Post-Construction Monitoring Survey of Nearshore Hard Bottom Habitats South of Fort Pierce Inlet Fort Pierce, Florida

December 2004

Prepared for:

Dr. Steven J. Schropp
Taylor Engineering, Inc.
9000 Cypress Green Drive, Suite 200
Jacksonville, Florida 32256
Telephone: (904) 731-7040

Prepared by:

Continental Shelf Associates, Inc.
759 Parkway Street
Jupiter, Florida 33477
Telephone: (561) 746-7946

Prepared Under Supervision of:
Paul S. Fitzgerald, Principal Investigator

Post-Construction Monitoring Survey of Nearshore Hard Bottom Habitats South of Fort Pierce Inlet Fort Pierce, Florida

December 2004

Prepared for:

Dr. Steven J. Schropp
Taylor Engineering, Inc.
9000 Cypress Green Drive, Suite 200
Jacksonville, Florida 32256
Telephone: (904) 731-7040

Prepared by:

Continental Shelf Associates, Inc.
759 Parkway Street
Jupiter, Florida 33477
Telephone: (561) 746-7946

Prepared Under Supervision of:
Paul S. Fitzgerald, Principal Investigator

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

Continental Shelf Associates, Inc. (CSA) was contracted by Taylor Engineering, Inc. to conduct a post-construction monitoring survey of nearshore hard bottom habitats near Fort Pierce, Florida. **Figure 1** shows the location of the survey area south of Fort Pierce Inlet. The monitoring survey was conducted in association with the beach nourishment project (May 2003) that commenced on the south side of the inlet and extended approximately 1.3 mi south. The purpose of this monitoring survey was to map and to determine the physical and biological conditions of these hard bottom habitats following the May 2003 beach nourishment project. The survey was conducted in accordance with the requirements as set forth by the March 2003 *Biological Monitoring Plan, Fort Pierce Beach Restoration Project* and Florida Department of Environmental Protection (FDEP) Permit Number 0126215-002-JC (Maquire and Schropp, 2003). The pre-construction monitoring survey was conducted between 12 April and 14 May 2003. The May 2003 beach nourishment project was completed near the end of May 2003. Several attempts were made to conduct the post-construction monitoring survey from late summer 2003 through spring 2004, but inadequate weather and site conditions in the nearshore survey areas precluded the survey efforts. In early summer 2004, the weather improved dramatically, and site conditions were optimal when the post-construction monitoring survey was conducted. Two monitoring transects were established and surveyed on the mitigation reef located offshore of FDEP (formerly Department of Natural Resources [DNR]) Monuments R-39 and R-41 (**Figure 1**). This report describes the results from the post-construction monitoring survey conducted between 3 and 4 June 2004 and compares the results to the pre-construction monitoring survey.

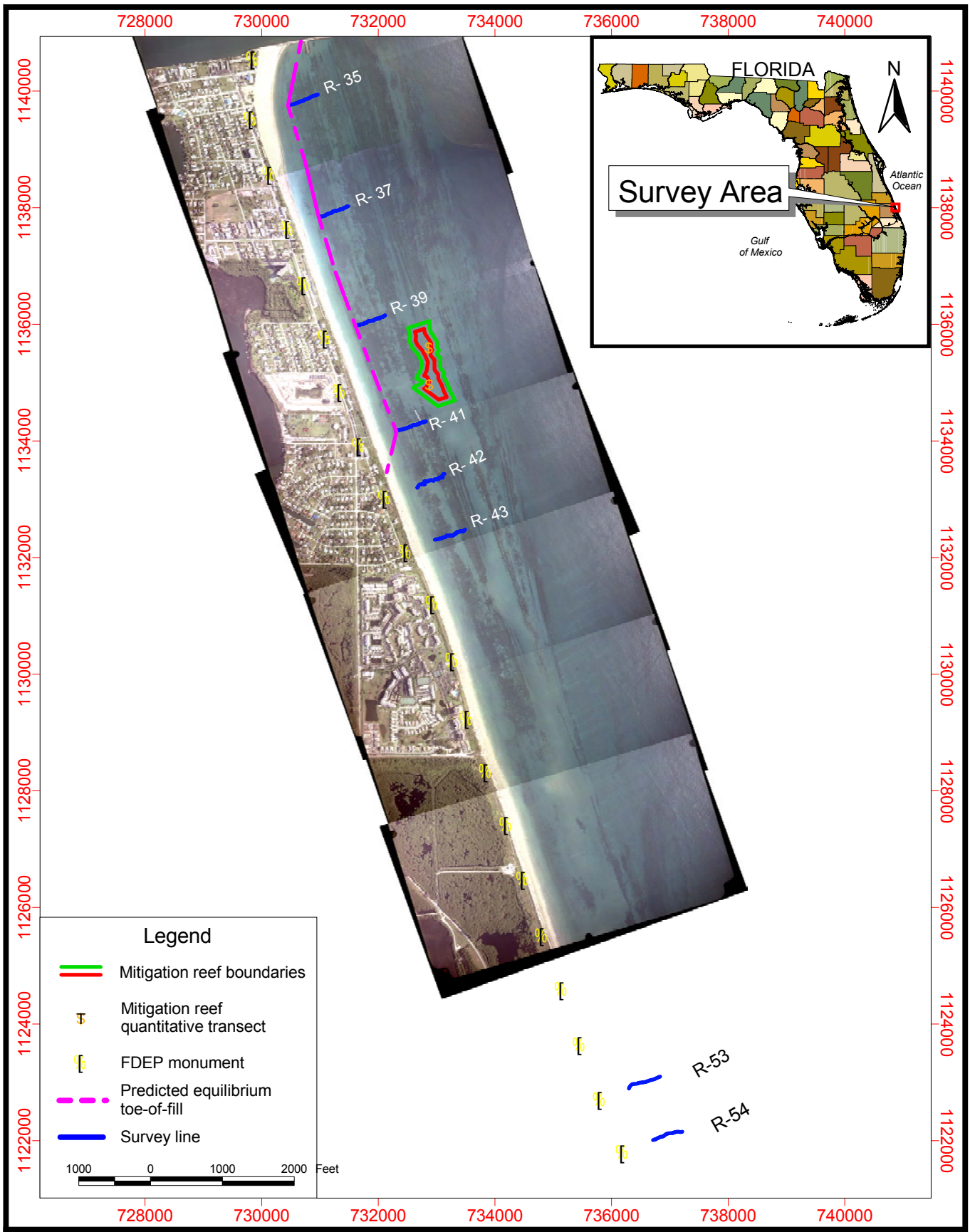

Figure 1. Overview of the survey area south of Fort Pierce Inlet, Fort Pierce, Florida. Aerial imagery for Survey Lines R-53 and R-54 is not available.

2.0 BACKGROUND

The pre-construction monitoring survey was conducted between 12 April and 14 May 2003. Eight cross-shore survey lines were established from FDEP Monuments R-35 through R-54. The survey lines commenced at the predicted equilibrium toe-of-fill (ETOF) and extended offshore approximately 500 ft. Qualitative video data were collected to identify substrate types and characterize biological communities along each survey line. Substrate observed along each survey line was identified and placed into one of the following categories:

- predominantly sand bottom with less than 10% exposed rock cover;
- 10% to 50% exposed rock cover; or
- substrate with greater than 50% exposed rock cover.

Navigational position data were used to map the identified substrate along post-plot survey lines. The reefs south of the Fort Pierce Inlet were generally composed of exposed rock colonized by algae and assorted benthic invertebrates, including sabellariid worms (*Phragmatapoma lapidosa*). These rock reefs parallel the shoreline south of the Fort Pierce Inlet. The pre-construction monitoring data (Continental Shelf Associates, Inc., 2003) indicated that the dominant substrate category observed in the survey area was greater than 50% exposed rock cover (58.5%). The second most abundant cover was the 10% to 50% exposed rock cover category, composing an average of 23.7% of the total survey line lengths surveyed. Substrate with 10% to 50% exposed rock cover was most abundant along survey lines in the middle of the survey area. The less than 10% exposed rock cover category composed an average of 17.8% of the total survey line lengths surveyed.

Three, permanent, 20-m quantitative transects were established along each of the eight survey lines. The first quantitative transect (01) started at the predicted ETOF and extended out 20 m seaward of the predicted ETOF. The second transect (02) started at 30 m seaward of the predicted ETOF and extended out 50 m seaward of the predicted ETOF. The third transect (03) started at 100 m seaward of the predicted ETOF and extended out 120 m seaward of the predicted ETOF. The video data collected along each quantitative transect were used to determine percent cover for scleractinia, octocorals, sponges, hydroids, zoanthids, and macroalgae. Quantitative data indicated that substrate (sand and rock) was the dominant cover along most transects, with an average of 74% cover. Biotic cover was higher than substrate cover along the following quantitative transects: R-39-01 (54.3% cover), R-39-02 (56.2% cover), R-43-01 (59.3% cover), and R-43-02 (77.2% cover). The high biotic cover at these stations was primarily due to dense algal cover on the exposed rock in the survey area.

An *in situ* species inventory of major taxonomic groups was conducted along and within 1 m to either side of each 20-m quantitative transect. The species inventory showed that relatively more complex and well-developed epibiotal and fish communities were observed associated with substrate that had greater than 50% exposed rock cover. This substrate typically had a relief of 2 to 3 ft. The epibiotal communities were dominated by various species of algae and echinoderms, along with low numbers of sponges and stony corals. Water visibility was less than optimal and made some species identification difficult. A total of 26 fish species was observed. The most common fishes observed along the survey transects included porkfish (*Anisotremus virginicus*), spottail pinfish (*Diplodus holbrooki*), slippery dick (*Halichoeres bivittatus*), and hairy blenny (*Labrisomus nuchipinnis*).

3.0 METHODS

3.1 FIELD METHODS

3.1.1 Survey Area

The post-construction monitoring survey included a series of cross-shore survey lines established at the following FDEP Monuments: R-35, R-37, R-39, R-41, R-42, R-43, R-53, and R-54. **Table 1** provides the navigation coordinates for each survey line. Navigation coordinates were collected in State Plane NAD-27, Clark 1866, zone Florida East, with units of measure in U.S. survey feet. **Figure 1** shows the location of the survey lines. Survey Lines R-42 and R-43 were used to assess the downdrift effects of project construction. Survey Lines R-53 and R-54 were monitoring reference sites. The survey lines commenced at the predicted ETOF and extended 500 ft offshore.

During the pre-construction monitoring survey, three, permanent, 20-m quantitative transects were established along each of the eight survey lines. The first quantitative transect (01) started at the predicted ETOF and extended out 20 m seaward of the predicted ETOF. The second transect (02) started at 30 m seaward of the predicted ETOF and extended out 50 m seaward of the predicted ETOF. The third transect (03) started at 100 m seaward of the predicted ETOF and extended out 120 m seaward of the predicted ETOF.

Two 20-m quantitative transects were installed on the mitigation reef located seaward of FDEP Monuments R-39 and R-41 (**Figure 1**). **Table 1** provides the navigation coordinates for the quantitative transects on the mitigation reef. Permanent markers with numbered tags were installed at either end of each quantitative transect and secured to the substrate with epoxy.

3.1.2 Video and Visual Data

Qualitative video documentation of the seafloor and associated biota was collected along the survey lines by towing a biologist diver equipped with a hand-held underwater video camera. The biologist diver continuously noted substrate type and vertical relief, and identified benthic assemblages, and areas of habitat burial along the survey line. Continually updated navigation position data were synchronized with the video data using the local time code on the camera, which was concurrently recorded onto the videotapes. The diver was towed along the survey line at a speed of approximately 0.5 to 1.0 kn and at a height of 0.5 to 2.0 ft above the seafloor.

Contiguous quantitative video data were collected along the entire length of each 20-m quantitative transect. A digital camera mounted to a framer and equipped with underwater lights was used to collect video in the high-energy and low-visibility environment associated with each survey line. The camera was kept perpendicular to the bottom substrate while surveying each survey line. Two lasers mounted to the top of the camera housing were set to converge at a point that would maintain a camera height of 50 cm above the seafloor.

General observations were made concerning the biological community at each station. An *in situ* inventory of major taxonomic groups was conducted along the entire length and within 1 m to either side of each 20-m quantitative transect. Observations of

fishes, turtle sightings, and benthic organisms were recorded on underwater slates during each dive.

Table 1. Starting and ending points for the survey lines established on the hard bottom habitats and mitigation reef south of Fort Pierce Inlet, Fort Pierce, Florida.

Survey Line	Starting Point*		Ending Point*	
	Northing	Easting	Northing	Easting
R-35	730467.2	1139756.9	730962.9	1139940.3
R-37	730978.7	1137842.8	731484.7	1138024.4
R-39	731610.1	1135957.8	732116.0	1136149.7
R-41	732302.1	1134152.5	732818.9	1134334.2
R-42	732668.2	1133192.5	733136.6	1133433.9
R-43	732969.0	1132304.1	733485.9	1132482.2
R-53	736299.1	1122890.1	736834.8	1123098.7
R-54	736710.3	1122008.5	737215.0	1122152.1
MT-1	732873.8	1134942.9	732873.8	1135002.9
MT-2	732864.2	1135579.1	732864.2	1135639.1

* Navigation coordinates were collected in State Plane NAD-27, Clark 1866, zone Florida East, with units of measure in U.S. survey feet.

3.2 DATA ANALYSIS

Following the survey, video data were returned to the laboratory for analytical review. Video data were reviewed to identify substrate types and characterize biological communities. Substrate observed along each survey line was identified and placed into one of the following categories:

- predominantly sand bottom with less than 10% exposed rock cover;
- 10% to 50% exposed rock cover; or
- substrate with greater than 50% exposed rock cover.

In order to map substrate types, the navigational position of a continuous span of a specific substrate type identified along an individual survey line was recorded. These navigation data were plotted to produce tracklines along each survey line. These tracklines with the substrate categories were then superimposed onto the 2003 georeferenced aerial imagery provided by Taylor Engineering, Inc.

Listings of all identifiable fish and invertebrate species observed along and within 1 m to either side of the quantitative transects were made *in situ* by the divers during the species inventory. Water visibility was often low and made some species identifications difficult. Species identified during the survey were generally those large enough to be

observed by the biologist diver while swimming along the survey lines. This may have excluded smaller cryptic fish species, some crustaceans, and any other species too small to be readily observed. Fish observed during the video survey were recorded and identified by the biologist diver *in situ*. Sea turtles observed in the proposed project area also were recorded.

Quantitative video data were processed, and digitized photographic frames were extracted and saved in JPEG format. Percent cover for stony corals, octocorals, sponges, hydroids, zoanthids, and macroalgae was estimated using the PointCount '99 software analysis program (Porter et al., 2001). PointCount '99 utilizes the random point method described by Bohnsack (1979) for accurately estimating percent coverage of corals, sponges, and associated substrate from digital underwater images. Ten random points were projected on every digitized quantitative image. The biota or substrate beneath each point was identified, and the data from each image were saved in a spreadsheet.

4.0 RESULTS AND DISCUSSION

4.1 QUALITATIVE SURVEY LINES

4.1.1 Substrate Characterization

Video data were collected along eight survey lines from FDEP Monuments R-35 through R-54. **Figures 2** through **9** show the substrate type distribution along each survey line superimposed over 2003 aerial imagery provided by Taylor Engineering, Inc. Substrate types observed along each survey line were placed into one of three categories: 1) predominantly sand bottom with less than 10% exposed rock cover; 2) 10% to 50% exposed rock cover; or 3) substrate with greater than 50% exposed rock cover. **Table 2** presents the composition of the substrate categories from each cross-shore survey line. Representative photographs of substrate types are presented in the **Appendix**. The hard bottom habitat observed south of the Fort Pierce Inlet was predominantly exposed limerock with an algal-dominated community that parallels the shoreline. Based on the analysis of qualitative data collected along the survey lines, the dominant substrate type observed during the survey was greater than 50% exposed rock cover, which composed an average of 42.7% of the total area surveyed. **Figure 10** shows percent cover of identified substrate classifications along each survey line. There was a decrease of 15.8% in the average percent contribution of 50% exposed rock cover between the pre- and post-construction surveys. The 50% exposed rock cover was still abundant along survey lines in the northern portions of the survey area, but sand bottom increased along the southern survey lines. Substrate relief in areas with greater than 50% exposed rock cover ranged from low (less than 2 ft) up to high (6 ft) relief, with an estimated average between 2 and 3 ft.

Table 2. A listing of the percentage and length of various substrate types observed along each survey line.

Survey Lines	Predominantly sand bottom with less than 10% exposed rock cover		10 to 50% exposed rock cover		Substrate with greater than 50% exposed rock cover	
	Distance (ft)	%	Distance (ft)	%	Distance (ft)	%
R-35	140	25.0	111	19.8	310	55.3
R-37	175	31.7	117	21.2	260	47.1
R-39	58	10.5	56	10.1	441	79.5
R-41	85	18.0	47	10.0	339	72.0
R-42	316	57.1	81	14.6	156	28.2
R-43	149	26.2	404	71.0	16	2.8
R-53	184	33.6	260	47.5	103	18.8
R-54	331	61.9	0	0.0	204	38.1
Average percent contribution		33.0		24.3		42.7

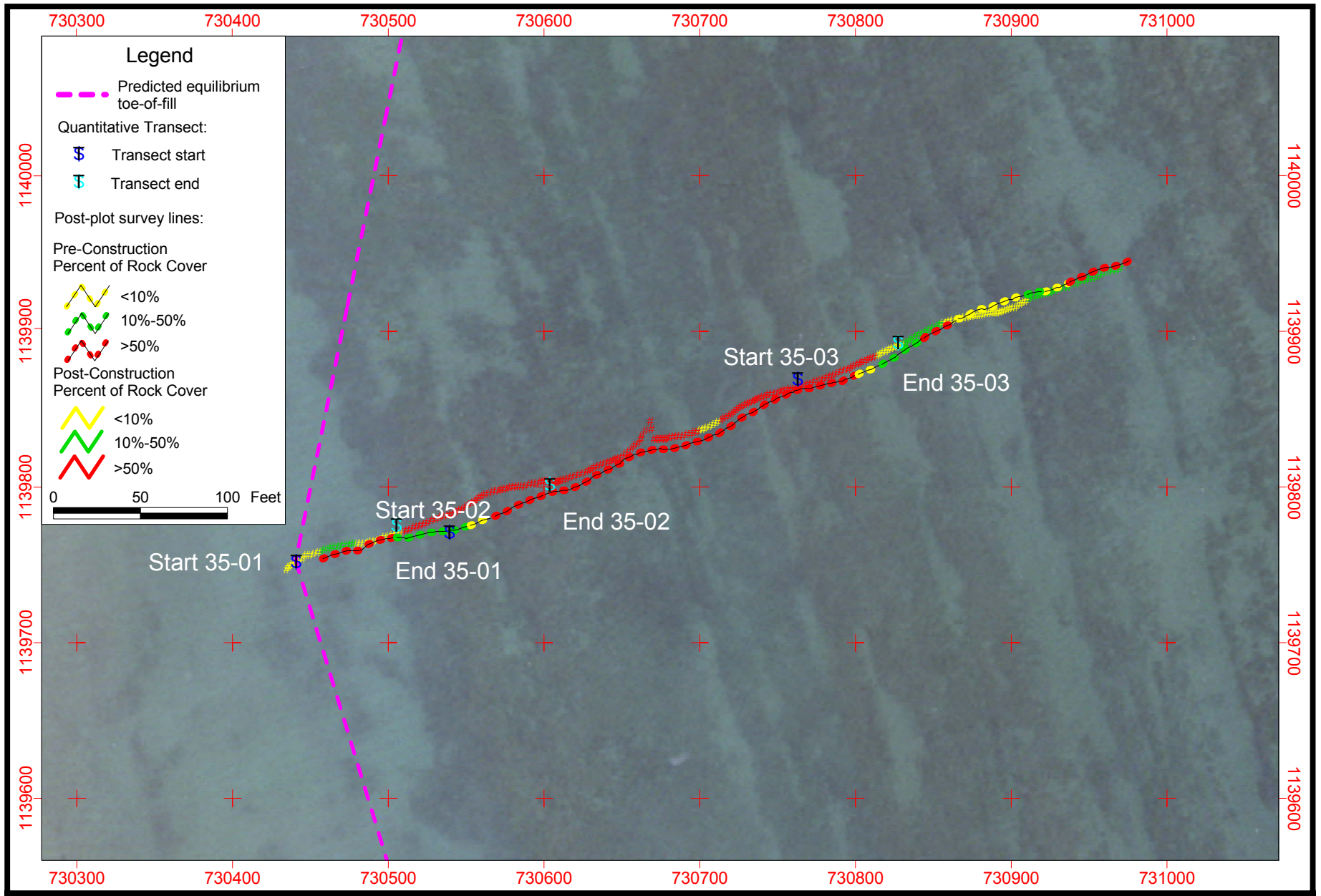

Figure 2. Post-plot Survey Line R-35 with identified rock substrate classifications superimposed over 2003 aerial imagery provided by Taylor Engineering, Inc.

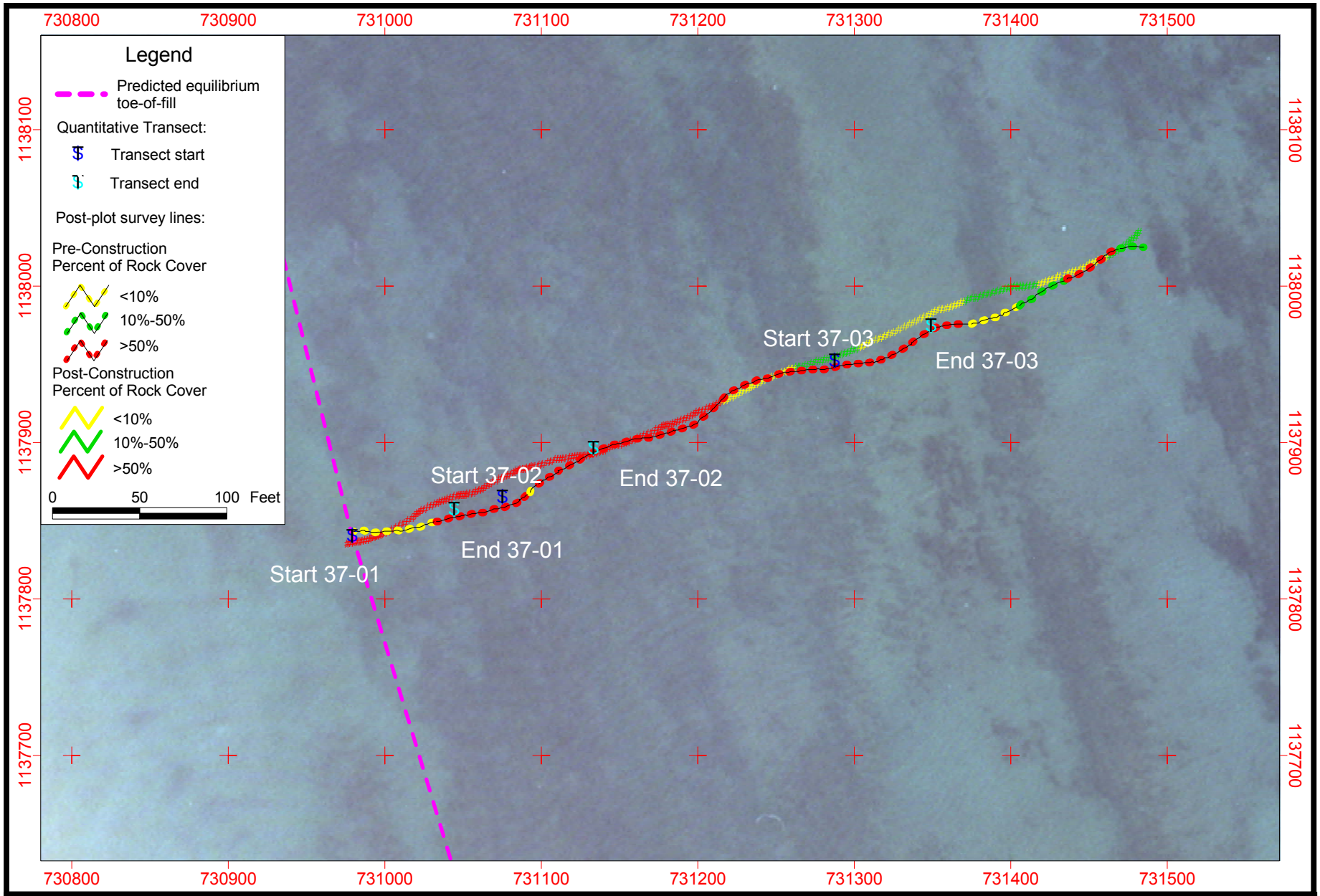

Figure 3. Post-plot Survey Line R-37 with identified rock substrate classifications superimposed over 2003 aerial imagery provided by Taylor Engineering, Inc.

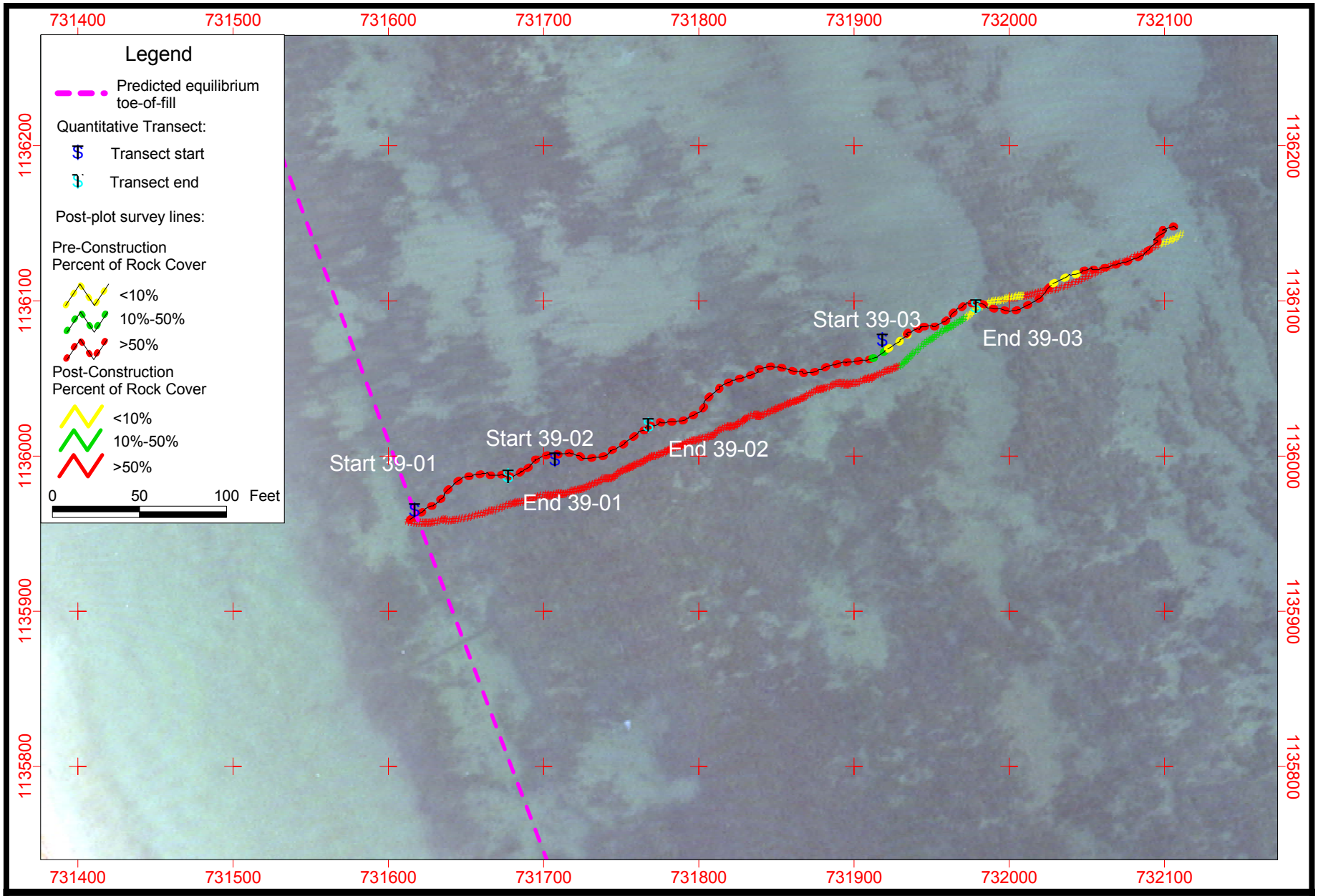

Figure 4. Post-plot Survey Line R-39 with identified rock substrate classifications superimposed over 2003 aerial imagery provided by Taylor Engineering, Inc.

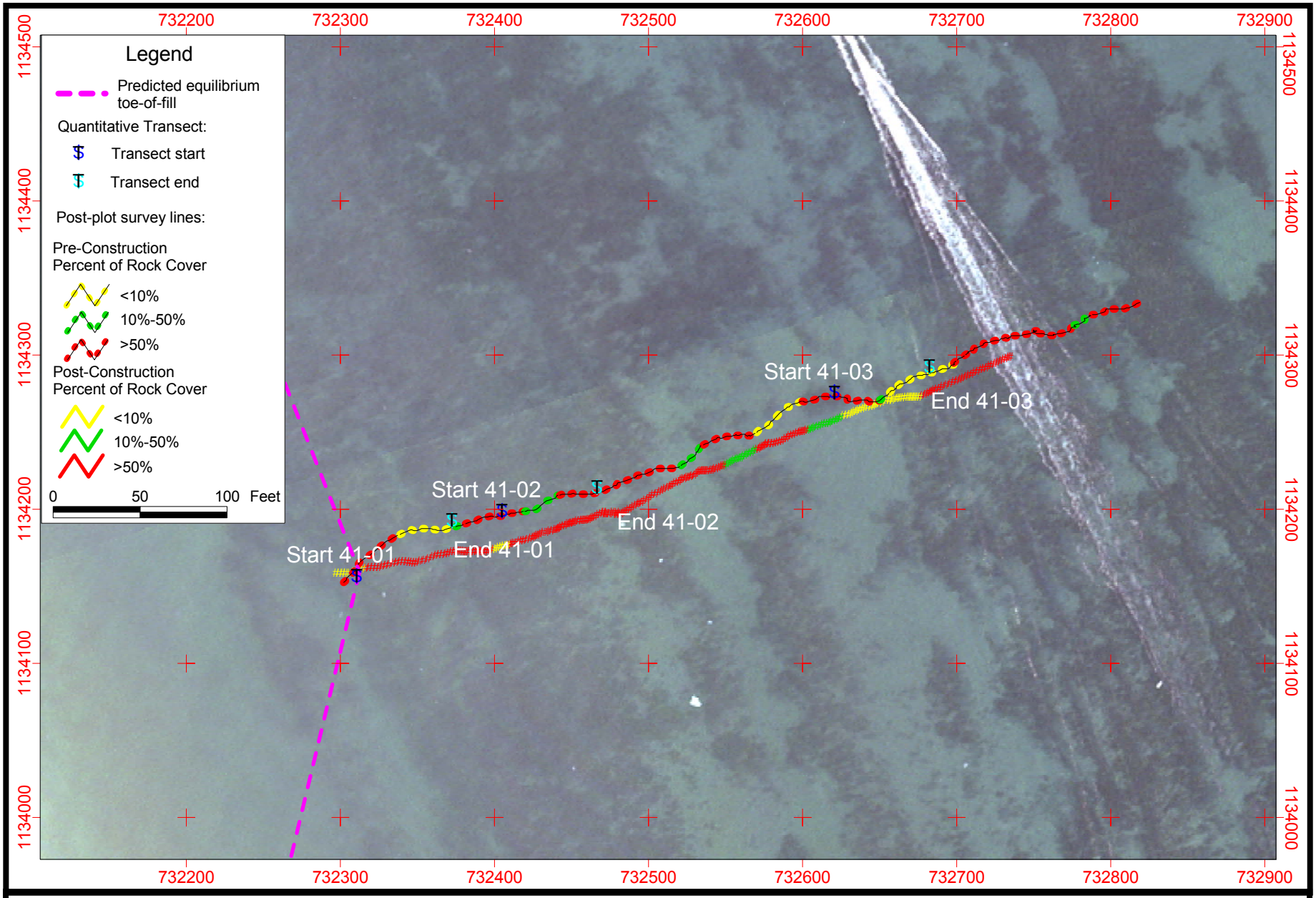

Figure 5. Post-plot Survey Line R-41 with identified rock substrate classifications superimposed over 2003 aerial imagery provided by Taylor Engineering, Inc.

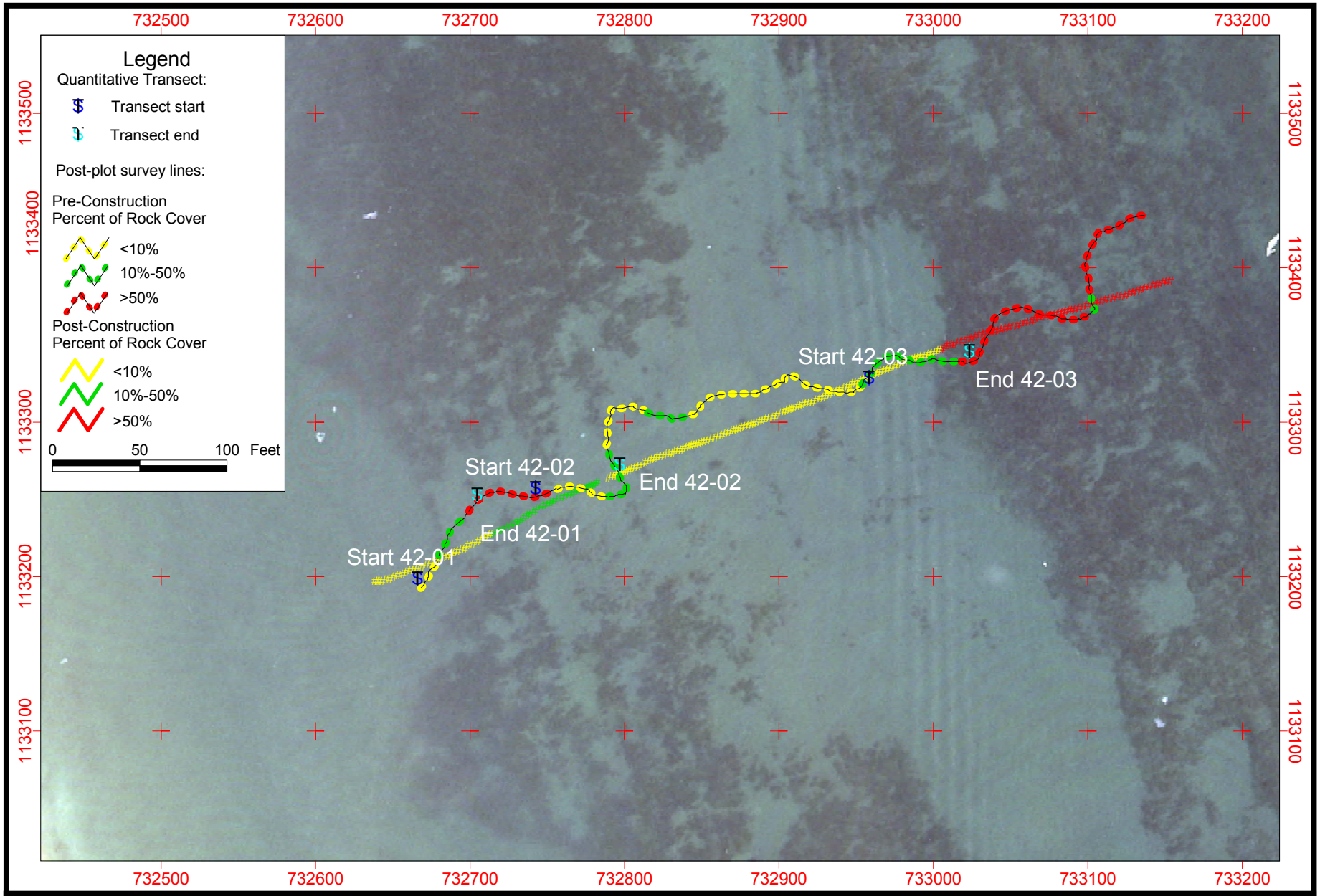

Figure 6. Post-plot Survey Line R-42 with identified rock substrate classifications superimposed over 2003 aerial imagery provided by Taylor Engineering, Inc.

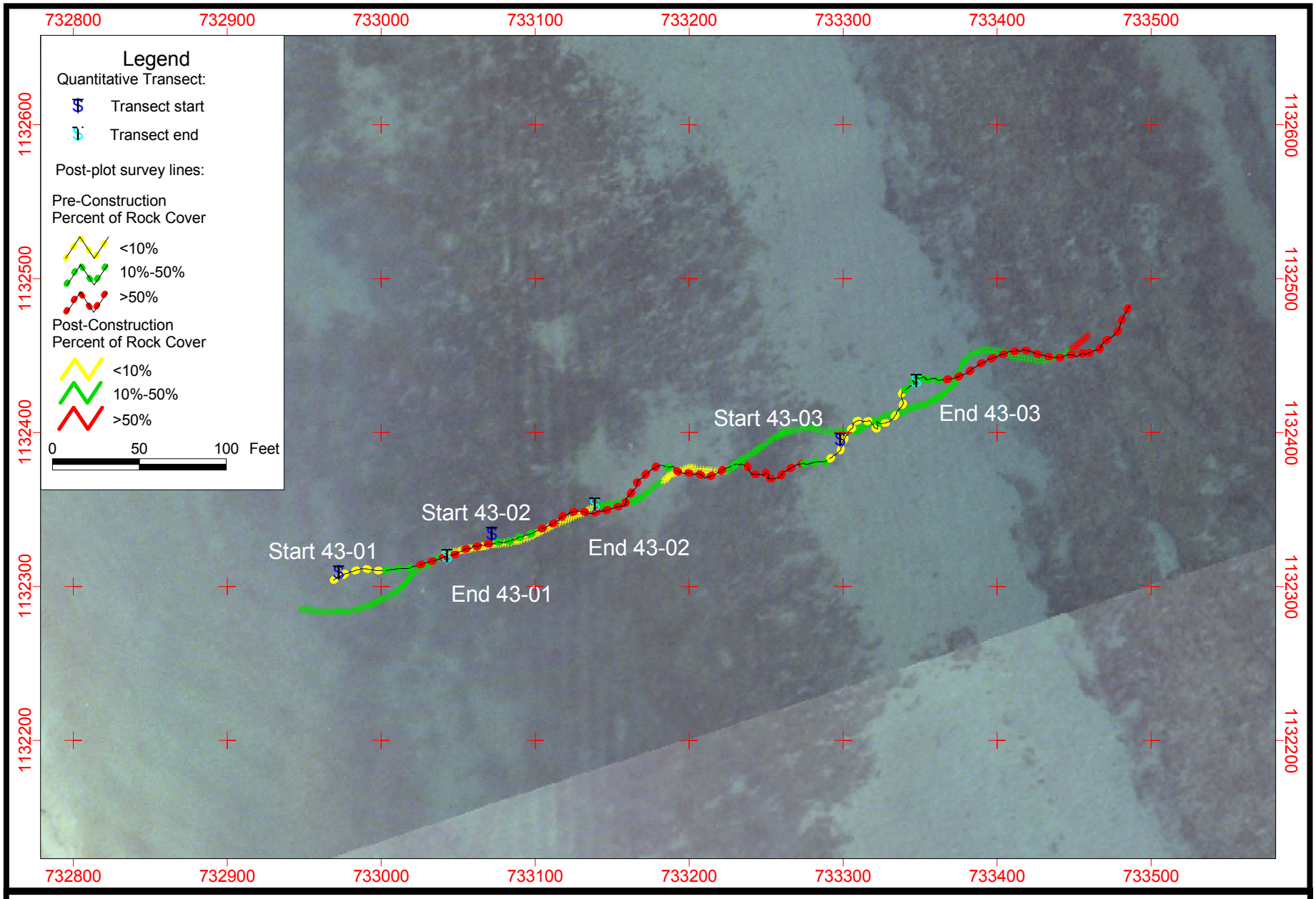

Figure 7. Post-plot Survey Line R-43 with identified rock substrate classifications superimposed over 2003 aerial imagery provided by Taylor Engineering, Inc.

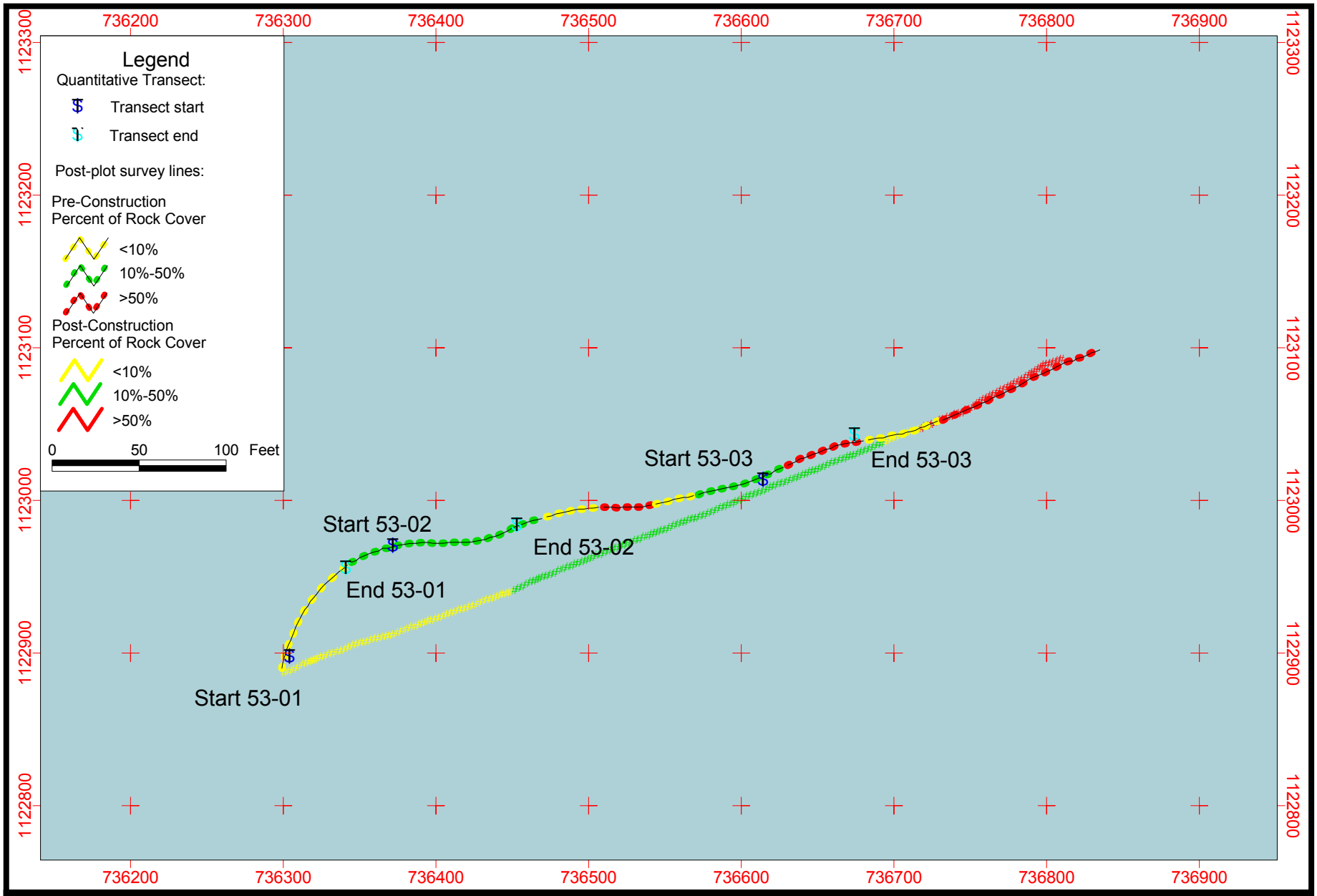

Figure 8. Post-plot Survey Line R-53 with identified rock substrate classifications. Aerial imagery for Survey Line R-53 is not available.

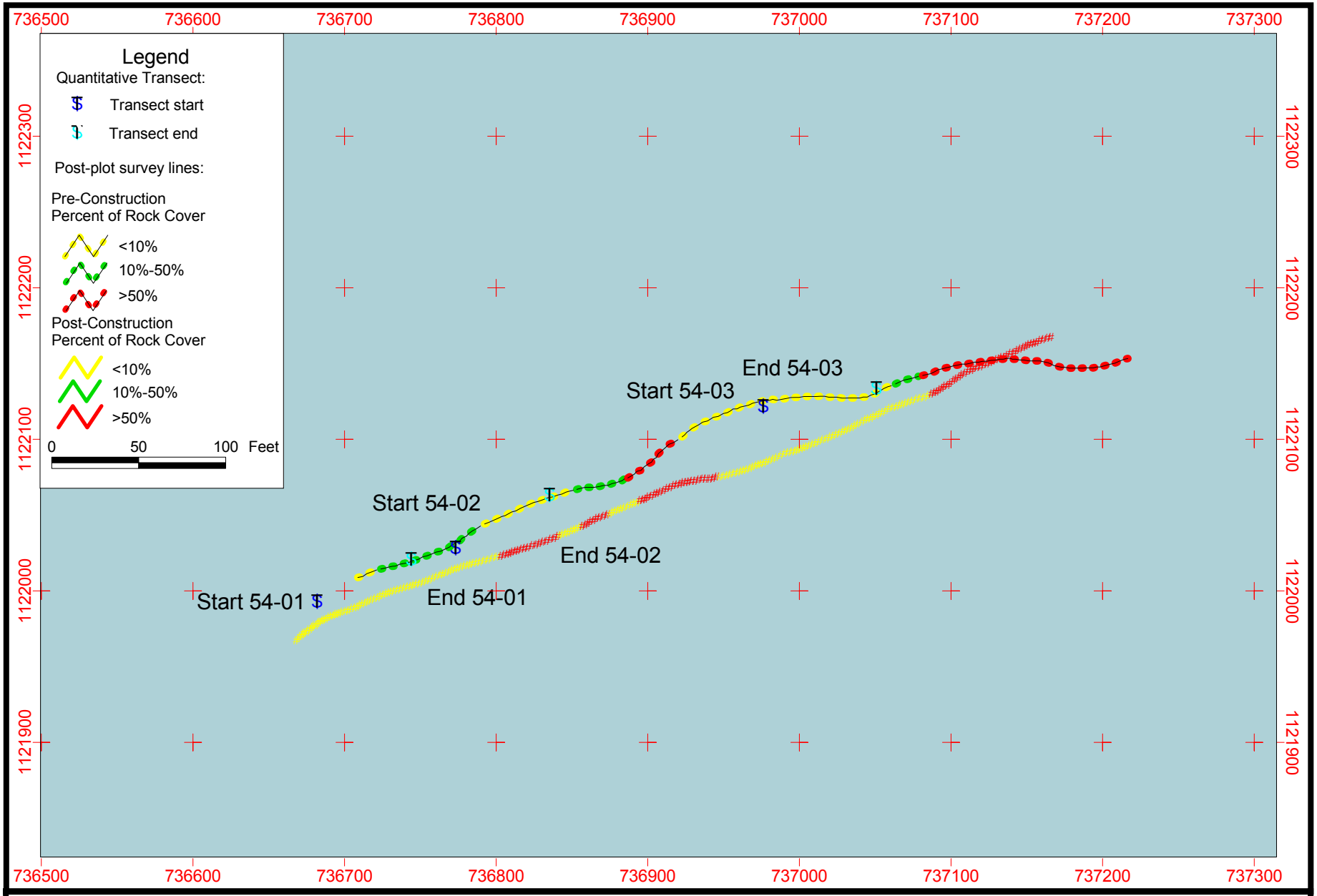

Figure 9. Post-plot Survey Line R-54 with identified rock substrate classifications. Aerial imagery for Survey Line R-54 is not available.

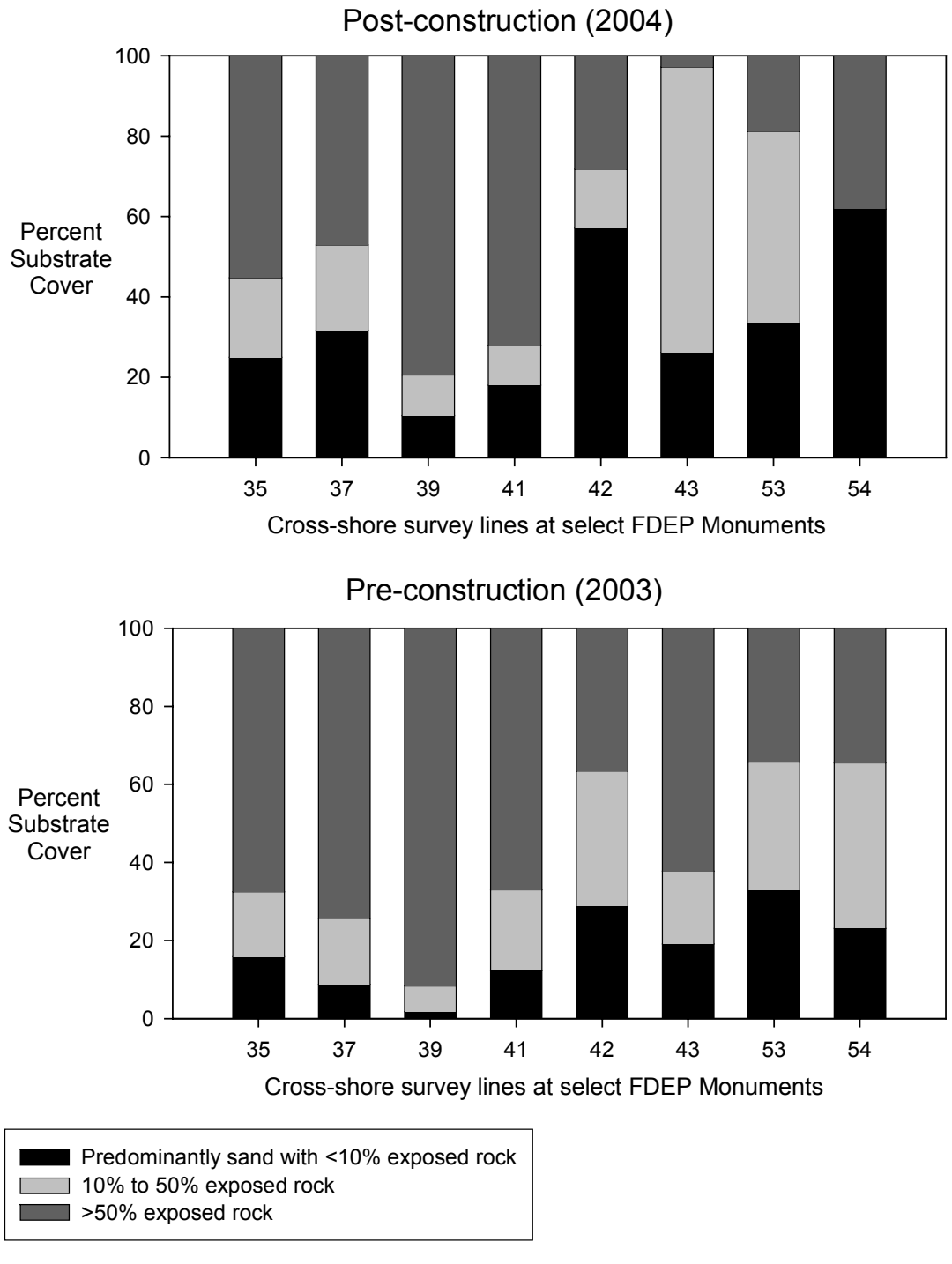

Figure 10. Percent cover of identified substrate classifications along each survey line. Cross-shore survey lines were located at Florida Department of Environmental Protection (FDEP) Monuments.

Substrate with 10% to 50% exposed rock cover composed an average of 24.3% of the total area surveyed. This substrate was most common along Survey Lines R-43 (71.0%) and R-53 (47.5%). There was only a slight difference in 10% to 50% exposed rock cover (3%) between the pre- and post-construction surveys. The biggest difference in 10% to 50% exposed rock cover between the pre- and post-construction surveys occurred at Survey Line R-54 and was 42.4% and 0.0%, respectively. Relief in areas of 10% to 50% exposed rock cover was less than 2 ft.

The predominantly sand with less than 10% exposed rock cover composed an average of 33% of the total area surveyed. The post-construction survey data indicated a considerable increase of this substrate type at most of the lines surveyed compared with the pre-construction survey estimates. The largest increases in sand bottom cover were observed along Survey Lines R-39 (post-construction 10.5% and pre-construction 1.8%), R-37 (post-construction 31.7% and pre-construction 8.8%), R-54 (post-construction 61.9% and pre-construction 23.1%), and R-42 (post-construction 57.1% and pre-construction 28.8%). The predominantly sand bottom areas observed along the survey lines were interspersed between the worm rock reef and were occasionally observed covering hard bottom with algae and other benthic epibiota emergent.

Isolated patches of recently exposed substrate with relatively clean rock surfaces and no fouling or epibenthic growth were observed in the survey area. These isolated patches were observed offshore as well as nearshore along the survey lines, and are indicative of sand movement in high-energy shallow water environments.

The aerial imagery used in the data post plots was collected in early spring of 2003. The time difference between the collection of aerial images and the post-construction survey may explain variations between mapped substrate data from post-plot tracklines and the exposed rock habitats visible in the aerial images. Areas of substrate change were observed along various segments and were not limited to the western portions of the survey lines nearest the predicted ETOF. Areas where substrate identified from video data differed considerably from substrate visible on aerial images occurring along isolated portions of Survey Lines R-35, R-37, R-39, R-41, R-42, and R-43. These isolated areas were generally between 20 and 50 ft in length, with one area as long as 75 ft. Most of the differences between substrate identified from video data and the aerial imagery generally occurred in areas where substrate types changed abruptly.

Two isolated areas in the middle and along the eastern portions of Survey Line R-35 were identified as predominantly sand bottom substrate, and the aerial imagery indicates this substrate was exposed rock cover (**Figure 2**). An area identified as greater than 50% exposed rock cover along the eastern portion of Survey Line R-37 appears to be predominantly sand bottom in the aerial image (**Figure 3**). Two small areas identified as greater than 50% exposed rock cover in the western and eastern portions of Survey Line R-39 appear to be predominantly sand bottom in the aerial image (**Figure 4**). An area along the eastern portion of Survey Line R-41 was identified as predominantly sand bottom but appears to be exposed rock cover in the aerial image (**Figure 5**). An area identified as greater than 50% exposed rock cover along the eastern portion of Survey Line R-42 appears to be predominantly sand bottom in the aerial image (**Figure 6**). Two areas along Survey Line R-43 were different from the aerial images. An area identified as predominantly sand bottom along the western portion of Survey Line R-43 appears to be partially covering exposed hard bottom. Another area identified as 10% to 50% exposed rock cover east of the middle portion of Survey Line R-43 appears to be predominantly sand bottom in the aerial image (**Figure 7**). Aerial images were not available for Survey Lines R-53 and R-54.

4.1.2 Biological Characterization

Table 3 provides a taxonomic list of species identified *in situ* by divers during the inventory along and within 1 m to either side of the 20-m quantitative transects. A total of 53 different taxa was identified during the *in situ* species inventory. Representative photographs of identified taxa are presented in the **Appendix**. Greater numbers of benthic species were observed in areas of higher vertical relief and near distinct ledges. The average number of identified taxa per transect was higher along the northern survey lines, including R-35 (21.7 taxa), R-37 (21 taxa), R-41 (21 taxa), and R-39 (17.7 taxa), where the greatest amount of higher relief substrate was identified. The average number of identified taxa was lower along the southern survey lines, including R-42 (11 taxa), R-43 (10 taxa), R-53 (4.3 taxa), and R-54 (4.3 taxa), where lower relief substrate predominated. Among the southern survey lines, numbers of taxa were generally lower along the westernmost quantitative transects compared to the middle and eastern transects. No epibiota was identified along the easternmost quantitative transect along Survey Line R-54 (R-54-03). The substrate along R-54-01 was sand bottom. The average number of taxa identified along the mitigation reef transects was 11 taxa for MT-1 and 12 taxa for MT-2.

Exposed rock areas were colonized by hydroids, small numbers of sponges, and occasional hard and soft corals, in addition to the relatively high algal cover. Similar biota were identified during the pre-construction monitoring survey. The sponges *Verongula* sp. and *Cliona* sp. were most common in the greater than 50% exposed rock cover areas. The hard corals *Oculina diffusa*, *Siderastrea siderea*, and *Siderastrea radians* also were observed in exposed rock cover areas. Low numbers of sponges and corals were observed during the survey. Sabellariid worm rock (*Phragmatopoma lapidosa*) was present on all three substrate types. In a few areas, the worm rock appeared to be sand-covered or eroded, but in most areas was healthy and in an accretionary or growth stage. Motile invertebrates observed associated with the rock outcrops consisted primarily of echinoderms, including the urchins *Arbacia punctulata* (abundant), *Lytechinus variegatus*, and *Diadema antillarum*, and the sea cucumber *Holothuria* ?*grisea* (species uncertain*)*. Spiny lobsters (*Panulirus argus*) were occasionally observed under small ledges associated with exposed rock outcrops but usually outside the boundaries of the species inventory.

4.2 QUANTITATIVE TRANSECTS

An average of approximately 70 still images was analyzed from each quantitative transect to determine the percent cover of identifiable species. **Tables 4**, **5**, and **6** present the percent cover of taxa and substrate from each of the quantitative transects surveyed during the post-construction monitoring survey. Substrate, predominantly sand and shell hash, was the dominant cover along most of the quantitative transects. Transects R-37-03, R-39-03, R-42-01, R-43-02, R-53-01, R-53-02, R-54-01, and R-54-03 had greater than 90% sand substrate and the lowest biotic cover. The average biotic cover was higher along the northern quantitative transects (41.4% cover) compared to the southern survey lines (11% cover). Analysis of pre-construction data showed similar results, with higher average biotic cover along northern transects (approximately 33.8% cover) compared to the southern transects (18.3% cover). Biotic cover was highest at the following quantitative transects: R-39-01 (70.4% cover), R-39-02 (69.6% cover), R-37-01 (67.9% cover), and R-37-02 (55.8% cover). Algae composed the highest percent cover in areas with exposed rock. Sabellariid worm rock (*Phragmatopoma lapidosa*) and the Atlantic purple-spined sea urchin (*Arbacia punctulata*) were the most common benthic invertebrates within the survey areas.

Table 3. List of taxa identified *in situ* along quantitative transects surveyed on nearshore hard bottom habitat south of the inlet in Fort Pierce, Florida.

Identified Taxa or Substrate		Transects Surveyed											
Scientific Name	Common Name	R-35-01	R-35-02	R-35-03	R-37-01	R-37-02	R-37-03	R-39-01	R-39-02	R-39-03	R-41-01	R-41-02	R-41-03
Algae													
Algae	unidentified macroalgae												
Botrycladia sp.	ball algae												
Bryothamnion sp.	bushy red algae	X	X	X	X	X					X	X	X
Caulerpa brachypus	brachypus algae				X	X		X	X	X			X
Caulerpa cupressoides	cactus tree algae		X			X	X	X	X		X	X	X
Caulerpa mexicana	flat feather algae	X	X				X	X	X	X		X	X
Caulerpa racemosa	grape algae		X	X		X	X						
Caulerpa sertularoides	feather algae	X	X			X	X	X		X	X	X	X
Caulerpa prolifera	blade algae	X			X	X				X	X		X
Caulerpa sp.	green algae												
Hydroid/Algae Mix	unidentified hydroid and algae mix												
Chlorophyta	unidentified green algae			X									
Codium sp.	dead man's fingers	X	X	X	X	X		X	X		X	X	X
Corallinaceae	unidentified calcareous algae												
Dictyopteris sp.	strapped brown algae	X		X	X	X	X	X	X	X	X	X	X
Dictyota sp.	branched algae	X	X	X	X	X	X	X	X	X	X	X	X
Gracilaria sp.	red algae	X	X		X	X	X	X	X	X	X	X	X
Halimeda sp.	lettuce algae	X	X	X	X	X	X	X	X	X	X	X	
Padina sp.	white scroll algae		X	X	X	X	X	X	X	X	X	X	X
Penicillus sp.	bristle brush algae					X							
Rhodophyta	unidentified red algae												
Rhodophyta	unidentified turf algae	X	X	X	X	X				X	X	X	X
Sargassum sp.	*Sargassum* algae	X	X	X	X	X				X	X		
Seagrass													
Halophila decipiens	paddle grass												
Porifera													
Cliona sp.	encrusting sponge			X								X	
Demospongia	unidentified red sponge			X									
Demospongia	unidentified encrusting sponge			X					X				
Verongula sp.	sponge			X		X	X						
Cnidaria													
Hydroida	unidentified hydroid		X		X		X	X	X	X		X	X
Oculina diffusa	ivory coral		X										
Oculina vericosa	dense ivory coral				X						X		
Palythoa sp.	encrusting zoanthid	X											
Phyllangia americana	flower coral				X	X							

Table 3. (Continued).

Identified Taxa or Substrate		Transects Surveyed											
Scientific Name	Common Name	R-35-01	R-35-02	R-35-03	R-37-01	R-37-02	R-37-03	R-39-01	R-39-02	R-39-03	R-41-01	R-41-02	R-41-03
Siderastrea radians	lesser starlet coral		X	X		X			X				
Siderastrea siderea	massive starlet coral		X	X		X	X				X		
Mollusca													
Mollusca	unidentified mollusc	X	X			X	X	X	X	X	X	X	X
Cypraea sp.	cowrie											X	
Fasciolaria tulipa	true tulip							X					
Nudibranchia	unidentified nudibranch					X		X				X	X
Arthropoda													
Panulirus argus	spiny lobster								X				
Menippe sp.	stone crab												X
Cirripedia	unidentified barnacle			X									
Echinodermata													
Arbacia punctulata	Atlantic purple-spined sea urchin	X	X	X	X	X	X	X	X	X	X	X	
Diadema antillarum	long spine sea urchin		X										
Holothuria ?grisea	sea cucumber	X	X	X	X	X	X	X	X	X	X	X	
Eucidaria tribuloides	pencil urchin		X								X		
Lytechinus variegatus	sea urchin		X	X									
Annelida													
Phragmatopoma lapidosa	sabellariid worm rock	X	X		X	X		X			X	X	X
Sabellidae	feather duster		X		X	X							X
Chordata													
Ascidia nigra	solitary tunicate											X	
Ascidiacea	unidentified colonial tunicates	X	X	X	X	X	X	X	X	X	X	X	X
Eudistoma sp.	white condominium tunicates	X	X		X	X		X		X	X	X	X

Table 3. (Continued).

Identified Taxa or Substrate		Transects Surveyed													
Scientific Name	Common Name	R-42-01	R-42-02	R-42-03	R-43-01	R-43-02	R-43-03	R-53-01	R-53-02	R-53-03	R-54-01	R-54-02	R-54-03	MT-1	MT-2
Algae															
Algae	unidentified macroalgae	X	X	X	X	X			X	X	X				
Botrycladia sp.	ball algae												X	X	
Bryothamnion sp.	bushy red algae	X	X	X	X	X									
Caulerpa brachypus	brachypus algae														
Caulerpa cupressoides	cactus tree algae										X				
Caulerpa mexicana	flat feather algae	X				X			X		X				
Caulerpa racemosa	grape algae	X							X						
Caulerpa sertularoides	feather algae	X				X									
Caulerpa prolifera	blade algae	X			X										
Caulerpa sp.	green algae	X													
Hydroid/Algae Mix	unidentified hydroid and algae mix	X							X		X				
Chlorophyta	unidentified green algae														
Codium sp.	dead man's fingers														
Corallinaceae	unidentified calcareous algae												X	X	
Dictyopteris sp.	strapped brown algae	X	X			X									
Dictyota sp.	branched algae	X	X	X	X	X			X	X	X		X	X	
Gracilaria sp.	red algae	X	X	X	X	X			X	X			X	X	
Halimeda sp.	lettuce algae	X	X			X			X	X	X				
Padina sp.	white scroll algae	X				X					X		X	X	
Penicillus sp.	bristle brush algae													X	
Rhodophyta	unidentified red algae												X	X	
Rhodophyta	unidentified turf algae	X	X	X	X	X			X				X		
Sargassum sp.	*Sargassum* algae												X		
Seagrass															
Halophila decipiens	paddle grass				X										
Porifera															
Cliona sp.	encrusting sponge														
Demospongia	unidentified red sponge														
Demospongia	unidentified encrusting sponge														
Verongula sp.	sponge														
Cnidaria															
Hydroida	unidentified hydroid	X				X			X				X	X	
Oculina diffusa	ivory coral														
Oculina vericosa	dense ivory coral														
Palythoa sp.	encrusting zoanthid														
Phyllangia americana	flower coral														
Siderastrea radians	lesser starlet coral														
Siderastrea siderea	massive starlet coral														

Table 3. (Continued).

Identified Taxa or Substrate		Transects Surveyed													
Scientific Name	Common Name	R-42-01	R-42-02	R-42-03	R-43-01	R-43-02	R-43-03	R-53-01	R-53-02	R-53-03	R-54-01	R-54-02	R-54-03	MT-1	MT-2
Mollusca															
Mollusca	unidentified mollusc														
Cypraea sp.	cowrie														
Fasciolaria tulipa	true tulip														
Nudibranchia	unidentified nudibranch														
Arthropoda															
Panulirus argus	spiny lobster														
Menippe sp.	stone crab														
Cirripedia	unidentified barnacle														
Echinodermata															
Arbacia punctulata	Atlantic purple-spined sea urchin	X	X	X					X					X	
Diadema antillarum	Long spine sea urchin														
Holothuria ?grisea	sea cucumber	X	X	X	X	X			X					X	
Eucidaria tribuloides	pencil urchin														
Lytechinus variegatus	sea urchin														
Annelida															
Phragmatopoma lapidosa	sabellariid worm rock	X		X						X	X			X	
Sabellidae	feather duster														
Chordata															
Ascidia nigra	solitary tunicate														
Ascidiacea	unidentified colonial tunicates	X	X	X		X			X				X	X	
Eudistoma sp.	white condominium tunicates	X							X				X		

Table 4. Percent cover estimates for taxa and substrate identified during analysis of quantitative data collected along Transects R-35-01 through R-41-03.

Identified Taxa or Substrate		Transects Surveyed											
		R-35-01	R-35-02	R-35-03	R-37-01	R-37-02	R-37-03	R-39-01	R-39-02	R-39-03	R-41-01	R-41-02	R-41-03
Scientific Name	Common Name	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover
Algae													
Corallinaceae	unidentified calcareous algae												
Caulerpa cupressoides	cactus tree algae								1.01				
Caulerpa racemosa	grape algae					0.14							
Caulerpa sp.	green algae						1.73						
Chlorophyta	unidentified green algae					1.93		0.60			1.03		
Hydroid/Algae Mix	unidentified hydroid and algae mix				6.90	3.58	1.92				13.30		
Bryothamnion sp.	bushy red algae	1.59	6.02	5.91	17.46	7.71	0.19	3.40	2.53	2.53	3.92	5.00	1.92
Dictyopteris sp.	strapped brown algae				0.85	0.28	0.19	0.60	0.91		0.10		
Dictyota sp.	branched algae			0.22	1.83	1.65	0.38	0.40	1.41	0.40	0.52	0.97	1.35
Gracilaria sp.	red algae				3.38	0.55	0.19	16.00	8.69	0.40	1.24	4.35	2.88
Halimeda sp.	lettuce algae					0.55			1.01				
Algae	unidentified macroalgae	3.77	3.41	4.95	13.52	5.79	0.20	15.40	9.19	0.80	3.51	16.77	2.69
Padina sp.	white scroll algae		0.23		0.85		0.38	0.20		0.27		0.65	1.92
Rhodophyta	unidentified red algae		0.11			4.55							
Sargassum sp.	*Sargassum* algae			0.32	0.56	0.55		1.20			0.41		
Rhodophyta	unidentified turf algae	1.01	29.66	40.75	20.56	25.76	0.19	29.40	43.43	0.53	22.37	12.10	2.50
Porifera													
Demospongia	unidentified encrusting sponge			0.43		0.14							
Cnidaria													
Hydroida	unidentified hydroid		0.22		0.28	0.14	0.19		0.20	0.80	0.31	1.13	0.19
Siderastrea siderea	lesser star coral		0.11										
Echinodermata													
Arbacia punctulata	Atlantic purple-spined sea urchin		0.91	0.97	0.56	0.14		0.20	0.81		0.72	0.81	
Holothuria ?grisea	sea cucumber		0.57	0.43	0.85		0.19	0.20	0.20		0.93	0.48	
Annelida													
Phragmatopoma lapidosa	sabellariid worm rock		0.80			2.34	1.15	2.80	0.10		0.82	11.61	0.38
Chordata													
Ascidacea	unidentified colonial tunicates		0.11	0.32	0.28				0.10			0.32	0.58

Table 4. (Continued).

Identified Taxa or Substrate		Transects Surveyed											
		R-35-01	R-35-02	R-35-03	R-37-01	R-37-02	R-37-03	R-39-01	R-39-02	R-39-03	R-41-01	R-41-02	R-41-03
Scientific Name	Common Name	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover
Substrate													
Detrital material		3.62		0.22									
Sediment on hard substrate		3.19	16.02	16.34	6.48	5.51	2.50	2.40	10.51		2.37	4.52	4.23
Exposed hard substrate including rock		1.01	2.73	3.33	1.41	0.83		0.80	2.12	0.13	1.86	0.48	
Rubble		1.45	6.25	4.95	0.99	0.28		1.00	1.31	0.40	1.75	5.32	1.73
Sand		81.16	27.05	10.97	14.08	4.82	90.57	5.40	3.23	91.87	36.19	27.90	75.38
Shell hash		3.19	5.34	9.89	8.17	32.51		19.60	10.40	1.87	8.04124	6.77	4.04
Other material in field of view			0.45		0.99	0.28		0.40	2.83		0.62	0.81	0.19
Grand Total		100	100	100	100	100	100	100	100	100	100	100	100

Table 5. Percent cover estimates for taxa and substrate identified during analysis of quantitative data collected along Transects R-42-01 through R-54-03.

Identified Taxa or Substrate		Transects Surveyed											
		R-42-01	R-42-02	R-42-03	R-43-01	R-43-02	R-43-03	R-53-01	R-53-02	R-53-03	R-54-01	R-54-02	R-54-03
Scientific Name	Common Name	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover
Algae													
Corallinaceae	unidentified calcareous algae												
Caulerpa cupressoides	cactus tree algae												
Caulerpa racemosa	grape algae		0.52										
Caulerpa sp.	green algae		0.13										
Chlorophyta	unidentified green algae												
Hydroid/Algae Mix	unidentified hydroid and algae mix		0.13							7.00		2.30	
Bryothamnion sp.	bushy red algae	0.85	17.66	2.25		1.30	8.97			2.00		0.14	
Dictyopteris sp.	strapped brown algae		0.39										
Dictyota sp.	branched algae	0.17	6.23	2.82		0.19	0.86		0.15	0.57			
Gracilaria sp.	red algae		1.56	0.42	0.46		0.52			0.14			
Halimeda sp.	lettuce algae									0.14			
Algae	unidentified macroalgae	0.51	6.49	1.55	1.85	0.93	0.34	0.47		1.86		0.27	
Padina sp.	white scroll algae		0.26				0.17						
Rhodophyta	unidentified red algae												
Sargassum sp.	*Sargassum* algae			0.99						0.43			
Rhodophyta	unidentified turf algae		4.94	2.54	6.01		3.79			3.14		25.14	0.25
Porifera													
Demospongia	unidentified encrusting sponge				0.15					0.29			
Cnidaria													
Hydroida	unidentified hydroid		0.13							0.14			
Siderastrea siderea	lesser star coral												
Echinodermata													
Arbacia punctulata	Atlantic purple-spined sea urchin				2.00								
Holothuria ?grisea	sea cucumber				0.77	0.19				0.14			
Annelida													
Phragmatopoma lapidosa	sabellariid worm rock				2.93	0.56	0.52			1.43		0.68	
Chordata													
Ascidacea	unidentified colonial tunicates		0.78		0.15					1.14			

Table 5. (Continued).

Identified Taxa or Substrate		Transects Surveyed											
		R-42-01	R-42-02	R-42-03	R-43-01	R-43-02	R-43-03	R-53-01	R-53-02	R-53-03	R-54-01	R-54-02	R-54-03
Scientific Name	Common Name	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover	% Cover
Substrate													
Detrital material										0.29			
Sediment on hard substrate			7.66	3.94	0.92	0.74	5.34			1.00		17.43	0.51
Exposed hard substrate including rock			0.39		18.03	0.19						1.62	
Rubble		0.51			4.62	0.37	1.18			1.43		3.51	0.25
Sand		97.97	52.60	85.49	41.61	95.00	78.30	99.53	99.85	77.14	100.00	48.11	98.99
Shell hash			0.13		20.49	0.56				1.71		0.81	
Other material in field of view													
Grand Total		100	100	100	100	100	100	100	100	100	100	100	100

Table 6. Percent cover estimates for taxa and substrate identified during analysis of quantitative data collected along Transects MT-1 and MT-2 on the mitigation reef.

Identified Taxa or Substrate		Transects Surveyed	
		MT-1	MT-2
Scientific Name	Common Name	% Cover	% Cover
Algae			
Corallinaceae	unidentified calcareous algae	1.72	2.34
Caulerpa cupressoides	cactus tree algae		
Caulerpa racemosa	grape algae		
Caulerpa sp.	green algae		
Chlorophyta	unidentified green algae	1.72	
Hydroid/Algae Mix	unidentified hydroid and algae mix	6.72	0.21
Bryothamnion sp.	bushy red algae		
Dictyopteris sp.	strapped brown algae		
Dictyota sp.	branched algae	0.17	
Gracilaria sp.	red algae	0.69	
Halimeda sp.	lettuce algae		
Algae	unidentified macroalgae	3.97	18.30
Padina sp.	white scroll algae		
Rhodophyta	unidentified red algae	0.86	0.21
Sargassum sp.	*Sargassum* algae		2.55
Rhodophyta	unidentified turf algae	19.14	8.09
Porifera			
Demospongia	unidentified encrusting sponge	0.34	
Cnidaria			
Hydroida	unidentified hydroid	0.17	0.43
Siderastrea siderea	lesser star coral		
Echinodermata			
Arbacia punctulata	Atlantic purple-spined sea urchin		
Holothuria ?grisea	sea cucumber		
Annelida			
Phragmatopoma lapidosa	sabellariid worm rock	2.41	
Chordata			
Ascidacea	unidentified colonial tunicates	8.28	7.66

Table. 6. (Continued).

Identified Taxa or Substrate		Transects Surveyed	
		MT-1	MT-2
Scientific Name	Common Name	% Cover	% Cover
Substrate			
Detrital material		0.52	
Sediment on hard substrate		2.93	0.85
Exposed hard substrate including rock		14.31	10.21
Rubble			
Sand		31.21	47.02
Shell hash		2.07	
Other material in field of view		2.76	2.13
Grand Total		100	100

Two quantitative transects were established and surveyed on the mitigation reef (**Figure 11**). Limestone boulders were interspersed on sand bottom, often in groups of multiple boulders with sand bottom between boulders. Divers also swam a qualitative survey line that extended from west to east across the entire mitigation reef, starting from each quantitative transect location (**Figure 11**). The high relief of several groups of boulders created shallow water hazards that prevented towing a diver across the reef. Substrate, mostly sand (39.1% average cover) and exposed rock (12.6% average cover), was the dominant cover on the mitigation reef. This is due to the relatively short time of deployment and the density of the boulders that were placed on the bottom. The dominant biotic cover was algae (33.4% average cover) and is typical of artificial reef material at this stage of deployment. Sabellariid worm rock (*Phragmatopoma lapidosa*) and unidentified colonial tunicates (Ascidacea) were the most common benthic invertebrates within the mitigation reef survey areas.

A list of fishes observed during the survey is presented in **Table 7**. A total of 29 fish species was observed during the post-construction survey compared to 26 fish species identified during the pre-construction survey. The most common fishes observed along the survey transects included porkfish (*Anisotremus virginicus*), spottail pinfish (*Diplodus holbrooki*), slippery dick (*Halichoeres bivittatus*), and hairy blenny (*Labrisomus nuchipinnis*). Both adult and juvenile individuals were observed for all of these species. Distributions of fishes followed that observed for epibiota, with greater numbers noted in areas of high vertical relief and near distinct ledges.

Two loggerhead sea turtles (*Caretta caretta*) and a hawksbill sea turtle (*Caretta caretta*) were observed on the surface while conducting the post-construction monitoring survey. Turtles have been observed in the vicinity of the survey area during previous survey efforts (Continental Shelf Associates, Inc., 2002, 2003).

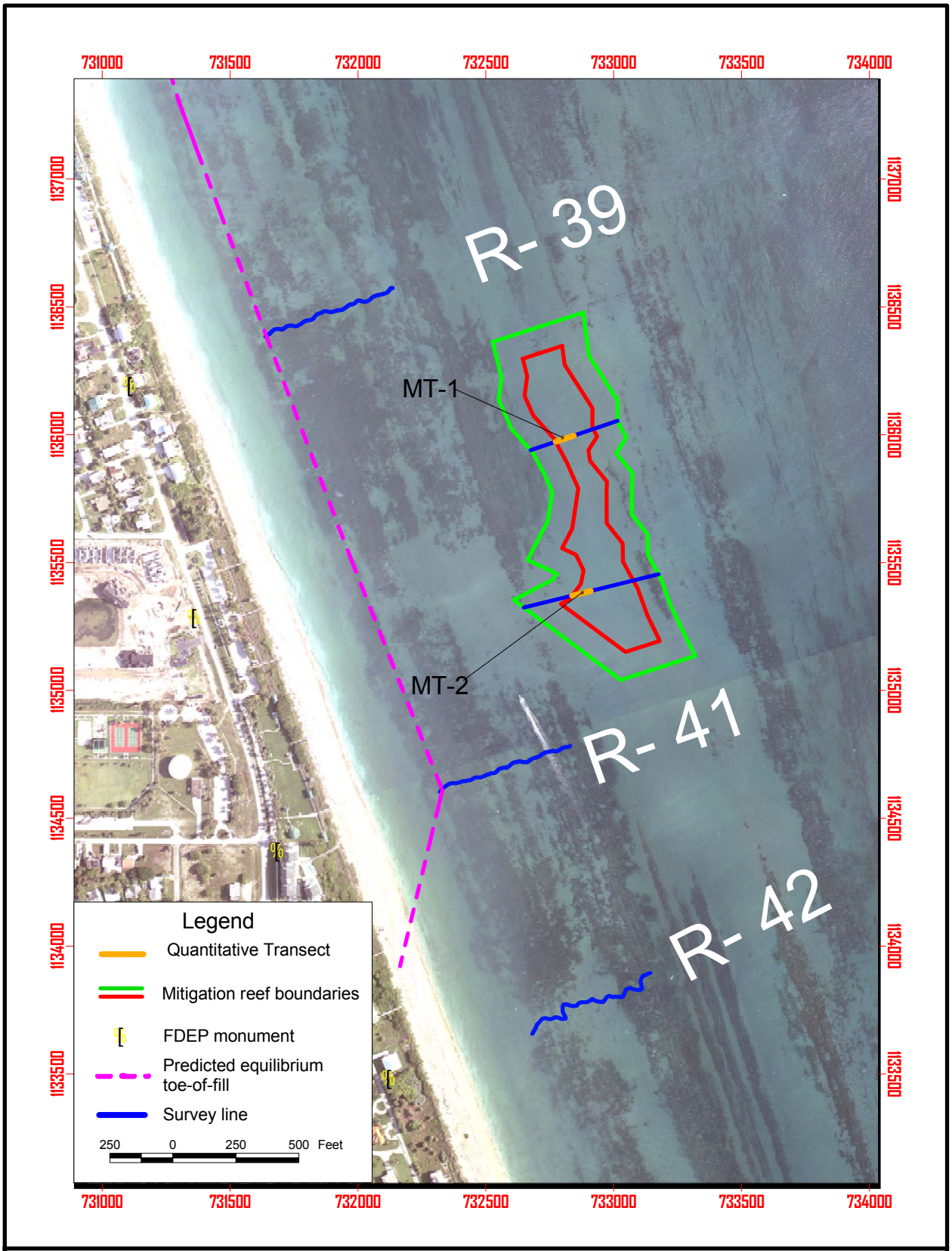

Figure 11. Quantitative Transects MT-1 and MT-2 along survey lines located on the mitigation reef.

Table 7. Fishes observed along cross-shore survey lines on hard bottom habitat south of Fort Pierce Inlet, Fort Pierce, Florida.

Scientific Name	Common Name
Abudefduf saxatilis	sergeant major
Acanthurus chirurgus	doctorfish
Acanthurus coeruleus	blue tang
Anisotremus surinamensis	black margate
Anisotremus virginicus	porkfish
Archosargus probatocephalus	sheepshead
Chaetodipterus faber	spadefish
Diplodus argenteus	silver porgy
Diplodus holbrooki	spottail pinfish
Echeneis naucrates	sharksucker
Equetus umbrosus	cubbyu
Equetus punctatus	spotted drum
Ginglymostoma cirratum	nurse shark
Haemulon aurolineatum	tomtate
Haemulon melanurum	cottonwick
Haemulon plumieri	white grunt
Haemulon spp.	grunt
Halichoeres bivittatus	slippery dick
Holacanthus ciliaris	queen angelfish
Hypsoblennius hentz	feather blenny
Labrisomus nuchipinnis	hairy blenny
Lachnolaimus maximus	hogfish
Lutjanus apodus	schoolmaster
Lutjanus griseus	gray snapper
Pomacentrus fuscus	dusky damselfish
Pomacentrus partitus	bicolor damselfish
Pomacentrus variabilis	cocoa damselfish
Scartella cristata	molly miller
Sparisoma rubripinne	redfin parrotfish

5.0 SUMMARY

The post-construction monitoring survey of hard bottom habitats south of Fort Pierce Inlet was conducted on 3 and 4 June 2004. The purpose of this monitoring survey was to map and to determine the physical and biological conditions of these hard bottom habitats following the May 2003 beach nourishment project. Qualitative video data were collected along eight cross-shore survey lines established at the following FDEP Monuments: R-35, R-37, R-39, R-41, R-42, R-43, R-53, and R-54. The survey lines commenced at the predicted ETOF and extended offshore approximately 500 ft. Simultaneous video and navigational position data were collected along each of the survey lines.

Qualitative video data were collected along each survey line. The qualitative data were reviewed to identify substrate types and characterize biological communities. Substrate observed along each survey line was identified and placed into one of three categories: 1) predominantly sand bottom with less than 10% exposed rock cover; 2) 10% to 50% exposed rock cover; or 3) substrate with greater than 50% exposed rock cover.

Navigational position data were used to map the identified substrate along post-plot survey lines. The reefs south of the Fort Pierce Inlet were generally composed of exposed rock that was colonized by algae and assorted benthic invertebrates, including sabellariid worms (*Phragmatapoma lapidosa*). These rock reefs parallel the shoreline south of the Fort Pierce Inlet. The dominant substrate type observed during the post-construction survey was greater than 50% exposed rock cover, which composed an average of 42.7% of the total area surveyed compared to 58.5% during the pre-construction survey. The second most abundant cover was predominantly sand with less than 10% exposed rock cover, with an average of 33% substrate cover. Sand cover increased along most of the lines surveyed compared with the pre-construction survey estimates. Substrate with 10% to 50% exposed rock cover composed an average of 24.3% of the total area surveyed. This substrate was most common along Survey Lines R-43 (71.0%) and R-53 (47.5%). There was only a slight difference in 10% to 50% exposed rock cover (3%) between the pre- and post-construction surveys.

Three, permanent, 20-m quantitative transects were established along each of the eight survey lines. The video data collected along each quantitative transect were used to determine percent cover for scleractinia, octocorals, sponges, hydroids, zoanthids, and macroalgae. Sand substrate was the dominant cover along most transects, with an average of 74% cover. The highest biotic cover was observed at the following quantitative transects: R-39-01 (70.4% cover), R-39-02 (69.6% cover), R-37-01 (67.9% cover), and R-37-02 (55.8% cover). The high biotic cover at these stations was primarily due to dense algal cover on the exposed rock in the survey area. The biotic cover was higher in the northern survey area during both the pre- and post-construction surveys.

Two quantitative transects were established and surveyed on the mitigation reef. Limestone boulders were interspersed on sand bottom often in groups of multiple boulders with sand bottom between boulders. The high relief of several groups of boulders created shallow water hazards that prevented towing a diver across the reef. Substrate, mostly sand (39.1% average cover) and exposed rock (12.6% average cover), was the dominant cover on the mitigation reef. This is due to the relatively short time of deployment and the

density of the boulders that were placed on the bottom. The dominant biotic cover was algae (33.4% average cover) and is typical of artificial reef material at this stage of deployment.

An *in situ* species inventory of major taxonomic groups was conducted along and within 1 m to either side of each 20-m quantitative transect. The species inventory showed that relatively more complex and well-developed epibiotal and fish communities were observed associated with substrate that had greater than 50% exposed rock cover. The epibiotal communities were dominated by various species of algae and echinoderms, along with low numbers of sponges and stony corals. A total of 53 different epibiota was identified during the *in situ* species inventory. The highest average numbers of taxa were identified along the northern survey lines. The lower relief substrate occurring in the southern survey area may have been a factor in the lower average number of taxa identified along these survey lines. A total of 29 fish species was observed during this survey compared to 26 fish species during the pre-construction survey. The most common fishes observed along the survey transects included porkfish (*Anisotremus virginicus*), spottail pinfish (*Diplodus holbrooki*), slippery dick (*Halichoeres bivittatus*), and hairy blenny (*Labrisomus nuchipinnis*).

6.0 REFERENCES

Bohnsack, J.A. 1979. Photographic quantitative sampling of hard bottom communities. Bull. Mar. Sci. 29(2):242-252.

Continental Shelf Associates, Inc. 2002. Second post-nourishment monitoring survey of nearshore hard bottom habitats south of Fort Pierce Inlet, Fort Pierce, Florida. Prepared for Taylor Engineering, Inc. 29 pp.

Continental Shelf Associates, Inc. 2003. Pre-construction monitoring survey of nearshore hard bottom habitats south of Fort Pierce Inlet, Fort Pierce, Florida. Prepared for Taylor Engineering, Inc. 29 pp.

Maquire, A. and S.J. Schropp. 2003. Biological Monitoring Plan, Fort Pierce Beach Restoration Project. Florida Department of Environmental Protection Permit No. 0126215-002-JC. Prepared for St. Lucie County Erosion District.

Porter, J.W., W.C. Jaap, J.L. Wheaton, V. Kosmynin, C.P. Tsokos, G. Yanev, K. Hackett, K.L. Paterson, D.M. Marcinek, J. Dotten, D. Eaken, M. Brill, M. Lybolt, M. Patterson, O.W. Meyer, K.G. Porter, and P. Dustan. 2001. Detection of coral reef change by the Florida Keys Coral Reef Monitoring Project, pp. 915-936. In: J.W. Porter and K.G. Porter (eds.), Linkages Between Ecosystems in the South Florida Hydroscape: The River of Grass Continues. CRC Press, Boca Raton, Florida.

APPENDIX

REPRESENTATIVE PHOTOGRAPHS

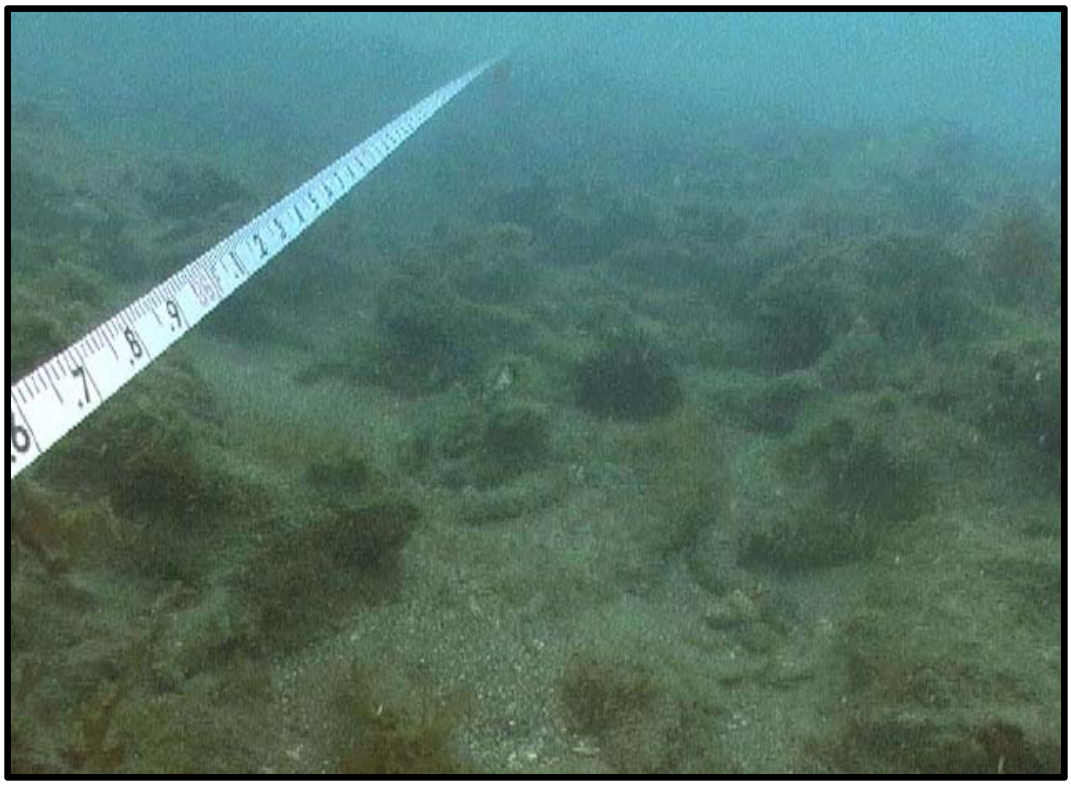

Photo 1 - Purple spine sea urchin (*Arbacia punctulata*) on exposed hard bottom along Survey Line R-35.

Photo 2 - Exposed hard bottom with algal cover and isolated patch of shell hash along Survey Line R-35.

Photo 3 - Sea cucumber *Isostichopus badionotus* on exposed hard bottom along Survey Line R-37.

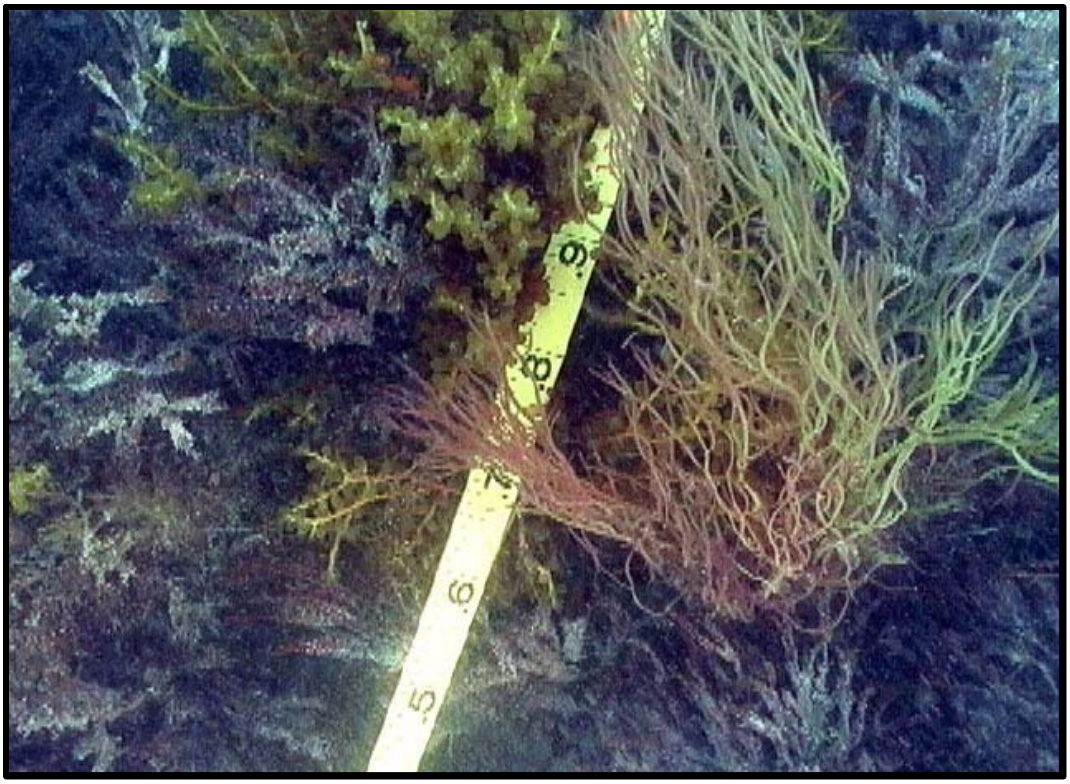

Photo 4 - Macroalgae on exposed hard bottom along Survey Line R-37.

Photo 5 - Purple spine sea urchin *Arbacia punctulata* on exposed hard bottom along Survey Line R-39.

Photo 6 - Shell hash bottom with scattered macroalgae along Survey Line R-39.

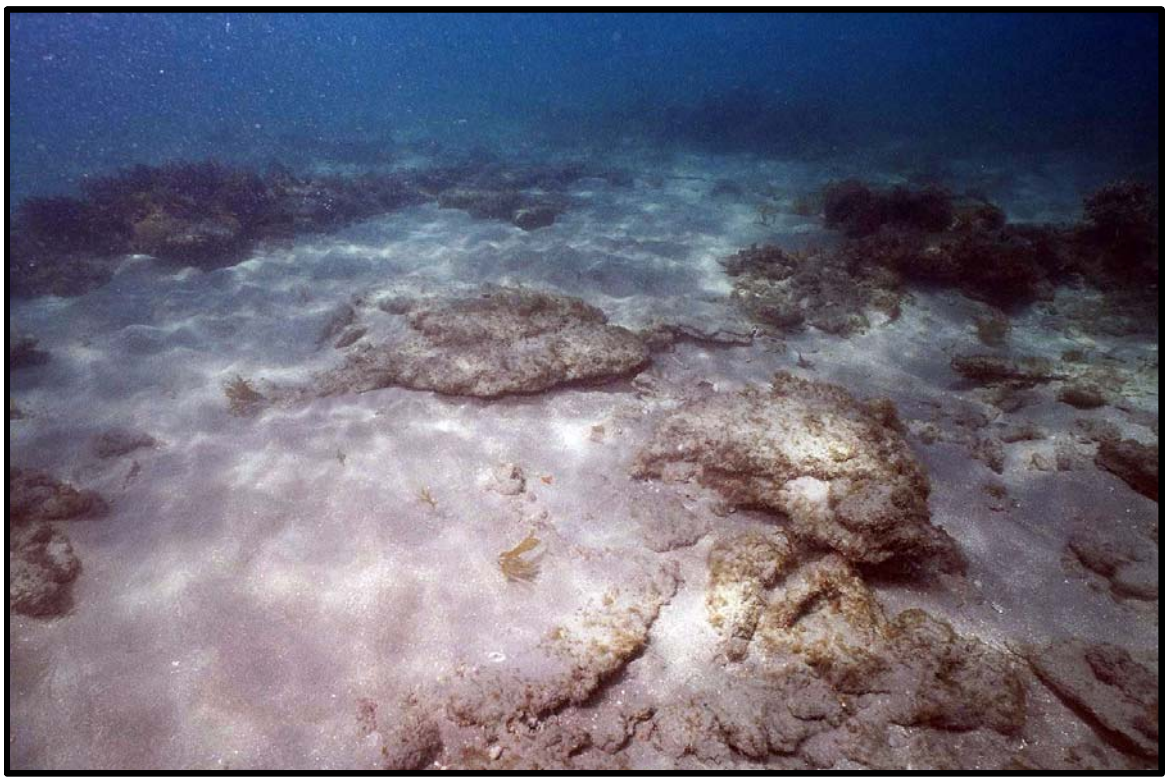

Photo 7 - Scattered exposed hard bottom along Survey Line R-41.

Photo 8 - Exposed hard bottom with macroalgae and sand along Survey Line R-41.

Photo 9 - Sand bottom near permanent transect marker along Survey Line R-42.

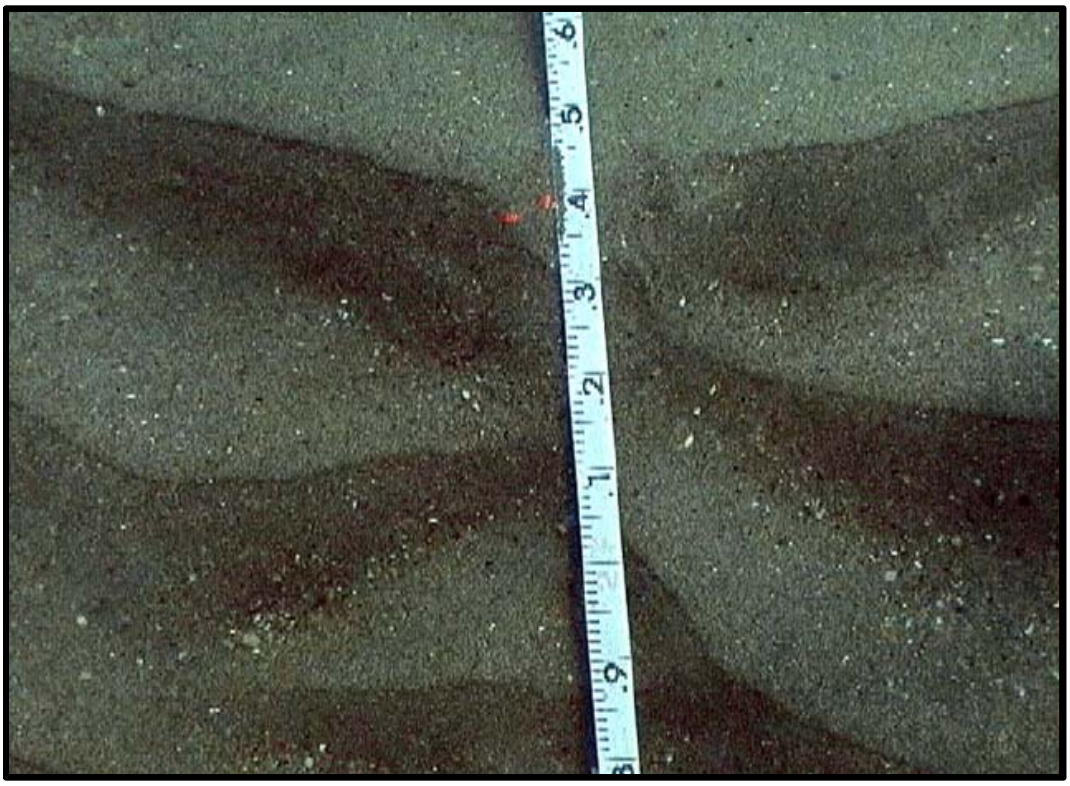

Photo 10 - Sand bottom along Survey Line R-42.

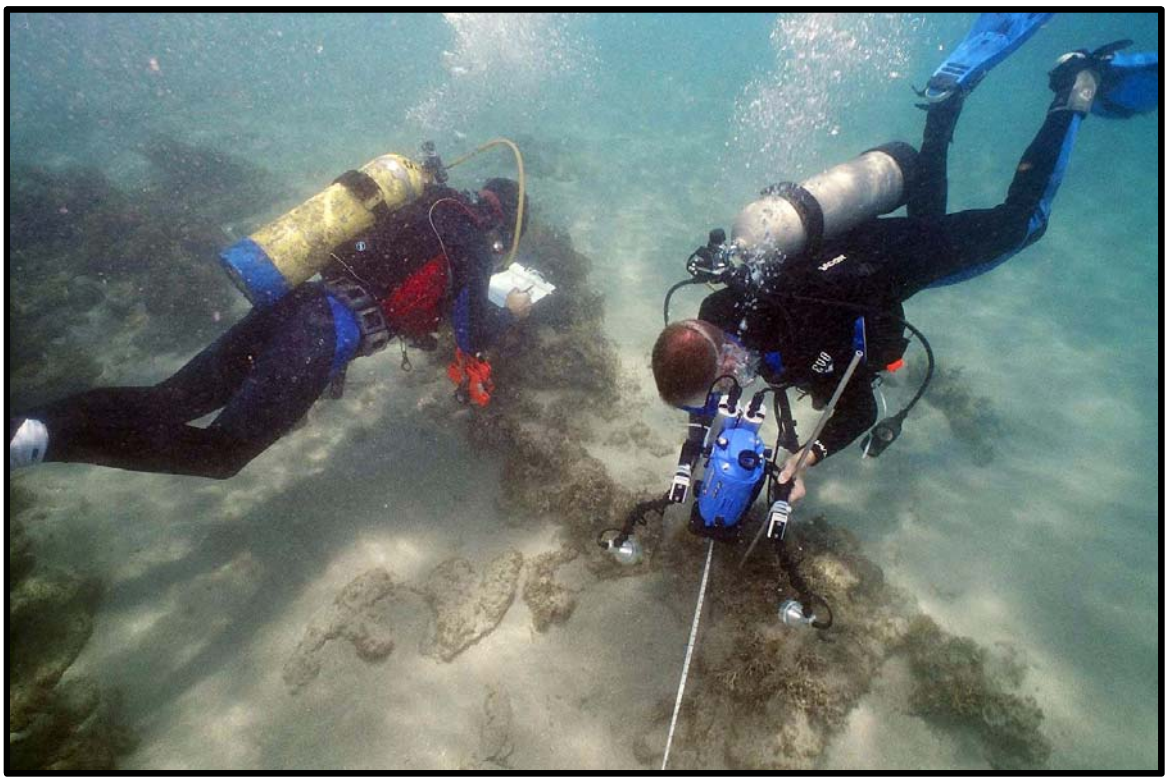

Photo 11 - Scattered exposed hard bottom along Survey Line R-43.

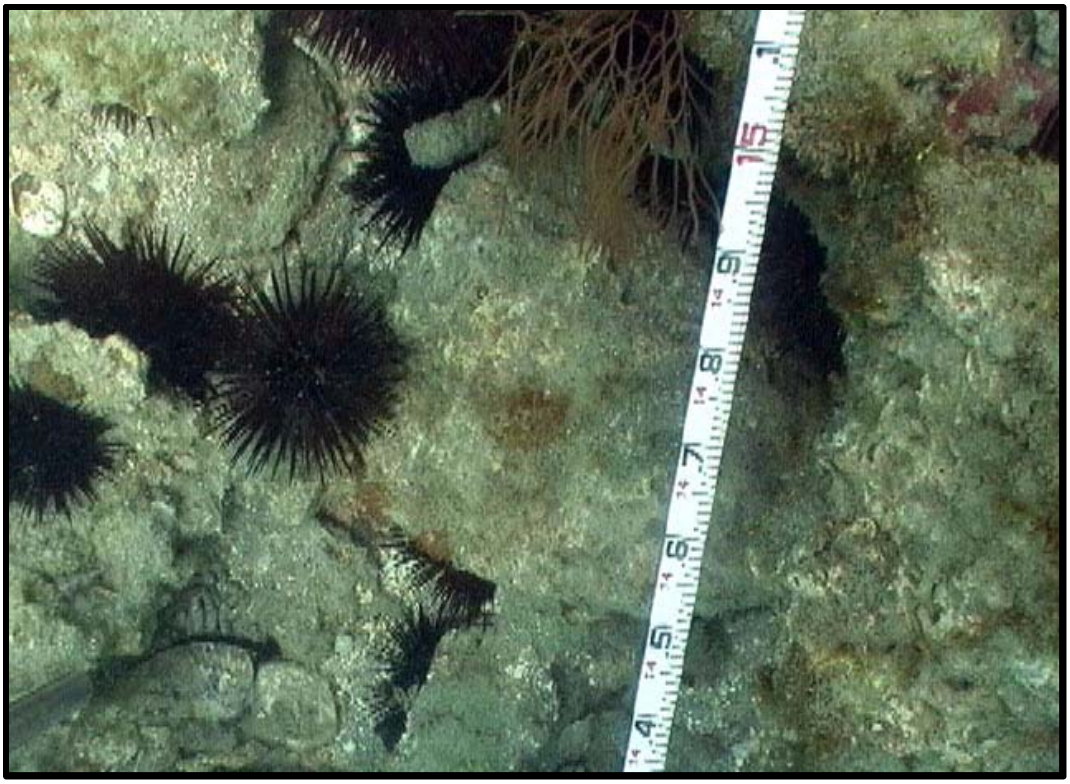

Photo 12 - Purple spine sea urchin (*Arbacia punctulata*) on exposed hard bottom along Survey Line R-43.

Photo 13 - Purple spine sea urchin (*Arbacia punctulata*) and hairy blenny (*Labrisomus nuchipinnis*) on exposed hard bottom along Survey Line R-53.

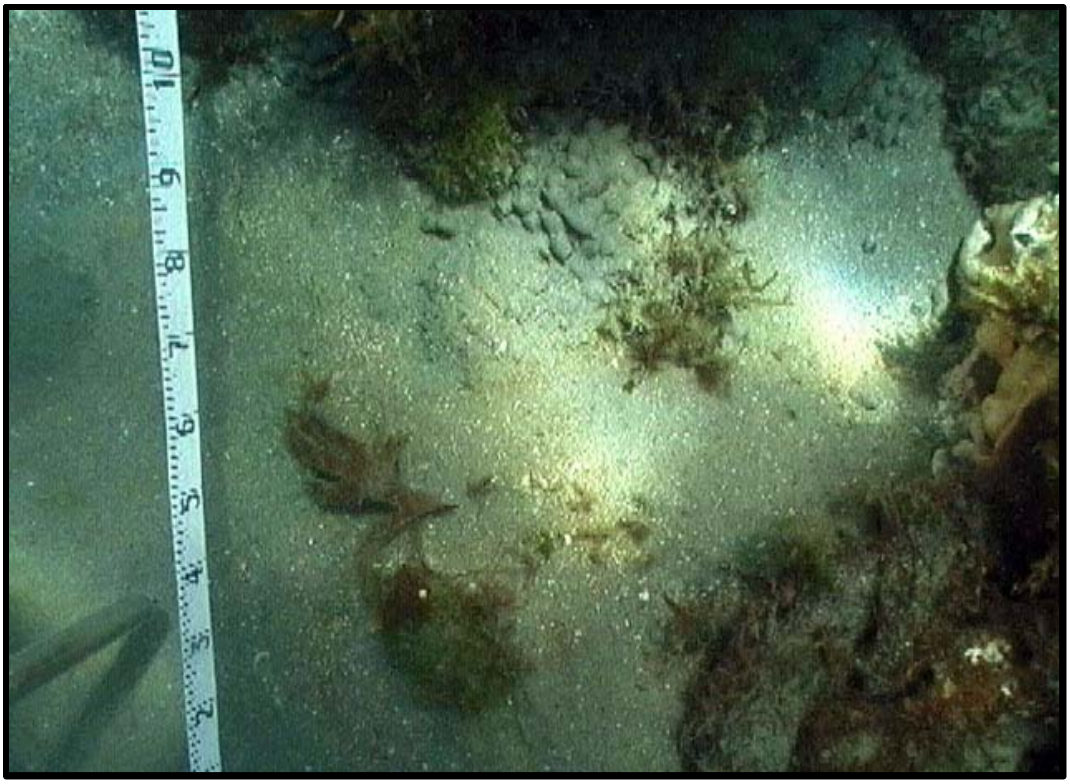

Photo 14 - Shell hash bottom with scattered macroalgae along Survey Line R-53.

Photo 15 - Short spine sea urchin (*Lytechinus variegatus*) on exposed hard bottom along Survey Line R-54.

Photo 16 - Sand bottom with scattered exposed hard bottom along Survey Line R-54.

Photo 17 - Deployment of mitigation reef off Fort Pierce, Florida.

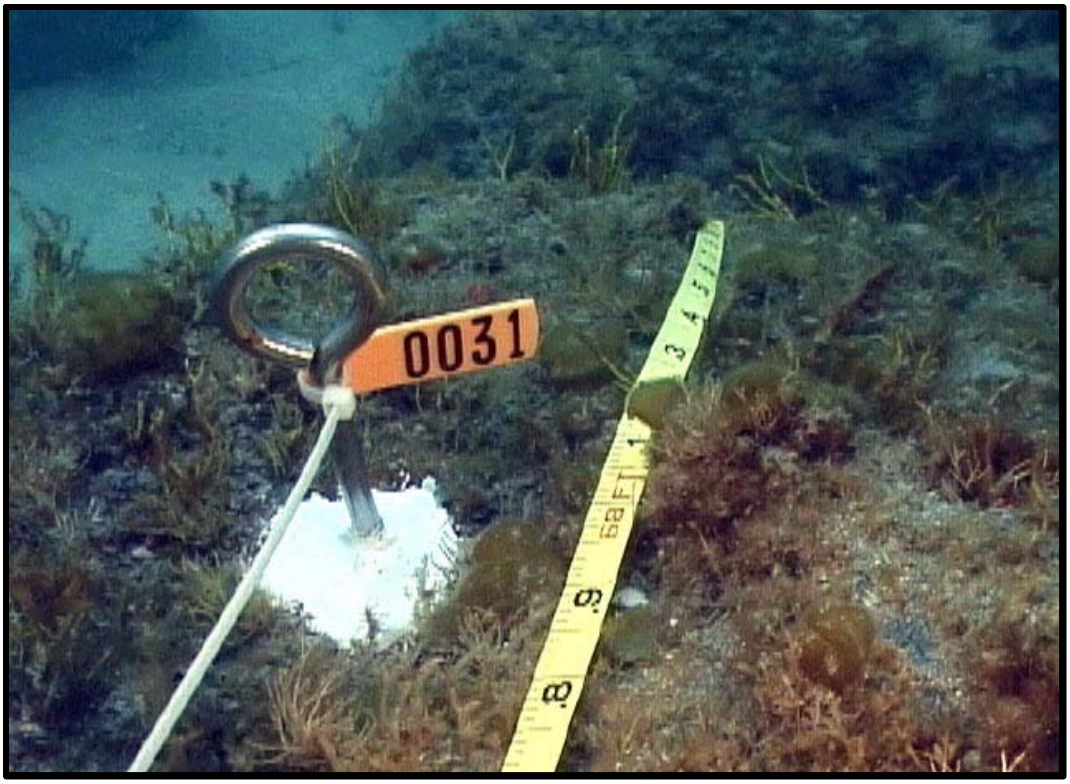

Photo 18 - Quantitative Transect MT-1 on mitigation reef with dense algal cover.

Photo 19 - Colonial tunicate *Eudistoma* sp. along Quantitative Transect MT-2 on the mitigation reef.

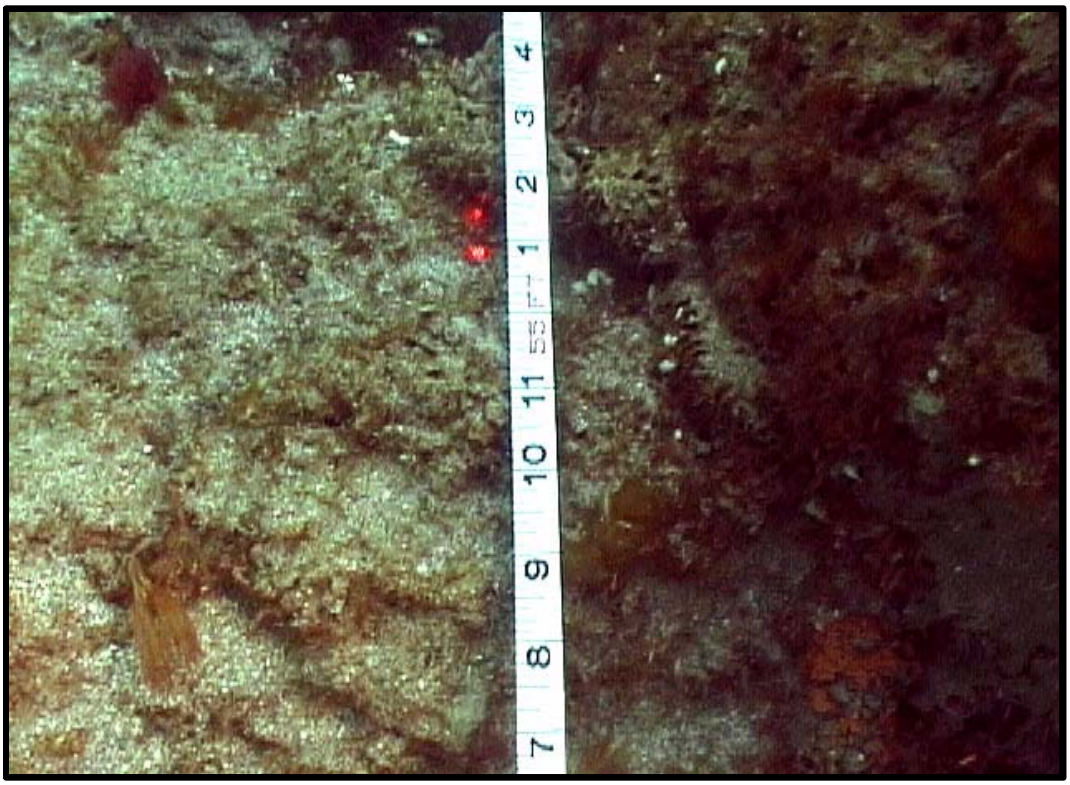

Photo 20 - Quantitative Transect MT-2 on mitigation reef with dense algal cover and sabellarid worms (*Phragmatapoma lapidosa*).