SECOND POST-NOURISHMENT MONITORING SURVEY OF NEARSHORE HARD BOTTOM HABITATS SOUTH OF FORT PIERCE INLET FORT PIERCE, FLORIDA

26 July 2002

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1.0 INTRODUCTION

Continental Shelf Associates, Inc. (CSA) was contracted by Taylor Engineering, Inc. and the St. Lucie Erosion District (St. Lucie County, Florida) to conduct a second post-nourishment monitoring survey of the hard bottom habitats south of Fort Pierce Inlet, Fort Pierce, Florida. The purpose of this monitoring survey was to map and to perform physical and biological characterizations of the seafloor substrate along 15 previously surveyed transects and at seven previously surveyed photoquadrat stations south of Fort Pierce Inlet. This monitoring survey also was intended to fulfill the second post-nourishment hard bottom monitoring in the beach nourishment project area required by the 1999 U.S. Army Corp of Engineers (COE) Capron Shoals Settlement Agreement (CSSA). The monitoring survey was conducted in compliance with the COE's original scope of work as set forth by the CSSA. This report describes the results from this second post-nourishment monitoring survey conducted on 1 May 2002.

2.0 BACKGROUND

The Fort Pierce Shore Protection Project included placement of sand, from the 1995 Fort Pierce Inlet maintenance dredging, on the beaches south of the Fort Pierce Inlet and a more extensive beach nourishment in 1999. A baseline pre-nourishment survey was conducted from 23 to 31 August and on 2 September 1994 to map and biologically characterize the hard bottom habitats south of Fort Pierce Inlet (Seabyte Inc., 1994). The baseline survey included video mapping along 35 transects that were oriented perpendicular to shore and referenced from Department of Natural Resources (DNR) monuments R-34 to R-51 and extended 2,000 ft offshore. Substrate observed along each transect was identified and placed into one of the following catagories:

- 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.

Successive surveys were to utilize this same substrate characterization for comparison purposes. Permanent photoquadrat stations were selected and established at seven locations. The permanent photoquadrat stations were designed to allow the collection of repeatable quantitative still photographic data.

The COE placed sand from Fort Pierce Inlet maintenance dredging on the beach in 1995. A post-nourishment monitoring survey was conducted on 29 May 1996 to determine if secondary impacts had occurred to nearshore hard bottom habitats (Continental Shelf Associates, Inc., 1997). A video mapping system was used to survey 13 transects from DNR monument R-34 through R-40. Monitoring of the permanent photoquadrat stations was not required during this survey. Substrate mapping characterizations were based on those developed during the 1994 baseline survey. Estimates of substrate with less than 10% exposed rock cover were slightly higher during the 1996 post-nourishment survey (30%) compared to the 1994 pre-nourishment survey (22%). Fine-textured grayish sediments (slit/clay) were observed along Transects R-35, R-36, R-36.5, and R-37.

To fulfill the 1999 COE CSSA, two post-nourishment monitoring surveys were to be conducted. The first post-nourishment monitoring survey was conducted from 22 through 26 May 2000 (Dial Cordy and Associates Inc., 2000). This survey included video mapping along 14 transects (DNR monuments R-34.5 through R-41) and photodocumentation of four of the seven permanent photoquadrat stations. Construction of the spur groin on the south jetty of the Fort Pierce Inlet precluded surveying the R-34 transect. It is not clear whether the May 2000 survey report presents substrate mapping characterizations that were based on those developed during the 1994 baseline survey. The May 2000 survey report indicates that the percent cover categories were based on the percentage of biotic cover on exposed rock rather than the percent cover of exposed rock substrate. This report also used the loss of exposed rock habitat, due to sand cover, west of the predicted equilibrium toe-of-fill as an assessment of direct impact due to the 1995 and/or 1999 beach nourishment projects. The May 2000 report concluded that 1.7 acres of greater than 50% exposed rock cover were directly impacted. This method, however, excluded shorewardmost edges of exposed rock that occurred east of the predicted equilibrium toe-of-fill. These methods of analysis may have arbitrarily caused a misinterpretation of impacts.

3.0 METHODS

3.1 FIELD METHODS

The field survey was conducted with the same procedures followed during the baseline pre-nourishment survey of August/September 1994. Fifteen video transects were surveyed within the beach nourishment area. Pre-plot transect locations and orientations are shown in **Figure 1**. The transects were referenced from DNR monuments R-34 through R-41. **Table 1** presents a list of the transects surveyed with starting and ending navigation points. These transects were oriented perpendicular to shore and extended approximately 2,000 ft offshore.

Video documentation of the seafloor and associated biota were collected along each of the 15 transects using an Integrated Video Mapping System (IVMS). Video data were collected by towing a biologist diver equipped with surface-supplied air and a high resolution color videocamera along each of the survey transects. The diver continuously described substrate type, vertical relief, and specific biota observed along each of the survey transects. Diver audio observations as well as the video data were conveyed over the videocamera cable to the survey vessel and recorded onto mini-digital video (mini-DV) and super-VHS videotapes. Continually updated navigation position data also were concurrently recorded onto the videotapes along with the specific transect number, time, and date. The diver was towed along the transects at a speed of approximately 1 kn and at a height of 1 to 3 ft above the bottom.

A minimum of 10 quantitative still photographs were collected from the seven photoquadrat stations previously surveyed during the August/September 1994 (Seabyte Inc., 1994) and May 2000 (Dial Cordy and Associates Inc., 2000) surveys. The locations of each photoquadrat station are shown in **Figure 1**. Navigation coordinates for the photoquadrat stations are presented in **Table 2**. Each photoquadrat station consisted of

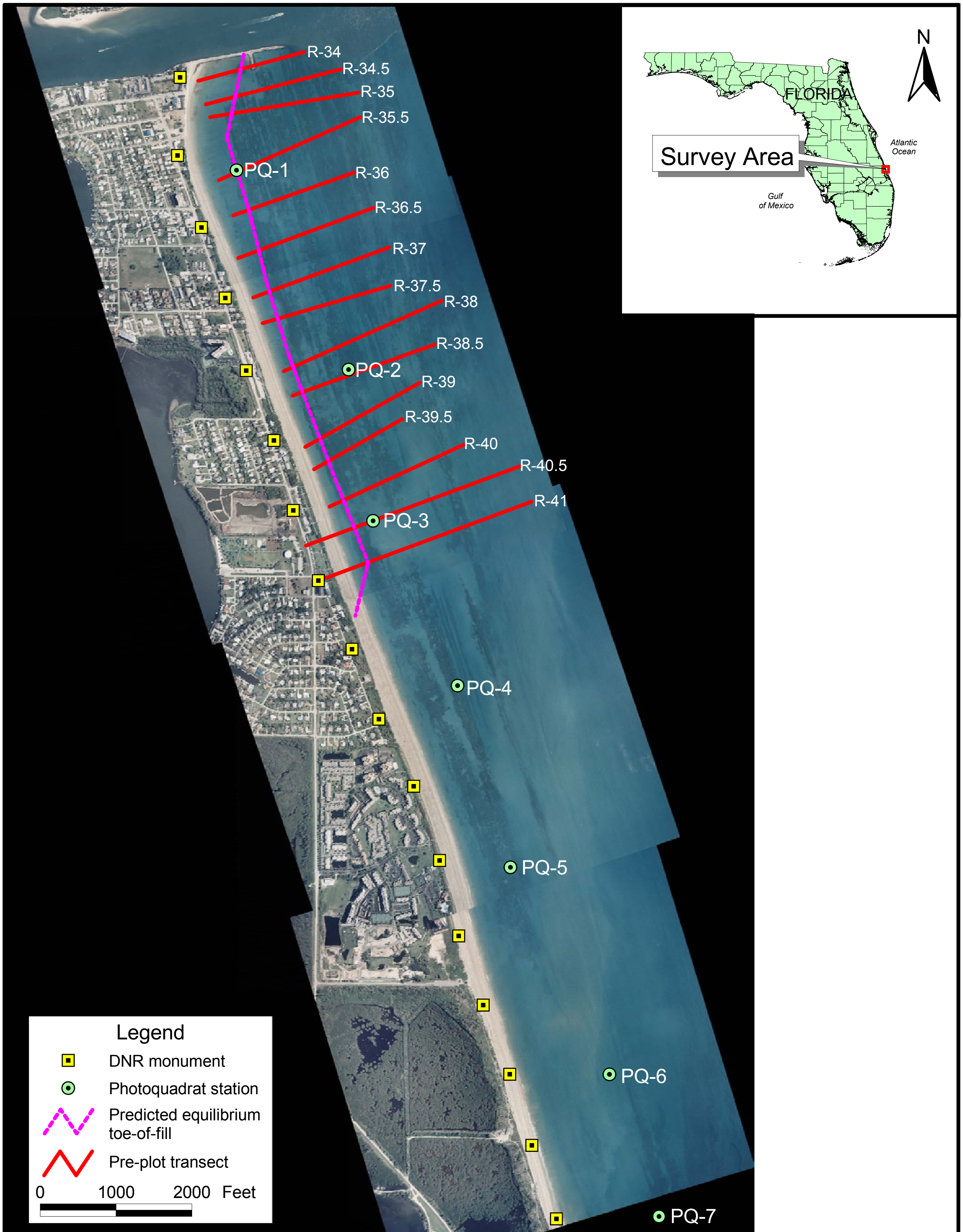


Figure 1. Overview of the survey area south of Fort Pierce Inlet, Fort Pierce, Florida.

Table 1. Starting and ending points for the pre-plot transects surveyed during the 1 May 2002 monitoring of nearshore hard bottom habitats south of Fort Pierce Inlet, Fort Pierce, Florida.

Transect	DNR Monument	Starting Point*		Ending Point*	
		Northing	Easting	Northing	Easting
1	R-34	1140504	730074	1140884	731467
2	R-34.5	1140195	730173	1140658	731954
3	R-35	1140026	730230	1140349	732184
4	R-35.5	1139197	730346	1140026	732209
5	R-36	1138733	730536	1139296	732126
6	R-36.5	1138171	730601	1138832	732382
7	R-37	1137651	730799	1138312	732588
8	R-37.5	1137314	730923	1137806	732605
9	R-38	1136682	731203	1137609	733281
10	R-38.5	1136359	731318	1137033	733190
11	R-39	1135684	731483	1136527	732992
12	R-39.5	1135389	731599	1136049	732761
13	R-40	1135712	733569	1134897	731805
14	R-40.5	1134384	731493	1135426	734306
15	R-41	1133920	731655	1134962	734468

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

Table 2. Photoquadrat station navigation coordinates sampled south of Fort Pierce Inlet, 1 May 2002.

Photoquadrat Station	Northing*	Easting*	Steel Rods Missing		
			NW	SW	SE
PQ-1	1139325	730576	X		
PQ-2	1136648	732053	X	X**	
PQ-3	1134707	732375			
PQ-4	1132479	733502		X	
PQ-5	1130045	734214			
PQ-6	1127362	735484			
PQ-7	1125491	736145		X	

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

** Only a small portion of the steel rod is remaining.

three permanent steel rods approximately 5 m apart forming an “L” shaped quadrat with the top to north and the bottom to south. Upon location of a photoquadrat station, a fiberglass reel tape was stretched out between each of the three rods starting from the northwest rod, extending to the southwest rod, and ending with the southeast rod. In the event that a rod was missing, the reel tape was extended 5 m in the direction of the missing rod and weighted temporarily with a lead weight. The locations of missing steel rods were noted during the photoquadrat dive and later recorded in the survey log upon surfacing.

An underwater 35-mm camera (Nikonos V equipped with a 28-mm lens and two Ikelite 150 substrobes) mounted on a stainless steel framer jig was used to collect the quantitative still photographs. Continuous still photographs were taken along the outside portion of the “L” shaped photoquadrat with the fiberglass reel tape in the top ¼ of each frame. The area photographed within each frame was 2.01 ft^2.

General observations were made concerning the biological community at each station. Observations of fishes and benthic organisms were recorded immediately upon surfacing from each photoquadrat station.

3.2 NAVIGATION

A Magnavox MX300 differential global positioning system interfaced with Hypak navigation software was utilized for survey vessel navigation. Navigation coordinates for the survey transects and permanent photoquadrat stations (**Table 1**) were provided by the 1994 baseline pre-nourishment survey post-plot transects (Seabyte Inc., 1994). Navigation coordinates were collected in State Plane NAD-27, Clark 1866, zone Florida East, with units of measure in U.S. survey feet. Diver layback behind the survey vessel was determined using a measured tow line, and the specific layback distance was incorporated into the navigation database.

3.3 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 transect 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 transect was recorded. These navigation data were plotted to produce tracklines along each survey transect. These tracklines, or post-survey transects, were then superimposed onto the 2001 georeferenced aerial images provided by Taylor Engineering, Inc. The May 2002 post-survey transects were used as the primary data set during analysis, and the 2001 aerial images were used as supplemental data. The 2001 aerial images with the superimposed post-survey transects were used to interpret substrate classification between each survey transect. Polygons were generated bordering each of the identified substrate classifications; they then were labeled and used to determine an approximate area for each substrate classification within the survey area. Some of the substrate classifications from the August/September 1994 polygon data were incomplete and had to be retraced, and some borders were added to complete unfinished polygons. The outermost perimeter of the August/September 1994 polygon data was used as a baseline for conducting the May 2002 substrate classification interpretation. This provided comparable survey areas for the August/September 1994 pre-nourishment and the May 2002 post-nourishment data sets.

The May 2000 report used the loss of exposed rock habitat, due to sand cover, west of the predicted equilibrium toe-of-fill as an assessment of direct impacts due to the 1995 and/or 1999 beach nourishment projects. This method, however, excluded the shorewardmost edge of exposed rock that occurred east of the predicted equilibrium toe-of-fill. To more accurately compare impact assessment between the August/September 1994 pre-nourishment baseline survey and the May 2002 post-nourishment monitoring survey, the shorewardmost edge of exposed rock was delineated from the May 2002 polygon data to produce a shoreward reef edge border. This shoreward reef edge border was then superimposed onto the August/September 1994 polygon data and the 2001 aerial images. The loss of exposed rock habitat was determined as the area that was (1) classified as exposed rock based on the August/September 1994 polygon data and (2) no longer visible west of the shoreward reef edge border as delineated from the May 2002 polygon data.

Listings of all identifiable fish and invertebrate species observed along the transects also were made during the video data review. These listings included species directly observed on the videotapes in addition to those identified *in situ* by the divers and recorded on the audio track of the videotapes. Species identified during the survey were only those large enough to be observed by the diver and/or recorded by the videocamera as the diver was being towed along the survey transects. This excluded many of the smaller cryptic fish species, most 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* with audio comments recorded on the videotapes. A relative abundance of each observed species was determined based upon the methods of Starck (1968). Fish abundances were determined from a review of the video data and *in situ* observations, and a relative abundance ranking was determined as follows:

- Rare - one individual;
- Occasional - 2 to 10 individuals;
- Frequent - 10 to 50 individuals;
- Abundant - 50 to 100 individuals; and
- Common - more than 100 individuals.

Quantitative photographs were digitized and saved in JPEG format onto a compact disk (CD). Percent cover of biota was estimated using the PointCount ’99 software analysis program (Porter et al., 2001; Dustan et al., in prep.). 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. Fifty random points were projected on every digitized quantitative photograph. The biota or substrate beneath each point was identified, and the data from each photograph were saved in a spreadsheet.

4.0 RESULTS AND DISCUSSION

4.1 VIDEO TRANSECTS

4.1.1 Hard Bottom Habitat

4.1.1.1 Transect Data

Fifteen video transects were surveyed from DNR monument R-34 through R-41. **Figures 2** through **6** show the substrate type distribution along each survey transect superimposed over June 2001 aerial images provided by Taylor Engineering, Inc. Substrate types observed along each survey transect 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. The 2001 aerial images were collected approximately 11 months prior to the May 2002 monitoring survey. This time delay may explain variations between mapped substrate data from post-plot transects and the exposed rock habitats visible in the aerial images. Two notable areas where substrate identified from video data were different from substrate visible on aerial images occurred along Transects R-38 and R-41. Near the eastern portion of Transect R-38, a section of substrate was identified from the video data as predominantly sand bottom with less than 10% exposed rock cover, and the aerial image indicates that this substrate is predominantly exposed rock (**Figure 4**). An area identified as greater than 50% exposed rock cover along the western portion of Transect R-41 appears to be predominantly sand bottom in the aerial image (**Figure 6**). Further review of the video data from these transects confirmed the original substrate classifications. This may be indicative of sediment

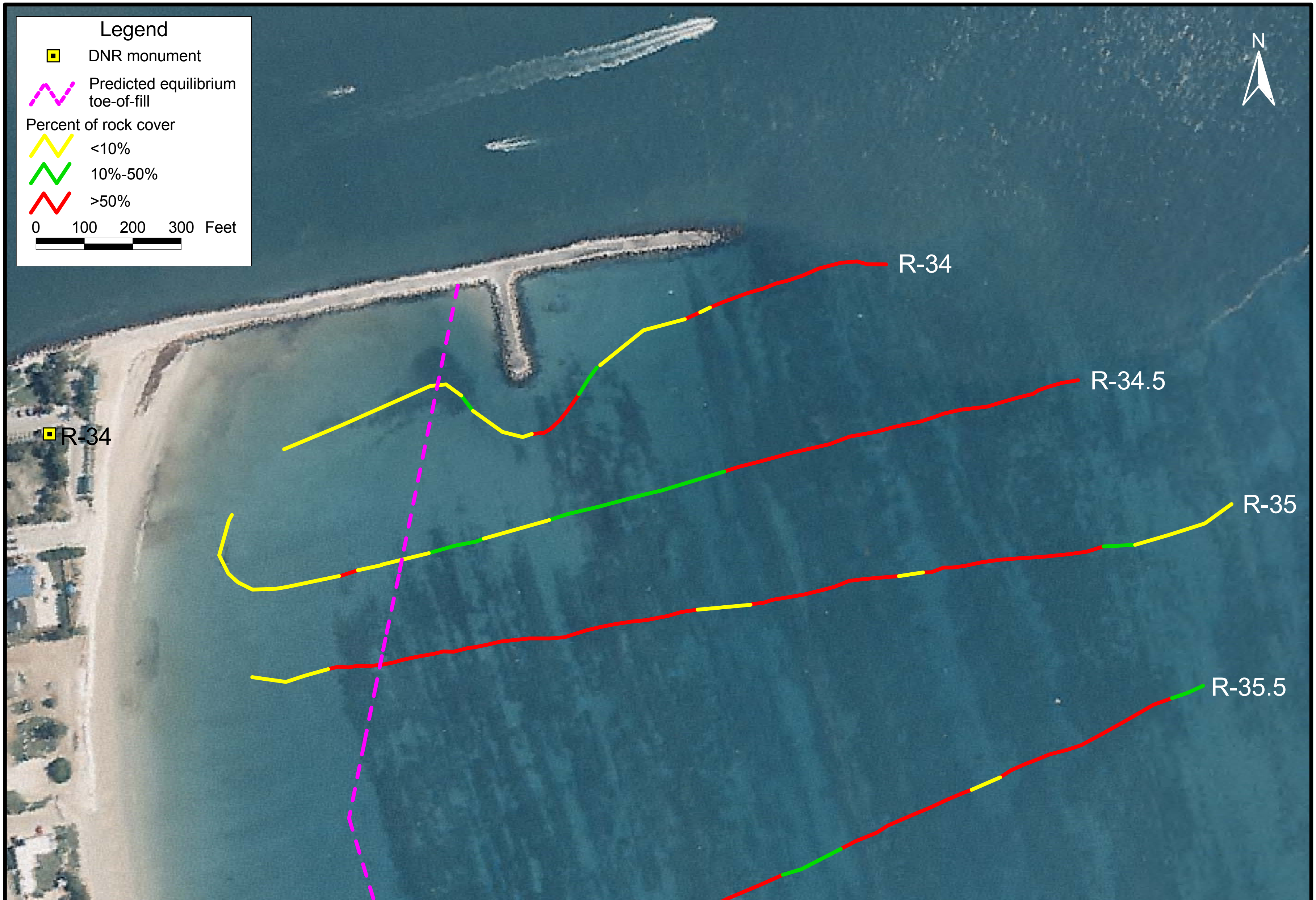


Figure 2. Post-plot Transects R-34, R-34.5, and R-35 with identified rock substrate classifications superimposed over 2001 aerial image.

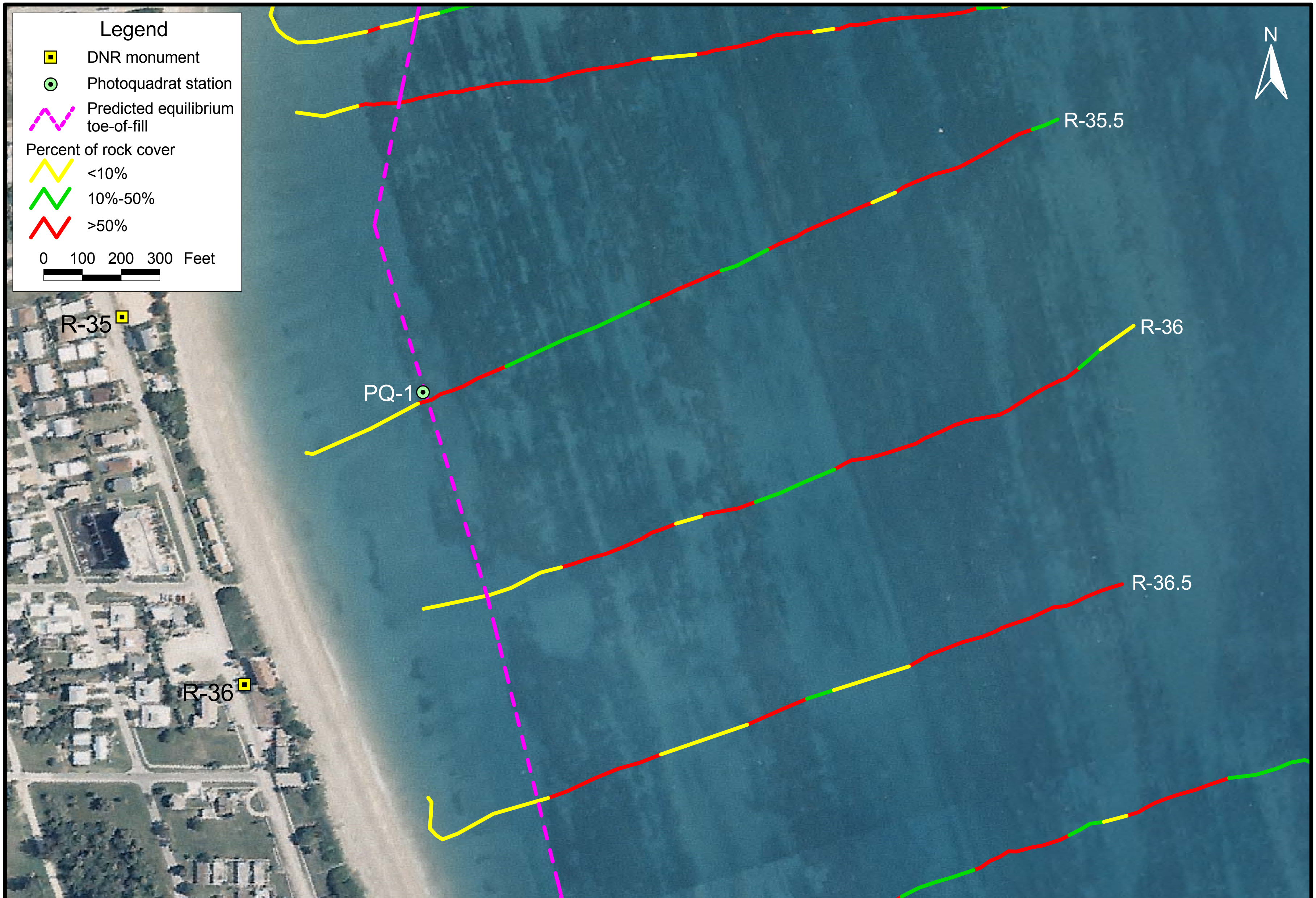


Figure 3. Post-plot Transects R-35.5, R-36, and R-36.5 with identified rock substrate classifications superimposed over 2001 aerial image.

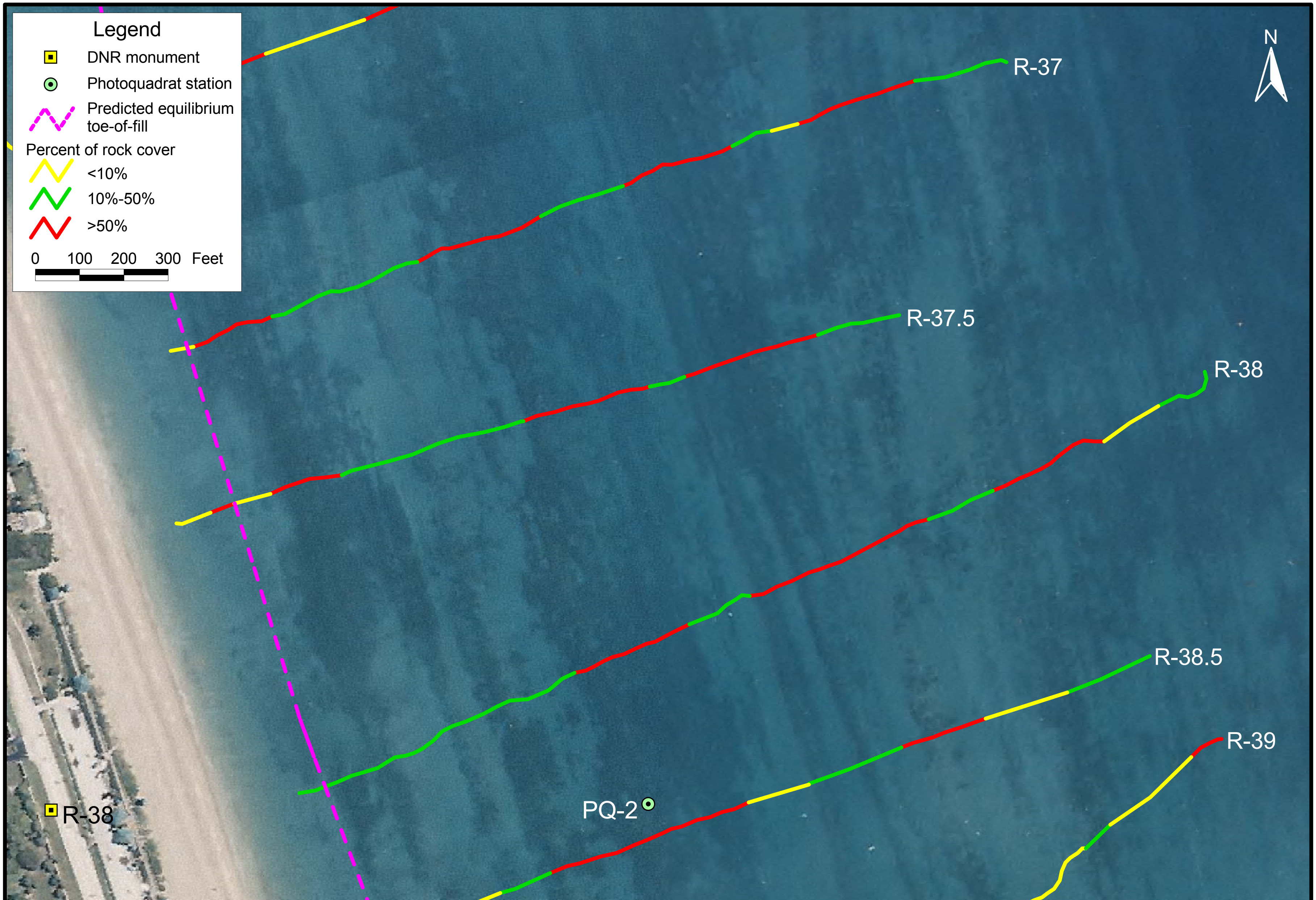


Figure 4. Post-plot Transects R-37, R-37.5, and R-38 with identified rock substrate classifications superimposed over 2001 aerial image.

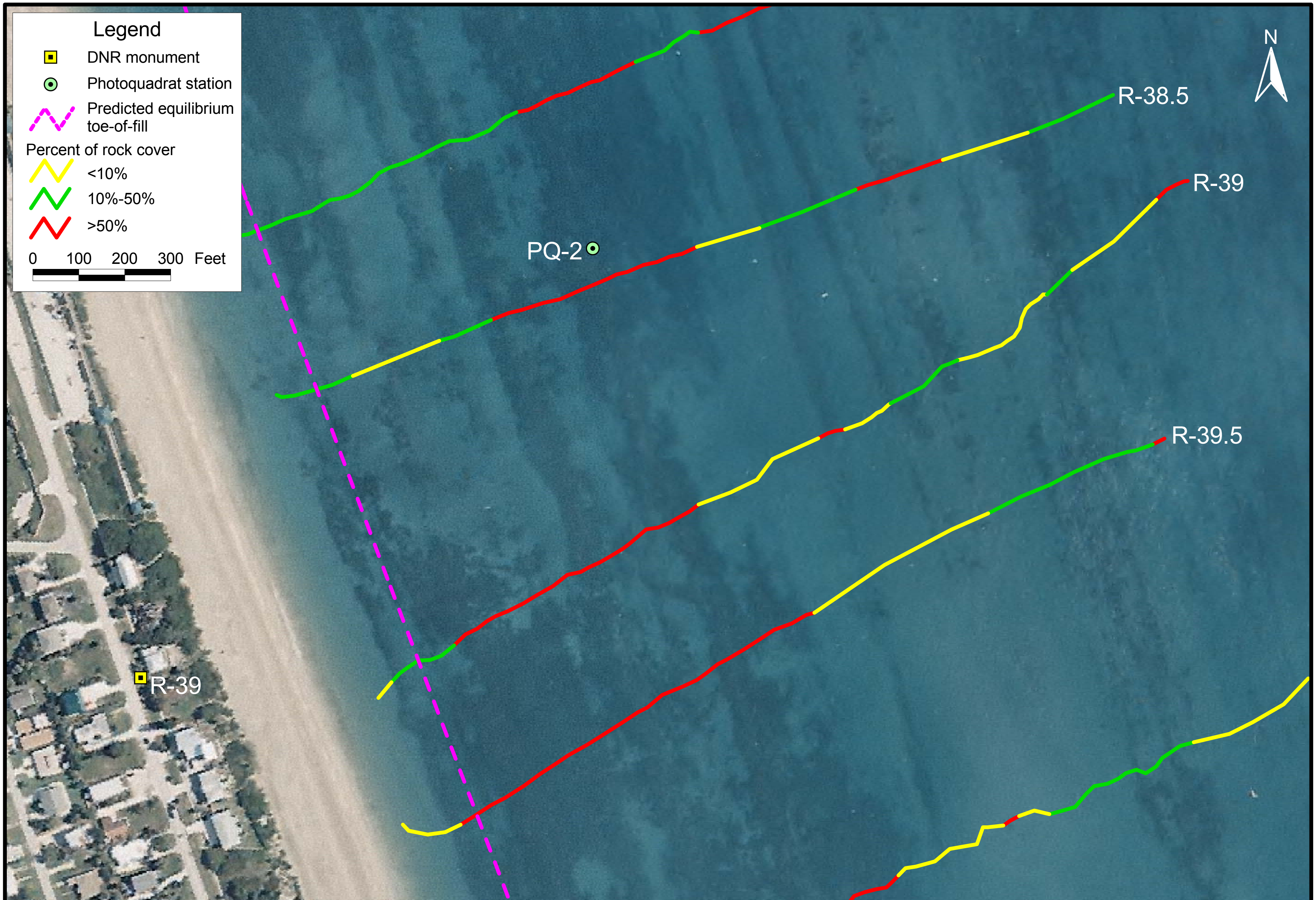


Figure 5. Post-plot Transects R-38.5, R-39, and R-39.5 with identified rock substrate classifications superimposed over 2001 aerial image.

Figure 6. Post-plot Transects R-40, R-40.5, and R-41 with identified rock substrate classifications superimposed over 2001 aerial image.

(sand) movement during the 11-month period between the aerial survey (June 2001) and the monitoring survey (May 2002).

The exposed rock outcrops observed south of the Fort Pierce Inlet were striated reef trends that parallel the shoreline. The percent of cover of exposed rock substrate from transect data is presented in **Table 3**. Based on the transects, the dominant substrate type observed during the survey was greater than 50% exposed rock cover, which comprised 45.6% of the total transect lengths surveyed. This substrate type was slightly more abundant along transects in the north and middle portions of the survey area. 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.

The transect data indicated that the second most abundant substrate type was predominantly sand with less than 10% exposed rock cover. This substrate type comprised 33.0% of the total transect lengths surveyed. The predominantly sand bottom areas observed along the survey transects were interspersed between the striated reef trends. Primarily distributed in the nearshore regions along the survey area, sand bottom becomes a dominant substrate along the offshore portions of Transects R-40, R-40.5, and R-41 near the southern end of the video survey area. Less sand bottom is observed along Transects R-37, R-37.5, and R-38, near the middle of the survey area, where exposed rock occurs close to the beach.

Substrate with 10% to 50% exposed rock cover comprised 21.4% of the total transect lengths surveyed. This substrate was most common near the middle of the survey area along Transects R-37, R-37.5, R-38, and R-38.5. This substrate type was typically observed on the eastern portions of striated reef trends. Relief in areas of 10% to 50% exposed rock cover was less than 0.6 m.

Isolated patches of recently exposed substrate with relatively clean rock surfaces and no fouling or epibenthic growth were observed in the survey area. This was indicative of sand movement in high energy shallow water areas with low relief hard bottom. These isolated patches of recently exposed substrate were observed offshore as well as nearshore along the survey transects.

4.1.1.2 Polygon Data

Figure 7 shows the May 2002 substrate classification polygons superimposed on 2001 aerial images. **Table 4** presents a summary of substrate classification areas from polygon data for the 2002 post-nourishment survey. The 2002 substrate classification polygons indicate that substrate with less than 10% exposed rock (42.1%) was the dominant substrate in the survey area. Substrate with greater than 50% exposed rock comprised approximately 38.6% of the total area surveyed. The substrate with the lowest estimated exposed rock cover was 10% to 50% exposed rock (19.3%). The percent cover of exposed rock substrate from transect and polygon data is presented in **Table 3**. The percent cover results of exposed rock substrate from transect and polygon data generally agree. The slight difference in the May 2002 results between the transect data and polygon data (**Table 3**) was possibly due to the interpretation of substrate classification between transects.

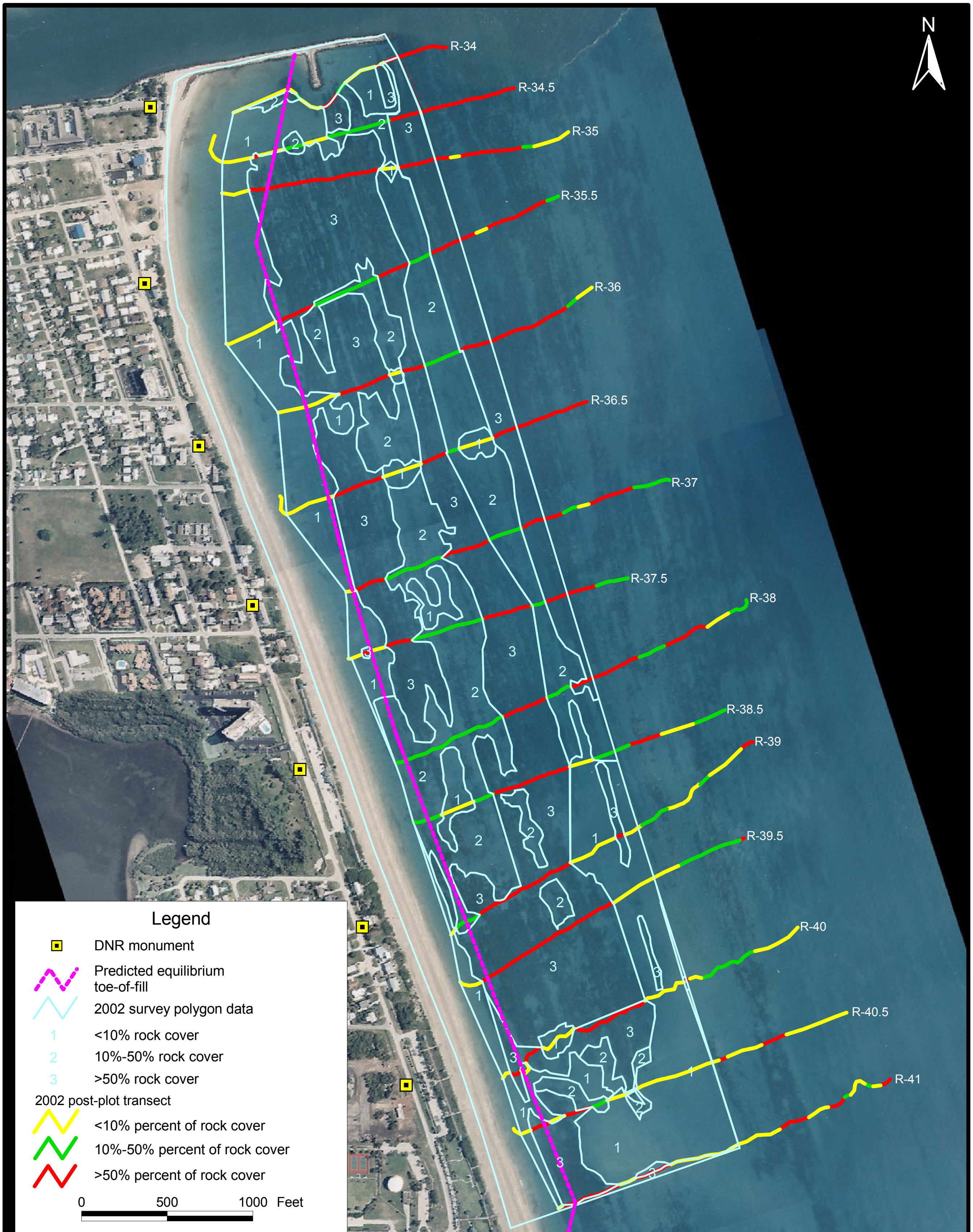


Figure 7. May 2002 rock substrate classification polygons with post-plot transects superimposed over the 2001 aerial images.

Table 3. May 2002 percent cover differences of exposed rock between transect data and polygon data.

Exposed Rock Cover	May 2002 Post-nourishment Monitoring Survey	
	Transect Data (%)	Polygon Data (%)
<10%	33	42.1
10% to 50%	21.4	19.3
>50%	45.6	38.6

Table 4. Substrate classification areas from polygon data for the 2002 post-nourishment monitoring survey.

Exposed Rock Cover	Total Survey Area (acres)
<10%	102.67
10% to 50 %	47.13
>50%	93.87

4.1.2 Biological Characterization

Table 5 lists benthic species identified *in situ* by divers and during the post-survey analyses of the videotape data. Greater numbers of benthic species were observed in areas of higher vertical relief and near distinct ledges. 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. The sponges *Ircinia variabilis* and *Cliona* spp. were most common in the greater than 50% exposed rock cover areas, and the hard corals *Oculina varicosa*, *O. diffusa*, and *Siderastrea* spp. also were most abundant in those locations. Sabellariid worm rock (*Phragmatopoma lapidosa*) was present on all three substrate types. In some areas the worm rock appeared to be somewhat sand-covered or eroded, but in most areas it appeared to be 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 *Eucidaris tribuloides*, and the sea cucumber *Holothuria ?grisea* (species uncertain). Spiny lobsters (*Panulirus argus*) were occasionally observed under small ledges associated with exposed rock outcrops.

A list of fishes observed during the survey, with estimated relative abundances, is presented in **Table 6**. A total of 32 fish species was observed. The most common fishes observed along the survey transects included porkfish (*Anisotremus virginicus*), spottail pinfish (*Diplodus holbrooki*), slippery dick (*Halichoeres bivattatus*), 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 the areas of high vertical relief and near distinct ledges. Larger individuals also were observed in areas of high veritical relief and near distinct ledges.

Table 5. Benthic taxa identified along survey transects.

ALGAE	ANNELIDA
Botryocladia occidentalis	*Hermodice carunculata*
Caulerpa racemosa	*Phragmatopoma lapidosa*
C. sertularioides	MOLLUSCA
Dictyota sp.	*Hypselodoris edenticulata*
Halimeda discoidea	*Strombus costatus*
Halymenia sp.	ARTHROPODA
?Hypnea sp.	*Panulirus argus*
Padina sp.	ECHINODERMATA
Sargassum sp.	*Arbacia punctulata*
Udotea sp.	*Diadema antillarum*
PORIFERA	*Encope michelini*
Cinachyra sp.	*Eucidaris tribuloides*
Cliona spp.	*Holothuria ?grisea**
Ircinia campana	*Lytechinus variegatus*
*I. ?strobilina***	*?Stichopus badionotus****
I. variabilis	ASCIDIACEA
Unidentified Porifera	*Ascidea nigra*
CNIDARIA	*Didemnum* sp.
Diploria strigosa	Unidentified colonial ascidians
Eudendrium sp.	
Leptogorgia virgulata	
Oculina diffusa	
O. varicosa	
Palythoa caribaeorum	
Pseudopterogorgia sp.	
Siderastrea radians	
S. siderea	
Solenastrea bournoni	
Unidentified Hydroida	

* ?Genus sp. – Identification of genus uncertain.
** Genus ?species – Identification of species uncertain.
*** ?Genus species – Identification of genus and species uncertain.

Table 6. Fishes and turtle observed along survey transects including estimates of relative abundance and life stage.

Scientific Name	Common Name	Relative Abundance	Life Stage
Abudefduf saxatilis	sergeant major	F	Ad, J
Acanthurus bahianus	ocean surgeon	F	Ad, J
Acanthurus chirugus	doctor fish	F	Ad, J
Acanthurus coeruleus	blue tang	F	Ad
Anisotremus surinamensis	black margate	F	Ad, J
Anisotremus virginicus	porkfish	A	Ad, J
Archosargus probatocephalus	sheepshead	F	Ad
Bodianus rufus	Spanish hogfish	O	Ad
Canthigaster rostrata	sharpnose puffer	O	Ad
Centropomus undecimalis	snook	R	Ad
Chaetodipterus faber	spadefish	F	Ad
Diplodus argenteus	silver porgy	O	Ad
Diplodus holbrooki	spottail pinfish	A	Ad, J
Equetus umbrosus	cubbyu	O	Ad
Eucinostomus lefroyi	silver jenny	R	Ad
Haemulon aurolineatum	tomtate	O	Ad
Haemulon melanurum	cottonwick	O	Ad
Haemulon plumieri	white grunt	O	Ad
Haemulon spp.	grunt	O	J
Halichoeres bivittatus	slippery dick	A	Ad, J
Holacanthus ciliaris	queen angelfish	O	Ad, J
Labrisomus nuchipinnis	hairy blenny	A	Ad, J
Lachnolaimus maximus	hogfish	R	Ad
Lutjanus griseus	gray snapper	O	Ad
Pomacentrus fuscus	dusky damselfish	O	Ad
Pomacentrus partitus	bicolor damselfish	O	Ad
Pomacentrus variabilis	cocoa damselfish	F	Ad, J
Rhinobatos lentiginosus	Atlantic guitarfish	R	Ad
Serranus subligarius	belted sandfish	O	Ad
Scorpaena brasiliensis	barbfish	R	Ad
Sparisoma rubripinne	redfin parrotfish	O	Ad
Squatina dumerili	Atlantic angel shark	R	Ad
Caretta caretta	loggerhead sea turtle	R	Ad

R = rare.
O = occasional.
F = frequent.
A = abundant.
C = common.
Ad = adult.
J = juvenile.

An adult loggerhead sea turtle (*Caretta caretta*) was observed while surveying along Transect R-37.5. The sea turtle was seen near the base of a low relief west-facing ledge and had a piece missing from the posterior portion of its carapace.

4.2 PHOTOQUADRAT STATIONS

A total of 10 quantitative still photographs was analyzed to determine the percent cover of identifiable species within each photoquadrat station. **Table 7** presents the percent cover of biota (plant and animal) and substrate (rock or sand) in each of the photoquadrat stations sampled during the May 2002 survey. Representative quantitative and qualitative photographs from each of the seven photoquadrat stations are presented in the **Appendix**. Substrate, predominantly sand and exposed rock, was the dominant cover in the photoquadrat stations except for Stations 6 and 7. Biotic cover was highest in the southernmost photoquadrat stations due to the presence of a dense algal cover and sabellariid worm rock (*P. lapidosa*), particularly at Station 7. Photoquadrat Stations 1 and 3 had the highest percent cover of substrate (sand) and the lowest biotic cover. Stations 2, 4, 6, and 7 had higher mean percent cover of animal species due primarily to the high relief of exposed rock cover at these stations. Algae, predominanatly turf algae, had the highest mean percent cover, and the sea urchin *A. punctulata* was the most common benthic invertebrate within the survey areas.

4.3 COMPARISON TO PREVIOUS MONITORING SURVEYS

4.3.1 Hard Bottom Habitat

4.3.1.1 Transect Data

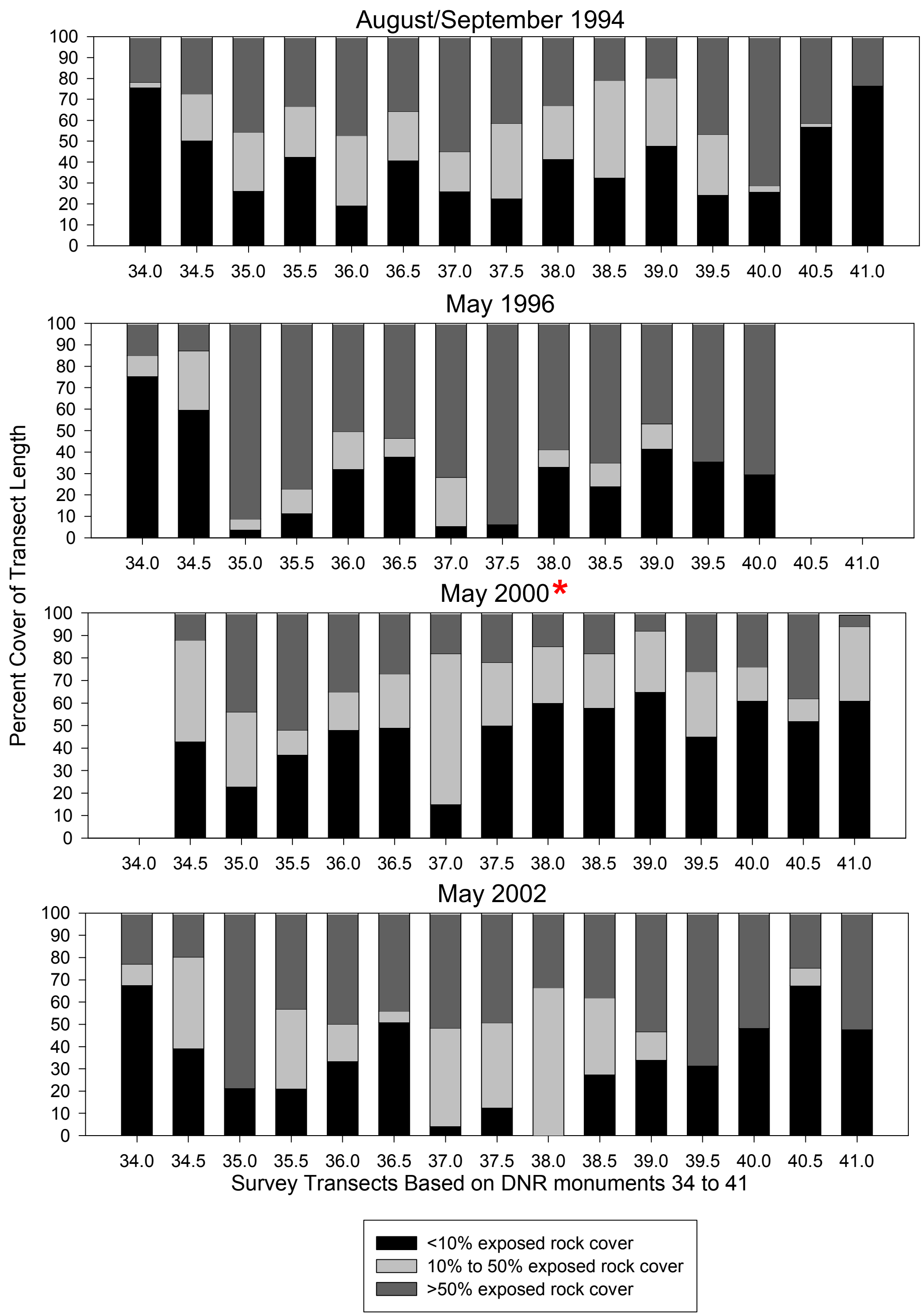
Figure 8 shows a comparison of the May 2002 survey transect data with previously mapped substrate data from the hard bottom habitat south of the Fort Pierce Inlet. These data were collected during three prior survey efforts: August/September 1994, May 1996, and May 2000. Substrate mapping data from these prior surveys are estimates taken from report figures and are not based on exact X, Y position coordinates from survey navigation databases. Transect lengths varied between each of the surveys; most of the August/September 1994 transect lengths were shorter than succeeding surveys. Therefore, transects from the May 1996 and the May 2002 surveys were truncated along the eastern and western ends so that they were comparable to similar transect segments and lengths of segments from the August/September 1994 survey. The total percent cover for each substrate classification, based on transect data only, generally agreed between the August/September 1994 and May 2002 surveys (**Table 8**). The May 1996 monitoring survey had a much higher total percentage of >50% exposed rock (63.6% cover). It is not clear whether the May 2000 survey report (Dial Cordy and Associates Inc., 2000) presents substrate mapping characterizations that were based on those developed during the 1994 baseline survey. The May 2000 survey report indicates that the percent cover categories were based on the percentage of biotic cover on exposed rock rather than the percent cover of exposed rock substrate.

Table 7. Percent cover of habitat characterized at permanent photoquadrat monitoring stations.

Photoquadrat Station	Habitat Characterization	Percent Cover
PQ-1	Exposed hard bottom	8.6
	Holothuroid	0.2
	Macroalgae	10.8
	Sand	70.4
	Sediment on hard substrate	7.2
	Turf algae	11.8
PQ-2	*Arbacia punctulata*	11.8
	Exposed hard bottom	37.8
	Oculina varicosa	0.8
	Rubble	10.4
	Sand	1.8
	Turf algae	37.4
PQ-3	Exposed hard bottom	8.2
	Macroalgae	4.4
	Rubble	3.8
	Sand	43
	Sediment on hard substrate	9.8
	Turf algae	30.8
PQ-4	*Arbacia punctulata*	5
	Exposed hard bottom	31.4
	Rubble	7.2
	Sand	1.2
	Sediment on hard substrate	8.2
	Turf algae	47
PQ-5	Exposed hard bottom	3
	Holothuroid	0.2
	Macroalgae	12.4
	Rubble	3
	Sand	25.8
	Sediment on hard substrate	22.2
	Turf algae	33.4

Table 7. (Continued).

Photoquadrat Station	Habitat Characterization	Percent Cover
PQ-6	Ascidiacea	2.6
	Arbacia punctulata	0.2
	Hydroidea	0.2
	Labrisomus nuchipinnis	0.2
	Macroalgae	12.4
	Porifera	0.4
	Sand	4.8
	Sediment on hard substrate	10.2
	Turf algae	68.8
	Worm exposed hard bottom	0.2
PQ-7	Ascidiacea	0.2
	Exposed hard bottom	0.2
	Holothuroid	0.8
	Macroalgae	2
	Rubble	1.6
	Sand	12.6
	Sediment on hard substrate	14.8
	Turf algae	43.8
	Worm exposed hard bottom	24



*** May 2000 survey report indicates that percent cover categories were based on percent biotic cover rather than percent exposed rock. Results may not be comparable to the other three surveys.**

Figure 8. Percent cover of rock substrate categories (<10%, 10% to 50%, and >50% exposed rock cover) occurring along Transects R-34 to R-41 during August/September 1994, May 1996, May 2000, and May 2002 surveys based on transect data only.

Table 8. Total percent cover of exposed rock substrate from the August/September 1994 and May 2002 surveys based on transect data only.

Survey	Total Percent Cover of Substrate Classifications		
	<10% Exposed Rock Cover	10% to 50% Exposed Rock Cover	>50% Exposed Rock Cover
August/September 1994 Pre-nourishment Baseline Survey	40.5	22.1	37.4
May 2002 Post-nourishment Monitoring Survey	33.4	20.8	45.8

4.3.1.2 Polygon Data

Figures 7 and **9** show substrate classifications from May 2002 and August/September 1994 polygon data, respectively. **Figure 9** shows a comparison of substrate identified during the August/September 1994 baseline survey with the May 2002 post-plot transects superimposed over the 2001 aerial images. The percent cover of exposed rock substrate from May 2002 transect data generally agreed with polygon data from the August/September 1994 survey (**Table 9**). **Table 10** presents a list of substrate classification areas (acres) based on August/September 1994 and May 2002 polygon data. The total survey area (acres) for less than 10% exposed rock cover identified during the May 2002 survey appeared to closely match the same substrate classification previously identified during the August/September 1994 baseline survey. The polygon data from the May 2002 total survey area indicated a decrease of 15.8 acres of 10% to 50% exposed rock cover. The total survey area for the greater than 50% exposed rock increased by 15.8 acres.

Table 9. August/September 1994 and May 2002 percent cover of exposed rock from transect data and polygon data.

Survey	Data Type	Exposed Rock Cover		
		<10%	10% to 50%	>50%
August/September 1994 Pre-nourishment Baseline Survey	Transect Data (%)	40.5	22.1	37.4
	Polygon Data (%)	42.2	25.8	32
May 2002 Post-nourishment Monitoring Survey	Transect Data (%)	33	21.4	45.6
	Polygon Data (%)	42.1	19.3	38.6

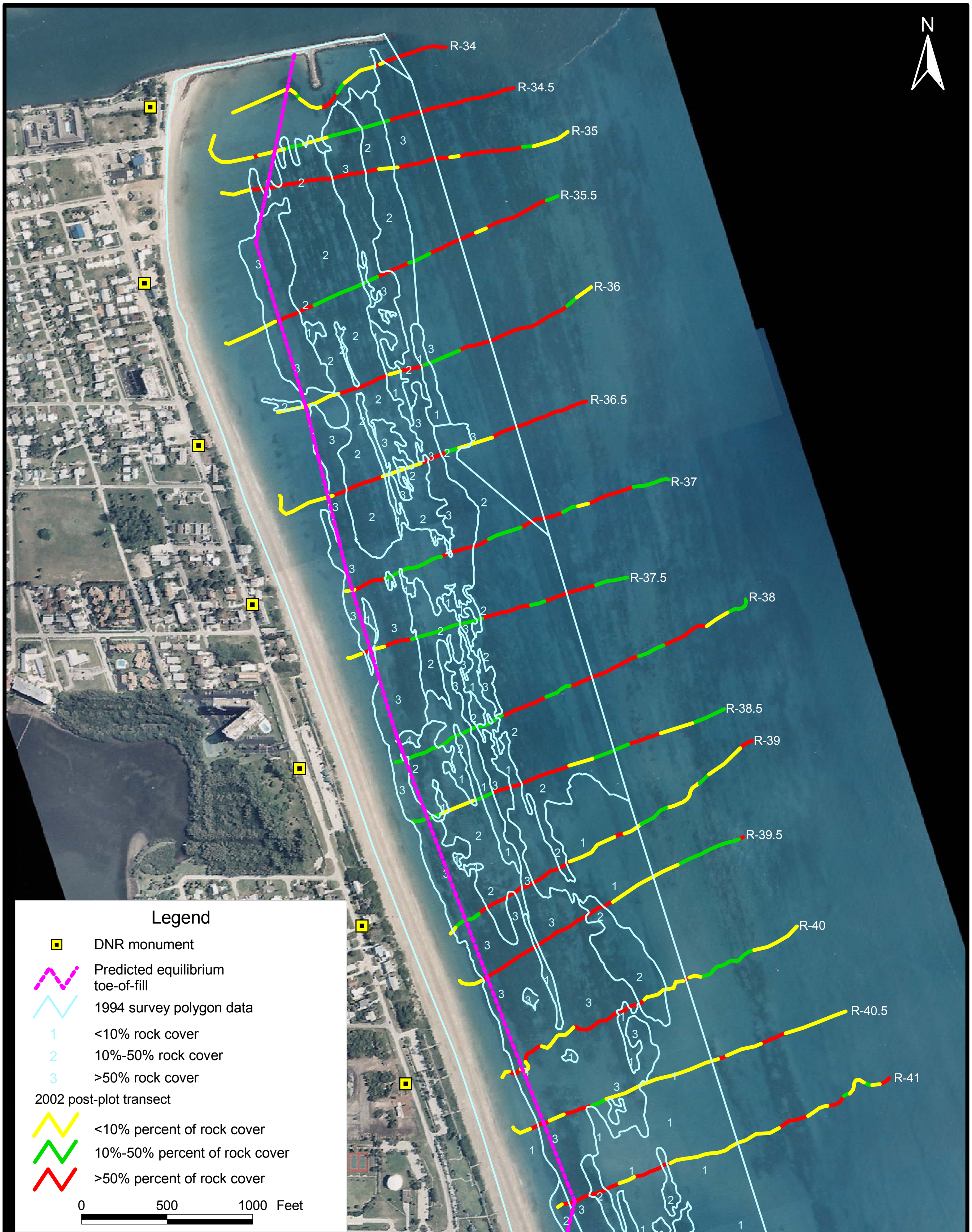


Figure 9. Comparison of identified rock substrate from the 1994 baseline survey with the May 2002 post-plot transects superimposed over the 2001 aerial images.

Table 10. Substrate classification areas from polygon data for the 1994 pre-nourishment baseline survey and the 2002 post-nourishment monitoring survey.

Survey	Exposed Rock Cover	Total Survey Area (acres)
1994 Pre-nourishment Baseline Survey	<10%	102.84
	10% to 50 %	62.91
	>50%	78.12
2002 Post-nourishment Monitoring Survey	<10%	102.67
	10% to 50 %	47.13
	>50%	93.87

The shorewardmost edge of exposed rock appeared more consistent between surveys along transects in the middle and southern portions of the survey area. The May 2000 report used the loss of exposed rock habitat, due to sand cover, west of the predicted equilibrium toe-of-fill as an assessment of direct impact due to the 1995 and/or 1999 beach nourishment projects. This method, however, excluded the shorewardmost edges of exposed rock that occurred east of the predicted equilibrium toe-of-fill and may have resulted in a misinterpretation of the impacts. **Figure 10** shows the estimated loss of exposed rock substrate west of the shoreward reef edge border between the August/September 1994 and the May 2002 surveys. The exposed rock classified during the August/September 1994 baseline survey, but no longer visible west of the shoreward reef edge border that was delineated from the May 2002 polygon data, was calculated as a loss of exposed rock habitat. These analyses indicate that 0.67 acres of substrate with 10% to 50% exposed rock cover and 4.35 acres of substrate with greater than 50% exposed rock cover was lost between the August/September 1994 and the May 2002 surveys. If the 1999 beach nourishment project had an effect on the physical or biological characterization of the exposed rock community south of Fort Pierce, Florida, it likely would have occurred nearest to shore. The loss of exposed rock habitat west of the shoreward reef edge border, therefore, may be attributed to direct impacts of the 1999 beach nourishment project. The placement of sand from the 1995 maintenance dredging of the Fort Pierce Inlet also may have contributed to the loss of exposed rock west of the shoreward reef edge border.

The differences in distribution of exposed rock habitat between the August/September 1994 and the May 2002 surveys may also be within the bounds of natural variability. This variability in exposed rock areas is caused by water currents, wave action, the resultant natural sand movement, and other physical forces typically associated with this high energy habitat.

4.3.2 Photoquadrat Stations

Table 11 presents the percent cover of biota (plant and animal) and substrate in each of the photoquadrat stations from the August/September 1994 baseline survey and the May 2000 and May 2002 monitoring surveys. Biotal cover was higher during the August/September 1994 survey than during successive monitoring surveys. Two of the photoquadrat stations surveyed during the May 2002 monitoring survey were predominantly sand (Stations 1 and 3). Only four of the seven photoquadrat stations were sampled during the May 2000 survey; Stations 1 and 3 were not located, and poor visibility at Station 2

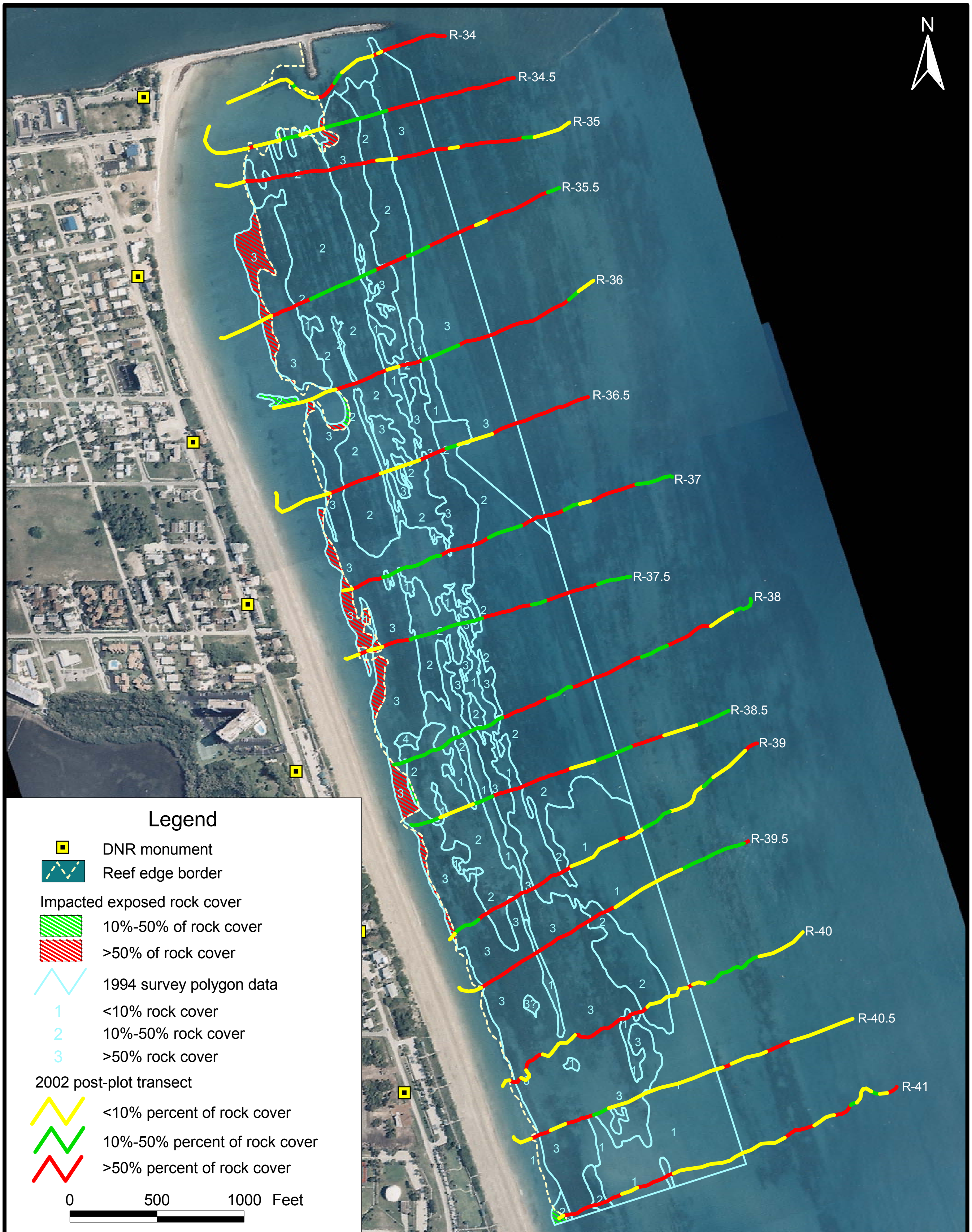


Figure 10. Impacted exposed rock determined from 2001 aerial photographs and 2002 post-plot transect data.

Table 11. Mean percent cover of plant, animal, and substrate at each photoquadrat station sampled during the August/September 1994 baseline survey, the May 2000 monitoring survey, and the May 2002 monitoring survey.

Photoquadrat Station	Mean Percent Cover			
	Survey	Plant	Animal	Substrate
PQ-1	August/September 1994	15	31	54
	May 2000	N/A	N/A	N/A
	May 2002	13.6	0.2	86.2
PQ-2	August/September 1994	7	44	47
	May 2000	N/A	N/A	N/A
	May 2002	37.4	12.6	50
PQ-3	August/September 1994	12	42	46
	May 2000	N/A	N/A	N/A
	May 2002	35.2	0	64.8
PQ-4	August/September 1994	10	60	30
	May 2000	0	4.4	95.6
	May 2002	47	5	48
PQ-5	August/September 1994	17	55	28
	May 2000	0.04	0.26	99.2
	May 2002	45.8	0.2	54‘
PQ-6	August/September 1994	31	39	30
	May 2000	0.01	0.04	99.95
	May 2002	81.2	3.8	15
PQ-7	August/September 1994	23	55	22
	May 2000	0	20.6	79.8
	May 2002	45.8	25	29.2

precluded data collection at that station. The quantitative data from the May 2000 report indicated high mean percent cover of substrate (rock, rock-sand, and shell) and a low percent cover of plant species from each station surveyed. With the exception of Station 6, the August/September 1994 survey reported a higher mean percent cover for both substrate and animal species than for plant species. The May 2002 survey, however, reported high values of plant species, primarily due to the presence of turf algae at each of the photoquadrat stations. This may be contributed, in part, to seasonal differences in algal densities. The May 2000 and May 2002 surveys had similar estimates for mean percent cover of animal species at Station 7, primarily due to the presence of sabellariid worm rock (*P. lapidosa*). It is possible that the 1999 beach nourishment project had a direct effect on the biotal cover at Stations 1 and 3. These stations occurred closest to shore and to the shoreward reef edge. However, the low biotal cover and increased sand cover at Stations 1 and 3 also may have been the result of the highly ephemeral, high energy environment. It is less likely that the 1999 nourishment project had a direct effect on the biotal cover at Stations 2, 6, and 7. These photoquadrat stations were positioned further east than Stations 1 and 3, and most occurred in predominantly slightly higher relief hard bottom areas. It was possible, however, that sand scouring may have had an indirect effect on the biotal cover at Stations 4 and 5. These photoquadrat stations occurred in low relief hard bottom areas that were more susceptible to scouring.

5.0 SUMMARY

The second post-nourishment monitoring survey was conducted on the hard bottom habitat south of the Fort Pierce Inlet, Fort Pierce, Florida. Video and diver observational data were collected along 15 previously surveyed transects and at seven previously surveyed photoquadrat stations. Transects were established from DNR monuments R-34 through R-41, were oriented perpendicular to shore, and extended offshore approximately 2,000 ft. Simultaneous video and navigational position data were collected along each of the 15 survey transects.

Video data were reviewed to identify substrate types and characterize biological communities. Substrate observed along each transect 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 plotted to map the identified substrate along post-plot transects. Exposed rock observed south of the Fort Pierce Inlet was composed of striated reef trends that parallel the shoreline. The May 2002 transect data indicated that the dominant substrate category observed in the survey area was greater than 50% exposed rock cover (45.6%). The second most abundant rock cover was the less than 10% category, comprising 33% of the total transect lengths surveyed. Sand was most abundant in the nearshore areas on the northern transects and along the southern transects. The 10% to 50% rock cover category comprised 21.4% of the total transect lengths surveyed. Substrate with 10% to 50% exposed rock cover was most abundant along transects in the middle of the survey area.

The 2001 aerial images were used to supplement May 2002 transect data for interpreting substrate classifications between survey transects. Polygons were generated to quantify the interpreted substrate. The less than 10% exposed rock cover (42.1%) and greater than 50% exposed rock cover (38.6%) categories were the dominant substrate types. The 10% to 50% exposed rock cover category comprised approximately 19.3% of the total survey area.

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 ahermatypic hard corals.

A total of 10 quantitative still photographs were analyzed from each of the seven photoquadrat stations to determine the percent cover of identifiable species. Substrate (sand and rock) was the dominant cover at most photoquadrat stations. Stations 1 (86%) and 3 (65%) had the highest cover of substrate. Stations 2, 4, 6, and 7 had high percent cover of animal species due to primarily high relief of exposed rock cover at these stations. Stations 6 and 7 had high biotic cover due to the presence of a dense algal cover and sabellariid worm rock (*P. lapidosa*).

A comparison of the hard bottom mapping data indicated that there has been moderate change in the overall percent of substrate types between the August/September 1994 and May 2002 surveys. Transect data indicate an increase in substrate with greater than 50% exposed rock cover and a slight decrease in substrate with less than 10% and 10% to 50% exposed rock cover. Substrate classification areas from polygon data for the total survey area indicate that the greater than 50% exposed rock cover category had increased 15.8 acres and the 10% to 50% exposed rock cover had decreased 15.8 acres between the August/September 1994 and the May 2002 surveys. The nearshore exposed rock west of the May 2002 delineated reef edge border with 10% to 50% and greater than 50% cover was shown to decrease approximately 0.67 and 4.35 acres, respectively, between the August/September 1994 and May 2002 surveys. Photoquadrat data indicated that biotic cover was greater during the August/September 1994 baseline survey compared to the May 2000 and May 2002 monitoring surveys.

It is possible that the 1999 beach nourishment project had an effect on the decreased biotal cover and exposed rock cover occurring closest to shore. The estimated area of direct impact was 5.02 acres, if the area of impact is based on the reported loss of 10% to 50% and greater than 50% exposed rock cover west of the May 2002 shoreward reef edge border. Indirect impacts may have included decreased biotic cover on some nearshore exposed rock. However, these changes in exposed rock cover catagories also may be the result of this being a highly ephemeral, high energy environment. With the available data, it was not possible to determine conclusively whether these differences in rock cover or biotic cover are the direct effect of the 1999 beach nourishment project.

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APPENDIX

REPRESENTATIVE PHOTOGRAPHS

Photo 1. Quantitative image of sand bottom at photoquadrat station 1.

Photo 2. Quantitative image of sand veneered hard bottom at photoquadrat station 1.

Photo 3. Quantitative image of purple sea urchins (*Arbacia punctulata*) on exposed hard bottom at photoquadrat station 2.

Photo 4. Qualitative image of purple sea urchins (*A. punctulata*) on exposed hard bottom near photoquadrat station 2.

Photo 5. Quantitative image of sand bottom with recently exposed hard bottom at photoquadrat station 3.

Photo 6. Qualitative image of exposed hard bottom with an unidentified filamentous green algae near photoquadrat station 3.

Photo 7. Quantitative image of exposed hard bottom with slight sand veneer at photoquadrat station 4.

Photo 8. Qualitative image of a sheepshead (*Archosargus probatocephalus*) over sabellariid worm rock (*Phragmatopoma lapidosa*) with purple sea urchins (*A. punctulata*) and unidentified ascidians near photoquadrat station 4.

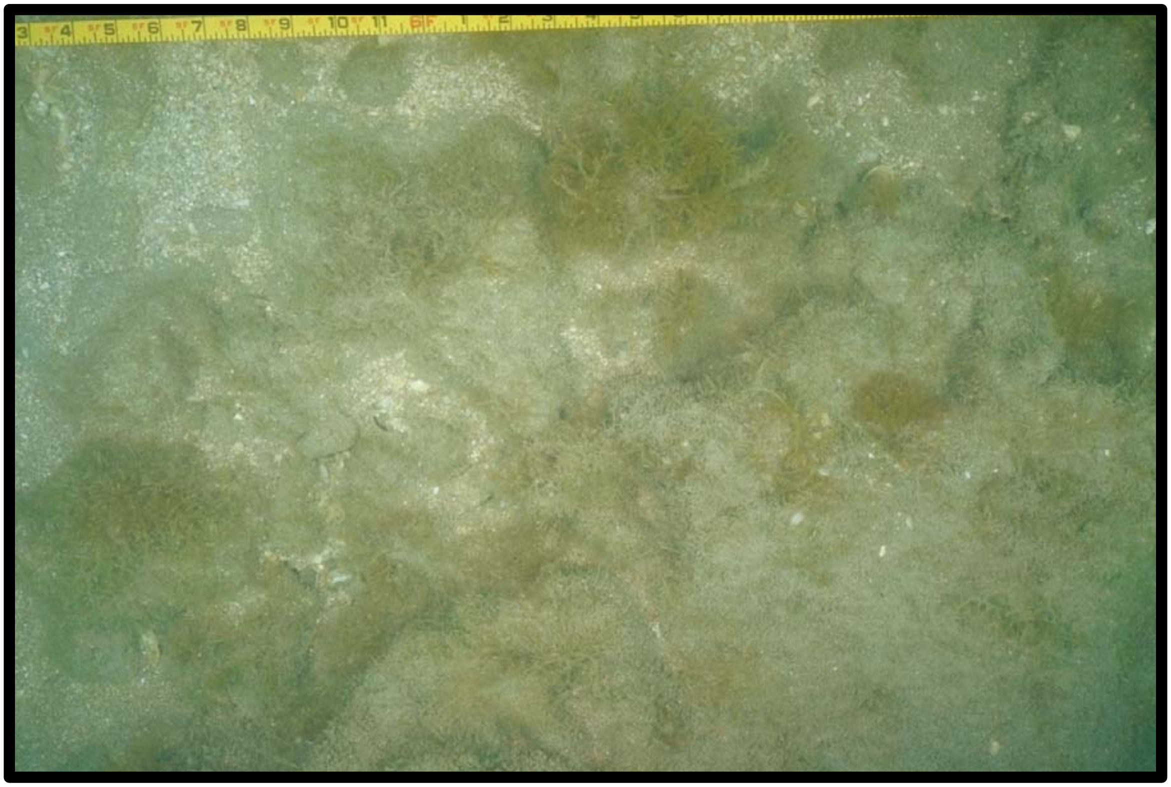

Photo 9. Quantitative image of exposed hard bottom with turf algae and a slight sand veneer at photoquadrat station 5.

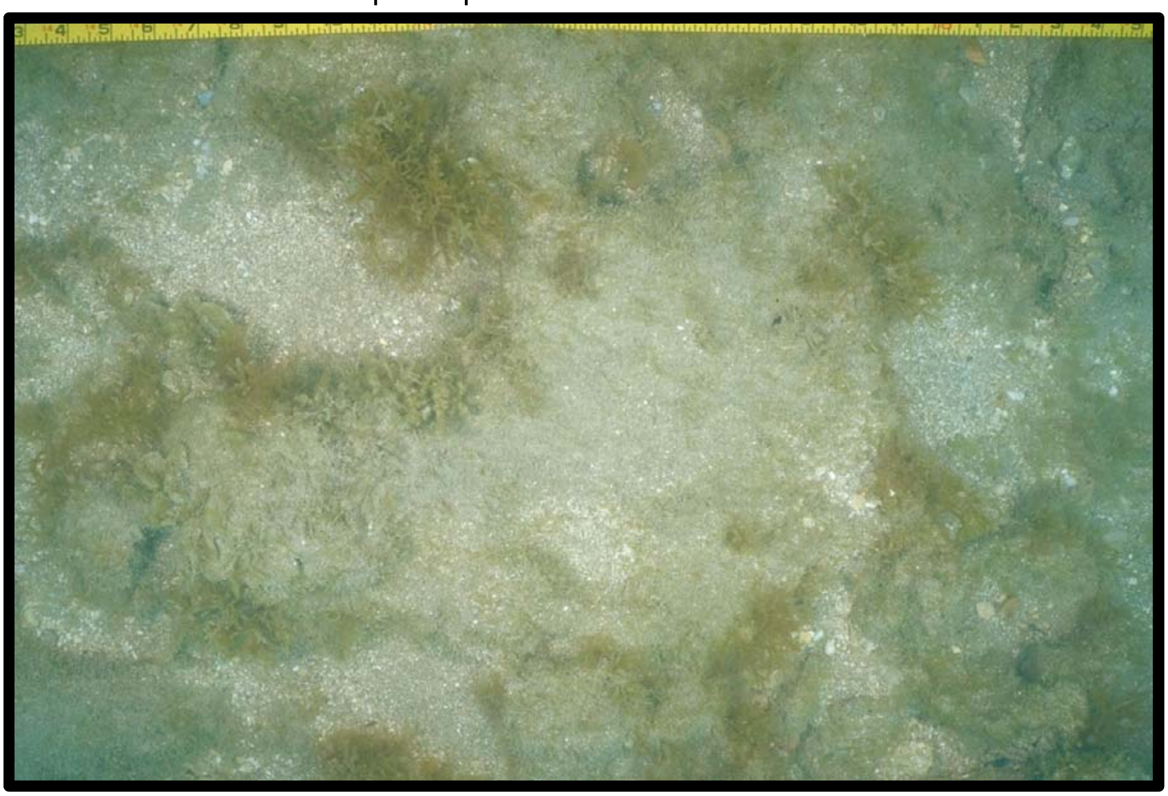

Photo 10. Quantitative image of exposed hard bottom with turf algae and a slight sand veneer at photoquadrat station 5.

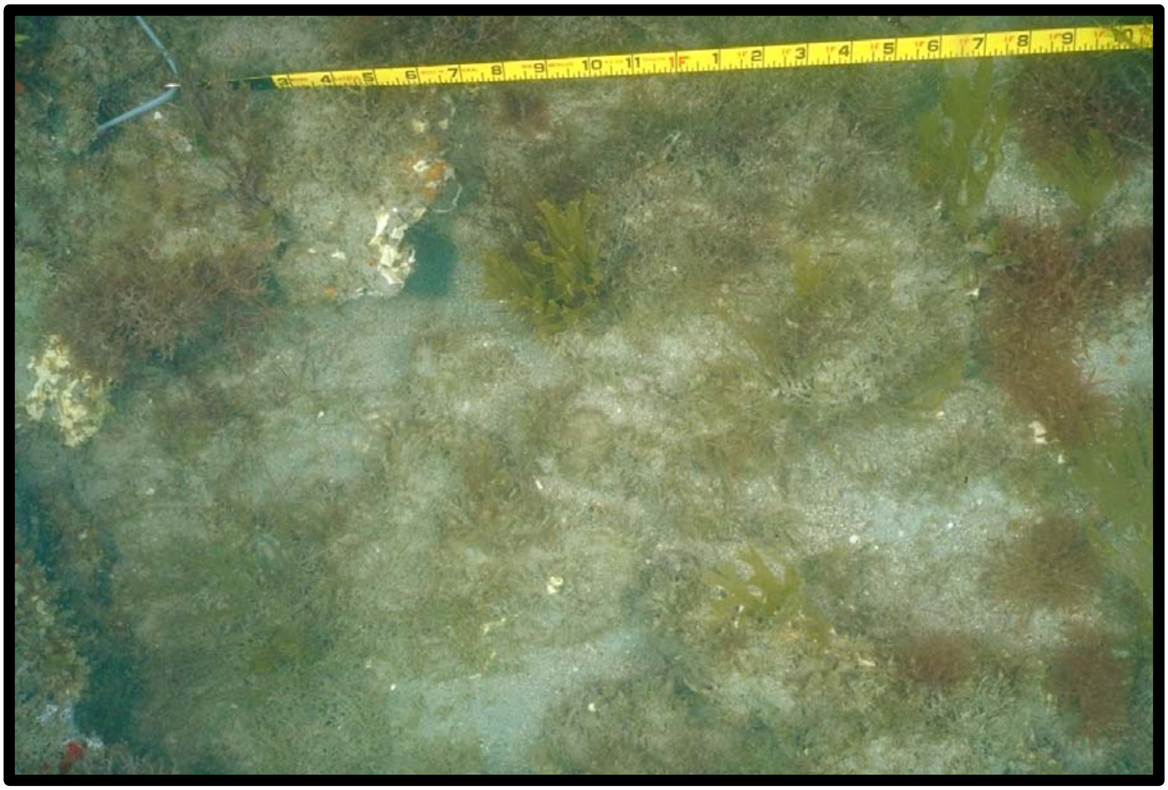

Photo 11. Quantitative image of exposed hard bottom with dense algal cover and unidentified colonial ascidians at photoquadrat station 6.

Photo 12. Quantitative image of exposed hard bottom with dense algal cover, unidentified colonial ascidians, and sabellariid worm rock (*P. lapidosa*) at photoquadrat station 6.

Photo 13. Quantitative image of sabellariid worm rock (*P. lapidosa*) with slight sand veneer at photoquadrat station 7.

Photo 14. Qualitative image of rock-boring urchin on sabellariid worm rock (*P. lapidosa*) near photoquadrat station 7.