than the mitigation site. In view of this observation and considering the fact that the migration site is only 300 to 400 m from the natural reef, these risks are limited.

Colonization of macroalgae from propagules is dependent on critical factors including an adequate surface bio-layer, which is formed in the presence of other settling organisms. Macroalgae regenerated from fragments appear to colonize more quickly and are more successful for propagation (Ohno et al., 1990). Subsequently, after colonization light penetration, nutrient levels, grazing, and water motion all contribute to the continued successful establishment and production of macroalgae. These processes can take from 7 weeks to several months. The Indian River County site had red and green macroalgal growth at approximately 6 months after deployment (**Appendix A**, **Table 2**).

Several species of fishes and invertebrates were found in association with the PALM instruments that were placed in approximately 4.6 m MLW depth off the Mid Reach nearshore since 24 May 2006 (**Appendix B**). The instruments have been deployed to measure the potential for *Phragmatopoma caudata* larvae to settle in deeper waters under chemical and directional flow treatments. The instruments also contain separate test surfaces used to measure macroalgal recruitment on different substrate types. When the units were examined after 44 days, they contained *Phragmatopoma caudata*, an abundance of hydroid species, and bryozoans. Fishes, crabs, mollusks, and invertebrates were also found in association with the units (**Appendix B**). Macroalgae, however, are not yet visibly detectable at this time.

7.0 SUMMARY

Mitigation reefs proposed for this project cannot be assumed to replace all ecological functions for the same suite of species or life stages that exist on natural reefs in shallower water. There are likely species-specific differences in sensory perception to water depth, wave energy, light penetration, turbidity, and other factors that may be different at the proposed mitigation site. In addition to these deterministic factors there is an element of uncertainty associated with the colonization of newly available substrate by marine organisms that leads to variability and unpredictability. Nevertheless, a speculative estimate of the fraction of the macroalgal, invertebrate, and fish species present at the impact site that will ultimately reside on the mitigation reefs located 300 to 400 m offshore is 75%. The extent of these discrepancies is unknown and therefore contribute to the risk associated with all habitat restoration projects.

In this report, an attempt was made to more specifically evaluate the impact and mitigation sites in terms of seven key ecological functions: habitat corridor, water quality, substrate, cover, nesting/reproduction, feeding, and nursery. Each of these seven functions was considered in regard to four major taxonomic groups: macroalgae, invertebrates, fishes (juvenile and adult, separately), and marine turtles. The ecological functions of both the impact and mitigation sites, with particular regard to the hard bottom habitat, were evaluated for both pre- and post-project conditions.

To facilitate the analyses of ecological functions, taxonomic groups, location (impact versus mitigation sites), and timing (before and after construction) were combined into multi-way tables. A scoring system of 0 to 10 was employed, with 0 representing least (or no) functional value and 10 representing the greatest functional value. A table was constructed for each of the three broad categories specified by the UMAM process: Location and Landscape Support, Water Environment, and Community Structure. From these tables, grand mean scores were input into the standard UMAM forms to calculate the project-specific mitigation ratio. Completed UMAM standard forms derived from the analyses are given in **Appendix C**.

When each of the seven key functions were viewed in the average-aggregate (grand means), the combined function of the *impact area* was estimated to decrease from about 8.5 to 2.6. The combined function of the *mitigation site* was estimated to increase from about 2.1 to 7.2. This represents a loss of about -5.9 at the impact site and a gain of about +5.1 at the mitigation site. The relative gain at the mitigation site is due, in large part, to the introduction of *any* hard bottom feature to an otherwise featureless seafloor. In this context, the net *gain* in ecological function at the mitigation site represents about 86% of the net *loss* at the impact site.

Alternately considered, the ecological function of the post-project mitigation site was scored as about 85% of the value of the pre-project impact site. Once again, this reflected the average of scores from the seven key ecological functions evaluated for each of the four taxonomic groups in this study, computed for both the impact and mitigation sites. Implicit in these results is the finding that macroalgae, invertebrates, fishes, green turtles, and other taxa are documented and/or predicted to utilize the mitigation site as described in this report.

Viewed in the context of the broad UMAM categories, net gains in function at the mitigation site were scored to be about 95% of the value of losses at the impact site. This value does not fully include risk. In this study, a risk factor of 1.5 was selected. Its application is numerically analogous to assigning a probability of 1/1.5 = 0.67 to the results of the initial evaluation. In this way, with risk factor included, the net gains in ecological function at the mitigation site are expected to be about 64% of the losses at the impact site. This value is of similar magnitude to the speculative estimate, above, that some 75% of the fish and invertebrate species present at the impact site will reside on the mitigation reefs located offshore.

By comparing the relative functional loss of the impacted habitat with the relative functional gain of the mitigative habitat, and including risk and time lag, the ratio of project mitigation-acreage versus impact-acreage is computed as follows:

$$\text{Ratio} = \frac{\text{Functional Loss of Impact Area (delta)} = 0.40}{\text{Relative Functional Gain of Mitigation Area (delta)} = 0.38} \times \text{Time Lag Factor} = 1.0 \times \text{Risk Factor} = 1.5 \quad \mathbf{= 1.58}$$

Time lag and especially, risk greatly influence the final outcome of the UMAM mitigation ratio. The analyses presented here yielded a final ratio of 1.6 acres of mitigation reef for every 1 acre of natural nearshore hard bottom lost to the project. The risk factor is related to inherent levels of uncertainty. Much of the uncertainty in marine ecosystems can be classified into informational gaps (biological ignorance) and natural variability (Mangel, 2006). To help reduce the uncertainty associated with constructing artificial reefs in waters deeper than those of the impact site, attempts are being made to shorten information gaps by 1) initiating the PALM study and 2) by examining artificial reefs deployed as mitigation for dredge-related hard bottom impacts offshore of Indian River County (south of the Mid Reach). Details, albeit preliminary, of the PALM study are provided in **Appendix B**. Site visits to the Indian River County mitigation reefs to the south revealed that macroalgal, invertebrate, and fish species known to occur on the hard bottom of the Mid Reach also were present on the artificial reefs. Notes and observations from the site visits are provided in **Appendix A**. These observations provide evidence that biota common to the natural nearshore hard bottom including macroalgae, invertebrates, and fishes will colonize structures 300 to 400 m from the existing reef. In addition, the design of the proposed mitigation reef better mimics the structural characteristics and therefore key ecological functions of nearshore hard bottom than does quarried limestone boulders used in similar mitigation efforts elsewhere.

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APPENDICES

APPENDIX A

DIVE SUMMARIES FROM DECEMBER 31, 2005
IN INDIAN RIVER COUNTY, FLORIDA

Table A-1. Indian River County – Mitigation reef dive summary for December 31, 2005. List of species found on the artificial reef created approximately 1 year earlier.

Fishes	Invertebrates	Macroalgae	Soft/Hard Corals	Surface Observations
Black margate (2” to 12”)	*Arbacia* sp. (urchins) - abundant		Gorgonian	Blue runner (caught on line)
Sheepshead (4” to 20”)	Sea cucumber			Spanish mackerel (caught on line)
Porkfish (1” to 10”)	*Phragmatopoma caudata*			*Caretta caretta* (loggerhead) seen at surface
Juvenile black margate	Hydroids			
3 species of blenny including hairy blenny and molly miller	Razor-like clams			

Water Temperature: 65^{o} F
Water Depth: ~ 20’

Approximately 1 year – *in situ*
Southern Mitigation Reef

Bottom topography: The mitigation boulders appear to have been previously colonized by some small clam-like organisms that are small and have a razor-like appearance. The colonies of *Phragmatopoma caudata* appear to be old or dead. The bottom around the mitigation site was fine sand. Water clarity approximately 5.

Comments: Many of the above species were photoed.
No detectable wave surge was felt during a 45-minute dive.

Divers: Mike McGarry, Virginia Barker, Karen Holloway-Adkins
Captain: Daryl Adkins

Table A-2. Indian River County – Mitigation reef dive summary for December 31, 2005. List of species found on the artificial reef created approximately 6 months earlier.

Fish	Invertebrates	Macroalgae	Soft/Hard Corals	Surface Observations
Black margates - juvenile	*Arbacia* sp. (urchins) - few	*Bryothamnion seaforthii*		
Sheepshead	Sea cucumber	*Gracilaria mammilaris*		
Porkfish	*Phragmatopoma caudata*	*Botryocladia occidentalis*		
Blennies	Hydroids	*Gelidium* spp.		
Snappers	Tunicates	*Solieria* spp.		
	Sponges	*Bryopsis plumose*		

Water Temperature: 65^{o} F
Water Depth: ~ 14'

Approximately 6 months – *in situ*
Northern Mitigation Reef

Bottom topography: The mitigation boulders appeared to have healthy colonies of *Phragmatopoma caudata*. The bottom around the mitigation site was relatively coarse.

Comments: Many of the above species were photoed (**Photos 3**, **4**, and **5**). A very detectable wave surge was felt during the dive, which lasted approximately 45 minutes. Visibility was approximately 7 to 10 ft.

Divers: Mike McGarry, Virginia Barker, Karen Holloway-Adkins
Captain: Daryl Adkins

Photo 3. Sponges and tunicates covering limestone boulders on the artificial reef offshore of Indian River County.

Photo 4. Red algae (*Botryocladia* sp.) and worm rock (*Phragmatopoma cuadata*) growing on the Indian River County artificial reef.

Photo 5. Juvenile porkfish (*Anisotremus virginicus*), black margate (*A. surinamensis*), and slippery dick (*Halichoeres bivittatus*) on the Indian River County artificial reef.

Table A-3. Indian River County – Natural reef dive summary for December 31, 2005. List of species found on the natural reef located just northeast of the Breckonshire Wreck dive in Vero Beach, Florida.

Fishes	Invertebrates	Macroalgae	Soft/Hard Corals	Surface Observations
Lizardfish (4.5”)	*Arbacia* sp. (urchins) – on leeward side in moderate numbers	*Solieria* sp.	Yellow gorgonian	
Dusky damselfish	*Phragmatopoma caudata*	*Halymenia* sp.	Oculina finger coral	
Cocoa damselfish		*Padina* sp.	Golf ball coral	
Spot or grunt				
Slippery dick				
Sheepshead				
Blennies				
Porkfish				
Cubbyu				
Gray snapper				
Black margate				

Water Temperature: 65^{o} F
Time: 1350 h

Water Depth: ~ 14’ -19’
NE of Breckonshire Wreck

Bottom topography: Low relief ledges (<2’). Coarse sand bottom surrounding limestone reef ledges with *Phragmatopoma caudata* growth. Water clarity top to bottom.

Comments: Many of the above species were photoed. A very detectable wave surge was felt during the dive, which lasted, approximately 30 minutes.

Divers: Mike McGarry, Virginia Barker, Karen Holloway-Adkins
Captain: Daryl Adkins

APPENDIX B

SHORT SUMMARY OF THE PRELIMINARY FINDINGS ON THE PROPAGULE AND LARVAE MEASUREMENT (PALM) METHOD AND INSTRUMENTS USED

Table B-1. Cursory list of organisms found in, around, or growing on the Propagule and Larvae Measurement (PALM) instruments. PALM instruments were deployed May 24, 2006. After 44 days (July 8, 2006) the instruments were raised for maintenance and to replace the panels used to measure larval recruitment of *Phragmatopoma caudata*.

Fishes	Invertebrates	Soft/hard Corals	Macroalgae
Sand perch (*Diplectrum* sp.)	Peppermint shrimp (*Lysmata wurdamnni*)		
Jackknife (juvenile) (*Equetus* sp.)	Hydroid zoanthid		
Sea bass (*Serranus* sp.)	Unbranched hydroid		
Molly miller (*Scartella cristata)*	Sun zoanthid		
Clingfish (*Gobiesox* sp.)	*Bugula neritina*		
Hairy blenny (*Labrisoma nuchipinnis*)	Barnacles		
Blenny – juvenile (*L. nuchipinnis*)	Sabella worm		
Saddled blenny (*Malacoctenus triangulatus)*	*Phragmatopoma caudata*		
Atlantic spadefish (*Chaetodipterus faber*)	Cuban stone crab		
Juvenile porkfish (*Anisotremus virginicus*)	Other crab species (unid.)		
Leopard searobin (*Prionotus scitulus*)	Atlantic strawberry cockle		
White grunt (*Haemulon plumieri*)			
Tomtate (*Haemulon auronlineatum*)			
Lane snapper (*Lutjanus synagris*)			

Water Temperature: – 80^o F PALM UNITS 1-3
Water Depth: 4.6 m (MLW)

Comments: The area under and around the base of the PALM is scoured out to a depth of approximately 10 to 12” – creating a small hole in which the unit sits. Spadefish swarm the boxes and blennies hide between the surface tiles that are 5/8” thick. Peppermint shrimp were abundant on the boxes. Grunts were actively feeding on the shrimp as the boxes were being lifted. Several different fish were observed foraging on the hydroids and other unidentified material on the surface of the boxes. The visibility on the day of exchange was 5’ to 6’. During previous maintenance dives the visibility has been less than 1” and as much as 3’ around the boxes. Light penetration is variable. The ropes used to secure the boxes to the screw anchors tend to attract fragments of macroalgae. It is undeterminable, at this time, whether the algae are growing on the ropes.

NOTE: The PALM is designed with an open bottom and 5-sides (top and 4 side panels). This “box” sits on an open concrete block base and is situated according to directional compass headings (N, S, E, W). The directional panels are designed to measure *Phragmatopoma caudata* larval recruitment under different current regimes. Each panel also tests different chemical treatments. The top of the box is designed to measure macroalgae growth on 4 different types of substrates. The side panels are replaced at intervals but the top (macroalgae) panel, while monitored and photoed, will remain *in situ* until the end of the experiment (March 2007).

APPENDIX C

UMAM SCORING TABLES – IMPACT AND MITIGATION

Completed UMAM form for the quantification of assessment area of impact.

PART II – Quantification of Assessment Area (impact or mitigation)

(See Sections 62-345.500 and .600, F.A.C.)

Site/Project Name	Application Number	Assessment Area Name or Number
Brevard County Mid Reach		
Impact or Mitigation **Impact Area**	Assessment conducted by:	Assessment date:

Scoring Guidance	Optimal (10)	Moderate (7)	Minimal (4)	Not Present (0)
The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface waterfunctions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

Indicator	w/o pres or current	with	Description
.500(6)(a) Location and Landscape Support	9	4.4	**Habitats surrounding the project area represent the full range needed for all wildlife listed in Part 1- exotic species are not present, wildlife access not limited, surrounding land use has not adversely affected fish and wildlife. Distance from offshore spawning sites and offshore adult habitat is less than optimal.**
.500(6)(b) Water Environment (n/a for uplands)	9	9	**No direct or indirect discharges affect water quality. Water depth, wave energy, currents, and light penetration are optimal for organisms listed in Part 1**
500(6)© Community structure 1. Vegetation and/or 2. Benthic Community	8.32	1.02	**Numbers and kinds of benthic organisms are optimal, exotic species are not present, natural colonization trajectories, recruitment, and age distribution are optimal for the area, species are in good condition, with typical biomass. Quasi-isolated nature of the site is less than optimal for receiving colonists and immigrants. Structural features are typical of the system with no evidence of physical damage. Topographic features are typical and optimal for the benthic community being evaluated. Spawning and nesting habitats are optimal for the community type.**

Score = sum of above scores/30 (if uplands, divide by 20)	
current or w/o pres	with
0.88	.048

If preservation as mitigation,
Preservation adjustment factor =
Adjusted mitigation delta =

For impact assessment areas
FL = delta x acres = 0.4*1=0.4

Delta = [with-current]
0.4

If mitigation
Time lag (t-factor) =
Risk factor =

For mitigation assessment areas
RFG = delta/(t-factor x risk) =

Form 62-345.900(2), F.A.C. [effective date 02-04-2004]

Completed UMAM form for the quantification of assessment area for mitigation site.

PART II – Quantification of Assessment Area (impact or mitigation)

(See Sections 62-345.500 and .600, F.A.C.)

Site/Project Name	Application Number	Assessment Area Name or Number
Brevard County Mid Reach		
Impact or Mitigation	Assessment conducted by:	Assessment date:
Mitigation		

Scoring Guidance	**Optimal (10)**	**Moderate (7)**	**Minimal (4)**	**Not Present (0)**
The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface waterfunctions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

Indicator	w/o pres or current	with	Comments
.500(6)(a) Location and Landscape Support	1	6.4	**The proposed reef locations are offshore and in deeper water than the impact sites. This results in differences in wave energy and light penetration and the location relative to local spawning and adult habitats is somewhat isolated.**
.500(6)(b) Water Environment (n/a for uplands)	9	9	**No reason to expect changes in water quality.**
500(6)© Community structure 1. Vegetation and/or 2. Benthic Community	0.9	7	**In deeper water, appropriate species composition and diversity will differ from those measured at the impact site. Some species may experience increased competition (and predation) from larger, older individuals that will affect mortality, growth rate, and condition. Spawning, nesting, and foraging areas for residents will be less than optimal. Topographic complexity and substrate characteristics will differ as will light penetration and wave energy.**

Score = sum of above scores/30 (if uplands, divide by 20)	
current or w/o pres	with
0.36	0.75

If preservation as mitigation,
Preservation adjustment factor =
Adjusted mitigation delta =

For impact assessment areas
FL = delta x acres =

Delta = [with-current]
0.38

If mitigation
Time lag (t-factor) = 1
Risk factor = 1.50

For mitigation assessment areas
RFG = delta/(t-factor x risk) = 0.253

Form 62-345.900(2), F.A.C. [effective date 02-04-2004]

Mitigation Determination Formulas
(See Section 62-345.600(3), F.A.C.)

For each impact assessment area:

(FL) Functional Loss = Impact Delta X Impact acres

For each mitigation assessment area:

(RFG) Relative Functional Gain = Mitigation Delta (adjusted for preservation, if applicable)/((t-factor)(risk))

(a) Mitigation Bank Credit Determination

The total potential credits for a mitigation bank is the sum of the credits for each assessment area where assessment area credits equal the RFG times the acres of the assessment area scored

Bank Assessment Area	RFG	X	Acres	=	Credits
example					
a.a.1					
a.a.2					
total					

(b) Mitigation needed to offset impacts, when using a mitigation bank

The number of mitigation bank credits needed, when the bank or regional offsite mitigation area is assessed in accordance with this rule, is equal to the summation of the calculated functional loss for each impact assessment area.

Impact Assessment Area	FL	=	Credits needed
example			
a.a.1			
a.a.2			
total			

(c) Mitigation needed to offset impacts, when not using a bank

To determine the acres of mitigation needed to offset impacts when not using a bank or a regional offsite mitigation area as mitigation, divide functional loss (FL) by relative functional gain (RFG). If there are more than one impact assessment area or more than one mitigation assessment area, the total functional loss and total relative functional gain is determined by summation of the functional loss (FL) and relative functional gain (RFG) for each assessment area.

	FL	/	RFG	=	Acres of Mitigation
example					
a.a.1	0.4		0.084		4.7
a.a.2					
total					

Form 62-345.900(3), F.A.C. [effective date 02-04-2004]

HABITAT EQUIVALENCY ANALYSIS (HEA): PROPOSED MITIGATION REEF FOR BREVARD COUNTY MID REACH SHORE PROTECTION PROJECT

August 2008
Revised December 2009

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1.0 INTRODUCTION

This document provides data and information supporting an analysis of impact and corresponding mitigation using the Habitat Equivalency Analysis (HEA). The HEA provides information concerning the amount of proposed restoration required for damaged or lost natural resources. HEA assumes that compensation for lost ecological services (functions) can be provided by restoration (mitigation) projects that provide comparable services and implicitly balances lost economic value with economic value provided by compensatory mitigation.

The impact and mitigation scenarios analyzed are proposed to occur off the Mid Reach segment of coastal Brevard County, Florida (Florida Department of Environmental Protection [FDEP] Monuments R-75.4 to R-118.3). The assessed impact is the loss of nearshore hard bottom habitat that will be buried during a shoreline protection project involving sand dredged from an offshore location and then placed to the onshore fill site by truck-haul. In the present case, the impact site is defined to mean the intertidal and subtidal nearshore hard bottom that would be impacted (i.e., buried) by the project. This specifically includes portions of the existing hard bottom that are ephemerally exposed near the low tide shoreline in water depths less than about 1 m (mean low water [MLW]).

The physical characteristics of the Mid Reach rock resource are described in detail in Olsen Associates, Inc. (2003). Nearshore hard bottom supports algae, invertebrates (sessile and motile), fishes, and marine turtles and is considered essential fish habitat and a habitat area of particular concern by the National Marine Fisheries Service and the South Atlantic Fishery Management Council (1998). Key ecological services provided by nearshore hard bottom include substrate, shelter, habitat connectivity, feeding sites, nesting sites, and nursery areas. A synthesis of ecological information on nearshore hard bottom of the Mid Reach was prepared by Continental Shelf Associates, Inc. (CSA) et al. (2006 and 2008).

The proposed mitigation seeks to restore ecological services lost to the burial of nearshore hard bottom habitat by constructing “like” replication of hard bottom (i.e., mitigation reef). The mitigation reef will be placed in a water depth of approximately 4.6 m (MLW) so that the top of the reef structure will be at a depth of approximately 4.0 to 4.3 m. The mitigation reef will be placed approximately 300 to 400 m from shore (seaward of the impact site) on sand bottom. Thus, the structural complexity of the mitigation reefs mimics the natural nearshore hard bottom, but for practical and logistical reasons the reefs are to be deployed in water depths that are slightly deeper than those at the impact site. Details of the mitigation reef design, construction, and deployment are presented in CSA et al. (2006 and 2008).

1.1 HABITAT EQUIVALENCY ANALYSIS

1.1.1 Method

The conceptual basis for HEA is that restoring or replacing habitat that offers comparable services can compensate for lost ecological services. Primary restoration addresses the impacted resource directly, while compensatory restoration is planned to replace lost services.

Primary restoration refers to actions concerned with the recovery of damaged natural resources to their baseline condition. These actions may include active tasks to accelerate habitat recovery or passive measures such as monitoring natural recovery. Alternatively, instead of primary restoration, compensatory restoration can be used to restore ecological services lost in perpetuity. In the case of the Mid Reach shoreline protection, we assumed that the impacted hard bottom areas would remain permanently buried and therefore would not recover naturally. Despite this assumption it is likely that the impacted acreage will vary and may be as low as 1.6 to 1.8 acres between beach fill placement activities and depending on local conditions. Nevertheless, lost ecological services would be restored through compensatory mitigation, i.e., through the construction of artificial mitigation reefs near to the impacted resource.

Following the HEA concept, responsible parties must pay for (or implement) compensatory restoration projects that are sufficient to provide replacement services that are equal in value to the lost services (Peacock, 1999). Compensation is determined in three steps:

1. Select and scale appropriate primary restoration;
2. Select appropriate compensatory restoration/mitigation; and
3. Scale the appropriate quantity of compensatory restoration.

Lost ecological services are characterized as a proportional reduction below pre-damage natural resource conditions (i.e., between 0% and 100% loss in function). These proportional reductions are then applied to the affected habitat area (acres) and aggregated over time (years) to obtain the total cumulative quantity of lost services (e.g., acre-years), in accordance with a present-value discount rate.

Restored or compensatory ecological services are similarly characterized as a proportion of the pre-damage natural resource's functions (i.e., between 0% and 100% repair or replacement of function, relative to the pre-damage natural resource). These proportional replacements in function are likewise aggregated over time to obtain the cumulative quantity of replaced services, relative to the lost ecological services of the impacted natural resource. Comparison of the two cumulative quantities (i.e., lost services versus restored or compensatory services) yields the requisite quantity of restored or compensatory services that must be provided.

1.1.2 Application

The first step in the analysis is to compute the scale of the damaged resource to be restored or compensated. The total area of impact associated with the proposed shore protection project along Brevard County's Mid Reach is 3.0 acres of nearshore hard bottom. As noted above, for purposes of this analysis, it is assumed that this impact area will be permanent; i.e., that the shore protection project is maintained indefinitely and that the impacted resource will not recover naturally. It is also assumed that the area of impact has an estimated 100% loss of ecological services following burial by the placement and subsequent equilibration of placed beach fill; and, it is assumed that this impact occurs wholly and immediately after construction. (This is a conservative assumption because some of the impact is actually predicted to occur over a period of several years after construction -- as a result of long-term equilibration and alongshore diffusion of the beach fill.)

Lost ecological services due to the burial of nearshore hard bottom are quantified in **Appendix Table A.1**. The current value of lost services in each year was calculated by applying the associated percent of lost services to the area (acres) of direct impact; or 100% x 3.0 acres in the present case. The present value of lost services in each year, through perpetuity, is the associated current value discounted through future years at 3.0% per year. These present values were then aggregated over all years to calculate the total quantity of lost services (acre-years) due to the impact. (In the present application, a 215-year period was selected as representative of "perpetuity" because the ultimate mathematical solution asymptotically closes toward its perpetual value at this point. That is, the computed solution differs by less than 0.0002% per year beyond a time period of 215 years. Thus, the 215-year analysis period is considered to adequately represent the asymptotic solution at perpetuity.)

The present value of lost services is the current value discounted to the year 2010, which is the proposed year of the impact, and is equal to 102.8 acre-years. See Table 1, below. The standard annual 3% discount rate was applied during the HEA. (The rate of 3% is historically used, but a higher Federal Reserve rate of for example 6.5% may be employed in some cases, for which the result is described later.)

The second step of the HEA process is to determine compensatory restoration and its relative productivity. During each year of replacement services, compensatory restoration provides a proportional equivalent of the natural resource baseline services that is referred to as its relative productivity.

The amount of time necessary for colonization of artificial reefs is reported to be highly variable (Cummings, 1994; Svane and Petersen, 2001). Colonization of the artificial reefs is defined as rehabilitation of the biological community following the impact to an ecological level comparable to the condition of the natural reef prior to the impact. This colonization period for the artificial reef is considered recovery time in the HEA. Recovery time depends on site-specific ecological conditions following the impact event and potential external disturbances that may affect successional processes during colonization. In the nearshore environment, ecological recovery will primarily depend on colonization of mitigated reefs by settling larvae and spores and on growth and reproduction of surviving biota at adjacent non-impact areas. Because the epibiota found on hard bottom of the Mid Reach consists primarily of macroalgae (CSA et al., 2006 and 2008), recovery is assumed to be rapid (1.5 to 2 years). We estimated colonization of the mitigation reefs will reach an ecological level comparable to that of the lost nearshore hard bottom in 2 years; this value was used in the HEA calculations as described below.

Because the mitigation reefs are being placed in deeper water than that of the impacted hard bottom, we conservatively estimated that a maximum 75% of the ecological services will be restored, or 64% including risk allowance, described below. This follows the analysis described in CSA et al. (2006), which considered the probable changes at the proposed impact and mitigation sites in terms of seven key ecological functions: habitat corridor, water quality, substrate, cover, nesting/reproduction, feeding, and nursery. Each of these seven functions was considered in specific regard to four taxonomic groups: macroalgae, invertebrates, juvenile and adult fishes, and marine turtles. From the average of scores from these seven key ecological functions, evaluated for each of the four taxonomic groups, the ultimate ecological function of the post-project mitigation sites was predicted to be about 85% of the pre-damage impact site. More broadly, with conservative inclusion of risk or uncertainty, the net gains in ecological function of the mitigation structures were allowed as about 64% of the losses at the impact site. The values of these assessments, from 64% to 85%, were consistent with the speculative estimate that some 75% of the macroalgal, invertebrate, and fish species present at the impact site will ultimately reside on the mitigation reefs (CSA et al., 2006 and 2008). The present analysis utilizes a value of 64%, which includes allowance for risk (uncertainty), and an approximate one-year time lag for substantiative development of ecological function of the compensatory restoration, as described by CSA et al (2006, 2008).

The relative productivity of the compensatory restoration is estimated to increase linearly for 1 year from 0% in year 2010 to 64% in year 2011. The assumed maximum relative productivity (64%) of the artificial structures is assumed to continue from year 2011 into perpetuity (or, for computational purposes in this case, through the year 2224 as described above). In this way, the total value of relative productivity of the mitigation reefs at current rates, for 2010, 2011, and 2012 to 2224, respectively, is 0 + 64% + (213 years x 64%) = 13,696%. The total present value of relative productivity, from 2010 through 2224, is 2,130%; or, applied to one-acre of constructed reef, equates to 21.3 acre-years. This is the total discounted acre-years of ecological services provided by each acre of compensatory restoration (**Table 1**).

Table 1. Cumulative lost services and relative productivity of compensatory restoration for Brevard County Mid Reach.

Year	Lost Services (Existing Hardbottom) - Acres		Relative Productivity of Compensatory Restoration (Mitigation Reef)	
	Current Value	Present Value	Current Value	Present Value
2010	3.0 Ac	3.0 Ac-yr	0%	0.0 %
2011	3.0 Ac	2.9 Ac-yr	64%	62.1%
2012	3.0 Ac	2.8 Ac-yr	64%	60.3%
2013-2224	3.0 Ac / yr	94.1 Ac-yrs	64% / yr	2007.1%
	Total:	102.8 Ac-yrs	Total:	2130%

Using the information above, the final step of the process (scaling the quantity of compensatory mitigation) indicates that it will require 102.8 acre-years/21.3 acre-years per compensatory acre = 4.8 acres of artificial structures to compensate for accrued lost services associated with a 3.0-acre area of impact at the Mid Reach shore protection project site. This considers that the losses at the impact site are constant (3.0 acres) and perpetual, and that the services provided by the mitigation reef are likewise perpetual; and, it presumes that the relative productivity of the mitigation reef is not more than 64% of the impacted resources. It considers that losses at the impact site are immediate after construction and that maximum productivity at the mitigation site occurs 1 year after its construction. The results suggest a requisite mitigation ratio of 4.8/3.0 = 1.6; or, approximately 1.6 acres of compensatory mitigation per acre of impact.

The results given above represent the base case using a discount rate of 3% and relative mitigation-reef productivity of 64%. To demonstrate how the results would vary with different discount rates, relative productivity values and time lags, a sensitivity analysis is presented in **Table 2**. From the table, this analysis shows that the requisite acreage of compensatory mitigation increases by about 5% when a discount rate of 6.5% is used in the calculations versus a discount rate of 3.0% Thus, for the predicted relative productivity of the mitigation reef being not more than 64% of the impacted resources, the requisite mitigation ratio increases from about 1.60 acres of compensatory mitigation per acre of impact (using a discount rate of 3%) to about 1.66 acres (using a discount rate of 6.5%); or, from approximately 1.6 to 1.7.

In the present case, varying the predicted productivity of the mitigation reef by ±X% results in an equivalent X percent-change in the requisite acreage of compensatory mitigation. For example, from **Table 2**, an approximate 17% increase in the value of predicted productivity (from 64% to 75%) results in a computed 17% decrease in required mitigation reef area. Varying the predicted time lag for the compensatory reef to reach its assumed productivity level, from one to two years, results in about a 2% to 3% change in the calculated mitigation ratio, on average (see **Table 2**).

Table 2. Compensatory mitigation calculated using different relative productivity and discount rates, and one-year versus two-year time lags for compensatory reef to reach assumed productivity level, for a constant and perpetual impact of 3.0 acres.

Productivity Level	Calculated Compensatory Mitigation Requirement (Acres / [mitigation ratio])			
	One-Year Time Lag		Two-Year Time Lag	
	Discount Rate = 3.0%	6.5%	3.0%	6.5%
64%	4.8 Ac/[1.6]	5.0 Ac/[1.7]	4.9 Ac/[1.6]	5.2 Ac/[1.7]
75%	4.1 Ac/[1.4]	4.3 Ac/[1.4]	4.2 Ac/[1.4]	4.4 Ac/[1.5]
85%	3.6 Ac/[1.2]	3.8 Ac/[1.3]	3.7 Ac/[1.2]	3.9 Ac [1.3]

The base predicted requirement for compensatory mitigation of 1.6 acres of compensatory mitigation reef per acre of loss at the impact site, calculated herein, is consistent with the 1.6 value computed by the Uniform Mitigation Assessment Method (UMAM) described by CSA et al (2006, 2008). The 64% productivity level of the compensatory reef, utilized herein, reflects the effective value of the UMAM approach after allowance for risk (uncertainty); and both approaches assume a one-year time lag for this productivity level to be reached, as described by CSA et al (2006, 2008). The results are not significantly sensitive to variation in the time lag or present-value discount rate. Ultimately, the mitigation requirement established for the project by the State of Florida Department of Environmental Protection (FDEP) will be based upon application of UMAM. As described herein, calculation by both the UMAM and HEA approaches results in a predicted requirement to construct approximately 1.6 x 3.0 acres = 4.8 acres of mitigation reef structure.

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HABITAT EQUIVALENCY ANALYSIS (HEA):
PROPOSED MITIGATION REEF FOR BREVARD COUNTY
MID REACH SHORE PROTECTION PROJECT

APPENDIX

Table A.1. Quantification of lost services based on the direct loss of 3,0 acres. Calculations are based on 3.0 acres of direct impact; an annual discount rate of 3.0% is used to calculate present value.

Year	Nearshore Hard Bottom	Current Value (acres)	Present Value (acre-years)
2010	100.0%	3.00	3.00
2011	100.0%	3.00	2.91
2012	100.0%	3.00	2.83
2013	100.0%	3.00	2.75
2014	100.0%	3.00	2.67
2015	100.0%	3.00	2.59
2016	100.0%	3.00	2.51
2017	100.0%	3.00	2.44
2018	100.0%	3.00	2.37
2019	100.0%	3.00	2.30
2020	100.0%	3.00	2.23
2021	100.0%	3.00	2.17
2022	100.0%	3.00	2.10
2023	100.0%	3.00	2.04
2024	100.0%	3.00	1.98
2025	100.0%	3.00	1.93
2026	100.0%	3.00	1.87
2027	100.0%	3.00	1.82
2028	100.0%	3.00	1.76
2029	100.0%	3.00	1.71
2030	100.0%	3.00	1.66
2031	100.0%	3.00	1.61
2032	100.0%	3.00	1.57
2033	100.0%	3.00	1.52
2034	100.0%	3.00	1.48
2035	100.0%	3.00	1.43
2036	100.0%	3.00	1.39
2037	100.0%	3.00	1.35
2038	100.0%	3.00	1.31
2039	100.0%	3.00	1.27
2040	100.0%	3.00	1.24
2041	100.0%	3.00	1.20
2042	100.0%	3.00	1.17
2043	100.0%	3.00	1.13
2044	100.0%	3.00	1.10
2045	100.0%	3.00	1.07
2046	100.0%	3.00	1.04
2047	100.0%	3.00	1.00
2048	100.0%	3.00	0.98
2049	100.0%	3.00	0.95
2050	100.0%	3.00	0.92
2051	100.0%	3.00	0.89
2052	100.0%	3.00	0.87

Table A.1. (Continued).

Year	Nearshore Hard Bottom	Current Value (acres)	Present Value (acre-years)
2053	100.0%	3.00	0.84
2054	100.0%	3.00	0.82
2055	100.0%	3.00	0.79
2056	100.0%	3.00	0.77
2057	100.0%	3.00	0.75
2058	100.0%	3.00	0.73
2059	100.0%	3.00	0.70
2060	100.0%	3.00	0.68
2061	100.0%	3.00	0.66
2062	100.0%	3.00	0.65
2063	100.0%	3.00	0.63
2064	100.0%	3.00	0.61
2065	100.0%	3.00	0.59
2066	100.0%	3.00	0.57
2067	100.0%	3.00	0.56
2068	100.0%	3.00	0.54
2069	100.0%	3.00	0.52
2070	100.0%	3.00	0.51
2071	100.0%	3.00	0.49
2072	100.0%	3.00	0.48
2073	100.0%	3.00	0.47
2074	100.0%	3.00	0.45
2075	100.0%	3.00	0.44
2076	100.0%	3.00	0.43
2077	100.0%	3.00	0.41
2078	100.0%	3.00	0.40
2079	100.0%	3.00	0.39
2080	100.0%	3.00	0.38
2081	100.0%	3.00	0.37
2082	100.0%	3.00	0.36
2083	100.0%	3.00	0.35
2084	100.0%	3.00	0.34
2085	100.0%	3.00	0.33
2086	100.0%	3.00	0.32
2087	100.0%	3.00	0.31
2088	100.0%	3.00	0.30
2089	100.0%	3.00	0.29
2090	100.0%	3.00	0.28
2091	100.0%	3.00	0.27
2092	100.0%	3.00	0.27
2093	100.0%	3.00	0.26
2094	100.0%	3.00	0.25
2095	100.0%	3.00	0.24
2096	100.0%	3.00	0.24
2097	100.0%	3.00	0.23
2098	100.0%	3.00	0.22

Table A.1. (Continued).

Year	Nearshore Hard Bottom	Current Value (acres)	Present Value (acre-years)
2099	100.0%	3.00	0.22
2100	100.0%	3.00	0.21
2101	100.0%	3.00	0.20
2102	100.0%	3.00	0.20
2103	100.0%	3.00	0.19
2104	100.0%	3.00	0.19
2105	100.0%	3.00	0.18
2106	100.0%	3.00	0.18
2107	100.0%	3.00	0.17
2108	100.0%	3.00	0.17
2109	100.0%	3.00	0.16
2110	100.0%	3.00	0.16
2111	100.0%	3.00	0.15
2112	100.0%	3.00	0.15
2113	100.0%	3.00	0.14
2114	100.0%	3.00	0.14
2115	100.0%	3.00	0.13
2116	100.0%	3.00	0.13
2117	100.0%	3.00	0.13
2118	100.0%	3.00	0.12
2119	100.0%	3.00	0.12
2120	100.0%	3.00	0.12
2121	100.0%	3.00	0.11
2122	100.0%	3.00	0.11
2123	100.0%	3.00	0.11
2124	100.0%	3.00	0.10
2125	100.0%	3.00	0.10
2126	100.0%	3.00	0.10
2127	100.0%	3.00	0.09
2128	100.0%	3.00	0.09
2129	100.0%	3.00	0.09
2130	100.0%	3.00	0.09
2131	100.0%	3.00	0.08
2132	100.0%	3.00	0.08
2133	100.0%	3.00	0.08
2134	100.0%	3.00	0.08
2135	100.0%	3.00	0.07
2136	100.0%	3.00	0.07
2137	100.0%	3.00	0.07
2138	100.0%	3.00	0.07
2139	100.0%	3.00	0.07
2140	100.0%	3.00	0.06
2141	100.0%	3.00	0.06
2142	100.0%	3.00	0.06
2143	100.0%	3.00	0.06
2144	100.0%	3.00	0.06

Table A.1. (Continued).

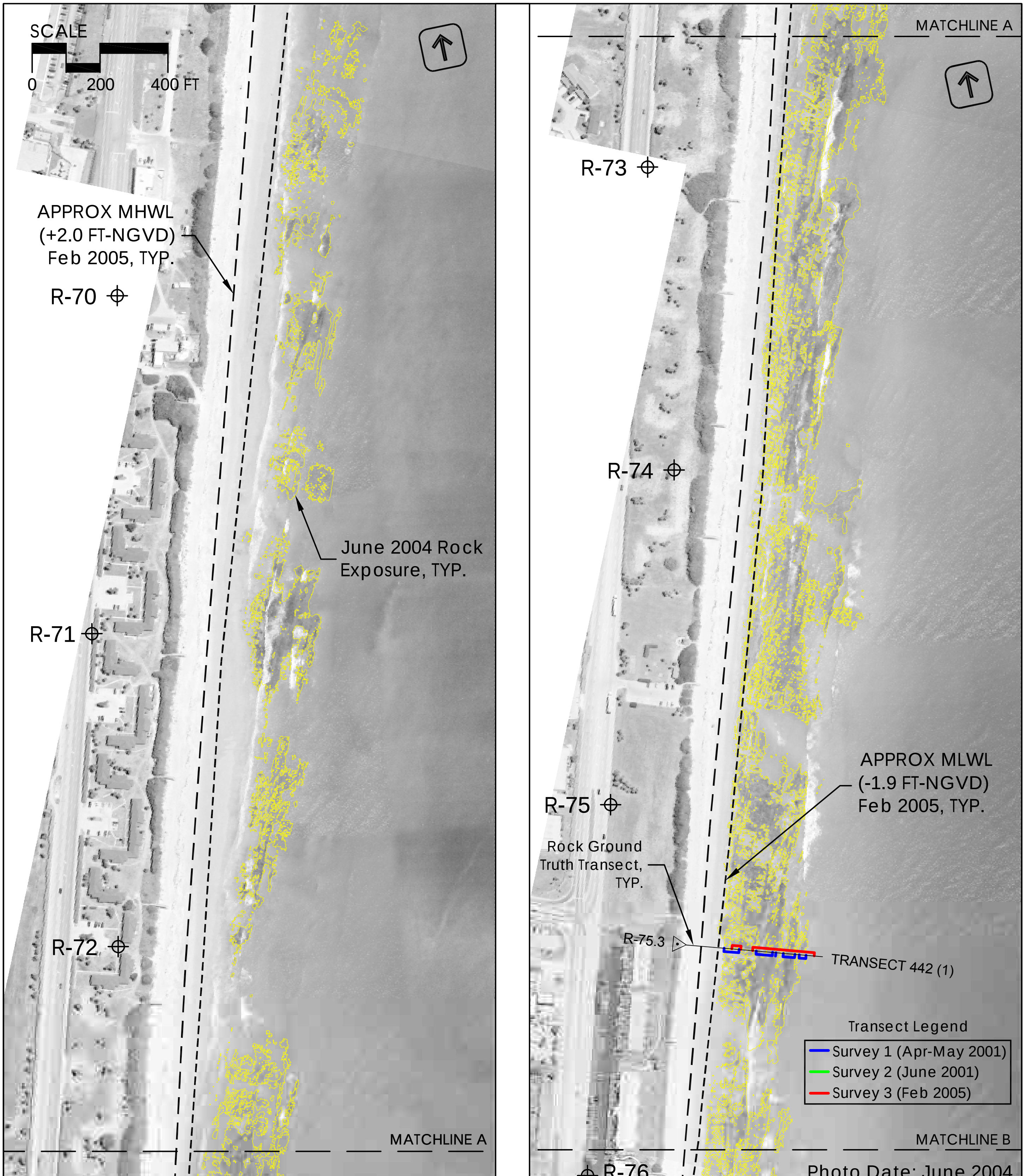
Year	Nearshore Hard Bottom	Current Value (acres)	Present Value (acre-years)
2145	100.0%	3.00	0.06
2146	100.0%	3.00	0.05
2147	100.0%	3.00	0.05
2148	100.0%	3.00	0.05
2149	100.0%	3.00	0.05
2150	100.0%	3.00	0.05
2151	100.0%	3.00	0.05
2152	100.0%	3.00	0.05
2153	100.0%	3.00	0.04
2154	100.0%	3.00	0.04
2155	100.0%	3.00	0.04
2156	100.0%	3.00	0.04
2157	100.0%	3.00	0.04
2158	100.0%	3.00	0.04
2159	100.0%	3.00	0.04
2160	100.0%	3.00	0.04
2161	100.0%	3.00	0.03
2162	100.0%	3.00	0.03
2163	100.0%	3.00	0.03
2164	100.0%	3.00	0.03
2165	100.0%	3.00	0.03
2166	100.0%	3.00	0.03
2167	100.0%	3.00	0.03
2168	100.0%	3.00	0.03
2169	100.0%	3.00	0.03
2170	100.0%	3.00	0.03
2171	100.0%	3.00	0.03
2172	100.0%	3.00	0.02
2173	100.0%	3.00	0.02
2174	100.0%	3.00	0.02
2175	100.0%	3.00	0.02
2176	100.0%	3.00	0.02
2177	100.0%	3.00	0.02
2178	100.0%	3.00	0.02
2179	100.0%	3.00	0.02
2180	100.0%	3.00	0.02
2181	100.0%	3.00	0.02
2182	100.0%	3.00	0.02
2183	100.0%	3.00	0.02
2184	100.0%	3.00	0.02
2185	100.0%	3.00	0.02
2186	100.0%	3.00	0.02
2187	100.0%	3.00	0.02
2188	100.0%	3.00	0.02
2189	100.0%	3.00	0.02
2190	100.0%	3.00	0.01

Table A.1. (Continued).

Year	Nearshore Hard Bottom	Current Value (acres)	Present Value (acre-years)
2191	100.0%	3.00	0.01
2192	100.0%	3.00	0.01
2193	100.0%	3.00	0.01
2194	100.0%	3.00	0.01
2195	100.0%	3.00	0.01
2196	100.0%	3.00	0.01
2197	100.0%	3.00	0.01
2198	100.0%	3.00	0.01
2199	100.0%	3.00	0.01
2200	100.0%	3.00	0.01
2201	100.0%	3.00	0.01
2202	100.0%	3.00	0.01
2203	100.0%	3.00	0.01
2204	100.0%	3.00	0.01
2205	100.0%	3.00	0.01
2206	100.0%	3.00	0.01
2207	100.0%	3.00	0.01
2208	100.0%	3.00	0.01
2209	100.0%	3.00	0.01
2210	100.0%	3.00	0.01
2211	100.0%	3.00	0.01
2212	100.0%	3.00	0.01
2213	100.0%	3.00	0.01
2214	100.0%	3.00	0.01
2215	100.0%	3.00	0.01
2216	100.0%	3.00	0.01
2217	100.0%	3.00	0.01
2218	100.0%	3.00	0.01
2219	100.0%	3.00	0.01
2220	100.0%	3.00	0.01
2221	100.0%	3.00	0.01
2222	100.0%	3.00	0.01
2223	100.0%	3.00	0.01
2224	100.0%	3.00	0.01
Total			102.82

APPENDIX SEIS-I

Occurrence of Nearshore Rock Outrcrops by Aerial Mapping and Transect Surveys



olsen
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COA No. 3491

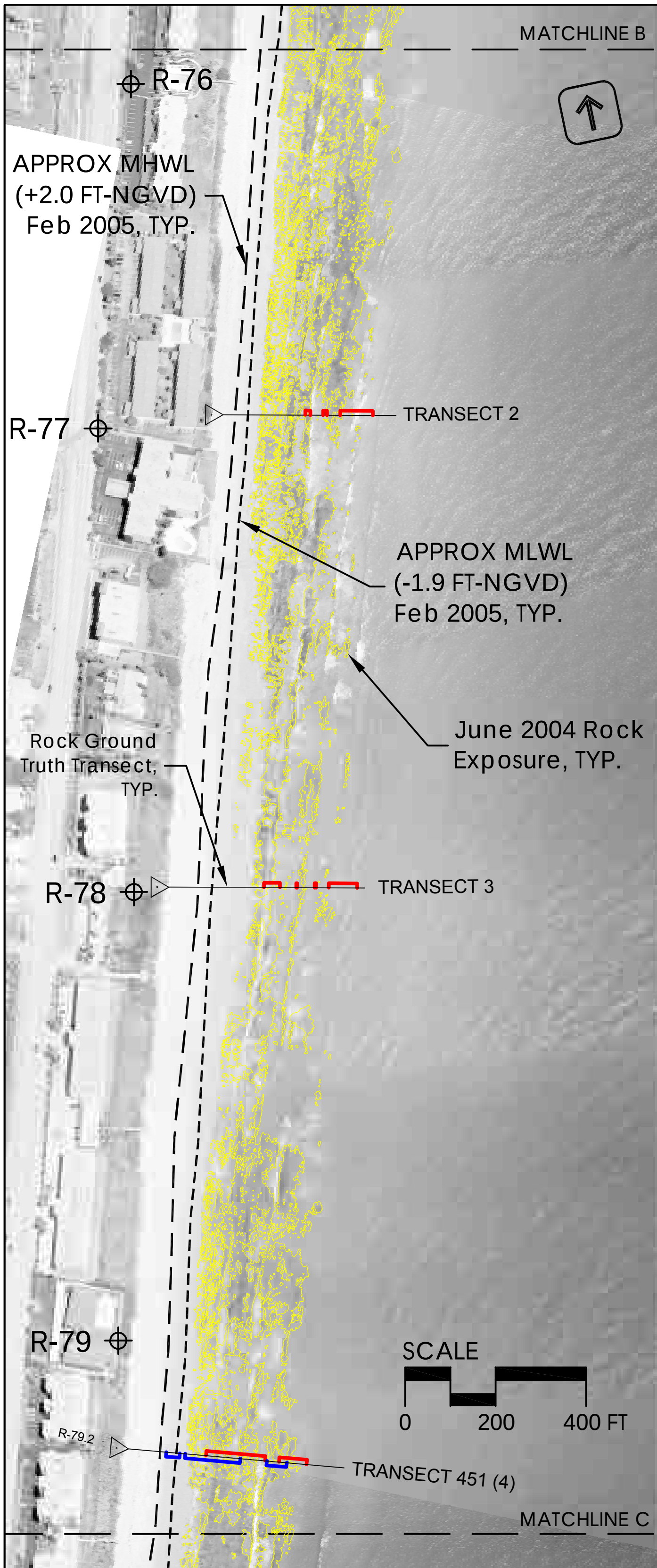
BREVARD COUNTY: MID REACH
ROCK EXPOSURE (2001, 2004, & 2005)

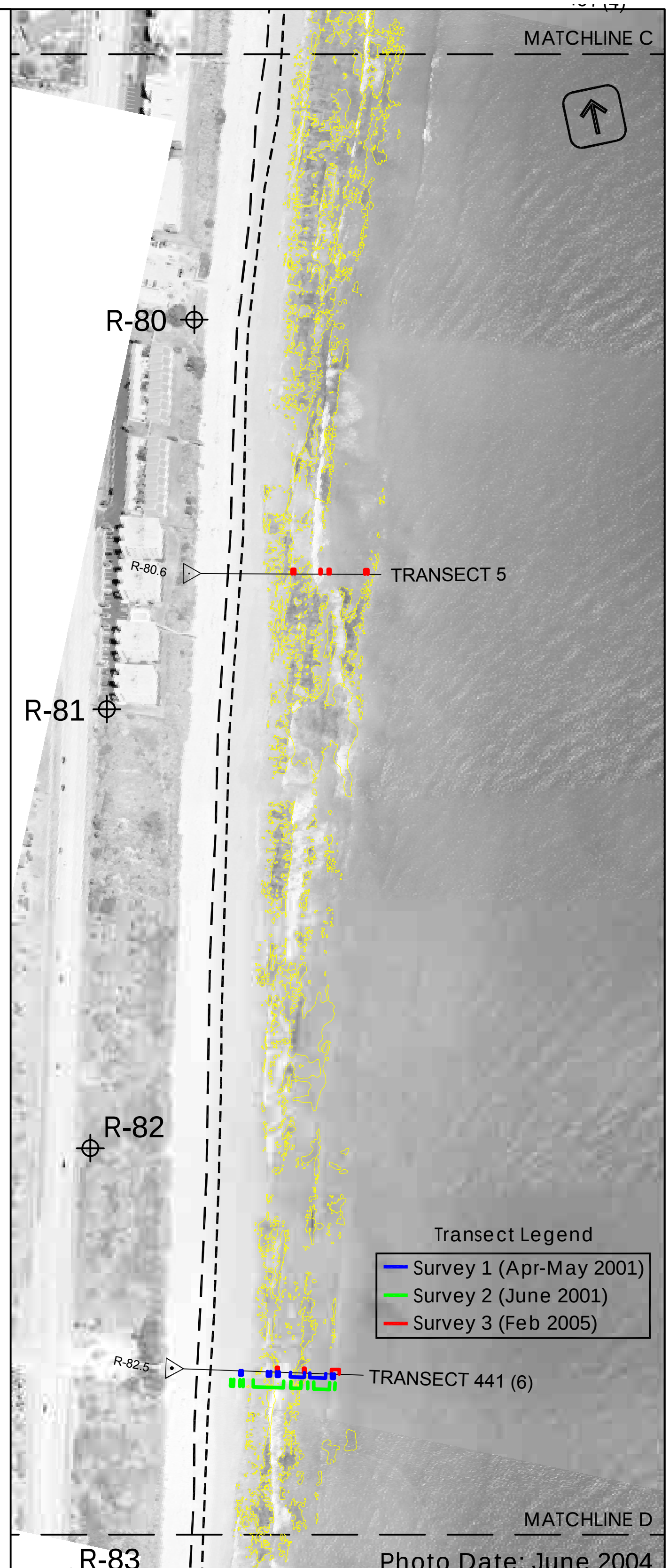
DATE	APPROVED	REVISION

10/31/05

DRAWN BY:
W.A.H.

SHEET
1 of 8





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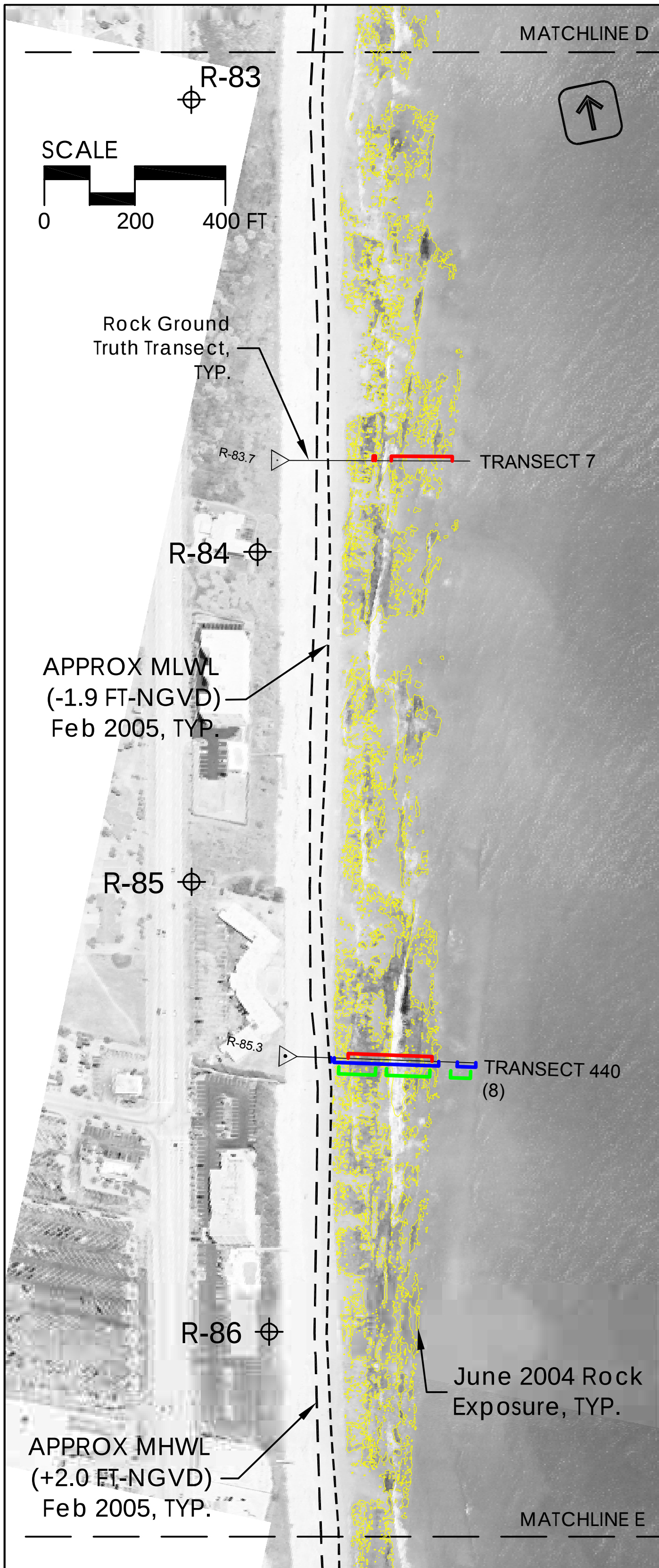

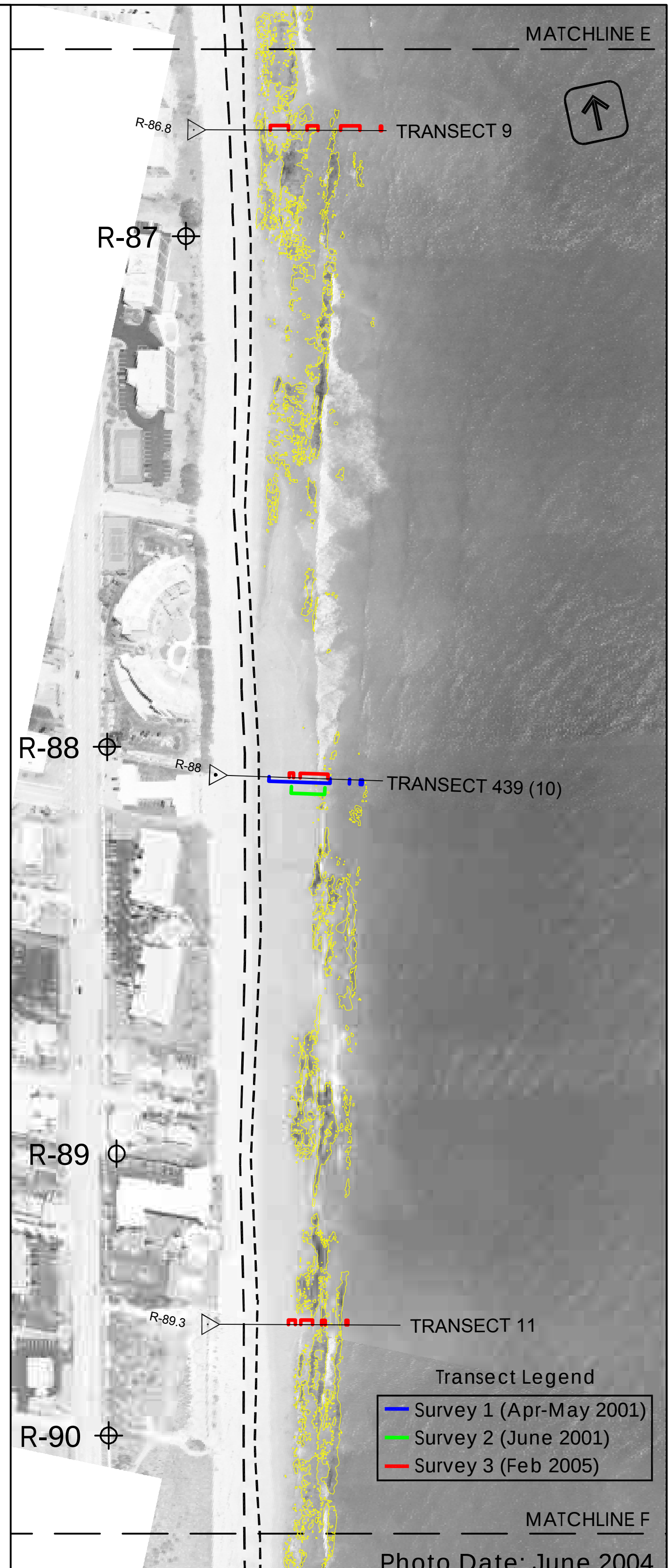

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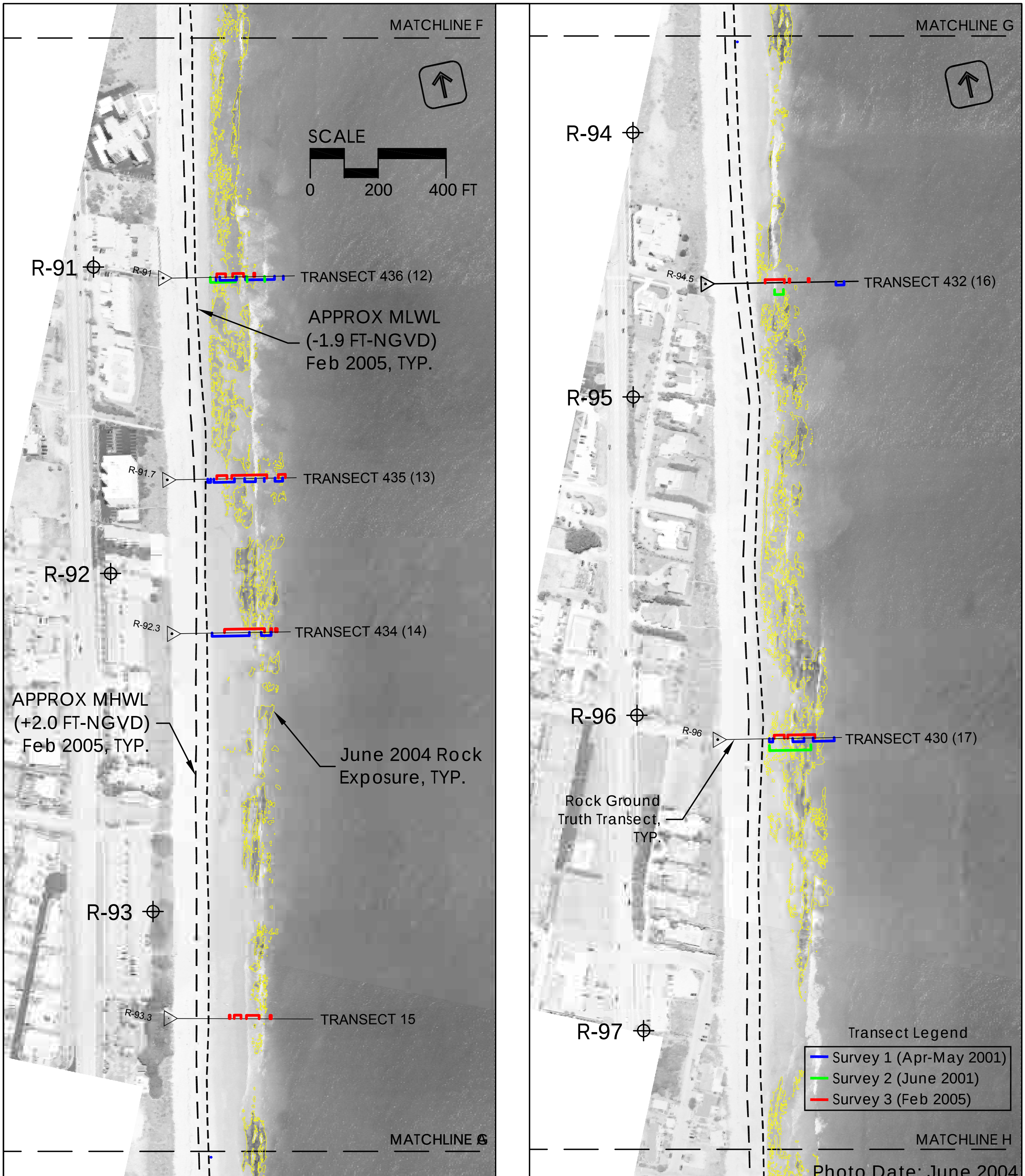

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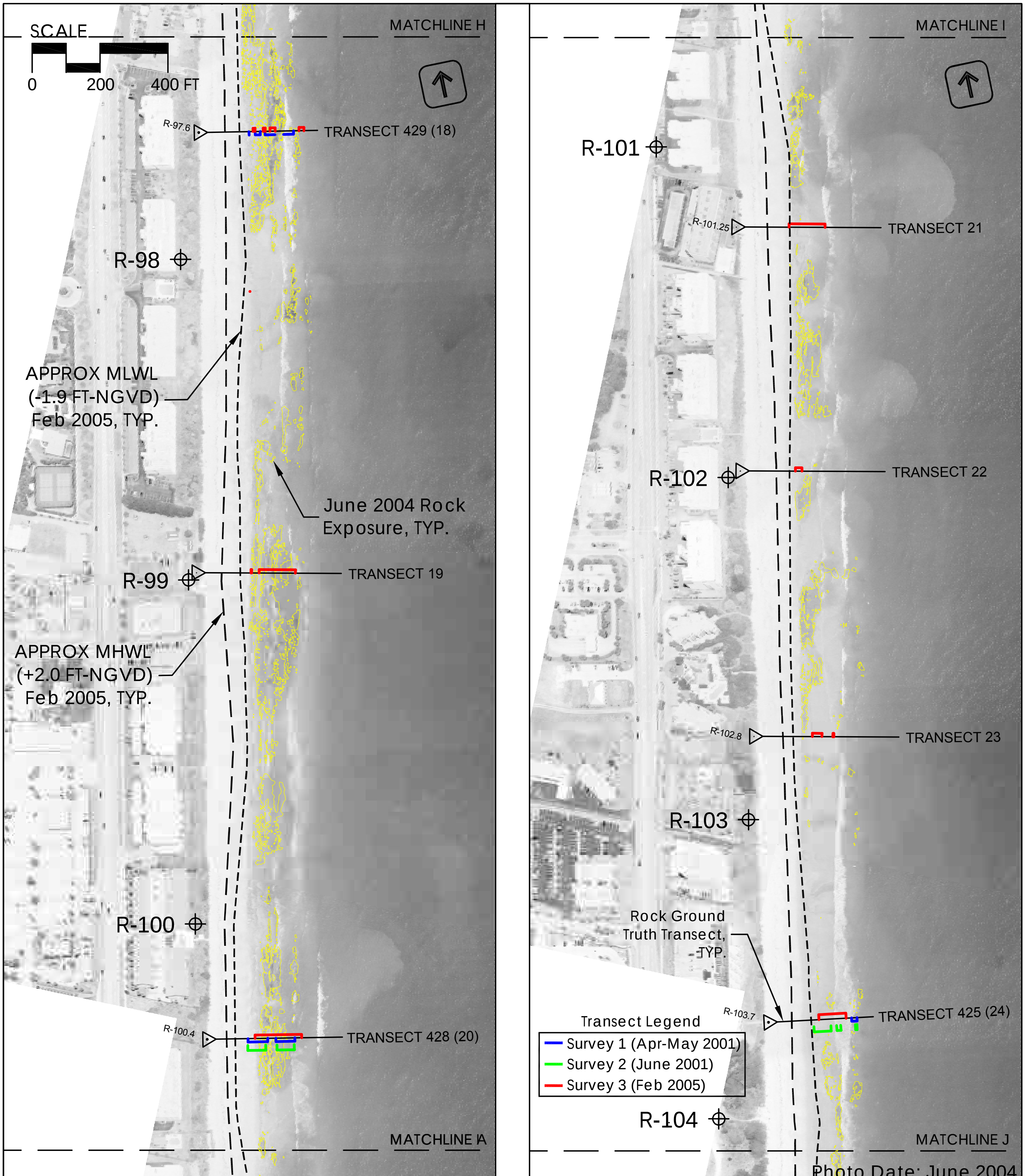

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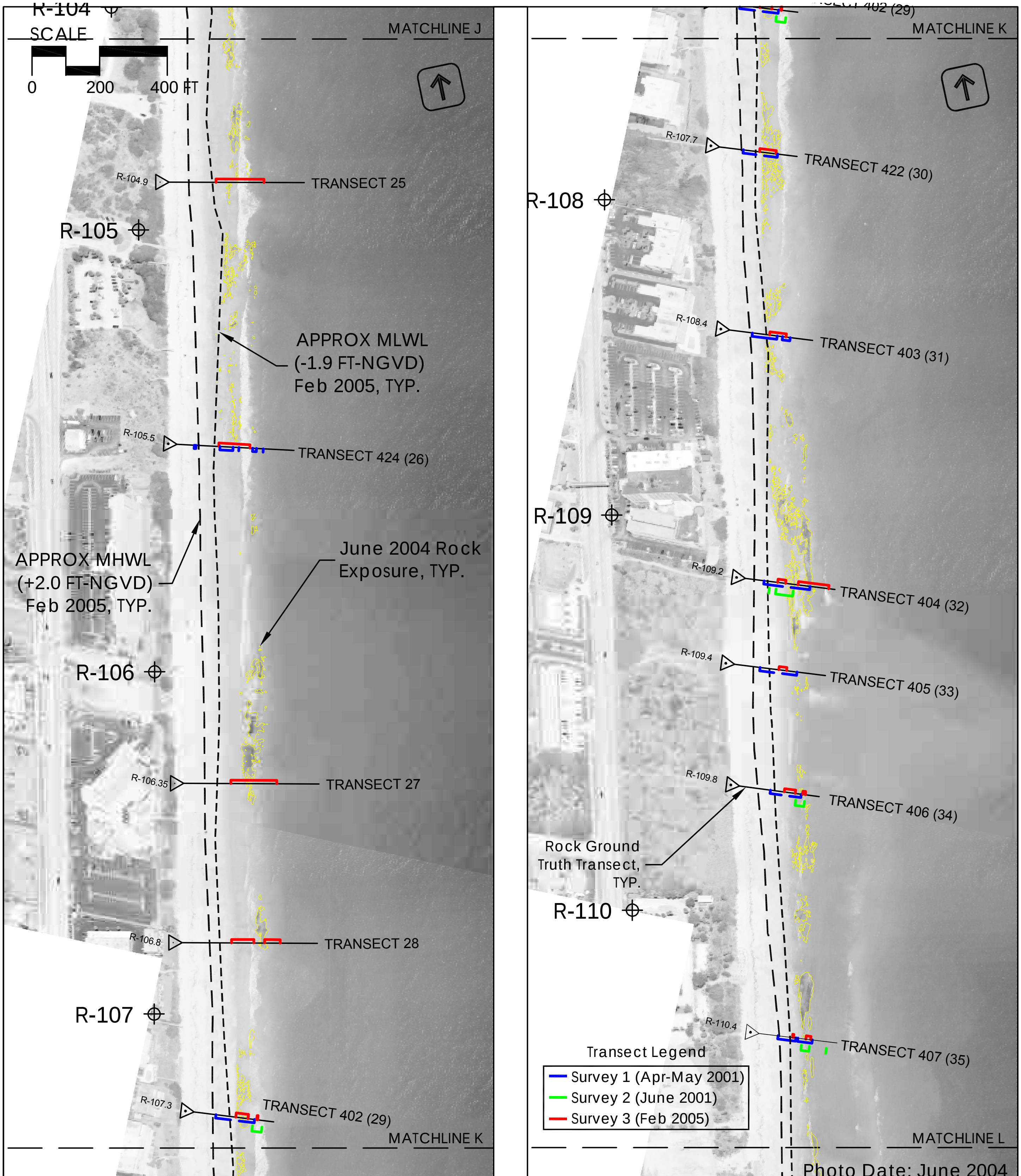

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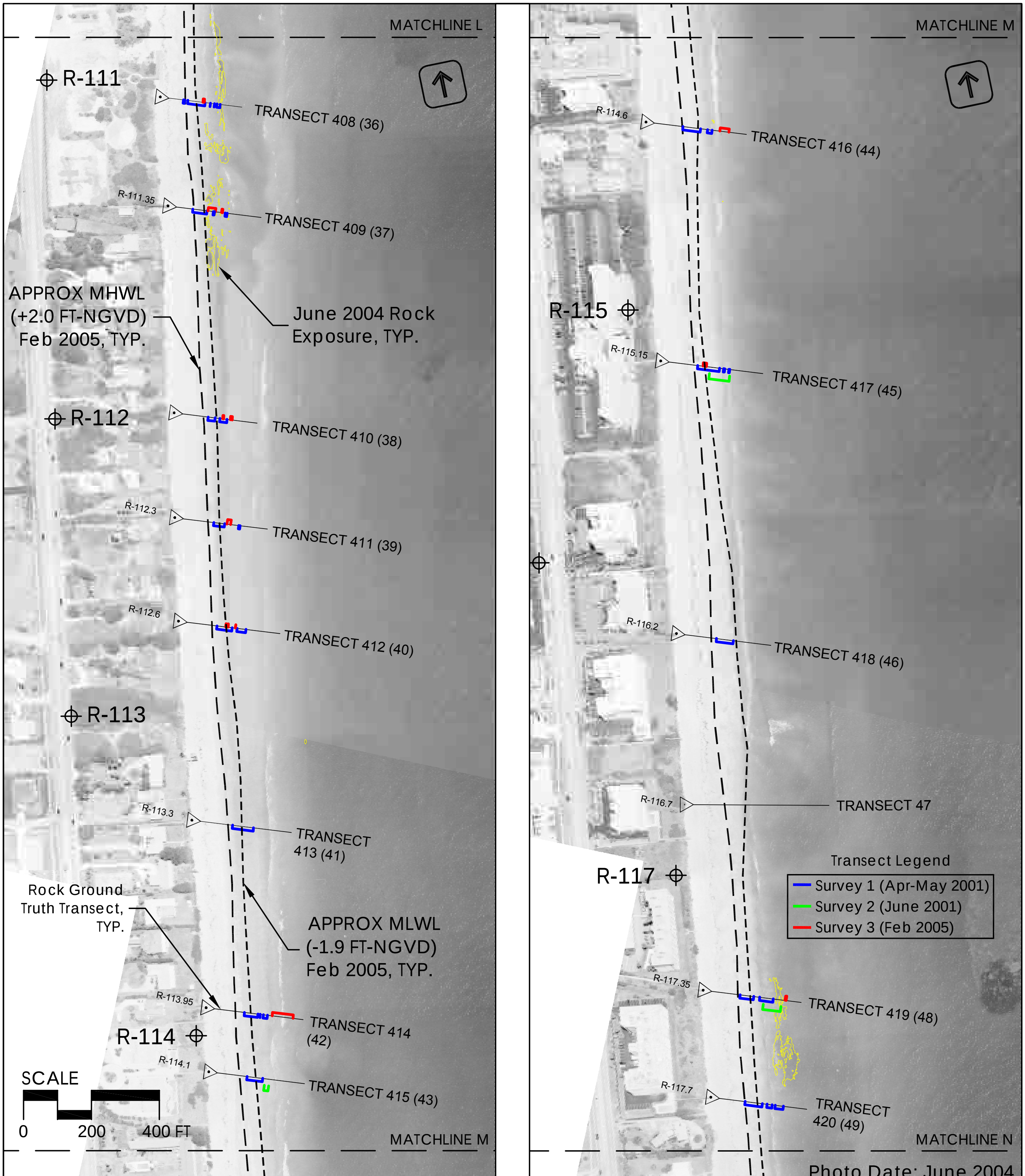

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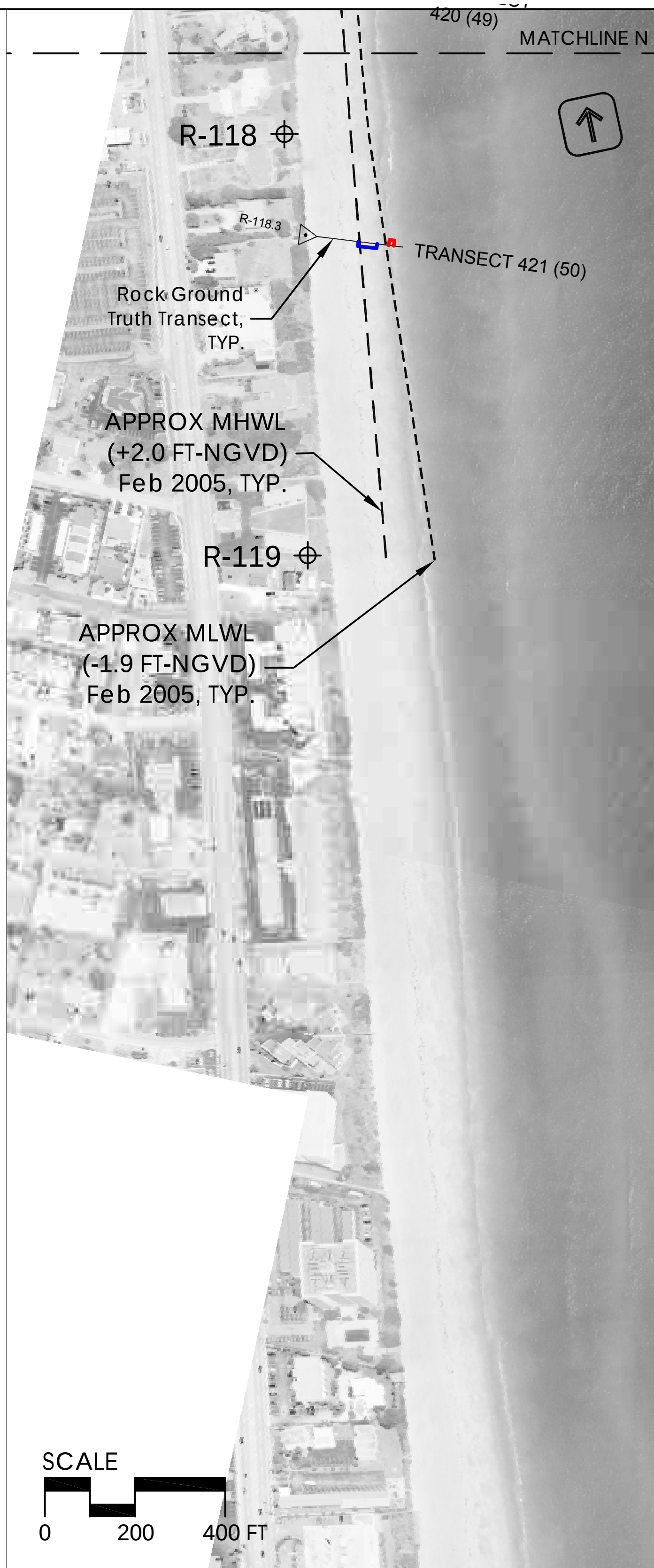

Transect Legend

- Survey 1 (Apr-May 2001)
- Survey 2 (June 2001)
- Survey 3 (Feb 2005)

Photo Date: June 2004

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Table 2a: Ground-truth transect location and azimuth data							
Transect	**Approx. R-Mon**	**Northing (FT-NAD27)**	**Easting (FT-NAD27)**	**Northerly distance between stations (ft)**	**Range**	**Grid Azimuth**	**Mon.***
1	R-75.3	1,410,085.5	629,717.3	--	0	83	IRC
2	R-77.0	1,408,685.8	629,926.4	1,400	7	83	PKD
3	R-78.0	1,407,640.0	630,025.8	1,046	0	83	IRC
4	R-79.2	1,406,409.4	630,195.6	1,231	0	83	HUB
5	R-80.6	1,405,080.1	630,389.9	1,329	0	83	IRC
6	R-82.5	1,403,349.2	630,718.9	1,731	0	80	PKD
7	R-83.7	1,402,100.0	630,950.2	1,249	0	80	IRC
8	R-85.3	1,400,815.6	631,240.7	1,284	0	80	X
9	R-86.8	1,399,605.1	631,508.0	1,211	0	80	IRC
10	R-88.0	1,398,220.8	631,851.5	1,384	0	80	PKD
11	R-89.3	1,397,029.8	632,087.0	1,191	0	77	IRC
12	R-91.0	1,395,891.3	632,359.2	1,138	0	77	PKD
13	R-91.7	1,395,310.6	632,487.1	581	-8	77	IRC
14	R-92.3	1,394,869.5	632,591.5	441	-12	77	IRC
15	R-93.3	1,393,761.8	632,828.9	1,108	0	77	IRC
16	R-94.5	1,392,670.0	633,093.4	1,092	0	77	PKD
17	R-96.0	1,391,364.6	633,407.8	1,305	0	77	PKD
18	R-97.6	1,389,911.8	633,734.8	1,453	-3	77	IRC
19	R-99.0	1,388,642.9	634,001.0	1,269	-10	77	IRC
20	R-100.4	1,387,300.2	634,298.5	1,343	-20	77	IRC
21	R-101.25	1,386,440.9	634,510.0	859	-9	77	IRC
22	R-102.0	1,385,740.5	634,671.1	700	-10	76	IRC
23	R-102.8	1,384,984.0	634,873.0	756	9	77	IRC
24	R-103.7	1,384,168.9	635,089.4	815	0	75	PK
25	R-104.9	1,383,384.3	635,254.4	785	10	77	IRC
26	R-105.5	1,382,632.3	635,438.8	752	0	81	IRC
27	R-106.35	1,381,653.8	635,666.7	978	0	81	IRC
28	R-106.8	1,381,192.1	635,759.8	462	0	81	IRC
29	R-107.3	1,380,712.7	635,898.8	479	0	85	PKD
30	R-107.7	1,380,296.0	635,992.0	417	0	85	PKD
31	R-108.4	1,379,771.3	636,133.9	525	0	85	PKD
32	R-109.2	1,379,063.3	636,331.0	708	0	85	PKD
33	R-109.4	1,378,807.0	636,332.5	256	-20	85	IRC
34	R-109.8	1,378,458.0	636,427.7	349	-15	85	IRC
35	R-110.4	1,377,753.6	636,621.3	704	-30	85	IRC
36	R-111.0	1,377,253.1	636,758.2	501	-22	85	IRC
37	R-111.35	1,376,944.4	636,864.6	309	-4	85	PKD
38	R-112.0	1,376,353.0	637,013.6	591	0	85	PKD
39	R-112.3	1,376,051.3	637,079.3	302	0	85	PKD
40	R-112.6	1,375,755.9	637,153.7	295	0	85	IRC
41	R-113.3	1,375,190.0	637,313.8	566	0	85	IRC
42	R-113.95	1,374,657.7	637,470.0	532	0	85	PKD
43	R-114.1	1,374,474.8	637,516.4	183	0	85	PKD
44	R-114.6	1,374,010.4	637,643.2	464	0	85	PKD
45	R-115.15	1,373,330.8	637,832.0	680	0	85	PKD
46	R-116.2	1,372,554.4	638,044.6	776	0	85	PKD
47	R-116.7	1,372,067.1	638,172.4	487	-12	85	IRC
48	R-117.35	1,371,543.1	638,339.5	524	0	85	PKD
49	R-117.7	1,371,239.4	638,427.7	304	0	85	PKD
50	R-118.3	1,370,696.2	638,568.9	543	0	85	PKD

Table 2b: Ground-truth transect survey dates

Transect	Approx. R-Mon	Loc'n north of R118.3 (ft) feet	stat. miles	Survey-1 Date	Survey-1 Rock Length (ft)	Survey-2 Date	Survey-2 Rock Length (ft)	Survey-3 Date	Survey-3 Rock Length (ft)	Comments
1	R-75.3	39,389	7.46	5/22/2001	147			12/16/2002	199	Pineda Ocean Club
2	R-77.0	37,990	7.20					12/30/2002	92	
3	R-78.0	36,944	7.00					12/16/2002	104	Opal Seas
4	R-79.2	35,713	6.76	5/25/2001	180			12/16/2002	195	East Horizons
5	R-80.6	34,384	6.51					12/30/2002	19	Monaco Condos
6	R-82.5	32,653	6.18	5/22/2001	98	6/21/2001	126	12/17/2002	24	
7	R-83.7	31,404	5.95					12/17/2002	140	
8	R-85.3	30,119	5.70	5/22/2001	272	6/22/2001	261	12/17/2002	185	Paradise Beach Club
9	R-86.8	28,909	5.48					12/17/2002	110	Buccaneer Beach
10	R-88.0	27,525	5.21	5/22/2001	139	6/22/2001	74	12/17/2002	70	
11	R-89.3	26,334	4.99					12/17/2002	39	
12	R-91.0	25,195	4.77	5/22/2001	134	6/22/2001	74	12/17/2002	54	
13	R-91.7	24,614	4.66	5/22/2001	128			12/18/2002	154	Emerald Shores
14	R-92.3	24,173	4.58	5/21/2001	61			12/18/2002	126	Eastwind Condos
15	R-93.3	23,066	4.37					12/18/2002	75	Pelican Bch So.
16	R-94.5	21,974	4.16	5/21/2001	24	6/22/2001	26	12/18/2002	63	Desota Avenue
17	R-96.0	20,668	3.91	5/21/2001	99	6/22/2001	122	12/18/2002	112	Sunrise Avenue
18	R-97.6	19,216	3.64	5/21/2001	102			12/18/2002	68	Lantana Condos
19	R-99.0	17,947	3.40					12/18/2002	110	
20	R-100.4	16,604	3.14	5/21/2001	114	6/22/2001	75	12/18/2002	137	
21	R-101.25	15,745	2.98					12/18/2002	106	
22	R-102.0	15,044	2.85	5/21/2001	0			12/18/2002	19	
23	R-102.8	14,288	2.71					12/18/2002	31	
24	R-103.7	13,473	2.55	5/21/2001	16	6/21/2001	67	12/18/2002	80	
25	R-104.9	12,688	2.40					12/18/2002	142	
26	R-105.5	11,936	2.26	5/22/2001	61			12/18/2002	92	
27	R-106.35	10,958	2.08					12/18/2002	136	
28	R-106.8	10,496	1.99					12/18/2002	112	
29	R-107.3	10,017	1.90	4/17/2001	115	6/21/2001	28	12/23/2002	39	
30	R-107.7	9,600	1.82	4/17/2001	102			12/23/2002	49	
31	R-108.4	9,075	1.72	4/17/2001	97			12/23/2002	70	
32	R-109.2	8,367	1.58	4/17/2001	137	6/21/2001	51	12/23/2002	115	Holiday Inn
33	R-109.4	8,111	1.54	4/17/2001	19			12/30/2002	23	
34	R-109.8	7,762	1.47	4/17/2001	92	6/21/2001	26	12/30/2002	63	
35	R-110.4	7,057	1.34	4/17/2001	96	6/20/2001	24	12/30/2002	54	
36	R-111.0	6,557	1.24	4/17/2001	71			12/30/2002	4	
37	R-111.35	6,248	1.18	4/17/2001	51	6/20/2001	0	12/30/2002	43	
38	R-112.0	5,657	1.07	4/17/2001	41			12/30/2002	28	
39	R-112.3	5,355	1.01	4/17/2001	36	6/20/2001	0	12/23/2002	11	
40	R-112.6	5,060	0.96	4/17/2001	71			12/23/2002	107	
41	R-113.3	4,494	0.85	4/17/2001	62	6/20/2001	0	12/23/2002	0	
42	R-113.95	3,962	0.75	4/17/2001	55			12/23/2002	62	
43	R-114.1	3,779	0.72	4/17/2001	46	6/20/2001	13	12/23/2002	0	
44	R-114.6	3,314	0.63	4/17/2001	65			12/23/2002	7	
45	R-115.15	2,635	0.50	4/16/2001	91	6/20/2001	60	12/30/2002	10	
46	R-116.2	1,858	0.35	4/16/2001	50			12/30/2002	0	Outrigger Condos
47	R-116.7	1,371	0.26					12/30/2002	0	
48	R-117.35	847	0.16	4/16/2001	80	6/20/2001	52	12/20/2002	1	
49	R-117.7	543	0.10	4/16/2001	80			12/30/2002	0	
50	R-118.3	-	0.00	4/16/2001	30			12/30/2002	11	

Table 3

Summary of total length of rock measured along each ground-truth transect line, by survey date.

	Transect	Approx. R-Mon	Dist-feet	Dist-miles	Survey Date	Survey1-ft	Survey Date	Survey2-ft	Survey Date	Survey3-ft
Reach 6	1	R-75.3	39,389	7.46	5/22/2001	147			12/16/2002	199
	2	R-77.0	37,990	7.20					12/30/2002	92
	3	R-78.0	36,944	7.00					12/16/2002	104
	4	R-79.2	35,713	6.76	5/25/2001	180			12/16/2002	195
	5	R-80.6	34,384	6.51					12/30/2002	19
	6	R-82.5	32,653	6.18	5/22/2001	98	6/21/2001	126	12/17/2002	24
	AVG		**36,179**	**6.85**	**5/23/2001**	**142**	**6/21/2001**	**126**	**12/20/2002**	**106**
Reach 5	7	R-83.7	31,404	5.95					12/17/2002	140
	8	R-85.3	30,119	5.70	5/22/2001	272	6/22/2001	261	12/17/2002	185
	9	R-86.8	28,909	5.48					12/17/2002	110
	10	R-88.0	27,525	5.21	5/22/2001	139	6/22/2001	74	12/17/2002	70
	11	R-89.3	26,334	4.99					12/17/2002	39
	12	R-91.0	25,195	4.77	5/22/2001	134	6/22/2001	74	12/17/2002	54
	13	R-91.7	24,614	4.66	5/22/2001	128			12/18/2002	154
	14	R-92.3	24,173	4.58	5/21/2001	61			12/18/2002	126
	AVG		**27,284**	**5.17**	**5/21/2001**	**147**	**6/22/2001**	**136**	**12/17/2002**	**110**
Reach 4	15	R-93.3	23,066	4.37					12/18/2002	75
	16	R-94.5	21,974	4.16	5/21/2001	24	6/22/2001	26	12/18/2002	63
	17	R-96.0	20,668	3.91	5/21/2001	99	6/22/2001	122	12/18/2002	112
	18	R-97.6	19,216	3.64	5/21/2001	102			12/18/2002	68
	19	R-99.0	17,947	3.40					12/18/2002	110
	AVG		**20,574**	**3.90**	**5/21/2001**	**75**	**6/22/2001**	**74**	**12/18/2002**	**86**
Reach 3	20	R-100.4	16,604	3.14	5/21/2001	114	6/22/2001	75	12/18/2002	137
	21	R-101.25	15,745	2.98					12/18/2002	106
	22	R-102.0	15,044	2.85	5/21/2001	0			12/18/2002	19
	23	R-102.8	14,288	2.71					12/18/2002	31
	24	R-103.7	13,473	2.55	5/21/2001	16	6/21/2001	67	12/18/2002	80
	25	R-104.9	12,688	2.40					12/18/2002	142
	AVG		**14,640**	**2.77**	**5/21/2001**	**43**	**6/21/2001**	**71**	**12/18/2002**	**86**
Reach 2	26	R-105.5	11,936	2.26	5/22/2001	61			12/18/2002	92
	27	R-106.35	10,958	2.08					12/18/2002	136
	28	R-106.8	10,496	1.99					12/18/2002	112
	29	R-107.3	10,017	1.90	4/17/2001	115	6/21/2001	28	12/23/2002	39
	30	R-107.7	9,600	1.82	4/17/2001	102			12/23/2002	49
	31	R-108.4	9,075	1.72	4/17/2001	97			12/23/2002	70
	AVG		**10,347**	**1.96**	**4/25/2001**	**94**	**6/21/2001**	**28**	**12/20/2002**	**83**
Reach 1	32	R-109.2	8,367	1.58	4/17/2001	137	6/21/2001	51	12/23/2002	115
	33	R-109.4	8,111	1.54	4/17/2001	19			12/30/2002	23
	34	R-109.8	7,762	1.47	4/17/2001	92	6/21/2001	26	12/30/2002	63
	35	R-110.4	7,057	1.34	4/17/2001	96	6/20/2001	24	12/30/2002	54
	36	R-111.0	6,557	1.24	4/17/2001	71			12/30/2002	4
	37	R-111.35	6,248	1.18	4/17/2001	51	6/20/2001	0	12/30/2002	43
	38	R-112.0	5,657	1.07	4/17/2001	41			12/30/2002	28
	39	R-112.3	5,355	1.01	4/17/2001	36	6/20/2001	0	12/23/2002	11
	40	R-112.6	5,060	0.96	4/17/2001	71			12/23/2002	107
	41	R-113.3	4,494	0.85	4/17/2001	62	6/20/2001	0	12/23/2002	0
	42	R-113.95	3,962	0.75	4/17/2001	55			12/23/2002	62
	43	R-114.1	3,779	0.72	4/17/2001	46	6/20/2001	13	12/23/2002	0
	44	R-114.6	3,314	0.63	4/17/2001	65			12/23/2002	7
	45	R-115.15	2,635	0.50	4/16/2001	91	6/20/2001	60	12/30/2002	10
	46	R-116.2	1,858	0.35	4/16/2001	50			12/30/2002	0
	47	R-116.7	1,371	0.26					12/30/2002	0
	48	R-117.35	847	0.16	4/16/2001	80	6/20/2001	52	12/20/2002	1
	49	R-117.7	543	0.10	4/16/2001	80			12/30/2002	0
	50	R-118.3	-	-	4/16/2001	30			12/30/2002	11
	AVG		**4,367**	**0.83**	**4/16/2001**	**65**	**6/20/2001**	**25**	**12/26/2002**	**28**

Brief summary of measured changes in beach profile and exposed rock occurrence along surveyed transect lines adjacent to, and along, the Mid Reach Project Area.

Representative results from prior and ongoing surveys along the shoreline of the Mid Reach and the adjacent one-mile shoreline of southern Patrick Air Force Base are presented in the following pages. These surveys and analyses have been conducted by Brevard County and the U. S. Air Force, and additionally incorporate survey data collected by the Florida Dept. of Environmental Protection (FDEP) and U. S. Army Corps of Engineers. Three principal groups of survey data and results are presented, described as follows. "R" values reflect locations of survey transects per the FDEP reference monuments along the shoreline.

1. **R70-R77.** Figures A through D depict two (2) "mean" beach profile lines and the mapped occurrence of exposed rock along each of eight R-monument, from available surveys. The "mean" beach profile refers to the average vertical elevation of the seabed at each location along the R-monument transect, computed from a series of historical beach profile surveys. Of these two "mean" profiles:

- The black profile represents the mean profile elevation computed from all available surveys *prior* to renourishment of the North Reach and Patrick AFB shorelines in Feb-April, 2005. These include data from up to 8 prior surveys from 1972 through June 2004[1].
- The red profile represents the mean profile elevation computed from all available surveys through the present; i.e., *prior to and after* the construction of beach renourishment in Feb-April, 2005. These include the data from the 8 prior surveys (1972-2004) plus four annual surveys after construction (2005-2008).[2]

Beach profile data from surveys in October 2004 through February 2005 are not included in the mean profile computations because these represent anomalous conditions immediately subsequent to the effects of Hurricanes Charley, Frances and Jeanne in Autumn, 2004.

Horizontal bars in each figure indicate the occurrence of exposed rock hardground along each the survey transect. These include the appearance of rock indicated by multi-spectral image analysis of aerial photographs in January 2001 and June 2004, and physical surveys in February 2005 through July 2008. The survey in February 2005 is considered to represent a "quasi-maximum", or at least anomalously large, extent of exposed rock because it was purposefully conducted after the severe erosion of sand from the beach-face and nearshore profile by the Autumn, 2004 hurricanes. The dashed vertical lines in each figure represent the landward and seaward limits at which exposed rock was observed in the pre-nourishment surveys (i.e., from 2001 through February 2005).

[1] Sept 1972, Aug 1986, Dec 1993, Dec 2000, Feb 2001, June 2002, June 2003, June 2004.
[2] April 2005, July 2006, August 2007, July 2008. Rock occurrence data for 2008 are draft.

2. **R82.5-R107.3**. Figures E through G depict the beach profile measured in August 2008, and the temporal occurrence of exposed rock hardgrounds from various surveys, for each of five (5) survey-transects along the Mid Reach. These transects are a representative sample of fifty (50) survey transects previously established along the Mid Reach at which the occurrence of exposed rock has been surveyed on random occasions. (The five transects shown in the figures are also those for which the greatest number of surveys are thus far available, specifically including surveys collected after 2002.) Excepting surveys in 2007 and 2008, these prior surveys have measured only the occurrence of rock (and not the profile elevation); therefore, temporal "mean" profile elevations are not shown for these transects.

3. **R110-R118.** Figures H through L depict two (2) "mean" beach profile lines and the mapped occurrence of exposed rock along each of nine R-monument, from available surveys. Like Figures A through D along Patrick Air Force Base, the "mean" beach profile refers to the average vertical elevation of the seabed at each location along the R-monument transect, computed from a series of historical beach profile surveys.

- The blue-dashed profile represents the mean profile elevation computed from all available surveys *prior* to renourishment of the South Reach shoreline in March-April, 2005. These include data from up to 16 prior surveys from 1972 through June 2004[3].
- The red profile represents the mean profile elevation computed from all available surveys through the present; i.e., *prior to and after* the South Reach beach renourishment in March-April, 2005. These include the data from the 16 prior surveys (1972-2004) plus three annual surveys after construction (2005-2007).[4]

Beach profile data from surveys in October 2004 through February 2005 are not included in the mean profile computations because these represent anomalous conditions immediately subsequent to the effects of Hurricanes Charley, Frances and Jeanne in Autumn, 2004.

Horizontal bars in each figure indicate the occurrence of exposed rock hardground along each the survey transect. These include the appearance of rock indicated by multi-spectral image analysis of aerial photographs in January 2001 and June 2004, and physical surveys in February 2005 through June 2007. The survey in February 2005 is considered to represent a "quasi-maximum", or at least anomalously large, extent of exposed rock because it was purposefully conducted after the severe erosion of sand from the beach-face and nearshore profile by the Autumn, 2004 hurricanes. The dashed vertical lines in each figure represent the landward and seaward limits at which exposed rock was observed

[3] Sept 1972, July 1983, Aug 1986, Sept 1989, Dec 1993, Sept 1997, Feb 1998, May 2000, Jan 2001, Dec 2001, May 2002, Dec 2002, March 2003, May 2003, June 2004. Not all surveys include data at each monument location.
[4] May 2005, July 2006, June 2007. Data from 2008 were not available at the time of this report.

in the pre-nourishment surveys (i.e., from 2001 through February 2005). At transects where no rock was observed, there are no dashed vertical lines.

The data and graphics in Figures A-D and Figures H-L, for R70-R77 and for R110-R118 are excerpted from monitoring reports prepared by the U. S. Air Force and Brevard County, respectively, pursuant to requirements of, and coordination with, EFH Conservation Recommendations prepared by the National Marine Fisheries Service in December 2004. These recommendations were prepared in regard to proposed, post-hurricane beach renourishment activities conducted by the U. S. Air Force along Patrick AFB in 2005 and by the U. S. Army Corps of Engineers along the North and South Reach of the Brevard County Shore Protection Project in 2005.[5]

Discussion. Comparison of the two "mean" profiles in Figures A-D and Figures H through L represent a graphical "trend analysis" in temporal change in profile elevations. That is, changes in the "mean" profile from pre-renourishment conditions through 2004 (black or blue-dashed lines) to present, post-renourishment conditions through 2007/08 (red lines) indicate the degree to which the beach is demonstrating long-term advance (accretion) or deepening (erosion). Specifically,

a) Figures A-D illustrate the beach profile trend along and immediately south of dune- and beach-face fill placement in 2005 at Patrick Air Force Base (in addition to the alongshore feeder effects of fill placed along the North Reach of the Brevard County Shore Protection Project (BCSPP) and northern Patrick AFB, spanning approximately 10.6 miles in total length).

b) Figures H through L illustrate the trend within 1-1/2 miles adjacent to (north of) the beach renourishment along the approximate 4-mile length of the South Reach of the BCSPP in 2005.

Comparison of the two "pre-renourishment" and "current" mean profiles likewise illustrates the cumulative effect of emergency, post-storm dune fill placement by Brevard County along the Mid Reach in 2005 through 2008.

In both sets of figures – along the south end of Patrick AFB and adjacent Mid Reach (R70-R77) and along the southern Mid Reach adjacent to the South Reach, BCSPP (R110-R118) -- the trends are similar. That is, in comparing the "pre-renourishment" and "current" profiles, the following is indicated:

- Slight advance (accretion) of the beach face landward of the shoreward limit of nearshore rock exposure, or mean low water line;
- No significant change, or slight decrease (erosion), in the profile elevation within the normal limits of nearshore rock exposure; and

[5] Additional details and description of the monitoring activity are presented in reports prepared by Olsen Associates, Inc. for the U. S. Air Force (45 CES/CECC) and Brevard County, in 2005 through 2008, and subsequently transmitted to NMFS by the USAF and Corps of Engineers.

- Mostly decrease (erosion) in the profile elevation seaward of the normal limits of nearshore rock exposure.

Likewise, comparison of the horizontal extent of nearshore rock exposure, as measured from 2001 through present, indicates no significant changes or trends in the amount of exposed hardgrounds at each transect. Substantial temporal fluctuations in the amount and locations of exposed hardgrounds are evident at each transect; however, these fluctuations do not exhibit any identifiable trend between pre- and post-renourishment conditions by year or alongshore location.

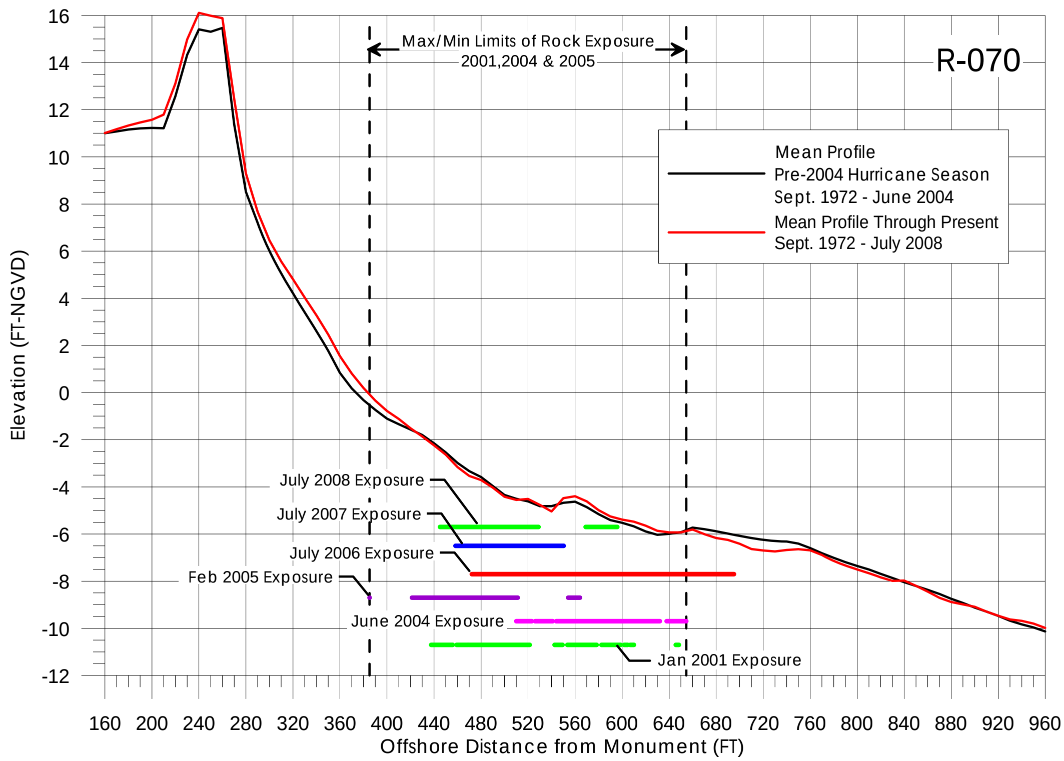
Additionally, comparison of the post-renourishment beach profiles with the standard-deviation of the pre-renourishment profiles (not shown in the figures) has not indicated the occurrence of profile fluctuations that exceed expected "normal" temporal fluctuations computed from the pre-project surveys[6].

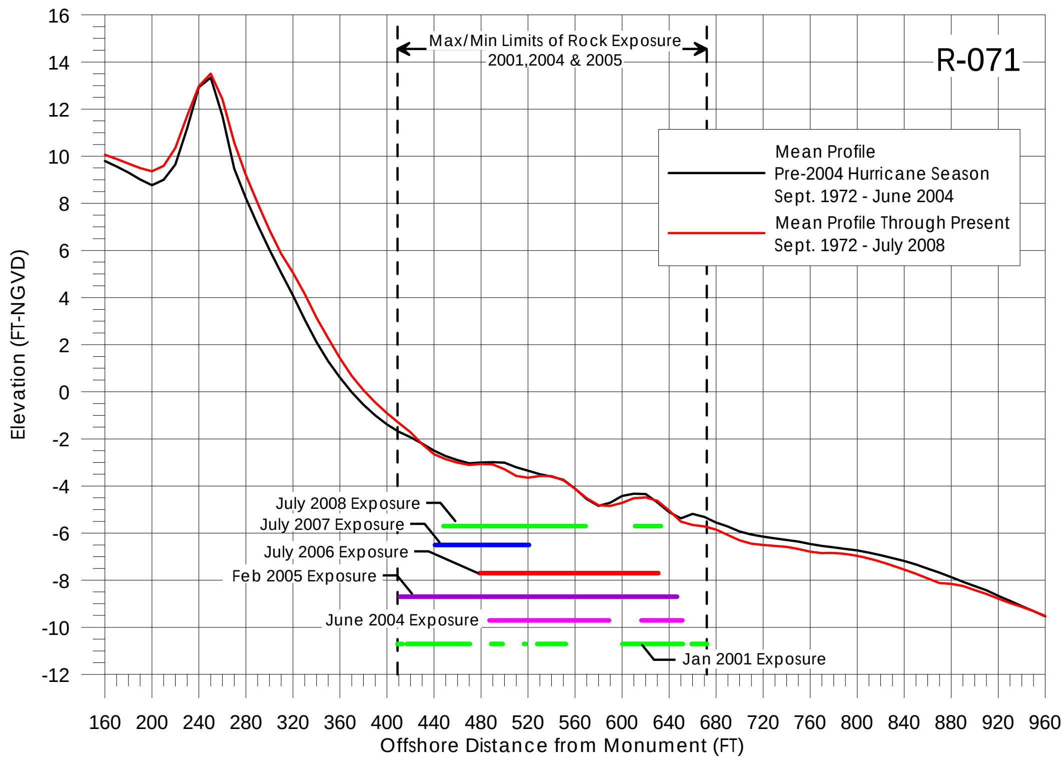
These results indicate no trend toward a accumulation of sand (accretion) below the mean low water line. Such accumulation would conceivably result in some burial of existing, exposed nearshore rock hardgrounds; but this is not indicated.

Figures E through G (R82.5-R107.3) illustrate changes in exposed rock occurrence at representative transects along the Mid Reach. These transects span locations between 1.3 miles south, and 2.1 miles north, of adjacent dune- and beach-fill renourishment activities constructed in 2005, and include locations of emergency, post-storm dune renourishment conducted by Brevard County along the Mid Reach in 2005-08. The data indicate no apparent trends in changes in the amounts or locations of exposed rock hardgrounds between pre-renourishment and post-renourishment conditions, despite large temporal fluctuations in the rock exposure at each transect between surveys. These fluctuations are reflective of the apparently significant natural variations in the amounts and cross-shore locations of exposed rock along the Mid Reach shoreline.

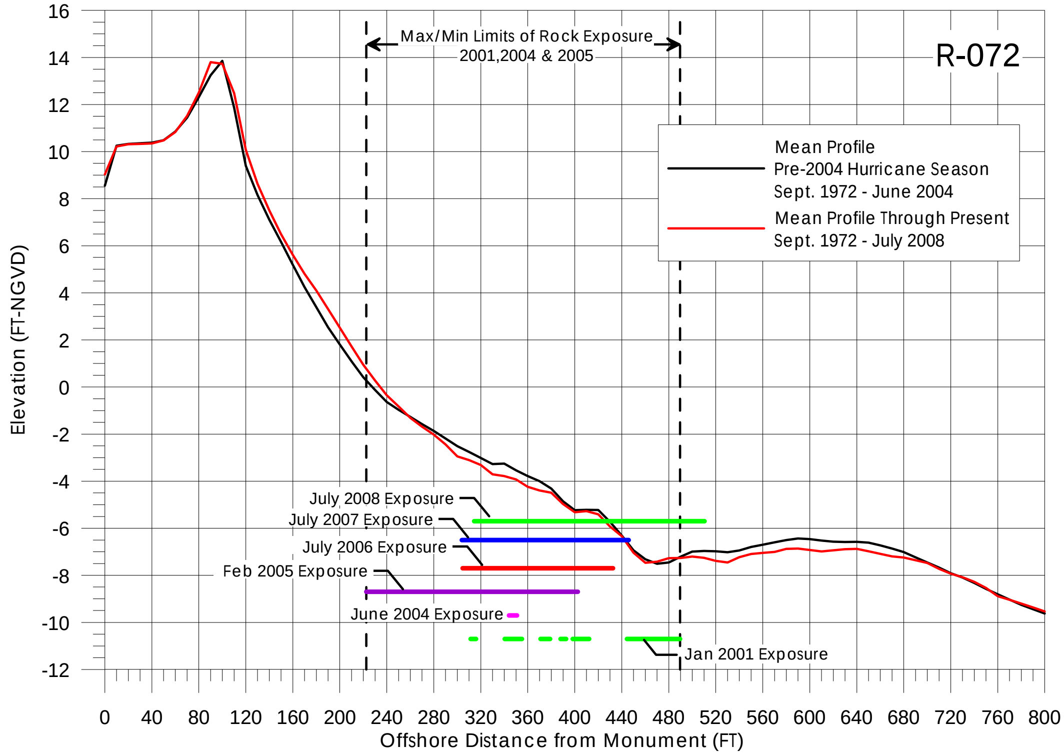
[6] Olsen Associates, Inc. "2005 Post-Storm Beach Renourishment, Patrick AFB; Year-Three Post-Construction Nearshore Rock Survey - 2008". Letter Report to Mr. John McGann, Amec Earth & Environmental Inc., Cocoa FL. Prepared by S. Howard, Olsen Associates, Inc., 4438 Herschel Street, Jacksonville, FL 32210. 2008.

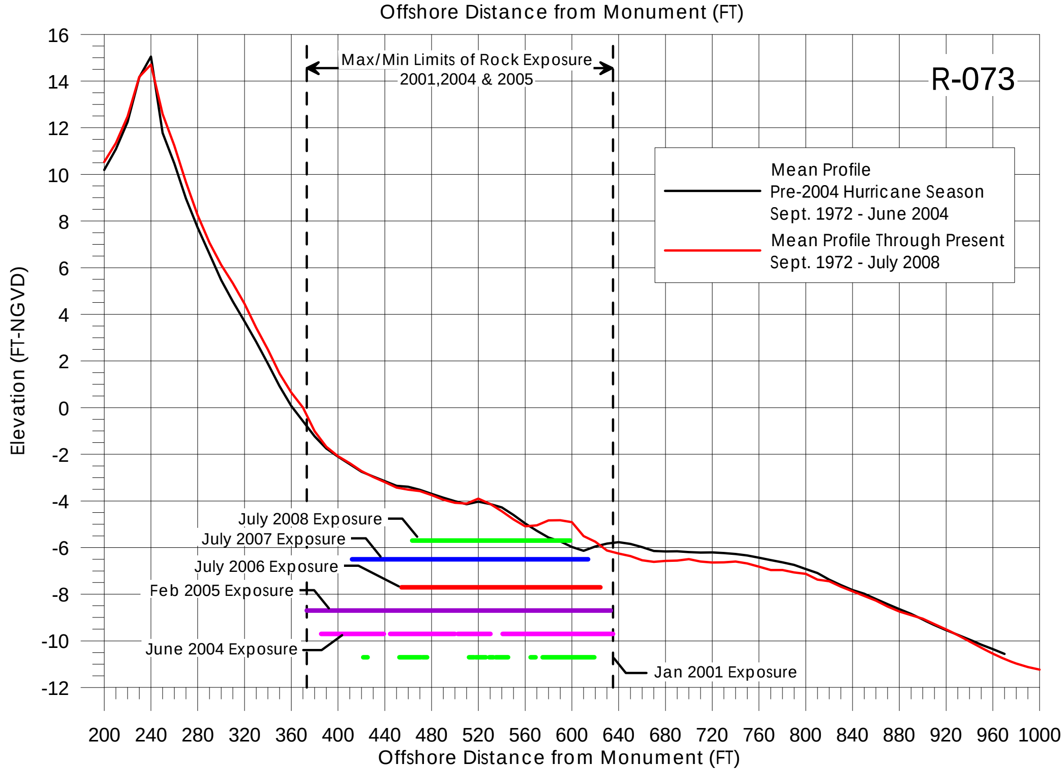
Olsen Associates, Inc. "Brevard County Shore Protection Project, South Reach; Year-Three Post-Construction Nearshore Rock Mapping (R110 to R118)". Letter Report to Mr. Mike McGarry, Brevard County Nat. Res. Mgt. Office. Prepared by S. Howard, Olsen Associates, Inc., 4438 Herschel Street, Jacksonville, FL 32210. In preparation, 2008.



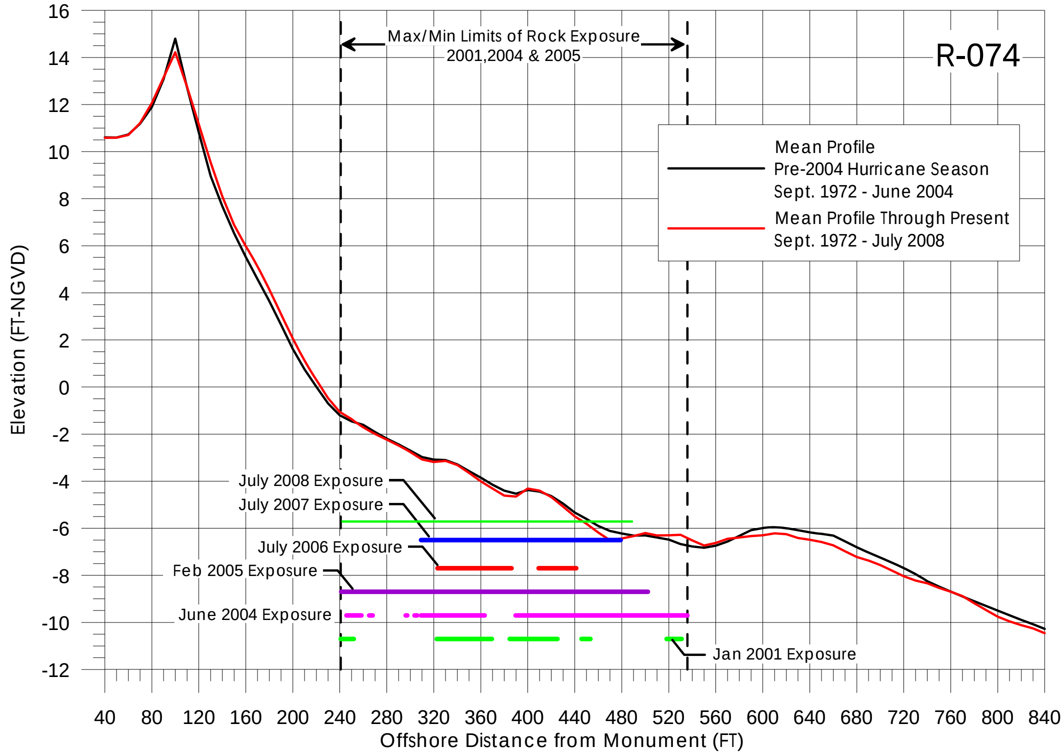


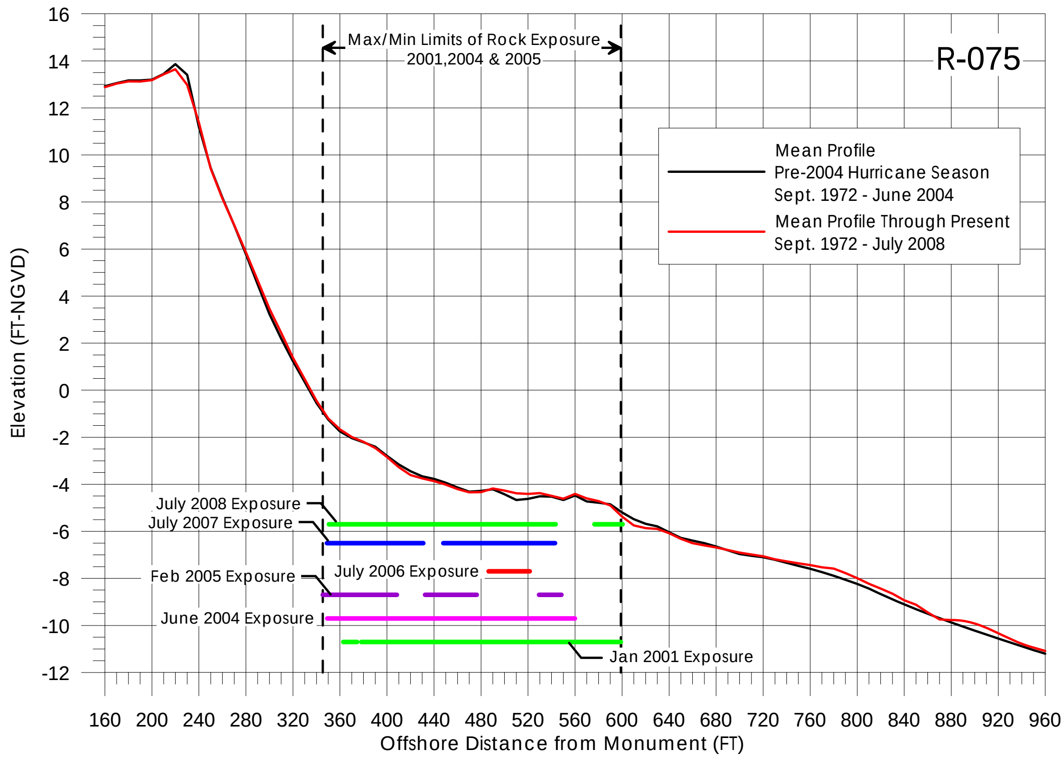
A. R70 and R71 (Patrick AFB): Comparison of mean beach profiles computed up to (1) pre-renourishment conditions [black] and up through (2) present post-renourishment conditions [red]. Mapped occurrences of exposed rock are also indicated.



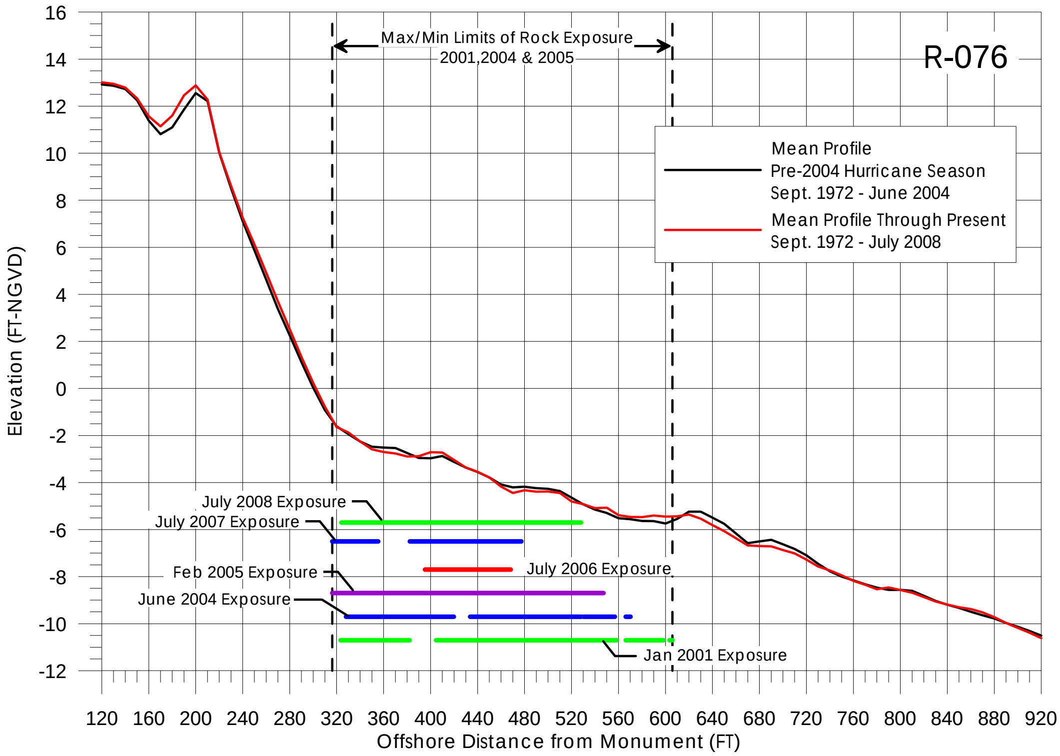


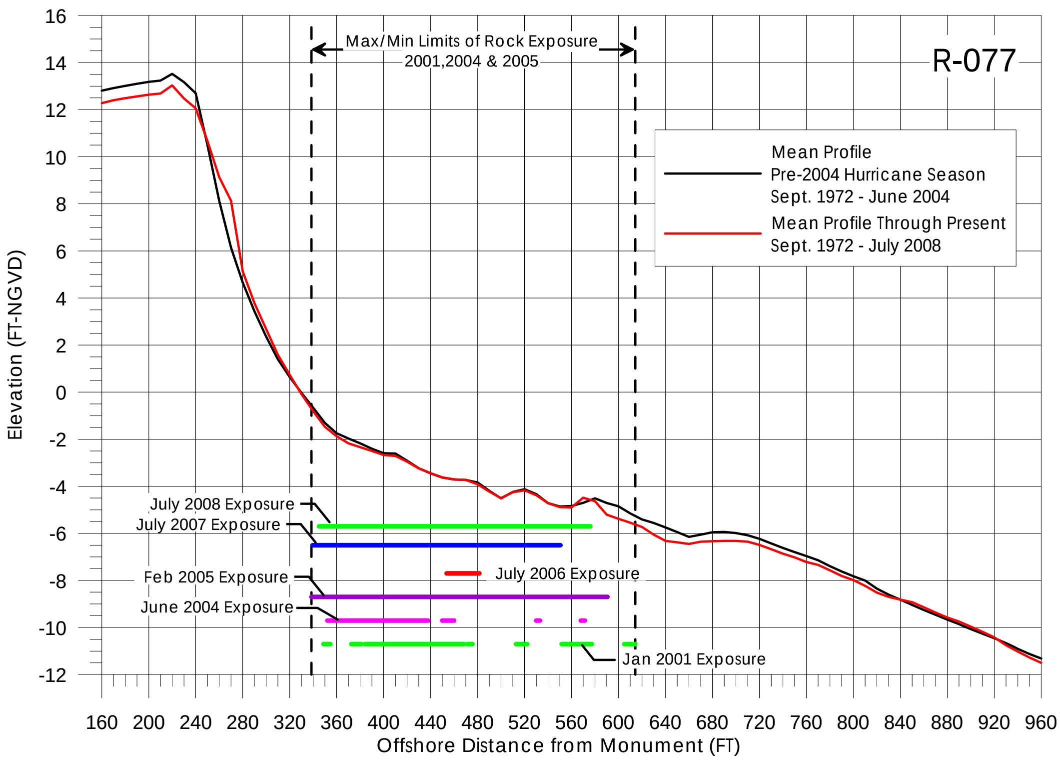
B. R72 and R73 (Patrick AFB): Comparison of mean beach profiles computed up to (1) pre-renourishment conditions [black] and up through (2) present post-renourishment conditions [red]. Mapped occurrences of exposed rock are also indicated.



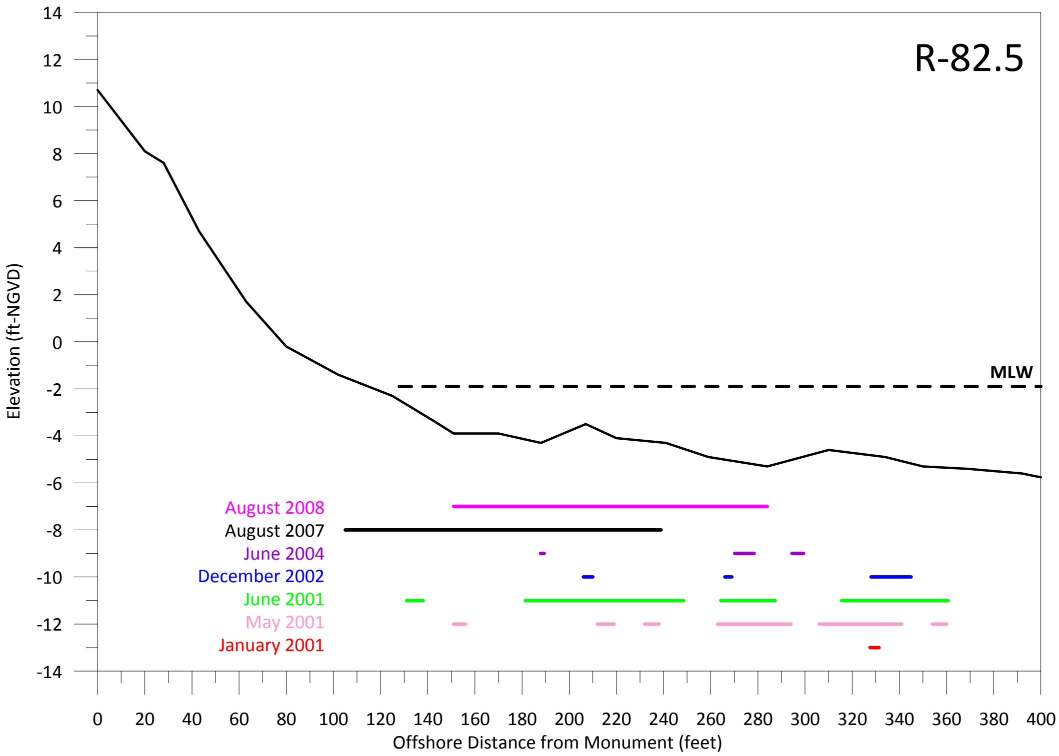


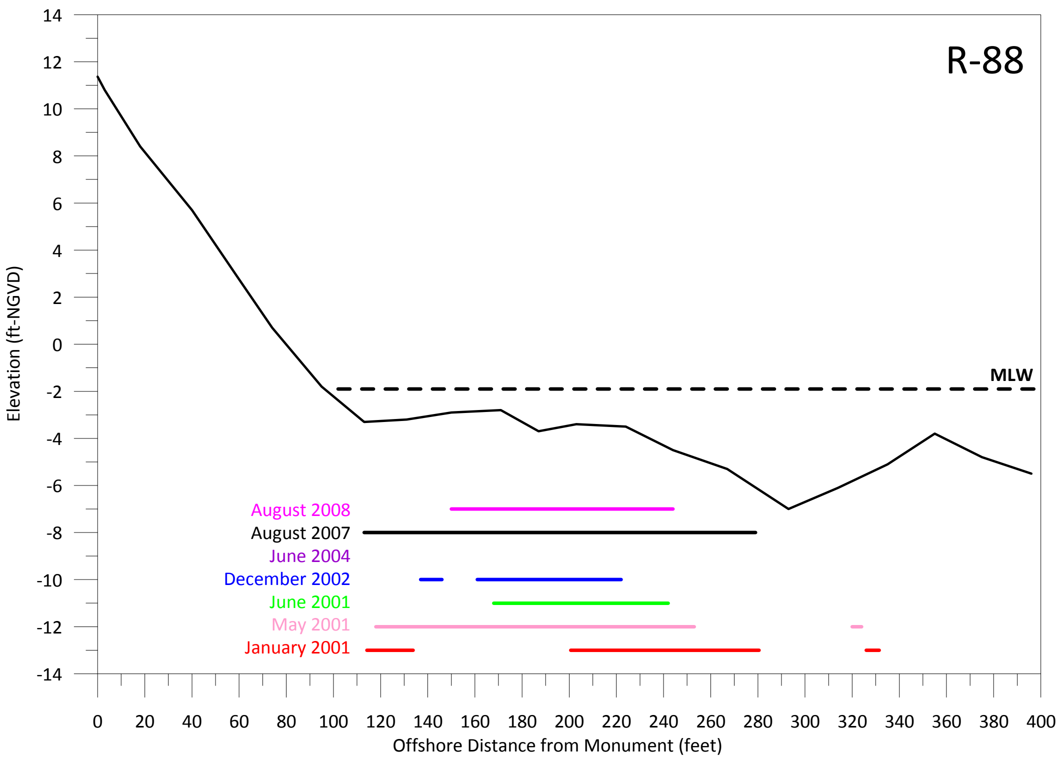
C. R74 and R75 (Patrick AFB): Comparison of mean beach profiles computed up to (1) pre-renourishment conditions [black] and up through (2) present post-renourishment conditions [red]. Mapped occurrences of exposed rock are also indicated.



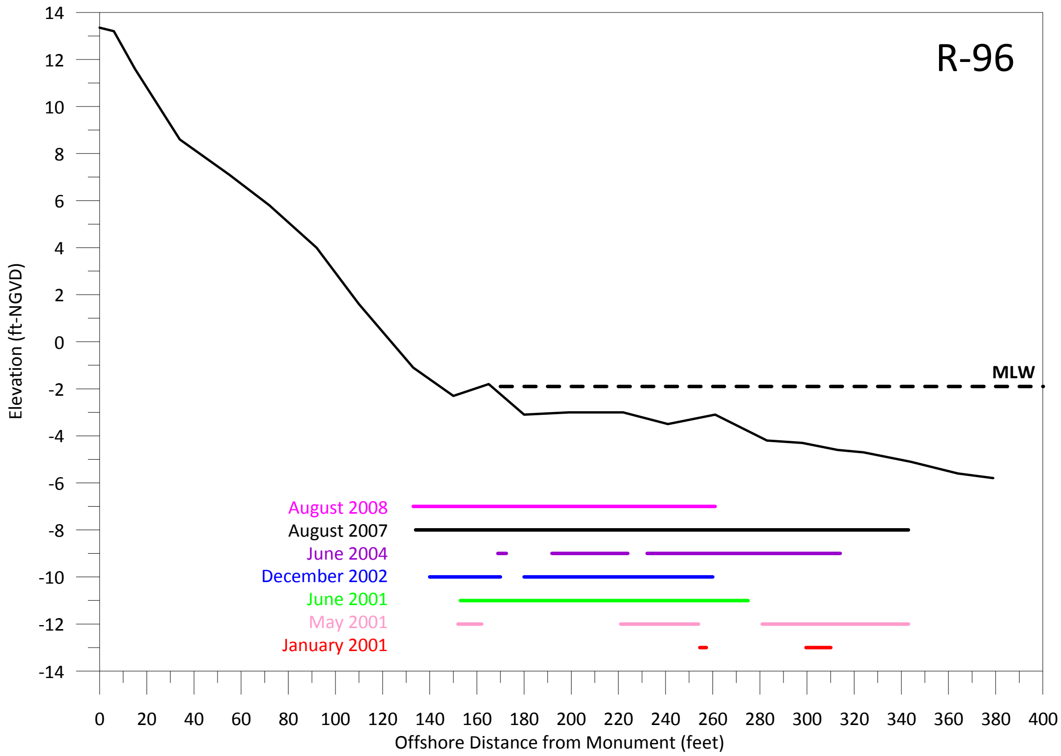


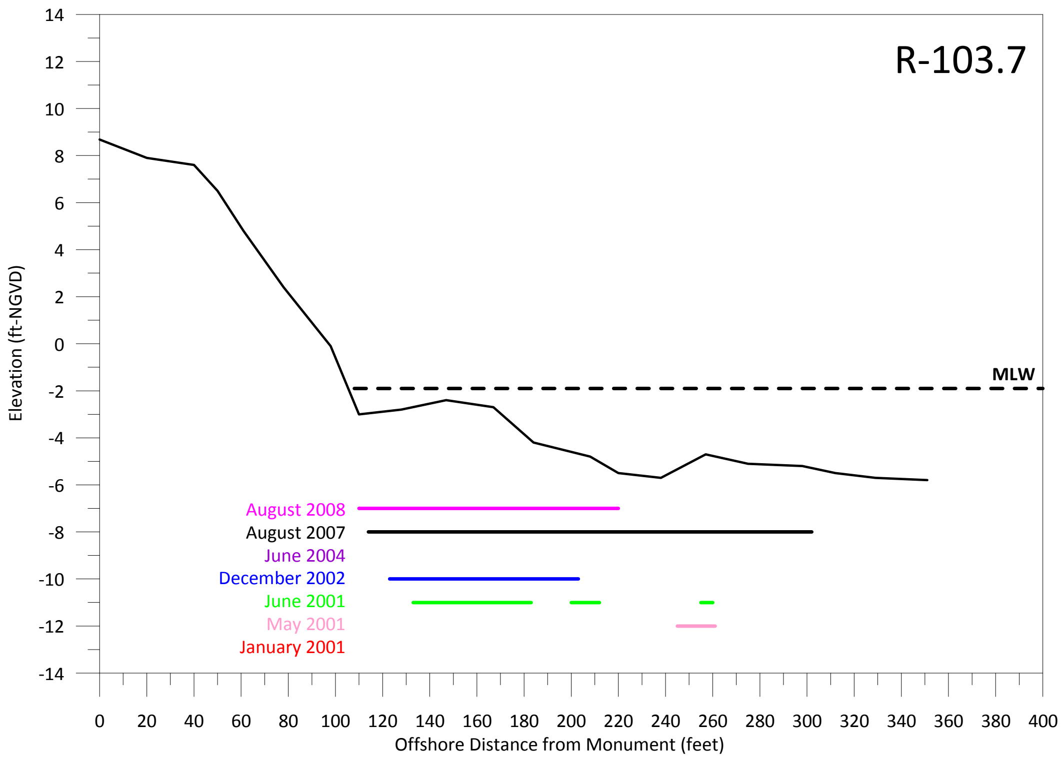
D. R76 and R77 (no. end of Mid Reach): Comparison of mean beach profiles computed up to (1) pre-renourishment conditions [black] and up through (2) present post-renourishment conditions [red]. Mapped occurrences of exposed rock are shown.



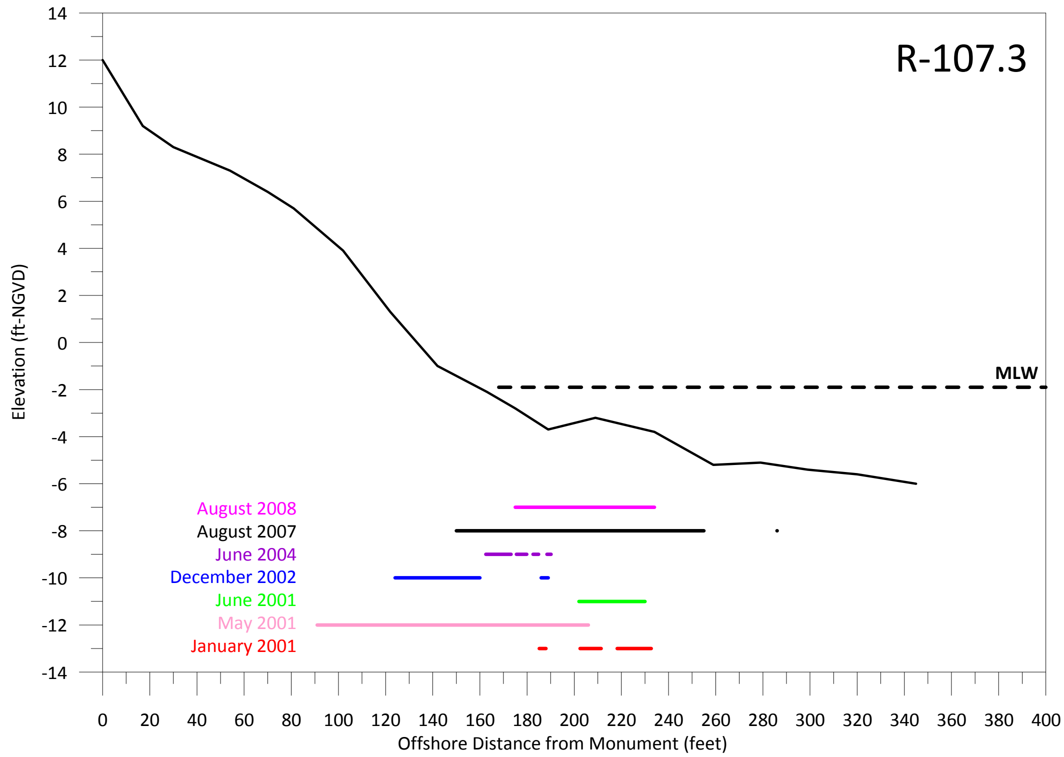


E. Transects R82.5 and R88 (Mid Reach). Mapped occurrences of exposed nearshore rock outcrops and August 2008 beach profile.

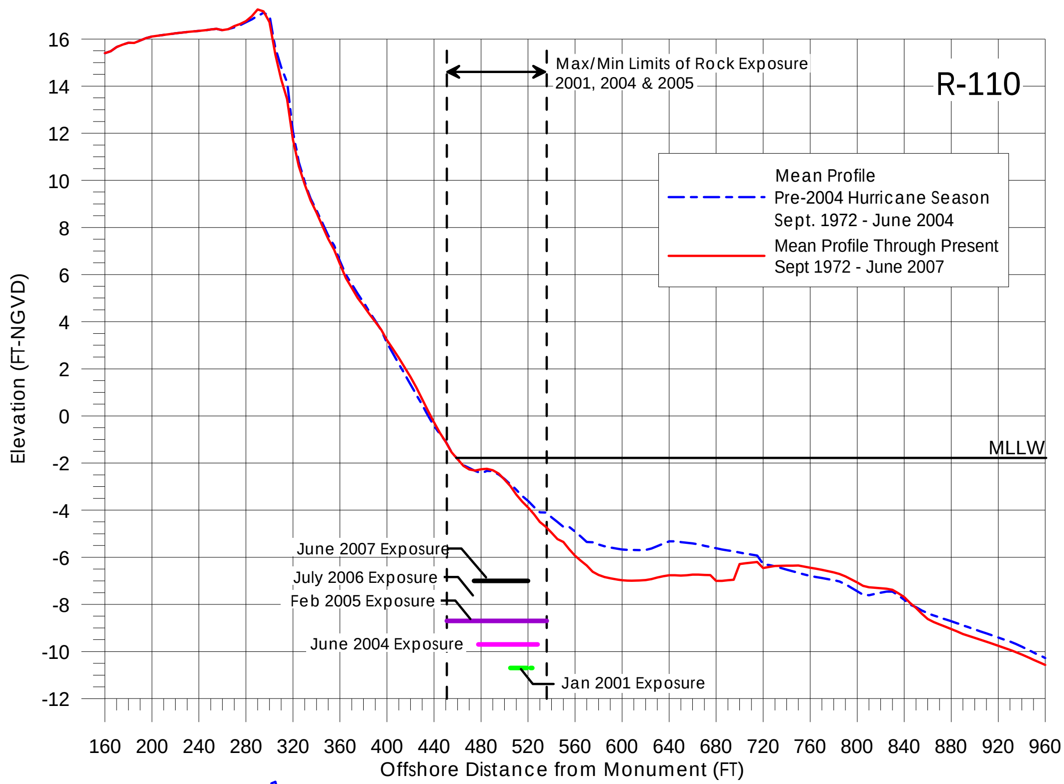


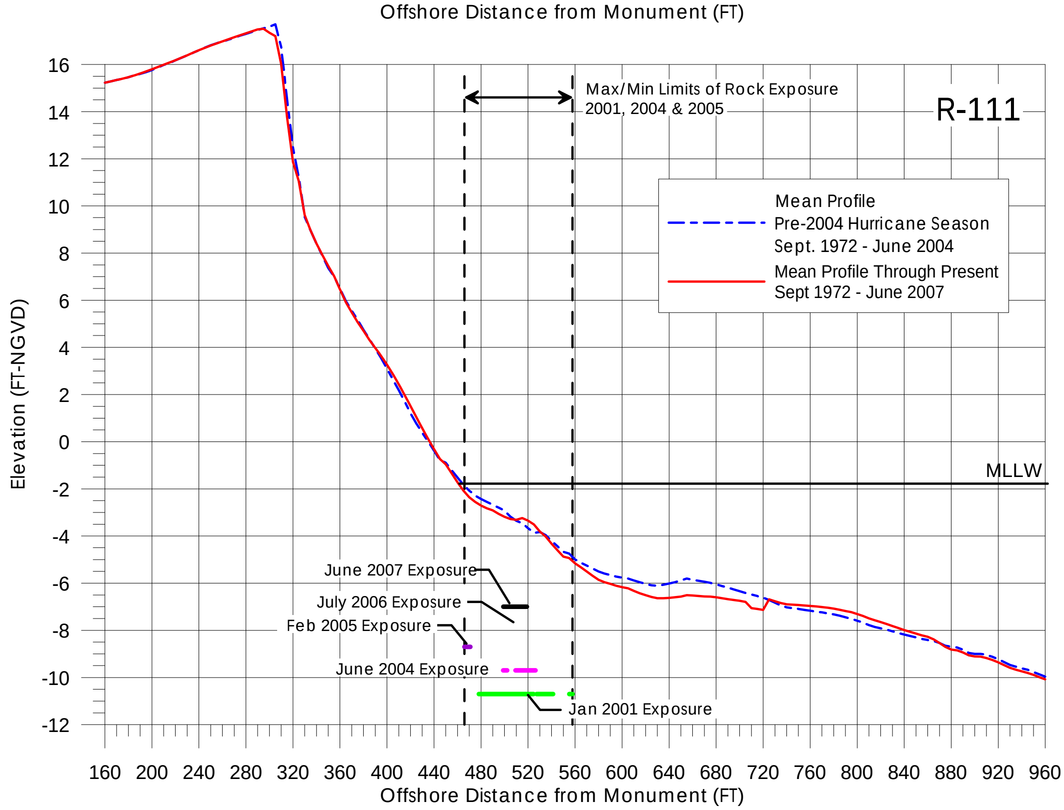


F. Transects R96 and R103.7 (Mid Reach). Mapped occurrences of exposed nearshore rock outcrops and August 2008 beach profile.

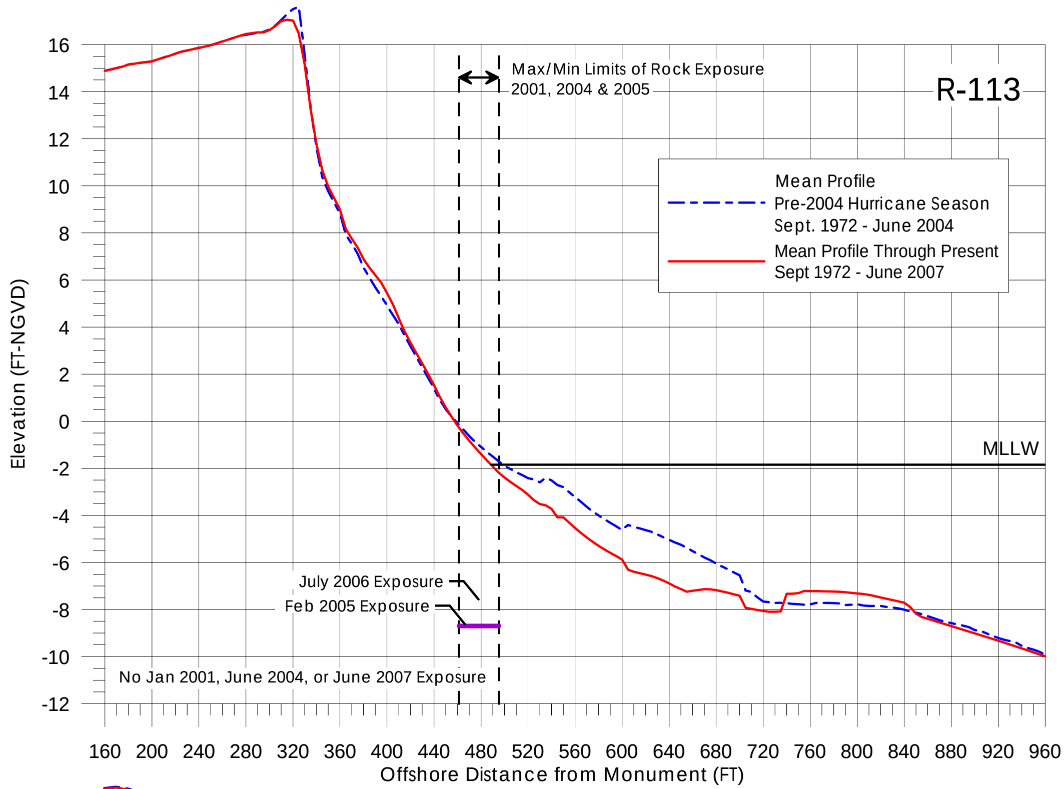


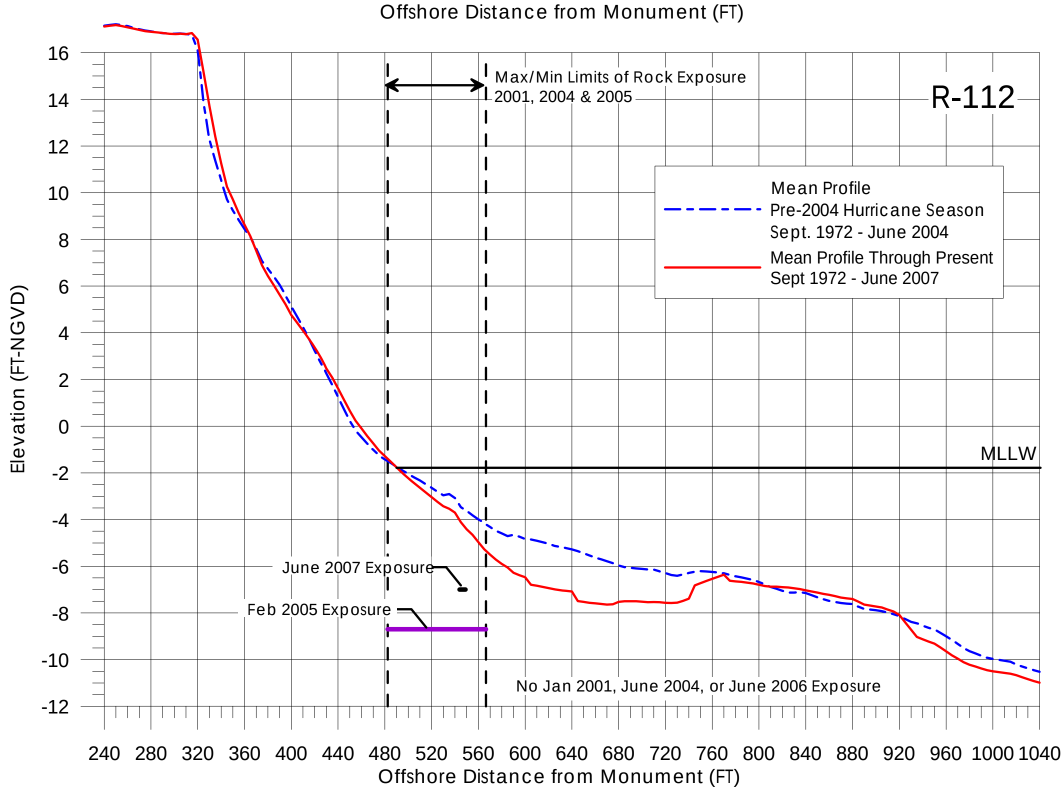
G. Transect R107.3 (Mid Reach). Mapped occurrences of exposed nearshore rock outcrops and August 2008 beach profile.



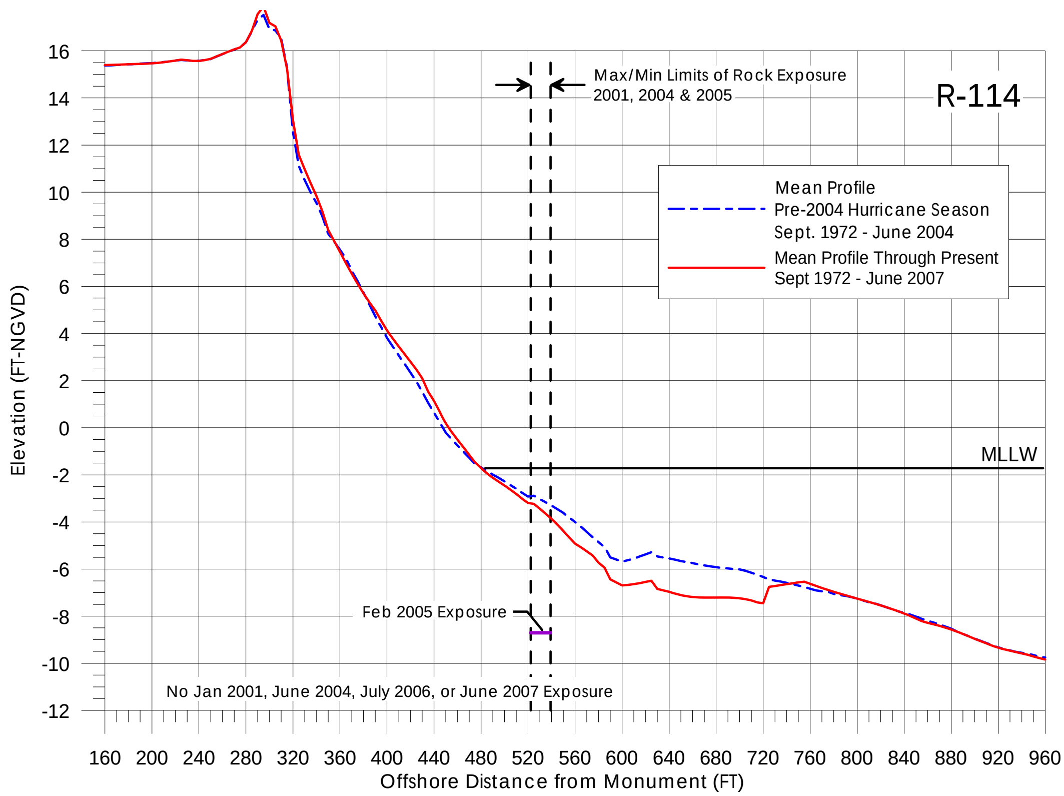


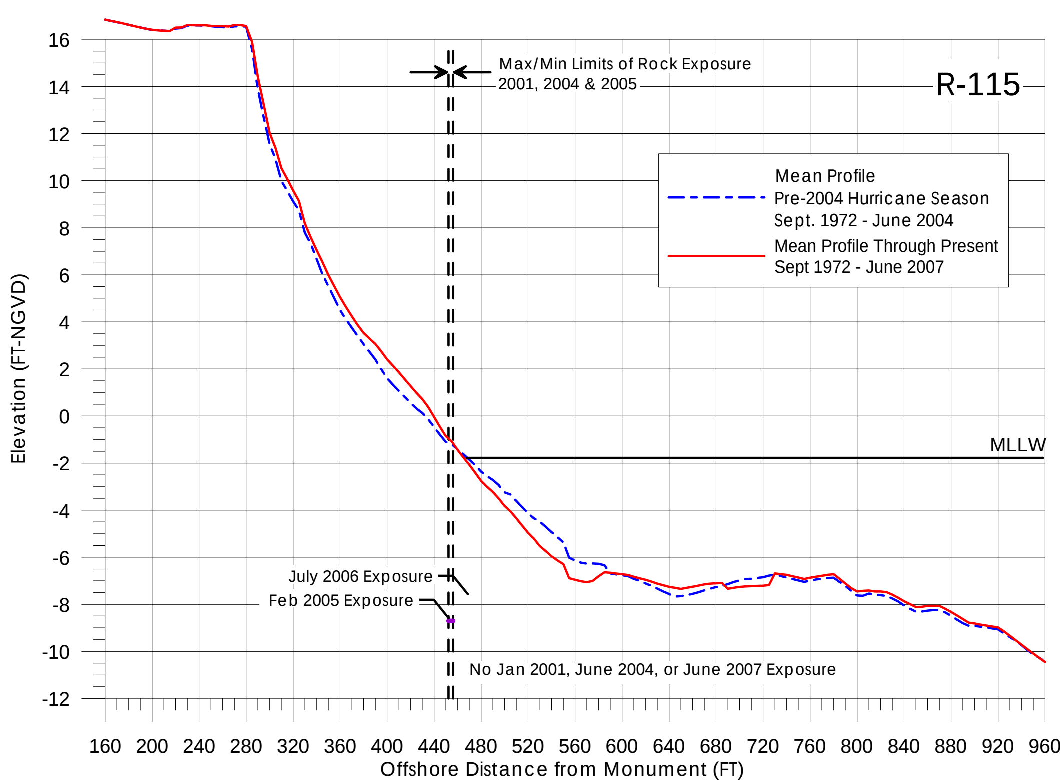
H. R110 and R111 (So. End of Mid Reach): Comparison of mean beach profiles computed up to (1) pre-renourishment conditions [blue dash] and up through (2) present post-renourishment conditions [red]. Mapped occurrences of exposed rock are shown.



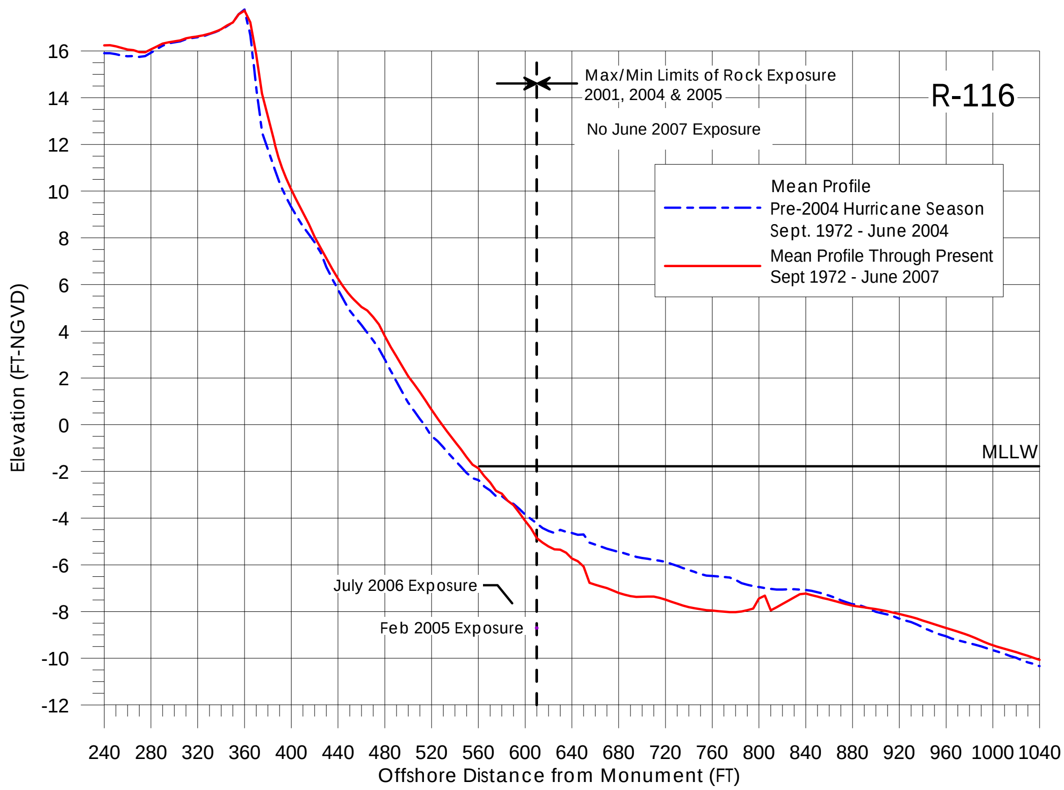


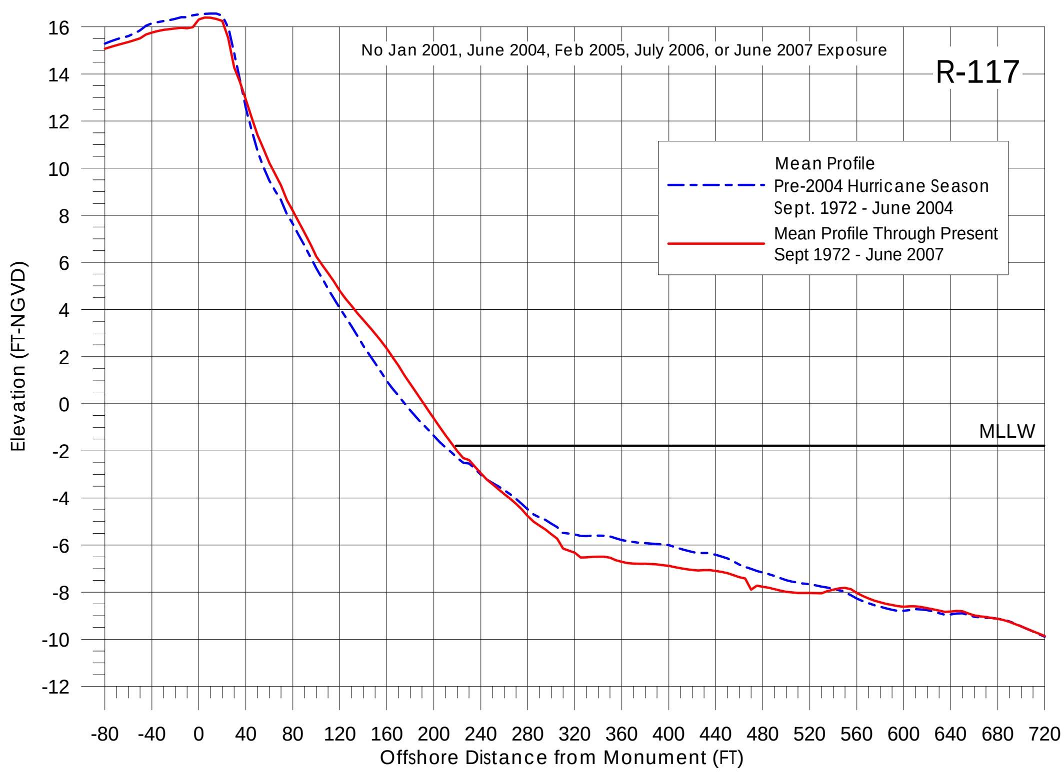
I. R112 and R113 (So. End of Mid Reach): Comparison of mean beach profiles computed up to (1) pre-renourishment conditions [blue dash] and up through (2) present post-renourishment conditions [red]. Mapped occurrences of exposed rock are shown.



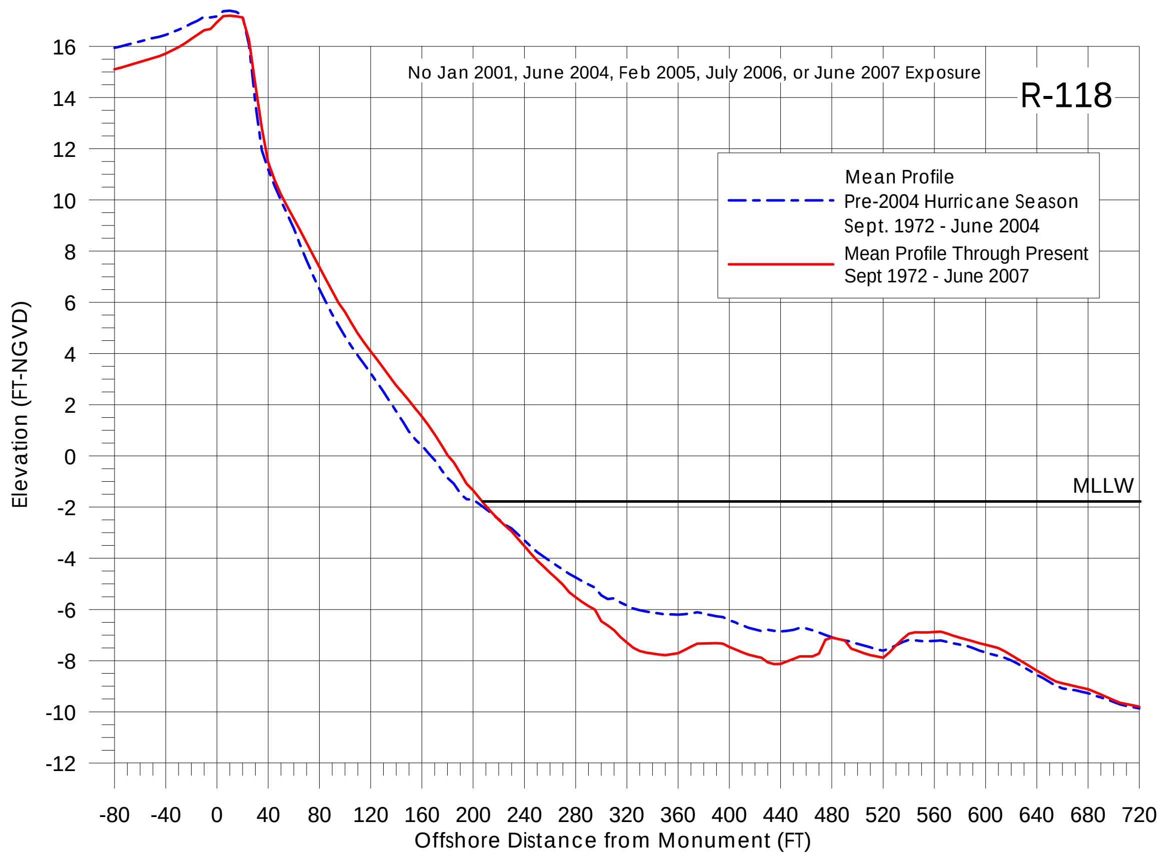


J. R114 and R115 (So. End of Mid Reach): Comparison of mean beach profiles computed up to (1) pre-renourishment conditions [blue dash] and up through (2) present post-renourishment conditions [red]. Mapped occurrences of exposed rock are shown.





K. R116 and R117 (So. End of Mid Reach): Comparison of mean beach profiles computed up to (1) pre-renourishment conditions [blue dash] and up through (2) present post-renourishment conditions [red]. Mapped occurrences of exposed rock are shown.



K. R118 (Far south end of Mid Reach, adjacent to South Reach of Brevard County Shore Protection Project): Comparison of mean beach profiles computed up to (1) pre-renourishment conditions [blue dash] and up through (2) present post-renourishment conditions [red]. Mapped occurrences of exposed rock are shown.

APPENDIX SEIS-J

Mitigation and Monitoring Plan

Brevard County Mid Reach Shore Protection Project

Mitigation and Monitoring Plan

Table of Contents

Introduction (Project Description)

The project will place beach-compatible sand fill along 7.6-miles of Atlantic Ocean shoreline along the "Mid Reach" shoreline of Brevard County, Florida, located between Florida Dept. of Environmental Protection (FDEP) reference monument locations R75.4 and R118.3. The source of the sand fill shall be the Canaveral Shoals I and II offshore borrow areas, with dredged material being stockpiled to a temporary upland disposal area and subsequently truck-hauled to the Mid Reach project fill area. Alternately, some or all of the fill material may be from acceptable upland sand sources, subject to quality, availability, and permit allowances.

The project is anticipated to impact approximately 3 acres of existing nearshore rock hardgrounds through initial placement, subsequent equilibration and alongshore diffusion of the beach fill sand. The existing rock reef is exposed in varying amounts and locations within the shallow waters immediately along the shoreline, mostly between about 0 and 4 ft water depth at low tide, and within 300-ft or less from the pre-project mean low water (MLW) shoreline.

To mitigate the anticipated impacts to the nearshore hardgrounds, the project will include (1) construction of artifical reef structures upon the nearshore seabed offshore of the project shoreline, (2) pre- and post-construction monitoring of the impact and mitigation reef areas. This document describes the physical and biological monitoring plan associated with the borrow, beach fill, existing nearshore hardgrounds, and mitigation reef elements of the proposed activity. This document likewise describes a contingency plan to address modifications of the plan should such modifications be determined to be necessary as a result of the monitoring surveys.

Routine monitoring and associated activities related to project construction and post-construction environmental monitoring – such as that required for turbidity, marine turtle nesting and other endangered species monitoring, beach compaction and escarpments, *et cetera*, are not described herein. These project requirements are described in Section 7.2.34 of the main document.

Description of the proposed dredging, beach fill, and mitigation reef structure is presented in Section 7.2.1 and 7.2.4.2 of the main document, and is not repeated in detail herein. A brief summary of the project's mitigation reef plan is presented below.

I. MITIGATION PLAN

A. Abbreviated Physical Description of Mitigation Reef Plan

The projects' Mitigation Plan will construct patch-type artificial reef structures in water depths of about -15 ft MLW along the project shoreline to mitigate anticipated adverse environmental impacts to the existing nearshore rock reef. The proposed reef structure will consist of articulated concrete mats with an integral coquina-rock surface. Each articulated reef mat will consist of approximately 18 cable-connected blocks. Each mat would be about 8-ft x 16-ft x 1-ft high and comprise about 90 lineal ft of valleys (ridges) between blocks and adjacent mats (**Figure 1**). Forty-two mats, in 6 rows and 7 offset columns would be placed adjacently -- along with two additional 'top-layer' mats along the landward edge to form an overhanging ledge. This would constitute one "set" of 44 mats. Each "set" of mats would create between about 0.15 and 0.16 acres of hard-bottom structure.

Each set of mats would be placed upon the sand seabed at ambient depths of between about -14.4 ft and -15.6 ft MLW; i.e., approximately centered along the -15 ft MLW contour, and located about 1000-ft from the mean low water shoreline (**Figure 2**). At 12" nominal relief (and 24" maximum relief along the landward edge), the coquina surface of the reef units would lay in water depths of between -12.4 ft MLW and -14.6 ft MLW, more or less.

Between two and five "sets" of mats would be spaced about 50 to 60 feet apart, along the approximate -15 ft contour, to form a reef "group". These reef "groups" would be spaced about 400 to 9000 feet apart, or more, to create the requisite total area of reef mitigation along the shoreline.

The top surface of the reef mat structures will feature almost all coquina cover with 1" to 4" deep crevices between the coquina stones that emulate the surface of the existing nearshore rock. The valleys between blocks, and the overhanging "ledge" on the landward end of a set of units, emulate the physical relief of crevices and ledges found across the existing natural hardbottom reef. In addition to the ledge feature, 8" to 16" gaps between the ends and sides of placed reef mats are purposefully intended to would provide resting areas appropriately sized for juvenile green turtles observed to rest and forage in similarly-sized crevices on the existing Mid Reach rock resource.

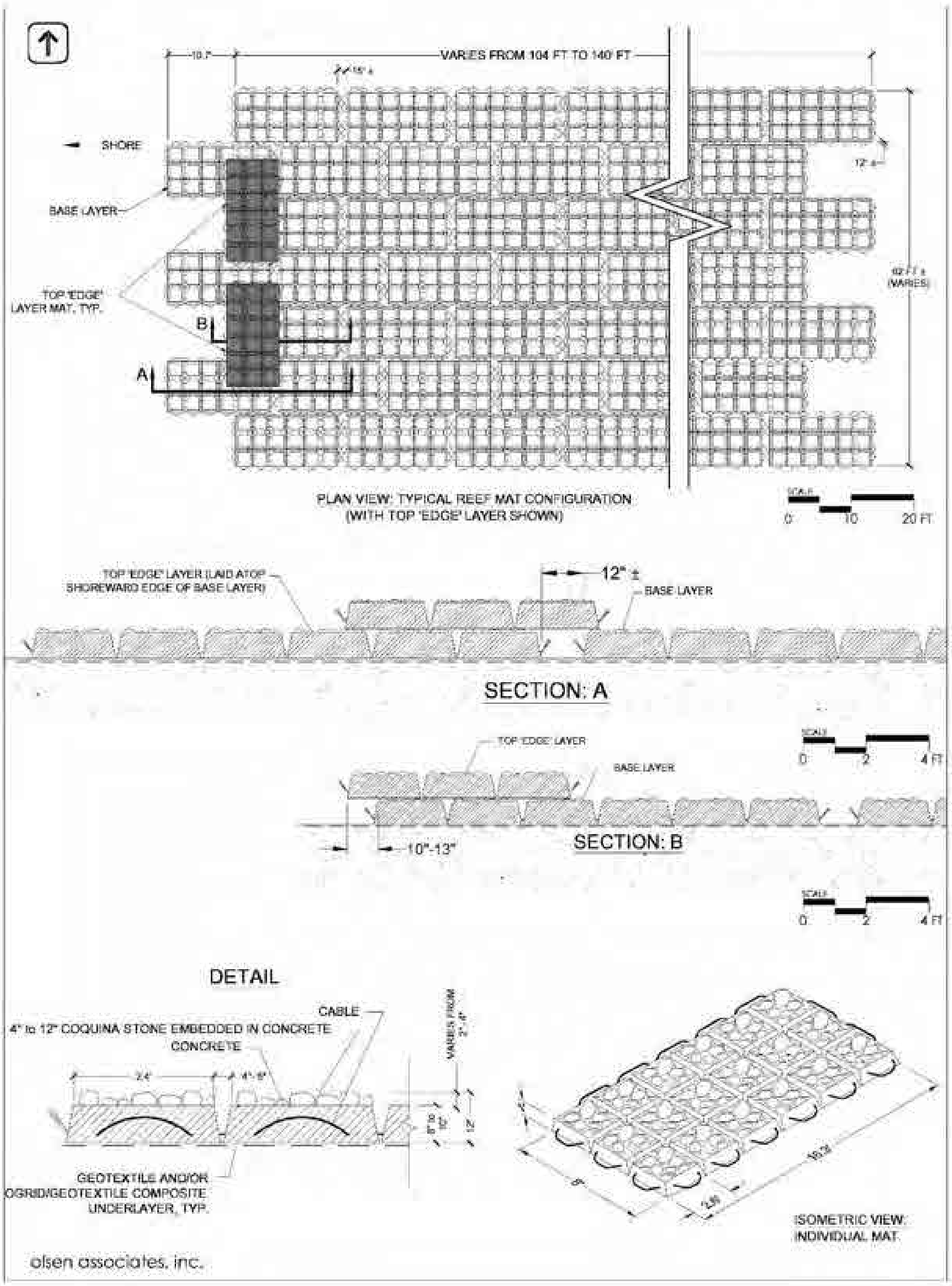


Figure 1: Schematic illustration of individual blocks (bottom left), articulated mats (bottom right), and typical lay-out of mats in one "set" of the mitigation reef structure (upper and middle graphics).

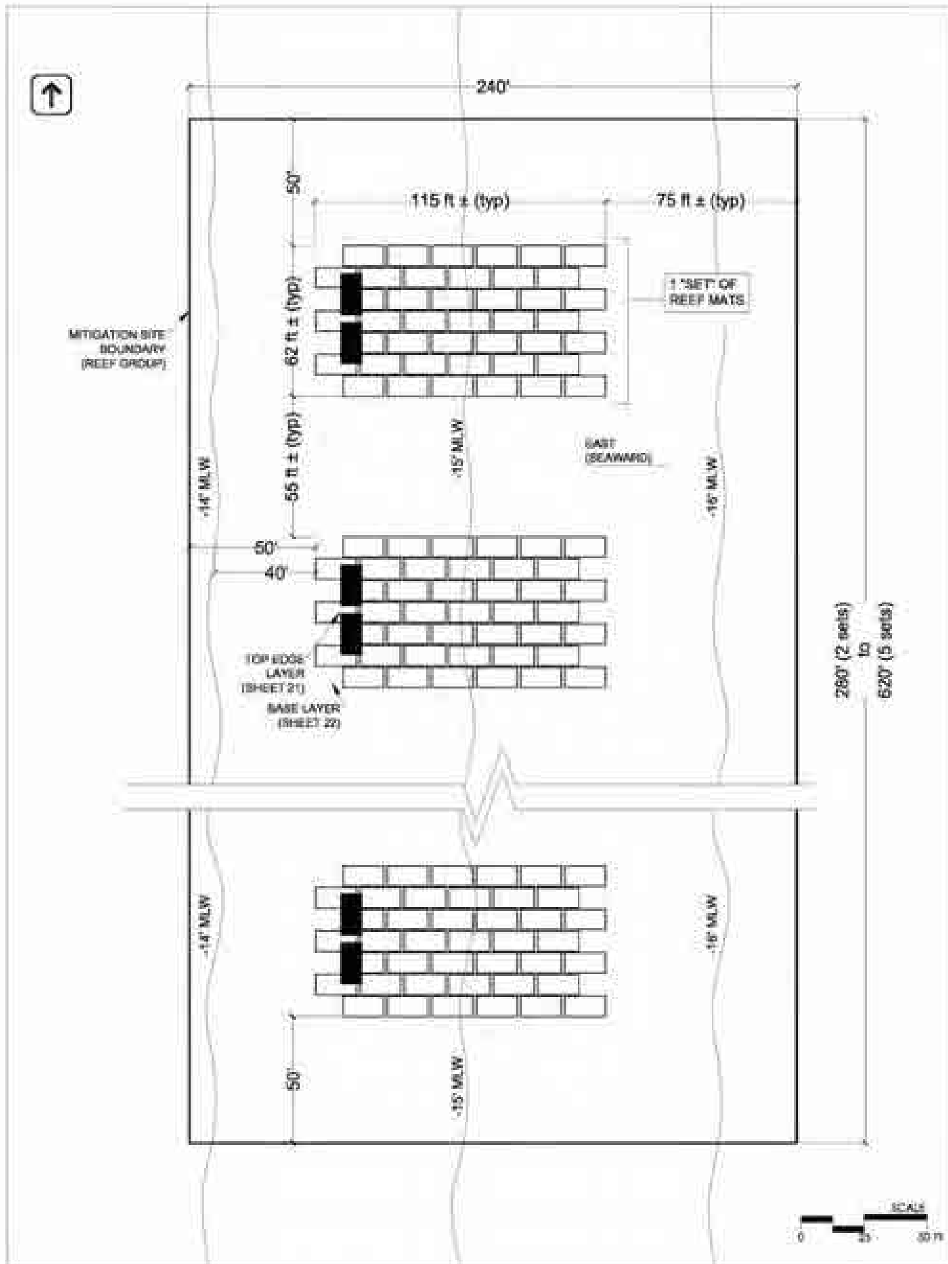


Figure 2: Plan view of several sets of reef-mat mitigation structures within one reef group.

The articulated mat (which is fundamental to the reef structure) serves as the requisite foundation for the area's sand bottom. Use of such articulated mats (without the special coquina surface) is a standard marine construction practice employed to establish hydraulically stable structures on sand seabeds prone to scour. The seabed at the mitigation sites is typically fine sand with no underlying rock stratum within at least 10-ft beneath the seabed.

There are no known existing hard-bottoms at or near the proposed mitigation sites, excepting the nearshore rock reefs along the project shoreline. The mitigation sites are typically located at least 800-ft seaward of these existing rock outcrops.

B. Mitigation Reef Construction and Schedule

1. Construction. The reef mats will be constructed (cast) at an upland yard, transported overland to a barge, and then transported over water to the installation sites. It is anticipated that all or most construction would be staged through Canaveral Harbor, located about 14 to 22 miles north-northwest of the mitigation reef sites. Placement of the mats from barges to the seabed will be by crane located upon floating and/or jack-up barges. The barges will utilize temporary anchors and/or spuds upon the sand seabed.

2. Schedule. Seabed installation of the reef mats is anticipated to require between 4 and 8 months (for two or one crane barge set-ups, respectively), spanning more than one year. It is most likely that that installation will occur in months of May through September, owing to favorable seas, but will not be limited to those times. Because the project's *beach fill* construction is limited to the months of November through April, installation of the mitigation reef structures is expected to occur in the summer months immediately preceding *and/or* following initial beach fill construction.

C. Calculation of Mitigation Reef Area

1. Initial Construction. For requisite purposes of engineering design and construction, the effective acreage of the initially constructed mitigation reef shall be equal to the base planform area of each mat that is placed, plus a nominal gap width allowance of 12-inches between adjacent mats within each set. The gap width between mats is purposefully intended as shelter and loafing areas for juvenile green turtles and other macrofauna, and emulates gaps in the natural nearshore hardbottom (see above). Inclusion of small gaps in the acreage of the mitigation reef is consistent with the acreage-calculation of the impacted natural reef. (That is, the aerial boundaries that map the exposure of the nearshore hardbottom – from which the project's acreage impacts are calculated – likewise include small gaps between exposed rock that are "counted" within the total hardbottom area of the existing resource. Allowance for an approximate 12-inch gap between adjacent mats in a set constitutes less than 13% of the set's total area, and is reasonably similar to, or less than, the existing rock outcrops.)

By numeric example, the mitigation acreage ascribed to one (1) set of 44 mats arranged as per Figures 1 or 2, above, with 12-inch gap allowance, would be equal to approximately 0.151 acres (6594 square feet)[1]. An initial mitigation requirement of 4.8-acres would therefore require about 32 sets of mats; or, about 1408 mats in total, more or less.

2. Post-Construction Monitoring. As described below, the area of exposed mitigation reef structure shall be periodically monitored by side-scan sonar survey with ground-truthing inspection and measurement by divers. These surveys shall include an immediate post-construction ("as-built") survey that will be related to the initial acreage assigned to each set and/or group of reef mats (per section I.C.1 above). The spatial coverage of exposed structure sensed by each survey shall be compared to the "as-built" survey in order to estimate the relative change (percentage gain or loss) in functional area of the mitigation reef structure.

II. MONITORING

A. Objectives & Considerations

1. The general objectives of the project monitoring plan described herein are to indicate
   a) physical beach fill performance,
   b) changes at the offshore borrow areas,
   c) physical impacts to the existing nearshore hardgrounds vis-à-vis changes in exposure (sand burial) of the hardgrounds,
   d) extent of impacts to epibiota, fishes, and turtles associated with nearshore hardgrounds subject to sand fill from the project;
   e) physical performance of the mitigation reef vis-à-vis changes in exposure and substrate, and
   f) extent of biological recruitment and activity at the mitigation site – both in an absolute sense and relative to the existing nearshore rock reef (hardgrounds) in specific terms of macroalgae, invertebrates, juvenile and adult fishes, and marine turtles.

2. The primary objectives of the biological elements of the monitoring plan are to assess potential impacts to the existing reef in the Mid Reach project area; and to evaluate the degree to which the mitigation reef replicates the ecological functions of the existing nearshore reef in terms of habitat for the major taxonomic groups listed above. Criteria for measurement and success of the mitigation reef shall be based upon the

[1] Assumes a 12-inch gap allowance between adjacent reef mats, and that the base area of each reef mat is 8.0-ft x 16.3 ft.

degree to which the reef is sufficiently exposed to serve these ecological functions relative to the predictions made in the project formulation.

3. The design of the monitoring program must take into account the challenging physical conditions at the site. These include typically turbid water with little or no visibility, and consistently energetic surf. Conditions at the existing reef site are further complicated by the very shallow water and breaking waves. Practical consideration of these conditions is necessary in order to develop a monitoring program and measurement criteria that are realistically achievable and which result in meaningful data. Sea state and visibility shall be monitored daily during the summertime to ensure that surveys are conducted on days with ideal weather and visibility conditions.

4. The monitoring program shall include the physical performance of the beach fill and borrow area, by traditional surveys, to assess the longevity and movement of the beach fill (volume and shoreline change) and bathymetric/volume changes at the offshore borrow area. [See Section II.B, below.]

5. The monitoring program shall include the physical and biological components of both the existing reef and the mitigation reef. [See Sections II.C and II.D, respectively, below.] Herein, the words hardgrounds or hardbottom, exposed rock, outcrops or rock reef are used interchangeable for convenience.

B. Beach Profile and Borrow Area

1. Scope

a) Beach profile surveys shall be made at existing FDEP Reference monuments R70 through R124. Surveys shall extend from the monument to -30 ft NGVD29 depth. All surveys shall utilize the azimuths previously surveyed by the Florida Dept. of Environmental Protection (FDEP) and survey methods shall comply with the latest FDEP Bureau of Beaches and Coastal Systems (BBCS) standards. The survey effort will be combined with those of the adjacent project areas (Patrick AFB and South Reach) as practicable.

b) The wading portion of all beach profiles shall extend to at least -6 ft NGVD or deeper and shall identify the presence and limits of *sand seabed* versus *exposed rock* substrate (as described below). Prior wading and diver surveys extending deeper than -6 ft NGVD (-4.1 ft MLLW) have not indicated the substantial presence of exposed hardgrounds beyond this depth. Any detected exposure of rock hardgrounds deeper than -6 ft NGVD would therefore not be indicative of post-construction effects of the constructed project. Therefore, wading surveys to at least -6 ft NGVD depth are deemed sufficient to monitor the effects of the project upon nearshore hardbottoms.

c) Bathymetric surveys of the offshore borrow area(s) dredged for the work shall be conducted at 250-ft maximum line spacing and shall extend a minimum of 250-ft beyond the borrow area limits.

d) Engineering analysis and a report shall be prepared pursuant to the post-construction survey and each subsequent survey. Reports shall document, at minimum, (1) the measured changes in volumes and shoreline locations along the beach fill monitoring area, and (2) measured changes in seabed elevation and volumes across the borrow area, relative to the prior monitoring survey(s). Reports shall be completed within 90 days after acquisition of survey data.

2. Schedule

a) Surveys of the beach profile shall be conducted at pre- and post-construction, and at 1, 2, 3, and 5 years after initial project construction if there is substantial sand fill from the project within the profile. Additional surveys may be conducted pursuant to severe storm events, as deemed necessary after consultation with FDEP.

b) Hydrographic surveys of the borrow area shall be conducted pre-construction, post-construction, and at year-3 post-construction.

c) Pre- and post-construction surveys shall be measured within 60-days prior and 90-days after construction; respectively. Annual beach profile and borrow area surveys shall be typically measured in the months of May through July.

C. Natural Nearshore Reef and Mitigation Reef – Physical Monitoring

1. Existing Nearshore Rock Reef (Physical Monitoring)

Physical monitoring of the existing (natural) rock reef will consist of the following elements.

a) <u>Wading Transects.</u> The extent of exposed rock and profile fluctuations shall be identified, relative to pre-project norms, along 99 nearshore wading transects. These transects shall include:

- Forty-nine (49) R-monument transects at R-70 through R-118, inclusive, and
- Fifty (50) project-specific wading transects, between R75.3 & R118.3.

The former group of 49 transects are included within the routine R-monument beach-profile physical surveys. Of these 49 transects, prior pre-project measurements of exposed rock exist along seventeen (17) lines, consisting of at least seven aerial or ground-truth surveys from 2001 through 2008 at monument locations R70-R77 and R110-R118. Prior (pre-project) measurements of profile fluctuations include various surveys from 1972 through 2007.

The latter group of 50 transects include wading lines that were specifically established along the Mid Reach, beginning in early 2001, in order to measure the natural extent and variability of local nearshore rock exposure. (See **Table 1**.) The cross-shore locations of exposed rock outcrops along each of these transects have been measured by ground-truth on up to five prior occasions since April 2001, plus two aerial surveys in 2001 and 2004.

The locations of exposed rock, along with the seabed profile, shall be measured during at least *two additional surveys* prior to initial project construction.

For each subsequent, post-construction survey, the occurrence of exposed rock shall be graphically contrasted with all prior surveyed occurrences of exposed rock at that transect location. Additionally, the seabed profile (elevations) shall be graphically contrasted with the pre-project mean and standard deviation of the beach profile at that transect location. (See **Figure 3a** as an example illustration.)

In this way, the observed variation of the rock exposure and seabed elevation, relative to the expected variation from pre-project conditions, indicates the degree (and locations) to which profile changes may be attributable to the project. For example, *post*-project profile variations that are within the observed standard-deviation of the *pre*-project profile would suggest that measured changes are not necessarily attributable to the project. Conversely, *post*-project profiles that are consistently lower or higher than the ±one standard-deviation limits of the *pre*-project profile would suggest deflation (increased rock exposure), or accretion (decreased rock exposure), respectively, that is potentially attributable to the project. The degree to which this observed profile deflation or accretion is anomalous would be assessed relative to the behavior of the other transects, including those in the “reference area” north of the project (R70-R75). And, the degree to which the observed profile deflation or accretion resulted in an apparent increase or decrease in rock exposure, for that transect, would be assessed relative to the historic (pre-project) exposure of rock measured along the transect.

Further, the mean beach profile will be computed (updated) through each subsequent, *post-construction* survey. This result will be contrasted to the mean, *pre-project* profile. Comparison of the mean beach profile at each transect – from pre-project to current (post-project) conditions – facilitates the identification of long-term *trends* in beach profile change at each transect. (See **Figure 3b** as an example illustration.) For instance, an increase in the *mean* seabed elevation from pre-project to current conditions, at some particular cross-shore location on the profile, would indicate a local tendency for sedimentation or accretion at that point. This would likewise indicate the potential for burial or impacts to nearshore rock at that location, if such exposed rock was previously known or presumed to occur at that location.

This measurement and analysis protocol, described above, is identical to that which has been conducted annually since 2005 to monitor the potential impact of beach fill placement upon adjacent nearshore rock at the northern and southern limits of the Mid-Reach. Specifically, this protocol is used to monitor the effect of the Patrick Air Force Base and South Reach beach fill projects upon the exposure of the adjacent natural rock hardbottoms; viz., from R70-R77 and R110-R118. This monitoring program was prepared to meet requirements prescribed by the National Marine Fisheries Service (NMFS) to the U. S. Air Force (45^{th} Space Wing) and U. S. Army Corps of Engineers, Jacksonville District, in regard to these two projects' potential impacts upon Essential Fish Habitat. The monitoring program has been reliably implemented by the Air Force and Brevard County along the north and south ends of the Mid Reach project area, respectively, since 2005. Example results from a 2006 monitoring report, for a single transect, are illustrated in **Figure 3a and 3b**.

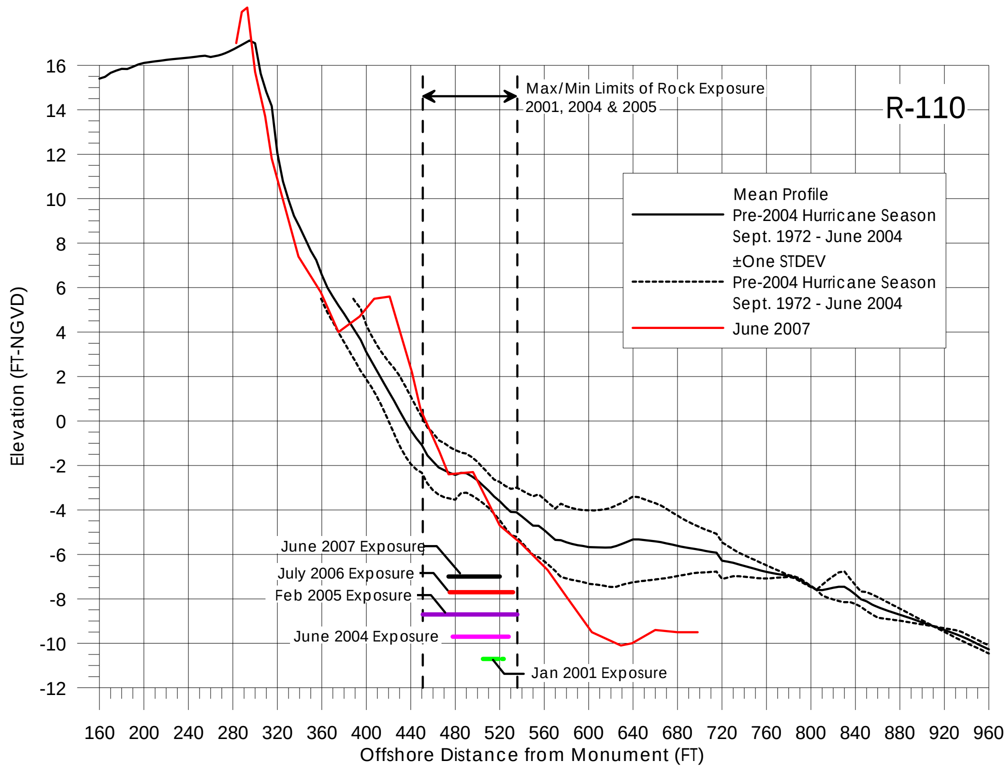
b) Controlled Color Aerial Photography will be collected along the project area shoreline, extending to at least 1.5-miles along the adjacent shoreline (approx. R70 through R124), in conditions conducive to imaging of the nearshore rock resource. As noted, the timing and frequency of the aerial photography is dependent upon the occurrence of favorable conditions. These conditions include low tide, calm surf, clear water, clear skies and proper sun angle. The confluence of these factors, along with the ability to accurately identify favorable conditions in order to mobilize the aerial photographer, may occur less than annually and at variable times of the year.

c) Trained multi-spectral image classification (mapping) of the exposed rock, from the aerial photographs, will be conducted if and when the quality of the surf conditions in the aerial photographs permit meaningful results. Results from the aerial photography (and image classification mapping) will be utilized in conjunction with the wading transect data and compared relative to the natural variability of the pre-project rock exposure, in order to assess the apparent changes in the post-project nearshore rock exposure, potentially attributable to the project, as fundamentally described in item (II-C1a), above.

d) Schedule. Wading surveys of the 99 transect lines shall be conducted at least twice, in addition to existing prior surveys, prior to construction. Post-construction wading surveys of these lines shall be conducted within 60 days after, and 1-, 2-, 3-, and 5-years after initial construction. Aerial photography (and multi-spectral image classification/aerial mapping) will be conducted prior to, post, and at 1-, 2-, 3-, and 5-years after initial construction as conditions allow. Analysis and engineering reports of the results shall be prepared after each survey event. Wading surveys shall be conducted in May through July. Photography shall be conducted as appropriate conditions permit.

Table 1: Transect locations, azimuths and existing measurement dates (to-date) for surveys of exposed nearshore rock occurrence.

Transect	Approx. R-Mon	Grid Azim.	Northing (FT-NAD27)	Easting (FT-NAD27)	Northerly distance between stations (ft)	Survey-1	Survey-2	Survey-3	Survey-4	Survey-5
1	R-75.3	83	1,410,085.5	629,717.3	--	5/22/2001		12/16/2002		
2	R-77.0	83	1,408,685.8	629,926.4	1,400			12/30/2002		
3	R-78.0	83	1,407,640.0	630,025.8	1,046			12/16/2002		
4	R-79.2	83	1,406,409.4	630,195.6	1,231	5/25/2001		12/16/2002		
5	R-80.6	83	1,405,080.1	630,389.9	1,329			12/30/2002		
6	R-82.5	80	1,403,349.2	630,718.9	1,731	5/22/2001	6/21/2001	12/17/2002	8/1/2007	8/1/2008
7	R-83.7	80	1,402,100.0	630,950.2	1,249			12/17/2002		
8	R-85.3	80	1,400,815.6	631,240.7	1,284	5/22/2001	6/22/2001	12/17/2002		
9	R-86.8	80	1,399,605.1	631,508.0	1,211			12/17/2002		
10	R-88.0	80	1,398,220.8	631,851.5	1,384	5/22/2001	6/22/2001	12/17/2002	8/1/2007	8/1/2008
11	R-89.3	77	1,397,029.8	632,087.0	1,191			12/17/2002		
12	R-91.0	77	1,395,891.3	632,359.2	1,138	5/22/2001	6/22/2001	12/17/2002		
13	R-91.7	77	1,395,310.6	632,487.1	581	5/22/2001		12/18/2002		
14	R-92.3	77	1,394,869.5	632,591.5	441	5/21/2001		12/18/2002		
15	R-93.3	77	1,393,761.8	632,828.9	1,108			12/18/2002		
16	R-94.5	77	1,392,670.0	633,093.4	1,092	5/21/2001	6/22/2001	12/18/2002		
17	R-96.0	77	1,391,364.6	633,407.8	1,305	5/21/2001	6/22/2001	12/18/2002	8/1/2007	8/1/2008
18	R-97.6	77	1,389,911.8	633,734.8	1,453	5/21/2001		12/18/2002		
19	R-99.0	77	1,388,642.9	634,001.0	1,269			12/18/2002		
20	R-100.4	77	1,387,300.2	634,298.5	1,343	5/21/2001	6/22/2001	12/18/2002		
21	R-101.25	77	1,386,440.9	634,510.0	859			12/18/2002		
22	R-102.0	76	1,385,740.5	634,671.1	700	5/21/2001		12/18/2002		
23	R-102.8	77	1,384,984.0	634,873.0	756			12/18/2002		
24	R-103.7	75	1,384,168.9	635,089.4	815	5/21/2001	6/21/2001	12/18/2002	8/1/2007	8/1/2008
25	R-104.9	77	1,383,384.3	635,254.4	785			12/18/2002		
26	R-105.5	81	1,382,632.3	635,438.8	752	5/22/2001		12/18/2002		
27	R-106.35	81	1,381,653.8	635,666.7	978			12/18/2002		
28	R-106.8	81	1,381,192.1	635,759.8	462			12/18/2002		
29	R-107.3	85	1,380,712.7	635,898.8	479	4/17/2001	6/21/2001	12/23/2002	8/1/2007	8/1/2008
30	R-107.7	85	1,380,296.0	635,992.0	417	4/17/2001		12/23/2002		
31	R-108.4	85	1,379,771.3	636,133.9	525	4/17/2001		12/23/2002		
32	R-109.2	85	1,379,063.3	636,331.0	708	4/17/2001	6/21/2001	12/23/2002		
33	R-109.4	85	1,378,807.0	636,332.5	256	4/17/2001		12/30/2002		
34	R-109.8	85	1,378,458.0	636,427.7	349	4/17/2001	6/21/2001	12/30/2002		
35	R-110.4	85	1,377,753.6	636,621.3	704	4/17/2001	6/20/2001	12/30/2002		
36	R-111.0	85	1,377,253.1	636,758.2	501	4/17/2001		12/30/2002		
37	R-111.35	85	1,376,944.4	636,864.6	309	4/17/2001	6/20/2001	12/30/2002		
38	R-112.0	85	1,376,353.0	637,013.6	591	4/17/2001		12/30/2002		
39	R-112.3	85	1,376,051.3	637,079.3	302	4/17/2001	6/20/2001	12/23/2002		
40	R-112.6	85	1,375,755.9	637,153.7	295	4/17/2001		12/23/2002		
41	R-113.3	85	1,375,190.0	637,313.8	566	4/17/2001	6/20/2001	12/23/2002		
42	R-113.95	85	1,374,657.7	637,470.0	532	4/17/2001		12/23/2002		
43	R-114.1	85	1,374,474.8	637,516.4	183	4/17/2001	6/20/2001	12/23/2002		
44	R-114.6	85	1,374,010.4	637,643.2	464	4/17/2001		12/23/2002		
45	R-115.15	85	1,373,330.8	637,832.0	680	4/16/2001	6/20/2001	12/30/2002		
46	R-116.2	85	1,372,554.4	638,044.6	776	4/16/2001		12/30/2002		
47	R-116.7	85	1,372,067.1	638,172.4	487			12/30/2002		
48	R-117.35	85	1,371,543.1	638,339.5	524	4/16/2001	6/20/2001	12/20/2002		
49	R-117.7	85	1,371,239.4	638,427.7	304	4/16/2001		12/30/2002		
50	R-118.3	85	1,370,696.2	638,568.9	543	4/16/2001		12/30/2002		



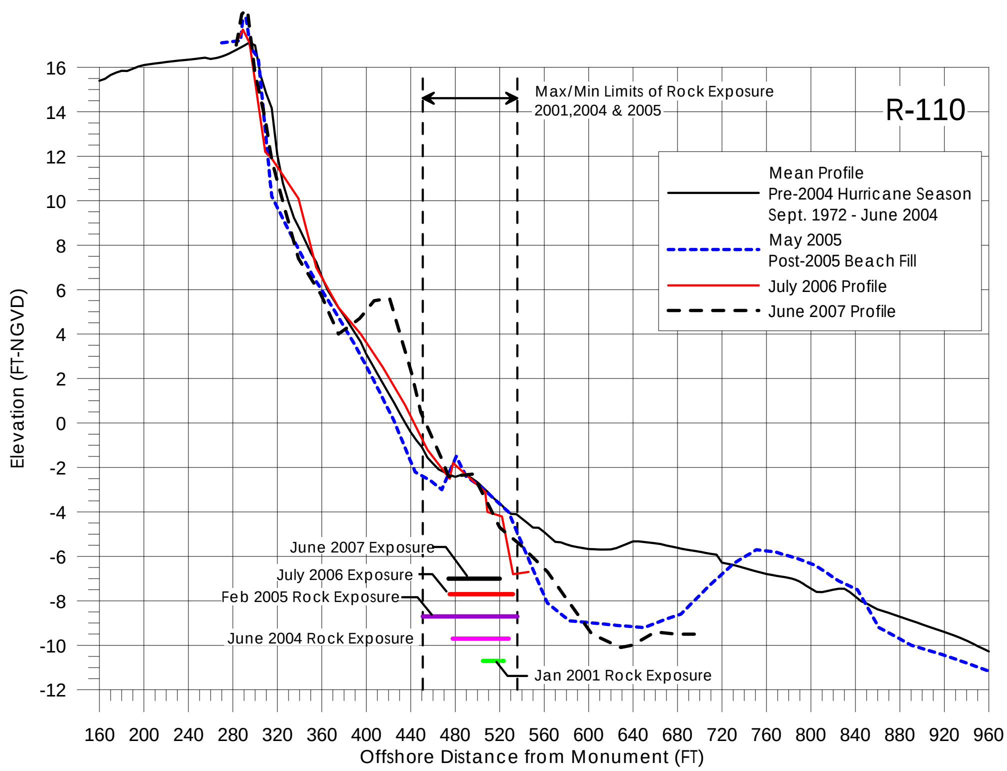


Figure 3a: Example monitoring results of wading transect surveys conducted at Mid-Reach shoreline. Upper – illustrates current profile relative to historic mean and standard deviation profiles. Lower – illustrates current profile relative to mean and recent prior profiles. Both – indicate locations of exposed rock surveyed along the transect.

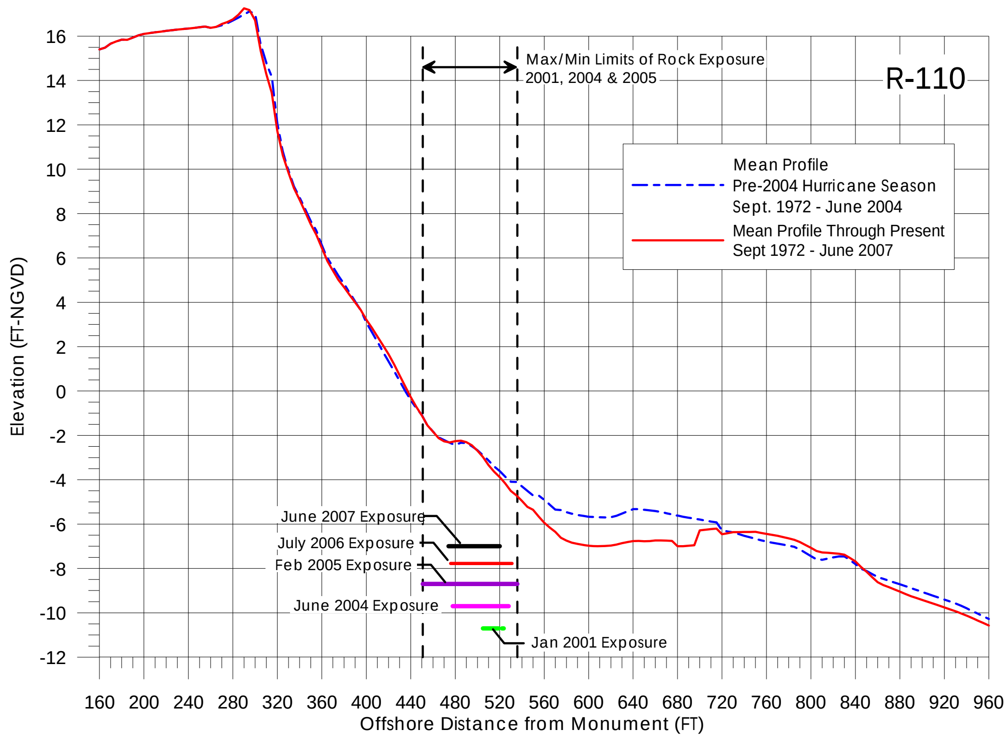


Figure 3b: Example monitoring results of wading transect surveys conducted at Mid-Reach shoreline (continued). The mean beach profile is computed and illustrated (i) through all pre-project surveys by the blue-dashed line and (ii) through current, post-project conditions by the red line. Comparison of the two mean profiles indicates long-term trends in profile change from pre-project to current (post-project) conditions.

2. Mitigation Reef (Physical Monitoring)

Physical monitoring of the mitigation reef will consist of the following elements.

a) Side-Scan Sonar. Principal measurement of the exposed surface of the mitigation reef shall be made by side-scan sonar. It is anticipated that each survey shall consist of two shore-parallel transects: along the western (landward) and eastern (seaward) margins of the reef placement areas, in opposite directions. A scaled, rectified mosaic image shall be developed from each transect. The area of the exposed reef structure, relative to the ambient seabed and including gaps between immediately adjacent placed mats within a set, shall be computed from these images. The percentage-change in exposed area, from the prior surveys, shall be computed and related to the initially constructed reef area.

b) <u>Diver Ground-Truthing & Inspection.</u> The approximate dimensions of exposed reef structure will be measured by divers at not less than five (5) reef sets. Two (2) sets shall be repeated at each survey, and the remainder shall be randomly selected at each survey. Using a graduated rule, divers shall take discretionary vertical measurements of sediment overburden thickness where it is apparent or evident. Divers shall additionally take not less than 10 measurements of sediment thickness atop the mitigation reef structure (including zero thickness where it occurs) at random or haphazardly selected locations across the surface of each of the surveyed reef sets. The general physical condition of the surveyed reef mats shall be likewise reported (including observation of settlement, scour, burial, structural integrity of blocks and cables, debris, and general indications of damage, etc., as visibility permits). Diver surveys shall be made in approximate temporal concurrence with the side-scan and bathymetric surveys, as conditions practicably allow. The results of the diver surveys will be compared to the side-scan survey for the purposes of ground-truth/verification.

c) <u>Dual-Frequency Bathymetric Survey.</u> The bathymetry over and adjacent to the mitigation reef sites shall be measured by dual-frequency acoustic survey. Survey line spacing will be not greater than 50-feet across reef structures and not greater than 100-ft across adjacent seabed, and shall extend to not less than 250-ft beyond the limits of the reef structures. The results of each survey shall be contrasted with those of previous surveys in plan and section.

d) <u>Schedule.</u> These surveys (items a, b, and c, above) shall be conducted at post-construction (within 60-days of completed deployment of each reef set), and at 1-, 2-, 3-, and 5-years after construction of the reef.

D. Natural Nearshore Reef and Mitigation Reef – Biological Monitoring

Biological monitoring of the natural nearshore reef and mitigation reef will consist of the following: epibiota, fishes, and marine turtles. The ultimate scope of the efforts will be highly dependent upon site conditions; and, as noted above, timing of the annual surveys will vary as a function of sea conditions.

1. Epibiota and Fishes

a) <u>*Survey Design.*</u>

The monitoring survey is designed to allow evaluation of both the mitigation reef as well as potential construction-related impacts to natural nearshore reef. The design incorporates spatial variation at several scales and includes pre-construction, post-construction, and annual temporal assessments.

The basis of the field program for monitoring epibiota and fishes is a *sampling "unit*", the size of which shall reflect the typical dimensions of a single set of mitigation reef mats (i.e., approximately 40 x 100 ft). This sampling unit is divided into four cells of equal area. Within each cell shall be three randomly located subsamples that are collected (assessed) for the biological response variables. (See **Figure 4.**) Sampling units shall be established at natural hardbottom areas, mitigation reef areas, and at a reference area.

<u>Natural Nearshore Hardbottom.</u> The locations of sampling units on natural hardbottom will be stratified over nearshore and offshore habitats within broad areas that systematically span the entire Mid-Reach project area. The distinction between inshore and offshore strata is based on water depth and distance from shore. Inshore sites to be sampled will include but not be limited to areas that are exposed during mean low water periods (i.e. intertidal). The cross-shore axis of the sampling unit will be the seaward extent of nearshore strata (i.e., 40 ft). Offshore habitats will encompass hard bottom that is completely subtidal and greater than 40 ft from shore.

Sampling units will be randomly positioned, during the pre-construction field survey, within four contiguous fill area blocks and one reference area block. (See **Figure 5.**) Once established, the locations of sampling units shall be permanent. Nearshore and offshore strata will not necessarily be contiguous but will be dependent upon the availability of hard bottom at the time of the initial survey. Strata will be determined during the initial survey based on current conditions of hard bottom availability and mean low water depth. Random placement of units will be constrained by the availability of suitable hard bottom within the larger fill area blocks. Given the discontinuous distribution of nearshore hard bottom throughout the Mid Reach, it may not be possible to locate three nearshore sample units in each of the Fill Area blocks.

Three sampling units shall be established on the natural nearshore hardbottom within a reference area. The reference area shall be located along the southern limits of Patrick Air Force Base (vicinity of R72-R74), which features hardbottom similar to that which exists along the Mid Reach project area and which is substantially beyond the direct impact of the project or adjacent, similar beach fill activities.

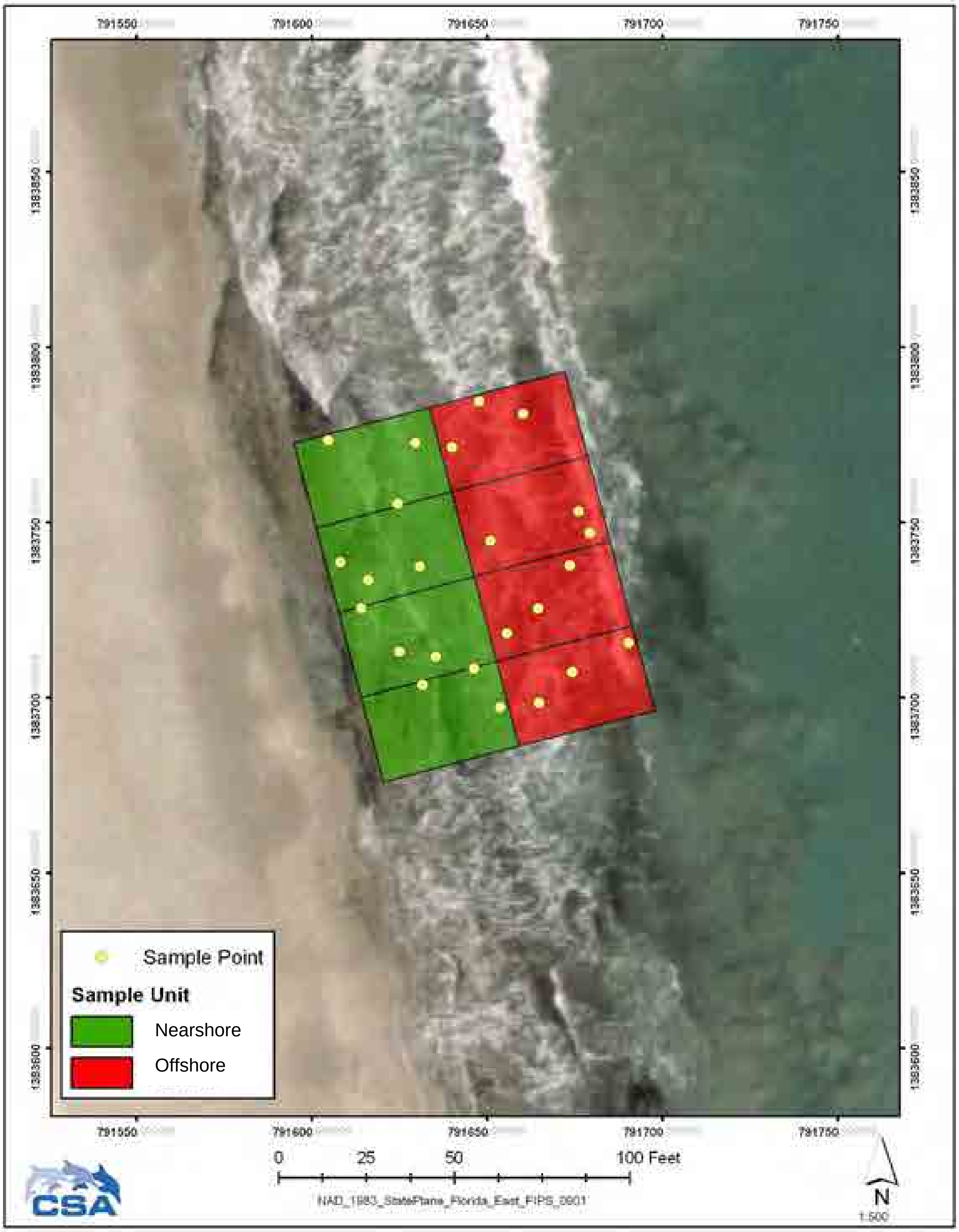


Figure 4. Example illustration of a nearshore and offshore sampling "unit" for biological monitoring of the natural nearshore hardbottom. (Nearshore and offshore sampling units may not be contiguous as shown above, depending upon sampling site selection.)

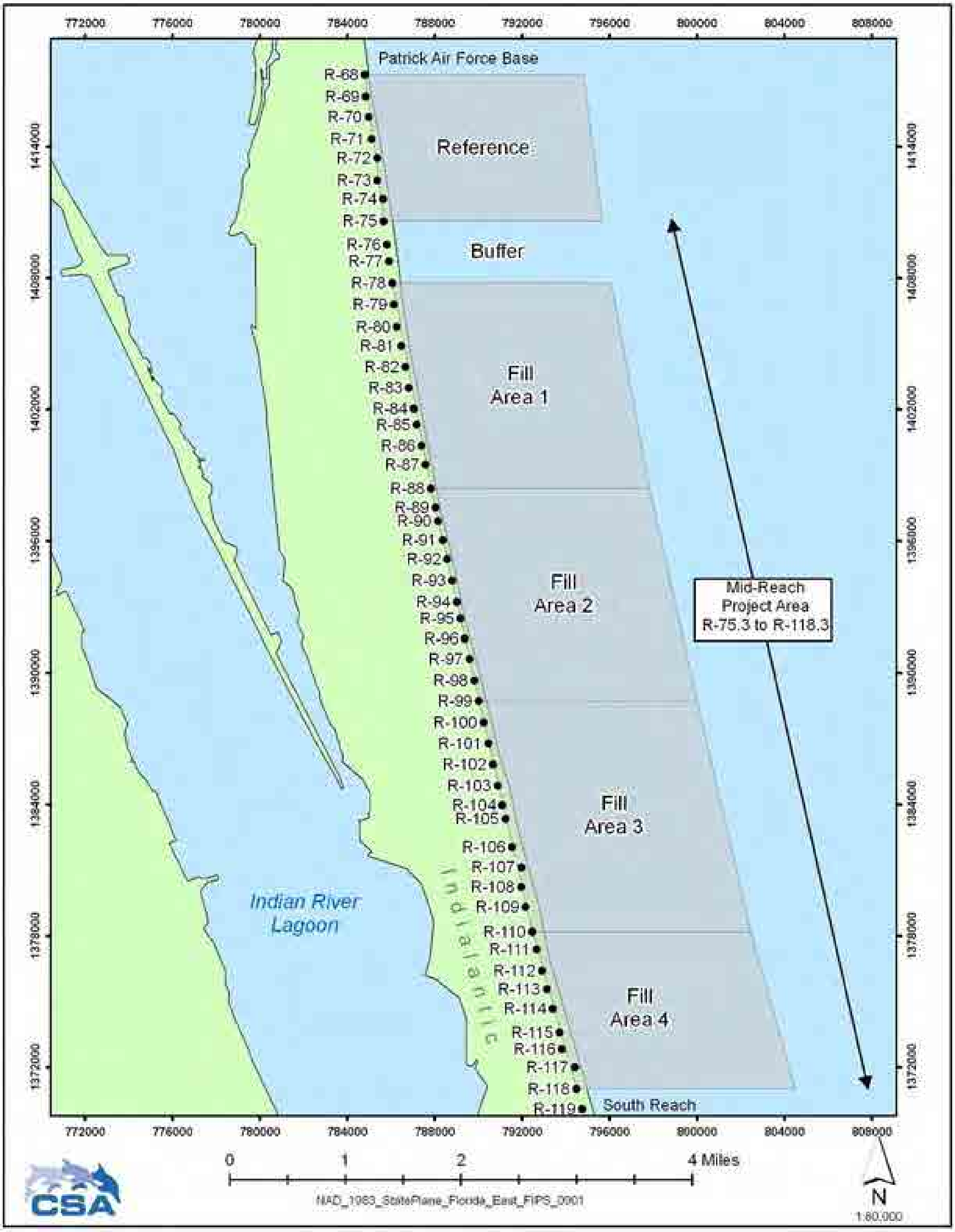


Figure 5. Fill area and reference-area blocks along the natural nearshore hardbottom of the project area and adjacent shorelines.

Mitigation Reef. Sampling units at the mitigation reef shall be established over each of four individual sets of reef mats (each individual set of mats being approximately 40-ft x 100-ft in area). The alongshore locations of these sampling units shall span the mitigation reef, with one each near the north and south limits of the reef extents and two near the center.

General. Once the sampling units are initially established they will remain fixed and permanent and their locations shall be relocated using DGPS coordinates for the duration of the monitoring program. For purposes of safety, the locations shall not be marked by permanent rods but shall be recovered within the physical accuracy limits of a high-resolution DGPS instrument. Random coordinates for subsample placement within cells will be generated prior to each field survey. Fixing the sample units in space means during the first survey means that it is possible that the entire unit could be covered by sand during subsequent field surveys. The sampling scheme is summarized in **Table 2.**

Table 2: Sampling scheme for epibiota.

Natural Hard Bottom						**Mitigation Reef**					
Epibiotal Images											
Sampling Reach	Unit	Stratum	Cells	Subsamples	Total	Sampling Reach	Unit	Stratum	Cells	Subsamples	Total
Reference	3	2	4	3	72	Reef Modules	4	1	4	3	48
Fill Area 1	3	2	4	3	72						
Fill Area 2	3	2	4	3	72						
Fill Area 3	3	2	4	3	72						
Fill Area 4	3	2	4	3	72						
Total					360						
Remote Video											
Sampling Reach	Unit	Stratum	Cells	Subsamples		Sampling Reach	Unit	Stratum	Cells	Subsamples	
Reference	3	1	1	3	9	Modules	4	1	4	3	48
Fill Area 1	3	1	1	3	9						
Fill Area 2	3	1	1	3	9						
Fill Area 3	3	1	1	3	9						
Fill Area 4	3	1	1	3	9						
Total					45						

b) Biological Response Variables.

Biological response variables are (1) epibiota (macroalgae and sessile invertebrates) cover and taxonomic composition; and (2) fish species composition and relative abundance. Marine turtles are addressed separately, below.

(1) Epibiota.

Epibiota will be sampled using digital video or still cameras mounted to rigid, portable stainless steel frames. The dimensions of the frame will be dictated by the height of the imaging camera(s) above the seafloor.

Because of the marginal visibility conditions in the area, sample images will be collected much closer to the bottom than typical quantitative imagery (e.g., 45 cm). For this reason the number of images (subsamples) will be relatively high. The steel frame from which the camera imagery shall be collected will be set to the proper distance, or height, for a photoquadrat of desired dimensions. For example a camera height above the seafloor of 15 cm would produce a photoquadrat of 300 cm^2.

These photoquadrats will be used to assess sessile invertebrate and macroalgal cover and occurrence. Digital photography of the stations shall be made directly, by videocamera as water clarity dictates. The camera-to-rock distance of the video camera will be maintained using a small stainless steel tripod. Representative samples of algae and sessile organisms will be collected as needed from or adjacent to the photoquadrat areas to confirm identifications. As an addition to photoquadrats, digital video data will be collected along swimming transects along and across the mitigation reef structures as conditions allow. Locations shall be annotated along the transect by DGPS.

Digital images from the photoquadrat stations and video transects will be evaluated to assess invertebrate and algal cover and taxonomic composition. Identification shall be made to the lowest practical taxon and ranked in order of percent cover. Total percent cover will be assessed by superimposing a random-dot overlay upon the photographic images using image analysis software.

The number of random points to be employed for point-count assessment on photograph and video images shall be established through sensitivity analysis of image evaluation from existing surveys and/or the first (pre-construction) survey. The data shall be analyzed with tests of 25, 50, and 100 random points on multiple frames, and the results shall be intercompared. The degree of difference of biotic estimates between each test, per image, will be assessed to determine the requisite number of sampling points ("dots") to achieve an adequate level of precision.

Image analyses will yield percent cover estimates for all identifiable taxa and major substrate types. Epibiotal taxa may be aggregated into broader taxonomic groups such as macroalgae, sponges, hydrozoans, bryozoans, worm rock, and tunicates. Substrate types include sand, bare rock, and dead wormrock, and algal turf.

The image size per each of the three sub-sample assessment points within each cell shall be determined based upon the conditions at the time of the first (pre-construction) survey, and this shall establish the image size to be used thereafter. The total image size per one sampling unit is (X cm^2 per sampling unit) multiplied by (3 images/cell) multiplied by (4 cells/unit) = 12X cm^2 per sampling unit. For example, as described above, a camera height of 15 cm above the seafloor would produce a photoquadrat of approximately 300 cm^2/image, or about 3,600 cm^2 per sampling unit. Or, a camera height of 45 cm above the seafloor would produce a photoquadrat of approximately 2700 cm^2/image, or about 32,400 cm^2 per sampling unit. Regardless of the image size that is established, the biota within the photoquadrat shall be expressed in terms of percent coverage; i.e., normalized by the total area of the image.

(2) Fishes.

Assessing fish assemblages associated with the natural and mitigation reefs is important but very difficult to achieve given the conditions of this area. To provide estimates of a portion (carnivorous species) of extant fish assemblages we propose to use baited remote video cameras (Willis et al, 2000; Watson et al, 2005).

Fixed duration (e.g., 10-minute) deployments of a video camera mounted to a heavy tripod will made at natural and mitigation reef *sampling units*. Camera tripods will be equipped with a plastic mesh bag filled with cut shrimp or fish. Four samples will be taken within each sampling unit on natural and mitigation reefs during each survey. These samples will not be collected in the nearshore stratum. All fish sampling will be dependent on sea conditions as well as horizonatal visibility. It is anticipated that at least 1.0 m will be needed to gather adequate data.

Video segments will be analyzed in the laboratory. Species observed in the video segments will be identified, and then the maximum number of each species seen at any one time is recorded as a measure of relative abundance.

2. Marine Turtles

Pre-construction monitoring will be conducted to provide a baseline of marine turtle distribution in the project area. Pre- and post-construction monitoring will consist of conducting marine turtle visual transect surveys over the proposed mitigation areas and the existing nearshore hard bottom (NHB). Monitoring will include the proposed project fill, designated buffer, reference and mitigation reef areas (Figure 8). Data will be used to compare sightings per survey and kilometer, and to determine variability of turtle distribution within the project area before construction. Data will also be used to conduct BACI analyses of turtle distribution post project construction (Krebs 1999).

a) Two observers and a boat driver, trained in the identification of marine turtles, will conduct systematic visual transect surveys from a shallow draft watercraft equipped with a sighting tower (Holloway-Adkins and Provancha 2005). When a turtle is observed, the boat driver will enter a time-stamped GPS waypoint, record the turtle species and its life-history stage (juvenile or adult).

b) Transects will be conducted parallel to shore at approximately 7 mph. A survey day will consist of conducting at least one transect along the nearshore hard bottom (NHB) in approximately 4-6' water depth and one transect over the mitigation reef site (MR) in approximately 15' water depth. Depending on inshore swell activity, NHB surveys will be conducted approximately 100 to 300 feet from shore and MR surveys are conducted approximately 750 to 1000 feet from shore. Transects will be randomly alternated to begin at either the designated reference location (R-68; Figure 2) and progress south, or begin at the southernmost Fill Area 4 (R-118) and proceed north.

c) Five survey days will be conducted for the pre-construction survey event and for each post-construction survey event for each area (NHB and proposed MR with reference and buffer sites included) for marine turtle distribution (**Table 3**). These surveys will be conducted in summer. The depth, temperature, and clarity of the water will be recorded for each survey, as well as the air temperature, wind speed and direction. Sea state and swell conditions will also be recorded. Survey conditions will be evaluated and every attempt made to maintain similar sampling conditions (i.e., calm sea conditions, water clarity, nearshore swell conditions, time of day, etc.) to provide optimal data collection.

d) Survey events will be conducted at pre-construction and at 1, 2, 3, and 5 years after initial project construction.

e) Transect survey data will be compared to previous marine turtle surveys conducted with the same methods and in the same location since 2005.

3. Schedule.

Biological monitoring surveys, indicated above, shall be conducted prior to, and at 1-, 2-, 3-, and 5-years after initial construction of the project.

Table 3. Sampling for the distribution of marine turtles in the Mid-Reach during the pre- and post-construction project time periods.

Survey Type	Survey Area	Survey Days	Min. Surveys	Min. Total Surveys
Pre-Construction *	NHB	SU (5)	1	5
	MR		1	5
Post-Construction	NHB	SU (5)	1	5
	MR		1	5

E. Natural Nearshore Reef and Mitigation Reef – Reporting.

1. Annual monitoring reports will be prepared and submitted within 90 days after field data collection. For expediency, each annual report may be released in separate components (physical changes, aerial mapping, epibiota and fishes, marine turtles) because of the different timing required for each. In that event, an annual summary report shall be issued that seeks to draw together the findings of the monitoring plan's various components.

2. The reports shall seek to quantify and contrast

(a) the extent of physical change (burial/exposure) at the nearshore and mitigation reefs, relative to historical pre-project variance and relative to predictions of with-project profile adjustment, and relative to the threshold mitigation acreage at the constructed reef sites.

(b) the extent to which the mitigation reef serves key ecological functions in terms of epibiota and fishes, within the context described below.

The basic question is whether or not after a period of time the mitigation reef supports fishes and epibiotal assemblage (e.g., macroalgae, sponges, wormrock) comparable to adjacent natural hard bottom habitats (both inshore and offshore strata). Response variables for this will be total biotic cover, cover of major taxa, and total number of taxa.

Statistical analyses will consist of univariate and multivariate techniques. Univariate analyses will be performed initially by factorial analysis of variance (ANOVA) using sampling units as replicates within treatments. Treatments will be before-after, reference impact, and times for project impact analysis and reef type over time for the evaluation of the mitigation reef. Response variables used in the ANOVAs will include: total epibiotic cover, cover of major taxa, cover of individual taxa as data allow, and total number of taxa. Confidence limits will also be calculated and plotted for all response variables. A non-parameteric multivariate ANOVA (Anderson, 2001) will be used to examine the effects of the project and reef type on the epibiotal assemblage as a whole. This approach uses a similarity matrix generated from the taxa-by-samples data set in the same design described above. In addition, we will using ordination (multidimensional scaling) to graphically examine patterns among samples over time. Results and interpretation of all analyses will be discussed and supported in the report with appropriate tables and graphics. Physical measurements, particularly those describing rock exposure along the 99 monitoring transects (per II.C.1) will be used when interpreting the biological data.

The same basic question described for the attached epibiota is applicable for the fish assemblage. Individual counts from camera deployments in each unit will serve as replicates in statistical analyses that will be similar to those described above for the epibiota. Response variables in ANOVAs will include number of species, number of individuals and numbers of selected species/life stages as data allow. Ordination and non-parametric multivariate ANOVA will be performed on species-by-sample matrices as described above. Life stage information for key species will be plotted as frequency of occurrence and proportional abundance by category among habitat types.

(c) Evaluation of project impacts to epibiota on natural hard bottom will be made by comparing fill area samples with reference area samples both before and after the start of construction. A three factor ANOVA (Reference-Impact, Before-After, and times) would be performed separately for nearshore and offshore strata. The test for impact will be a significant before-after x reference impact interaction. Response variables will be the same as those mentioned above for mitigation reef evaluation. Other analyses will include ordination and non-parametric multivariate ANOVA.

(d) Additional observation of scientific/academic value will be likewise noted.

3. The findings of the monitoring program and reports will serve toward documenting the studies described above and for determining the performance of the project relative to planning projections, as well as requirements for alternate or additional future actions.

III. PERFORMANCE STANDARDS AND EVALUATION

The following describes the performance standards of the project in specific regard to (1) the extent to which the beach fill activity impacts the nearshore rock habitat, and (2) the extent to which the mitigation reef fulfills the displaced functions of the impacted habitat. The means of measurement are described in Section II above.

The project is anticipated to impact approximately 3 acres of nearshore hardbottom through sedimentation or burial. As compensatory mitigation associated with these impacts, the project shall *initially* construct approximately 4.8 acres of mitigation reef. This includes some contingency (or risk factor), principally for potential burial, sedimentation, or failure of a portion of the reef.

(i) Per the Habitat Equivalency Analysis (HEA), the mitigation requirement reflects a conservative assessment that 75% the ecological services of the impacted hard bottom will be restored by the mitigation reef within two years after its construction – suggesting a requisite mitigation ratio of about 1.39 acres of compensatory mitigation per acre of impact; or, 1.39 x 3.0Ac = 4.17 acres of mitigation. (CSA 2006, 2008; see Appendix SEIS-H, page 4). This is the fundamentally-required mitigation acreage, to which an additional 15% contingency (0.63 acres) is allowed for potential burial of the reef, etc., for a total of 4.8-Ac of reef to be initially constructed, including contingency.

(ii) Per the Uniform Mitigation Assessment Method (UMAM), the mitigation requirement reflects an assessment that functional loss of the impact area is about 1.05 to 1.28 times the relative functional gain of the mitigation area, including temporal effects, but without consideration of risk factor. This suggests a fundamental requirement for 3.15 to 3.84 acres of mitigation, without risk factor. Inclusion of moderate/low risk factor of 1.5 to 1.25, respectively (i.e., 50% to 25% multiplier) yields a total of 4.8-Ac of reef to be initially constructed, including contingency.

Per these project assessments, the fundamental mitigation area required to replace the ecological function of the impacted area (without additional contingencies in construction, for risk) is between 3.15 and 3.84 acres, or 4.17 acres. The upper mid-range of these values (4.0 acres of mitigation reef) reflects an assessment that the mitigation reef shall provide 75% of the ecological functions of the impacted area. An additional 0.8 acres of mitigation reef is initially constructed as allowance for temporal considerations, contingency, and risk.

The following terms are defined for purposes of the project's Monitoring & Mitigation Plan, as described below:

- The term *"Threshold Mitigation Acreage"* (TMA) is the assessed mitigation area required to replace the ecological function of the project's impact area, less the risk factor (i.e., that factor which addresses uncertainty in mitigation requirements prior to construction and subsequent monitoring of the project). The TMA shall be the minimum, long-term effective planform area of exposed, functional mitigation reef that is to be provided by the project.
- The term "*Impact Acreage*" (IA) is the net amount of nearshore rock hardgrounds that is impacted by the project.
- The term "*Functional Mitigation Acreage*" (FMA) is the effective area of exposed mitigation reef, provided by the project, that is providing predicted ecological function which is otherwise displaced by the project at the impact site.
- The term "*Average With-Project Acreage*" (AWPA) is the mean, measured value of functional mitigation reef area from all prior and current surveys; viz., it is the mean of all prior and total FMA values.

For this project, the threshold mitigation acreage (TMA) is presumed to be approximately 4.0 acres, per above. This is based upon a predicted Impact Acreage (IA) of approximately 3.0 acres. The Impact Area shall be assumed to be the initially predicted value (3.0 acres) unless the project's monitoring surveys of the existing nearshore hardbottom indicate substantiative and/or compelling reasons for its adjustment: either greater or lesser. This would include indication that the post-project changes in the rock exposure and/or profile elevation are significantly different than those initially predicted, relative to the natural variations expected in without-project conditions.

Assessed over the long-term, the acreage of the exposed, functional mitigation reef (FMA) should be equal to or greater than the minimum acreage requirement for functional mitigation reef (TMA). If not, then future adaptive actions shall be required, per below.

The area (acreage) of the functional mitigation reef, from any given survey, shall be measured as described in Section II.C.2. The long-term acreage of the exposed, functional mitigation reef shall be described by the average with-project acreage of the reef (AWPA); that is, the cumulative year-by-year mean value of the exposed, functional mitigation reef area.

The monitoring data described herein shall be evaluated after the Year-5 post-construction survey to assess the project's impacts to the nearshore hardgrounds and the performance of the mitigation reef. This period of time includes the cumulative effects of the initial project construction plus one renourishment, and likewise includes an adequately sufficient time to assess the biotic recruitment, function, and physical behavior of the mitigation reef as described in Section II above. Interim-year results shall be reported and reviewed, prior to the Year-5 summary review, including prior to the project's first renourishment. Should the AWPA be less than the TMA after the Year-5 survey, or should annual assessments of the AWPA or nearshore rock surveys indicate significant trends that are adverse or inconsistent with the project's predicted performance, then adaptive actions shall be taken. These actions may consist of additional monitoring, analysis, and/or modifications to the project plan, subject to coordination between the Corps of Engineers, non-federal sponsor and the relevant regulatory agencies.

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Willis T.J., Millar R.B. and Babcock R.C. 2000. Detection of spatial variability in relative density of fishes: comparison of visual census, angling, and baited underwater video. Marine Ecology Progress Series 198:249–260.

Sub-Appendix K: Meeting Notes

Department of Environmental Protection

Jeb Bush
Governor

Marjory Stoneman Douglas Building
3900 Commonwealth Boulevard
Tallahassee, Florida 32399-3000

Colleen M. Castille
Secretary

7 October 2005

Ernest N. Brown, Director
Natural Resources Management Office
Brevard County Board of County Commissioners
2725 Judge Fran Jamieson Way, Bldg. A
Viera, FL 32940-6605

REQUEST FOR ADDITIONAL INFORMATION (RAI #1)

JCP File Number: **0254479-001-JC, Brevard County**
Applicant Name: Brevard County Board of County Commissioners
Project Name: Brevard County Mid-Reach Beach Restoration

Dear Mr. Brown:

This letter is to acknowledge receipt of your application for a Joint Coastal Permit, pursuant to Chapter 161 and Part IV of Chapter 373, Florida Statutes; and authorization to use state-owned submerged lands, pursuant to Chapter 253, Florida Statutes.

Please be advised that your permit application is considered to be incomplete as provided for by Chapter 120.60, Florida Statutes (F.S.), and Rule 62B-49, Florida Administrative Code (F.A.C.). Receipt of information requested below is required. The items of information are numbered to correspond with the item numbers on the application form.

When replying to this Request for Additional Information (RAI), please address your response to my attention (the undersigned permit processor). Please keep your RAI response separate from Scope of Work (SOW) submittals to the Project Manager in the Bureau's Beach Erosion Control Program. Misdirecting your response or combining your response with SOW matters will delay the review of your application. Please feel free to **courtesy copy** any other individuals with your response, but only responses addressed to the permit processor will be reviewed as part of your permit application.

Please submit three (3) hard copies of your response. Also, please prepare and submit one (1) electronic copy of your response (response document text, all attachments, and drawings) and submit it on a CD in Adobe Acrobat Reader® (.pdf) format.

4. *Location of activity referenced to Section/Township/Range:*

It appears that Section 36, Township 26 South, Range 37 East should be included in the description. Please confirm.

5. *Describe in general the proposed activity including any phasing*

Please describe the beach-dune conditions that would initiate nourishment of the dune and beach berm restoration project area between DEP Monuments R-75 and R-99 (after completion of the two year maintenance cycle). Please confirm that the proposed scope of the nourishment event will not exceed reconstruction of the fill template constructed during the original dune restoration.

Has Canaveral Shoals Borrow Area I been excavated for any previous project? If yes, when did excavation first commence?

Be advised that, while staff acknowledges the likely need for nourishing the northern section of Mid-Reach (R-75.3 to R-99) every two years because of the limited placement volume proposed, the Department's present policy is to authorize only one-time construction under a beach restoration permit (i.e., along a stretch of beach where no sand has previously been placed seaward of the mean high water line) so that the effects of the project design may be properly assessed from the monitoring surveys prior to approval of follow up operations. The applicant may apply at any time for a subsequent nourishment permit, though this application may not be deemed complete or approved until monitoring results have been submitted following completion of work under the initial (restoration) permit. Requests submitted under the JCP program do not preclude simultaneous applications for Coastal Construction Control Line permits that authorize construction above the mean high water/erosion control line, such as for dune enhancement.

8. *Identify the requested permit duration in years.*

You have requested a permit duration of ten (10) years. The construction phase of beach restoration projects are normally permitted for five (5) years or less, pursuant to Rule 62B-49.011(1), F.A.C., unless it is sufficiently demonstrated that the activity "cannot reasonably be expected to be completed within five years after commencement of construction." A permit of more than five years also requires that "the impacts of the activity, considering its nature, the size of the system and any required mitigation, can be accurately assessed, and offset where appropriate." Because substantial uncertainties exist over the long-term effects of this project on the natural resources and the efficacy of the proposed mitigation, staff is presently not inclined to support extended or recurrent construction events under the initial authorization. Please revise your request to five (5) years or less, or provide evidence that a longer duration is required for the initial (once only) construction event. Note that a time extension may be requested should construction activities approach the expiration date.

10. Have you obtained approval from the Department of State, Division of Historical Resources? If yes, provide a copy of the letter of approval.

The Division of Historical Resources (DHR) previously described objects within "Borrow Area II" that are related to the U.S. Space Program (underwater archaeological survey #6730). These objects should be avoided, or recovered and identified, in order to determine their eligibility for the *National Register of Historic Places* (especially anomalies C2-01, C2-02, C2-08, C2-12, C2-13, C2-14, C2-16 and C2-17). Do the anomalies listed as CC-01 to CC-09 on Sheet 17 of 24 in Attachment A of the permit application include the C2 anomolies of particular concern? If not, please submit a description and/or drawing identifying the locations of all space program objects in relation to the borrow area and how they will be avoided or recovered.

12. Are you requesting authorization to use Sovereign Submerged Lands?

As you inferred, the Department will be able to issue a letter of consent for the beach fill placement area below the mean high water/erosion control line and for the mitigation area. A submerged lands authorization will also be required for the Canaveral Shoals I borrow area, because it is within State waters. A public easement is required for a borrow area that has been or will be used for more than 5 years. Previous authorizations to use this borrow area do not automatically apply to a new project location. An easement may also be required for the rehandling area, according to Paragraphs 18-21.005(1)(c) and (f), F.A.C., where the rehandling area is treated as a "borrow area," as well. If a current easement already exists for Canaveral Shoals I, then that easement may need to be modified to address the duration and the placement location. Your response to Item No. 8 (permit duration) will assist us in the proper determination.

13. A copy of the Division of State Lands title determination. If you do not have title determination, department staff will request that the Division of State Lands conduct a title check.

The Division of State Lands has determined that lands lying below the mean high water line for the length of the project are state owned. A number of shore-adjacent parcels, sometimes extending down to the mean low water line, are subject to Lease No. 3485. This 50-year lease was issued on 15 June 1987 to Brevard County, with the purpose of allowing the County to represent the State in managing the land for "public outdoor recreation and related purposes." No further information is required for this item.

14. Written evidence of title to the subject riparian upland property in the form of the recorded deed, title insurance, legal opinion of title, or a long term lease which specifically includes riparian rights. Evidence submitted must demonstrate that the applicant has sufficient title interest in the riparian upland property. If the applicant is *not the property owner, then authorization for such use from the property owner must be provided.*

According to Paragraph 18-21.004(3)(b), F.A.C., evidence of upland interest is not required from governmental entities such as the applicant when conducting restoration or enhancement activities, provided that such activities do not unreasonably infringe on riparian rights. No further information is required for this item.

18. *Applications for permits and authorizations to use sovereign submerged lands shall be accompanied by a fee. The fee shall be the sum of the fees required by Chapters 62-4 and 62B-41, F.A.C., for processing of the permit application and Rule 18-21.001, F.A.C., for processing the request for authorization to use sovereign submerged lands.*

The sum of the fees required by Chapters 62-4, 62B-41, and 18-21, Florida Administrative Code, has been calculated as **$20,410.75**. A breakdown is as follows: Rule 62-4.050(4)(b) requires $10,000 for construction over approximately 400 acres of surface waters, and Rule 62B-41.0085(3)(b) requires $17,500 for the 1.6 million cubic yards designated for beach fill. However, Rule 62B-41.0085(6) allows a waiver of the portion of the fees required under Chapter 62B-41 in excess of the local government pro rata contribution to the project. Therefore, since this project is cost shared with the state government, considering the local cost share at 59.49% of the non-federal expenses and the computed 62B-41 fee (above) of $17,500, the local pro rata share permit fee under Chapter 62B-41 is $10,410.75. (Please note, the pro rata provisions of Rule 62B-41.0085(6) apply to the fee requirements within Rule 62B-41 only.)

Rule 18-21.009, F.A.C., will require an additional $500 processing fee if an Easement is necessary.

20. *Two copies of a topographic and bathymetric survey drawing of the proposed project site in accordance with Rule 62B-41.008(1)(h), F.A.C. Identify the elevation of the mean high water and mean low water referenced to NGVD for each Wetland or surface water site and the source of the tidal datum information.*

We acknowledge that you will provide this information. The application will remain incomplete pending submittal of the survey drawing(s).

21. *Provide a legal description of all property involved, including sovereign submerged lands used in carrying out the project.*

A public easement is required for Borrow Area I if it has been or will be used for more than 5 years. A legal description will only be required for the nearshore rehandling area if it is determined that an Easement is needed, following Item No. 13 above. If an Easement is required, you will need to submit two (2) copies of the legal description and a surveyor's sketch of the project area and specific boundaries, signed and sealed by the registered surveyor. The same will be required for the Canaveral Shoals Borrow Area I if an easement is necessary for this project and a previous easement has not been executed.

23. *An engineering description of as-built drawings, if available, of any existing structures on the site which may be directly or indirectly affected by, or which may directly or indirectly affect the proposed activity.*

When available, please submit the feasibility study that addresses the elimination or reduction of storm water outfalls at the beach. Also discuss the removal of any stormwater outfalls, located within the scope of this project, that aren't addressed in that study. The application will remain incomplete pending submittal of the study and discussion.

Are there any derelict structures within the project area, including any damage or degraded armoring structures or geotextile dune scour protection structures? Are there any private outfalls within the project area? If so, please indicate the structures on the plan sheets provided as Attachment A in the JCP application and submit a plan to remove said structures from the beach and dune system.

24. *Two complete sets of construction plans and specification for the proposed activity, certified by an engineer duly registered pursuant to Chapter 471, Florida Statutes. The plans shall include the following:*

    c. *Details of construction, including materials and general construction procedures and equipment to be used (e.g., construction access, dredging method, dredged material containment, pipeline location).*

Please provide additional description of the construction method to mechanically place fill material in the dune and beach berm restoration project area between Monuments R-75 and R-99. Specifically, what is the method to measure and control the total volume of material placed per linear foot of shoreline given? Bureau staff is familiar with filling and grading of fill material to restore a dune and backshore berm. Olsen Associates (2003) describe a placement and re-grading procedure. Given that the proposed activity will extend across the beach to the mean low water line, the staff is concerned that insufficient measurement of volume placed, or volume losses during construction by wave action, will result in the placement of material that exceeds the design volume, and consequently, exceeds the predicted coverage of nearshore hardbottom.

The drawings in Attachment A of the application designate construction access points. Are all staging areas (including pipeline stockpile locations) landward of the beach and dune system at these points? See FWC Comment (7).

25. *In addition to the full-size drawings requested above, the information requested under Items Nos. 20, 23, and 24 above shall be provided on 8 1/2-inch by 11-inch paper.*

Please add a title page and table of contents. Please provide any drawings that reflect updates stemming from your responses to Item Nos. 23, 37, etc.

26. *An aerial map of a scale of 1" = 200', showing: the project boundaries, DNR Reference Monument locations, major county landmarks, and special aquatic or terrestrial sites (parks, sanctuaries, refuges, etc.) within the project boundary and one quarter mile in both shore-parallel directions of the project boundary;*

We acknowledge that you will provide this information with your response to Item No. 20. Your application will remain incomplete pending submittal of the aerial map.

28. *Permit applications for excavation or fill activities shall include the following detailed information concerning the material to be excavated:*

    a. *Core boring logs and sediment grain size analyses from representative points throughout the area to be excavated. Logs should extend at least two feet below the proposed bottom elevation. The depth of each visible horizon in the log should be reported relative NGVD and the material in each stratum classified according to grain size.*

    b. *Particle size analysis to the sediment and a measure of the percent organics by dry weight. Gradation curves should be produced from sieve analysis of each stratum in the core. Grain size distribution must be determined down to the standard unit 230 sieve size.*

Normally copies of the above information are required for every new permit file; however, Staff has reviewed core logs and sediment analyses for the borrow areas as submitted with the contract specifications for the Patrick Air Force Base Beach Restoration Project (Permit No. 0176167-001-JC). Stemming from this review:

- Please provide updated plan and section views of the borrow areas showing the volume of material that has been removed in previous projects.
- Please provide munsell colors for the samples collected from borrow areas I and II, and the access channels.
- Please provide carbonate contents/ estimates of shell content for both borrow areas and the access channels as well as the native beach.
- In what grain size fraction is the carbonate dominant (for borrow areas I and II and the access channels and for the native beach)?
- For borrow area I and the access channels the silt content appears to increase with depth in the cores. Please discuss how you will avoid putting this material on the beach and monitor for turbidity.

29. *Using an established natural community classification system, describe each natural community within the area of influence of the proposed activity and include;*

a. Acreage.

Profile drawings from Attachment A in the JCP application for profiles at DEP Reference Monuments R-78, R-81 and R-93 show no coverage of hardbottom by the equilibrium toe of fill, but this conflicts with the plan views provided under Attachment B1. Please explain the discrepancy.

Please address FWC Comments (1) and (2).

b. Identification of the flora and fauna to the lowest taxon practicable.

c. Characterization of dominant and important flora and fauna and estimates of percent biotic cover.

d. Sampling locations, date of sampling or measurements; and methods used for sampling.

When available, please submit the report that details and analyzes the biological field studies conducted in February 2005, including the section on marine turtle abundance and foraging, fishes and epibiota. The application will remain incomplete pending receipt of the report.

Please address FWC Comments (3), (8), (9) and (10). Note that following submittal of FWC Comment (10), our office made available to FWC staff an electronic copy of the January 2003 report "Assessment of Nearshore Rock and Shore Protection Alternatives Along the 'Mid-Reach' of Brevard County, Florida" (Olsen Associates).

Please provide a plan for monitoring the intertidal infauna. This plan should include the pre-construction baseline data and post-construction recovery.

30. Detailed information on season of occurrence, density, and location of threatened or endangered species whose range occurs within the proposed activity.

See above comments under Item No. 29.

31. Results of available wildlife surveys that have been conducted on the sites, and any comments pertaining to the proposed activity from the Florida Fish and Wildlife Conservation Commission and the U. S. Fish and Wildlife Service.

Please submit a Biological Opinion for the project from the U.S. Fish and Wildlife Service and/or the NOAA National Marine Fisheries Service, as appropriate, via consultation initiated by the U.S. Army Corps of Engineers. The Biological Opinion(s) include authorization for incidental take of endangered species (including sea turtles), which is required prior to the issuance of a state permit for a restoration project, pursuant to Chapter 370.12(h), F.S.

Please address FWC Comments (4) and (5)

32. *A general description of all commercial and recreational fisheries, diving regions, and other recreational uses within the area of influence of the proposed activity.*

At the northern section of the projects boundary has a long history of surfing, and like fishing, "surfing breaks have social and economic value for coastal communities" (Scarfe 2003). However, the application neglected to mention that the project area was used for surfing. Are there any other significant commercial or recreational uses that were not listed?

33. *Analysis of the expected effect of the proposed activity on the coastal system including but not limited to:*

    a. *Analysis of the expected effect of the proposed activity on the existing coastal conditions and natural shore and inlet processes.*

The description of the method used to assess alongshore spreading of the beach restoration fill material placed between R-99 and R-118 is acceptable. However, the calculations for diffusion of the fill reference a 0.5-foot per year erosion rate. Is the eroded material conserved in estimates of sand that spreads along adjacent beaches, or is it considered to be transported offshore, or otherwise lost from the system? What volume does this represent? Please confirm that the depiction of the anticipated toe of equilibrium profile for the reach north of R-99 on the drawings in Attachment B1 include material from fill spreading.

Please provide a detailed description with references of the analytical method use to predict the equilibrated profile of the dune and beach berm restoration project area between Monuments R-75 and R-99. Include calculations and annotated figures to illustrate the method as applied to the two representative profiles of this area used in Olsen (2003). With regard to the assessment that the initial impact to nearshore hardbottom is a reasonable estimate of the maximum impacts from subsequent nourishment events, please specify the net losses of fill material, above and below the water line, for this outcome to occur. Olsen (2003) is not explicit as to whether this assessment is based upon total loss of all fill material from the project area. What are the annual transport rates for material into and out of the Mid-Reach, distinguished by northern and southern fill sections?

Please provide an analysis of whether the equilibrium of material will affect bathymetry and associated wave refraction such that predominantly "surfable" waves change to "ordinary" waves. Surfable waves are waves in which the break point peels along the wave crest, and ordinary waves are waves that tend to break all at once or at two different places within the same wave crest thus limiting the length of the ride and surfing experience. This area in Brevard County with its hardbottom characteristic tends to create surfable waves. Other areas that are the southern portion of the project area with lack of hardbottom characteristic tend to exhibit more ordinary waves.

> *b.* *Analysis of the compatibility of the fill material with respect to the native sediment the disposal site. The analysis should include all relevant computations, the overfill ratios, and composite graphs of the grain-size distribution of the fill material and the native sediment at the disposal site.*

- Please submit a sediment quality control/quality assurance plan that will ensure that the sediment to be used for beach restoration or nourishment will meet the standard in paragraph 62B-41.007(2)(j), F.A.C.
- Please provide all relevant computations, the overfill ratios, and composite graphs of the grain-size distribution of the fill material and the existing or native sediment at the disposal site.
- Please provide the results for any sediment sampling of material from the Canaveral Shoals Borrow Areas following placement upon the beach under the Brevard County North Reach (0134869-002-JC), Brevard County South Reach (0137212-005-JC), or Patrick A.F.B. (0176167-001-JC) projects.
- For borrow area I in most cores the shell content is greater than 10%. How does this compare to the native beach?

> *d.* *Analysis of how water quality and natural communities will either be impacted, undisturbed, preserved or maintained within the area of influence of the proposed activity with an estimate of the affected acreage of each impacted community.*

- Please discuss the likelihood, size, level of exceedance and duration of turbidity plumes being generated by wave action reworking the newly place fill material following the completion of construction. Also, please be advised that turbidity monitoring must be conducted by an independent third party.
- What is the proposed time of year and duration of the sand stockpile on the beach? Will light from buildings or roads be visible from this elevated berm?
- What is the distance between borrow area I and the nearest hardbottom communities? Please describe the survey(s) used to determine this distance.

35. *Describe any methods proposed to protect threatened or endangered species.*

Please address FWC Comment (6)

36. *A written statement providing the necessity and justification for the potential impacts to the coastal ecosystem which may be caused by the proposed coastal construction.*

Please address FWC Comment (13). Note that following the submittal of this FWC comment, FWC staff members (Trindell and Mille) were sent hard copies of "Appendix D Pertinent Correspondence" from the 1996 Brevard County Shore Protection Project Feasibility Report with Final Environmental Impact Statement, which includes the referenced State Clearinghouse consistency determination.

37. *A detailed narrative description of any proposed mitigation plans, including purpose, maintenance, monitoring, estimated cost, construction sequence and techniques.*

The proposed mitigation does not appear to be sufficient to offset the anticipated impacts of the beach fill, because impact sites and the mitigation sites provide very different habitat types with different functions. Artificial reefs placed at a depth of 14+ feet (NGVD) are not expected to fully mimic the functions of rock outcrops in 0 to 4 feet of water. Staff appreciates the review of mitigation alternatives that the applicant has already described in the 2003 Assessment of Nearshore Rock and Shore Protection Alternatives, however, the applicant is encouraged to further research mitigation concepts that will allow placement of stable hardbottom closer to shore, in shallower water. For instance, you may wish to consult further with Mr. Dan Bates of Palm Beach County, who is referenced (in the 2003 alternatives report) as part of your evidence for the stability of the proposed geogrid mattresses. Currently, under the Juno Beach nourishment project (Permit No. 0127642-001-JC), Palm Beach County is considering options for placing additional mitigation hardbottom close enough to shore to allow land-based construction methods.

The choice of geogrid mattresses is based on your assessment that no rock substrate exists within ten (10) feet of the sandy sea bottom beyond the exposed reef. Please provide a map of the location of the jet probes and more detailed results of the "sub-bottom surveys" used to make this determination. Is it possible that near surface solid substrate exists just seaward of the emergent rock reefs along the northern section of Mid-Reach, even if only for a more limited amount of mitigation material?

If "like for like" mitigation ultimately remains unfeasible, then the Department would conduct an assessment of proposed mitigation plan to determine if an increased acreage of mitigation would be sufficient to off-set the proposed impacts according to a functional evaluation performed under the Universal Mitigation Assessment Method (UMAM), pursuant to Rule 62-345, F.A.C. Please provide estimates of functions of the (final) proposed mitigation to assist staff in performing the assessment. At a minimum, list (for both the impact site and the mitigation site) all biological functions (e.g., algal substrate, predation on larval fish, sea turtle foraging grounds, competition between juvenile and adult turtles, etc.), water depths, wave climate, vertical relief, and the other pertinent evaluation criteria from Rule 62-345, F.A.C. Then estimate the degree to which the proposed mitigation will provide these functions (on a scale of 0 to 10). Highlighting habitat differences with respect to endangered, threatened or special concern species may be appropriate.

Staff recognizes that coordination with the U.S. Army Corps of Engineers (USACE) is imperative in determining acceptable mitigation, and a November 2005 meeting is currently planned to help our two agencies form a consensus on appropriate mitigation measures for hardbottom impacts in general. You are encouraged to solicit comments from the USACE, formal or informal, on the mitigation plans for this specific project as early as possible. Bureau staff is willing to join in coordination meetings, as necessary, if you feel there is a conflict between Department and USACE perspectives on a preferred mitigation plan.

Please provide a detailed physical monitoring plan for the project. It is recommended the plan be similar to monitoring conducted for the South Reach project, and indeed, could be consolidated into a comprehensive monitoring program for the county. In addition, the plan should include physical monitoring requirements for assessing the conditions along R-75 to R-99 that would initiate maintenance nourishment activities without contributing additional hardbottom impacts. A detailed biological monitoring and mitigation plan will also be required once the conceptual design, construction and siting of the mitigation work has been approved by the Department.

While staff recognizes the difficulties in simply designing and constructing a viable mitigation site to offset the biological impacts associated with the expected loss of hardbottom, the applicant is further encouraged to consider a mitigation hardbottom design that creates an additional surfing break. Please estimate the technical and financial feasibility of incorporating such a feature into the mitigation work.

Please address FWC Comments (11) and (12)

38. *An analysis of available alternatives to the proposed coastal construction, on meeting the stated performance objectives and any related affects on the coastal system.*

The discussion of dune restoration only along the segment between R-75 and R-99 in Olsen Associates (2003) uses a design constraint of 2.5 cubic yards per foot as the volume density based upon constructability. However, recent post-storm dune restoration activities in this area placed significantly more fill material (up to 8.7 cubic yards per foot) along the eroded dune bluff (CCCL Permit No. BE-1134E). Please reassess the alternative of a dune restoration only project along this segment that would meet the performance objectives and reduce predicted impacts to nearshore hardbottom.

Please publish the enclosed Notice of Application. Pursuant to Section 403.815, Florida Statutes and Rule 62-110.106, Florida Administrative Code, you (the applicant) are required to publish at your own expense the enclosed Notice of Application. This notice shall be published one time only within 14 days, in the legal ad section of a newspaper of general circulation in the area affected. For the purpose of this rule, "publication in a newspaper of general circulation in the area affected" means publication in a newspaper meeting the requirements of Sections 50.011

and 50.031, Florida Statutes, in the county where the activity is to take place. The applicant shall provide proof of publication to the Department within seven (7) days of publication.

If the applicant fails to provide all information required to complete the application within six (6) months after a request for additional information has been sent, the staff will close the permit application file after written notice to the applicant, except that a request for an extension of time for a period agreeable to the Department, but not to exceed one year, shall be granted upon demonstration by the applicant that the delay in completion of the application has been caused by matters beyond the control of the applicant. Application files closed under these procedures shall be closed without prejudice and a new application, accompanied by the appropriate fee, shall be required to renew the application.

If the processing of the application is prolonged, or if a storm event is known to have altered the shoreline such that the staff determines that the topographic and bathymetric survey data is no longer adequate to complete its analysis, then an updated survey shall be required as specified in Item No. 20 above. In the event that an updated survey is required, the application shall be treated as an amended application.

If I may be of any further assistance, please contact me at the letterhead address (add Mail Station 300) or by telephone at (850) 414-7806.

Sincerely,

Steven MacLeod, Environmental Specialist
Bureau of Beaches and Coastal Systems

Enclosure: Notice of Application
FWC Comment Letter (dated 09/29/05)

cc:
Virginia Barker, Brevard County
Kevin Bodge, Olsen Associates, Inc.
Irene Sadowski, USACE, CESAJ-RD-NA-M
Osvaldo Rodriguez, USACE, CESAJ-DP-B
George Getsinger, NOAA/NMFS, Jacksonville
Rob Bittner, USFWS, Jacksonville
Robbin Trindell, FWC, ISMS
Keith Mille, FWC, MFMS
Janet Llewellyn, DEP, Secretary
Michael Sole, DEP, Chief of Staff
Dave Herbster, DEP, Central District
Michael Barnett, DEP, BBCS-Chief
Martin Seeling, DEP, BBCS-JCP
Vladimir Kosmynin, DEP, BBCS-JCP
Robert Brantly, DEP, BBCS-CE
Beth Forrest, DEP, BBCS-CE
James LaGrone, DEP, BBCS-CE
Paden Woodruff, DEP, BBCS-BECP
Jackie Larson, DEP, BBCS-BECP

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
P. O. BOX 4970*
JACKSONVILLE, FL 32232-0019*

REPLY TO
ATTENTION OF

July 5, 2006

Regulatory Division
North Permits Branch
Cocoa Field Office
SAJ-2005-6689(IP-IS)

Brevard County Board of County Commissioners
Attn: Mike McGarry
2725 Judge Fran Jamieson Way, Building A
Viera, Florida 32940-6605

Dear Mr. McGarry:

Reference is made to your response letter dated May 3, 2006 (Attachment 1), at which time you requested a 90-day minimum time extension to investigate mitigation options for the project as proposed. In your letter you stated that all alternatives suggested in our comment letter dated April 6, 2006 (Attachment 2) were considered previously but were found to be limited by a complicated matrix of physical factors. Therefore, it is apparent to the Corps that the County strongly believes that direct impacts to nearshore hardbottom cannot be eliminated nor significantly reduced and still meet the objectives of the project.

The Corps' position is that the project as proposed will likely result in significant degradation of the aquatic ecosystem due to unacceptable impacts. You have failed to convince us that you have selected the least damaging practicable alternative. The work as proposed has unacceptable impacts and we will move forward with an unfavorable decision unless the impacts to nearshore hardbottom are eliminated or significantly reduced.

We believe that our file information is sufficient for us to make a permit decision. As described in our April 6, 2006 letter, we are concerned that the following public interest factors weigh in favor of finding the proposal contrary to the public interest: conservation, general environmental concerns, fish and wildlife values and mitigation.

As requested in your letter, the Corps will grant your 90-day extension to August 3, 2006 to provide the data you are currently collecting. At that time we will close our record and make a decision.

Sincerely,

Osvaldo Collazo
Chief, North Permits Branch

Enclosures

RECEIV
JUL 10 2006
JACKSONVILLE D
USACE

RD-NA/Sadowski
RD-E/Burns
RD-N/Collazo

Brevard County, Florida Storm Damage Reduction Project
Mid-Reach Segment
Interagency Meeting
June 13, 2007
U.S. Army Corps of Engineers Office, Jacksonville, Florida

Meeting Minutes:

1. The following were in attendance:
Kevin Bodge, Olsen Associates, Inc.
Virginia Barker, Brevard County
Mike McGarry, Brevard County
Karen Holloway-Adkins, East Coast Biologists
Ann Marie Lauritsen, USFWS/Jax FO
John Milio, USFWS/Jax ES FO
Jason Engle, USACE, Jax District
Candida Bronson, USACE, Jax District
Paul Stodola, USACE, Jax District
Kenneth Dugger, USACE, Jax District
Irene Sadowski, USACE, Jax District
George Getsinger, NMFS HLD
Osvaldo Rodriguez, USACE, Jax District
Jessie Pettingill, USACE, Jax District

The following were in attendance via telephone conference call:
Marty Seeling, Florida DEP
Steve MacLeod, Florida DEP
William Weeks, Florida DEP
Caitlin Lustic, Florida DEP
Jackie Larson, Florida DEP
Vladamir Kosmynin, Florida DEP
Dennis Klemm, NMFS
Pace Wilber, NOAA Fisheries
Robbin Trindell, FFWCC

2. Osvaldo Rodriguez welcomed everyone to the meeting and introductions were made. Candida Bronson and Paul Stodola gave a short powerpoint presentation based on the read-ahead materials and then opened up the floor for discussion.

3. Robbin Trindell opened up the discussion by asking which models were used to predict equilibration and if they were the same as in non-rock areas. The concern was if the rock impact presented was reasonable or if it underestimated the impact. Jason Engle explained how the rock impact was calculated, by using historical data from the Mid-Reach and translating the profile seaward. This approach assumes

that the natural slope of the shoreline would be translated seaward with the addition of material. Kevin Bodge added that with the small amount of fill proposed, this is a valid approach. He added that fills at Patrick AFB can be used as a case study. Data from the Patrick AFB project have shown a stable fill, with longshore movement of material essentially in balance between what is moving north and what is moving south. It was requested that a summary of the Patrick AFB project and monitoring results be included in the next documentation for the Mid-Reach project.

4. A concern was stated about turbidity impacts to the nearshore rock. Clarification resulted in the concern being not only the physical burial of rock but the impact on adjacent rock by turbidity caused by the fill. This would occur at every renourishment. Kevin Bodge stated that the material proposed was very low in fines content and is not expected to cause a turbidity issue. Information on the borrow material will be provided in the next set of documentation.

5. Ann Marie Lauritsen turned the discussion to the mitigation and monitoring plan. The monitoring plan in the read-ahead material discusses physical and biological monitoring over a period of 5 years. Provisions are included for actual versus predicted losses. A question was asked if the permits can include a requirement to recalculate the amount of mitigation based on the monitoring data of impacts. Marty Seeling stated that there is precedence for this, and additional mitigation is usually required at the next renourishment.

6. A technical question on the UMAM calculation was directed to DEP. Paul Stodola had used the technique of applying a zero to the post-burial rock area and a zero to the sandy bottom prior to construction of the mitigation reef. Marty Seeling agreed that this was appropriate.

7. George Getsinger asked if any studies were completed of the effects on the rock within the Mid-Reach following the Patrick AFB fill. Kevin Bodge stated that the Patrick AFB fill has been relatively stable, except for the 2004 hurricanes when a loss of material was noted. The material did not visibly migrate north or south but was lost to the project. Monitoring was done for about a ½ mile south into the Mid-Reach area. Generally the Mid-Reach rock coverage is the same as historical amounts with no noticeable impact from the Patrick AFB fill. The rock is highly variable through time, with certain outcroppings buried while others emerge, but generally the same amount of rock is exposed through time. This is also variable with seasons and storm events.

8. The discussion moved to the topic of functional loss versus functional gain with respect to the rock impact and the mitigation proposed. Marty Seeling expressed reservations regarding the deeper depth of the mitigation reef compared to the shallow impact area. He did acknowledge that it may not be possible to verify if every function exists in both places and that best professional judgment may be used on the appropriateness of the mitigation. Karen Holloway-Adkins added some information from the environmental studies, stating that it was estimated that 64-85%

of the function of the natural rock will be replicated by the mitigation reef. Concern was expressed over lost functions and cumulative effects. Virginia Barker added that out of the 7 sub-sets of functions studied, all were present at the mitigation site. George Getsinger suggested that the studies are missing specific age classes that may be affected. Anne Marie suggested that some of the concerns could be addressed through the monitoring plan. The monitoring plan should be tailored to address the uncertainties in the project and allow for adjustments in the mitigation required.

9. The Indian River County mitigation project was brought up as an example of mitigation in the same 14 to 16 foot water depth. The monitoring report was just published for review. Vladamir Kosmynin and Robbin Trindell had looked at the report and offered that there was no baseline data where the natural rock was studied before impact, so that study does not answer all of our questions. It was stressed that the monitoring plan for Brevard Mid-Reach needs to contain a pre-construction survey of the impact area. Several others had not had the opportunity to review the report. Candida Bronson offered to get an electronic copy from Brevard County and make available.

10. In a broad sense, Robbin Trindell said that the presented plan appears to be the right alternative. Concerns now focus on the mitigation and monitoring plan. George Getsinger seconded that idea. The monitoring plan needs to include baseline studies, the impact area and adjacent areas and include both physical and biological monitoring.

11. George Getsinger asked about the Port Canaveral sand bypassing project and how that might affect the Mid-Reach project. In particular, what are the effects of placing a large volume of sand at one time rather than annually? Jason Engle stated that several studies have shown that the volume of sand is appropriate and that effects to the Mid-Reach have not been shown. Since the initial construction of the North Reach project, there is plenty of sand to feed the longshore littoral drift, so no further impacts should occur. Kevin Bodge added that monitoring of the fill placement from the bypassing project has shown the same annual longshore transport regardless of the timing of the bypassing, i.e. the transport volume is the same in year one as in year six. So it appears that there is no effect on the transport of sand south by placing a large volume every six years as opposed to a smaller volume every year.

12. It was asked for a briefing on the PALM study. Karen Holloway-Adkins provided the briefing and status. Three modules were constructed and deployed for the purpose of studying recruitment of sabellariid worms and macroalgae on different substrates. Following 44 days in place at 15 foot water depth, one of the modules was pulled out of the water on May 5th. Dr. McCarthy of Jacksonville University is still studying the samples and a report has not been compiled yet. From observations, Karen stated that there had been some scour and burial of the modules, and that there was good recruitment and diversity of macroalgae. The

bottom line was that both the sabellariid worm and macroalgae were recruiting at the deeper depths.

13. Paul Stodola initiated further discussion into the UMAM calculations. In particular the risk factor has a big impact on the final mitigation ratio and is under question. The Corps of Engineers is presently using 2.0 in its draft UMAM. Marty Seeling said it may be that a factor over 2.0 is appropriate. His main concerns are over structural stability of the mitigation reefs and the appropriateness of the mitigation reef design. It was suggested that some of these concerns may be addressed in the monitoring plan. For example, subsidence or other change in the physical size of the mitigation reef is easily monitored and conditions of the permit could require more mitigation. The appropriateness is a more difficult question. However, the point was raised that requiring more mitigation of a type that may not work is not any better. The baseline data collection was mentioned again as a requirement in determining if the mitigation is working to replace the lost functions or not. FDEP stated they are generally happy with the studies done to date. All available data to date from the Brevard County environmental studies needs to be included in the next document. The monitoring plan needs to include specifics with a schedule, cost and parameters to be studied. It should be multi-season, include some species-specific studies, and age and depth related parameters.

14. George Getsinger asked about the non-structural measures listed in the read-ahead material and if any of them proved to be a viable alternative to construction. The read-ahead contains descriptions of several non-structural measures and qualitative evaluations of why each of them do not fully address the problems at the Mid-Reach. No non-structural measures were included in the final array of alternatives. The condemnation and acquisition measure was carried forward to identify parcels for acquisition but proved to be an incomplete solution due to the high variability of structure age, design, and set-back from the shoreline. Other policy changes are difficult to implement as the Corps does not have jurisdiction and local authority is variable, some Brevard County, some City of Satellite Beach, and some City of Indian Harbour Beach.

15. Summing up. Robbin Trindell and George Getsinger voiced their support. A lot of progress has been made on this project, the alternatives evaluation was very thorough, and the team is headed in the right direction. Ann Marie Lauritsen added that the team has shown avoidance and minimization of impacts, acknowledging there is still work to be done on the mitigation and monitoring plan. Marty Seeling commended the Corps for the work completed and agreed with Ann Marie on the work needed for the mitigation and monitoring plan. John Milio and Irene Sadowski agreed also. The Corps had invited the agencies to participate in the study as “collaborating agencies” and NMFS and USFWS have accepted. George Getsinger and Ann Marie Lauritsen offered to work directly and informally with Paul Stodola to help develop the monitoring plan.

16. The next steps for the project were summarized as presentation of the proposed plan to Corps headquarters at the AFB meeting in late August or September followed by preparation of the draft report. Brevard County and all the environmental resource agencies will be invited to the AFB meeting and documentation will be made available. The purpose of the meeting is to get approval of the proposed plan. It is likely that the monitoring plan will not be complete at that time but will be completed prior to the draft report.

17. The meeting was adjourned at 12:25 pm.

Florida Department of
Environmental Protection
Marjory Stoneman Douglas Building
3900 Commonwealth Boulevard
Tallahassee, Florida 32399-3000

November 26, 2007

Ernest N. Brown, Director
Natural Resources Management Office
Brevard County Board of County Commissioners
2725 Judge Fran Jamieson Way, Bldg. A
Viera, FL 32940-6605

REQUEST FOR ADDITIONAL INFORMATION (RAI #6)

JCP File Number:	**0254479-001-JC, Brevard County**
Applicant Name:	Brevard County Board of County Commissioners
Project Name:	Brevard County Mid-Reach Beach Restoration

Dear Mr. Brown:

This letter is to acknowledge receipt of additional information, submitted on your behalf by Olsen and Associates, Inc., and to inform you that the application for a Joint Coastal Permit made pursuant to part IV of Chapter 373, Florida Statutes (F.S.), is still considered by the staff to be incomplete. Receipt of the information requested below is required to complete the application. The items of information are numbered to correspond with the item numbers on the application form.

Please be advised that your permit application is considered to be incomplete as provided for by Chapter 120.60, Florida Statutes (F.S.), and Rule 62B-49, Florida Administrative Code (F.A.C.). Receipt of information requested below is required. The items of information are numbered to correspond with the item numbers on the application form.

When replying to this Request for Additional Information (RAI), please address your response to my attention (the undersigned permit processor). Please keep your RAI response separate from Scope of Work (SOW) submittals to the Project Manager in the Bureau's Beach Erosion Control Program. Misdirecting your response or combining your response with SOW matters will delay the review of your application. Please feel free to **courtesy copy** any other individuals with your response, but only responses addressed to the permit processor will be reviewed as part of your permit application.

Please submit three (3) hard copies of your response. Also, please prepare and submit one (1) electronic copy of your response (response document text, all attachments, and drawings) and submit it on a CD in Adobe Acrobat Reader® (.pdf) format.

23. An engineering description of as-built drawings, if available, of any existing structures on the site which may be directly or indirectly affected by, or which may directly or indirectly affect the proposed activity.

The Department has reviewed the Brevard County Beach Outfalls Removal Feasibility Study Report dated October 19, 2007. Among the feasible options presented in the Report for the 17 outfalls in the Mid-Reach project area, Option 1 is acceptable to FDEP. FDOT has already retrofitted Outfall #2. According to the Study Report, Option 1A is the only option feasible for Outfall #14.

The beach restoration design dune elevations range from 12.6 feet to 15.0 feet. Berm elevation is at 10.6 feet. The design of exfiltration pipe, trench and the new outfall structure with the riser (Option 1) will need to consider the post-construction dune and berm elevations at each of the outfall locations.

Please provide letters of agreement between the County and those responsible for the maintenance of each of the outfalls granting the County permission to modify the design of those structures for all 17 outfalls. The Department acknowledges that the City of Satellite Beach will be handling the retrofitting of Outfalls 11, 12, and 13 according to the new conceptual design; however, we need assurance that all of the outfalls will be modified and maintained in conjunction with this permit. Please also provide correspondence from the DEP District Office regarding any permits or permit modifications that may be required to retrofit stormwater outfalls that were originally permitted through that office.

Please note that final plans and specifications including before and after drawings of each of the outfalls will be required as a Notice to Proceed Item.

Comments from FWC:

In general, we support decreasing storm water discharge to marine turtle nesting beaches and waters of the state. Any infiltration structures should be designed such that the potential for interference with nesting marine turtles or impacts to nests, such as increased water content in the incubation substrate, is minimized. The permittee should ensure that beach areas that will be affected by the infiltration system, either through the presence of structures in the nesting beach or by changes in water flow and content, should be clearly marked and all nesting or nesting attempts in those areas be clearly summarized in the annual reports of marine turtle nesting, nesting success, incubation length, and hatch and emergence success.

33. Analysis of the expected effect of the proposed activity on the coastal system including but not limited to:

b. Analysis of the compatibility of the fill material with respect to the native sediment in the disposal site. The analysis should include all relevant computations, the overfill ratios, and composite graphs of the grain-size distribution of the fill material and the native sediment at the disposal site.

Please revise the Sediment QA/QC Plan to reflect the following comments:

Under the Background – Sediment Borrow Sources section (page 2), there is a typo at the end of the paragraph on CS-I. The last sentence giving the volume says that the volume is for CS-II. Please correct this error.

On page 4 in the Table of Sediment Parameters, please change the allowable mean grain size to 0.25 to 0.45 mm as listed on page 3.

The average carbonate values of the borrow areas is 39%, and the average carbonate content of the native beach is 37 to 29%. Please reduce the maximum carbonate content to 45% (on page 3 and in the table on page 4).

Under the Project Monitoring and Quality Assurance Section, please remove the portions dealing with truck-haul beach fill from an upland source. Please note that these portions could be used to modify the QA/QC plan if an upland source is added at a later date.

37. A detailed narrative description of any proposed mitigation plans, including purpose, maintenance, monitoring, estimated cost, construction sequence and techniques.

The Department has completed a cursory review of the Biological Monitoring Plan. The proposed monitoring is acceptable, although small details may still need to be discussed. Please continue to work with the Department to get this document approved.

While it is not considered a completeness item, please address the following concern from FWC:

While the overall proportion of shell material in offshore borrow sites may be similar to the component measured on a beach face, the composition and reactivity of the material may be very different. In addition, shell material may be differentially distributed across a beach, with large amounts accumulating in the swash or subtidal portion of the berm. What is the proportion of shell material in the sub aerial portion of the berm? How does the composition and nature of the shell material compare between the beach and the borrow site – are both recent shell or is the borrow area characterized by relict, and potentially chemically and physically altered, shell?

Please be sure to provide any updates or amendments to the Biological Opinions from NMFS and FWS reflecting the design modifications to the original permit application.

If the applicant fails to provide all information required to complete the application within six (6) months after a request for additional information has been sent, staff will close the permit application file after written notice to the applicant, except that a request for an extension of time for a period agreeable to the Department, but not to exceed one year, shall be granted upon demonstration by the applicant that the delay in completion of the application has been caused by matters beyond the control of the applicant. Application files closed under these procedures shall be closed without prejudice and a new application, accompanied by the appropriate fee, shall be required to renew the application.

If the processing of the application is prolonged, or if a storm event is known to have altered the shoreline such that the staff determines that the topographic and bathymetric survey data is no longer adequate to complete its analysis, then an updated survey shall be required as specified in Item No. 20 of the JCP application form. In the event that an updated survey is required, the application shall be treated as an amended application.

If I may be of any further assistance, please contact me at the letterhead address (add Mail Station 300), by e-mail at Caitlin.Lustic@dep.state.fl.us, or by telephone at (850) 413-7766.

Sincerely,

Caitlin Lustic

Caitlin Lustic
Bureau of Beaches and Coastal Systems

cc:

Virginia Barker, Brevard County
Irene Sadowski, USACE, CESAJ-RD-NA-M
George Getsinger, NOAA/NMFS, Jacksonville
AnnMarie Lauristen, USFWS, St. Petersburg
Janet Llewellyn, DEP, Director
Dave Herbster, DEP, Central District
Martin Seeling, DEP, BBCS-JCP
Robert Brantly, DEP, BBCS-CE
Paden Woodruff, DEP, BBCS-BECP
BBCS Permit File
Kevin Bodge, Olsen Associates, Inc.
Osvaldo Rodriguez, USACE, CESAJ-DP-B
Robbin Trindell, FWC, ISMS
Keith Mille, FWC, MFMS
Michael Sole, DEP, Secretary
Michael Barnett, DEP, BBCS-Chief
Vladimir Kosmynin, DEP, BBCS-JCP
El Kromhout, DEP, BBCS-CE
Wagner Yajure, DEP, BBCS-BECP

CESAJ-PD-PN 16 January 2008

MEMORANDUM FOR THE RECORD

SUBJECT: Brevard County Shore Protection Project, Mid-Reach Segment, Conference Call on Seawall Alternative

Attendees:

Jason Engle	USACE, EN-WC	904-232-2230
Paul Stodola	USACE, PD-EA	904-232-3271
Candida Bronson	USACE, PD-PN	904-232-3873
Osvaldo Rodriguez	USACE, DP-C	904-232-2909
Bradd Schwichtenberg	USACE, PD-PN	904-232-1697
Eric Bush	USACE, PD-P	904-232-1517
Kevin Bodge	Olsen Associates	904-387-6114
Mike McGarry	Brevard County	321-633-2016
Roxane Dow	Florida DEP	
Marty Seeling	Florida DEP	
Paden Woodruff	Florida DEP	
Gene Chalecki	Florida DEP	
Guy Weeks	Florida DEP	
Steve MacLeod	Florida DEP	
Jeff Groska	HQUSACE	202-761-4700
Lee Ware	HQUSACE	202-761-0523

1. The subject conference call was held on December 17, 2007. Reference documentation titled “Issue Paper on Seawall Alternative” dated December 7, 2007 was distributed by email beforehand. The purpose of the meeting was to discuss an HQ USACE request to reconsider a seawall to be included in alternative plans for the Brevard County Mid-Reach project including a 4.1 mile long seawall along a portion of the study area.

2. It was confirmed by the Florida Department of Environmental Protection (FDEP), Bureau of Beaches and Coastal Systems staff that Florida statutes restrict the use of coastal armoring (e.g., seawalls) and that these statutes are included in Florida’s Coastal Zone Management Plan. The statutes allow construction of armoring for structures that are vulnerable to damage from frequent coastal storms. The alternative of 4.1 miles of seawall does not meet the requirements of the statute and would be inconsistent. It was stated that this determination is made from a Florida statute with 35 years of history, not an agency rule, so is not eligible for a permit variance.

3. Discussion continued on the use of the seawall in the shorter reach 5A which includes two segments of seawall, together equaling 3300 feet in length, to protect the most vulnerable structures. It was stated that this alternative is contrary to FDEP policy and

would also be determined inconsistent. FDEP has strived to eliminate hard structures in favor of beach nourishment due to adverse impacts to adjacent properties and the environment. The Florida statutes allow armoring as a last resort for vulnerable structures but armoring is not viewed as an acceptable solution for longterm beach management. FDEP will not support additional armoring in Florida. Therefore, it is expected that the alternative for seawall construction in reach 5A would be inconsistent with the Florida statute.

4. It was agreed by all parties that it would be appropriate to screen out the seawall alternative in all portions of the study area based on the inconsistency determination from FDEP. HQUSACE recommended that the draft report include a clear explanation of why the alternative was screened out, including reference to the Florida statutes. Jacksonville District will coordinate a draft write-up of the screening section with FDEP and HQUSACE before completion of the draft report.

5. Other remaining items to complete the draft report were discussed. HQUSACE is still unclear about the National Economic Development (NED) plan which determines Federal participation. It was agreed that Jacksonville District will revisit the alternative screening and selection to remove the seawalls and verify the NED plan. Another remaining item from the Alternative Formulation Briefing meeting was the cost effectiveness and incremental cost analysis for the mitigation plan. Jacksonville District is in the process of completing this work and plans to coordinate that information prior to the draft report.

6. Jacksonville District will coordinate an In Progress Review (IPR) meeting by conference call to close-out discussion on the remaining items prior to completing the draft report. The remaining items to be discussed at the meeting will include the justification write-up to remove the seawall alternative, the determination of the NED plan, and the cost effectiveness and incremental cost analysis of the mitigation plan. Participants should include Jacksonville District, South Atlantic Division, HQUSACE, Brevard County and consultants, Florida Department of Environmental Protection, Florida Fish and Wildlife Conservation Commission, US Fish and Wildlife Service, and National Marine Fisheries Service. It is anticipated that this meeting will be held in late January or early February.