APPENDIX J

HARDBOTTOM AND FISH COMMUNITY CHARACTERIZATION REPORTS

SUB-APPENDIX J1

BASELINE NEARSHORE HARDBOTTOM CHARACTERIZATION REPORT

Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project

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EXECUTIVE SUMMARY

CSA International, Inc. (CSA) was contracted through Coastal Technology Corporation (Coastal Tech) to conduct a baseline biological community mapping and characterization survey along the southern St. Lucie County coastline prior to potential beach nourishment for the St. Lucie County South Beach Project. The survey area extends from Florida Department of Environmental Protection (FDEP) Range Monument R-77 in St. Lucie County south to FDEP Range Monument R-3 in Martin County. The survey was proposed to be conducted in a two-tiered approach over a period of two summers to account for possible delays due to adverse field conditions.

CSA received a notice to proceed on 8 August 2008 and began work on 15 August 2008 during the first acceptable weather window. Three of the 22 proposed permanent cross-shore transects were installed, one near FDEP Range Monument R-104 in St. Lucie County (Transect R-104.5) and two in Martin County (R-1 and R-3). Persistently adverse sea conditions related to the passage of Tropical Storms Fay, Hanna, and Kyle in late August and September 2008 prevented installation and survey of additional transects. However, ideal field conditions during the summer of 2009 allowed for completion of the following remaining survey objectives:

- Establish and survey the remaining 19 proposed permanent cross-shore transects (Tier 1: R-77, R-80, R-84, R-88, R-92, R-96, R-100, R-108, and R-112; Tier 2: R-78, R-82, R-86, R-90, R-94, R-98, R-102, R-106, R-110, and R-114);
- Map the nearshore hard bottom edge within the project area; and
- Perform single video transect surveys along the length of each of six potential pipeline corridors.

Twenty-two permanent transects were installed perpendicular to shore near proposed FDEP range monuments. Final transect locations varied slightly from the initial proposed locations to avoid areas devoid or largely devoid of hard bottom and to ensure transect installation near candidate pipeline corridor routes identified by Coastal Tech. Permanent transects were installed at R-77.7, R-78.7, R-80.4, R-82.8, R-85, R-86.3, R-88.7, R-90.4, R-92, R-93.5, R-100, R-101, R-102, R-103.2, R-104.5, R-105.9, R-109.2, R-110, R-110.5, and R-112 in St. Lucie County and R-1 and R-3 in Martin County. Each transect extended from the landward edge of exposed nearshore hard bottom to the easternmost extent of exposed hard bottom along the transect not exceeding 150 m in total length.

Scientists collected quantitative and qualitative video data along the entire length of each transect to determine percent cover of benthic flora, fauna, and substrate components. In addition, *in-situ* quadrats were sampled at 10 to 12 point-intercept locations along each transect. The nearshore hard bottom edge was mapped to document the position of the nearshore edge of exposed hard bottom and characterize associated benthic communities within the survey area.

Percent cover of each taxa as well as major categories (macroalgae, fauna, substrate, and biotic turf) was calculated from quantitative video using the point count method and from raw *in-situ* quadrat data. Percent cover data sets were log transformed and subjected to nonparametric statistical analyses with PRIMER 6.1.6 statistical software to investigate potential patterns in datasets.

Substrate was the dominant benthic cover for both video and *in-situ* quadrat data with a mean percent cover of 51.2% and 61.9%, respectively, and was composed primarily of sediment over hard substrate. Macroalgae was the second most dominant major category group with a mean percent cover of 32.0% for video data and 33.6% for quadrat data. Dominant macroalgal taxa observed included turf algae, the red algae *Bryothamnion seaforthii* and *Hypnea musciformis*, and the green alga *Caulerpa* sp. Sabellariid wormrock (*Phragmatopoma lapidosa*) was the most abundant fauna; other common faunal taxa observed included encrusting sponges, tunicates, urchins, and holothurids. Only three scleractinian coral (*Phyllangia americana americana*) polyps were observed along project area transects on Transect R-110.5 in the 20-m quadrat and accounted for an overall mean count per quadrat of 0.3 along this transect.

Some compositional trends were observed through statistical analysis of video and quadrat data indicating two distinct nearshore environments among transects. Transects installed further from shore, but still along the nearshore edge, in 3 to 4 m water depths supported greater faunal diversity when compared to the more nearshore transects in 1 to 2 m water depths. Additionally, transects along the northern portions (R-77 to R-90.4) were dominated by more robust, canopy-forming red algae and wormrock while transects further to the south supported a more prolific turf algae component.

Three distinct hard bottom communities within the survey area were described from nearshore hard bottom mapping: a low- to medium-relief (0.5 to 1.5 m) wormrock-dominated ledge, low-relief consolidated coquina ledge, and a low- to medium-relief deeper water ledge composed of large slab rock structures. These three types of hard bottom features supported vastly different benthic communities from north to south along the survey area and ranged from approximately 11 m to 196 m from the 2008 mean high water line.

Six potential pipeline corridors were mapped during the survey just offshore FDEP Range Monuments R-89 (PC-1), R-100 (PC-2), R-101 (PC-3), R-104 (PC-4), R-108 (PC-5), and R-114 (PC-6). Hard bottom was recorded along nearshore portions of four of the six pipeline corridors with the remaining two corridors composed entirely of unconsolidated sand and/or low-relief consolidated shell hash mounds.

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1.0 INTRODUCTION

CSA International, Inc. (CSA) was contracted through Coastal Technology Corporation (Coastal Tech) to conduct a baseline biological community mapping and characterization survey along the southern St. Lucie County coastline prior to potential beach nourishment for the St. Lucie County South Beach Project. The survey area extends from Florida Department of Environmental Protection (FDEP) Range Monument R-77 in St. Lucie County south to FDEP Range Monument R-3 in Martin County. Locations for 22 permanent cross-shore monitoring transects were initially selected at FDEP range monuments at approximately 600-m (2,000-ft) intervals to provide even coverage of the entire survey area (**Figure 1**).

The mapping and characterization survey was proposed to be conducted in a two-tiered approach over a period of two summers to account for possible adverse field conditions. Eleven Tier 1 cross-shore transects were to be established and surveyed at FDEP Range Monuments R-77, R-80, R-84, R-88, R-92, R-96, R-100, R-104, R-108, R-112, and R-115 along the entire north-to-south length of the project area, with establishment and survey of 11 Tier 2 cross-shore transects at FDEP Range Monuments R-78, R-82, R-86, R-90, R-94, R-98, R-102, R-106, R-110, R-114, and R-2, as conditions allowed. Prior to the initiation of field surveys, aerial imagery collected in 2008 was reviewed to determine the presence/absence of nearshore hard bottom in the vicinity of proposed transect locations. Transect positions were shifted north or south at several locations to intersect what appeared to be more significant hard bottom features.

CSA received a notice to proceed on 8 August 2008 and began work on 15 August 2008 during the first acceptable weather window. Three permanent cross-shore transects were established and surveyed in 2008, one south of FDEP Range Monument R-104 (Transect R-104.5) in St. Lucie County and two reference transects (Transects R-1 and R-3) in Martin County. Transects R-1 and R-3 were established due to insufficient hard bottom near proposed Transects R-115 and R-2, respectively. Persistently adverse sea states and poor underwater visibility conditions in the survey area due to passage of Tropical Storms Fay, Hanna, and Kyle prevented completion of all survey objectives in 2008 (CSA International, Inc., 2008). However, excellent field conditions encountered during the summer of 2009 allowed for the completion of the remaining survey objectives.

The baseline survey objectives for 2009 were as follows:

- Establish and survey the remaining 19 proposed permanent cross-shore transects (Tier 1: R-77, R-80, R-84, R-88, R-92, R-96, R-100, R-108, R-112; Tier 2: R-78, R-82, R-86, R-90, R-94, R-98, R-102, R-106, R-110, R-114);
- Map the nearshore hard bottom edge within the project area; and
- Perform single video transect surveys along the length of each of six potential pipeline corridors.

This report presents the results from the baseline biological community mapping and characterization survey conducted for the St. Lucie County South Beach Project, including data collection and analyses from 2008 and 2009 surveys. Representative frame-grabbed images from quantitative video transects and nearshore hard bottom edge mapping video, qualitative still photographs of *in-situ* quadrats, and listings of observed fauna are provided in **Appendix A**. Raw data from quantitative video (point count) and *in-situ* quadrats are provided in **Appendix B** and **Appendix C**, respectively.

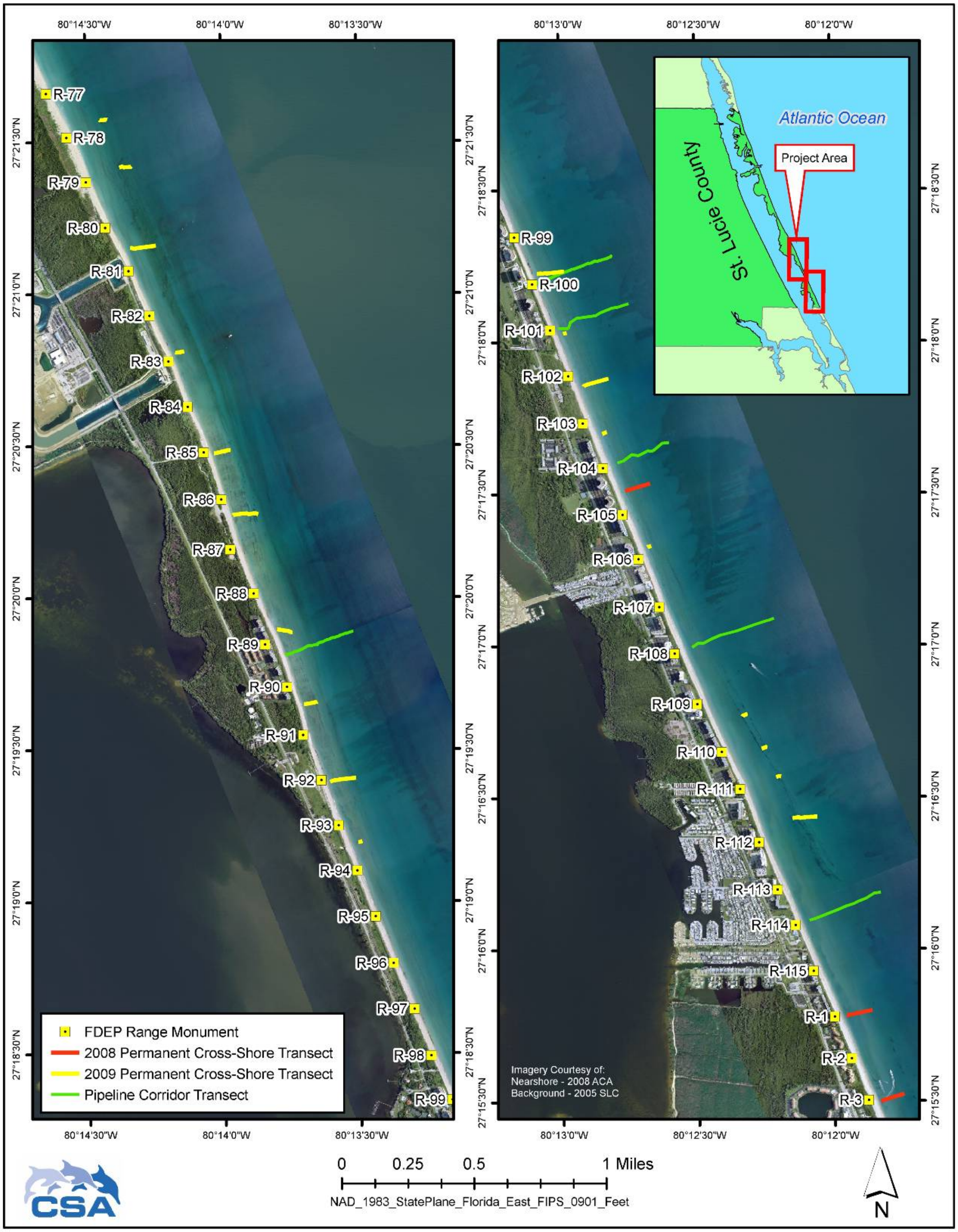


Figure 1. Survey area overview showing 22 established permanent cross-shore transects and 6 potential pipeline corridors mapped during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Transects established in 2008 are shown in red; transects established in 2009 are shown in yellow; pipeline corridors are shown in green.

2.0 METHODS

2.1 FIELD METHODS

The baseline survey was conducted during the summers of 2008 and 2009, with three permanent transects established on 15 August 2008 and remaining transects and survey objectives completed between 28 June and 15 July 2009 (**Table 1**). Weather conditions during the majority of the 2009 survey were ideal, with seas generally less than 0.6 m (2 ft) and subsurface visibility ranging from 2.0 to 3.0 m (6 to 10 ft). However, despite ideal field conditions, visibility in the extreme nearshore surfzone could be limited and ranged from 0 to 1 m (0 to 3 ft).

Table 1. Assigned tier and installation and survey dates for permanent cross-shore transects and potential pipeline corridors surveyed during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

Transect/Pipeline Corridor	Tier	Installation Date	Hard Bottom Survey Date†	Fish Survey Date
R-77.7	1	1 July 2009	1 July 2009	7 July 2009
R-78.7	2	2 July 2009	2 July 2009	18 September 2009 and 2 October 2009
R-80.4	1	30 June 2009	30 June 2009	1 July 2009
R-82.8	2	1 July 2009	1 July 2009	1 July 2009
R-85	1	3 July 2009	3 July 2009	3 July 2009
R-86.3	2	9 July 2009	9 July 2009	10 July 2009
R-88.7	1	10 July 2009	10 July 2009	10 July 2009
R-90.4	2	30 June 2009	30 June 2009	7 July 2009
R-92	1	29 June 2009	29 June 2009	7 July 2009
R-93.5	2	30 June 2009	30 June 2009	2 October 2009
R-100	1	28 June 2009	28 June 2009	3 July 2009
R-101	2	15 July 2009	15 July 2009	15 July 2009
R-102	1	28 June 2009	28 June 2009	2 October 2009
R-103.2	2	15 July 2009	15 July 2009	15 July 2009
R-104.5*	1	15 August 2008	15 August 2008	15 August 2008
R-105.9	2	2 July 2009	2 July 2009	ND
R-109.2	1	10 July 2009	10 July 2009	7 July 2009
R-110	2	2 July 2009	2 July 2009	2 October 2009
R-110.5	1	15 July 2009	15 July 2009	15 July 2009
R-112	2	29 June 2009	29 June 2009	3 July 2009
R-1**	1	15 August 2008	15 August 2008	7 July 2009
R-3**	2	15 August 2008	15 August 2008	15 August 2008
PC-1	---	---	16 July 2009	---
PC-2	---	---	16 July 2009	---
PC-3	---	---	17 July 2009	---
PC-4	---	---	17 July 2009	---
PC-5	---	---	17 July 2009	---
PC-6	---	---	17 July 2009	---

* Transect was installed and partially surveyed in 2008; however, it was completely covered by sand in 2009.
** Only quantitative video was collected along transect.
† Hard bottom survey includes quantitative and qualitative video and *in-situ* quadrat data collection for permanent cross-shore transects; only qualitative video data collected for potential pipeline corridors.
ND = Data not collected.

2.1.1 Permanent Cross-Shore Transects

A total of 22 permanent transects were installed perpendicular to shore near proposed FDEP monuments. Final transect locations varied from initial proposed locations to avoid areas devoid or largely devoid of hard bottom and to ensure transects were installed, if possible, near candidate pipeline corridor routes identified by Coastal Tech. Permanent transects were installed at R-77.7, R-78.7, R-80.4, R-82.8, R-85, R-86.3, R-88.7, R-90.4, R-92, R-93.5, R-100, R-101, R-102, R-103.2, R-104.5, R-105.9, R-109.2, R-110, R-110.5, and R-112 in St. Lucie County and R-1 and R-3 in Martin County. Transects were not installed from FDEP Range Monuments R-94 to R-99, R-107 to R-109, and R-112 to R-115 due to insufficient hard bottom in the area. Proposed transects in these areas were moved north or south within the survey area to maximize transect coverage along portions of the survey area with hard bottom features.

Each transect extended from the landward edge of exposed nearshore hard bottom to the easternmost extent of exposed hard bottom, not exceeding 150 m in total length. Transects were permanently established using uniquely tagged stainless steel 20-cm eyebolts, 40-cm short rods, and 60-cm long rods. Markers were installed along all transects at the 0-, 5-, 10-, and 20-m marks, and every 10 m for the duration of the transect length, unless otherwise dictated by hard bottom availabilty (**Table 2**). The shorter, low-relief eyebolts were installed along the shallow portions of transects where the proximity of the nearshore rock to the shoreline could pose the possibility of longer rods causing injury to swimmers, surfers, fishermen, etc. The short rods were installed along deeper transect segments to increase the possibility of marker relocation during potential future monitoring events. When water depths allowed, long rods were installed to more clearly mark transect end points. Where significant (>5 m) sand and/or shell hash gaps occurred between shore-parallel bands of hard bottom, a marker was placed at both the landward and seaward hard bottom edges. A differential global positioning system (DGPS) was used to collect latitude and longitude data at all permanent markers installed for each transect. Coordinates for all permanently installed 0-m markers for all transects are displayed in **Table 3**.

2.1.2 Video Data Collection

Scientists collected quantitative video data along the entire length of each of the 22 permanent cross-shore transects to determine percent cover of substrate and biotic groups including scleractinian corals (to the genus level), octocorals, macroalgae (to lowest possible taxonomic unit), cyanobacteria, sponges, tunicates, hydroids, wormrock (*Phragmatopoma lapidosa*), zoanthids, urchins, holothuroids, other benthic fauna, and substrate. A Sony® TRV 900 digital videocamera in an Amphibico® Navigator housing equipped with underwater lights was used to record video in progressive scan mode. The video camera was held perpendicular to the bottom substrate with two lasers converging at a distance 25 cm from the camera lens to maintain a constant camera height above the seafloor (**Photo 1**).

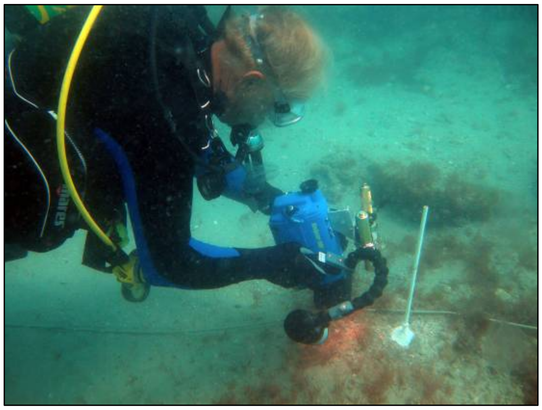


Photo 1. Scientist collecting quantitative video data along a permanent cross-shore transect.

Qualitative video data also were collected along the entire length of each transect approximately 40 to 50 cm above the seafloor at a 45º angle to facilitate determination of benthic relief changes, identification of macroalgal species, and to assist documentation of scleractinian corals and other fauna of interest in the general vicinity of each transect.

Table 2. Marker location and type installed on permanent cross-shore transects established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Note: shaded areas denote start and end of significant (>5 m) sand and/or shell hash gaps.

Transect																					
R-77.7		R-78.7		R-80.4		R-82.8		R-85		R-86.3		R-88.7		R-90.4		R-92		R-93.5		R-100	
Marker Location (m)	Marker Type	Marker Location (m)	Marker Type	Marker Location (m)	Marker Type	Marker Location (m)	Marker Type	Marker Location (m)	Marker Type	Marker Location (m)	Marker Type	Marker Location (m)	Marker Type	Marker Location (m)	Marker Type	Marker Location (m)	Marker Type	Marker Location (m)	Marker Type	Marker Location (m)	Marker Type
0	EB	0	EB	0	EB	0	EB	0	N/A	0	EB	0	EB	0	EB	0	EB	0	EB	0	EB-HB patch
3	SR- start sand	5	EB	5	EB	5	EB	5	EB-start sand	5	EB	5	EB	12	EB	5	EB	5	EB	10	EB-end sand
10	SR-end sand	10	EB	10	EB	10	EB	12	EB-end sand	11	EB	10	EB	20	EB	10	EB	10	EB	20	EB
20	EB	19	EB	15	SR- start sand	21	EB	20	EB	20	EB	20	EB	30	EB	20	EB	20	EB-start sand	30	EB
22	SR-start sand	30	EB	23	SR-end sand	31	EB	30	EB	29	EB	31	EB	50	EB	30	EB	27	EB-end sand	44	SR-start sand
43	SR-end sand	37	SR-start sand	30	EB	37	EB-start sand	40	EB	40	EB	39	EB	60	EB	40	EB	29	EB	58	EB-HB patch
46	LR	67	SR-HB patch	36	SR-start sand	53	EB-HB patch	51	EB	50	EB	50	EB	70	EB	48	EB-start sand				
		75	LR-HB patch	152	LR-HB patch			60	EB	60	EB	60	EB	80	EB	56	EB-end sand				
								70	EB	70	EB	70	EB			59	EB				
								81	EB-start sand	80	EB	81	EB-start sand			68	EB				
								93	EB-end sand	89	EB-start sand	92	EB-end sand								
								100	EB	101	EB-end sand	95	EB								
								102	EB	122	EB										
										136	EB										

EB = eyebolt (20 cm high); SR = short rod (40 cm high); LR = long rod (60 cm high); HB = hard bottom.

Table 2. (Continued).

Transect																					
R-101		R-102		R-103.2		R-104.5		R-105.9		R-109.2		R-110		R-110.5		R-112		R-1		R-3	
Marker Location (m)	Marker Type	Marker Location (m)	Marker Type	Marker Location (m)	Marker Type	Marker Location (m)	Marker Type	Marker Location (m)	Marker Type	Marker Location (m)	Marker Type	Marker Location (m)	Marker Type	Marker Location (m)	Marker Type	Marker Location (m)	Marker Type	Marker Location (m)	Marker Type	Marker Location (m)	Marker Type
0	EB	0	EB	0	EB	0	EB	0	EB	1	EB	1	EB	0	EB	0	SR-HB patch	0	EB	0	EB
6	EB	5	EB-start sand	7	EB	8	EB	5	EB	5	EB	10	SR-start sand	8	SR-start sand	30	SR-end sand	4.5	EB	5	EB
8	EB-start sand	20	EB-end sand	10	EB			10	EB	10	SR-start sand	30	SR-end sand	15	SR-end sand	40	SR-start sand	10	EB	10	EB-HB patch
22	EB-end sand	30	EB	19	EB			19	EB	30	SR-end sand	36	LR	19	EB	49	SR-HB patch	12.5	EB	20	EB-HB patch
25	EB			29	EB			26	EB	35	LR			31	LR	70	SR-end sand				
																74	SR				

EB = eyebolt (20 cm high); SR = short rod (40 cm high); LR = long rod (60 cm high); HB = hard bottom.

Table 3. Geographic coordinates of permanently installed 0-m markers for cross-shore transects established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

Transect	0-m Transect Marker			
	Easting (X)	Northing (Y)	Latitude (N)	Longitude (W)
R-77.7	902605.2	1100625.3	27°21'34.3647"	80°14'26.7191"
R-78.7	902993.8	1099680.5	27°21'24.9857"	80°14'22.4734"
R-80.4	903212.9	1098087.7	27°21'09.2003"	80°14'20.1514"
R-82.8	904110.0	1096000.3	27°20'48.4762"	80°14'10.3448"
R-85*	904884.2	1093989.6	27°20'28.5189"	80°14'01.8967"
R-86.3	905262.5	1092750.9	27°20'16.2300"	80°13'57.7864"
R-88.7	906142.2	1090484.1	27°19'53.7301"	80°13'48.1873"
R-90.4	906684.8	1088989.9	27°19'38.9011"	80°13'42.2737"
R-92	907205.0	1087442.2	27°19'23.5436"	80°13'36.6126"
R-93.5	907766.6	1086243.6	27°19'11.6404"	80°13'30.4688"
R-100	910109.7	1080392.5	27°18'13.5571"	80°13'04.8989"
R-101	910630.2	1079201.0	27°18'01.7263"	80°12'59.2122"
R-102	911037.4	1078145.5	27°17'51.2493"	80°12'54.7721"
R-103.2	911413.8	1077202.6	27°17'41.8891"	80°12'50.6659"
R-104.5	911874.6	1076062.0	27°17'30.5659"	80°12'45.6381"
R-105.9	912309.7	1074945.5	27°17'19.4829"	80°12'40.8938"
R-109.2	914211.7	1071569.9	27°16'45.9378"	80°12'20.0515"
R-110	914591.5	1070932.7	27°16'39.6042"	80°12'15.8874"
R-110.5	914880.2	1070365.7	27°16'33.9715"	80°12'12.7281"
R-112	915205.7	1069546.7	27°16'25.8411"	80°12'09.1788"
R-1	916285.0	1065615.7	27°15'46.8472"	80°11'57.4974"
R-3	916975.2	1063904.8	27°15'29.8618"	80°11'49.9713"

* Coordinate of 0-m mark, permanent marker not installed.
Coordinate Datum: NAD_1983_StatePlane_Florida_East_FIPS_0901_Feet, using WGS 84.

2.1.3 *In-situ* Quadrat Sampling

In-situ quadrats were sampled at 10 to 12 point-intercept locations (unless otherwise noted due to lack of hard bottom substrate) along each of the permanent transects. The first quadrat was located at the nearshore hard bottom edge (0-m mark) with subsequent quadrats placed at established transect markers or at designated hard bottom locations along the transects. A diver equipped with a 0.25-m^2 grid sampled each quadrat site to determine percent cover of scleractinian corals, octocorals, macroalgae, cyanobacteria, sponges, tunicates, hydroids, wormrock, zoanthids, urchins, holothuroids, and substrate. Individual counts were made of all scleractinian corals, octocorals, sponges (not including *Cliona* sp., which was assessed for percent cover only), colonies of tunicates, urchins, and holothuroids within the quadrat. Percent cover of consolidated substrate (rock), unconsolidated substrate (sand, shell hash, rubble, and rhodoliths), and sediment over hard substrate were recorded. Scleractinian corals and octocorals also were assessed by size class distribution (diameter of scleractinian/height of octocoral), with size classes 1, 2, 3, and 4 corresponding to <5 cm, 5 to 15 cm, 15 to 25 cm, and >25 cm, respectively.

Maximum and mean heights of thalli (stalks) for the two dominant algal species were determined from measurements at five selected locations within each quadrat. Maximum physical relief of hard bottom within each quadrat was measured to the nearest centimeter. In addition, sediment accumulation was measured on the flat (horizontal) surface of hard bottom within all *in-situ* quadrats. Sediment thickness was measured to the nearest centimenter at five random locations within each quadrat. Sediment accumulation was also measured and recorded at each permanent marker (rod or eyebolt) along transects and at a point 1 m west of the same marker.

2.1.4 Nearshore Hard Bottom Edge Mapping

Hard bottom edge mapping was conducted from 10 to 12 June and on 16 July 2009 to map and document the nearshore edge of exposed hard bottom and associated benthic communities between FDEP Range Monument R-77 in St. Lucie County and FDEP Range Monument R-2 in Martin County. The nearshore hard bottom edge was surveyed by a two-diver team on SCUBA towing a taut-line radio telemetry buoy with attached DGPS antenna, which transmitted continuous positions to Hypack® hydrographic survey software on board the survey vessel. For descriptive analysis, geo-referenced qualitative video data were collected along the entire nearshore hard bottom edge. The camera was positioned at an oblique angle approximately 40 cm (or within visibility limits) above the seafloor to qualitatively document the benthos.

2.1.5 Pipeline Corridors

Six potential shore-perpendicular pipeline corridors selected by Coastal Tech were surveyed by a two-diver team on SCUBA on 16 and 17 July 2009. The team began each survey in the nearshore surf zone and swam east until the end of the corridor was reached, towing a taut-line radio telemetry buoy with a DGPS antenna. Geo-referenced qualitative video data were collected to document the presence of sensitive hard bottom and/or wormrock communities and assist in descriptive analyses of substrate types along each pipeline corridor.

2.2 DATA ANALYSIS

2.2.1 Video Data Analysis

One or two (depending on length of transect and hard bottom availablility) segments from each of the cross-shore video transects were quantitatively analyzed from digitally frame-grabbed underwater video images. **Table 4** displays the video segments analyzed for each transect and total length of hard bottom analyzed within each segment. The first segment included the first 20 m of available hard bottom (commencing at the 0-m mark at the exposed nearshore hard bottom edge) along each transect while the second segment (if adequate hard bottom was available) included hard bottom at an interval between the 40- and 70-m marks along each transect.

Digitized video frames from each video segment were extracted and saved in .jpg format. The percent cover of benthic biota and substrate was estimated using the CPCe V3.6 (Coral Point Count with Excel extensions) software analysis program (Kohler and Gill, 2006). CPCe utilizes the random point count method described by Bohnsack (1979) to accurately estimate percent cover of benthic organisms and associated substrate from digital underwater images. A total of 25 random points was projected on each quantitative image. Biota or substrate beneath each point was identified, and the data from each image were saved in a spreadsheet for percent cover calculations and statistical analyses by transect segment. In addition, overall percent cover of individual taxa and major categories (scleractinian corals, macroalgae, fauna, cyanobacteria, and substrate) was calculated as the total percent cover (points identified for survey area ÷ total points for survey area = overall percent cover) for the entire survey area. As a result of the objective to target and characterize available hard bottom within the survey area, all video transect frames containing only sand/fine shell hash and with no visible floral or faunal components were eliminated from the point count analysis.

Table 4. Transect segments selected for quantitative video analysis for permanent cross-shore transects established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

Transect	Quantitative Video Analysis		
	Transect Segment (m)	Hard Bottom Length (m)	Number of Frames Analyzed
R-77.7	0-22	15	53
	40-46	3	17
R-78.7	0-26	20	77
	40-75	2	11
R-80.4	0-28	20	85
R-82.8	0-20	20	78
	40-53	4	12
R-85	0-26.5	20	80
	40-60	20	94
R-86.3	0-20	20	91
	40-60	20	84
R-88.7	0-20	20	81
	40-63	20	96
R-90.4	0-20	20	46
	40-60	20	74
R-92	0-20	20	93
	40-69	13	64
R-93.5	0-20	20	72
R-100	0-29	20	84
	40-59	2	9
R-101	0-25	11	48
R-102	0-30	16	78
R-103.2	0-29	20	97
R-104.5*	ND	ND	ND
R-105.9	0-21	20	95
R-109.2	0-35	12	57
R-110	0-36	10	49
R-110.5	0-29	20	86
R-112	0-40	11	46
	40-74	8	41
R-1	0-12	10	52
R-3	0-20	8	38

Note: R-104.5 was installed in 2008; however, it was completely covered by sand in 2009.

Video identification was constrained to visually conspicuous organisms with well-defined diagnostic characteristics for visual identification. Identification of small benthos (e.g., solitary tunicates, bryozoans, hydroids, barnacles, etc.) often was not possible; therefore, cover may be underestimated with video identification and point count methods. Within the macroalgae category, turf algae was used for low-relief (<5 cm), unidentifiable algae in order to differentiate it from larger, canopy-forming, branching macroalgae. Biotic turf was utilized as a category for the unidentifiable, low-relief mat comprising of a mix of small biotic elements including turf algae, cyanobacteria, bryozoans, and/or hydroids and other abiotic elements.

For quality assurance and control (QAQC) purposes, 10% of the extracted point count frames from each transect segment were analyzed and identical points identified by two analysts to assess inter-observer variablility within the method. If point identification agreement between the two analysts did not meet 90% (excluding turf vs. biotic turf discrepancies) along the transect segment, data collected from this segment were re-analyzed until identified point agreement met the 90% QAQC standard.

Video percent cover data were imported into PRIMER 6.1.6 statistical software, log transformed, and used to create similarity matrices with the Bray-Curtis similarity index (Bray and Curtis, 1957). These similarity matrices were analyzed using nonparametric multi-dimensional scaling (MDS) and group average cluster analysis to visualize potential patterns in data. To accentuate visualization of clusters, similarity clusters were overlaid on MDS plots and also displayed as dendrograms. To gain a better understanding of the similarity clusters, similarity percentages (SIMPER) (Clarke, 1993) were run to determine specific categories responsible for significant differences between clusters.

2.2.2 *In-situ* Quadrat Data Analysis

Data from *in-situ* quadrat sampling were reviewed and entered into a Microsoft Excel spreadsheet. Mean percent cover of all identified taxa and major categories were calculated by transect and overall percent cover was calculated as a mean across all transects. Mean sediment depths were derived from five random measurements within each quadrat while sediment depths at each permanent marker and 1 m west of each marker along transects were calculated and compiled into a single table for comparisons. Multivariate analyses were performed on *in-situ* quadrat data using methods identical to those described for video data.

2.2.3 Nearshore Hard Bottom Edge Mapping Analysis

Nearshore hard bottom edge navigational positions were exported for use in ArcGIS software and displayed in relation to aerial imagery and other spatial features. Geo-referenced video data were qualitatively reviewed to describe the benthic landscape including physical relief and fauna/species of interest.

2.2.4 Pipeline Corridor Analysis

Navigational positions collected by divers along the six potential pipeline corridors were imported into ArcGIS software and layered and displayed in relation to aerial imagery and other spatial features. Geo-referenced video data were qualitatively reviewed to describe the benthic landscape including presence of sensitive hard bottom and/or sabellariid wormrock communities.

3.0 RESULTS

Two distinct hard bottom communities were observed during quantitative and qualitative transect analyses. Transects R-77.7, R-78.7, R-109.2, R-110, R-110.5, and R-112 were established at a greater distance from the shoreline than the remaining transects due to lack of nearshore hard bottom habitat in those areas. The western end (0-m mark) of these transects ranged from approximately 162 m (R-109.2) to 196 m (R-112) from the 2008 MHWL (mean high water line) while the remaining transects ranged from approximately 11 m (R-86.3) to 48 m (R-80.4, R-93.5) from the 2008 MHWL. The increased distance from shore coupled with greater water depth along these six transects resulted in a hard bottom community distinct from that of the more nearshore transects.

Table 5 presents the 0-m mark distance from MHWL and substrate delineation for all permanently installed transects. A total of 58 taxa were recorded during video and *in-situ* transect analysis, including 41 macroalgal taxa and 17 faunal taxa. Total observed taxa were similar between sampling methods with a higher number of taxa (48) recorded from *in-situ* quadrats when compared to video analysis (40). **Table 6** presents a comprehensive list of taxa observed during the Baseline Nearshore Hard Bottom Characterization Survey.

3.1 VIDEO DATA

Quantitative video data were collected along all established transects with the exception of Transect R-104.5. Transect R-104.5 was installed and partially surveyed in August 2008, but due to adverse weather conditions could not be completed during the 2008 field effort. Transect R-104.5 could not be surveyed in 2009 due to sand movement in the area and resultant sand burial of the entire transect. This transect was installed in an area that is believed to be an ephemeral hard bottom environment with regular burying and scouring occurring year round. Additionally, qualitative video data were not collected along Transects R-1 and R-3.

Two video segments within the designated distance intervals (0 - 30 m and 40 - 70 m) were analyzed from 10 of the installed transects (**Appendix D**, **Figures D-1** to **D-22**). Due to lack of sufficient hard bottom, only one video segment was analyzed from the remaining 11 transects. Percent cover of taxa and substrate was calculated from point count analyses for all 31 transect segments and are shown in **Table 7**.

Substrate was the dominant major category recorded during video analysis, totalling 51.2% overall percent cover (**Figure 2**). Sediment over hard substrate accounted for a majority of this category with an overall cover of 45.6%. Thirty-three macroalgal taxa were identified from quantitative video data with an overall cover of 32.0%. The biotic turf category accounted for 13.1% overall percent cover along transect segments. Fauna provided an overall percent cover of 2.8%, with wormrock responsible for the majority of faunal cover at 2.4%.

Percent cover of substrate ranged from 27.0% along the 0-20 m segment of Transect R-88.7 to 72.5% along the 0-20 m segment of Transect R-90.4 (**Figure 3**). Sediment over hard substrate was the dominant substrate type (overall cover = 45.6%) along all transect segments, followed by unconsolidated (overall cover = 4.1%) and consolidated (overall cover = 1.4%) substrate. Shell hash was recorded most frequently (overall cover = 3.6%) of the three unconsolidated substrate types ranging from 0.5% (R-100, 40-59 m) to 9.0% (R-92, 0-20 m).

Table 5. Distances of permanently installed 0-m markers from 2008 mean high water level (MHWL) and substrate delineation for transects established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

Transect	0-m Mark Distance from MHWL (m)	Start (m)	End (m)	Segment Length (m)	Substrate Type
R-77.7	191	0	3	3	Hard Bottom
		3	10	7	Sand
		10	14	4	Partially Exposed Hard Bottom
		14	20	6	Hard Bottom
		20	22	2	Partially Exposed Hard Bottom
		22	43	21	Sand
		43	46	3	Hard Bottom
R-78.7	194	0	1	1	Partially Exposed Hard Bottom
		1	4	3	Sand
		4	13	9	Hard Bottom
		13	16	3	Sand
		16	28	12	Partially Exposed Hard Bottom
		28	37	9	Hard Bottom
		37	67	30	Sand
		67	68	1	Partially Exposed Hard Bottom
		68	74	6	Sand
		74	75	1	Partially Exposed Hard Bottom
R-80.4	48	0	15	15	Partially Exposed Hard Bottom
		15	23	8	Sand
		23	33	10	Hard Bottom
		33	36	3	Partially Exposed Hard Bottom
		36	151	115	Sand
		151	152	1	Hard Bottom
R-82.8	30	0	42	42	Partially Exposed Hard Bottom
		42	43	1	Sand
		43	44	1	Partially Exposed Hard Bottom
		44	52	8	Sand
		52	53	1	Partially Exposed Hard Bottom
R-85	19	0	4.5	4.5	Partially Exposed Hard Bottom
		4.5	5.5	1	Hard Bottom
		5.5	12	6.5	Sand
		12	20	8	Partially Exposed Hard Bottom
		20	40	20	Hard Bottom
		40	44	4	Partially Exposed Hard Bottom
		44	45	1	Hard Bottom
		45	50	5	Partially Exposed Hard Bottom
		50	51	1	Hard Bottom
		51	70	19	Partially Exposed Hard Bottom
		70	82	12	Hard Bottom
		82	91	9	Sand
		91	102	11	Hard Bottom

Table 5. (Continued).

Transect	0-m Mark Distance from MHWL (m)	Start (m)	End (m)	Segment Length (m)	Substrate Type
R-86.3	11	0	3	3	Partially Exposed Hard Bottom
		3	6	3	Hard Bottom
		6	13	7	Partially Exposed Hard Bottom
		13	20	7	Hard Bottom
		20	25	5	Partially Exposed Hard Bottom
		25	28	3	Hard Bottom
		28	30	2	Partially Exposed Hard Bottom
		30	40	10	Hard Bottom
		40	42	2	Partially Exposed Hard Bottom
		42	50	8	Hard Bottom
		50	52	2	Partially Exposed Hard Bottom
		52	64	12	Hard Bottom
		64	83	19	Partially Exposed Hard Bottom
		83	84	1	Hard Bottom
		84	88	4	Partially Exposed Hard Bottom
		88	89	1	Hard Bottom
		89	98	9	Sand
		98	101	3	Hard Bottom
		101	102	1	Partially Exposed Hard Bottom
		102	121	19	Sand
		121	130	9	Partially Exposed Hard Bottom
		130	133	3	Hard Bottom
		133	136	3	Partially Exposed Hard Bottom
R-88.7	17	0	5	5	Hard Bottom
		5	10	5	Partially Exposed Hard Bottom
		10	20	10	Hard Bottom
		20	41	21	Partially Exposed Hard Bottom
		41	42	1	Hard Bottom
		42	43	1	Partially Exposed Hard Bottom
		43	46	3	Sand
		46	48	2	Partially Exposed Hard Bottom
		48	50	2	Hard Bottom
		50	57	7	Partially Exposed Hard Bottom
		57	68	11	Hard Bottom
		68	79	11	Partially Exposed Hard Bottom
		79	81	2	Hard Bottom
		81	82	1	Partially Exposed Hard Bottom
		82	92	10	Sand
		92	95	3	Partially Exposed Hard Bottom
R-90.4	23	0	53	53	Partially Exposed Hard Bottom
		53	58	5	Hard Bottom
		58	61	3	Partially Exposed Hard Bottom
		61	80	19	Hard Bottom

Table 5. (Continued).

Transect	0-m Mark Distance from MHWL (m)	Start (m)	End (m)	Segment Length (m)	Substrate Type
R-92	22	0	1	1	Partially Exposed Hard Bottom
		1	5	4	Hard Bottom
		5	24	19	Partially Exposed Hard Bottom
		24	40	16	Hard Bottom
		40	44	4	Partially Exposed Hard Bottom
		44	48	4	Hard Bottom
		48	55	7	Sand
		55	59	4	Hard Bottom
		59	68	9	Sand
		68	69	1	Partially Exposed Hard Bottom
R-93.5	48	0	1	1	Partially Exposed Hard Bottom
		1	10	9	Hard Bottom
		10	20	10	Partially Exposed Hard Bottom
		20	27	7	Sand
		27	29	2	Hard Bottom
R-100	32	0	1	1	Partially Exposed Hard Bottom
		1	8	7	Sand
		8	12	4	Partially Exposed Hard Bottom
		12	21	9	Hard Bottom
		21	23	2	Sand
		23	30	7	Hard Bottom
		30	44	14	Sand
		44	45	1	Partially Exposed Hard Bottom
		45	58	13	Sand
		58	59	1	Hard Bottom
R-101	42	0	1	1	Hard Bottom
		1	8	7	Partially Exposed Hard Bottom
		8	22	14	Sand
		22	25	3	Partially Exposed Hard Bottom
R-102	37	0	4	4	Partially Exposed Hard Bottom
		4	5	1	Hard Bottom
		5	19	14	Sand
		19	30	11	Hard Bottom
R-103.2	36	0	1	1	Partially Exposed Hard Bottom
		1	6	5	Sand
		6	17	11	Partially Exposed Hard Bottom
		17	20	3	Hard Bottom
		20	23	3	Partially Exposed Hard Bottom
		23	26	3	Sand
		26	27	1	Hard Bottom
		27	28	1	Sand
		28	29	1	Hard Bottom
R-104.5	34	0	10	10	Hard Bottom

Table 5. (Continued).

Transect	0-m Mark Distance from MHWL (m)	Start (m)	End (m)	Segment Length (m)	Substrate Type
R-105.9	26	0	1	1	Hard Bottom
		1	4	3	Partially Exposed Hard Bottom
		4	5	1	Hard Bottom
		5	11	6	Partially Exposed Hard Bottom
		11	12	1	Sand
		12	19	7	Hard Bottom
		19	24	5	Partially Exposed Hard Bottom
		24	26	2	Hard Bottom
R-109.2	162	0	2	2	Hard Bottom
		2	5	3	Sand
		5	8	3	Hard Bottom
		8	10	2	Sand
		10	11	1	Partially Exposed Hard Bottom
		11	29	18	Sand
		29	30	1	Partially Exposed Hard Bottom
		30	35	5	Hard Bottom
R-110	184	0	3	3	Hard Bottom
		3	8	5	Sand
		8	10	2	Hard Bottom
		10	29	19	Sand
		29	31	2	Hard Bottom
		31	33	2	Partially Exposed Hard Bottom
		33	35	2	Sand
		35	36	1	Hard Bottom
R-110.5	188	0	2	2	Hard Bottom
		2	4	2	Sand
		4	6	2	Partially Exposed Hard Bottom
		6	8	2	Hard Bottom
		8	15	7	Sand
		15	21	6	Hard Bottom
		21	30	9	Partially Exposed Hard Bottom
		30	31	1	Hard Bottom
R-112	196	0	1	1	Partially Exposed Hard Bottom
		1	30	29	Sand
		30	31	1	Hard Bottom
		31	42	11	Partially Exposed Hard Bottom
		42	49	7	Sand
		49	50	1	Partially Exposed Hard Bottom
		50	57	7	Sand
		57	58	1	Partially Exposed Hard Bottom
		58	69	11	Sand
		69	74	5	Partially Exposed Hard Bottom

Table 5. (Continued).

Transect	0-m Mark Distance from MHWL (m)	Start (m)	End (m)	Segment Length (m)	Substrate Type
R-1	ND	0	1	1	Hard Bottom
		1	4.5	3.5	Partially Exposed Hard Bottom
		4.5	6	1.5	Hard Bottom
		6	8	2	Sand
		8	12	4	Hard Bottom
R-3	ND	0	3	3	Partially Exposed Hard Bottom
		3	5	2	Sand
		5	6	1	Partially Exposed Hard Bottom
		6	10	4	Sand
		10	12	2	Hard Bottom
		12	18	6	Sand
		18	20	2	Hard Bottom

ND = Data not collected.

Table 6. Floral and faunal taxa identified from *in-situ* quadrat and video data collected during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

Taxa		Video	*In Situ*
Chlorophyta	*Bryopsis* spp.		•
	Caulerpa cf. *laetevirens*	•	•
	Caulerpa mexicana	•	•
	Caulerpa prolifera/brachypus	•	•
	Caulerpa sertularioides	•	•
	Caulerpa sp.	•	•
	Codium spp.	•	•
	Enteromorpha spp.		•
	Halimeda spp.	•	•
	Ulva sp.	•	•
	Unidentified green algae	•	
Phaeophyta	*Colpomenia sinuosa*	•	
	Dictyopteris spp.	•	•
	Dictyota sp.	•	•
	Padina sp.	•	•
	Spatoglossum schroederi	•	•
	Unidentified brown algae	•	
Rhodophyta	*Acanthophora muscoides*	•	•
	Agardhiella subulata	•	•
	Botryocladia occidentalis	•	
	Branching corraline red algae		•
	Bryothamnion seaforthii	•	•
	Chondria spp.	•	•
	Dasya spp.	•	•
	Encrusting corraline red algae	•	•
	Gracilaria blodgettii		•
	Gracilaria mammillaris	•	
	Gracilaria spp.	•	•
	Heterosiphonia spp.	•	•
	Hypnea musciformis	•	•
	Hypnea spinella		•
	Hypnea sp.	•	•
	Laurencia chondrophycus poiteaui		•
	Laurencia papillosa		•
	Laurencia sp.	•	•
	Liagoria valida		•
	Spyridia spp.	•	•
	Unidentified red algae	•	•
	Unidentified red algae w/encrusting *Bryozoa* sp.	•	
Other Macroalgae	Turf algae	•	•
	Unidentified algae	•	

Table 6. (Continued).

Taxa		Video	*In Situ*
Macroalgal Taxa		33	34
	Aplysia spp. (count)		•
	Barnacles		•
	Cinachyra (count)		•
	Cliona spp.		•
	Encrusting bryozoans		•
	Encrusting sponge	•	•
	Encrusting tunicate		•
	Holothurid (count)	•	•
	Hydroids		•
	Octocoral (count)		•
	Phyllangia americana americana (count)		•
	Tunicate colony (count)	•	•
	Unidentified anemone (count)		•
	Unidentified fauna	•	
	Unidentified sponge	•	
	Unidentified urchin	•	
	Wormrock	•	•
Faunal Taxa		7	14
Total Observed Taxa		40	48

Table 7. Percent cover of taxa, substrate, and major categories from video data collected along permanent cross-shore transects established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

Taxa or Substrate	Transect Segment (m)																																Overall
	R-77.7		R-78.7		R-80.4	R-82.8		R-85		R-86.3		R-88.7		R-90.4		R-92		R-93.5	R-100		R-101	R-102	R-103.2	R-104.5*	R-105.9	R-109.2	R-110	R-110.5	R-112		R-1	R-3	
	0-22	40-46	0-26	40-75	0-28	0-20	40-53	0-26.5	40-60	0-20	40-60	0-20	40-63	0-20	40-60	0-20	40-69	0-2	0-29	40-59	0-25	0-30	0-29	ND	0-21	0-35	0-36	0-29	0-40	40-74	0-12	0-20	
MACROALGAE																																	
Chlorophyta																																	
Caulerpa cf. *laetevirens*								0.1			0.2	0.1										0.2		ND									**0.0**
Caulerpa mexicana			0.1		0.5	0.2	0.7															0.3	0.1	ND		0.1	0.3	0.2		0.1			**0.1**
Caulerpa prolifera/brachypus					0.1									0.3	0.1	0.4	0.2	0.7	1.0	0.0	2.7	5.3	0.0	ND		0.1		0.2		0.2			**0.4**
Caulerpa sertularioides						0.4					0.0*					0.2					0.1			ND									**0.0**
Caulerpa sp.						0.1	0.7																										**0.0**
Codium sp.								0.2																ND				0.1					**0.0**
Halimeda spp.								0.6	0.2	0.7	0.2	0.2	0.8	0.7										ND							0.3	0.1	**0.1**
Ulva sp.					0.0*	0.2		4.7	2.1	2.5	1.9	2.0	2.2		0.5	0.5	0.1		0.0					ND									**0.7**
Unidentified green algae			0.1	0.7	0.0			0.3		0.2	0.2	0.1	0.1		0.1	0.1	0.2	0.1				0.5	0.0	ND	0.1	0.1		0.0					**0.1**
Phaeophyta																																	
Colpomenia sinuosa											0.1													ND									**0.0**
Dictyopteris spp.					0.0*																			ND									**0.0**
Dictyota sp.	0.3		0.7	0.4	0.7			1.0			0.4	0.6	0.2											ND		0.1		0.5			0.3		**0.2**
Padina sp.			0.4		0.2		5.9	0.1					0.1			0.6		0.4					0.2	ND	2.2	0.2					0.4		**0.2**
Spatoglossum schroederi												0.6				0.3		0.1						ND	0.0								**0.0**
Unidentified brown algae											0.0*					0.1		0.1						ND									**0.0**
Rhodophyta																																	
Acanthophora muscoides										0.0*														ND									**0.0**
Agardhiella subulata			0.1																					ND									**0.0**
Botryocladia occidentalis									0.4															ND									**0.0**
Bryothamnion seaforthii																						4.0		ND									**0.2**
Chondria spp.			0.2		0.0*			0.1	0.0*			0.2			0.6									ND			0.2	0.0					**0.0**
Dasya spp.									0.5				0.3									0.1		ND									**0.0**
Encrusting corraline red algae			0.1	1.8												0.2	0.1			1.4			0.1	ND			0.1						**0.0**
Gracilaria mammillaris			0.1																					ND									**0.0**
Gracilaria spp.	0.5		0.2		0.3			0.2	0.0*		0.0*			0.2	0.3		0.3							ND									**0.1**
Heterosiphonia spp.								2.4	0.7	0.4	1.1	0.1	1.9	0.9	0.9	0.3	0.1					0.3		ND							1.1		**0.4**

Table 7. (Continued).

Taxa or Substrate	Transect Segment (m)																																Overall
	R-77.7		R-78.7		R-80.4	R-82.8		R-85		R-86.3		R-88.7		R-90.4		R-92		R-93.5	R-100		R-101	R-102	R-103.2	R-104.5*	R-105.9	R-109.2	R-110	R-110.5	R-112		R-1	R-3	
	0-22	40-46	0-26	40-75	0-28	0-20	40-53	0-26.5	40-60	0-20	40-60	0-20	40-63	0-20	40-60	0-20	40-69	0-2	0-29	40-59	0-25	0-30	0-29	ND	0-21	0-35	0-36	0-29	0-40	40-74	0-12	0-20	
Hypnea musciformis			0.1																					ND									**0.0**
Hypnea sp.	0.5	3.2	1.5		0.0			1.3	0.0	0.2	0.1		0.0	0.5	0.2	0.7	0.8					0.1		ND	0.3	2.3	1.1	1.2					**0.4**
Laurencia sp.								2.4	2.1	0.6	0.2	7.5	1.6	1.4	2.0	0.2	0.7							ND									**0.8**
Spyridia spp.	1.4	0.5	1.3										0.0											ND	0.0	0.4		1.2					**0.2**
Unidentified red algae	19.9	24.9	18.4	13.2	5.5		3.8	19.7	18.5	12.9	20.2	21.0	21.5	12.3	6.9	4.3	3.0	0.1				0.3	0.7	ND	0.2	11.5	3.5	21.4	0.7	4.0	2.1		**9.2**
Unidentified red algae w/encrusting *Bryozoa* sp.	1.0										0.0													ND									**0.0**
Other Macroalgae																																	
Turf algae	2.2	1.2	10.7	11.7	20.4	18.7	9.8	10.6	12.8	17.2	13.6	15.6	11.9	8.8	9.3	24.2	25.2	31.2	25.7		13.3	23.7	18.1	ND	11.3	27.5	19.6	12.6	14.9	9.1	37.9	6.5	**16.7**
Unidentified algae	2.0	1.7	2.5	1.5	1.7		3.5	4.2	1.3	4.4	8.6	3.7	4.3	1.6	1.5	1.4	0.8	0.1	0.0			1.1	0.0	ND	0.6	1.5	0.6	3.7	0.5	1.4	2.7		**2.0**
Detached algal wrack	1.5				0.5	0.1		0.5	0.1	2.7	0.4	0.5	1.0		0.8	2.0	0.6	2.3	0.1	2.7	0.2		0.5	ND	3.1	1.3	0.3	3.4	0.3	0.3	2.1	1.4	**1.0**
BIOTIC TURF																																	
Biotic turf	25.7	23.7	14.6	14.3	33.3	12.7	17.4	6.6	3.1	9.3	13.8	5.5	6.0	0.8	3.7	4.6	6.3	2.2	22.8	37.4	14.4	19.5	24.5	ND	13.6	8.7	25.8	17.1	16.9	17.9	12.0	3.9	**13.1**
FAUNA																																	
Encrusting orange sponge																								ND		0.9	0.3	0.4		1.6			**0.1**
Encrusting red sponge			0.1	1.8												0.2	0.1			1.4			0.1	ND			0.1						**0.0**
Encrusting sponge											0.1		0.0			0.1								ND				0.0		0.5			**0.0**
Holothurid			0.2						0.2				0.1		0.2									ND									**0.0**
Hydroids		0.2													0.6		0.1					1.3		ND		0.3	0.4	0.0		1.0			**0.1**
Other fauna	0.2	0.2	0.1	0.4	0.1													0.1				0.1		ND	0.0		0.0	0.0					**0.0**
Tunicate		1.0	1.0																					ND			0.5						**0.1**
Unidentified sponge																0.0								ND		0.1				0.7			**0.0**
Unidentified urchin	0.2																							ND									**0.0**
Wormrock										5.5	4.9	15.4	6.0		8.3	4.3	0.2							ND	3.1							22.6	**2.4**
SUBSTRATE																																	
Consolidated																																	
Rock	3.3	7.2	2.1	7.3	0.6	0.4		0.9		0.0	1.4	0.5	0.5		1.0	1.2	4.7	1.7	0.2	20.7	0.3	0.7	0.3	ND	4.4	0.9	3.6	1.0	2.0	1.1	0.3	3.3	1.4
Unconsolidated																																	
Rubble	0.8	1.5	0.3	0.7	0.1	0.1		0.1	0.1	2.1	0.4	1.1					0.1	0.9	0.3	0.5		0.2	0.0	ND	0.1							1.9	**0.3**
Shell	1.9	0.5	0.5		0.1			0.3	0.1	0.3	0.1			0.2	0.1	0.3	0.1	0.2	0.0			0.1	0.1	ND	0.1				0.1		0.1	0.1	**0.2**
Shell hash	1.4	8.1	2.1	0.7	2.3	3.7	2.1	5.8	1.3	2.8	3.6	1.8	2.8	3.5	5.3	9.0	4.3	2.7	5.1	0.5	2.5	8.4	2.9	ND	5.7	2.7	4.6	1.1	2.7	2.6	2.6	1.3	**3.6**

Table 7. (Continued).

Taxa or Substrate	Transect Segment (m)																																Overall
	R-77.7		R-78.7		R-80.4	R-82.8		R-85		R-86.3		R-88.7		R-90.4		R-92		R-93.5	R-100		R-101	R-102	R-103.2	R-104.5*	R-105.9	R-109.2	R-110	R-110.5	R-112		R-1	R-3	
	0-22	40-46	0-26	40-75	0-28	0-20	40-53	0-26.5	40-60	0-20	40-60	0-20	40-63	0-20	40-60	0-20	40-69	0-2	0-29	40-59	0-25	0-30	0-29	ND	0-21	0-35	0-36	0-29	0-40	40-74	0-12	0-20	
Sediment Over Hard Substrate																																	
Sediment over hard substrate	37.1	25.9	42.6	45.4	33.4	63.7	56.1	38.3	56.4	38.0	28.1	23.7	38.6	68.9	57.8	44.9	52.0	57.0	44.7	35.6	66.5	34.0	52.1	ND	55.2	41.4	39.1	35.7	61.9	59.4	37.9	58.9	45.6
MAJOR CATEGORIES																																	
MACROALGAE	27.8	31.6	36.4	29.3	29.6	19.4	24.4	47.6	38.8	39.3	47.0	51.6	45.0	26.7	22.2	33.4	31.5	32.8	26.7	1.4	16.1	35.8	19.4	ND	14.7	43.8	25.3	41.2	16.1	14.8	44.9	6.6	32.0
Chlorophyta			0.2	0.7	0.8	0.7	1.4	5.7	2.3	3.4	2.6	2.4	3.1	1.0	0.6	1.2	0.5	0.8	1.0		2.8	6.3	0.2	ND	0.1	0.3	0.3	0.6		0.3	0.3	0.1	1.5
Phaeophyta	0.3		1.1	0.4	0.9		5.9	1.1			0.6	1.2	0.3			1.0		0.6					0.2	ND	2.2	0.3		0.5			0.8		0.5
Rhodophyta	23.3	28.6	21.9	15.0	5.9		3.8	25.9	22.4	14.3	21.6	28.7	25.4	15.2	10.9	5.6	4.9	0.1		1.4		4.8	0.8	ND	0.5	14.2	4.9	23.9	0.7	4.0	3.2		11.3
Turf Algae	2.2	1.2	10.7	11.7	20.4	18.7	9.8	10.6	12.8	17.2	13.6	15.6	11.9	8.8	9.3	24.2	25.2	31.2	25.7		13.3	23.7	18.1	ND	11.3	27.5	19.6	12.6	14.9	9.1	37.9	6.5	16.7
BIOTIC TURF	25.7	23.7	14.6	14.3	33.3	12.7	17.4	6.6	3.1	9.3	13.8	5.5	6.0	0.8	3.7	4.6	6.3	2.2	22.8	37.4	14.4	19.5	24.5	ND	13.6	8.7	25.8	17.1	16.9	17.9	12.0	3.9	13.1
FAUNA	0.5	1.5	1.4	2.2	0.1				0.2	5.5	5.0	15.4	6.1		9.1	4.6	0.3	0.1		1.4		1.3	0.1	ND	3.2	1.3	1.3	0.5		3.9		22.6	2.8
Total Sponge			0.1	1.8							0.1		0.0			0.3	0.1			1.4			0.1	ND		1.0	0.3	0.4		2.8			0.2
SUBSTRATE	44.5	43.2	47.6	54.2	36.5	67.8	58.2	45.3	57.9	43.3	33.7	27.0	41.9	72.5	64.2	55.4	61.3	62.6	50.4	57.2	69.3	43.3	55.5	ND	65.4	44.9	47.3	37.8	66.6	63.2	41.0	65.4	51.2
Consolidated	3.3	7.2	2.1	7.3	0.6	0.4		0.9		0.0	1.4	0.5	0.5		1.0	1.2	4.7	1.7	0.2	20.7	0.3	0.7	0.3	ND	4.4	0.9	3.6	1.0	2.0	1.1	0.3	3.3	1.4
Unconsolidated	4.1	10.1	2.9	1.5	2.5	3.8	2.1	6.1	1.5	5.2	4.2	2.8	2.8	3.6	5.4	9.3	4.6	3.8	5.4	0.9	2.5	8.7	3.1	ND	5.9	2.7	4.6	1.1	2.8	2.6	2.7	3.3	4.1
Sediment Over Hard Substrate	37.1	25.9	42.6	45.4	33.4	63.7	56.1	38.3	56.4	38.0	28.1	23.7	38.6	68.9	57.8	44.9	52.0	57.0	44.7	35.6	66.5	34.0	52.1	ND	55.2	41.4	39.1	35.7	61.9	59.4	37.9	58.9	45.6

Note: Cells showing values of 0.00 represent percent cover >0.0 but <0.1.
ND = No data collected.

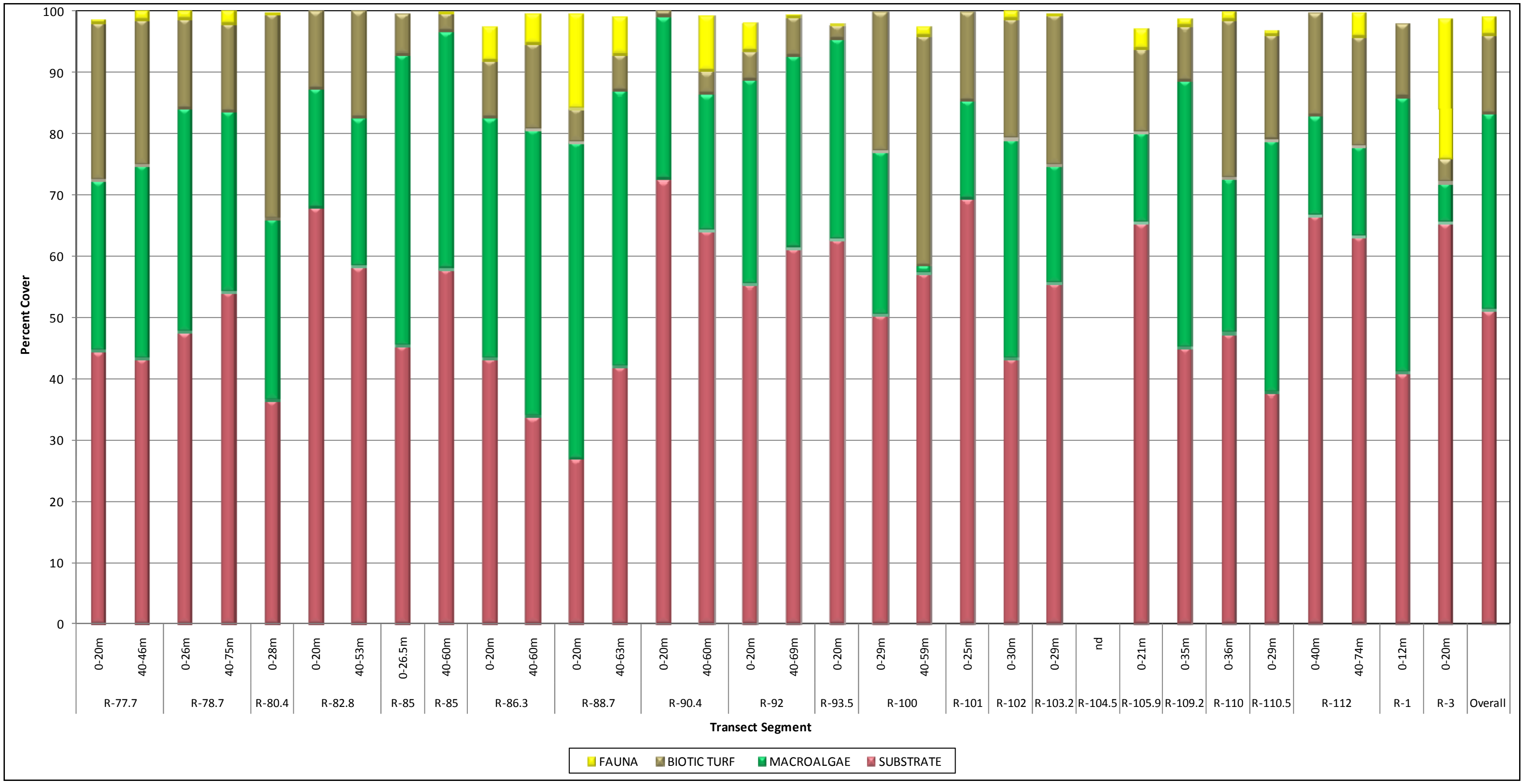


Figure 2. Percent cover of major categories from video data collected along permanent cross-shore transects established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

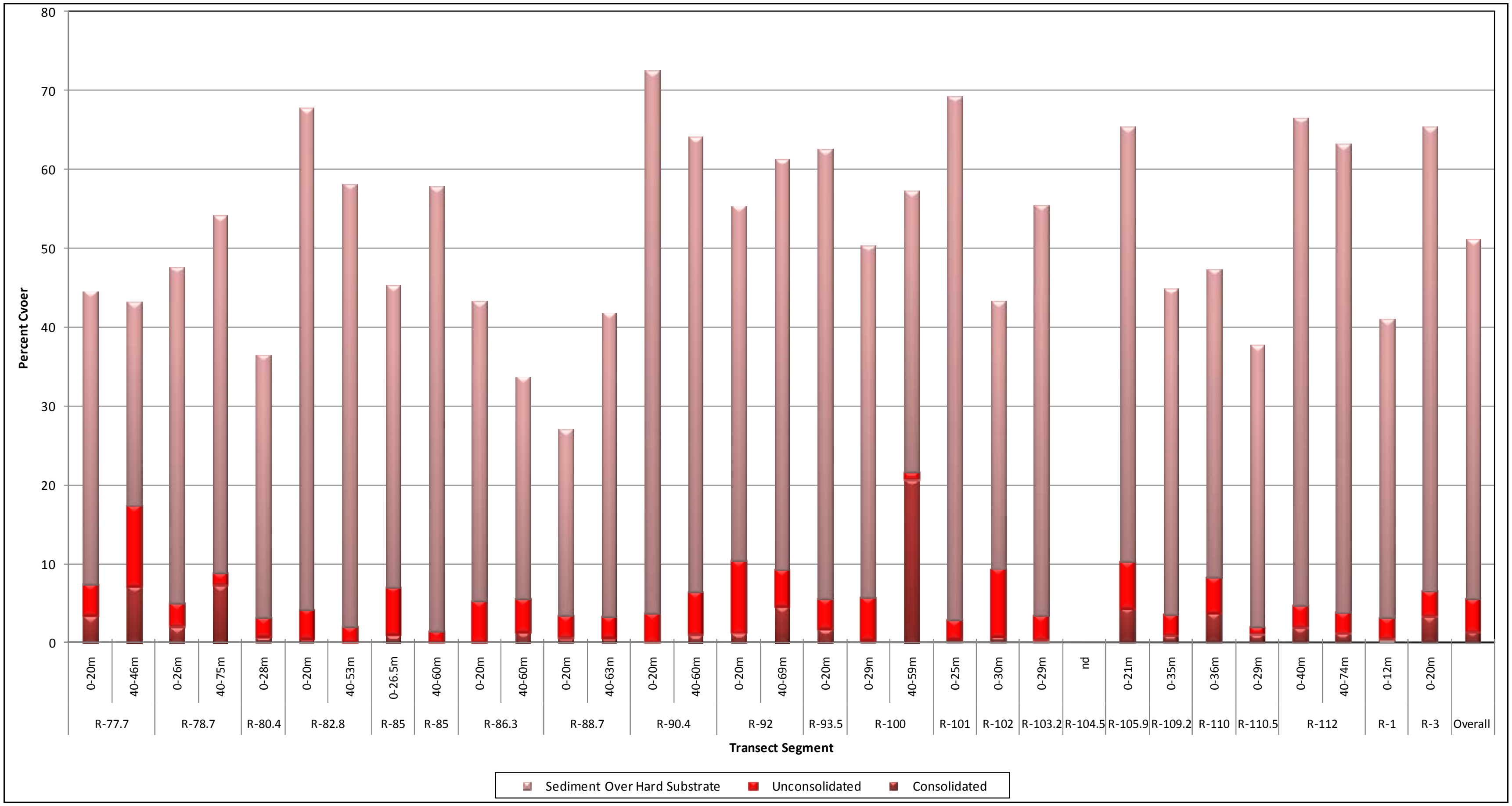


Figure 3. Percent cover of substrate subcategories from video data collected along permanent cross-shore transects established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

Four major macroalgal divisions were observed during video analysis including Chlorophyta (9 taxa), Phaeophyta (6 taxa), Rhodophyta (16 taxa), and other macroalgae (2 taxa). Detached algal wrack was observed along most transect segments, with an overall cover of 1.0%, but was not included in taxa counts or overall macroalgal cover calculations. Macroalgal cover was lowest (1.4%) along transect segment R-100 (40-59 m) and highest (51.6%) along segment R-88.7 (0-20 m), with an overall percent cover of 32.0% (**Figure 4**). Turf algae was the dominant macroalgae along most transects with greatest cover occurring in the southern portion of the survey area, south of Transect R-92. Unidentified red algae was the most commonly identified red algae category with an overall percent cover of 9.2%, followed by *Laurencia* sp. (0.8%) and *Hypnea* sp. (0.4%). The most abundant species of green algae were *Ulva* sp. and *Caulerpa prolifera/brachypus* with combined overall percent covers of 0.7% and 0.4%, respectively. Phaeophyta was the least observed macroalgal division along video transects with dominant taxa including *Padina* sp. and *Dictyota* sp.

Biotic turf was observed along all video segments with percent cover ranging from 0.8% on Transect R-90.4 (0-20 m) to 37.4% on Transect R-100 (40-59 m). Faunal percent cover ranged from 0.0% on four transect segments to 22.6% on Transect R-3 (0-20 m) (**Figure 5**). Wormrock was the dominant fauna along nine transect segments and was most prolific between Transects R-86.3 and R-92. Other observed fauna included hydroids, encrusting orange sponges (including *Cliona* spp.), and tunicates, each accounting for 0.1% overall percent cover. Scleractinian corals were not observed within quantitative or qualitative video transects.

QAQC checks performed on video analysis data resulted in six quantitative video segments not initially meeting the 90% agreement threshold (**Table 8**). Discrepancies observed along these segments were addressed to determine the cause of disagreement between point designations. The majority of the variance between observers was due to the subjective nature of the analyses with much of the dissimilarity caused by substrate versus biotic turf designations along the segments. These points were reanalyzed by both observers to reach consensus regarding the point identifications. Following review, point identifications were adjusted in the dataset, which resulted in inter-observer variablility of less than 10%, meeting the 90% agreement threshold on all transect segments.

3.2 *IN-SITU* QUADRAT DATA

Fifty-three taxa and substrate types were identified during *in-situ* quadrat sampling including 34 macroalgal taxa, 14 faunal taxa, and 5 distinct substrate types. Overall, substrate was the dominant benthic cover accumulating an overall mean percent cover of 61.9% and was dominated by sediment over hard substrate (overall mean = 47.7%) (**Table 9**). Macroalgae accounted for an overall mean percent cover of 33.6% and was represented in greatest abundance by turf algae (overall mean = 19.5%) while fauna accounted for an overall mean percent cover of 4.5% within the survey area (**Figure 6**).

Substrate comprised the greatest mean percent cover along all surveyed transects ranging from 42.5% on Transect R-80.4 to 77.0% on Transect R-103.2. Sediment over hard substrate was responsible for the greatest contribution to the substrate category along all transects with a maximum mean percent cover of 69.2% recorded on Transect R-101. Consolidated substrate (rock) was the least abundant substrate type within quadrats and ranged from 0.0% on Transects R-82.8, R-1, and R-3 to 23.8% on Transect R-78.7, with an overall mean percent cover of 6.1% for the entire survey area (**Figure 7**).

Thirty-four macroalgal taxa were observed within *in-situ* quadrats from the following divisions including Chlorophyta (10), Phaeophyta (4), Rhodophyta (19), and turf algae (1). Mean percent cover of macroalgae was lowest in quadrats on Transect R-104.5 at 0.8% and highest in quadrats along Transect R-1 at 49.5% (**Figure 8**). Turf algae was the dominant macroalgal division along most transects ranging from 0.8% on Transect R-104.5 to 54.4% on Transect R-80.4. Rhodophyta was the dominant macroalgal division with an overall mean of 10.2% and was represented by *B. seaforthii* (2.1%), *Gracilaria* sp. (1.4%), and *H. musciformis* (1.3%). Division Chlorophyta was less abundant with an overall mean percent cover of 3.3%, with a large contribution by *Caulerpa prolifera/brachypus* (1.6%). Division Phaeophyta accounted for an overall mean percent cover of only 0.6%, and was dominated by *Padina* sp. (0.4%).

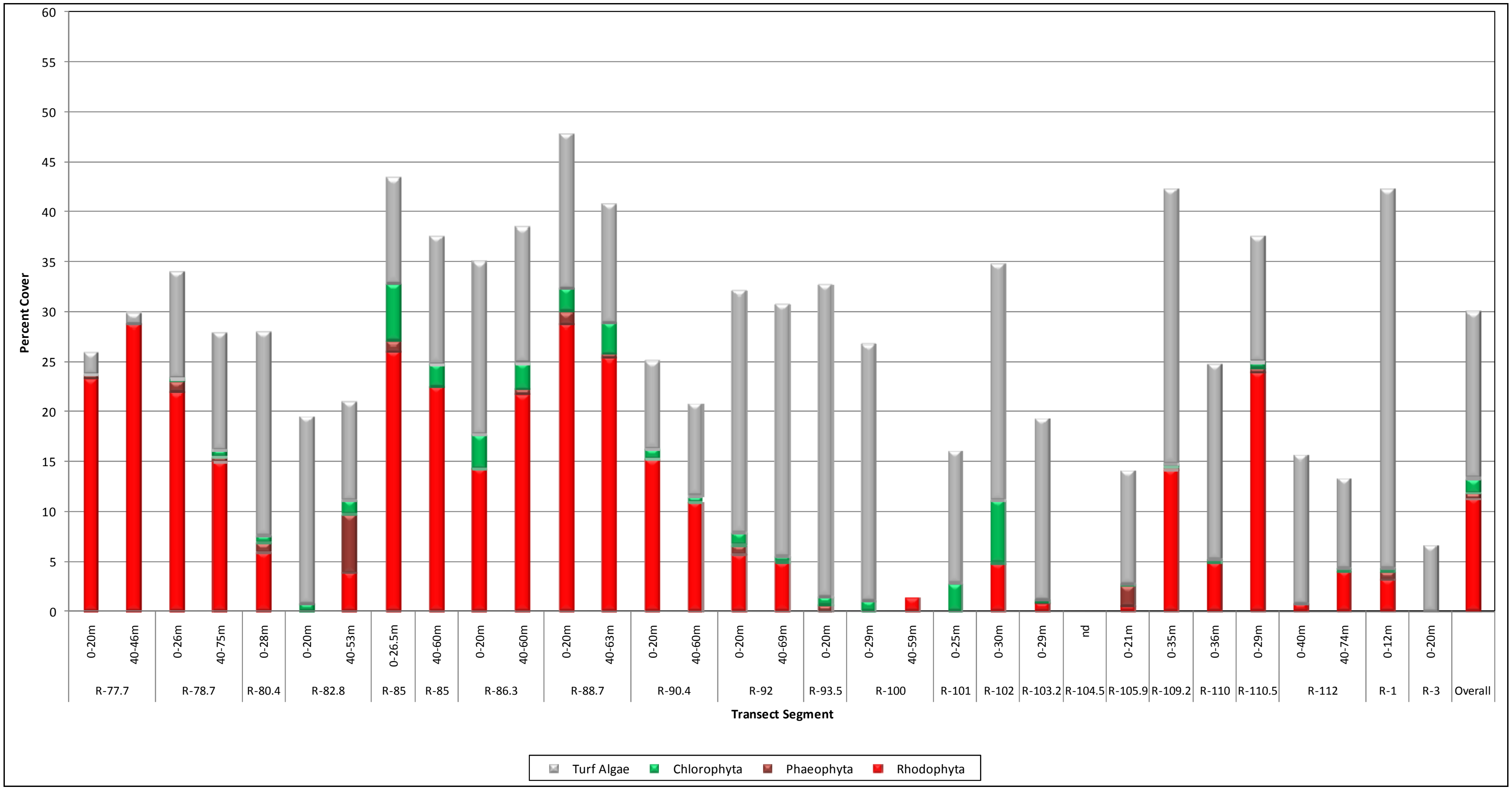


Figure 4. Percent cover of total macroalgae (by division) from video data collected along permanent cross-shore transects established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

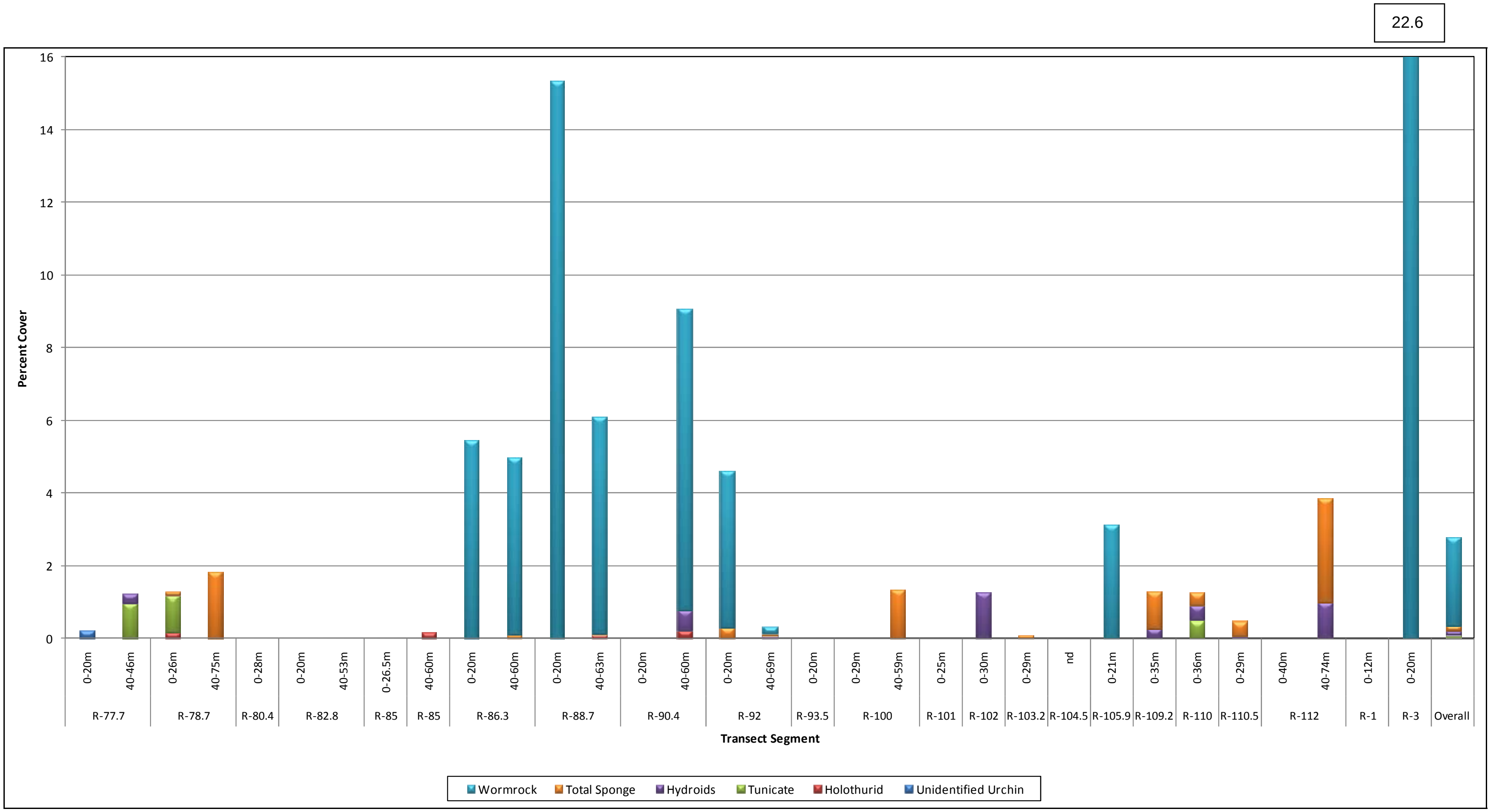


Figure 5. Percent cover of selected faunal taxa from video data collected along permanent cross-shore transects established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

Table 8. Results of quality assurance and control measures following 10% two-observer identification comparisons of video point count data collected during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

Transect	Video Segment (m)	Original Point Agreement (%)	Point Agreement w/o Turf vs. Biotic Turf (%)	Final Point Agreement
R-77.7	0-22	90	90	90
	40-46	76	84*	96
R-78.7	0-26	86	90	90
	40-75	76	80*	96
R-80.4	0-28	98	98	98
R-82.8	0-20	91	91	91
	40-53	88	96	96
R-85	0-26.5	86	89*	97
	40-60	99	99	99
R-86.3	0-20	93	93	93
	40-60	88	90	90
R-88.7	0-20	94	94	94
	40-63	92	92	92
R-90.4	0-20	97	97	97
	40-60	89	90	90
R-92	0-20	92	92	92
	40-69	90	90	90
R-93.5	0-20	94	94	94
R-100	0-29	87	95	95
	40-59	100	100	100
R-101	0-25	92	92	92
R-102	0-30	78	90	90
R-103.2	0-29	76	76*	94
R-104.5	na	na	na	na
R-105.9	0-21	85	85*	97
R-109.2	0-35	80	89*	94
R-110	0-36	85	90	90
R-110.5	0-29	85	92	92
R-112	0-40	84	90	90
	40-70	86	91	91
R-1	0-12	93	93	93
R-3	0-20	93	93	93

* Denotes transect segments that did not meet 90% agreement, requiring additional analysis.

Table 9. Mean percent cover of taxa, substrate, and major categories from *in-situ* quadrat data collected along permanent cross-shore transects established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

Taxa or Substrate	Transect																						Overall Mean
	R-77.7	R-78.7	R-80.4	R-82.8	R-85	R-86.3	R-88.7	R-90.4	R-92	R-93.5	R-100	R-101	R-102	R-103.2	R-104.5	R-105.9	R-109.2	R-110	R-110.5	R-112	R-1	R-3	
MACROALGAE																							
Chlorophyta																							
Bryopsis spp.	0.6	0.1																					0.0
Caulerpa cf. *laetevirens*	5.0																						0.2
Caulerpa mexicana		0.6		0.3	0.1		0.4	3.1		0.6		0.9		1.3		0.7	0.5	0.9	1.1				0.5
Caulerpa prolifera/brachypus		0.6	0.2	0.3	0.1		0.6	3.1	0.1	6.9	0.6	10.4	13.2			0.2				0.7			1.6
Caulerpa sertularioides	0.3				0.1		0.3	0.6				1.6		0.6									0.2
Caulerpa sp.						0.1	0.1	0.6	1.3									0.1			0.3		0.1
Codium isthmocladium							0.2																0.0
Enteromorpha spp.			0.2	1.0																			0.1
Halimeda spp.				0.5	0.7	0.7	1.4	3.1													0.3		0.4
Ulva sp.					1.3	2.4	1.5		0.9														0.4
Phaeophyta																							
Dictyopteris spp.																			0.3				0.0
Dictyota sp.		0.2		0.9	0.5	1.1	0.3							0.4					0.3		0.5		0.2
Padina sp.				2.5		0.2	0.6			0.9				0.4		2.3					0.5	0.8	0.4
Spatoglossum schroederi					0.3																		0.0
Rhodophyta																							
Acanthophora muscoides							1.6	3.8										0.1					0.3
Agardhiella subulata		4.4				0.3											3.4	0.6	1.9				0.5
Branching corraline red algae								0.6															0.0
Bryothamnion seaforthii					14.8	4.8	6.3		0.3				4.3	1.8				0.9	0.6	1.4			2.1
Chondria spp.		2.1		0.6	2.1	0.2	1.3	2.5	0.6								0.8	0.6	0.3				0.6
Dasya spp.		3.0				4.0	2.6																0.6
Encrusting corraline red algae									0.5		1.6									0.3	0.5		0.1
Gracilaria blodgettii																			1.1				0.1
Gracilaria spp.	11.3	2.7		0.3	1.5	1.0		1.3	0.2								2.0	1.5	4.3	4.3			1.4
Heterosiphonia gibbesii		0.2		0.3	3.8	1.7	0.9	0.6	0.2														0.5
Hypnea musciformis		0.8			1.8	1.7	2.3	1.9	2.5								9.3		5.1	1.2			1.3
Hypnea sp.	10.0	0.6	1.5					0.6										0.9					0.6
Hypnea spinella		3.9			0.4				1.0										3.3				0.4
Liagoria valida														0.8					0.1				0.0
Laurencia chondrophycus poiteaui								1.3															0.1
Laurencia papillosa					2.5		1.7		0.1														0.3

Table 9. (Continued).

Taxa or Substrate	Transect																						Overall Mean
	R-77.7	R-78.7	R-80.4	R-82.8	R-85	R-86.3	R-88.7	R-90.4	R-92	R-93.5	R-100	R-101	R-102	R-103.2	R-104.5	R-105.9	R-109.2	R-110	R-110.5	R-112	R-1	R-3	
Laurencia sp.					3.8	2.8	5.6	1.9															0.9
Spyridia spp.	1.3	2.2																	0.7				0.2
Unidentified red algae		1.4	0.2						1.0														0.1
Other Macroalgae																							
Turf algae	18.3	5.9	54.4	41.0	10.1	9.3	11.0	12.5	18.3	21.0	27.1	12.1	25.4	17.4	0.8	17.2	13.6	30.5	14.6	15.6	47.5	11.8	19.5
FAUNA																							
Barnacles		0.7										0.1		0.1				0.3		0.3			0.1
Cliona spp.						0.1												0.1		0.4			0.0
Encrusting bryozoans						0.3	0.1					0.1							0.1				0.0
Encrusting sponge		0.8			0.2	0.1					0.1	0.1					1.5	1.8	2.7	1.9			0.4
Encrusting tunicate		1.9																0.4					0.1
Hydroids	0.3							1.3						0.4		1.1	0.8	3.3		0.7			0.3
Wormrock			1.0			9.2	2.9	2.5	0.5						43.8	17.3						28.3	3.5
Aplysia spp. (count)																			0.1				0.0
Cinachyra (count)					0.6	0.6	0.2							0.1			0.3		3.2	3.6			0.4
Holothurid (count)		2.7			0.2			0.1									1.5		0.1				0.2
Octocoral (count)		0.6																					0.0
Phyllangia americana americana (count)																			0.3				0.0
Tunicate colony (count)		0.6									1.5						0.2						0.1
Unidentified anemone (count)						0.1											1.0						0.0
SUBSTRATE																							
Consolidated																							
Rock	20.0	23.8	0.5		6.3	1.3	2.9	2.5	7.8	5.0	11.9	2.5	1.4	15.9	1.3	5.0	3.3	3.5	3.9	9.6			6.1
Unconsolidated																							
Rubble		1.1				0.4	0.4	1.3							2.5			2.5					0.3
Sand	6.3	6.7		0.6	1.5	2.9	6.0	4.4	4.0		10.0	1.4	3.6	11.3	19.8	1.7	4.2	3.8	9.4	15.0	5.5	24.3	5.5
Shell hash	2.5		0.7	8.8	4.3	2.1	1.9	5.0	4.0	1.3	2.5	1.4	3.0	2.5		1.1	1.7			0.7		0.5	2.2
Sediment Over Hard Substrate																							
Sediment over hard substrate	24.4	36.4	41.3	43.1	44.0	53.8	47.2	45.6	56.7	64.4	46.1	69.2	49.1	47.4	32.0	53.4	58.8	48.4	50.2	47.9	45.0	34.5	47.7
MAJOR CATEGORIES																							
MACROALGAE	46.6	28.7	56.5	47.5	43.8	30.0	38.6	37.5	27.0	29.4	29.4	24.3	42.9	22.5	0.8	20.3	29.7	36.1	33.7	23.6	49.5	12.5	33.6
Chlorophyta	5.9	1.2	0.4	1.8	2.2	3.2	4.8	12.1	2.6	7.5	0.6	10.8	13.2	1.9		0.9	0.5	1.0	1.0	0.7	0.5	0.0	3.3
Phaeophyta		0.2		3.4	0.8	1.3	0.8			0.9				0.8		2.3			0.6		1.0	0.8	0.6
Rhodophyta	22.5	21.3	1.7	1.1	30.8	16.3	22.1	14.4	6.4		1.6		4.3	2.5			15.6	4.6	17.4	7.2	0.5		10.2
Turf Macroalgae	18.3	5.9	54.4	41.0	10.1	9.3	11.0	12.5	18.3	21.0	27.1	13.5	25.4	17.4	0.8	17.2	13.6	30.5	14.6	15.6	47.5	11.8	19.5

Table 9. (Continued).

Taxa or Substrate	Transect																						Overall Mean
	R-77.7	R-78.7	R-80.4	R-82.8	R-85	R-86.3	R-88.7	R-90.4	R-92	R-93.5	R-100	R-101	R-102	R-103.2	R-104.5	R-105.9	R-109.2	R-110	R-110.5	R-112	R-1	R-3	
FAUNA	0.3	3.3	1.0		0.2	9.6	3.0	3.8	0.5		0.1	0.4		0.5	43.8	18.4	2.3	5.8	2.8	3.3		28.3	4.5
Total Sponge	0.0	0.8	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	1.5	1.9	2.7	2.3	0.0	0.0	0.4
SUBSTRATE	53.1	68.0	42.5	52.5	56.1	60.4	58.4	58.8	72.5	70.6	70.5	75.3	57.1	77.0	55.5	61.2	68.0	58.1	63.5	73.1	50.5	59.3	61.9
Consolidated	20.0	23.8	0.5		6.3	1.3	2.9	2.5	7.8	5.0	11.9	2.5	1.4	15.9	1.3	5.0	3.3	3.5	3.9	9.6			6.1
Unconsolidated	8.8	7.8	0.7	9.4	5.8	5.4	8.3	10.6	8.0	1.3	12.5	2.9	6.6	13.8	22.3	2.8	5.8	6.3	9.4	15.7	5.5	24.8	8.0
Sediment Over Hard Substrate	24.4	36.4	41.3	43.1	44.0	53.8	47.2	45.6	56.7	64.4	46.1	69.2	49.1	47.4	32.0	53.4	58.8	48.4	50.2	47.9	45.0	34.5	47.7

Note: Cells showing values of 0.0 represent percent cover >0.0 but <0.1.

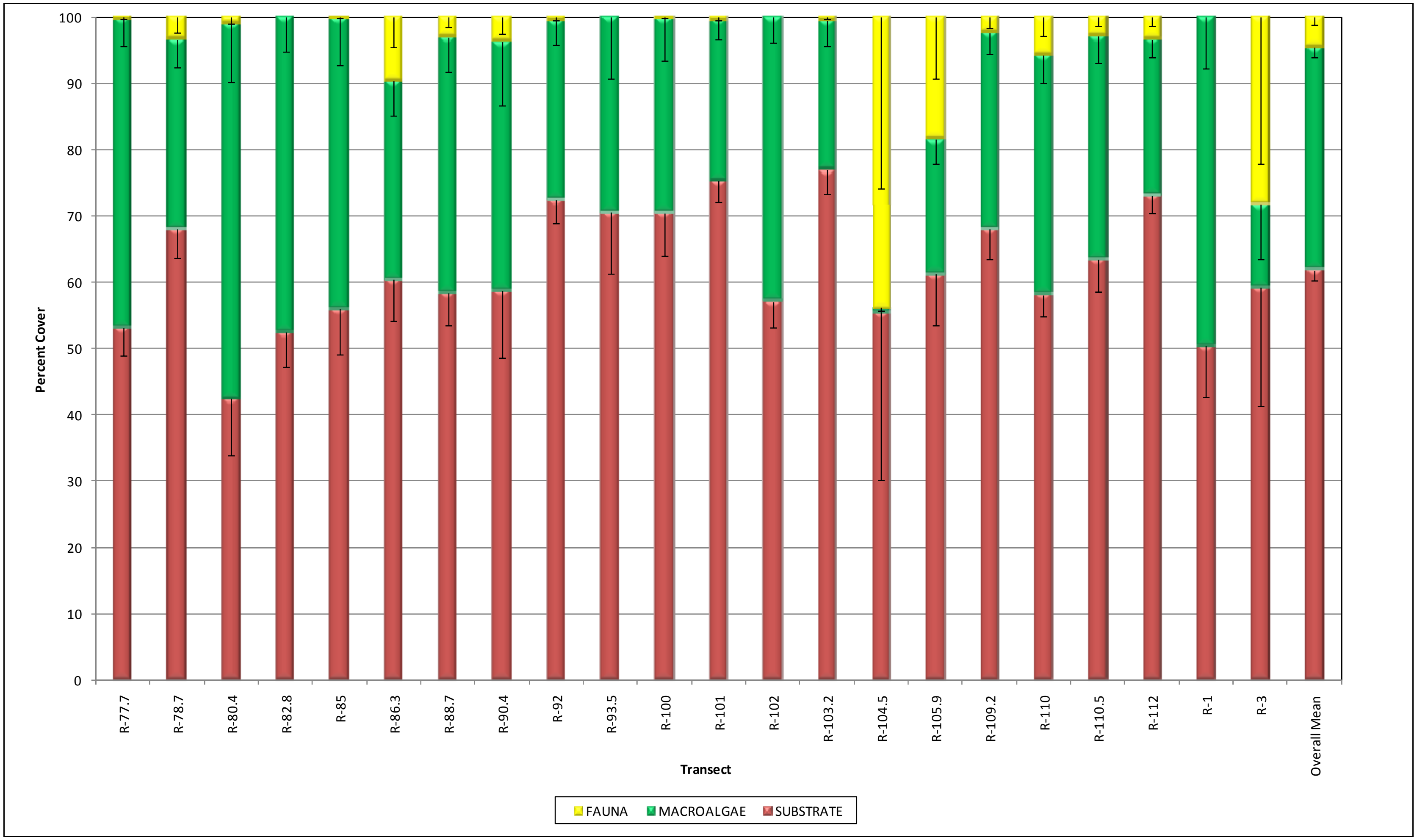


Figure 6. Mean percent cover of major categories from *in-situ* quadrat data collected along permanent cross-shore transects established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Error bars represent ± standard error.

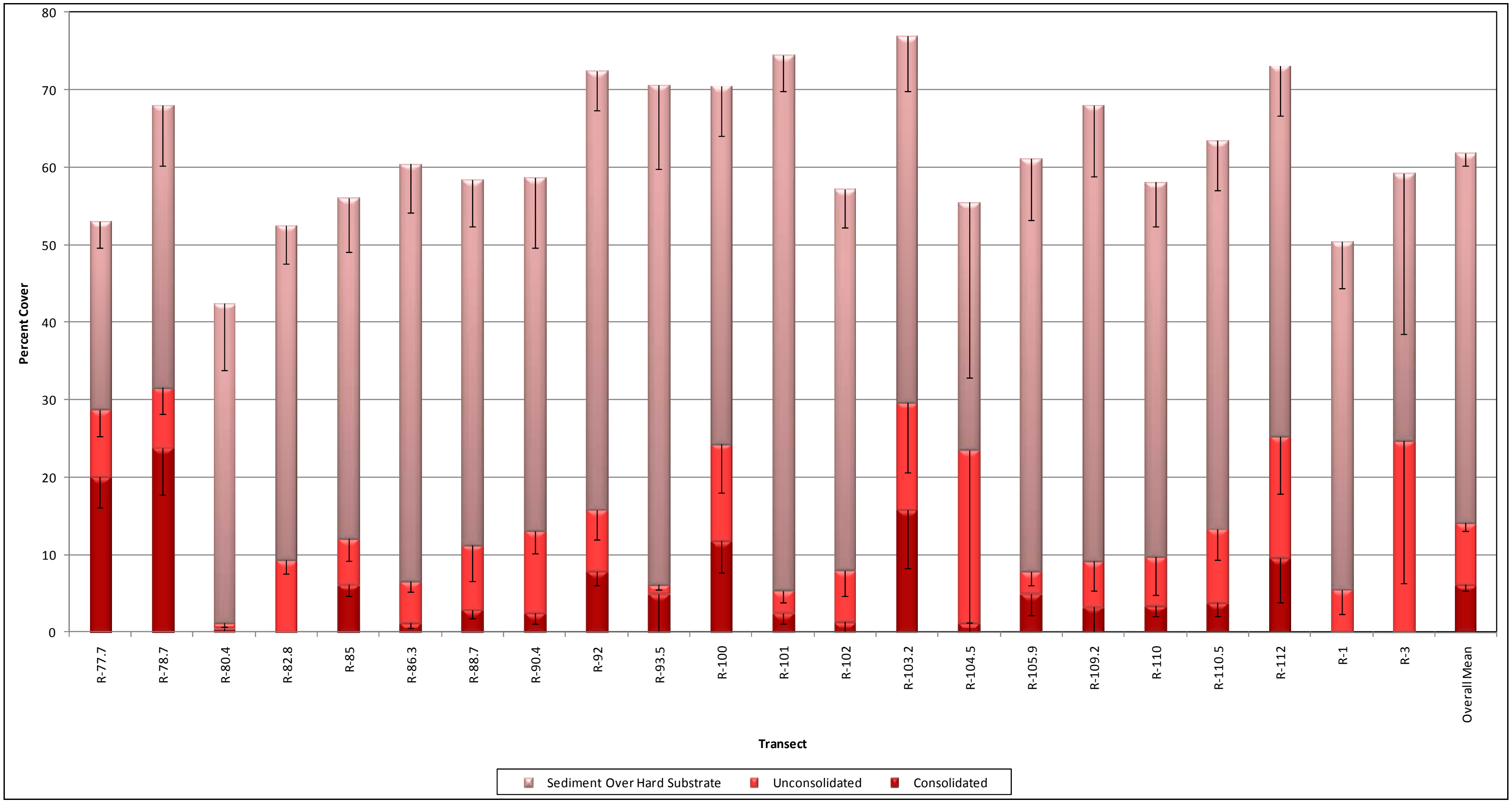


Figure 7. Mean percent cover of substrate subcategories from *in-situ* quadrat data collected along permanent cross-shore transects established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Error bars represent ± standard error.

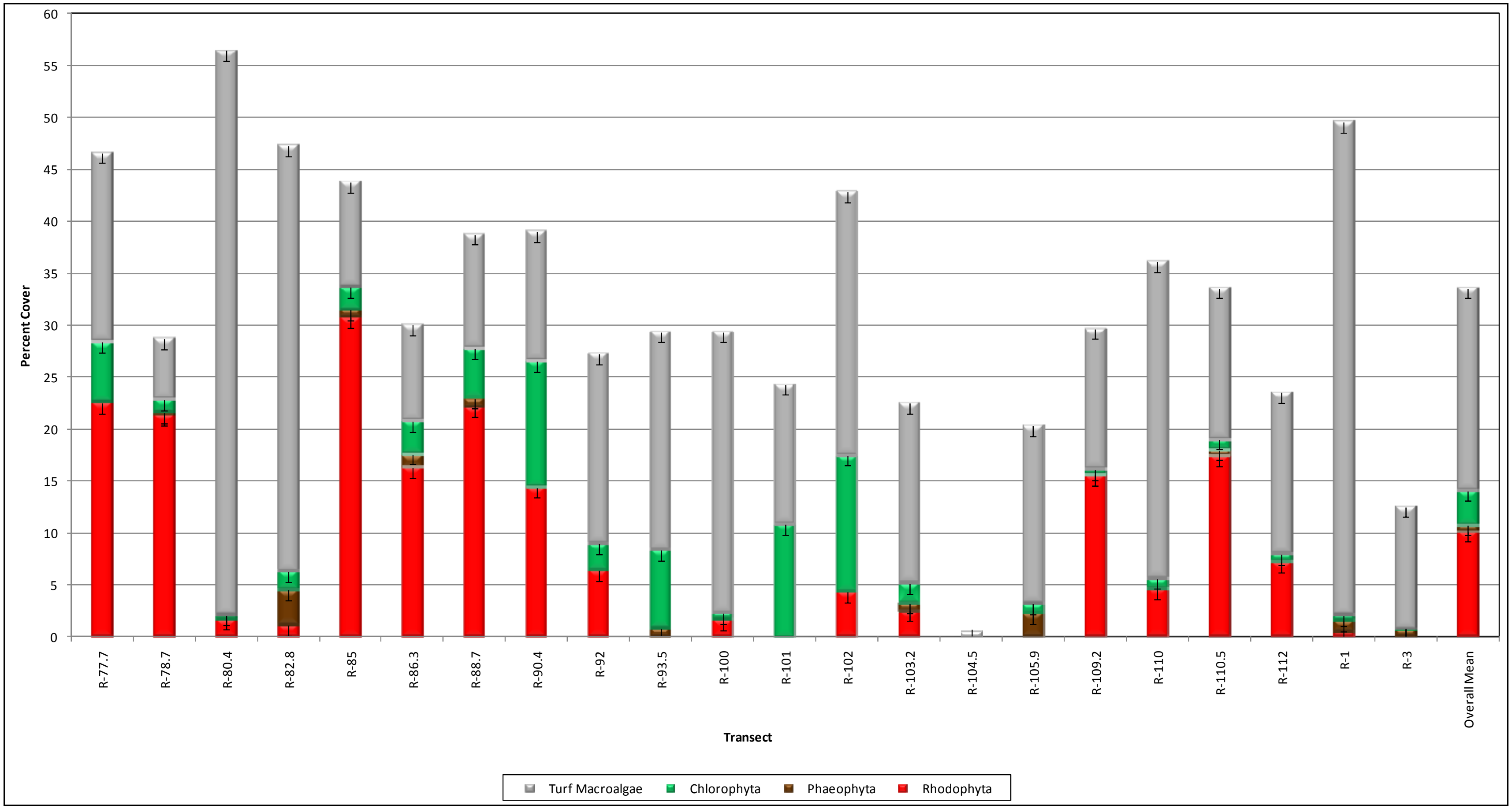


Figure 8. Mean percent cover of total macroalgae (by division) from *in-situ* quadrat data collected along permanent cross-shore transects established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Error bars represent ± standard error.

Mean maximum and overall mean heights of the two dominant macroalgal species observed for each transect are displayed in **Table 10**. Raw macroalgal height data including a comprehensive list of dominant macroalgal species observed in all *in-situ* quadrats is included in **Appendix C**. Mean maximum height of the dominant macroalgal species was lowest on Transect R-104.5 (1.0 cm) and highest on Transect R-88.7 (10.6 cm). Transect R-104.5 was dominated by low-growing turf algae, while Transect R-88.7 was composed of more robust, canopy-forming macroalgae including *B. seaforthii* and *Laurencia* sp. Turf algae was recorded as one of the two most dominant macroaglal taxa for the majority of *in-situ* quadrats with *Caulerpa* sp. and *H. musciformis* as other dominant macroalgal species. Overall mean height of the dominant macroalgal species mirrored the mean maximum algal height, with the lowest mean height observed on Transect R-104.5 at 0.5 cm and the highest mean height on Transect R-88.7 at 5.6 cm. This trend was also observed in the mean maximum and overall mean height of the second most dominant algal species with the lowest and highest measurements recorded in quadrats along Transect R-100 (0.3 cm; 0.2 cm) and Transect R-3 (12.0 cm; 7.0 cm), respectively.

Mean percent cover of fauna ranged from 0.0% on Transects R-82.8, R-93.5, R-102, and R-1 up to 43.8% on Transect R-104.5 (**Table 9**). Wormrock provided the greatest contribution to mean faunal percent cover in quadrats at 3.5%, followed by encrusting sponge at 0.4%, and hydroids at 0.3% (**Figure 9**). Other fauna recorded as counts within quadrats included the sponge *Cinachyra* sp. (overall mean count = 0.4), holothurids (0.2), and tunicates (0.1). Three scleractinian coral polyps (*Phyllangia americana americana*) were observed in the 20-m quadrat on Transect R-110.5.

Mean sediment thickness recorded within quadrats ranged from 0.2 cm on Transect R-105.9 to 5.1 cm on Transect R-3, with the majority of mean measurements less than 2.0 cm (**Table 11**). Maximum hard bottom relief ranged from 0.0 to 76.0 cm with the lowest mean relief of 5.7 cm recorded on Transect R-100 and highest mean relief of 25.5 cm on Transect R-109.2 (**Table 11**). A list of sediment thickness and maximum hard bottom relief measurements recorded within quadrats along all transects is included in **Appendix C**.

Sediment depth was measured at the base of permanent transect markers and 1 m west of each marker (**Table 12**). Due to installation activities and the substrate cleaning/scouring that occurs during the process, sediment depths at all markers were 0.0 cm, except on Transect R-93.5 where mean sediment depth on the transect was 0.1 cm due to 0.5 cm of sediment at the 29-m marker. Sediment depths 1 m west of markers ranged from 0.0 to 40.0 cm with the lowest mean sediment depth of 0.1 cm recorded on Transect R-105.9 and the highest mean sediment depth of 18.3 cm on Transect R-3.

3.3 NEARSHORE HARD BOTTOM EDGE MAPPING

Divers mapped the nearshore hard bottom edge in the survey area between FDEP Range Monuments R-77 and R-2 (**Appendix D**, **Figures D-23** to **D-32**). Marine conditions during the mapping process were ideal with seas less than 0.3 m (1 ft) and underwater visibility ranging from 1.0 to 3.0 m (3.0 to 10.0 ft).

Nearshore hard bottom features and community composition showed considerable variability through the length of the survey area. Three distinct nearshore hard bottom features observed during qualitative video review included low- to medium-relief (0.5 to 1.5 m) sabellariid wormrock (Community One), low-relief (0.5 m) consolidated coquina rock (Community Two), and medium-relief (1.5 m) large rock slab ledges (Community Three). These distinctions were based on a combination of physical (water depth, distance from shore, hard bottom relief) and compositional (dominant floral and faunal species) characteristics.

Table 10. Mean maximum and overall mean heights of the two dominant species of macroalgae from *in-situ* quadrat data collected along permanent cross-shore transects established during the Baseline Nearshore Hard bottom Characterization Survey for the St. Lucie County South Beach Project.

		Transect																						Overall
		R-77.7	R-78.7	R-80.4	R-82.8	R-85	R-86.3	R-88.7	R-90.4	R-92	R-93.5	R-100	R-101	R-102	R-103.2	R-104.5	R-105.9	R-109.2	R-110	R-110.5	R-112	R-1	R-3	
		Macroalgal Height																						
Dominant Macroalgae #1	Max (cm) (SE)	8.1 (0.5)	7.8 (0.8)	3.7 (0.2)	4.1 (0.7)	9.1 (1.6)	6.1 (1.8)	10.6 (2.1)	7.9 (1.6)	6.0 (1.9)	3.0 (0.2)	2.0 (0.4)	2.7 (0.8)	5.4 (2.3)	1.8 (0.3)	1.0 (0.0)	2.5 (0.6)	8.4 (3.1)	2.9 (0.2)	3.8 (1.1)	5.1 (1.8)	2.9 (0.4)	1.5 (0.5)	5.4 (0.4)
	Mean (cm) SE)	5.1 (0.5)	5.2 (0.6)	2.2 (0.2)	3.4 (0.7)	4.9 (1.0)	2.9 (1.0)	5.6 (1.1)	5.1 (1.2)	2.2 (0.6)	2.1 (0.2)	1.0 (0.2)	1.3 (0.3)	3.1 (1.3)	0.8 (0.1)	0.5 (0.0)	1.3 (0.3)	3.5 (0.9)	1.1 (0.1)	2.0 (0.8)	2.3 (1.0)	1.3 (0.1)	1.0 (0.5)	2.9 (0.2)
Dominant Macroalgae #2	Max (cm) (SE)	5.5 (1.0)	5.4 (1.1)	6.8 (1.9)	3.5 (0.4)	8.1 (1.5)	6.5 (1.0)	4.0 (1.3)	6.3 (1.4)	4.0 (2.0)	3.0 (0.4)	0.3 (0.3)	1.2 (0.1)	2.4 (0.3)	5.2 (1.4)	na	3.2 (1.1)	3.3 (0.8)	4.7 (0.7)	10.6 (2.0)	3.0 (1.1)	1.5 (1.5)	12.0 (na)	5.0 (0.4)
	Mean (cm) (SE)	3.3 (0.6)	3.3 (0.8)	5.3 (1.4)	3.0 (0.4)	5.9 (1.3)	4.0 (0.7)	2.3 (0.8)	4.8 (1.2)	2.1 (0.9)	2.0 (0.4)	0.2 (0.2)	0.6 (0.1)	1.3 (0.3)	3.5 (1.1)	na	2.0 (0.7)	1.7 (0.6)	3.2 (0.5)	6.7 (0.9)	1.6 (0.5)	1.0 (1.0)	7.0 (na)	3.2 (0.2)

Table 11. Mean sediment thickness and maximum hard bottom relief from *in-situ* quadrat data collected along permanent cross-shore transects established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

Parameter	Transect																					
	R-77.7	R-78.7	R-80.4	R-82.8	R-85	R-86.3	R-88.7	R-90.4	R-92	R-93.5	R-100	R-101	R-102	R-103.2	R-104.5	R-105.9	R-109.2	R-110	R-110.5	R-112	R-1	R-3
Mean Sediment Thickness (cm) (SE)	1.0 (0.2)	0.7 (0.2)	1.0 (0.1)	1.1 (0.1)	1.0 (0.1)	0.7 (0.1)	1.0 (0.2)	1.1 (0.2)	0.9 (0.2)	1.3 (0.2)	1.1 (0.5)	0.8 (0.2)	1.0 (0.2)	0.9 (0.3)	2.9 (1.3)	0.2 (0.0)	0.9 (0.3)	0.3 (0.1)	0.6 (0.3)	1.1 (0.4)	0.7 (0.1)	5.1 (2.7)
Maximum Hard Bottom Relief (cm) (SE)	14.9 (1.6)	21.7 (2.9)	10.7 (3.2)	8.5 (1.9)	16.8 (5.6)	14.3 (3.4)	17.4 (3.2)	12.6 (7.3)	11.9 (3.2)	9.6 (3.8)	5.7 (2.2)	17.1 (4.6)	8.0 (4.6)	25.1 (9.1)	11.0 (4.5)	9.9 (4.2)	25.5 (6.9)	22.5 (7.1)	22.2 (3.9)	13.3 (5.5)	17.5 (6.4)	20.2 (6.2)

SE = standard error.

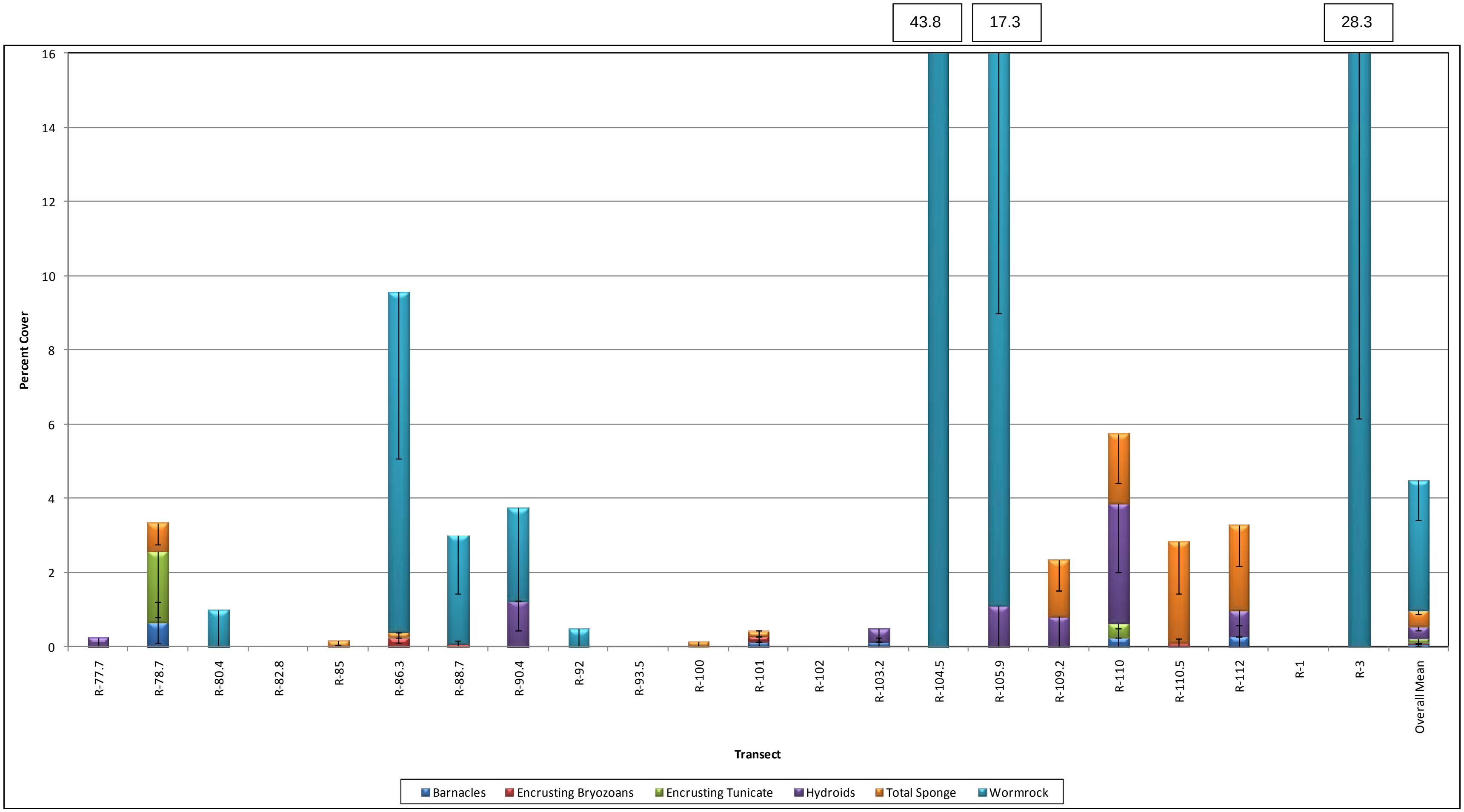


Figure 9. Mean percent cover of selected faunal taxa from *in-situ* quadrat data collected along permanent cross-shore transects established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Error bars represent ± standard error.

Table 12. Sediment depths measured at permanent transect markers and 1 m west of markers on permanent cross-shore transects established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

Transect																				
R-77.7			R-78.7			R-80.4			R-82.8			R-85			R-86.3			R-88.7		
Marker Location (m)	Sediment Depth (cm)		Marker Location (m)	Sediment Depth (cm)		Marker Location (m)	Sediment Depth (cm)		Marker Location (m)	Sediment Depth (cm)		Marker Location (m)	Sediment Depth (cm)		Marker Location (m)	Sediment Depth (cm)		Marker Location (m)	Sediment Depth (cm)	
	At Marker	1 m West of Marker		At Marker	1 m West of Marker		At Marker	1 m West of Marker		At Marker	1 m West of Marker		At Marker	1 m West of Marker		At Marker	1 m West of Marker		At Marker	1 m West of Marker
0	0.0	13.0	0	0.0	30.0	0	0.0	5.0	0	0.0	4.0	5	0.0	1.5	0	0.0	9.0	0	0.0	1.0
3	0.0	0.0	5	0.0	28.0	5	0.0	1.0	5	0.5	3.0	12	0.0	6.5	5	0.0	0.0	5	0.0	0.0
10	0.0	14.0	10	0.0	0.0	10	0.0	0.5	10	1.0	0.5	20	0.0	1.0	10	0.0	2.0	10	0.0	0.3
20	0.0	0.0	20	0.0	9.0	15	0.0	3.0	21	1.0	2.0	30	0.0	3.0	20	0.0	1.0	20	0.0	0.5
22	0.0	1.0	30	0.0	0.0	23	0.0	3.0	31	1.0	2.0	40	0.0	2.0	30	0.0	1.0	30	0.0	2.0
43	0.0	18.0	38	0.0	4.5	30	0.0	0.5	36	2.0	2.0	50	0.0	4.0	40	0.0	0.0	40	0.0	0.3
46	0.0	0.0	67	0.0	16.0	36	0.0	3.0	54	0.5	30.0	60	0.0	4.5	50	0.0	5.0	50	0.0	5.0
			75	0.0	2.5							70	0.0	2.0	60	0.0	0.5	60	0.0	2.0
												80	0.0	1.0	70	0.0	0.3	70	0.0	0.5
												93	0.0	1.0	80	0.0	4.0	80	0.0	1.0
												100	0.0	0.5	90	0.0	0.0	93	0.5	4.0
												103	0.0	2.0	100	0.0	2.0	96	0.0	27.0
Mean	**0.0**	**6.6**	**Mean**	**0.0**	**11.3**	**Mean**	**0.0**	**2.3**	**Mean**	**0.9**	**6.2**	**Mean**	**0.0**	**2.4**	**Mean**	**0.0**	**2.1**	**Mean**	**0.0**	**3.6**
SE	**0.0**	**3.0**	**SE**	**0.0**	**4.3**	**SE**	**0.0**	**0.6**	**SE**	**0.2**	**3.5**	**SE**	**0.0**	**0.5**	**SE**	**0.0**	**0.8**	**SE**	**0.0**	**2.2**

SE = standard error.

Table 12. (Continued).

Transect																				
R-90.4			R-92			R-93.5			R-100			R-101			R-102			R-103.2		
Marker Location (m)	Sediment Depth (cm)		Marker Location (m)	Sediment Depth (cm)		Marker Location (m)	Sediment Depth (cm)		Marker Location (m)	Sediment Depth (cm)		Marker Location (m)	Sediment Depth (cm)		Marker Location (m)	Sediment Depth (cm)		Marker Location (m)	Sediment Depth (cm)	
	At Marker	1 m West of Marker		At Marker	1 m West of Marker		At Marker	1 m West of Marker		At Marker	1 m West of Marker		At Marker	1 m West of Marker		At Marker	1 m West of Marker		At Marker	1 m West of Marker
0	0.0	3.0	0	0.0	4.0	0	0.0	3.0	0	0.0	6.0	0-horiz	0.0	10.0	0	0.0	8.0	0	0.0	30.0
12	0.0	14.0	5	0.0	0.5	5	0.0	0.5	10	0.0	0.5	3	0.0	11.0	5	0.0	3.0	7	0.0	11.0
20	0.0	2.0	10	0.0	1.5	10	0.0	1.0	20	0.0	2.0	5	0.0	1.0	20	0.0	2.0	10	0.0	0.5
30	0.0	2.0	20	0.0	3.0	19	0.0	2.0	30	0.0	0.0	7	0.0	4.0	30	0.0	0.0	20	0.0	0.0
50	0.0	1.0	30	0.0	1.0	27	0.0	2.0	44	0.0	12.0	22	0.0	1.5				28	0.0	0.5
60	0.0	0.5	40	0.0	0.0	29	0.5	1.0	60	0.0	17.0							30	0.0	13.0
70	0.0	0.5	48	0.0	1.0															
80	0.0	1.0	56	0.0	4.5															
			60	0.0	0.3															
			69	0.0	4.0															
Mean	**0.0**	**3.0**	**Mean**	**0.0**	**2.0**	**Mean**	**0.1**	**1.6**	**Mean**	**0.0**	**6.3**	**Mean**	**0.0**	**5.5**	**Mean**	**0.0**	**3.3**	**Mean**	**0.0**	**9.2**
SE	**0.0**	**1.6**	**SE**	**0.0**	**0.5**	**SE**	**0.1**	**0.4**	**SE**	**0.0**	**2.8**	**SE**	**0.0**	**2.1**	**SE**	**0.0**	**1.7**	**SE**	**0.0**	**4.8**

SE = standard error.

Table 12. (Continued).

Transect																							
R-104.5			R-105.9			R-109.2			R-110			R-110.5			R-112			R-1			R-3		
Marker Location (m)	Sediment Depth (cm)		Marker Location (m)	Sediment Depth (cm)		Marker Location (m)	Sediment Depth (cm)		Marker Location (m)	Sediment Depth (cm)		Marker Location (m)	Sediment Depth (cm)		Marker Location (m)	Sediment Depth (cm)		Marker Location (m)	Sediment Depth (cm)		Marker Location (m)	Sediment Depth (cm)	
	At Marker	1 m West of Marker		At Marker	1 m West of Marker		At Marker	1 m West of Marker		At Marker	1 m West of Marker		At Marker	1 m West of Marker		At Marker	1 m West of Marker		At Marker	1 m West of Marker		At Marker	1 m West of Marker
0	0.0	19.0	0	0.0	1.0	0-horiz	0.0	8.0	0-horiz	0.0	20.0	0-horiz	0.0	17.0	0	0.0	25.0	0	0.0	15.0	0	0.0	12.0
5	0.0	0.0	5	0.0	0.0	5	0.0	11.0	10	0.0	0.5	2	0.0	0.0	30	0.0	28.0	5	0.0	3.0	5	0.0	34.0
8	0.0	40.0	10	0.0	0.0	10	0.0	35.0	30	0.0	0.5	9	0.0	0.3	40	0.0	1.0	10	0.0	0.3	10	0.0	27.0
10	0.0	0.0	14	0.3	6.5	30	0.0	1.0	31	na	na	14	0.0	15.0	48	0.0	33.0	12	0.0	7.0	20	0.0	0.0
			18	0.0	0.0	36	0.0	0.5	36	0.0	13.0	20	0.0	0.5	70	0.0	10.0						
			20	0.0	0.0							30	0.0	0.0	73	0.0	2.0						
			23	0.0	0.5																		
			26	0.0	0.5																		
Mean	**0.0**	**14.8**	**Mean**	**0.0**	**1.1**	**Mean**	**0.0**	**11.1**	**Mean**	**0.0**	**8.5**	**Mean**	**0.0**	**5.5**	**Mean**	**0.0**	**16.5**	**Mean**	**0.0**	**6.3**	**Mean**	**0.0**	**18.3**
SE	**0.0**	**9.5**	**SE**	**0.0**	**0.8**	**SE**	**0.0**	**6.3**	**SE**	**0.0**	**4.8**	**SE**	**0.0**	**3.3**	**SE**	**0.0**	**5.7**	**SE**	**0.0**	**3.2**	**SE**	**0.0**	**7.6**

SE = standard error.

Nearshore hard bottom Community One was characterized by a low- to medium-relief hard bottom ledge with a significant wormrock component. This often discontinuous hard bottom ledge was observed from permanent Transect R-82.8 south to FDEP Range Monument R-94. The nearshore edge was close to the shoreline with distance from the MHWL ranging from 11 to 48 m (as measured from the western ends of permanent transects within this area). Wormrock was observed along the length of this area while other observed fauna included hydroids and unidentified encrusting sponge. Algal species observed in this area included canopy-forming red algae (*B. seaforthii* and *Hypnea* sp.) as well as low-growing turf algae and *Caulerpa* sp. Fishes observed in this community included spottail pinfish (*Diplodus holbrooki*), juvenile grunts (*F. Haemulidae*), nurse shark (*Ginglymostoma cirratum*), and black seabass (*Centropristis striata*).

Nearshore hard bottom Community Two consisted of low-relief consolidated coquina rock ledges and was observed from FDEP Range Monument R-100 south to Range Monument R-106. The nearshore ledge was similar to hard bottom Community One in proximity to shoreline with distance from the 2008 MHWL ranging from approximately 26 m to 42 m. The hard bottom ledge was typically well defined, undercut exposed consolidated coquina rock ledge with little to no benthic cover. Sand along the hard bottom edge in this area was coarse in size with areas of large consolidated shell rubble. Where macroalgae was observed, it was typically composed of turf algae and low-growing green algae *Caulerpa* cf. *laetevirens*, *Caulerpa sertularioides*, and *Codium* sp. Sabellariid wormrock was observed in very low densities in northern portions of this area near Range Monument R-101 and in the extreme southern end along Transect R-105.9, but was not a large component of this nearshore hard bottom community. Fishes observed in this community included sand drum (*Umbrina coroides*), spottail pinfish, electric ray (*Narcine brasiliensis*), hairy blenny (*Labrisomus nuchipinnis*), and grey snapper (*Lutjanus griseus*).

Nearshore hard bottom Community Three consisted of a medium-relief broken rock slab ledge. This ledge was often discontinuous and observed in the northern (Transects R-77.7 to R-82.8) and southern (Transects R-109.2 to R-112) extent of the survey area. This hard bottom community was dominated by large (1- to 3-m diameter), flat rock structures found in deeper (3 to 4 m) water and was considerably farther from the shoreline (10 to 196 m from MHWL) when compared to the other nearshore hard bottom communities. This area supported many faunal species not observed in the more nearshore hard bottom areas including spiny lobster (*Panulirus argus*), octocorals (*Leptogorgia* sp.), holothuroids, and a variety of encrusting sponges. Fishes observed in this community included porkfish (*Anisotremus virginicus*), sheepshead (*Archosargus probatocephalus*), striped burrfish (*Chilomycterus schoepfii*), highhat (*Pareques acuminatus*), juvenile angelfish (*Pomacanthus* sp.), and many other species of newly settled juvenile fishes.

Additionally, three large shore-parallel sand gaps were observed within the survey area that lacked nearshore hard bottom structures or featured very small patches of exposed hard substrate. Shore-parallel sand gaps recorded along the survey area (R-94 to R-99; R-107 to R-109, and R-112 to R-2) totalled approximately 3,700 m (12,000 ft) in length and consisted primarily of fine, unconsolidated sand substrate.

3.4 PIPELINE CORRIDORS

Six potential pipeline corridors located near FDEP Range Monuments R-89 (PC-1), R-100 (PC-2), R-101 (PC-3), R-104 (PC-4), R-108 (PC-5), and R-114 (PC-6) were surveyed (**Appendix D**, **Figures D-33** to **D-38**). Hard bottom or partially exposed hard bottom was present along the nearshore portions of four (PC-1, PC-2, PC-3, and PC-5) of the six corridors (**Table 13**). The remaining pipeline corridors consisted entirely of unconsolidated sand and/or low-relief shell hash mounds.

Nearshore segments (0-96 m) of PC-1 were represented by a low- to medium-relief hard bottom community similar to that described in **Section 3.3** as nearshore hard bottom Community One. Macroalgae observed along the corridor included unidentified branching red algae, turf algae, and the green alga *Ulva* sp. Wormrock was a significant component to the nearshore portion of this corridor with an estimated 15% to 30% cover.

Table 13. Distance from mean high water line (MHWL) and substrate delineation of potential pipeline corridors mapped during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

Pipeline Corridor	Distance from MHWL (m)	Start (m)	End (m)	Segment Length (m)	Substrate Type
PC-1	7	0	35	35	Hard bottom
		35	52	18	Partially exposed hard bottom
		52	87	34	Hard bottom
		87	96	9	Partially exposed hard bottom
		96	477	381	Sand
PC-2	11	0	17	17	Sand
		17	78	61	Partially exposed hard bottom
		78	279	201	Sand
		279	314	35	Shell hash
		314	514	200	Sand
PC-3	26	0	62	62	Hard bottom
		62	413	351	Sand
		413	479	66	Shell hash
PC-4	54	0	202	202	Sand
		202	241	38	Shell hash
		241	285	45	Sand
		285	355	70	Shell hash
PC-5	51	0	19	19	Sand
		19	25	6	Partially exposed hard bottom
		25	532	507	Sand
PC-6	48	0	470	470	Sand

Nearshore segments of PC-2 and PC-3 were more indicative of nearshore hard bottom Community Two observed during edge mapping and were characterized by a low-relief hard bottom shelf system with little to no floral or faunal components. Macroalgae observed along these corridors included low-growing turf algae and *Caulerpa prolifera/brachypus.*

Photo 2. Consolidated shell hash mound observed at the 285-m mark along potential pipeline corridor PC-4.

The partially exposed hard bottom community observed along PC-5 was very patchy with only a 6-m interval of observed hard bottom. This segment of the corridor provided little macroalgal or faunal cover, however, some turf algae was observed on protruding faces of the hard bottom patches. This may be an area of ephemeral hard bottom exposure.

Areas of low-relief shell hash mounds were observed along the offshore segments of three pipeline corridors (PC-2, PC-3, and PC-4). These areas were composed of consolidated large shells with attached epiphytic algae and provided little to no benthic relief (**Photo 2**). Though hard bottom was not observed along these segments, the sparse macroalgal canopy supported by the shell hash mounds provided habitat to a number of fishes, including leopard sea robin (*Prionotus scitulus*), juvenile grunt (*Haemulon* sp.), and juvenile lane snapper (*Lutjanus synagris*).

4.0 DISCUSSION

Twenty-two permanent cross-shore transects were established in the survey area from FDEP Range Monument R-77 in St. Lucie County south to FDEP Range Monument R-3 in Martin County. Two distinct nearshore environments were observed during transect analysis indicating a significant shift in habitat composition when comparing nearshore transects to those established 100 m farther offshore. Transects established near the shore in 1- to 2-m water depths showed some variability in benthic cover from north to south but were generally characterized by turf algae, *Caulerpa* sp., and wormrock. Transects installed farther from shore, but still along the nearshore edge in 3- to 4-m water depths were typified by greater faunal diversity including octocorals and many species of encrusting sponges and tunicates, while also supporting turf algae and mixed red algae benthic components.

4.1 VIDEO DATA

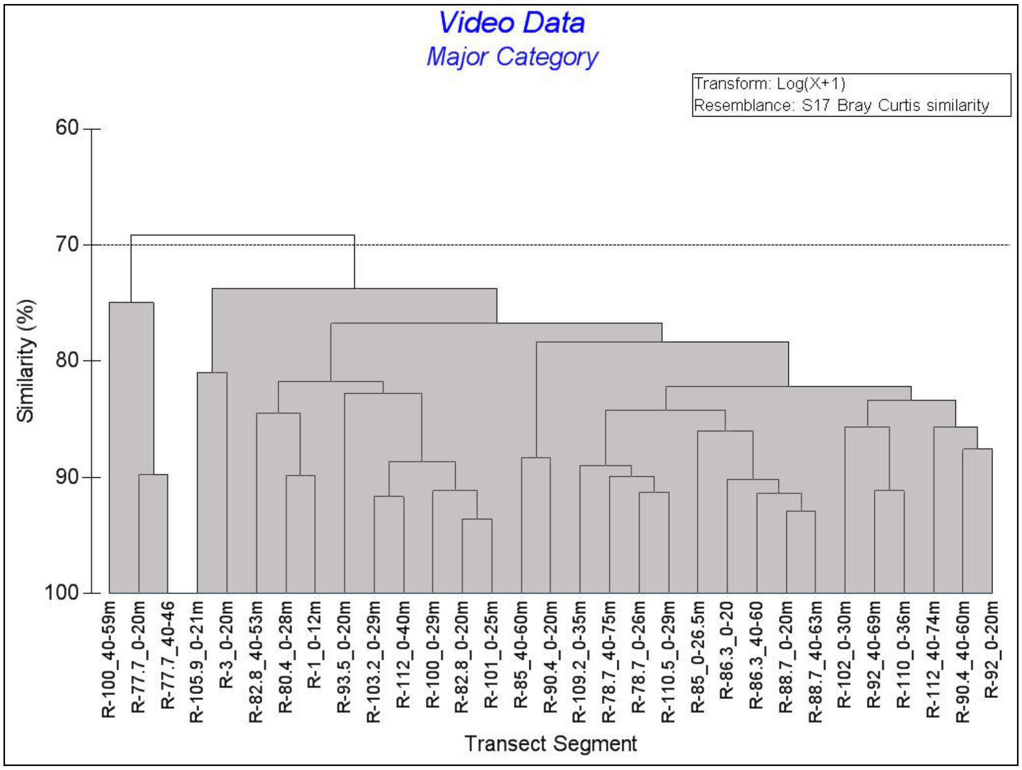
Thirty-one quantitative video segments were analyzed by point count analysis to characterize the nearshore environment in the survey area. Substrate, primarily sediment over hard substrate, was the dominant benthic cover along most transect segments, followed by macroalgae. Some macroalgal composition trends were observed within the survey area with the section from Transects R-77 to R-90.4 dominated by more robust, canopy-forming red algae while transects farther south had a larger turf algae component.

Overall, fauna comprised a small fraction of the nearshore hard bottom cover with wormrock constituting a majority of this cover. Wormrock was primarily observed between Transects R-86.3 and R-92, although the highest percent cover was recorded along Transect R-3. Wormrock was a significant component along the nearshore segments of these transects forming large monotypic outcroppings that were often exposed during low tides. Other observed fauna included holothurids, hydroids, tunicates, and encrusting sponge. No coral colonies were observed during quantitative and qualitative video review.

Statistical analysis of video data yielded some trends within the dataset with much of the dissimilarity among transects related to floral and faunal distribution. MDS ordinations and similarity clustering showed little dissimilarity in major category (macroalgae, substrate, biotic turf, and fauna) percent cover (**Figure 10**) with analysis of the biota dataset (macroalgae and fauna) indicating several dissimilarities in the biotic cover along transects (**Figure 11**). Three distinct clusters at 54% similarity were observed from biota analyses, showing strong dissimilarity among transects. Cluster A comprised a single transect segment (R-100, 40-59 m), Cluster B comprised 14 segments including both segments of Transects R-77.7, R-78.7, R-85, R-86.3, R-88.7, and R-90.4 and individual transect segments R-109.2 (0-35 m) and R-110.5 (0-29 m). Cluster C contained the remaining 16 transect segments. SIMPER routines indicated dissimilarity between clusters was driven by the greater percent cover of unidentified red algae, unidentified algae, and wormrock along transects in Cluster B accounting for 36% of the dissimilarity among clusters. These analyses confirm trends observed through descriptive statistics showing a greater macroalgae canopy and wormrock presence along the northern transects (R-77 to R-90.4) when compared to the more turf algae-dominated benthic community common along southern transects (R-92 to R-3).

4.2 *IN-SITU* QUADRAT DATA

In-situ quadrat data were collected along all installed transects and strongly mirrored video data when comparing large-scale trends in benthic cover along the survey area. Substrate was the dominant cover along most transects with sediment over hard substrate accounting for a majority of this cover. Like video analysis, high-growing, robust macroalgal cover was more prolific along the northern portions of the survey area while southern transects were dominated by low-growing turf algae.



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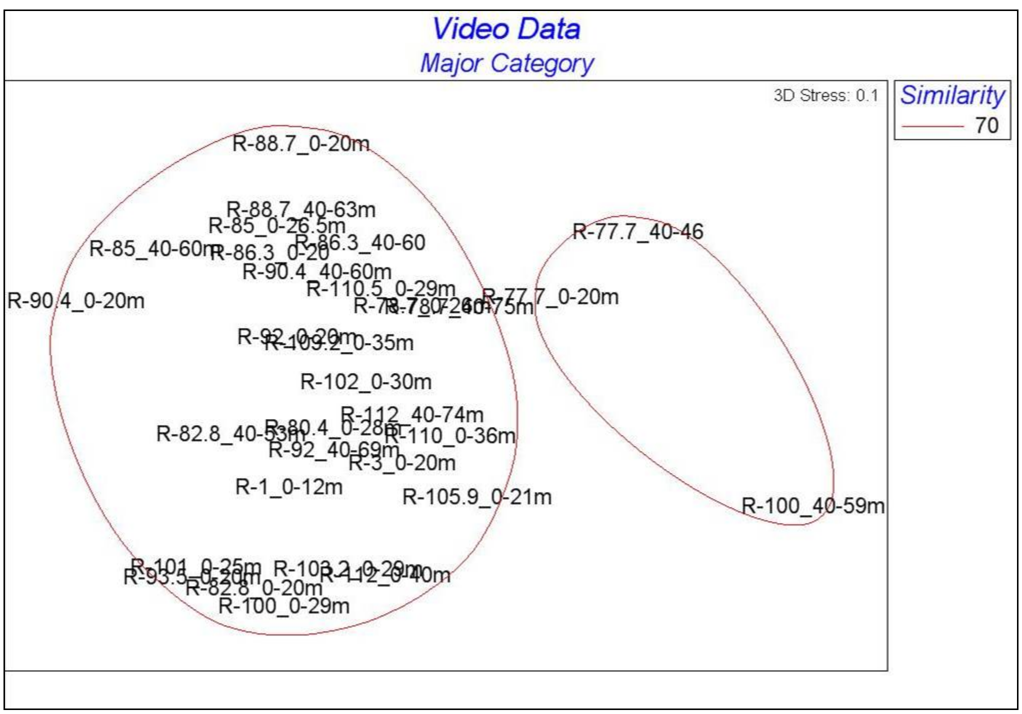


b

Figure 10. Cluster analysis (a) and multi-dimensional scaling plot (b) based on a Bray-Curtis similarity matrix of major category percent cover from transect video data collected during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

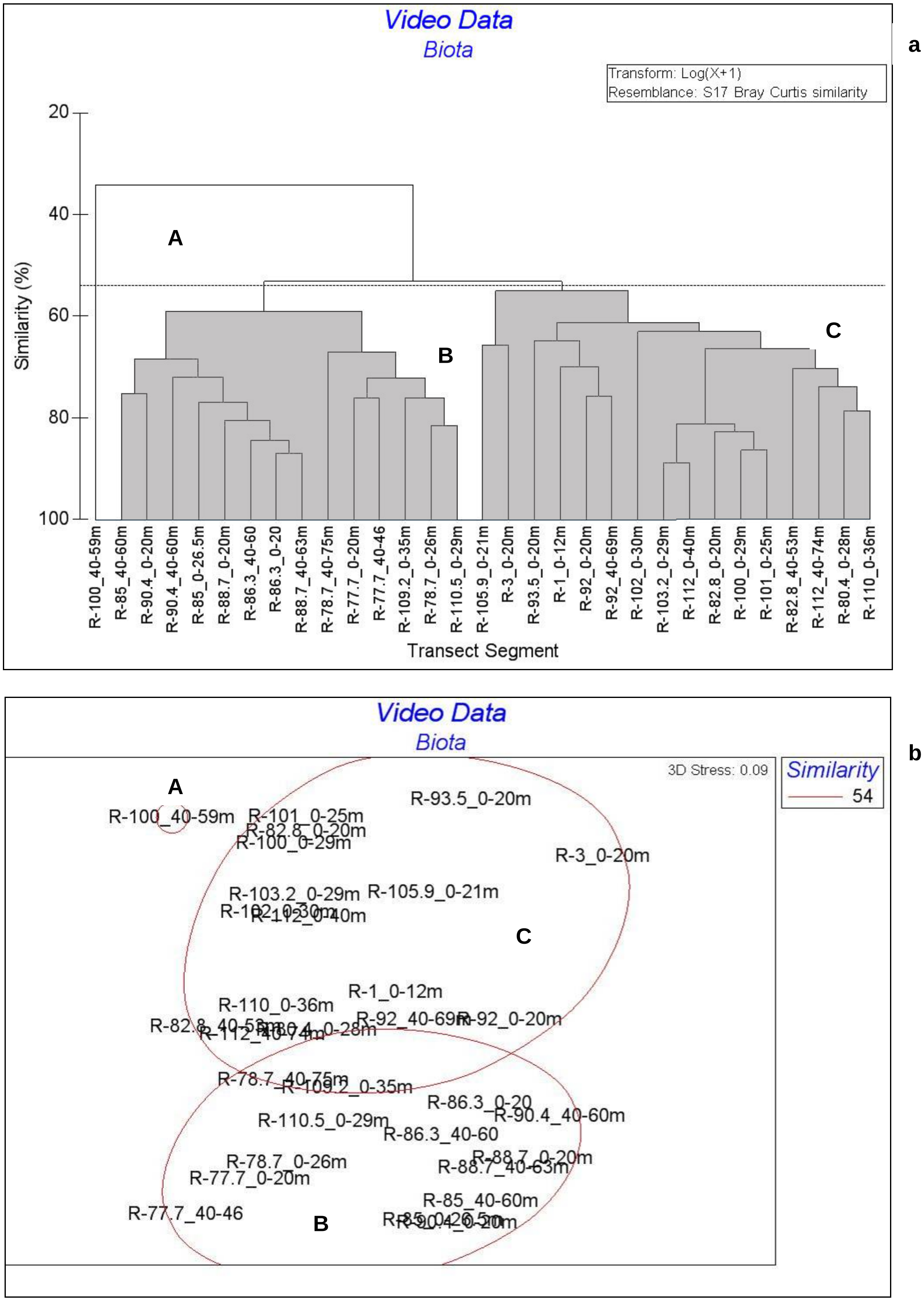


Figure 11. Cluster analysis (a) and multi-dimensional scaling plot (b) based on a Bray-Curtis similarity matrix of biota percent cover from transect video data collected during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

A greater number of faunal taxa were observed within *in-situ* quadrats (14) when compared to video data (7) due to the ability of divers to more readily identify small, cryptic faunal species common to the nearshore habitats. Wormrock distribution and percent cover noted within the survey area were similar to that observed in video data, with wormrock recorded along 8 of the 22 transects. Although wormrock percent cover was greatest along Transect R-104.5, it is noted that this transect was surveyed in 2008 and was completely covered in sand at the time of the 2009 survey. Only three scleractinian coral polyps were recorded within quadrats with no coral colonies suitable for transplant observed within the survey area.

MDS ordinations and similarity clustering of *in-situ* quadrat major category data indicated some dissimilarity among transects with Transects R-104.5 and R-3 clustering out at 62% similarity (**Figure 12**). Although this separation was relatively minor, SIMPER routines showed that greater faunal percent cover, primarily wormrock, coupled with lesser red algal cover along these two transects was responsible for 43% of the observed dissimilarity.

Analysis performed on the biotic component of the dataset indicated strong clustering with four distinct clusters observed at 38% similarity (**Figure 13**). Cluster A included Transects R-3, R-104.5, and R-105.9; Cluster B included Transects R-85, R-86.3, R-88.7, and R-90.4; Cluster C included Transects R-80.4, R-82.8, R-93.5, R-100, R-101, R-102, R-103.2, and R-1; Cluster D included Transects R-77, R-78.7, R-92, R-109.2, R-110, R-110.5, and R-112. The greatest separation appeared to be Cluster A from the remainder of the dataset with the dominance of wormrock and turf algae along these transects. While wormrock was also a large component of transects in Cluster B, high percent cover of branching macroalgae, including *H. musciformis* and *Laurencia* sp., created some separation between the two clusters. Cluster D was composed of seven transects, including the six transects installed at a greater distance from shore. While Clusters D and C showed the greatest similarity (38%), transects in Cluster D presented a greatly differing benthic community. SIMPER routines indicated greater percent cover of canopy-forming red algae (*Gracilaria* sp. and *Hypnea* sp.) and encrusting sponge along these transects were responsible for 27% of dissimilarity among clusters.

4.3 NEARSHORE HARD BOTTOM EDGE MAPPING

Nearshore hard bottom mapping described three distinct hard bottom communities within the survey area featuring a wormrock-dominated ledge, consolidated coquina ledge, and a deeper water ledge composed of large, flat rock structures. These hard bottom types offered vastly contrasting benthic communities from north to south along the survey area and ranged from approximately 11 to 196 m from the shoreline (2008 MHWL).

Hard bottom Community One was a very shallow, often exposed, low- to medium-relief nearshore ledge dominated by wormrock and robust macroalgal species. This nearshore hard bottom was observed in the northern portion of the survey area between FDEP Range Monuments R-82 and R-94 and was often discontinuous and patchy. Hard bottom Community Two was recorded between FDEP Range Monuments R-100 and R-106 as a low-relief consolidated coquina rock ledge with little to no macroalgal or faunal cover. Although this hard bottom community appeared to be the most continuous during the survey, due to the burial of Transect R-104.5 following the 2008 installation and the barren nature of this hard bottom, the nearshore ledge in this area may be ephemeral with occasional sand burial and scouring along its length. Hard bottom Community Three was the most discontinuous of observed hard bottom types and was associated with the deeper, more offshore transects located in the northern (Transects R-77.7 to R-82.8) and southern (Transects R-109.2 to R-112) reaches of the survey area. This hard bottom edge was characterized by large, flat boulders along the length of the ledge system and offered a more diverse faunal community when compared to the remaining hard bottom types.

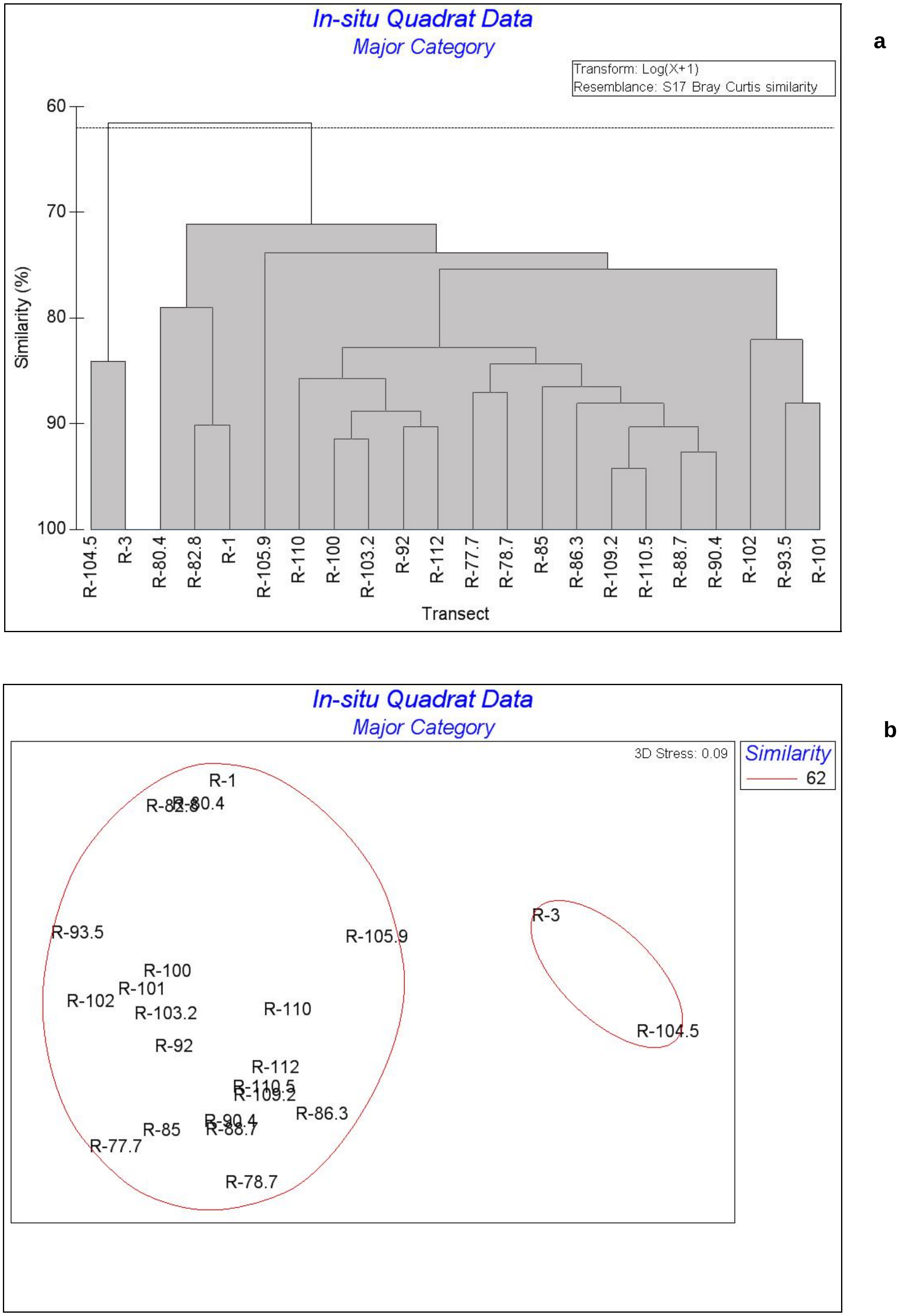
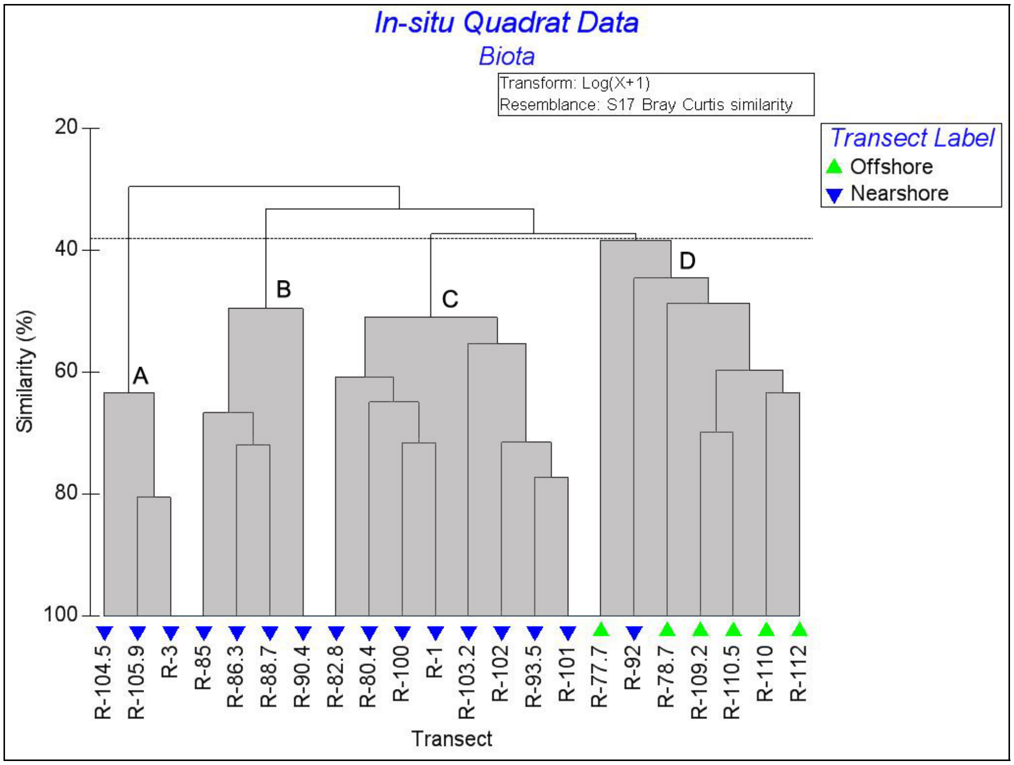


Figure 12. Cluster analysis (a) and multi-dimensional scaling plot (b) based on a Bray-Curtis similarity matrix of major category percent cover from *in-situ* quadrat data collected during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.



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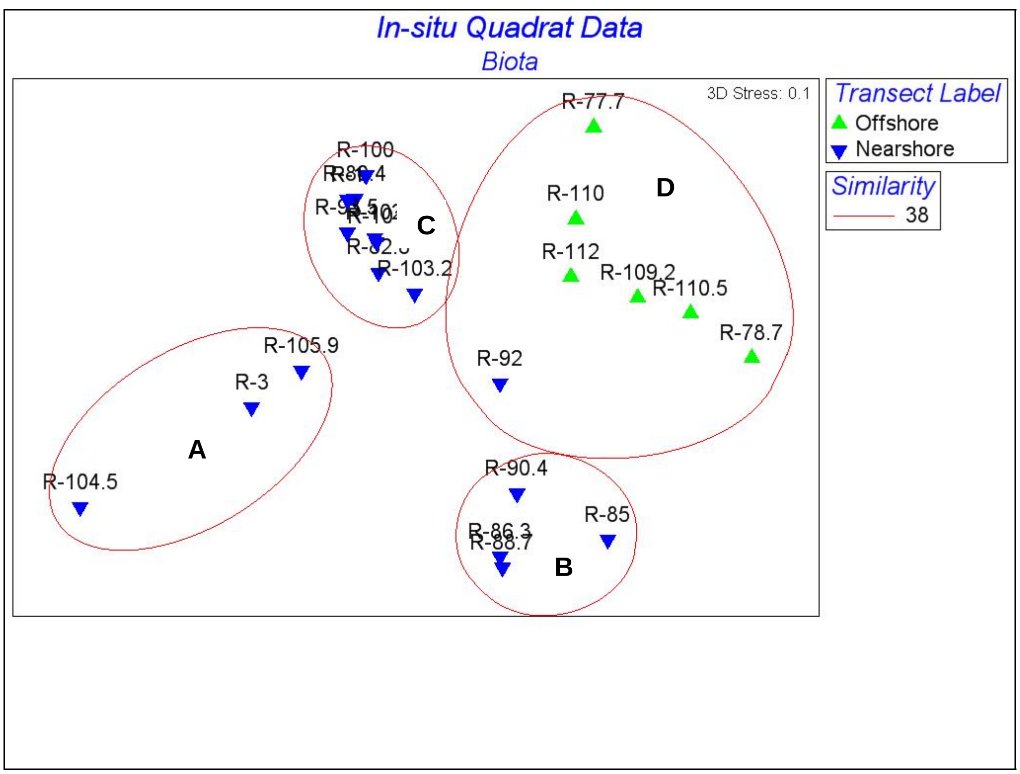

b

Figure 13. Cluster analysis (a) and multi-dimensional scaling plot (b) based on a Bray-Curtis similarity matrix of biota percent cover from *in-situ* quadrat data collected during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

The ecological functions of defined nearshore hard bottom communities within the survey area vary depending on the dominant floral or faunal species observed. The nearshore hard bottom environment along the eastern coast of Florida is utilized by over 1,000 species of invertebrates, fishes, algae, turtles, and other fauna. These species interact with each other and physical factors on a continual basis providing valuable functions within these nearshore habitats. Previous literature has defined nearshore functional groupings into two categories, including structure-shelter functional groupings (habitat builders, nesting and spawning site usage, attachment resource, nursery area, and cross-shelf faunal distribution) and trophic functional groupings (herbivory, carnivory, autotrophy, detritivory and omnivory, and cleaning symbioses) (CSA International, Inc., 2009). While these groupings are observed in some degree along all nearshore hard bottom habitats along the Florida coast, communities defined in this survey are characterized by certain physical and biological factors and contain a combination of the above designations. **Table 14** displays the number of taxa and substrate categories observed along transects within the three observed nearshore hard bottom communities for combined video and *in-situ* quadrat data.

Table 14. Number of taxa and substrate categories noted on transects within the three observed nearshore hard bottom communities for combined video and *in-situ* quadrat data collected during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

Taxa or Substrate	Nearshore Hard Bottom Community		
	One	Two	Three
MACROALGAE TOTAL	36	19	32
Chlorophyta	10	6	10
Phaeophyta	5	3	3
Rhodophyta	19	8	17
Other macroalgae	2	2	2
BIOTIC TURF TOTAL	1	1	1
FAUNA TOTAL	11	9	19
SUBSTRATE TOTAL	5	5	5
Consolidated	1	1	1
Unconsolidated	3	3	3
Sediment Over Hard Substrate	1	1	1

Nearshore hard bottom Community One was primarily characterized by the proximity to shoreline and the low- to medium-relief nature of the ledge. These physical characteristics promote the growth of wormrock while also supporting a large percent cover of robust, canopy-forming red algae. In addition to the structure/shelter provided by the nearshore ledge itself, the characterizing taxa observed in this community offer their own contributions to the ecological function of the habitat. The polychaete *P. lapidosa* (wormrock) is a reef building species common to the Florida coast and is a substantial contributor to the biological diversity of the nearshore environment in this area, supporting hundreds of species of invertebrates as a direct food source and habitat contributor (Gore et al., 1978). Additionally, the robust algal component associated with this community also offers shelter and nutrient source to hundreds of invertebrates, fishes, and turtle species.

While hard bottom Community Two was similar to Community One in some portions of the survey area (i.e., Transect R-105.9) with higher wormrock and macroalgal cover, the nearshore hard bottom ledge was generally lower in relief and supported a lower percent cover of floral and faunal species. This hard bottom community lacked the substantial ecological contribution provided by wormrock and robust macroalgae observed in Community One and was dominated by the low growing and often sporadic turf algae. Although turf algal species do perform similar functions to other macroalgal species including habitat, food source, and oxygen and nutrient production, these functions, particularly habitat source, are less contributing due to the growth habit of the algal species. It is noted that this community appears representative of a low relief, hard bottom community that is constantly subjected to sand movement, scouring, and potential burial throughout its length and may require additional, temporal observations to collect a better understanding of the long-term ecological function of the area.

Nearshore hard bottom Community Three was observed in greater water depths than Communities One and Two offering contrasting species composition and ecological function. This hard bottom community was composed of large, flat rock slab structures and provided substantially greater rugosity and crevices within the habitat. These physical characteristics alone provide for decreased turbidity and wave action and greater habitat opportunities for settling fishes, invertebrates, and sea turtle species. While this community was similar to Community One with high percent cover of robust, canopy-forming macroalgae (particularly in northern reach), it offered a much greater diversity of faunal species including octocorals, sponges, tunicates, and hydroids despite the absence of wormrock. In addition to their ecological contribution to the community food web, these species enhance the habitat by creating additional structure/shelter to be used by fishes and invertebrate species.

Following the review of nearshore hard bottom video and 2008 aerial images, it appears the large shore-parallel sand gap recorded from FDEP Range Monument R-112 south to R-2 may have contained considerably more hard bottom structure during the 2008 season when compared to 2009 mapping data. Although Transect R-1 was established within this area in 2008, the nearshore hard bottom edge near this transect was not mapped in 2009 due to the absence of adequate hard bottom. These results indicate this area, like the nearshore hard bottom edge near Transect R-104.5, may be ephemeral in nature with continual sand burial and scouring occurring throughout the year, causing this discrepancy between the mapping data and the 2008 aerial images.

Figures D-11, **D-12**, **D-13**, **D-14**, and **D-19** depict substrate delineations of Transects R-100, R-101, R-102, R-103.2, and R-110.5, respectively, with overlaid 2009 nearshore hard bottom edge mapping indicating transect 0-m mark installation shoreward of the most nearshore hard bottom available in the area. Following additional qualitative video review, it was observed that this discrepancy was the result of transects established on small, low-relief (<0.5 m), sometimes partially exposed rock outcroppings nearshore of the mapped hard bottom ledge to maximize hard bottom availablility along the transect. Nearshore hard bottom mapping methods were designed to map the most prominent nearshore ledge in the area and may not always jog shoreward to map small (<2 m), isolated outcroppings as observed along these transects. As a result of this method, it gives the appearance there may have been significant hard bottom shoreward of what the hard bottom mapping figure indicates. However, this transect was actually established on one of these small outcroppings to maximize hard bottom analysis along the survey transect and was not recorded during the nearshore edge mapping procedure. The nearshore hard bottom mapping line delineates the most prominent nearshore ledge in the area and may not always coincide with the 0-m mark of installed transects.

Additionally, Transect R-101 appeared to be installed west of the nearshore hard bottom edge mapping line. After video review, it was observed that hard bottom was very sporadic in this area and adequate hard bottom was not available along the offshore portion of this transect, giving the appearance the transect ends just west of the nearshore hard bottom edge.

4.4 PIPELINE CORRIDORS

Hard bottom was recorded along the nearshore segments of four of the six mapped potential pipeline corridors. Hard bottom along pipeline corridors PC-2, PC-3, and PC-5 was relatively low-relief with little to no benthic growth. Nearshore hard bottom along pipeline corridor PC-1 was more significant in relief and benthic community with substantial macroalgal cover and wormrock present throughout the stretch of hard bottom. The remaining two pipeline corridors (PC-4 and PC-6) consisted entirely of unconsolidated sand substrate and/or low-relief consolidated shell hash mounds.

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APPENDICES

APPENDIX A

Representative Images

Image A-1. Digitized frame extracted from quantitative video data collected along Transect R-80.4 (0-28 m) showing *Padina* sp., *Caulerpa prolifera*/*brachypus*, *Gracilaria* sp., and turf algae.

Image A-2. Digitized frame extracted from quantitative video data collected along Transect R-88.7 (0-20 m) showing sabellariid wormrock (*Phragmatopoma lapidosa*) and *Caulerpa* cf. *laetevirens*.

Image A-3. Digitized frame extracted from quantitative video data collected along Transect R-93.5 (0-20 m) showing *Caulerpa prolifera*/*brachypus*, turf algae, and biotic turf.

Image A-4. Digitized frame extracted from quantitative video data collected along Transect R-102 (0-30 m) showing turf algae, sediment over hard substrate, and shell hash.

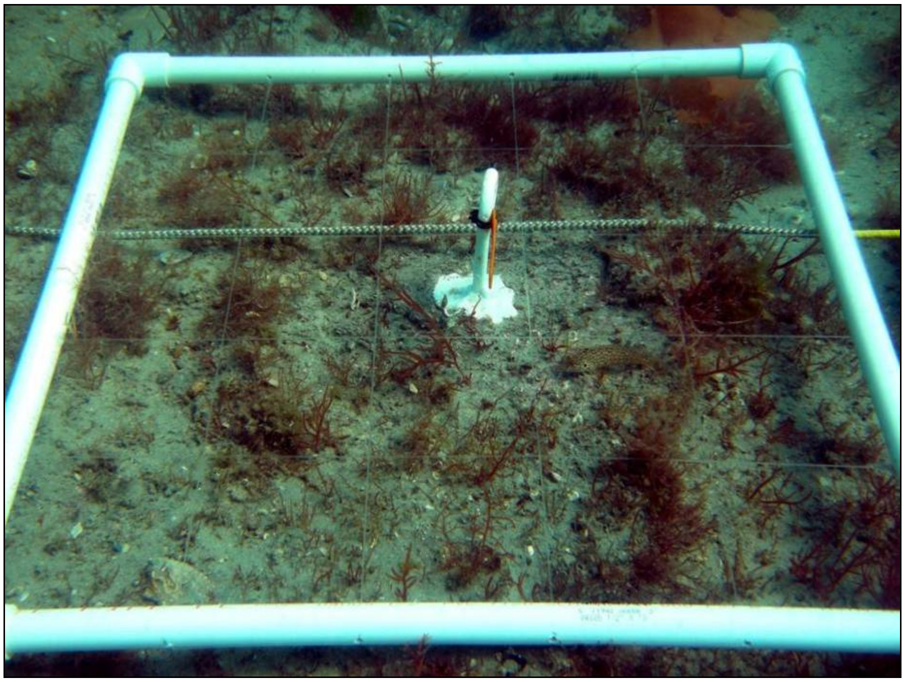

Image A-5. Photograph of *in-situ* quadrat on Transect R-77.7 at 20 m containing *Gracilaria* sp., *Hypnea* sp., rock, and sediment over hard substrate.

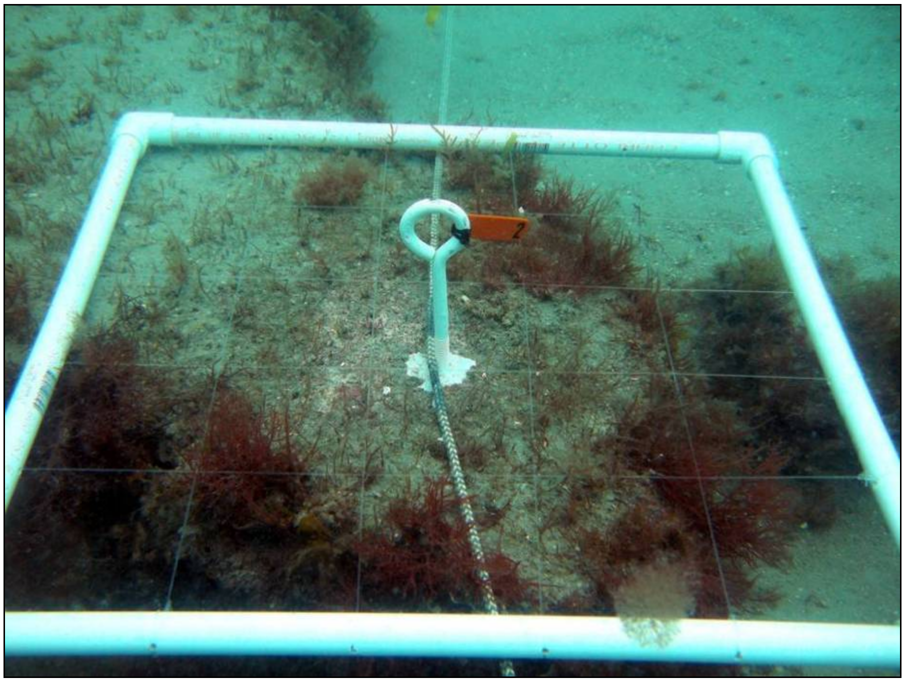

Image A-6. Photograph of *in-situ* quadrat on Transect R-78.7 at 20 m containing *Dictyot*a sp., *Agardhiella subulata,* turf algae, sand, and sediment over hard substrate.

Image A-7. Photograph of *in-situ* quadrat on Transect R-85 at 100 m containing *Bryothamnion seaforthii,* turf algae, rock, and sediment over hard substrate.

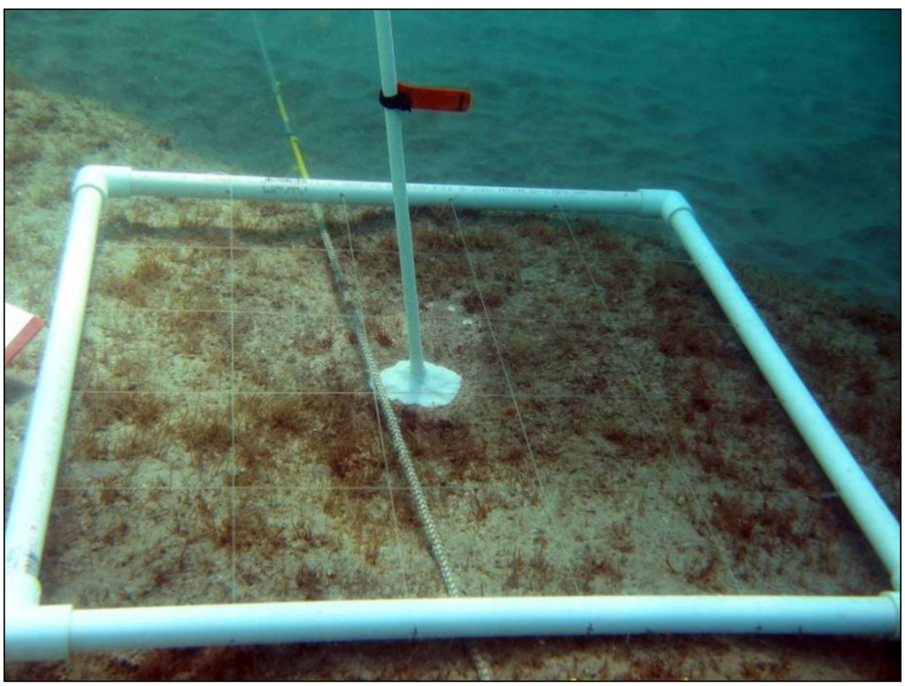

Image A-8. Photograph of *in-situ* quadrat on Transect R-110 at 10 m containing turf algae, rock, and sediment over hard substrate.

Image A-9. Nearshore hard-bottom edge Community Three observed near Transect R-110. Low- to medium-relief, hard-bottom ledges/slabs with porkfish (*Anisotremus virginicus*), turf algae, and broken algal wrack accumulation are shown in photograph.

Image A-10. Nearshore hard-bottom Community Two observed near Transect R-105.9. Low-relief consolidated coquina hard-bottom ledges with limited benthic growth and large shell rubble are shown in photograph.

Image A-11. Nearshore hard-bottom Community Three observed near Transect R-80.4. Low- to medium-relief large hard-bottom slab ledge with turf algae is shown in photograph.

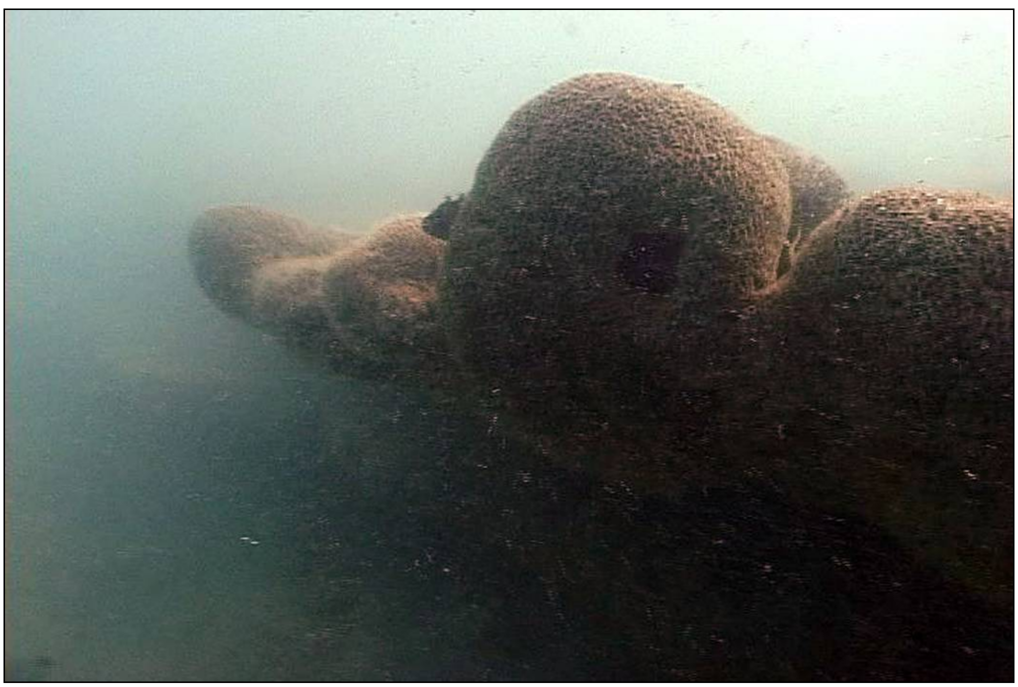

Image A-12. Nearshore hard-bottom Community One observed near Transect R-93.5. Medium-relief, hard-bottom ledge with sabellariid wormrock (*Phragmatopoma lapidosa*) is shown in photograph.

Image A-13. Sub-adult green sea turtle (*Chelonia mydas*) observed during nearshore hard bottom edge mapping near Transect R-80.4.

Image A-14. Boring sponge *Cliona celata* observed at the 136-m mark along Transect R-86.3.

Image A-15. Photograph of unidentified tunicate colony observed at the 36-m mark along Transect R-110 with unidentified red algae, spottail pinfish (*Diplodus holbrooki*), tomtate (*Haemulon aurolineatum*), and porkfish (*Anisotremus virginicus*).

Image A-16. Photograph of *Caulerpa prolifera*/*brachypus*, *C. mexicana*, and *C.* cf. *laetevirens* identified within *in-situ* quadrat along Transect R-90 (80 m).

Image A-17. Photograph of hydroids observed along Transect R-90 at the 60-m mark.

Image A-18. Photograph of sponge ?*Strongylamma baki* and juvenile cocoa damselfish (*Stegastes variabilis*) observed along Transect R-110.5 at the 25-m mark.

APPENDIX B

Point Count Analysis Data

(Provided In Electronic Format)

APPENDIX C

In-situ Quadrat Data

(Provided in Electronic Format)

APPENDIX D

Permanent Cross-shore Transects,
Mapped Nearshore Hard Bottom Edges, and
Mapped Potential Pipeline Corridor Delineations

LIST OF FIGURES

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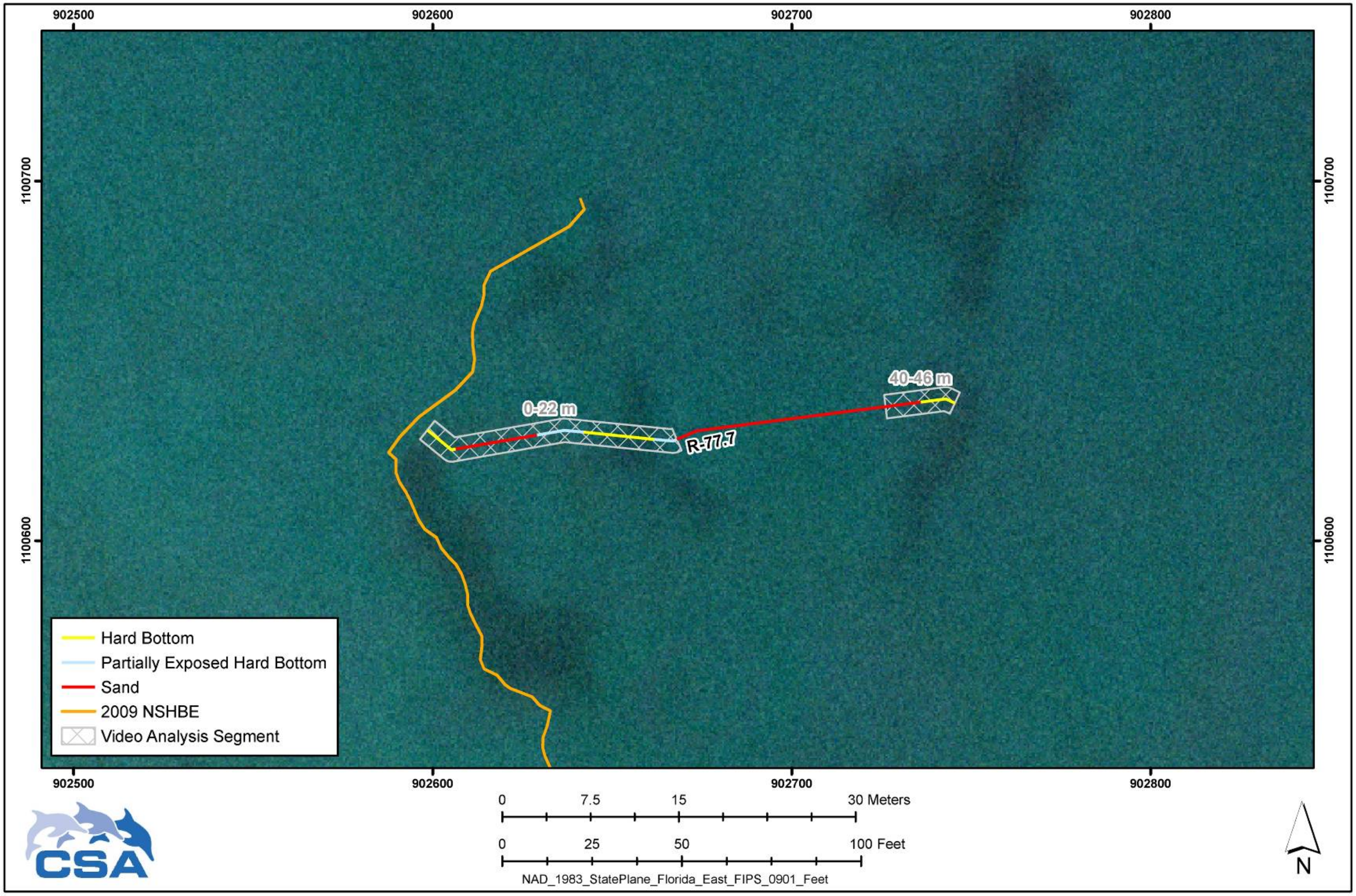
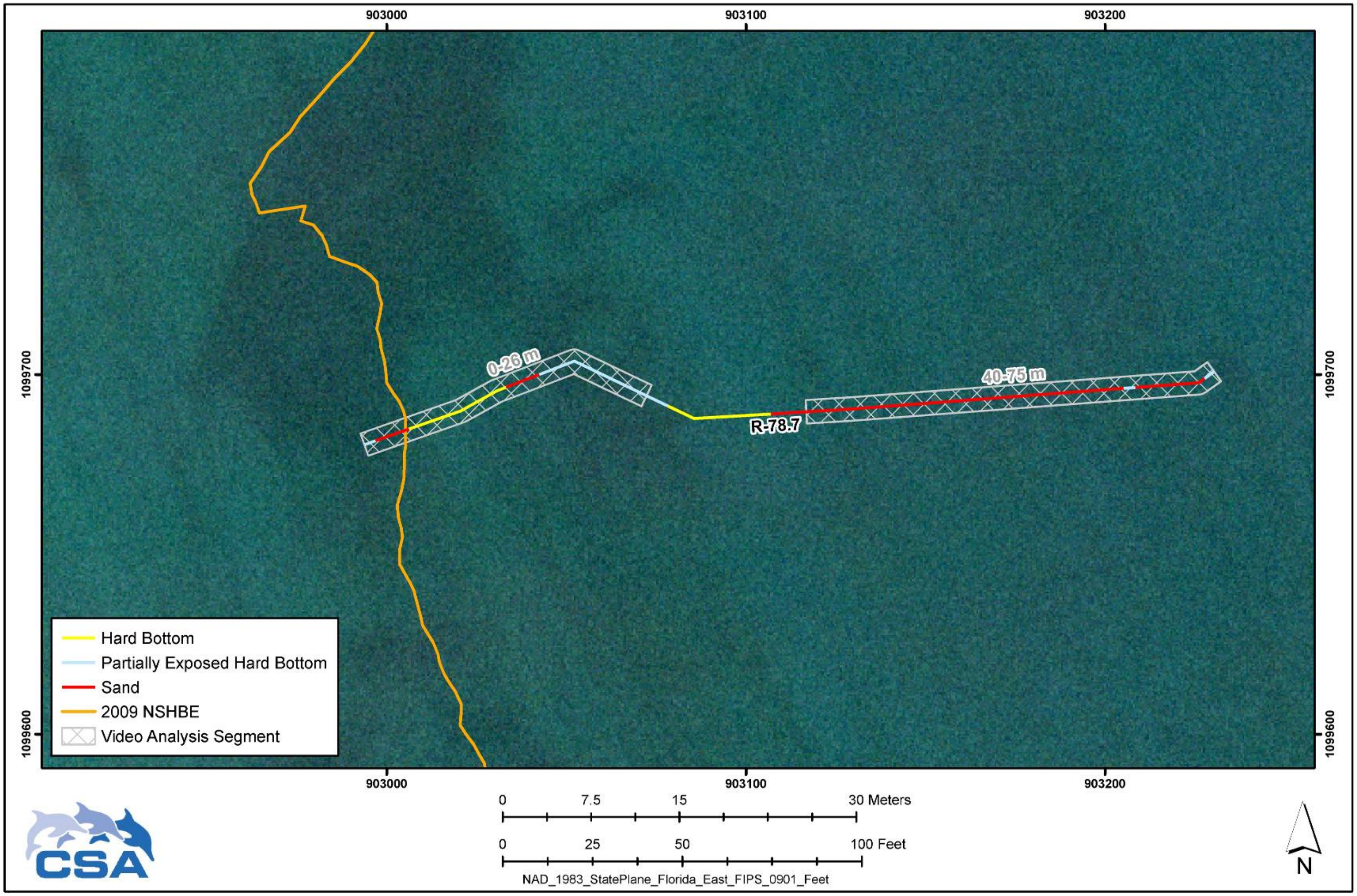


Figure D-1. Transect R-77.7 established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Yellow lines denote hard bottom, blue lines denote partially exposed hard bottom, red lines denote sand and/or shell hash gaps, and orange line denotes mapped nearshore hard bottom edge (NSHBE). Boxes indicate the two transect segments selected for video analysis. Hard bottom survey conducted 01 July 2009.



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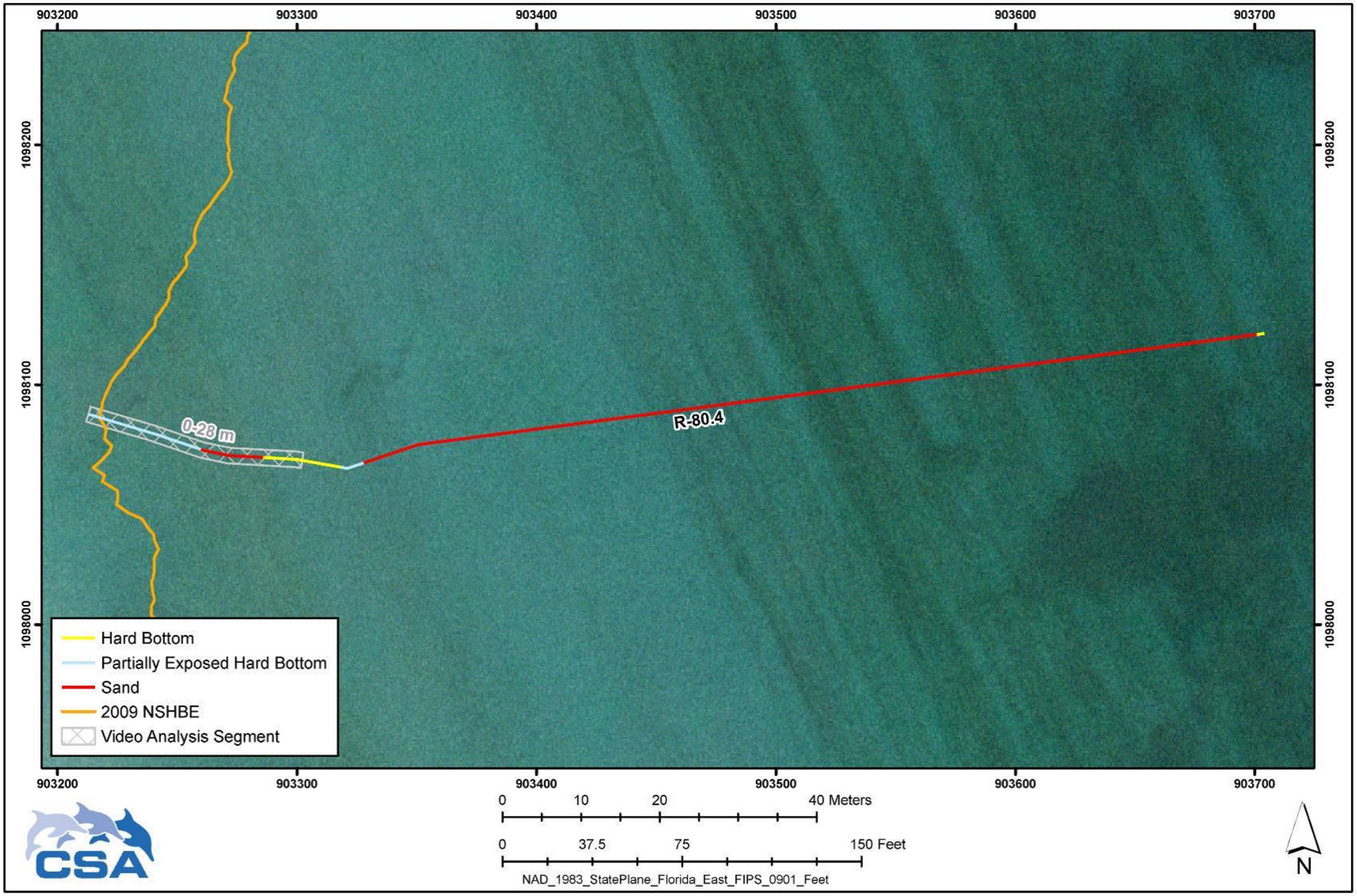

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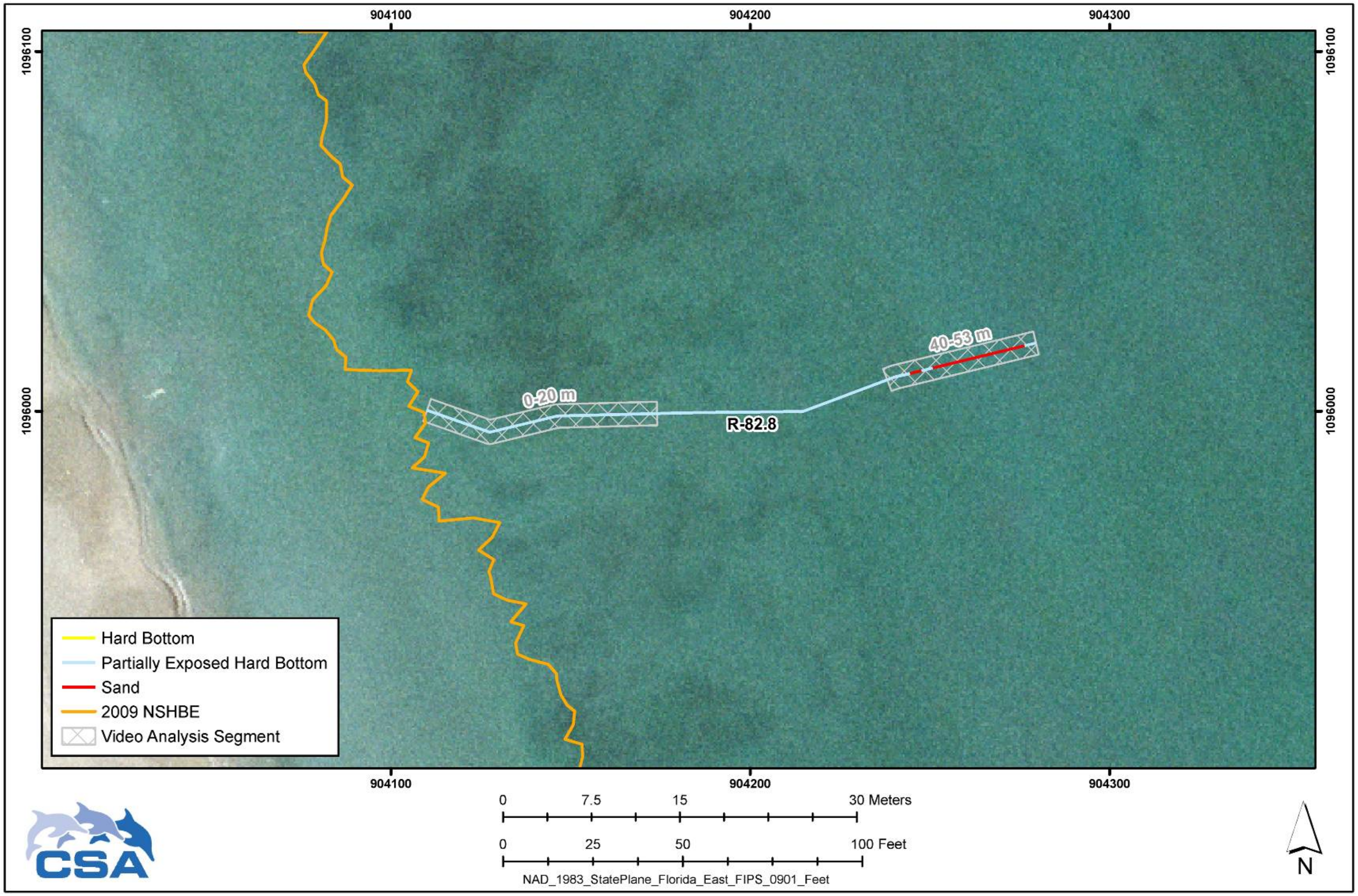

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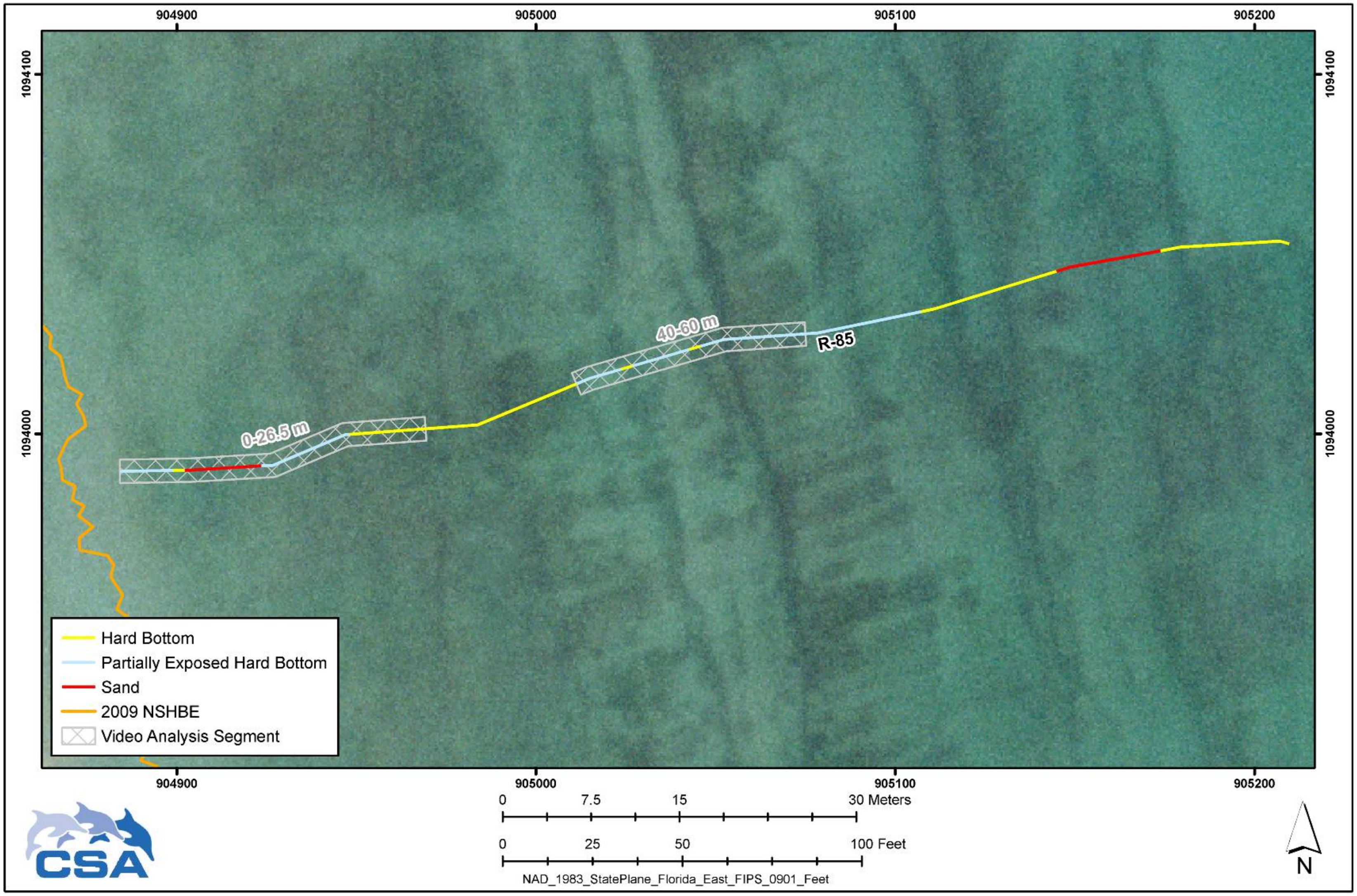
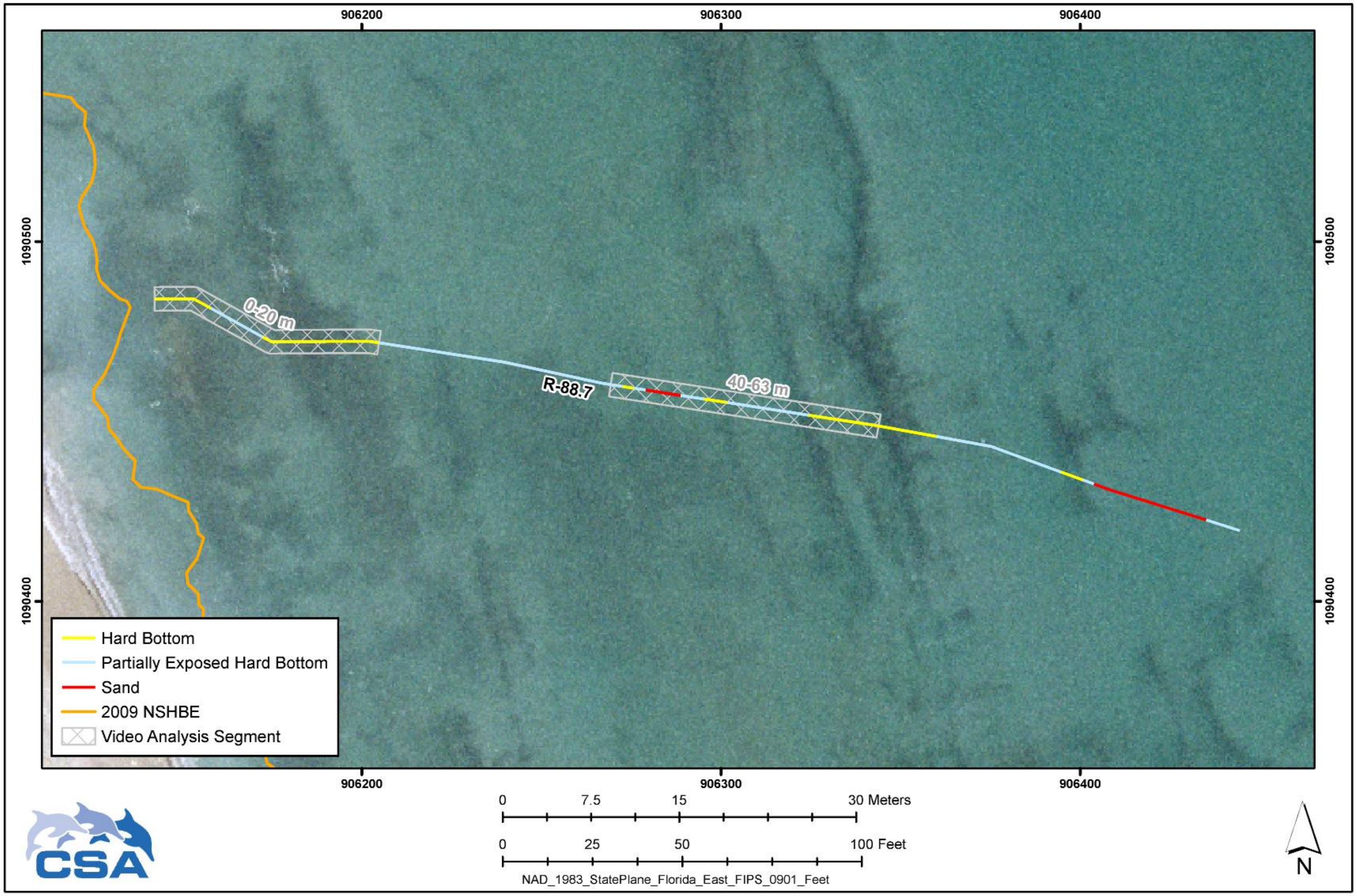


Figure D-5. Transect R-85 established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Yellow lines denote hard bottom, blue lines denote partially exposed hard bottom, red lines denote sand and/or shell hash gaps, and orange line denotes mapped nearshore hard bottom edge (NSHBE). Boxes indicate the two transect segments selected for video analysis. Hard bottom survey conducted 03 July 2009.

Figure D-6. Transect R-86.3 established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Yellow lines denote hard bottom, blue lines denote partially exposed hard bottom, red lines denote sand and/or shell hash gaps, and orange line denotes mapped nearshore hard bottom edge (NSHBE). Boxes indicate the two transect segments selected for video analysis. Hard bottom survey conducted 09 July 2009.



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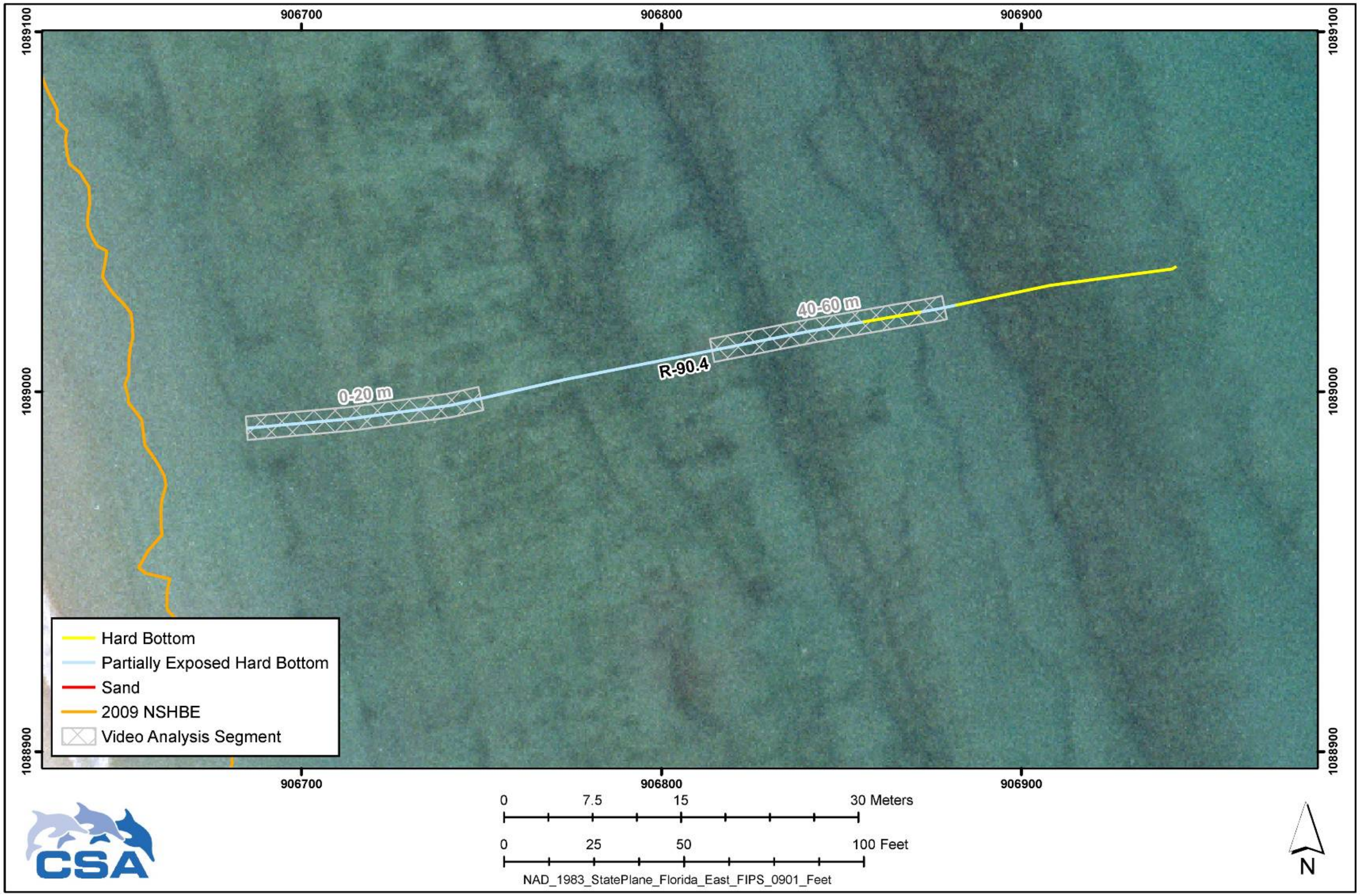


Figure D-8. Transect R-90.4 established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Yellow lines denote hard bottom, blue lines denote partially exposed hard bottom, and orange line denotes mapped nearshore hard bottom edge (NSHBE). Boxes indicate the two transect segments selected for video analysis. Hard bottom survey conducted 30 June 2009.

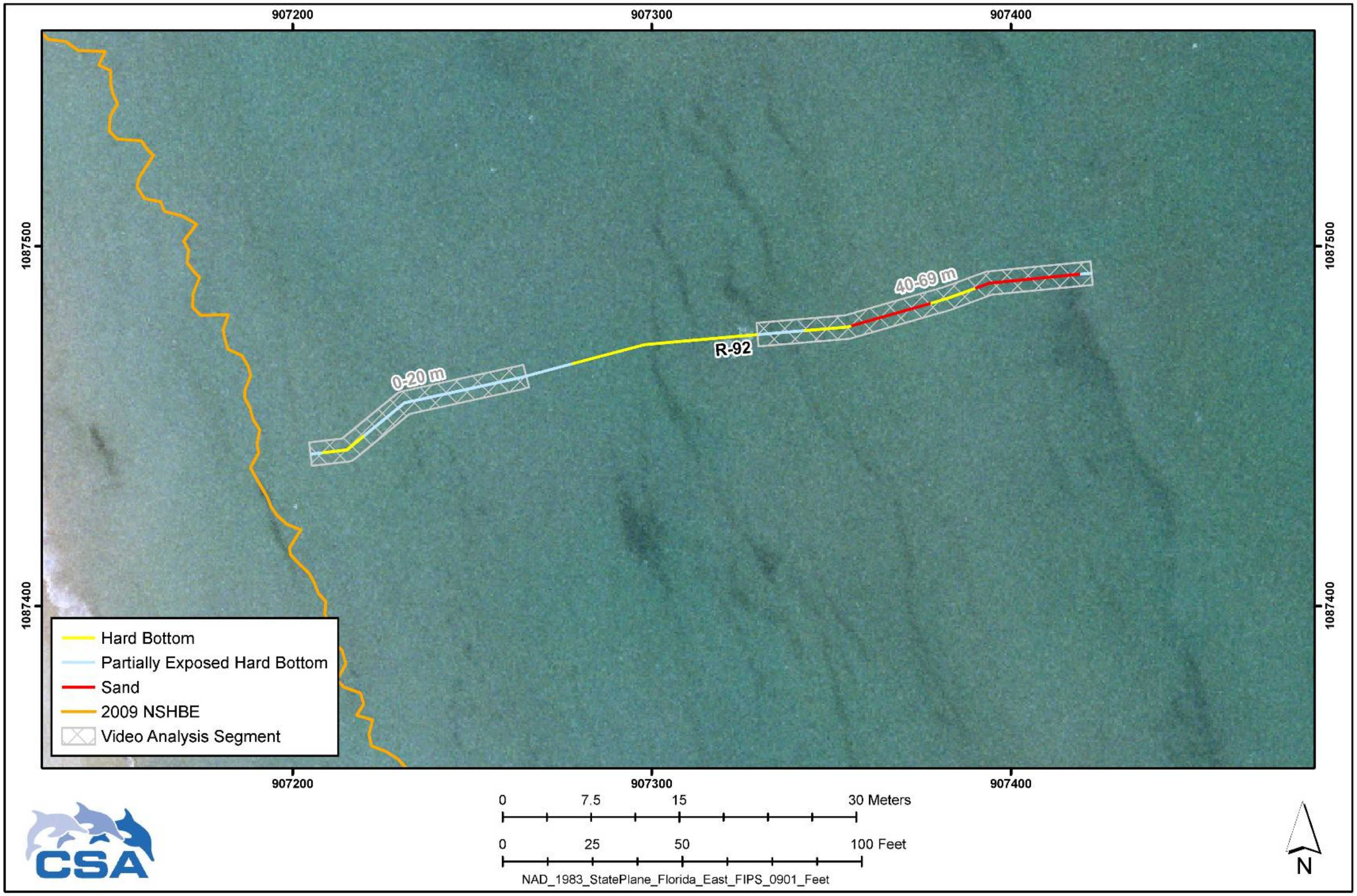


Figure D-9. Transect R-92 established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Yellow lines denote hard bottom, blue lines denote partially exposed hard bottom, red lines denote sand and/or shell hash gaps, and orange line denotes mapped nearshore hard bottom edge (NSHBE). Boxes indicate the two transect segments selected for video analysis. Hard bottom survey conducted 29 June 2009.

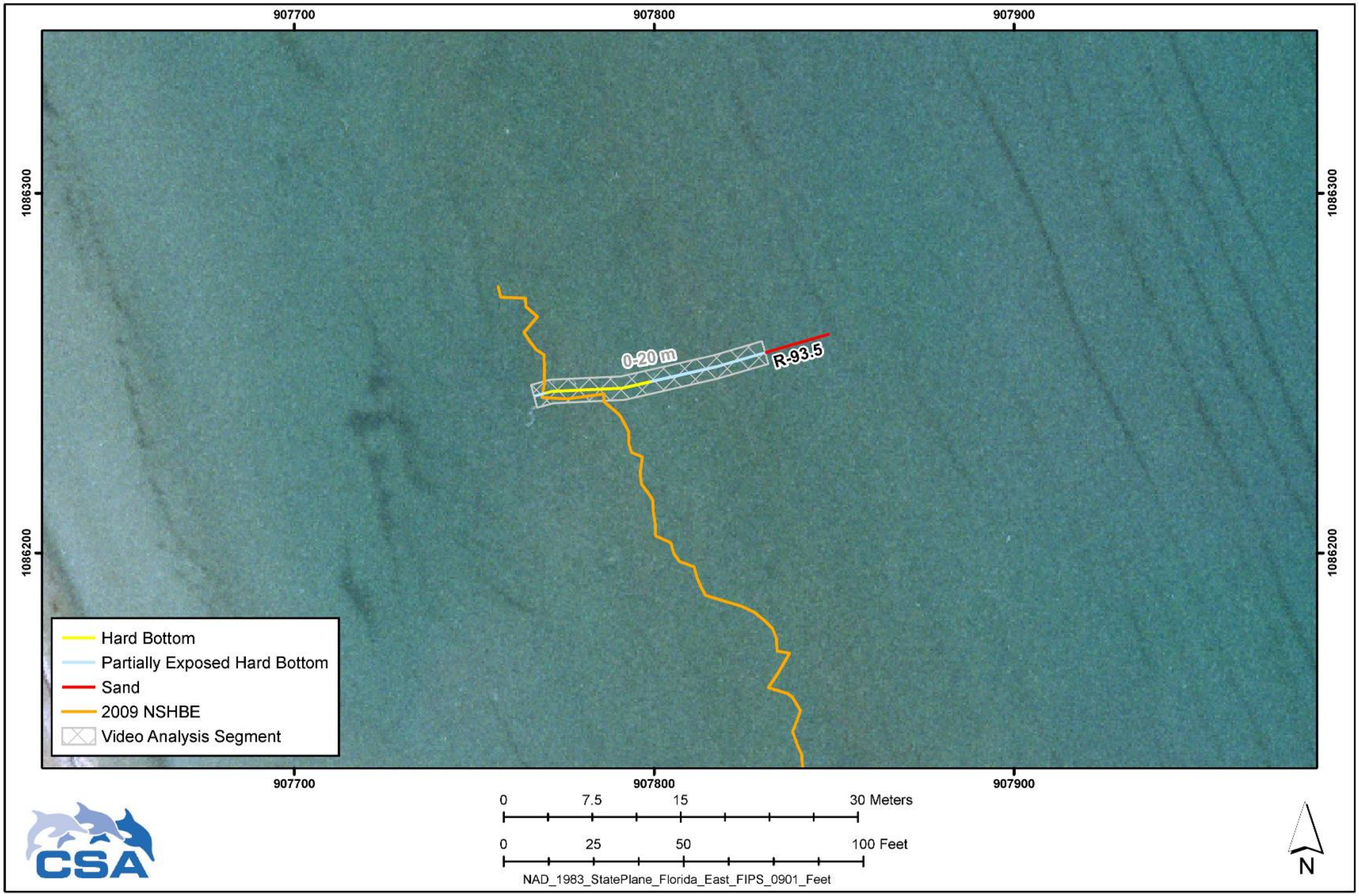


Figure D-10. Transect R-93.5 established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Yellow line denotes hard bottom, blue lines denote partially exposed hard bottom, red line denotes sand and/or shell hash gaps, and orange line denotes mapped nearshore hard bottom edge (NSHBE). Box indicates the transect segment selected for video analysis. Hard bottom survey conducted 30 June 2009.

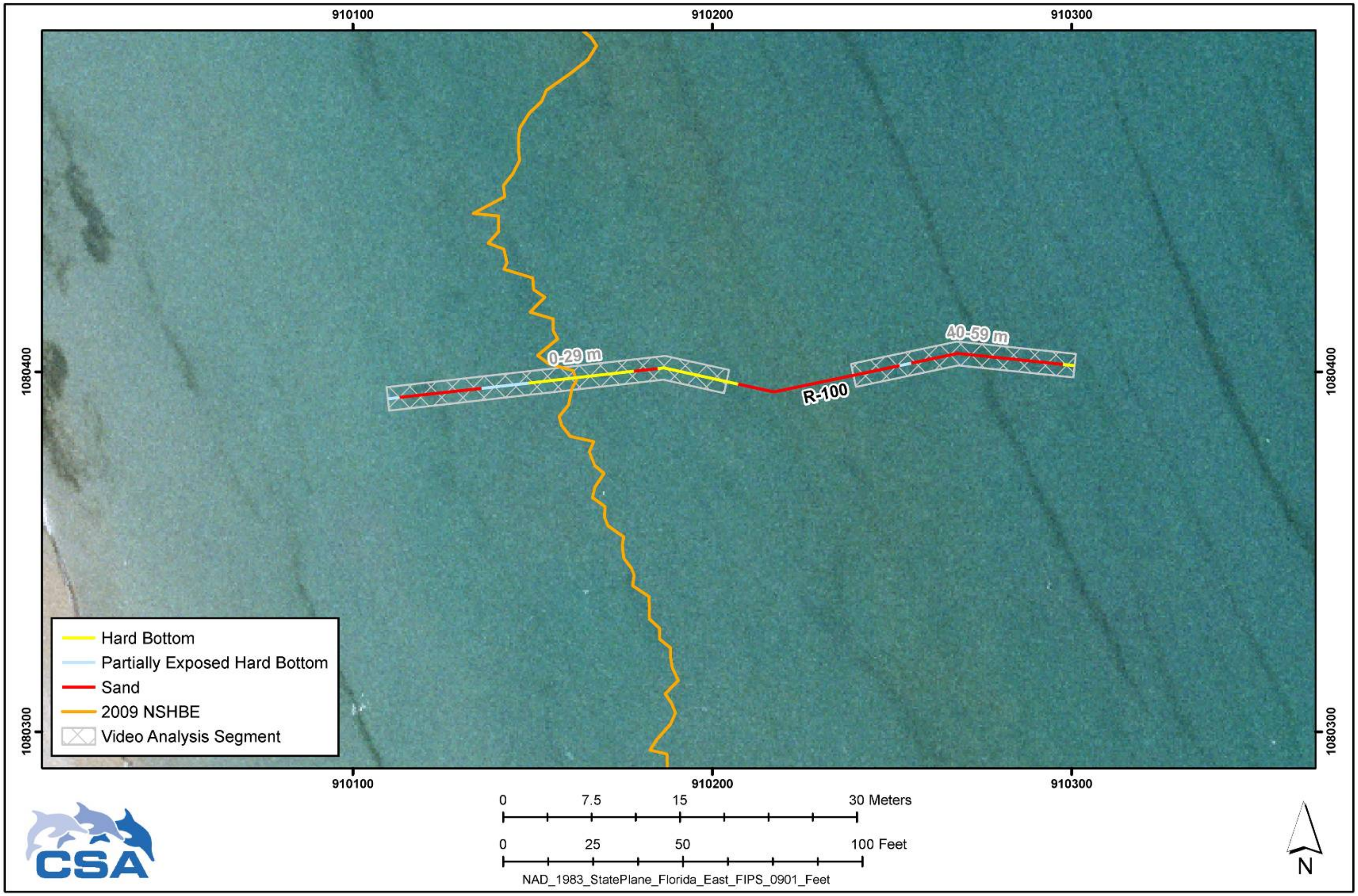


Figure D-11. Transect R-100 established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Yellow lines denote hard bottom, blue lines denote partially exposed hard bottom, red lines denote sand and/or shell hash gaps, and orange line denotes mapped nearshore hard bottom edge (NSHBE). Boxes indicate the two transect segments selected for video analysis. Hard bottom survey conducted 28 June 2009.

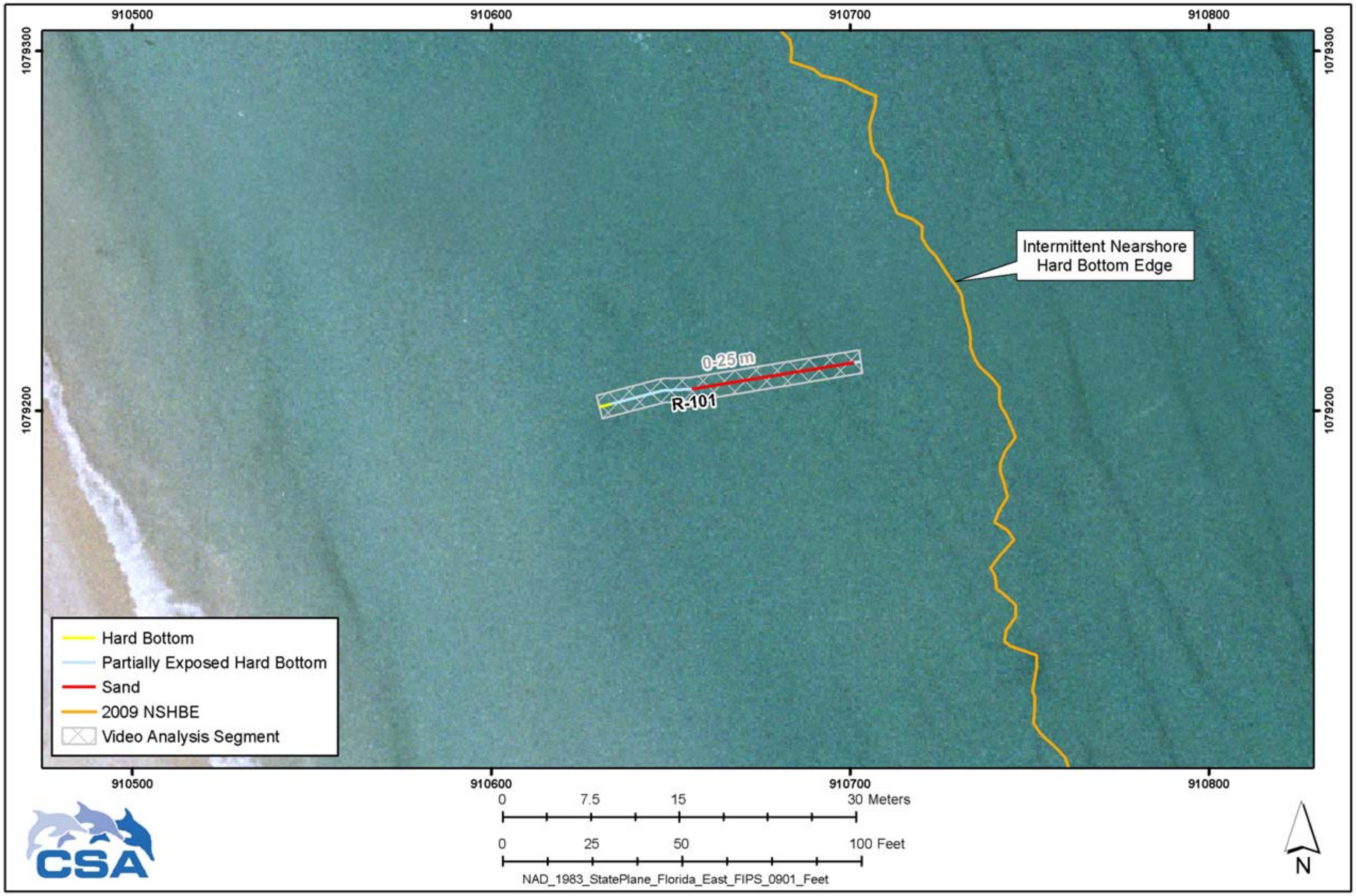


Figure D-12. Transect R-101 established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Yellow line denotes hard bottom, blue line denotes partially exposed hard bottom, red lines denote sand and/or shell hash gaps, and orange line denotes mapped intermittent nearshore hard bottom edge (NSHBE). Box indicates the transect segment selected for video analysis. Hard bottom survey conducted 15 July 2009.

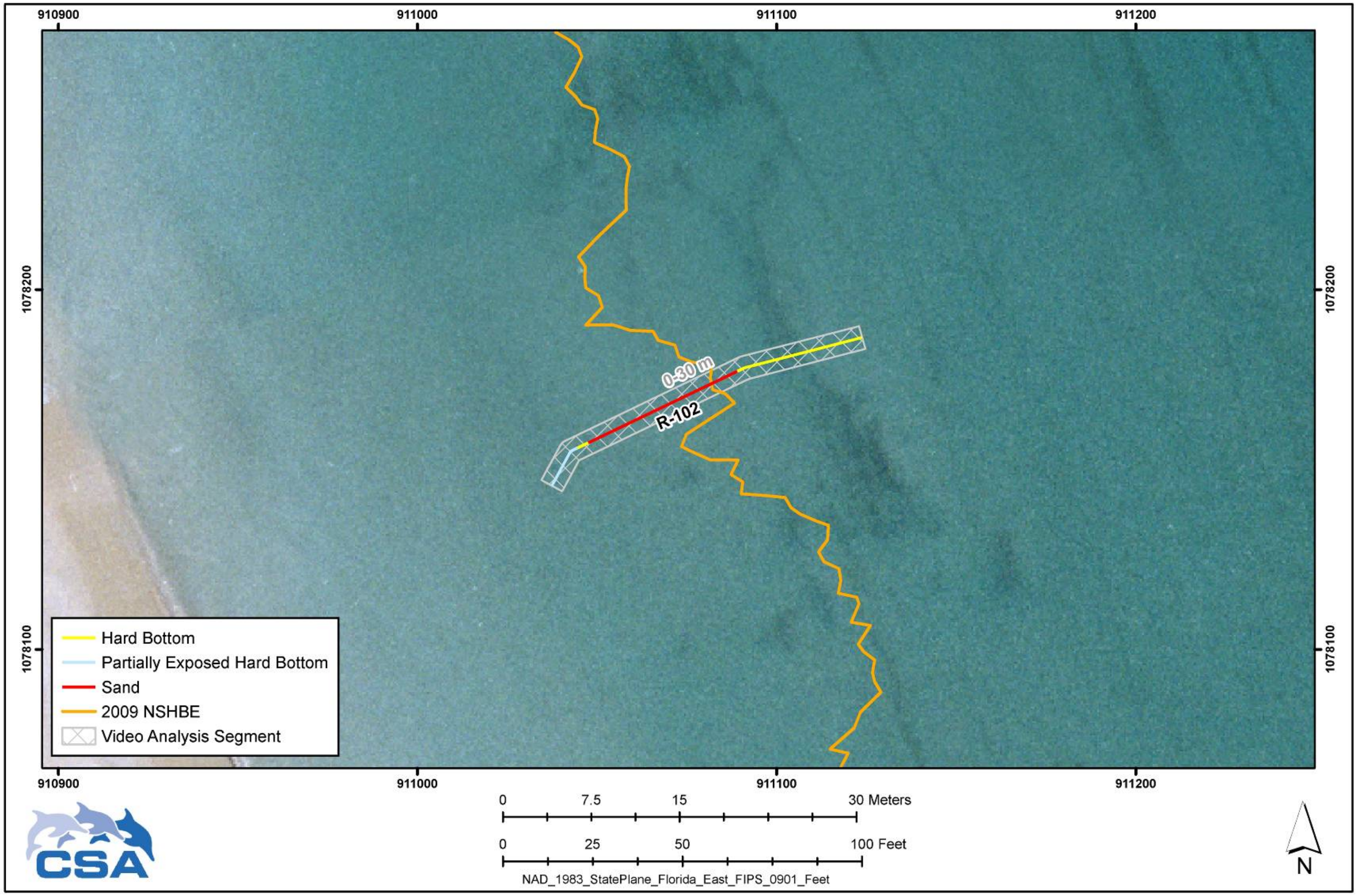
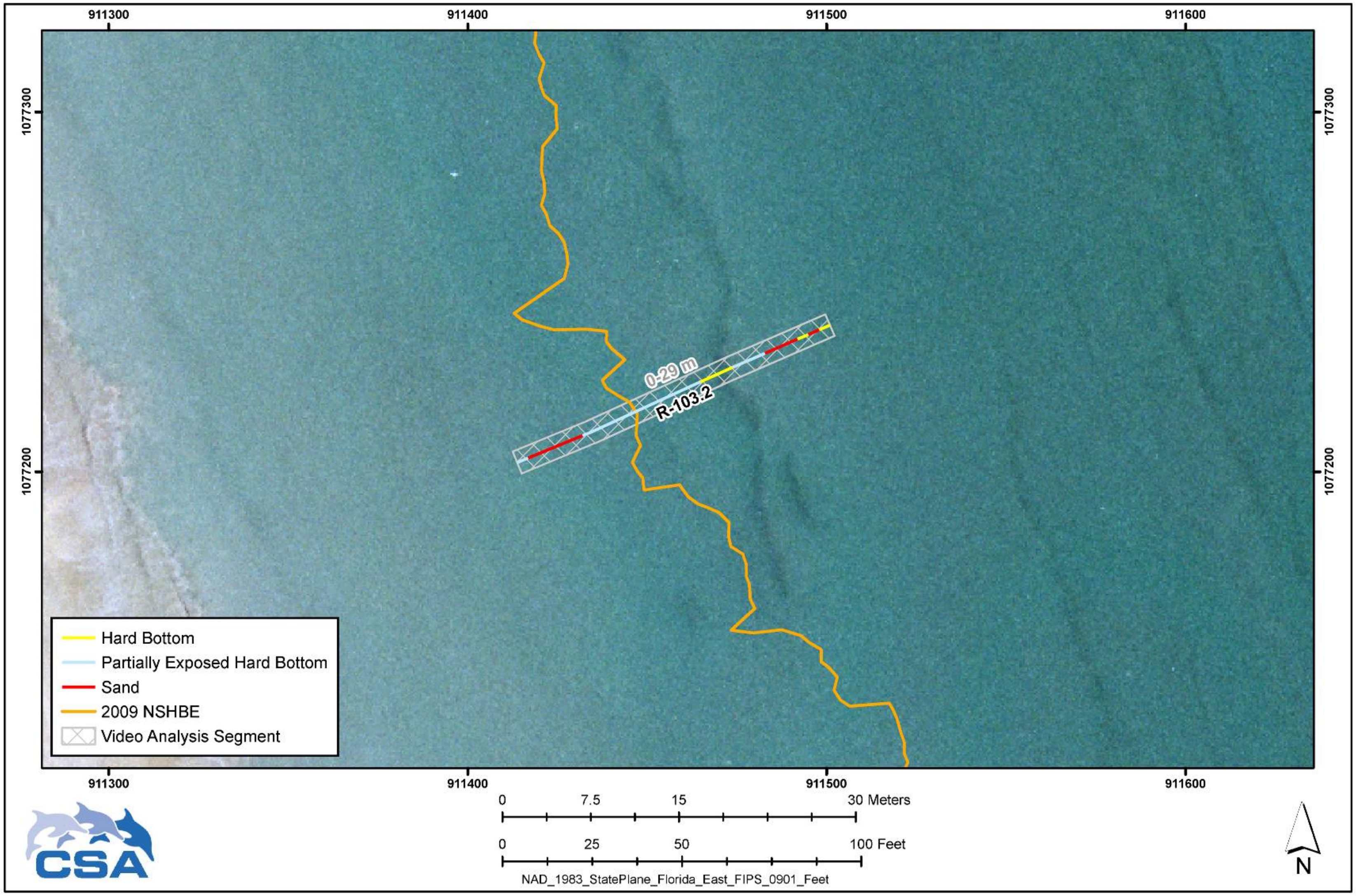


Figure D-13. Transect R-102 established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Yellow lines denote hard bottom, blue line denotes partially exposed hard bottom, red line denotes sand and/or shell hash gaps, and orange line denotes mapped nearshore hard bottom edge (NSHBE). Box indicates the transect segment selected for video analysis. Hard bottom survey conducted 28 June 2009.



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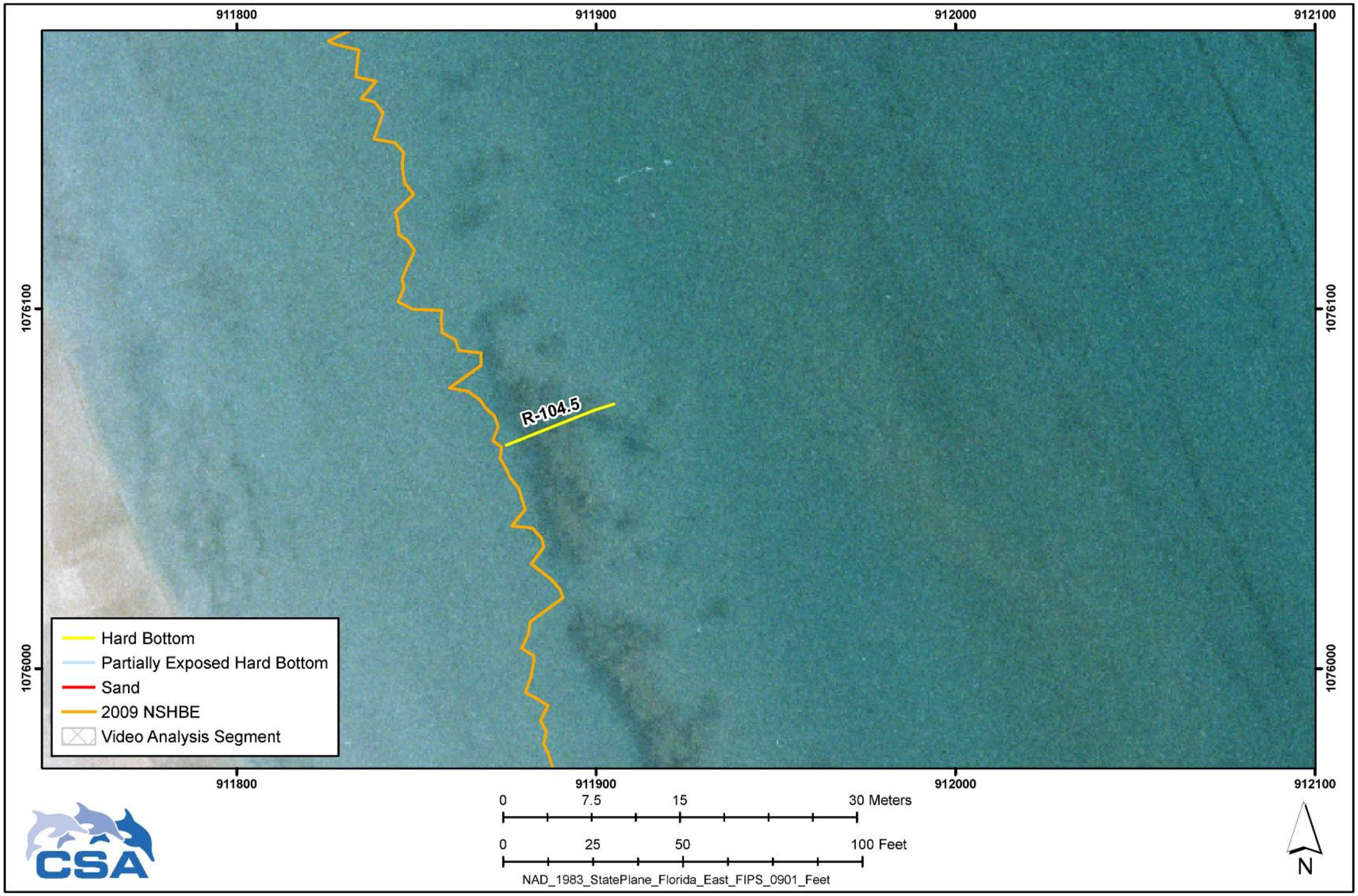

Figure D-15. Transect R-104.5 established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Yellow line denotes hard bottom, and orange line denotes mapped nearshore hard bottom edge (NSHBE). Partial hard bottom survey conducted 15 August 2008; figure denotes condition as of 02 October 2009.

Figure D-16. Transect R-105.9 established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Yellow lines denote hard bottom, blue lines denote partially exposed hard bottom, red line denotes sand and/or shell hash gaps, and orange line denotes mapped nearshore hard bottom edge (NSHBE). Box indicates the transect segment selected for video analysis. Hard bottom survey conducted 02 July 2009.

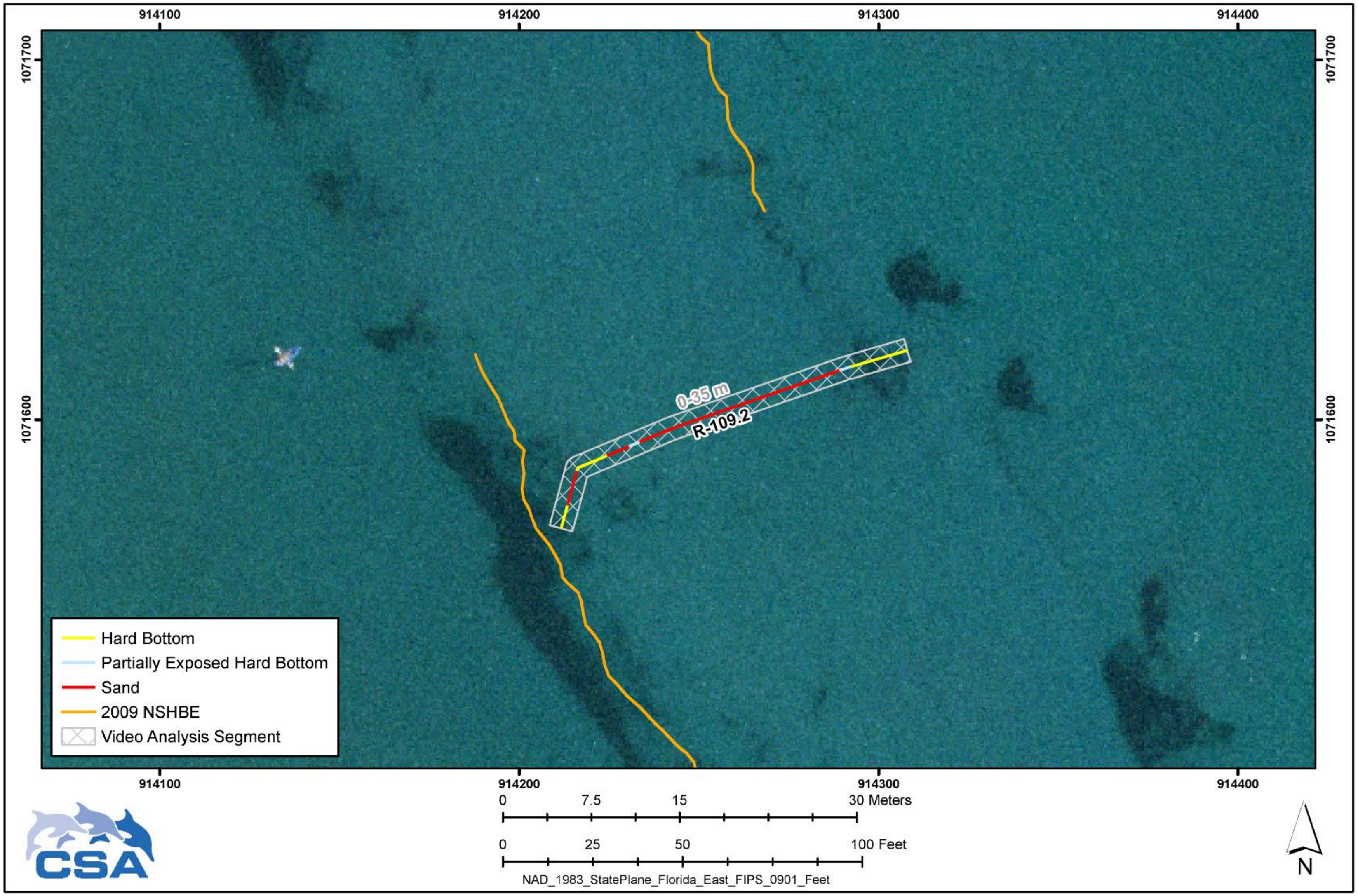

Figure D-17. Transect R-109.2 established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Yellow lines denote hard bottom, blue lines denote partially exposed hard bottom, red line denotes sand and/or shell hash gaps, and orange line denotes mapped nearshore hard bottom edge (NSHBE). Box indicates the transect segment selected for video analysis. Hard bottom survey conducted 10 July 2009.

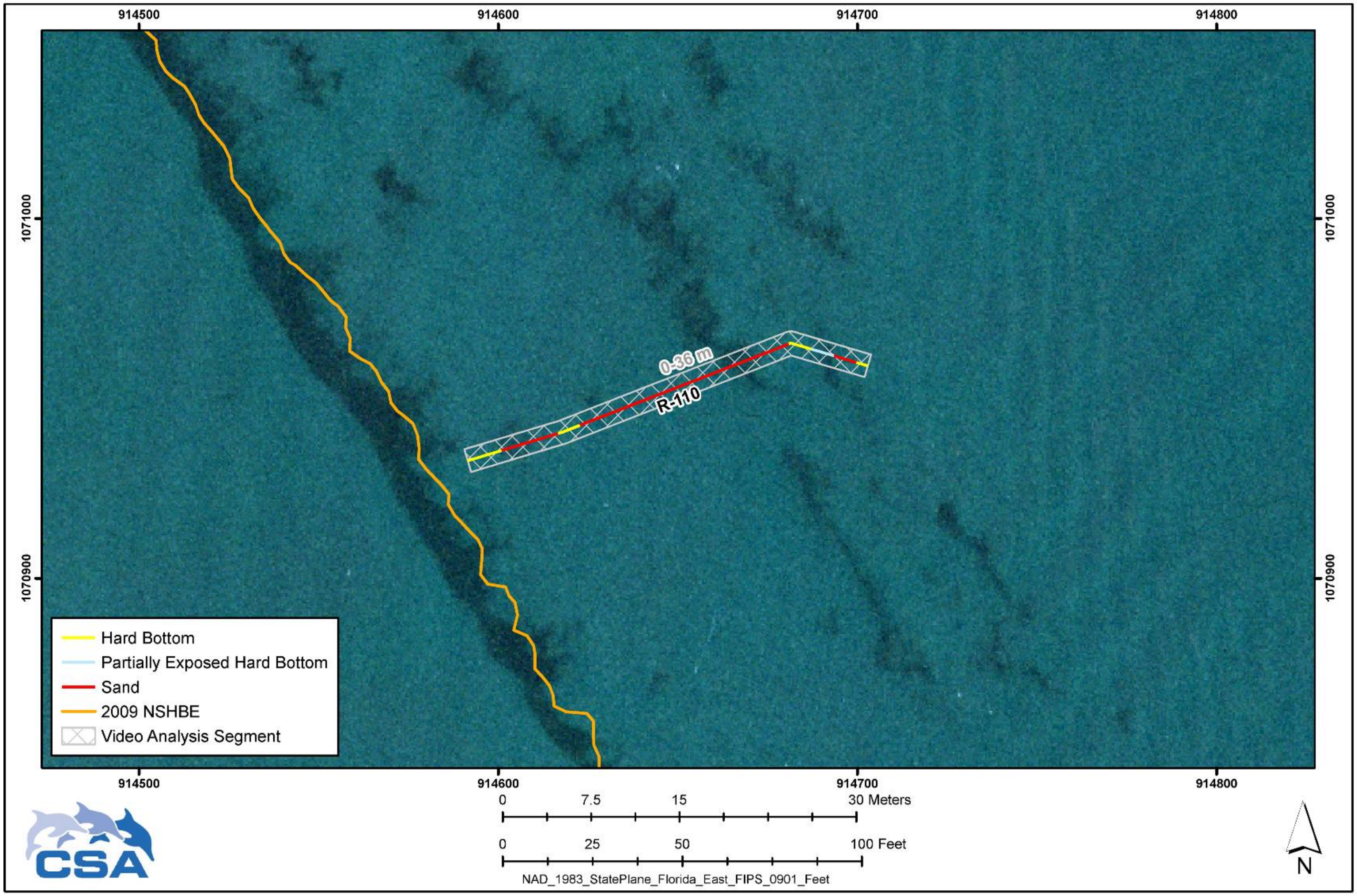

Figure D-18. Transect R-110 established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Yellow lines denote hard bottom, blue line denotes partially exposed hard bottom, red lines denote sand and/or shell hash gaps, and orange line denotes mapped nearshore hard bottom edge (NSHBE). Box indicates the transect segment selected for video analysis. Hard bottom survey conducted 02 July 2009.

Figure D-19. Transect R-110.5 established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Yellow lines denote hard bottom, blue lines denote partially exposed hard bottom, red lines denote sand and/or shell hash gaps, and orange line denotes mapped nearshore hard bottom edge (NSHBE). Box indicates the transect segment selected for video analysis. Hard bottom survey conducted 15 July 2009.

Figure D-20. Transect R-112 established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Yellow line denotes hard bottom, blue lines denote partially exposed hard bottom, red lines denote sand and/or shell hash gaps, and orange line denotes mapped nearshore hard bottom edge (NSHBE). Boxes indicate the two transect segments selected for video analysis. Hard bottom survey conducted 29 June 2009.

Figure D-21. Transect R-1 established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Yellow lines denote hard bottom, blue line denotes partially exposed hard bottom, red line denotes sand and/or shell hash gaps, and orange line denotes mapped nearshore hard bottom edge (NSHBE). Box indicates the transect segment selected for video analysis. Hard bottom survey conducted 15 August 2009.

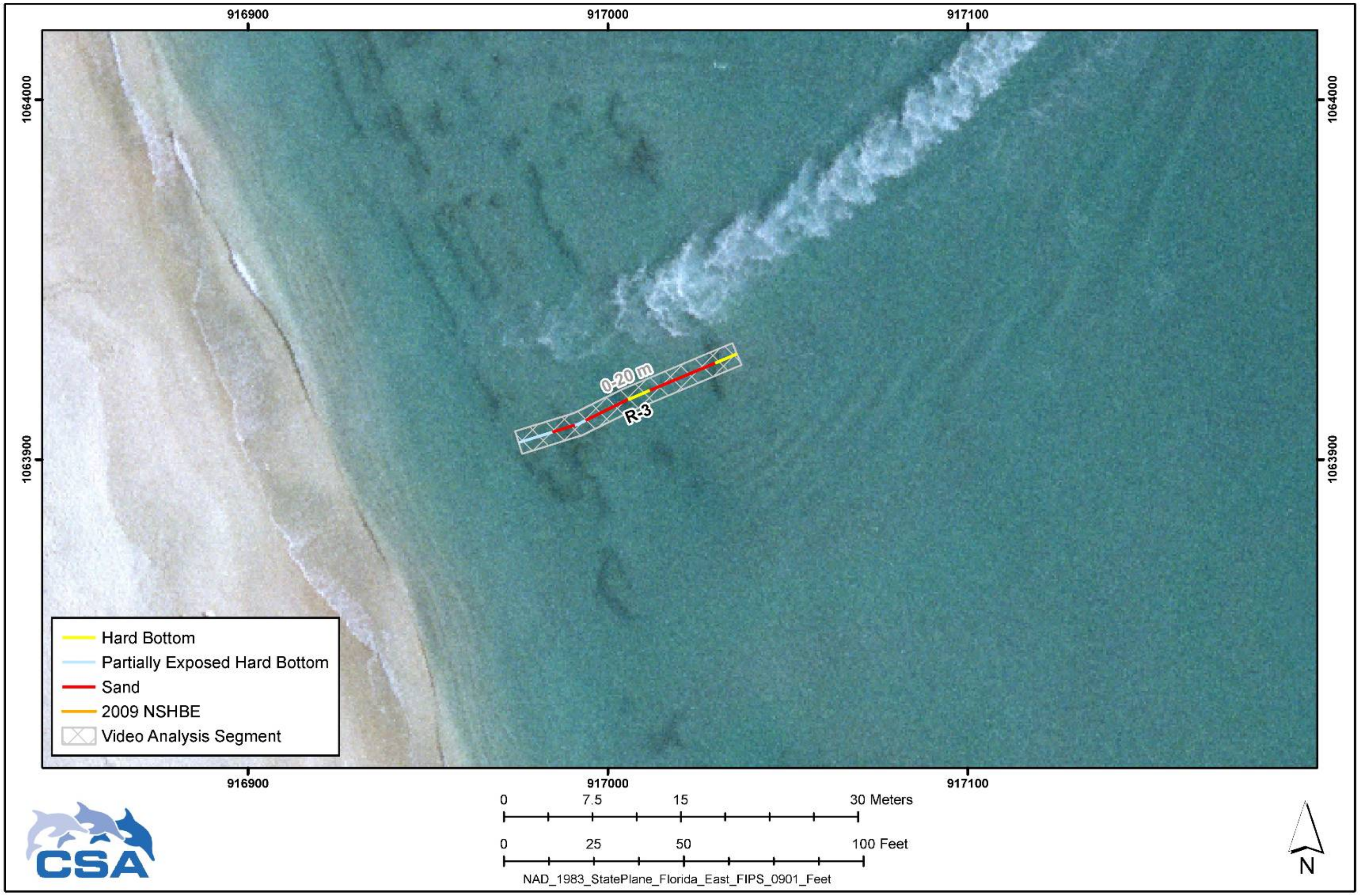

Figure D-22. Transect R-3 established during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Yellow lines denote hard bottom, blue lines denote partially exposed hard bottom, red lines denote sand and/or shell hash gaps, and orange line denotes mapped nearshore hard bottom edge (NSHBE). Box indicates the transect segment selected for video analysis. Hard bottom survey conducted 15 August 2009.

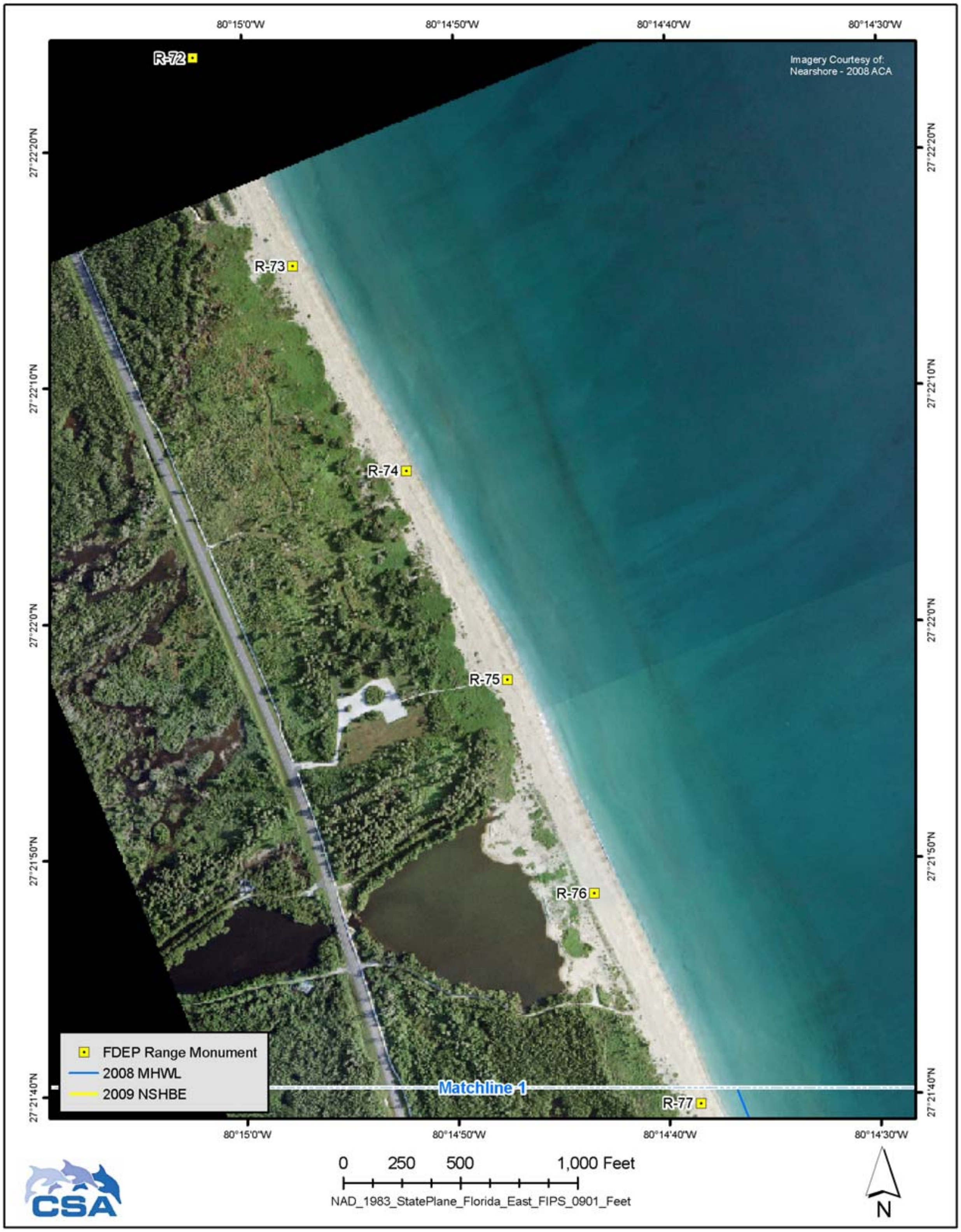

Figure D-23. Overview of the nearshore hard bottom edge (NSHBE) between FDEP Range Monuments R-73 and R-77 mapped during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

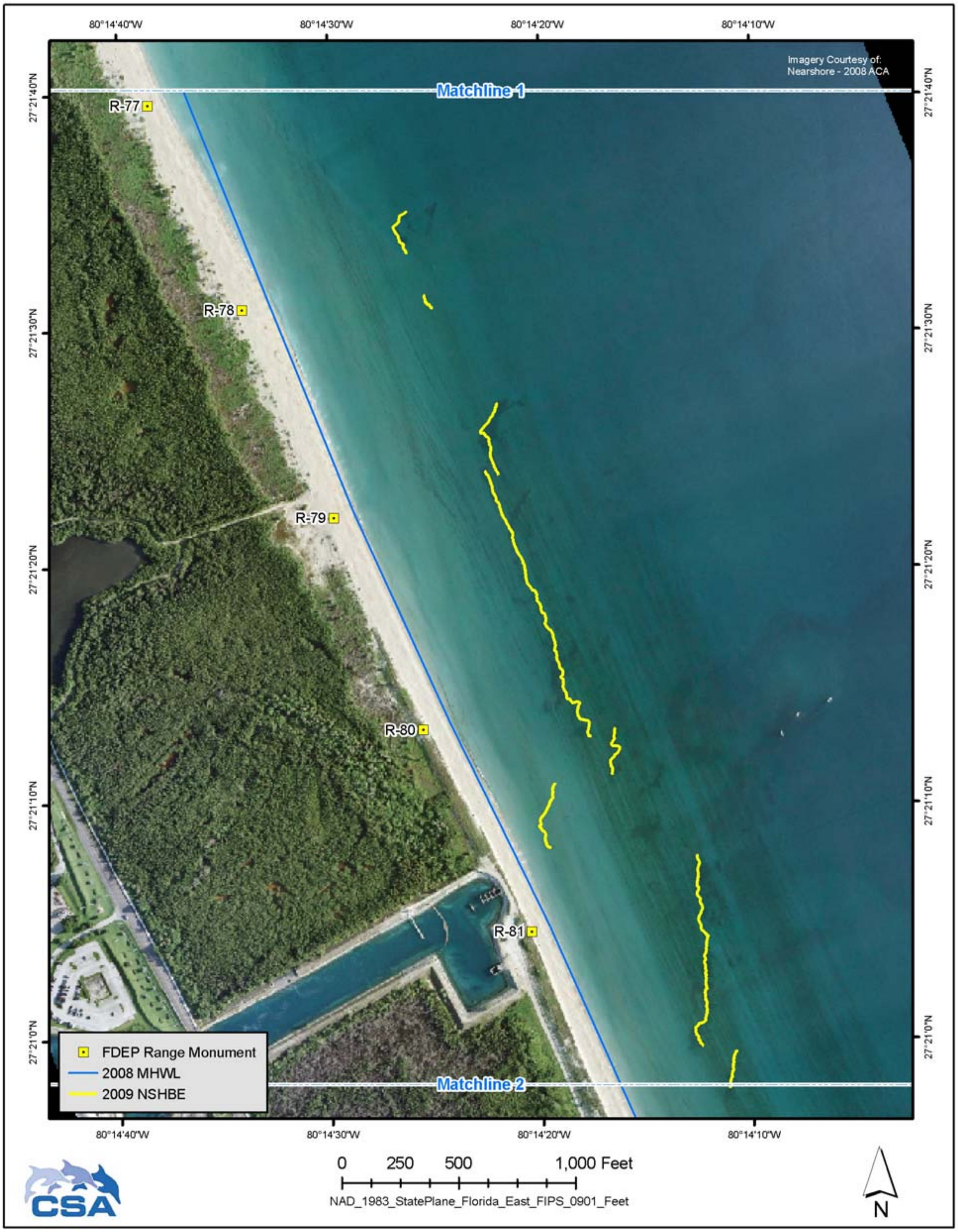

Figure D-24. Overview of the nearshore hard bottom edge (NSHBE) between FDEP Range Monuments R-77 and R-81 mapped during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

Figure D-25. Overview of the nearshore hard bottom edge (NSHBE) between FDEP Range Monuments R-82 and R-86 mapped during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

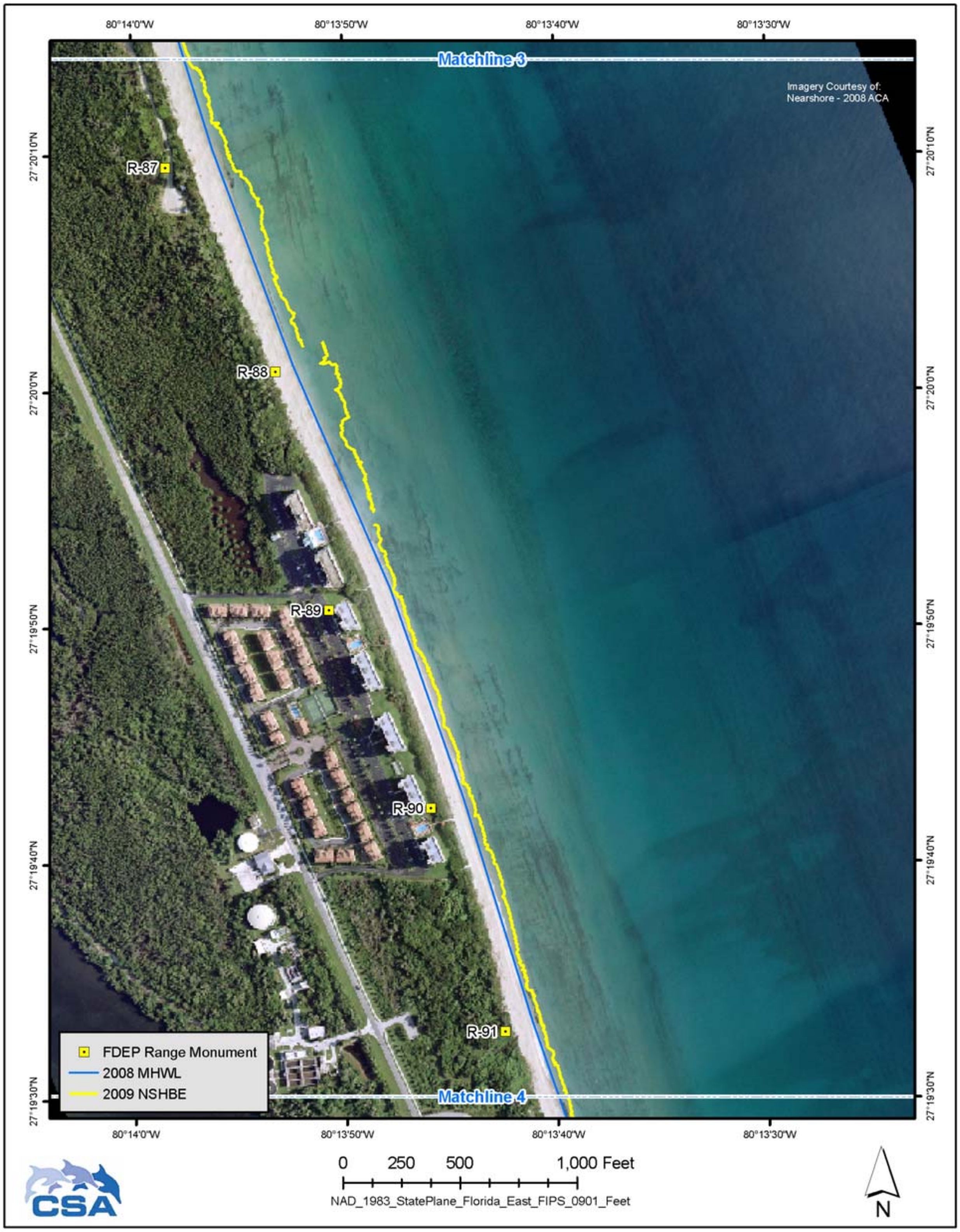

Figure D-26. Overview of the nearshore hard bottom edge (NSHBE) between FDEP Range Monuments R-87 and R-91 mapped during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

Figure D-27. Overview of the nearshore hard bottom edge (NSHBE) between FDEP Range Monuments R-92 and R-96 mapped during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

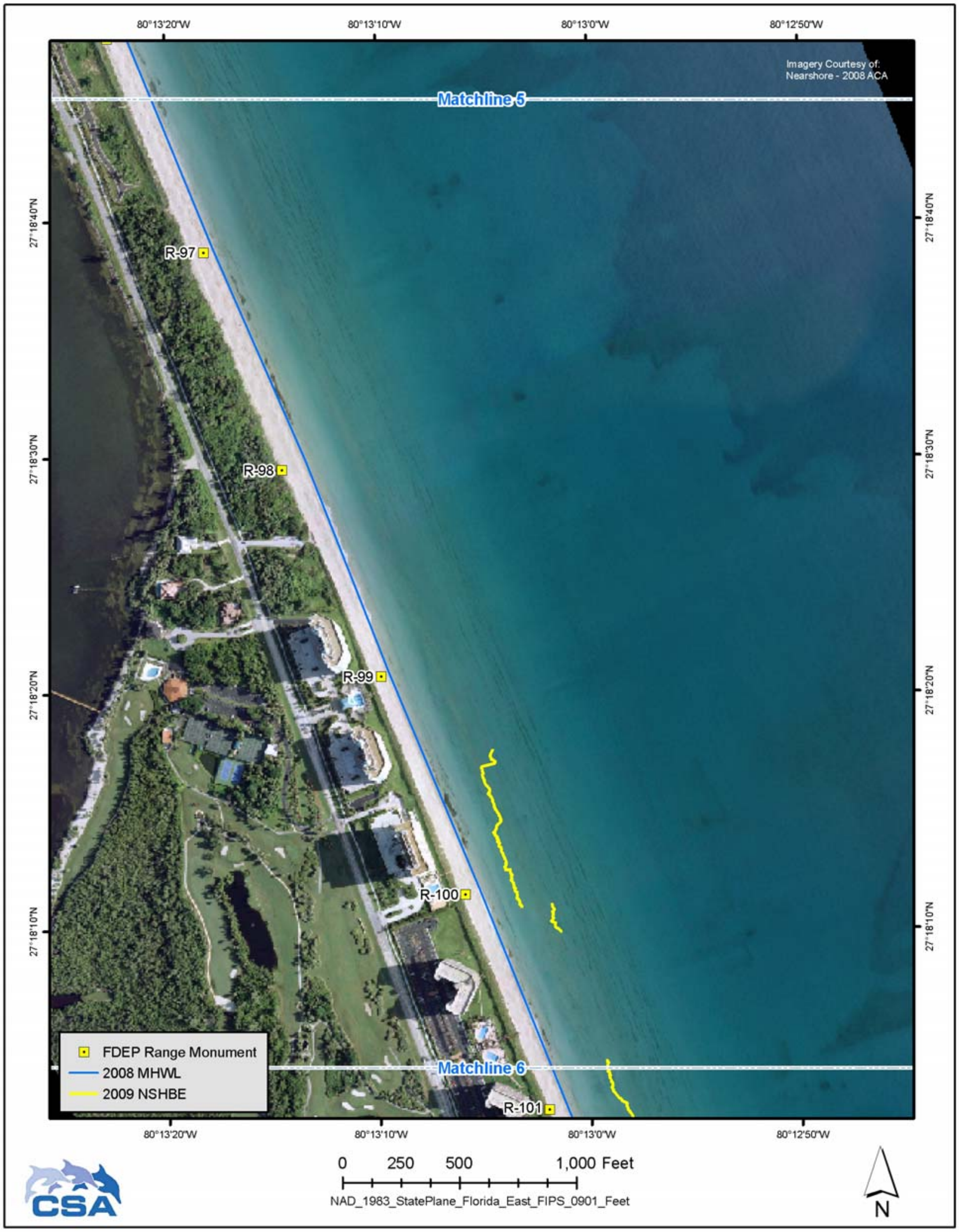

Figure D-28. Overview of the nearshore hard bottom edge (NSHBE) between FDEP Range Monuments R-97 and R-101 mapped during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

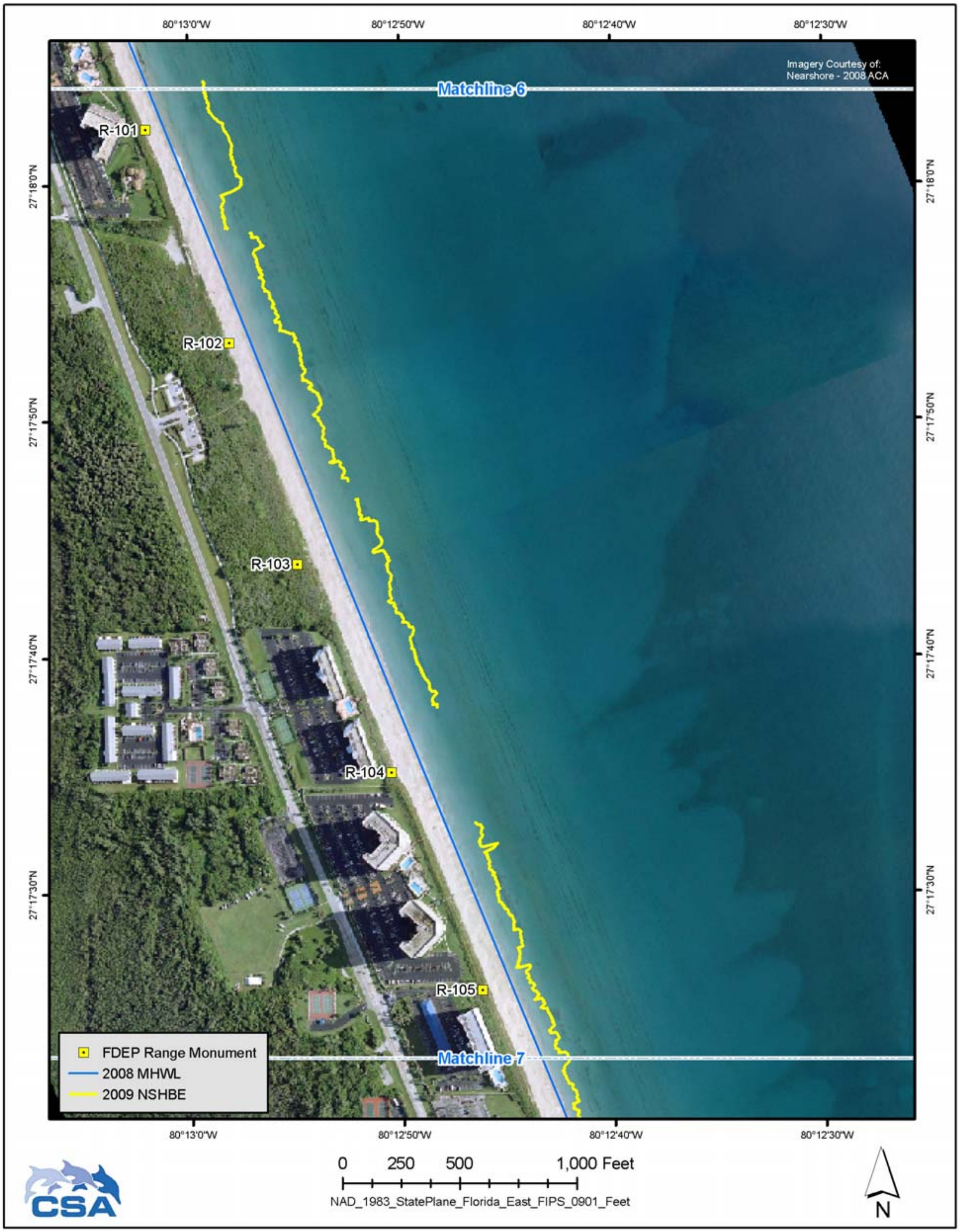

Figure D-29. Overview of the nearshore hard bottom edge (NSHBE) between FDEP Range Monuments R-101 and R-105 mapped during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

Figure D-30. Overview of the nearshore hard bottom edge (NSHBE) between FDEP Range Monuments R-106 and R-109 mapped during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

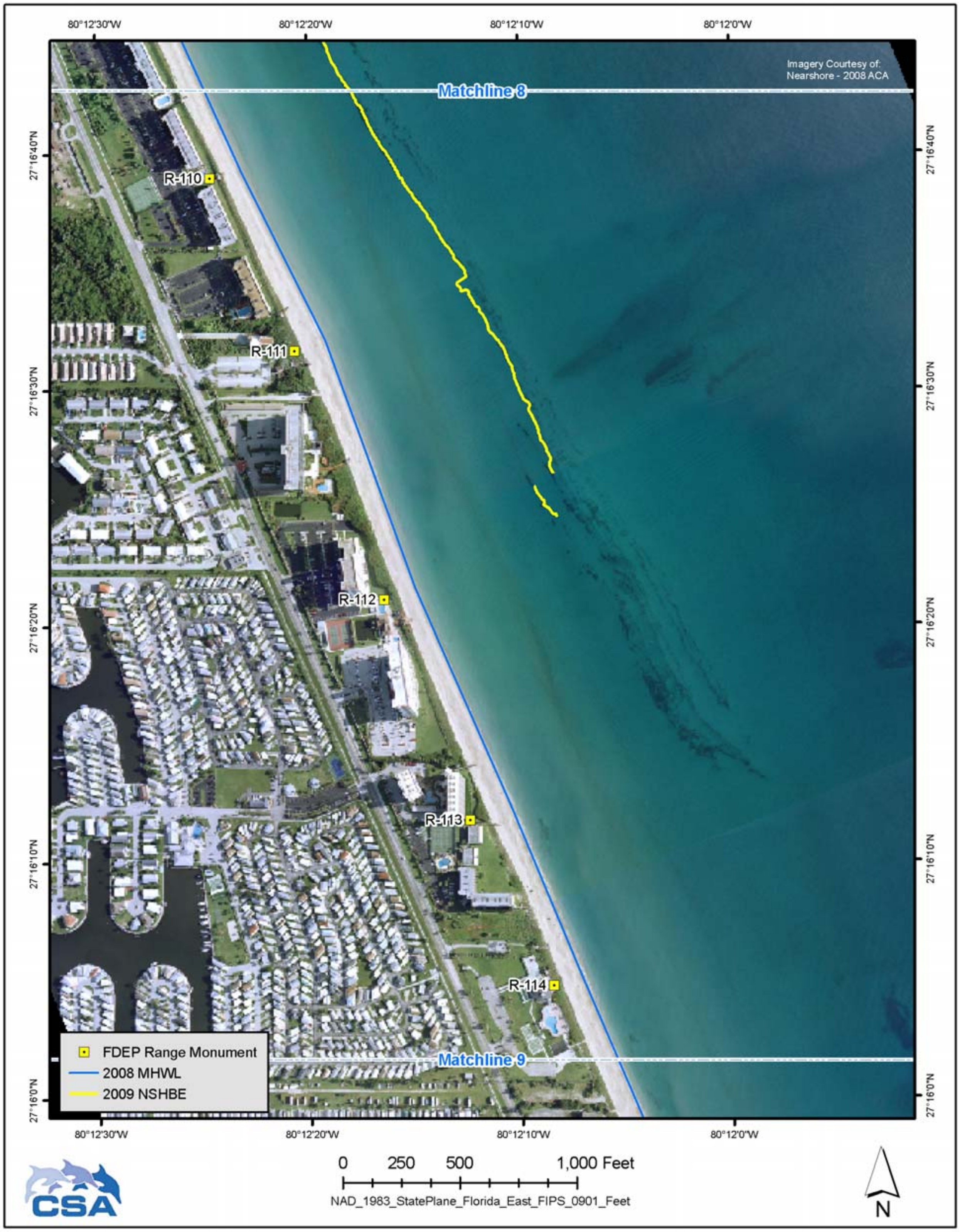

Figure D-31. Overview of the nearshore hard bottom edge (NSHBE) between FDEP Range Monuments R-110 and R-114 mapped during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

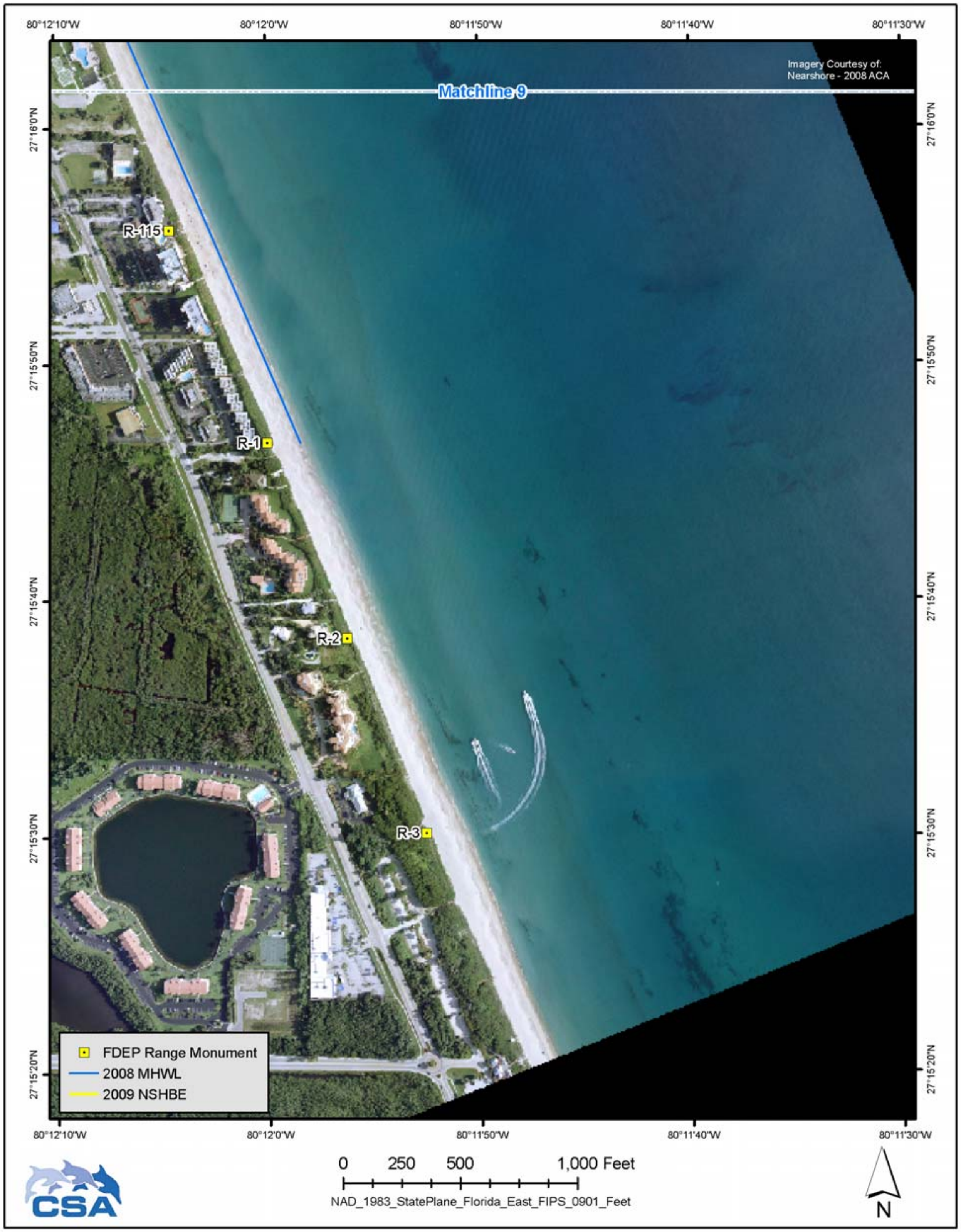

Figure D-32. Overview of the nearshore hard bottom edge (NSHBE) between FDEP Range Monuments R-115 and R-3 mapped during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project.

Figure D-33. Potential pipeline corridor PC-1 near FDEP Range Monument R-89 mapped during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Yellow lines denote hard bottom, blue lines denote partially exposed hard bottom, and red line denotes sand. Geo-referenced qualitative video data were collected along the entire proposed pipeline corridor. Survey conducted 16 July 2009.

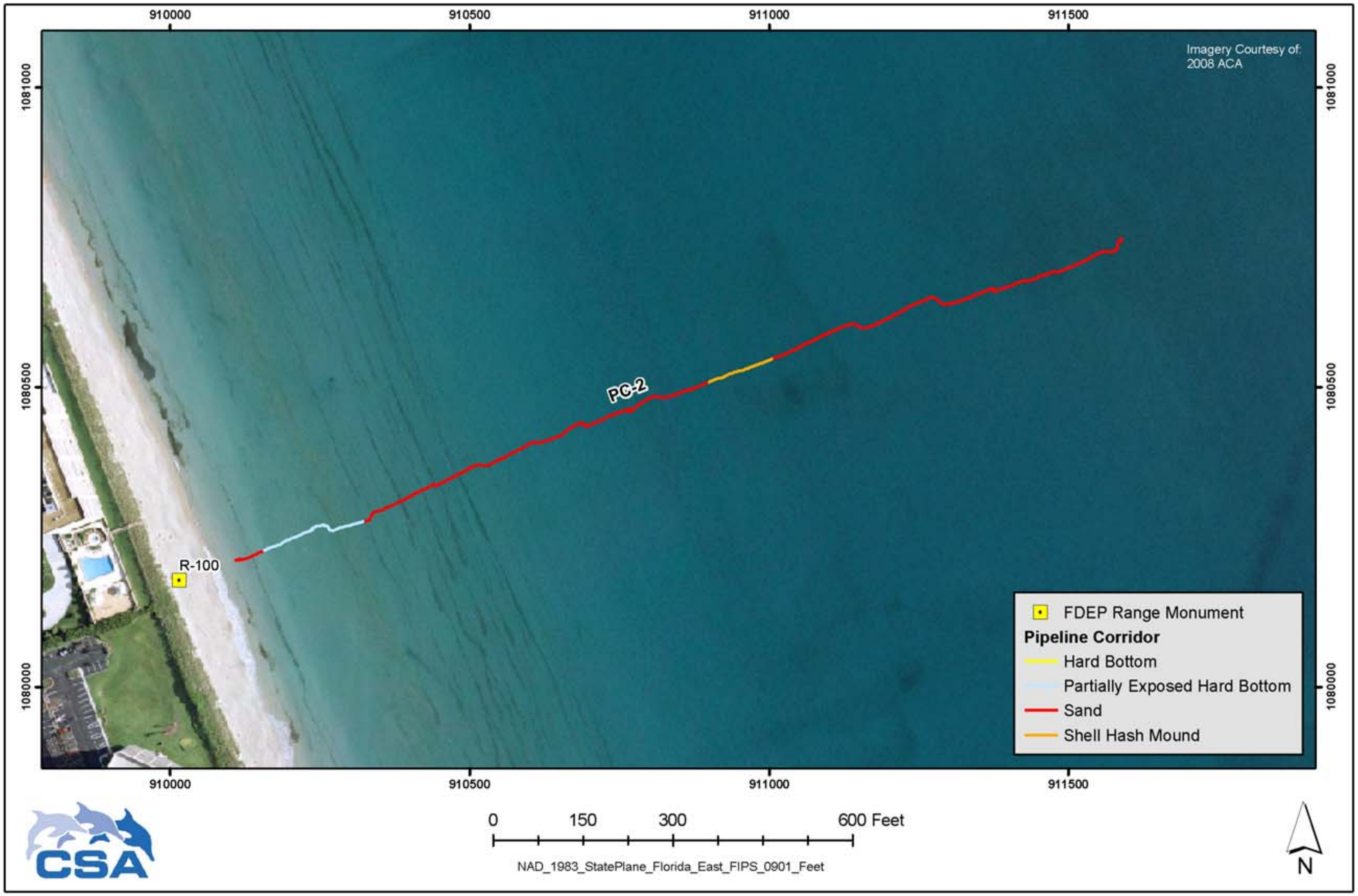

Figure D-34. Potential pipeline corridor PC-2 near FDEP Range Monument R-100 mapped during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Blue line denotes partially exposed hard bottom, red lines denote sand, and orange line denotes shell hash mound. Geo-referenced qualitative video data were collected along the entire proposed pipeline corridor. Survey conducted 16 July 2009.

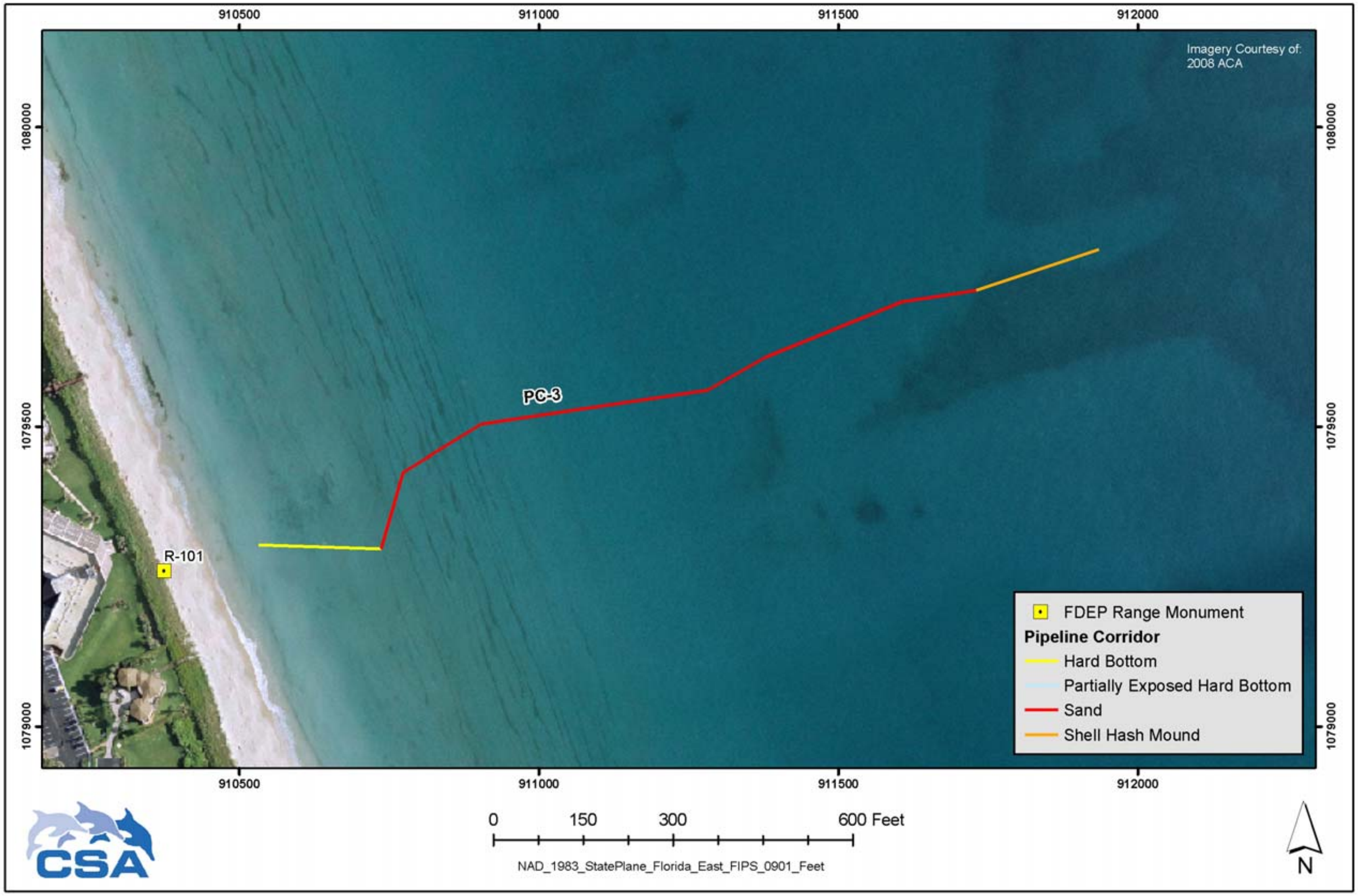

Figure D-35. Potential pipeline corridor PC-3 near FDEP Range Monument R-101 mapped during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Yellow line denotes hard bottom, red line denotes sand, and orange line denotes shell hash mound. Geo-referenced qualitative video data were collected along the entire proposed pipeline corridor. Survey conducted 17 July 2009.

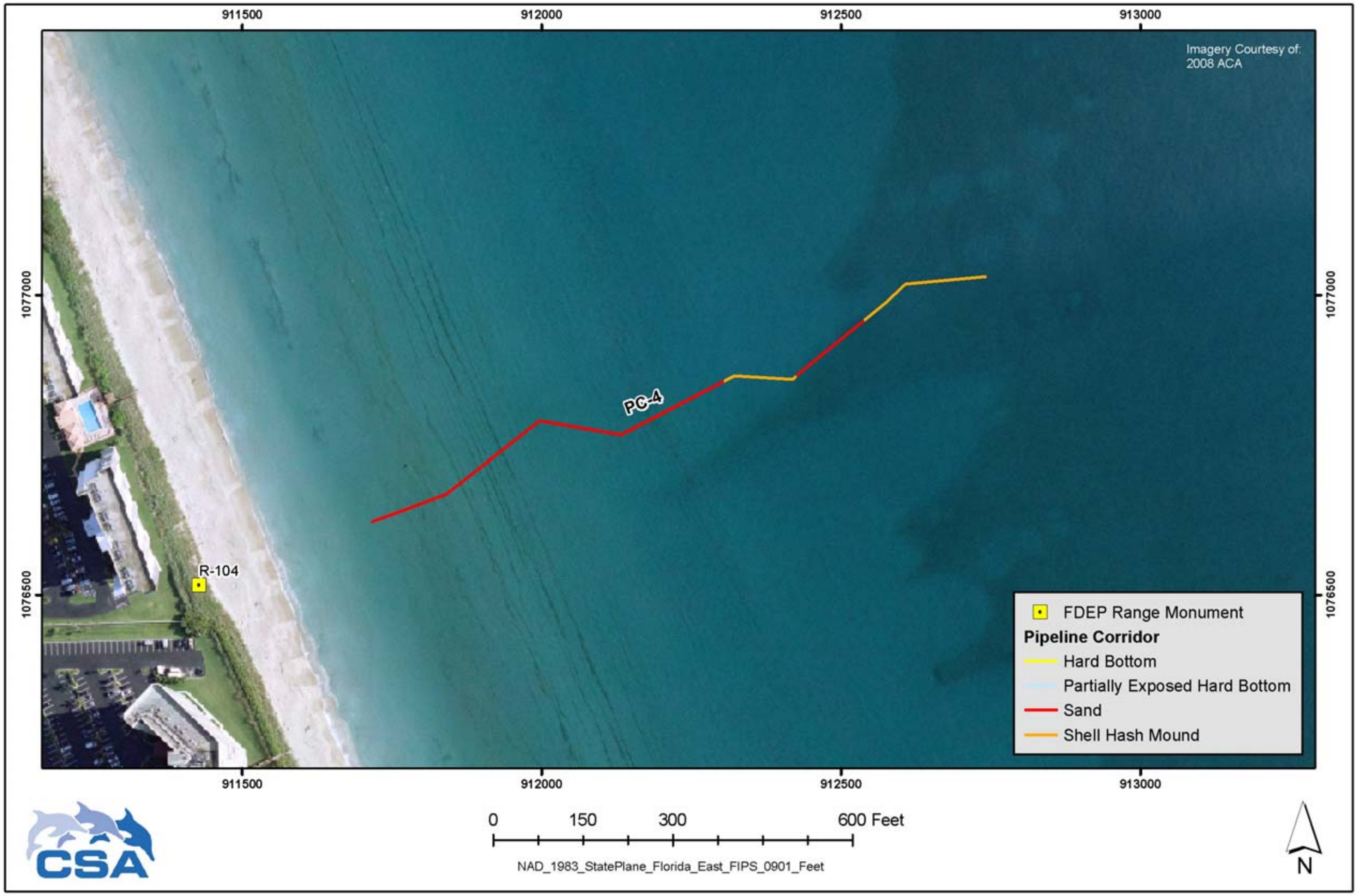

Figure D-36. Potential pipeline corridor PC-4 near FDEP Range Monument R-104 mapped during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Red lines denote sand and orange lines denote shell hash mound. Geo-referenced qualitative video data were collected along the entire proposed pipeline corridor. Survey conducted 17 July 2009.

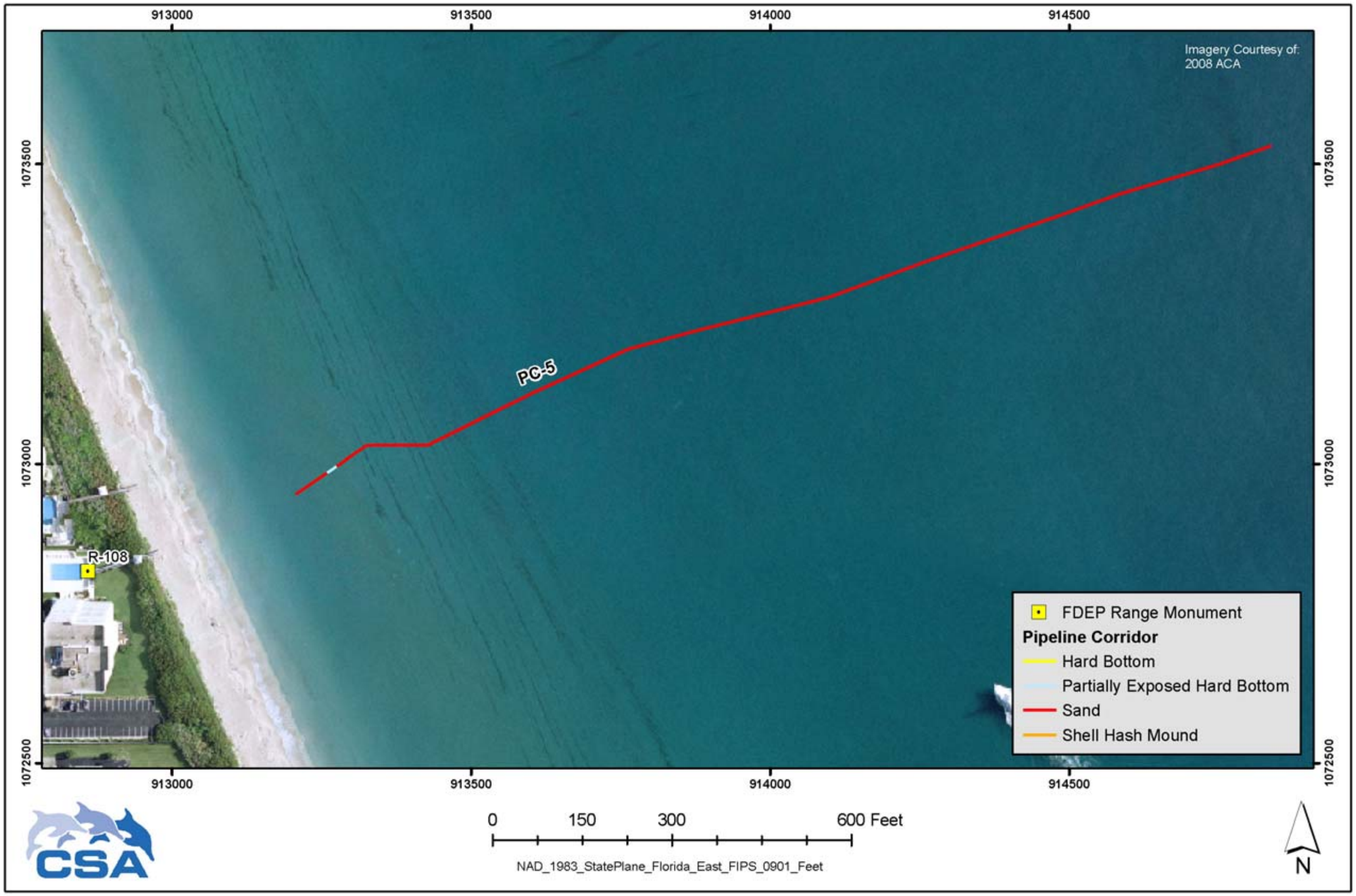

Figure D-37. Potential pipeline corridor PC-5 near FDEP Range Monument R-108 mapped during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Blue line denotes partially exposed hard bottom and red lines denote sand. Geo-referenced qualitative video data were collected along the entire proposed pipeline corridor. Survey conducted 17 July 2009.

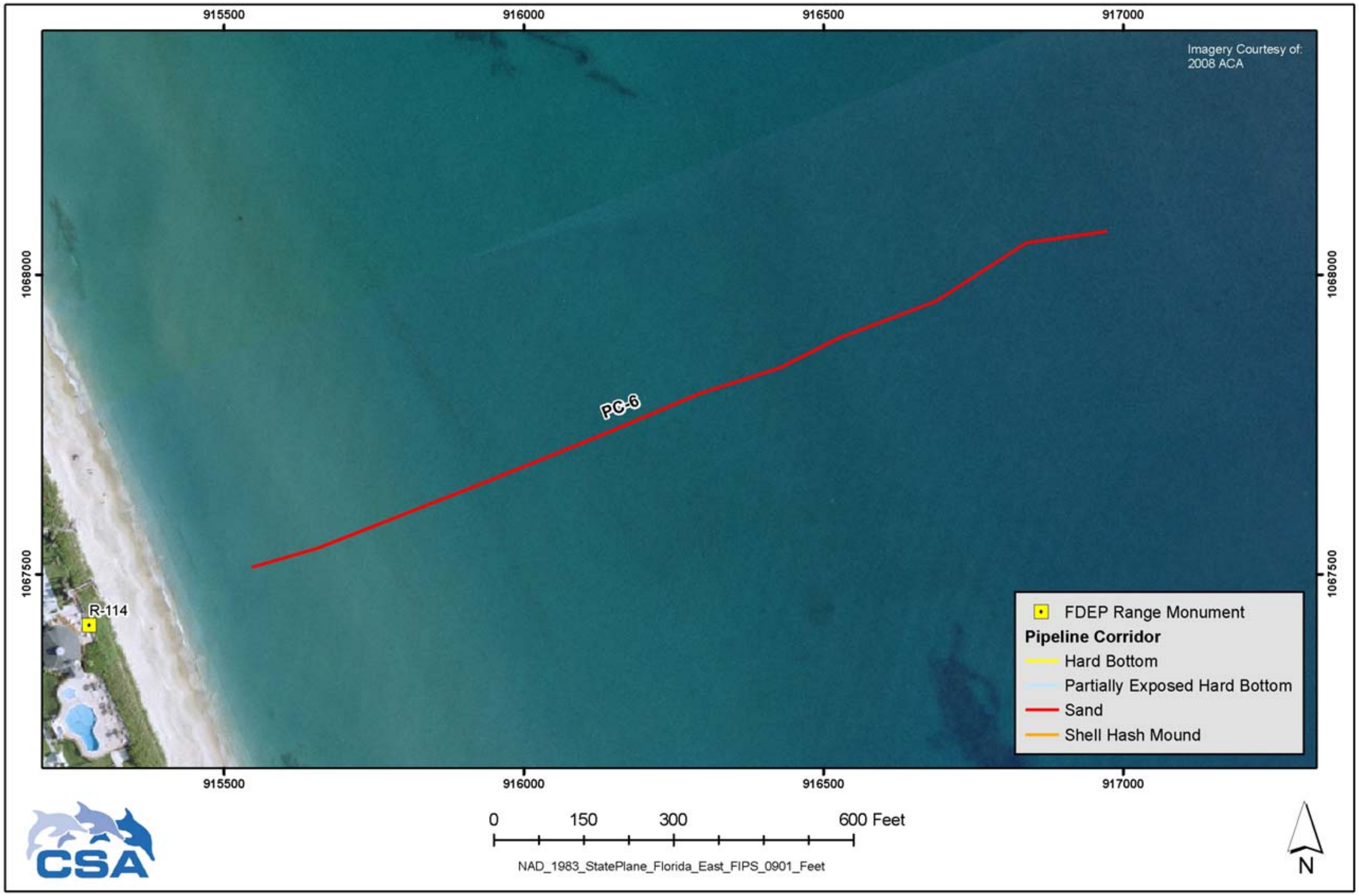

Figure D-38. Potential pipeline corridor PC-6 near FDEP Range Monument R-114 mapped during the Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Red line denotes sand. Geo-referenced qualitative video data were collected along the entire proposed pipeline corridor. Survey conducted 17 July 2009.

SUB-APPENDIX J2

HARDBOTTOM FISH ASSEMBLAGE CHARACTERIZATION REPORT

St. Lucie County South Beach Project:
Characterization of Hard Bottom Fish Assemblages

January 2010

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1.0 INTRODUCTION

CSA International, Inc. (CSA) was contracted by Coastal Technology Corporation (Coastal Tech) to characterize the ichthyofauna associated with nearshore hard bottom along the southern St. Lucie County, Florida coastline prior to potential beach nourishment for the St. Lucie County South Beach Project. In eastern Florida, nearshore hard bottom habitat supports more fish species than either the soft bottom or water column habitats and has been designated essential fish habitat (EFH) by the South Atlantic Fishery Management Council (SAFMC) (1998). Species or species groups managed by SAFMC known to inhabit nearshore hard bottom include the snapper-grouper complex consisting of 73 species, coastal pelagics (5 species), and spiny lobster. EFH is defined as “those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity” [16 United States Code (U.S.C.) § 1801(10)]. The EFH final rule summarizing EFH regulations (50 Code of Federal Regulations [CFR] Part 600) outlines additional interpretation of the EFH definition. Within the EFH designation, nearshore hard bottom has also been identified as a Habitat Area of Particular Concern (HAPC). HAPCs either play important roles in the life history (e.g., spawning, feeding, or settlement areas) of federally managed fish species or are especially vulnerable to degradation from fishing or other human activities. As EFH, nearshore hard bottom provides basic ecological functions such as shelter, food, and spawning sites to a suite of managed species and their prey. An understanding of ecological functions in general as well as of specific components of local ecosystems is an integral part of the Uniform Mitigation Assessment Method (UMAM) (Chapter 62, 345 Florida Administrative Code) process used by State agencies to evaluate environmental effects and subsequent mitigation in the event of unavoidable impacts.

A first step toward providing basic information on habitat use is a field survey of assemblage structure, including species richness, species composition, abundance (or density), and size class distribution. Structure of nearshore hard bottom fish assemblages has been investigated in other areas off eastern Florida (Lindeman and Snyder, 1999; Baron et al., 2004; CSA International, Inc., 2009a), but other than broad faunal characterizations (Gilmore, 1977; Gilmore et al., 1981) there have been no such studies on nearshore hard bottom fishes of St. Lucie County.

The objective of this effort was to conduct a field study of fish assemblage structure on nearshore hard bottom habitat off St. Lucie County. Data gathered during the field study will contribute information needed to complete both an EFH assessment and a UMAM evaluation expected as part of the permitting process for the beach nourishment project.

2.0 METHODS

2.1 FIELD METHODS

The project area extends from Florida Department of Environmental Protection (FDEP) Range Monument R-77 in St. Lucie County south to FDEP Range Monument R-3 in Martin County. A concurrent mapping and substratum characterization study established 22 permanent cross-shore survey transects (CSA International, Inc., 2009b), which were also utilized for this study. Survey transects were established based on aerial imagery collected in 2008 to map the extent of nearshore hard bottom in the area. The survey transects within the project are shown in **Figure 1**.

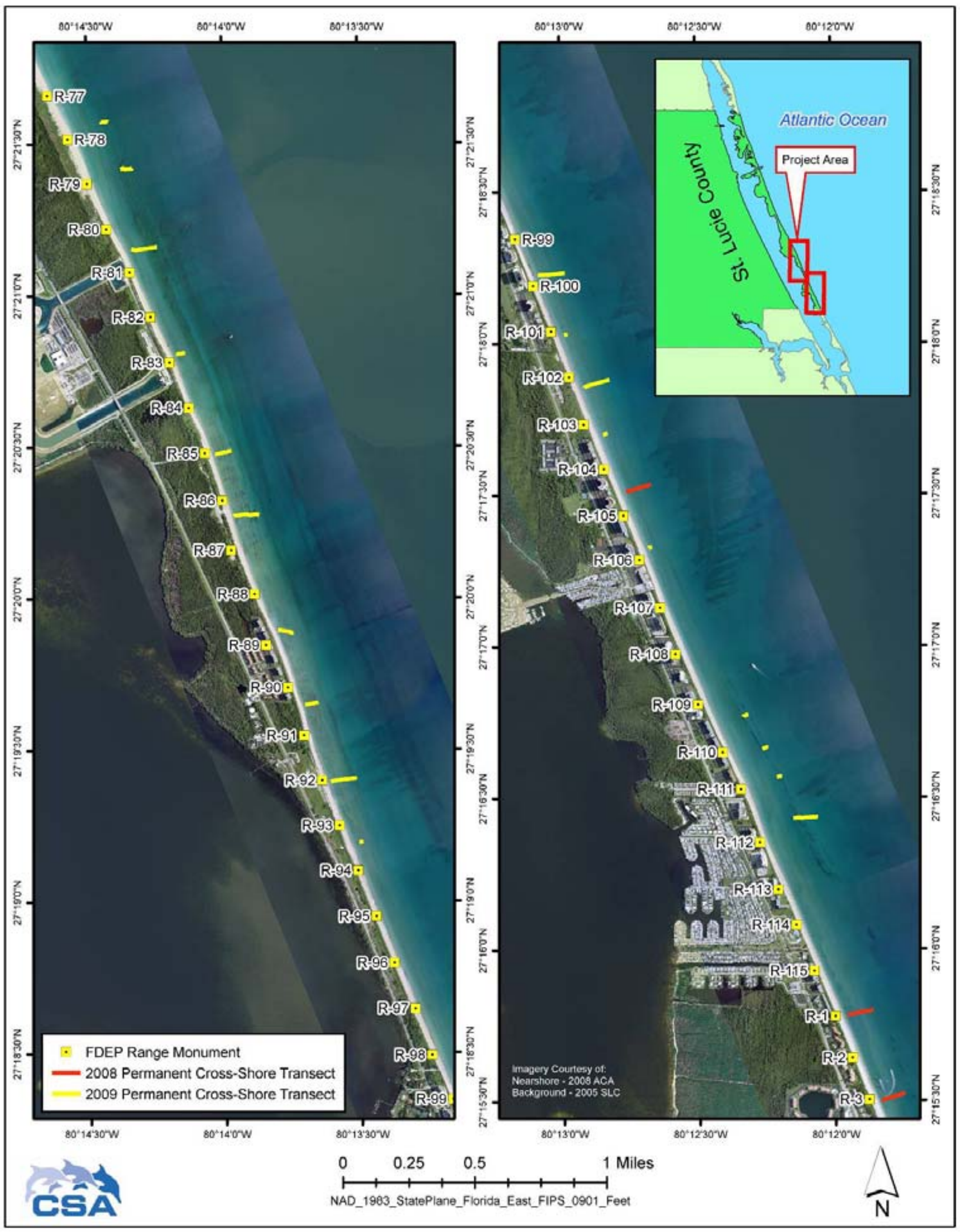

Figure 1. St. Lucie County South Beach Project area survey transects relative to the St. Lucie County, Florida shoreline.

The survey transects provided a spatial framework for conducting visual censuses of fishes within the project area. A diver/ichthyologist utilized two approaches, strip transects and timed swims, to census fishes along each of the survey transects. Strip transects provided species richness as well as density data by species and size class for cross-shelf subdivisions (strata) of survey transects, whereas timed swims provided relative abundance data for the survey transect as a whole. Timed swims were conducted to complement the quantitative strip transects by augmenting estimates of overall richness and size class occurrence.

At each survey transect, two strip transects were planned within each of three cross-shelf strata (inshore, middle, and offshore) of the hard bottom feature traversed by the survey transect. The exact position of the cross-shelf strata depended upon the nature of hard bottom along individual survey transects. Strip transects were constrained to begin only on hard bottom because many of the survey transects crossed patchy features with considerable sand cover between hard bottom outcrops. Placement of the strip transects was determined during the field surveys using the survey transect as a baseline. In some instances inshore strip transects were not possible due to extremely shallow water, turbulent conditions, or both. Strip transects measured 15 m x 2 m, with an observational corridor extending from surface to bottom and 2 m in front of the diver/ichthyologist. The two strip transects within each stratum were considered subsamples; for data summaries and analyses, these subsamples were summed within each cross-shelf stratum. Fishes were counted in the following size (total length) categories: 0-20 mm, 21-40 mm, 41-60 mm, 61-80 mm, 81-100 mm, 101-200 mm, 201-300 mm, 301-400, and >400 mm. Lengths of all fishes were estimated with the aid of a hand-held ruler affixed to a 1-m plastic pole. Newly settled taxa (20 mm or less) were recorded at the lowest practicable taxonomic level.

Timed swims consisted of a modified roving census (Kimmel, 1985) where the diver/ichthyologist swam about haphazardly for 5 minutes recording all fishes observed around the survey transect within each of the three cross-shelf strata. During a timed swim, the diver is free to look under ledges, in crevices, and overhead in the water column. A single 5-minute swim was conducted for each survey transect.

2.2 DATA ANALYSIS

Fish assemblages of the project area were assessed for patterns in species composition, species richness, density of individual species, size composition of species, and to associate fish assemblages with measures of hard bottom physical structure.

To assess spatial patterns in species composition across survey transects, similarity was separately compared with multivariate analyses for both timed swim and transect data. For each data set, a matrix of Bray-Curtis similarities (Bray and Curtis, 1957) comparing proportional abundances of all species among samples was constructed with log-transformed (log10 [x+1]) raw data. For strip transect data, subsamples were summed for each species in each of the cross-shelf stratum from each survey transect. This resulted in a 52 sample x 66 species matrix that provided a basis for analysis of patterns in species composition as well as statistical tests of differences among cross-shelf strata. Timed swim data from each survey transect were used to construct a 21 sample x 47 species Bray-Curtis matrix. Visualization of patterns in these matrices was achieved through group-average cluster analysis and multidimensional scaling (MDS) ordination, complementary techniques effective in discerning patterns in multivariate data. Statistical significance of clusters formed by the cluster analysis was established with the similarity profile (SIMPROF) permutation test. The test statistic, π, is the summed absolute distances between real and simulated similarity profiles. SIMPROFs were conducted using 4,999 permutations to test the null hypothesis that the resultant groups in the cluster analysis did not differ from one another in multivariate structure at the 5% level. Similarity percentages (SIMPER) were used to identify particular species responsible for any significant groups identified by SIMPROF. A test of the hypothesis of no difference in species composition among the cross-shelf strata (inshore, middle, and offshore) was conducted with analysis of similarities (ANOSIM) (Clarke, 1993) on the subset of 12 survey transects with strip transect counts from all three cross-shelf strata. All multivariate analyses were performed with PRIMER-E software (Clarke and Gorely, 2006).

Physical characteristics of the hard bottom measured along survey transects were compared with univariate measures of species richness (total species per sample), density (strip transects), and relative abundance (timed swims) with Pearson's product-moment correlation coefficient. T-tests were used to test the hypothesis that the correlations were greater than or equal to zero; significance was established at $p<0.05$.

3.0 RESULTS

Of the 22 survey transects established for the project area, 21 were sampled for fishes. One survey transect, R-105.9, was not sampled due to unworkable conditions during the field surveys following establishment of that transect. Of the 21 survey transects sampled, 11 were suitable for three strata (inshore, middle, and offshore), 9 were suitable for two strata (middle and offshore), and one (Transect R-102) had only a single stratum, resulting in a total of 52 strip transect samples. Roving surveys were conducted at 21 survey transects. **Table 1** summarizes sampling locations and dates.

Table 1. Summary of timed swim and strip transect fish censuses conducted within the St. Lucie County South Beach Project area.

Survey Transect	Date	Timed Swims	Strip Transects (Strata)			
			Inshore	Middle	Offshore	Total
R-77.7	7 July 2009	1	1	1	1	3
R-78.7	18 September 2009	--	1	1	1	3
	2 October 2009	1	--	--	--	--
R-80.4	1 July 2009	1	1	1	1	3
R-82.8	1 July 2009	1	1	1	--	2
R-85	3 July 2009	1	1	1	--	2
R-86.3	10 July 2009	1	--	1	1	2
R-88.7	10 July 2009	1	1	1	1	3
R-90.4	7 July 2009	1	1	1	1	3
R-92	7 July 2009	1	1	1	1	3
R-93.5	2 October 2009	1	--	1	1	2
R-100	3 July 2009	1	1	1	1	3
R-101	15 July 2009	1	1	1	1	3
R-102	2 October 2009	1	--	--	1	1
R-103.2	15 July 2009	1	1	1	1	3
R-104.5	7 July 2009	1	1	1	--	2
R-109.2	7 July 2009	1	1	1	--	2
R-110	2 October 2009	1	1	1	--	2
R-110.5	15 July 2009	1	1	1	1	3
R-112	3 July 2009	1	1	1	1	3
R-1	7July 2009	1	1	1	--	2
R-3	15 August 2008	1	1	1	--	2
Total		21	18	20	13	52

3.1 HARD BOTTOM CHARACTERISTICS

Measurements made along the survey transects used to characterize habitat structure included mean relief, hard bottom width, distance from mean high water level (MHWL) to the inshore edge of the hard bottom feature, and water depth (**Figure 2**). Mean relief measurements did not exhibit any consistent patterns and varied considerably among the survey transects, ranging from 6 to 26 cm (**Figure 2(A)**). Examples of hard bottom features from the area are depicted in **Photos 1** and **2**. Greatest width of the hard bottom feature occurred along the segment from FDEP Monuments R-85 to R-92 (**Figure 2(B)**). Hard bottom width did not show any particular trends along the project area shoreline. Distances from MHWL to the inshore edge of hard bottom were greatest for survey transects located at the southern (FDEP Monuments R-109.2 to R-112) and northern (FDEP Monuments R-77.7 and R-78.7) ends of the project area (**Figure 2(C)**); at these transects, distances from MHWL to the inshore edge of hard bottom exceeded 150 m. Water depth was obviously related to the distance between MHWL and the inshore hard bottom edge, with the deepest survey transects occurring at the southern and northern ends of the project area. In several areas along survey transects, wormrock (*Phragmatopoma lapidosa*) augmented the structural complexity of the hard bottom (**Photo 3**).

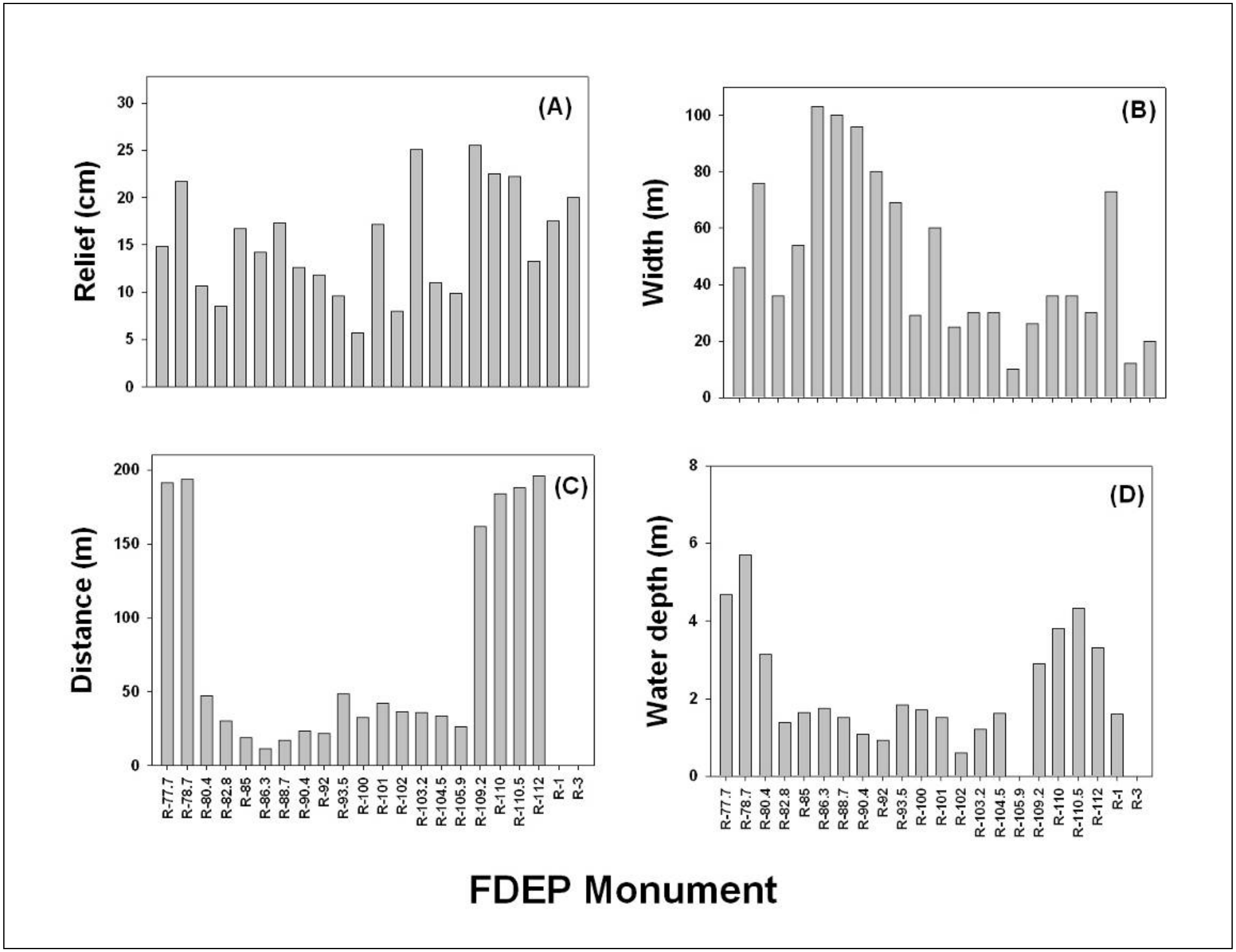

Figure 2. Hard bottom habitat characteristics [(A) relief, (B) width of hard bottom, (C) distance from mean high water level to inshore edge of hard bottom, and (D) water depth] measured along survey transects in the St. Lucie County South Beach Project area.

Photo 1. Hard bottom feature along Transect R-85.

Photo 2. Hard bottom ledge along Transect R-85.

Photo 3. Wormrock reef growing on hard bottom substrate along Transect R-85.

3.2 FISH ASSEMBLAGE

Fishes recorded along the survey transects by both census methods included 71 taxa from 29 families (**Table 2**). Families represented by the greatest numbers of taxa included grunts (Haemulidae) (9), jacks (Carangidae) (8), sea basses (Serranidae) (4), snappers (Lutjanidae) (4), wrasses (Labridae) (4), and drums (Sciaenidae) (4). Comparison of taxonomic lists from the two census methods indicated that more species overall were recorded for strip transects (68) than for timed swims (47). Of the 71 taxa recorded within the study area, 24 were federally managed. All but two (Spanish mackerel [*Scomberomorus maculatus*], a coastal pelagic species, and nurse shark [*Ginglymostoma cirratum*], a coastal shark) were members of the snapper-grouper management unit.

Table 2. Fish taxa and families observed during timed swims and along strip transects in the St. Lucie County South Beach Project area. Species shown in bold are managed by the South Atlantic Fishery Management Council.

Family		Species		Timed Swim	Strip Transect
Common Name	Scientific Name	Common Name	Scientific Name		
Carpet sharks	Ginglymostomatidae	**Nurse shark**	***Ginglymostoma cirratum***	●	●
Moray eels	Muraenidae	Green moray	*Gymnothorax funebris*	●	●
		Purplemouth moray	*Gymnothorax vicinus*		●
Lizardfishes	Synodontidae	Inshore lizardfish	*Synodus foetens*	●	●
Toadfishes	Batrachoididae	Oyster toadfish	*Opsanus tau*	●	
Scorpionfishes	Scorpaenidae	Spotted scorpionfish	*Scorpaena plumieri*		●
Snooks	Centropomidae	Common snook	*Centropomus undecimalis*	●	●
Sea Basses	Serranidae	Belted sandfish	*Serranus subligarius*	●	●
		Black sea bass	***Centropristis striata***	●	●
		Sand perch	*Diplectrum formosum*		●
		Whitespotted soapfish	*Rypticus maculatus*		●
Cardinalfishes	Apogonidae	Twospot cardinalfish	*Apogon pseudomaculatus*	●	●
Jacks	Carangidae	Atlantic bumper	*Chloroscombrus chrysurus*		●
		Bar jack	***Caranx ruber***		●
		Blue runner	***Caranx crysos***		●
		Crevalle jack	***Caranx hippos***	●	●
		Greater amberjack	***Seriola dumerili***		●
		Lookdown	*Selene vomer*		●
		Round scad	*Decapterus punctatus*		●
		Yellow jack	***Caranx bartholomaei***	●	●
Snappers	Lutjanidae	**Gray snapper**	***Lutjanus griseus***	●	●
		Lane snapper	***Lutjanus synagris***	●	●
		Mahogany snapper	***Lutjanus mahogoni***		●
		Yellowtail snapper	***Ocyurus chrysurus***		●
Mojarras	Gerreidae	Flagfin mojarra	*Eucinostomus melanopterus*		●
		Mojarras (newly settled)	Gerreidae (newly settled)	●	●
Grunts	Haemulidae	**Black margate**	***Anisotremus surinamensis***	●	●
		Cottonwick	***Haemulon melanurum***		●
		French grunt	***Haemulon flavolineatum***		●
		Pigfish	*Orthopristis chrysoptera*	●	●
		Porkfish	***Anisotremus virginicus***	●	●
		Sailors choice	***Haemulon parra***	●	●
		Spanish grunt	***Haemulon macrostomum***		●

Table 2. (Continued).

Family		Species		Timed Swim	Strip Transect
Common Name	Scientific Name	Common Name	Scientific Name		
		Tomtate	***Haemulon aurolineatum***	●	●
		White grunt	***Haemulon plumieri***	●	●
Porgies	Sparidae	**Sheepshead**	***Archosargus probatocephalus***	●	●
		Silver porgy	*Diplodus argenteus*	●	●
		Spottail pinfish	*Diplodus holbrooki*		●
Drums	Sciaenidae	Cubbyu	*Pareques umbrosus*	●	●
		Drums (newly settled)	Sciaenidae (newly settled)		●
		High-hat	*Pareques acuminatus*	●	●
		Striped croaker	*Bairdiella sanctaeluciae*	●	●
Goatfishes	Mullidae	Spotted goatfish	*Pseudupeneus maculatus*	●	●
Sweepers	Pempheridae	Glassy sweeper	*Pempheris schomburgkii*	●	●
Spadefishes	Ephippidae	**Atlantic spadefish**	***Chaetodipterus faber***	●	●
Angelfishes	Pomacanthidae	Blue angelfish	*Holacanthus bermudensis*		●
		French angelfish	*Pomacanthus paru*		●
		Gray angelfish	*Pomacanthus arcuatus*	●	●
Damselfishes	Pomacentridae	Cocoa damselfish	*Stegastes variabilis*	●	●
		Dusky damselfish	*Stegastes fuscus*		●
		Sergeant major	*Abudefduf saxatilis*	●	●
Wrasses	Labridae	Blackear wrasse	*Halichoeres poeyi*	●	●
		Bluehead	*Thalassoma bifasciatum*	●	●
		Puddingwife	***Halichoeres radiatus***	●	●
		Slippery dick	*Halichoeres bivittatus*	●	●
Parrotfishes	Scaridae	Parrotfish (newly settled)	Scaridae (newly settled)	●	●
Labrisomid blennies	Labrisomidae	Hairy blenny	*Labrisomus nuchipinnis*	●	●
		Saddled blenny	*Malacoctenus triangulatus*	●	●
Combtooth blennies	Blenniidae	Molly miller	*Scartella cristata*	●	●
		Seaweed blenny	*Parablennius marmoreus*	●	●
Gobies	Gobiidae	Bridled goby	*Coryphopterus glaucofraenum*		●
Surgeonfishes	Acanthuridae	Blue tang	*Acanthurus coeruleus*	●	
		Doctorfish	*Acanthurus chirurgus*	●	●
		Ocean surgeonfish	*Acanthurus bahianus*		●
Barracudas	Sphyraenidae	Great barracuda	*Sphyraena barracuda*	●	
		Guaguanche	*Sphyraena guachancho*	●	●
Mackerels	Scombridae	**Spanish mackerel**	***Scomberomorus maculatus***	●	●
Triggerfishes	Balistidae	**Gray triggerfish**	***Balistes capriscus***		●
Puffers	Tetraodontidae	Bandtail puffer	*Sphoeroides spengleri*	●	●
		Sharpnose puffer	*Canthigaster rostrata*		●
Total Taxa				●	●
Total Families				**47**	**68**

3.2.1 Timed Swims

Timed swim abundance data are shown in **Table 3**. Ranked in order of abundance, the 10 numerically dominant taxa in timed swims were black margate (*Anisotremus surinamensis*), silver porgy (*Diplodus argenteus*), newly settled grunts (*Haemulon* spp.), sailors choice (*Haemulon parra*), hairy blenny (*Labrisomus nuchipinnis*), porkfish (*Anisotremus virginicus*), newly settled mojarras (*Eucinostomus* spp.), molly miller (*Scartella cristata*), cubbyu (*Pareques umbrosus*), and cocoa damselfish (*Stegastes variabilis*). Collectively, these 10 taxa represented 87% of the numerical abundance recorded during the timed swims. Silver porgy and hairy blenny were the most frequently observed species, occurring in 20 of 21 (95%) of the timed swims, followed by black margate and porkfish, which occurred in 17 of 21 (81%) of the timed swims.

Cluster analyses of the timed swim data are presented in **Figure 3**. Three clusters of samples were formed: A, B, and C. Clusters A and B were significantly different at the 40% similarity level (SIMPROF, $\pi = 2.21$, $p = 0.2\%$, 4,999 permutations). Cluster C included only two samples and was significantly different from Clusters A and B (SIMPROF, $\pi = 3.16$, 0.04%, 4,999 permutations). MDS ordination agreed with the separation of the three clusters (**Figure 4**).

Species typifying Clusters A and B are listed in **Table 4**. Tomtate (*Haemulon aurolineatum*), porkfish, silver porgy, and cubbyu contributed most to within-group similarity of Cluster A. Cluster B was typified by silver porgy, black margate, hairy blenny, newly settled grunts, and molly miller. Species important in discriminating the two clusters were tomtate, black margate, newly settled grunts, and porkfish.

3.2.2 Strip Transects

The number of species and log10 transformed density per stratum varied among the survey transects (**Figure 5**). Numbers of species recorded from individual strip transects ranged from 1 at Transect R-90.4 to 21 at Transect R-78.7. Overall, fish densities (untransformed) averaged 3.1 individuals/m^2 and ranged from 24.2 individuals/m^2 at Transect R-77.7 to 0.08 individuals/m^2 at Transect R-90.4.

Table 5 lists species observed in strip transects over the project area. Numerically dominant species observed in strip transects included newly settled grunts, tomtate, newly settled mojarras (*Eucinostomus* spp.), black margate, porkfish, silver porgy, hairy blenny, cubbyu, white grunt (*Haemulon plumieri*), and cocoa damselfish. These 10 taxa represented over 90% of the total abundance of fishes (**Table 5**). Two species, silver porgy and hairy blenny, occurred in 20 of 21 (95%) survey transects, and black margate occurred in 19 of 21 (90%) of the survey transects. Nine additional species occurred at 10 (≥48%) or more of the survey transects.

Assemblage patterns derived from the strip transect data were examined with multivariate analyses. First, a cluster analysis was conducted on a 52 sample x 66 taxa matrix constructed from strip transect data. The cluster analysis produced five clusters (A through E). Two of the five clusters consisted of single anomalous samples, and another consisted of three samples (**Figure 6**); the two remaining clusters (C and E, consisting of 19 and 27 samples, respectively) were formed at a 30% level of similarity. These two clusters were significantly different (SIMPROF, $\pi = 3.52$, $p = 0.01\%$, 4,999 permutations). Cluster analysis was corroborated by the MDS ordination shown in **Figure 7**. The two clusters formed by cluster analysis (Clusters C and E) clearly separated along the first (horizontal) MDS axis.

SIMPER analysis revealed the species typifying the two clusters (**Table 6**). Twelve taxa contributed 2% or greater to the within-cluster similarity of Cluster E, including porkfish, tomtate, newly settled grunts, cocoa damselfish, and hairy blenny. Five taxa (porkfish, newly settled grunts, hairy blenny, black margate, and silver porgy) contributed to most of the within-cluster similarity in Cluster C. The most important discriminating species were tomtate, newly settled grunts, porkfish, black margate, and cocoa damselfish (**Table 6**).

Table 3. Fishes observed in timed swims conducted along survey transects in the St. Lucie County South Beach Project area, ranked by order of abundance.

Common Name	Scientific Name	Transect																					Total	Percent
		R-77.7	R-78.7	R-80.4	R-82.8	R-85	R-86.3	R-88.7	R-90.4	R-92	R-93.5	R-100	R-101	R-102	R-103.2	R-104.5	R-109.2	R-110	R-110.5	R-112	R-1	R-3		
Black margate	*Anisotremus surinamensis*			124	65	106	28	21		10	16	111	8	5	32	40	13	6		4	45	1	729	16.81
Silver porgy	*Diplodus argenteus*	25	33	6	42	94	40	23	56	33	48	36	25		20	40	12	39	3	5	69	20	715	16.49
Grunts	*Haemulon* spp. (newly settled)	100		120	80		12	12		18		94	4		20		50	2	120	55			687	15.84
Sailors choice	*Haemulon aurolineatum*	215	39	10						20							80	31	12	32		15	454	10.47
Hairy blenny	*Labrisomus nuchipinnis*	20	2	3	27	55	3	18	20	7	6	17	10	1	28	22	3	11	9	17	42		341	7.86
Porkfish	*Anisotremus virginicus*	35	41	8	1	18	7	4		2	3			4	17		59	21	14	36	2	3	291	6.71
Mojarras	*Eucinostomus* spp. (newly settled)	15		41					20			31			20		80			12			236	5.44
Molly miller	*Scartella cristata*			15		21		3	29	4		10			9	36			13		8		148	3.41
Cubbyu	*Pareques umbrosus*	7	4			5						2	1				8	27	7	30			93	2.14
Cocoa damselfish	*Stegastes variabilis*	9	10			5	3								1			13	27	14			83	1.91
Sergeant major	*Abudefduf saxatilis*					12	27		4			10			4		1	14	2				76	1.75
Blackear wrasse	*Halichoeres bivittatus*	3	1			6		28	3	6		2					1	5	1	3			63	1.45
White grunt	*Haemulon plumieri*	12	6	8			5	4									4		6	16			61	1.41
Lane snapper	*Lutjanus synagris*	4	4										1				6	23	1				49	1.13
Glassy sweeper	*Pempheris schomburgkii*						30					3			12								45	1.04
Striped croaker	*Bairdiella sanctaeluciae*		18				4				1						6	2					31	0.71
Seaweed blenny	*Parablennius marmoreus*				1	1											1		20	8			31	0.71
Common snook	*Centropomus undecimalis*											1									24		25	0.58
Crevalle jack	*Caranx hippos*		1								22							1					24	0.55
Twospot cardinalfish	*Apogon pseudomaculatus*	4			1						1						13						19	0.44
Tomtate	*Haemulon parra*			9								3			4								19	0.44
Sheepshead	*Archosargus probatocephalus*	8			1			2	1	1		2											18	0.42
Slippery dick	*Halichoeres poeyi*					1		9	3														14	0.32
Pigfish	*Orthopristis chrysoptera*																	10	3				13	0.30
Atlantic spadefish	*Chaetodipterus faber*		10																				10	0.23
Saddled blenny	*Malacoctenus triangulatus*	1					2												4	3			10	0.23
Black sea bass	*Centropristis striata*	2	6																	1			9	0.21
Gray snapper	*Lutjanus griseus*		2			2												2			1		7	0.16
Guaguanche	*Sphyraena guachancho*	3															4						7	0.16
Blue tang	*Acanthurus chirurgus*		1															2		2			5	0.12
Yellow jack	*Caranx bartholomaei*																2						2	0.05
Green moray	*Gymnothorax funebris*									1													2	0.05
Puddingwife	*Halichoeres radiatus*					1												1					2	0.05
Parrotfish	*Sparisoma* spp.							2															2	0.05
Spanish mackerel	*Scomberomorus maculatus*																	2					2	0.05
Bandtail puffer	*Sphoeroides spengleri*														1				1				2	0.05

Table 3. (Continued).

Common Name	Scientific Name	Transect																					Total	Percent
		R-77.7	R-78.7	R-80.4	R-82.8	R-85	R-86.3	R-88.7	R-90.4	R-92	R-93.5	R-100	R-101	R-102	R-103.2	R-104.5	R-109.2	R-110	R-110.5	R-112	R-1	R-3		
Great barracuda	*Sphyraena barracuda*															1					1		2	0.05
Doctorfish	*Acanthurus coeruleus*																1						1	0.02
High-hat	*Pareques acuminatus*			1																			1	0.02
Nurse shark	*Ginglymostoma cirratum*						1																1	0.02
Oyster toadfish	*Opsanus tau*	1																					1	0.02
Gray angelfish	*Pomacanthus arcuatus*		1																				1	0.02
Spotted goatfish	*Pseudupeneus maculatus*	1																					1	0.02
Spotted scorpionfish	*Scorpaena plumieri*																			1			1	0.02
Belted sandfish	*Serranus subligarius*																		1				1	0.02
Inshore lizardfish	*Synodus foetens*														1								1	0.02
Bluehead	*Thalassoma bifasciatum*																	1					1	0.02
Total Individuals		239	465	179	345	218	327	162	126	136	97	102	322	49	10	169	139	344	213	244	4,337	192	39	
Total Species		16	18	16	11	8	13	12	11	8	7	10	13	6	3	13	5	18	19	17	47	8	4	

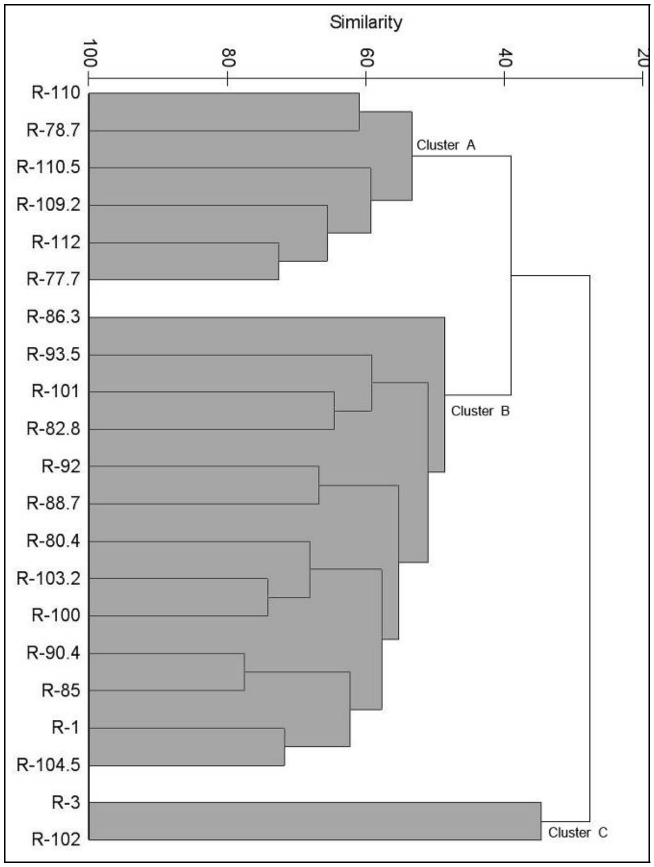

Figure 3. Dendrogram from cluster analysis of samples from a Bray-Curtis similarity matrix based on timed swim data collected from survey transects in the St. Lucie County South Beach Project area.

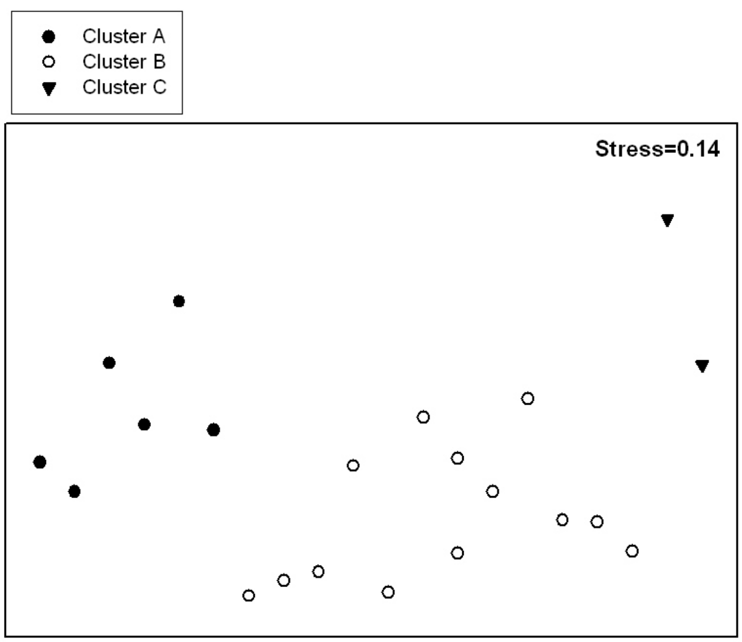

Figure 4. Multidimensional scaling ordination of samples from a Bray-Curtis similarity matrix of timed swim data collected from survey transects in the St. Lucie County South Beach Project area.

Table 4. Percent contribution (>2%) of fish species typifying and discriminating Clusters A and B derived from SIMPER analysis of timed swim data collected along survey transects in the St. Lucie County South Beach Project area.

Typifying Species	Scientific Name	Cluster A	Cluster B
Tomtate	*Haemulon aurolineatum*	15.38	
Porkfish	*Anisotremus virginicus*	15	5.69
Silver porgy	*Diplodus argenteus*	10	26.51
Cubbyu	*Pareques umbrosus*	9.51	
Grunts (newly settled)	*Haemulon* spp. (newly settled)	8.84	6.91
Hairy blenny	*Labrisomus nuchipinnis*	8.06	19.38
Cocoa damselfish	*Stegastes variabilis*	7.82	
White grunt	*Haemulon plumier*	5.97	
Lane snapper	*Lutjanus synagris*	3.99	
Slippery dick	*Halichoeres bivittatus*	3.9	
Mojarras (newly settled)	*Eucinostomus* spp. (newly settled)	2.34	
Black margate	*Anisotremus surinamensis*		25.36
Molly miller	*Scartella cristata*		6.64
Average within-cluster similarity		57.99	54.97
Discriminating Species	**Scientific Name**	**Cluster A versus Cluster B**	
Tomtate	*Haemulon aurolineatum*	9.47	
Black margate	*Anisotremus surinamensis*	7.41	
Grunts (newly settled)	*Haemulon* spp. (newly settled)	6.33	
Porkfish	*Anisotremus virginicus*	5.82	
Cubbyu	*Pareques umbrosus*	5.81	
Cocoa damselfish	*Stegastes variabilis*	5.64	
Mojarras (newly settled)	*Eucinostomus* spp. (newly settled)	4.75	
Molly miller	*Scartella cristata*	4.46	
White grunt	*Haemulon plumieri*	4.38	
Lane snapper	*Lutjanus synagris*	3.68	
Silver porgy	*Diplodus argenteus*	3.14	
Sergeant major	*Abudefduf saxatilis*	3.05	
Slippery dick	*Halichoeres bivittatus*	3.02	
Striped croaker	*Bairdiella sanctaeluciae*	2.87	
Seaweed blenny	*Parablennius marmoreus*	2.79	
Hairy blenny	*Labrisomus nuchipinnis*	2.73	
Average between-cluster dissimilarity		60.9	

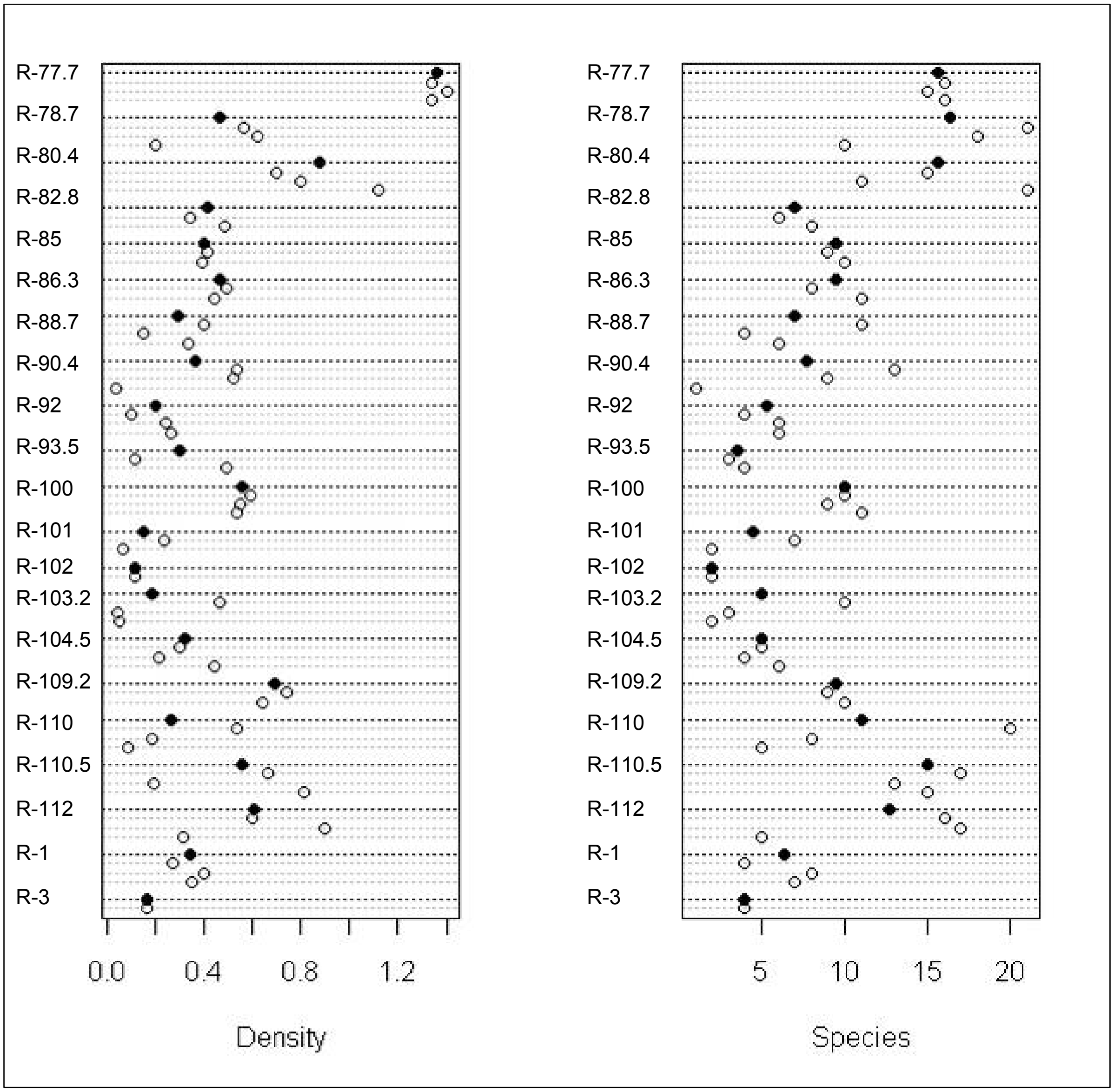

Figure 5. Plots of numbers of species and log transformed (log10) densities (n/m^2) of fishes observed from strip transects sampled along the St. Lucie County South Beach Project survey transects. Open circles indicate values for individual strip transects; solid circles indicate mean values for the survey transect.

Table 5. Fish species observed from strip transects sampled along the St. Lucie County South Beach Project survey transects, ranked by total abundance.

Common Name	Scientific Name	Transects																					Total	Percent
		R-77.7	R-78.7	R-80.4	R-82.8	R-85	R-86.3	R-88.7	R-90.4	R-92	R-93.5	R-100	R-101	R-102	R-103.2	R-104.5	R-109.2	R-110	R-110.5	R-112	R-1	R-3		
Grunts (newly settled)	*Haemulon* spp. (newly settled)	1,620		363	75	12			7			147			50	33	205	8	24	328	12		2,884	29.59
Tomtate	*Haemulon aurolineatum*	1,100	59	166		15			16								64	28	281	50	39		1,818	18.65
Mojarras (newly settled)	*Eucinostomus* spp.	705		206								92	10		34		80		33	98	20		1,278	13.11
Black margate	*Anisotremus surinamensis*		10	77	47	72	69	34	47	15	47	116	14	8	10	72	42	2	8	35	16		741	7.60
Porkfish	*Anisotremus virginicus*	196	78	92	9	23	8	5	25		24	12			1		57	16	44	46	2		638	6.54
Silver porgy	*Diplodus argenteus*	2	77	18	28	6	51	29	17	19	61	41	22	10	12	30		35	6	2	31	11	508	5.21
Hairy blenny	*Labrisomus nuchipinnis*	51	35	41	24	20	37	40	18	38	10	31	4		16	30	2	10	10	6	39	13	475	4.87
Cubbyu	*Pareques umbrosus*	81	11	42		1	1	1	13			21	1		1		4	3	14	31	2		227	2.33
White grunt	*Haemulon plumieri*	58	15	23				19									4		33	4			156	1.60
Cocoa damselfish	*Stegastes variabilis*	17	14	27	1	6	1										6	20	25	15			132	1.35
Slippery dick	*Halichoeres bivittatus*		15	7	1	5	17	22	1									3	17	8			96	0.98
Atlantic bumper	*Chloroscombrus chrysurus*	50		45																			95	0.97
Molly miller	*Scartella cristata*		1	17		4	11	16	1	5		1				29			2		5		92	0.94
Seaweed blenny	*Parablennius marmoreus*	12		4		7	1		1								2		47	11			85	0.87
Lane snapper	*Lutjanus synagris*	2	32	3								1			1			28	8	2			77	0.79
Sergeant major	*Abudefduf saxatilis*		7	8	2	8		9	1	1		1	1		1	1	1	2	4	1	2	1	51	0.52
Sailors choice	*Haemulon parra*	5		43								1											49	0.50
Glassy sweeper	*Pempheris schomburgkii*				1		35										2		7				45	0.46
Striped croaker	*Bairdiella sanctaeluciae*		1	25				2										1		13			42	0.43
Common snook	*Centropomus undecimalis*																				24		24	0.25
Saddled blenny	*Malacoctenus triangulatus*	21					1												1				23	0.24
Bar jack	*Caranx ruber*																				22		22	0.23
Sheepshead	*Archosargus probatocephalus*	2	5					1	3	1		1					1	1	1			2	18	0.18
Twospot cardinalfish	*Apogon pseudomaculatus*	11							2										3				16	0.16
Black sea bass	*Centropristis striata*	7	5									1					1			1			15	0.15
Doctorfish	*Acanthurus chirurgus*	7	1															3					11	0.11
Crevalle jack	*Caranx hippos*																	11					11	0.11
Drums	Sciaenidae			11																			11	0.11
Atlantic spadefish	*Chaetodipterus faber*		1	4								3											8	0.08
Gray angelfish	*Pomacanthus arcuatus*	4	4																				8	0.08
Blackear wrasse	*Halichoeres poeyi*					1		5	1														7	0.07
Blue runner	*Caranx crysos*	1																5					6	0.06
Gray snapper	*Lutjanus griseus*		4	1																			5	0.05
Lookdown	*Selene vomer*																						0	0.00
Parrotfish	*Sparisoma* spp.	1				2		1		1													5	0.05
Bandtail puffer	*Sphoeroides spengleri*		1																2	2			5	0.05
Guaguanche	*Sphyraena guachancho*			5																			5	0.05

Table 5. (Continued).

Common Name	Scientific Name	Transects																					Total	Percent
		R-77.7	R-78.7	R-80.4	R-82.8	R-85	R-86.3	R-88.7	R-90.4	R-92	R-93.5	R-100	R-101	R-102	R-103.2	R-104.5	R-109.2	R-110	R-110.5	R-112	R-1	R-3		
Gray triggerfish	*Balistes capriscus*		3																				3	0.03
Spottail pinfish	*Diplodus holbrooki*									3													3	0.03
Cottonwick	*Haemulon melanurum*				3																		3	0.03
Yellowtail snapper	*Ocyurus chrysurus*		1														1			1			3	0.03
Whitespotted soapfish	*Rypticus maculatus*	3																					3	0.03
Greater amberjack	*Seriola dumerili*	1																	2				3	0.03
Belted sandfish	*Serranus subligarius*		3																				3	0.03
Ocean surgeonfish	*Acanthurus bahianus*			1														1					2	0.02
Yellow jack	*Caranx bartholomaei*		1	1																			2	0.02
Bridled goby	*Coryphopterus glaucofraenum*	2																					2	0.02
Round scad	*Decapterus punctatus*																			2			2	0.02
Nurse shark	*Ginglymostoma cirratum*						1					1											2	0.02
French grunt	*Haemulon flavolineatum*		1															1					2	0.02
Puddingwife	*Halichoeres radiatus*																	1	1				2	0.02
Pigfish	*Orthopristis chrysoptera*			1														1					2	0.02
French angelfish	*Pomacanthus paru*																	2					2	0.02
Spotted scorpionfish	*Scorpaena plumieri*		1																1				2	0.02
Inshore lizardfish	*Synodus foetens*														1					1			2	0.02
Sharpnose puffer	*Canthigaster rostrata*																		1				1	0.01
Sand perch	*Diplectrum formosum*																		1				1	0.01
High-hat	*Pareques acuminatus*								1														1	0.01
Purplemouth moray	*Gymnothorax vicinus*																			1			1	0.01
Spanish grunt	*Haemulon macrostomum*											1											1	0.01
Blue angelfish	*Holacanthus* bermudensis		1																				1	0.01
Mahogany snapper	*Lutjanus mahogoni*																	1					1	0.01
Spotted goatfish	*Pseudupeneus maculatus*																			1			1	0.01
Spanish mackerel	*Scomberomorus maculatus*																	1					1	0.01
Dusky damselfish	*Stegastes fuscus*			1																			1	0.01
Bluehead	*Thalassoma bifasciatum*																			1			1	0.01
Total		3,959	387	1,232	191	182	233	184	154	83	142	471	52	18	127	195	472	184	576	660	214	27	9,743	
Species		24	27	26	10	14	12	13	15	8	4	16	6	2	10	6	15	23	25	23	12	4	66	

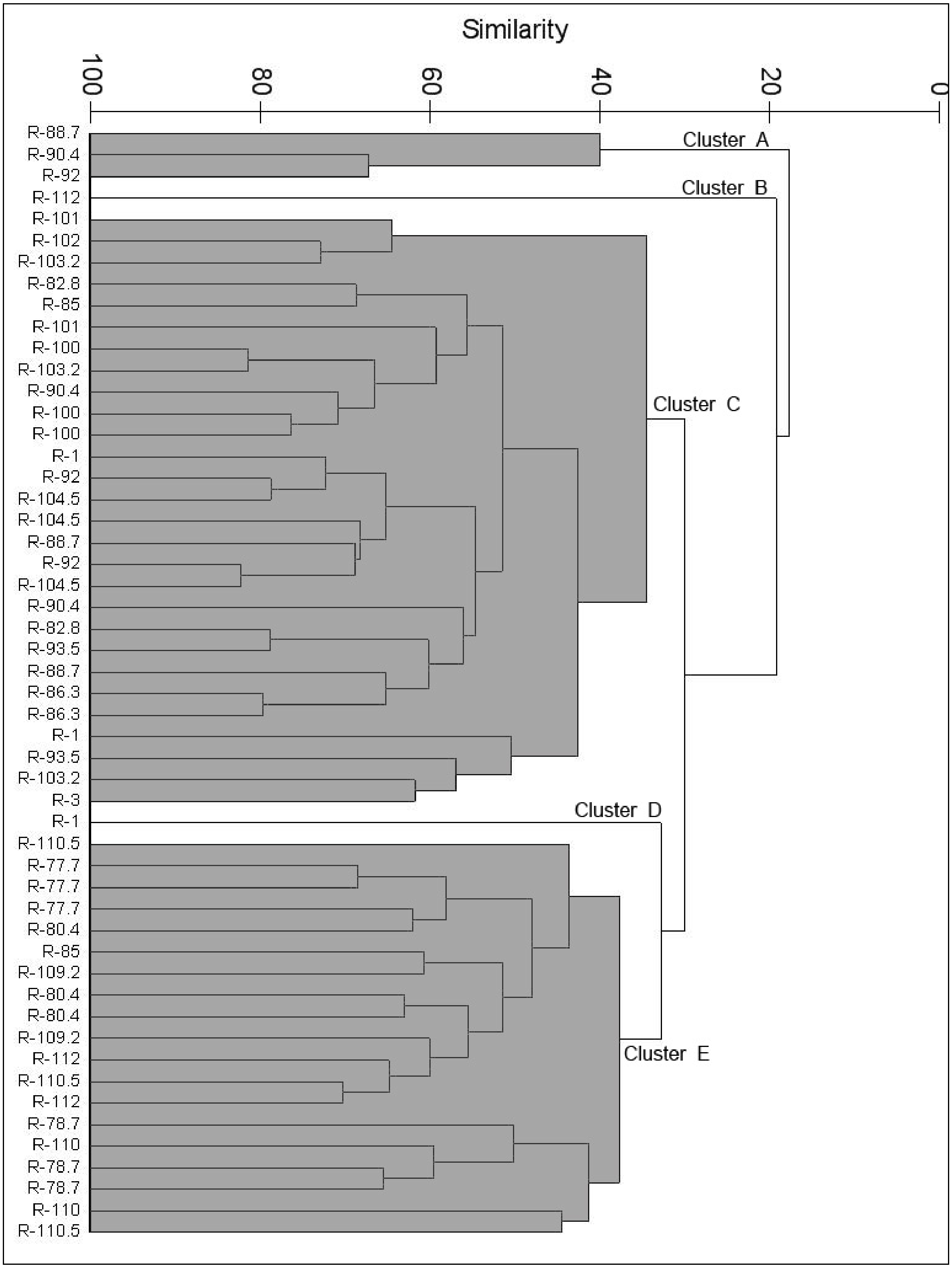

Figure 6. Dendrogram from cluster analysis of samples from a Bray-Curtis similarity matrix based on strip transect data collected along survey transects in the St. Lucie County South Beach Project area.

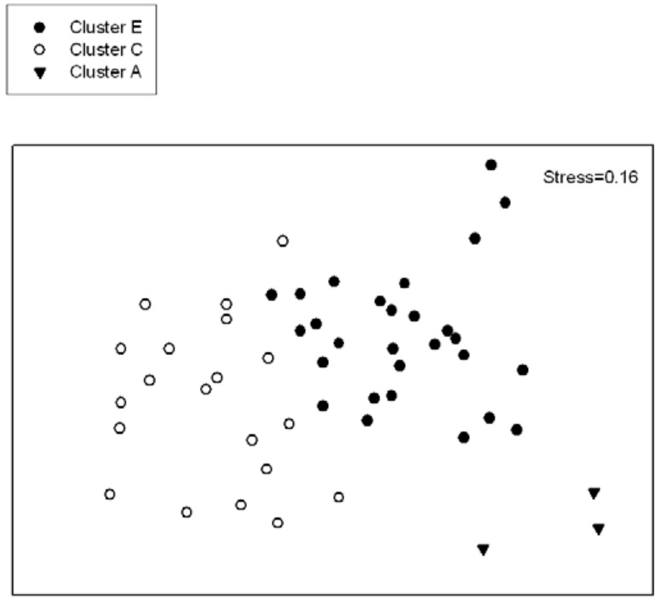

Figure 7. Multidimensional scaling ordination of samples from a Bray-Curtis similarity matrix of strip transect data collected from survey transects in the St. Lucie County South Beach Project area.

Table 6. Percent contribution (>2%) of fish species typifying and discriminating Clusters E and C derived from SIMPER analysis of strip transect data collected from survey transects in the St. Lucie County South Beach Project area.

Typifying Species	Scientific Name	Cluster E	Cluster C
Porkfish	*Anisotremus virginicus*	17.12	4.04
Tomtate	*Haemulon aurolineatum*	13.31	
Grunts (newly settled)	*Haemulon* spp. (newly settled)	11.48	3.83
Cocoa damselfish	*Stegastes variabilis*	9.93	
Hairy blenny	*Labrisomus nuchipinnis*	9.64	26.3
Cubbyu	*Pareques umbrosus*	7.19	
Black margate	*Anisotremus surinamensis*	5.94	28.56
Silver porgy	*Diplodus argenteus*	4.49	29.89
White grunt	*Haemulon plumier*	3.63	
Lane snapper	*Lutjanus synagris*	3.56	
Mojarras (newly settled)	*Eucinostomus* spp. (newly settled)	3.42	
Seaweed blenny	*Parablennius marmoreus*	2.48	
Discriminating Species	Scientific Name	Cluster E versus Cluster C	
Tomtate	*Haemulon aurolineatum*	9.65	
Grunts (newly settled)	*Haemulon* spp. (newly settled)	9.35	
Porkfish	*Anisotremus virginicus*	7.92	
Black margate	*Anisotremus surinamensis*	6.08	
Cocoa damselfish	*Stegastes variabilis*	5.95	
Mojarras (newly settled)	*Eucinostomus* spp. (newly settled)	5.91	
Silver porgy	*Diplodus argenteus*	5.61	
Cubbyu	*Pareques umbrosus*	5.15	
White grunt	*Haemulon plumieri*	4.08	
Hairy blenny	*Labrisomus nuchipinnis*	4.04	
Lane snapper	*Lutjanus synagris*	3.73	
Seaweed blenny	*Parablennius marmoreus*	3.34	
Slippery dick	*Halichoeres bivittatus*	3.12	
Molly miller	*Scartella cristata*	2.97	
Sergeant major	*Abudefduf saxatilis*	2.36	

One-way ANOSIM was conducted to examine the hypothesis of no difference in assemblage composition across three depth strata (inshore, middle, and offshore) using 12 transects as replicates. The results indicated that there was no difference in composition across the three depth strata (R = -0.035, *p* = 92.0%, 4,999 permutations).

Size distributions of fishes observed in strip transects were skewed toward smaller individuals (**Figure 8**). The observation of very high numbers of newly settled grunts and mojarras greatly influenced this pattern. Most taxa observed were less than 80 mm total length. Largest individuals (>400 mm) observed were snook (*Centropomus undecimalis*) and nurse shark. Size distributions of porkfish and black margate for cross-shelf strata are given in **Figure 8**; **Figure 9** illustrates the pattern for silver porgy, hairy blenny, and tomtate.

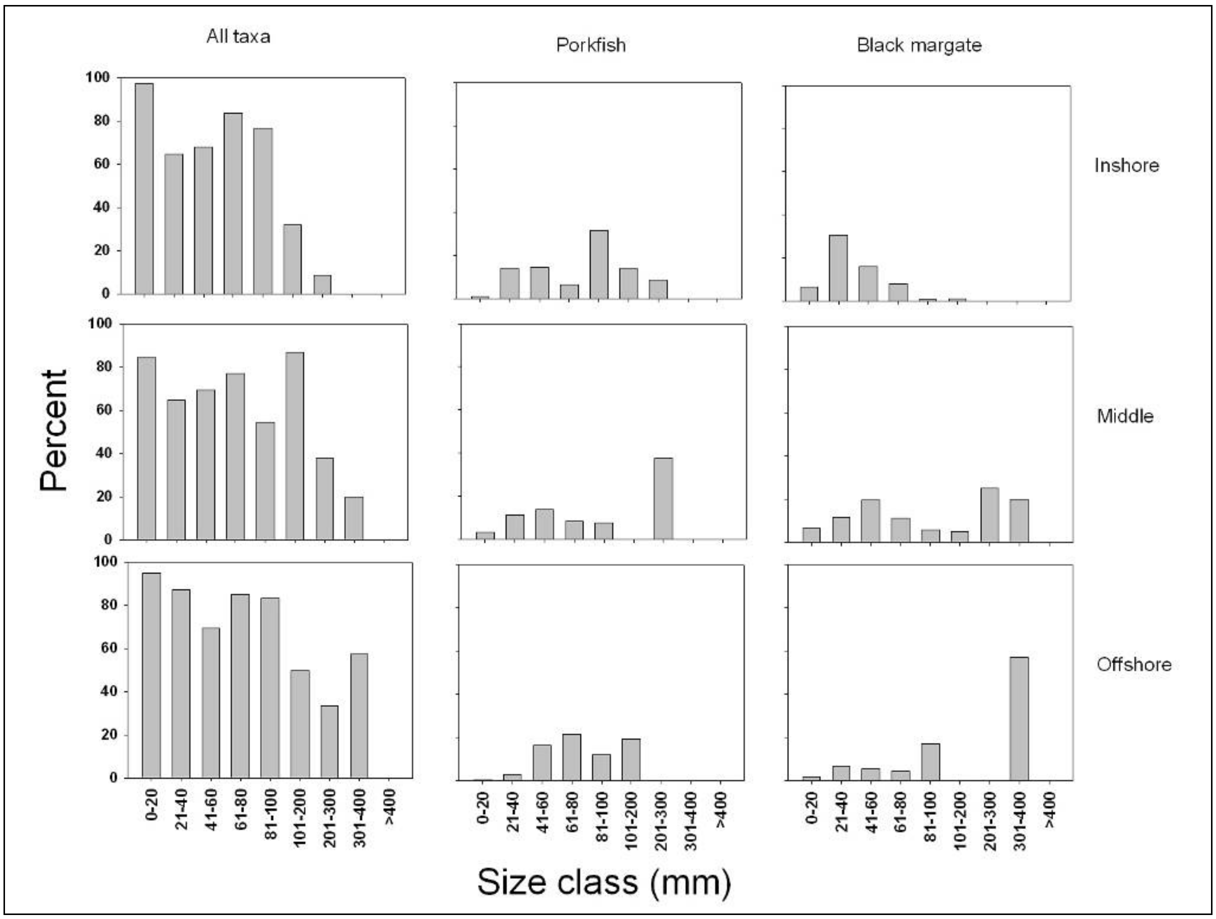

Figure 8. Size distributions of all taxa, porkfish (*Anisotremus virginicus*), and black margate (*Anisotremus surinamensis*) recorded in strip transects by cross-shelf stratum in the St. Lucie County South Beach Project area.

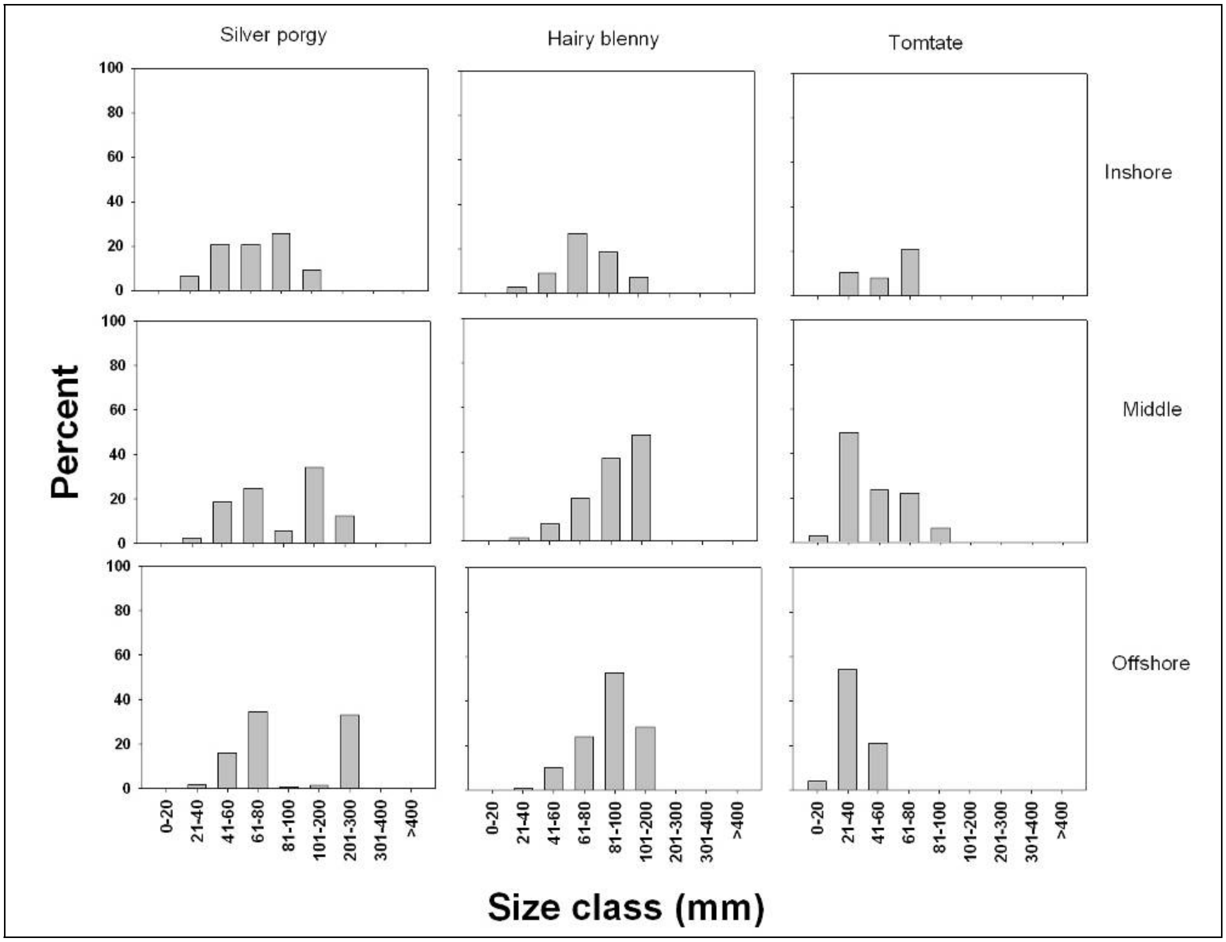

Figure 9. Size distributions of silver porgy (*Diplodus argenteus*), hairy blenny (*Labrisomus nuchipinnis*), and tomtate (*Haemulon aurolineatum*) recorded in strip transects by cross-shelf stratum in the St. Lucie County South Beach Project area.

3.3 RELATIONSHIPS BETWEEN PHYSICAL CHARACTERISTICS OF HARD BOTTOM AND FISH ASSEMBALGES

Physical characteristics of the hard bottom discussed in **Section 3.1** were correlated with univariate biological response variables as well as multivariate patterns revealed in the analysis of the two data sets presented in **Section 3.2**. For timed swims, the physical characteristics are averages for the entire survey transect correlated with timed swims covering much of the same survey transect. Physical characteristics recorded in strip transects (relief and water depth) were more closely related to measured biotic variables (density and species richness), which allowed a finer scale analysis of habitat association within the project area. These analyses are presented separately by data type in the following subsections.

3.3.1 Timed Swims

Correlations between species richness and physical hard bottom characteristics were generally positive, but there was considerable variation among the data points (**Figure 10**). The strongest patterns of association were with distance from inshore edge to MHWL (r = 0.745, p = 0.001, n = 21) and water depth (r = 0.752, p = 0.0001, n = 21). Clearly, these two physical characteristics were also positively correlated (r = 0.875, p = 0.000, n = 21). The relationship between species richness and hard bottom width was not statistically significant (r = 0.342, p = 0.1295, n = 21).

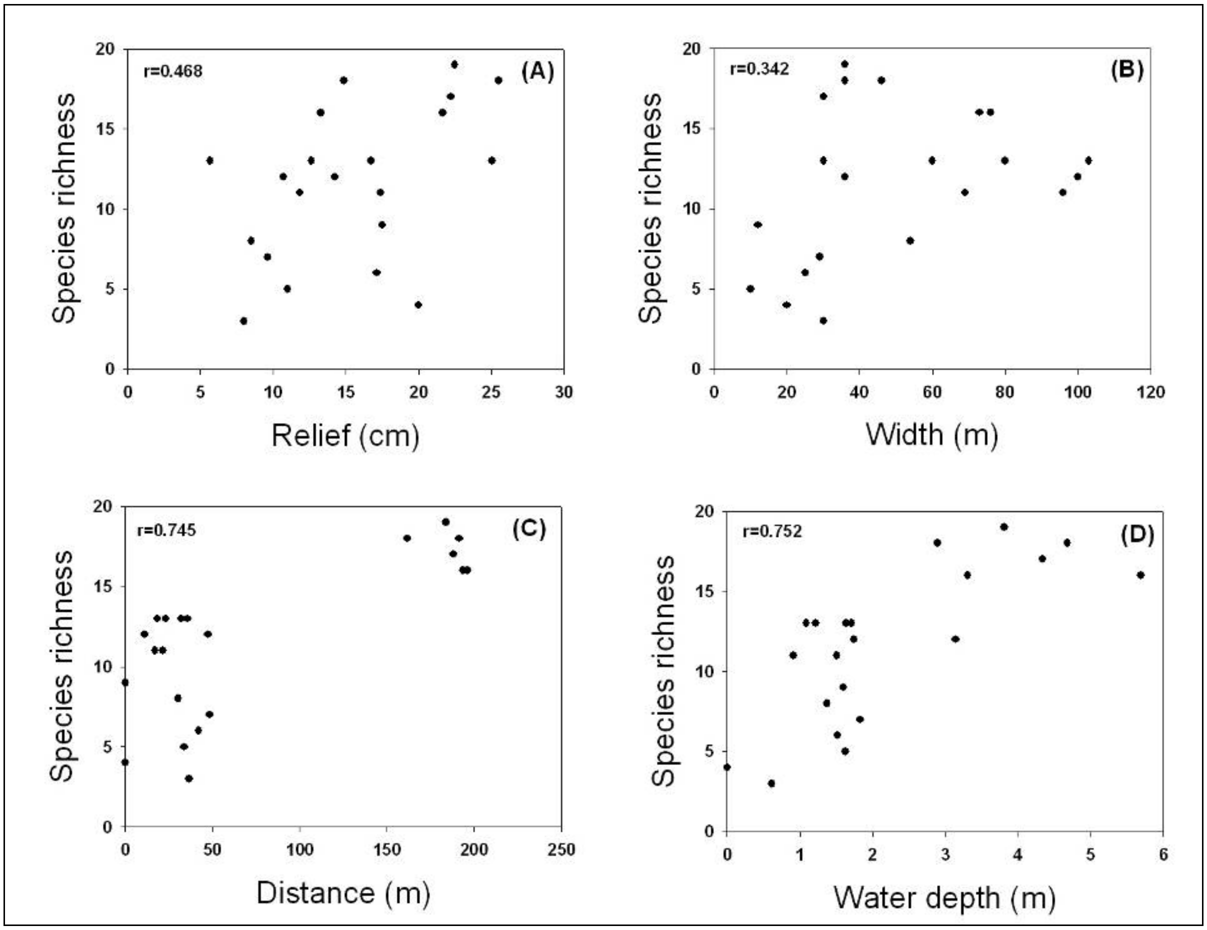

Figure 10. Scatter plots of physical characteristics of hard bottom [(A) relief, (B) width, (C) distance from inshore edge to mean high water level, and (D) water depth] versus species richness recorded during timed swims at survey transects in the St. Lucie County South Beach Project area. Pearson's product-moment correlation coefficient (r) is given in the upper left corner of each plot.

Scatter plots of relative abundance (number of individuals) versus relief, width of hard bottom, distance from inshore margin, and water depth are shown in **Figure 11**. Relative abundance was weakly correlated with relief (r = 0.029, p = 0.903, n = 21), hard bottom width (r = 0.197, p = 0.393, n = 21), and distance to hard bottom edge (r = 0.406, p = 0.0608, n = 21). A statistically significant positive correlation was found between water depth and relative abundance (r = 0.536, p = 0.0123, n = 21).

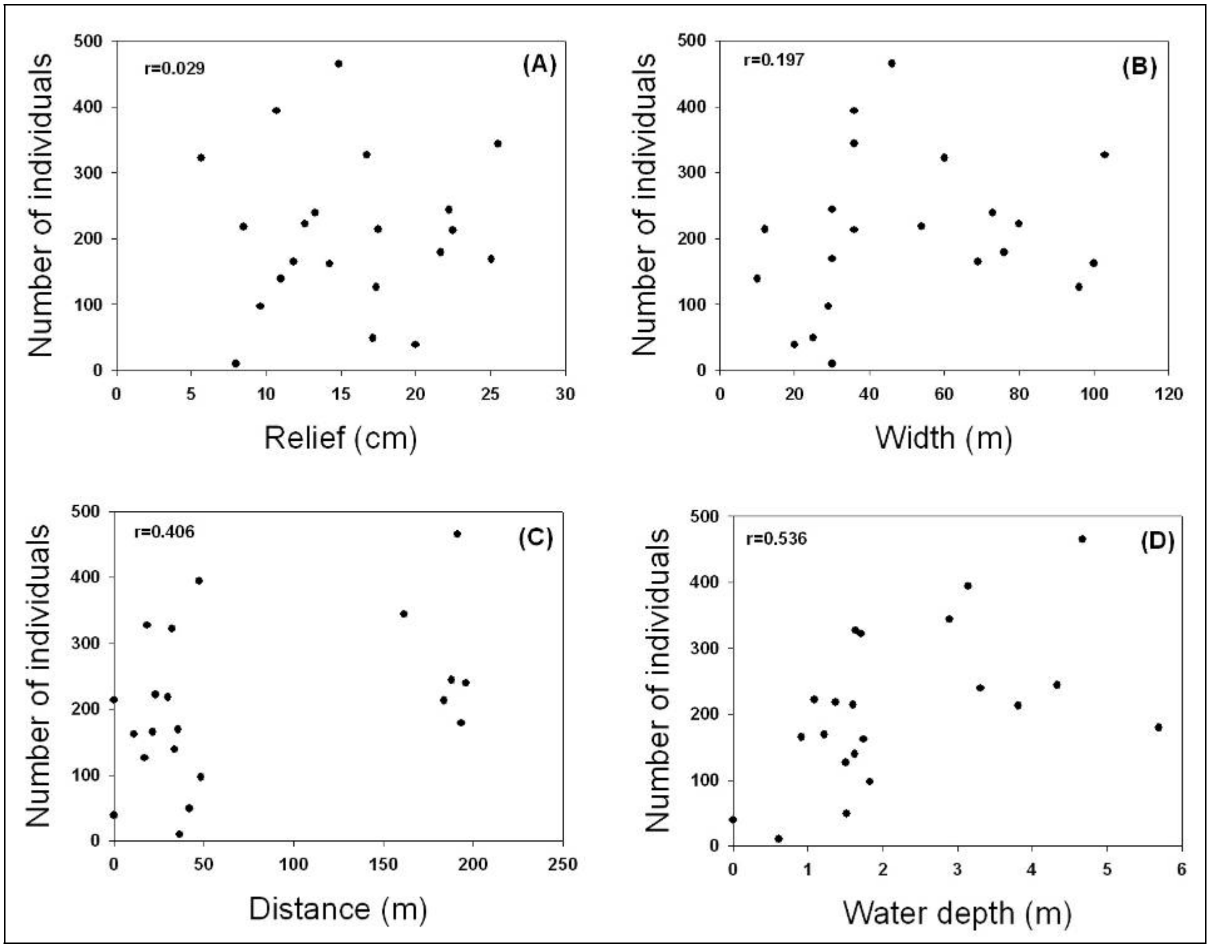

Figure 11. Scatter plots of physical characteristics of hard bottom [(A) relief, (B) width, (C) distance from inshore edge to mean high water level, and (D) water depth] versus relative abundance data recorded during timed swims at survey transects in the St. Lucie County South Beach Project area. Pearson's product-moment correlation coefficient (r) is given in the upper left corner of each plot.

When the physical characteristics of the hard bottom were superimposed on the MDS ordination plot originally presented in **Figure 4**, patterns emerged that suggested which characteristics best explained species composition among the samples (**Figure 12**). Relief and width of hard bottom had little effect on patterns of similarity revealed by MDS (**Figures 12(A)** and **12(B)**). Both distance from MHWL and water depth were greater for the samples to the left of both ordination plots in **Figures 12(C)** and **12(D)**. These patterns also reflect the clusters identified by SIMPROF cluster analysis (**Figure 4**). Cluster A tended to have higher values for both distance and water depth than the other two clusters (B and C).

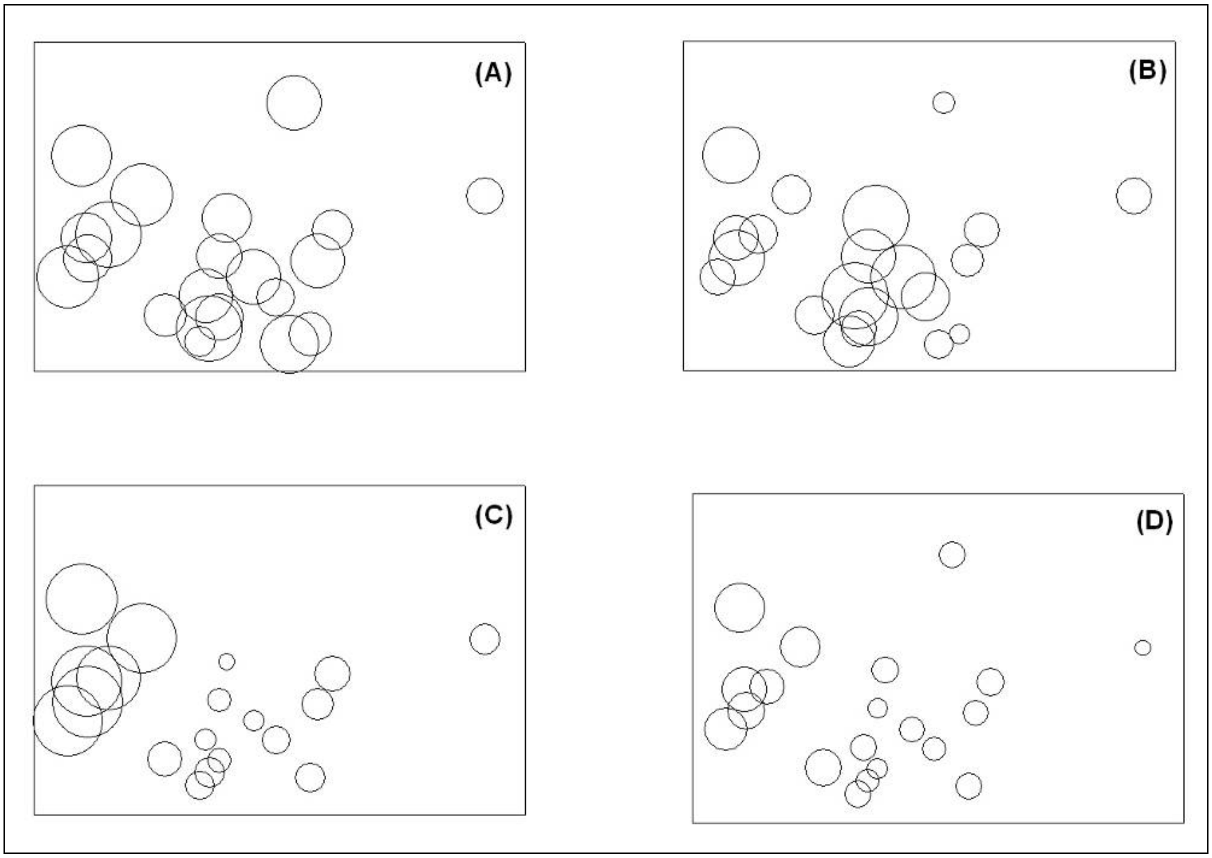

Figure 12. Physical characteristics of hard bottom [(A) relief, (B) width, (C) distance from inshore edge to mean high water level, and (D) water depth] superimposed as bubbles over multidimensional scaling ordination of timed swim samples. The area of each bubble reflects the value of the measurement.

3.3.2 Strip Transects

Species richness was not significantly correlated with relief (r = 0.244, p = 0.0811, n = 52) in strip transect data (**Figure 13**). The correlation between water depth and species richness was statistically significant (r = 0.630, p = 0.0000, n = 52). Density of fishes observed along strip transects was not correlated significantly with relief (r = 0.067, p = 0.6381, n = 52); however, water depth was positively and significantly correlated with density (r = 0.414, p = 0.0023, n = 52) (**Figure 13**).

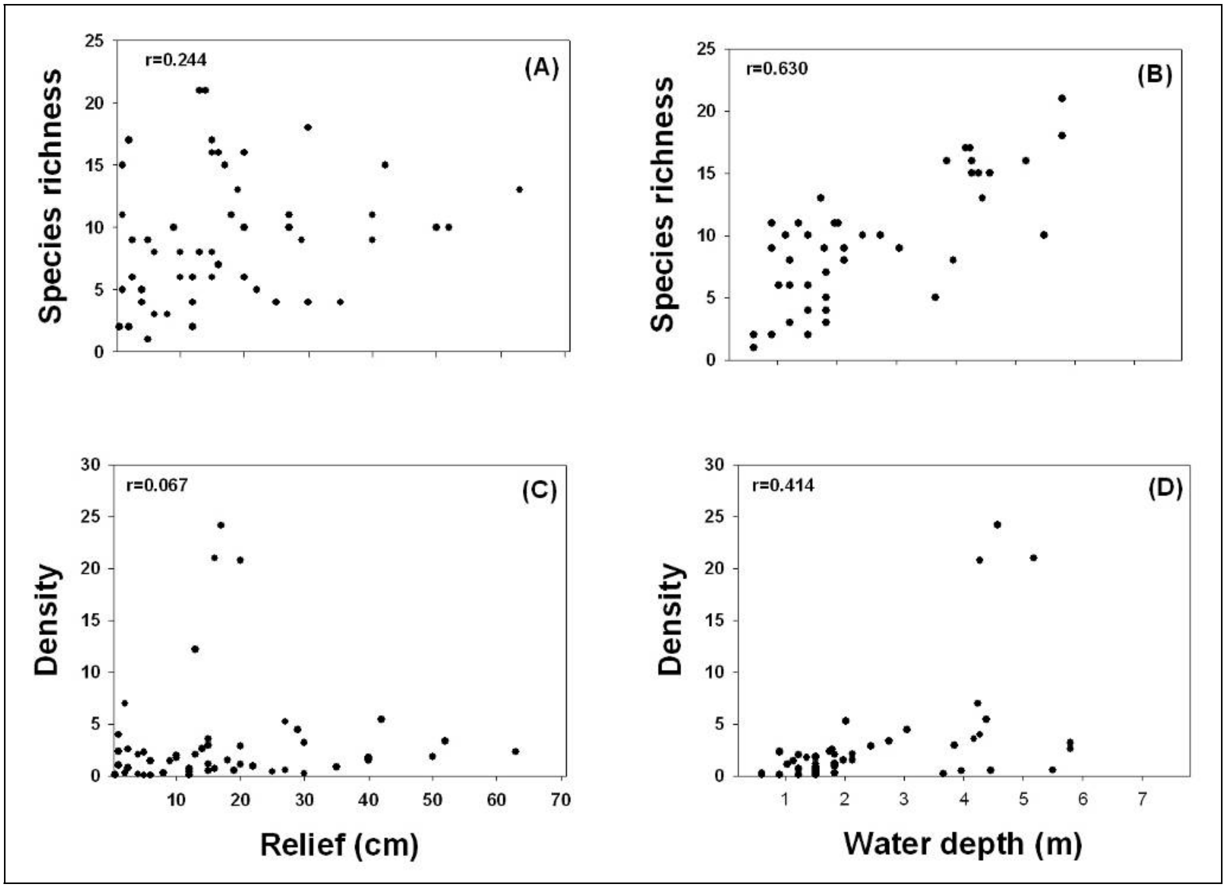

Figure 13. Scatter plots of hard bottom relief and water depth versus species richness [(A) and (B), respectively] and density [(C) and (D), respectively]. Data were collected from strip transects at two or three cross-shelf strata along each survey transect. Pearson's product-moment correlation coefficient (r) is given in the upper left corner of each plot.

Multivariate comparisons of these variables are shown in **Figure 14**. Ordination plots using the same MDS previously presented in **Figure 7** were used to show how relief and water depth influenced the observed patterns. Based on the superimposition of relief on the ordination as bubbles, relief was not an important influence on species composition among the strip transect samples. Water depth data formed a recognizable pattern in **Figure 14(B)**. This pattern was related to the SIMPROF clusters as well, with greater depths associated with Cluster E (see **Figure 6**, left side of plot).

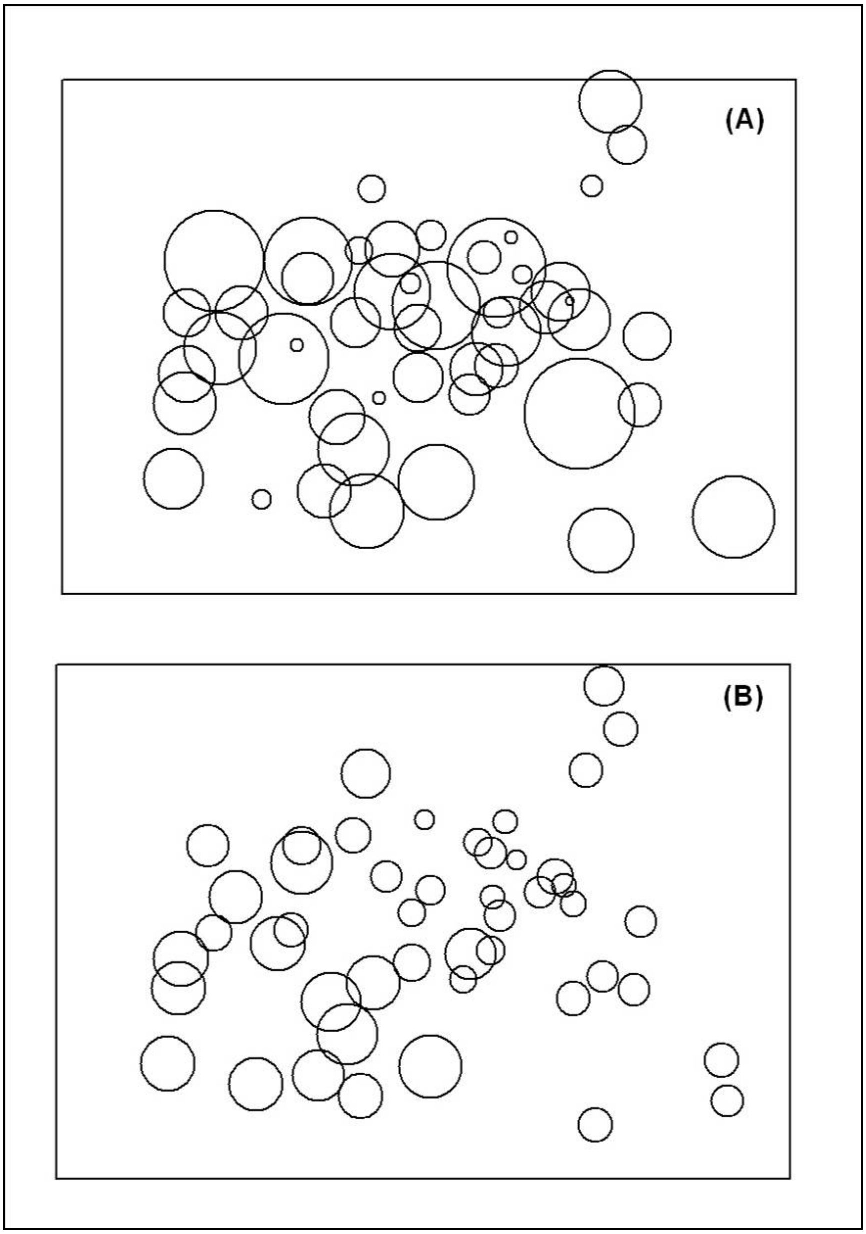

Figure 14. Physical characteristics of hard bottom showing (A) relief and (D) water depth superimposed as bubbles over multidimensional scaling ordination of strip transect samples. The area of each bubble reflects the value of the measurement.

4.0 DISCUSSION

Fishes assembled on the nearshore hard bottom with the project area were primarily reef-associated species expected for the geographical region (Gilmore et al., 1981; CSA International, Inc., 2009b). The overall composition and relative abundance reported for the project area resembled those reported for nearshore hard bottom habitats off Jupiter (Lindeman and Snyder, 1999; Continental Shelf Associates, Inc., 2006) approximately 25 miles to the south. The assemblage was composed of 71 species, but 10 or fewer, including black margate, silver porgy, newly settled grunts, sailors choice, hairy blenny, and porkfish were numerically dominant. The grunt family (Haemulidae), represented by nine taxa, dominated taxonomically as well as numerically in the project area.

A total of 24 federally managed species was recorded from the project area. Represented primarily by the grunt and jack families, many of these managed species were also present as newly settled or juvenile stage individuals. Clearly, the area serves as a nursery habitat for the young of most of the managed species recorded; this has been documented for other areas in Florida (Lindeman et al., 2000). Although most of these species were from the snapper-grouper complex, one coastal pelagic species (Spanish mackerel) and one coastal shark (nurse shark) were observed during the field surveys. Other economically important species (e.g., snook) were observed during the survey. Bonnethead shark (*Sphyrna tiburo*), tarpon (*Megalops atlanticus*), cobia (*Rachycentron canadum*), king mackerel (*Scomberomorus cavalla*), and Florida pompano (*Trachinotus carolinus*) were seen near or over hard bottom but were not formally recorded during timed swims or in strip transects. Although not a fishery species, the striped croaker (*Bairdiella sanctaeluciae*) is a species of special concern (Gilmore and Snelson, 1992) and was recorded at five of the survey transects.

From the species and size composition of fishes reported for the project area, some general observations regarding ecological functions of the nearshore hard bottom can be made. Obvious functions that may be inferred from the data collected include spawning, feeding, and sheltering. No spawning by any species was observed, however, the presence of adult blennies, damselfishes, and oyster toadfish (*Opsanus tau*), all species that lay eggs on the substratum, suggests spawning by these species occurs in the area. In addition, high numbers of newly settled grunts and mojarras indicate that spawning must occur nearby. For grunts, this would likely be on offshore reefs. Mojarras, however, are primarily inshore species, but spawning may occur in the coastal ocean, possibly near nearshore hard bottom. Many species and individuals inhabiting nearshore hard bottom feed on planktonic resources transported from surrounding waters. Juvenile and newly settled grunts (*Haemulon* spp. and *Anisotremus* spp.) are primary examples of this mode of feeding. As individuals grow, their diets will shift to larger benthic invertebrates inhabiting sandy areas around the periphery of the hard bottom. Primary herbivores present during the survey were larger silver porgy, but very few of the herbivorous fishes from the surgeonfish and parrotfish families, which are important in nearshore hard bottom areas farther to the south (Lindeman and Snyder, 1999; Baron et al., 2004; CSA International, Inc., 2009b), were observed. Invertebrate grazers were represented by silver porgy and sheepshead, and piscivores included barracuda, snook, blue runner, crevalle jack, and Spanish mackerel. With the presence of predators (both large and small), many of the smaller inhabitants sought refuge under ledges and other interstitial spaces provided by the habitat. A number of species, including blennies, cardinalfishes, damselfishes, cubbyu, striped croaker, black margate, sailors choice, and moray eels, were observed using ledges, crevices, or holes as shelter. Use of shelter is motivated by predator avoidance, wave surge, and sensitivity to light.

Cross-shelf strata samples did not show significant differences or any particular trends with respect to species composition. Given the very small distances from inshore to offshore, it is not surprising that the distribution of fishes across the habitat did not change. Nevertheless, data partitioned in cross-shelf fashion will provide good baseline information from which to compare with subsequent surveys, especially the inshore stratum where hard bottom is most likely to be lost in the event of natural or project-related sand movement. Water depth did appear to influence the distribution and abundance of some species and lead to the formation of depth-related clusters. The deeper sites that grouped together in the cluster analysis were also greater distances from shore and presumably offshore of the high wave energy zone, which may attract more diverse assemblages.

The strip transect method produced quantitative data that surpassed timed swims in total species recorded and revealed similar patterns in the data. This finding is counter to what is usually found, i.e., timed swims were added to ensure that richness was adequately characterized. Timed swims allow the diver to search for cryptic species or newly settled individuals that would be missed by systematically placed strip transects. The difference is likely due to the fact that at each survey transect, a minimum of four strip transects was censused, and these transects encompassed most of the hard bottom present along the survey transects. Duration of timed swims was set *a priori* to be 5 minutes, which may not have been enough time to thoroughly search each survey transect. It is suggested that for future sampling of fishes in this project area, duration of timed swims should be increased to 10 minutes, or the timed swims should be eliminated and only strip transects surveyed.

Exploratory analysis of species composition within the project area revealed different assemblages occurred at survey transects where hard bottom was farther from shore and consequently in slightly deeper water. Differences were not qualitative but mostly reflected differences in the relative abundances of individual species. Deeper areas may promote the assembly of more species and individuals seeking refuge from wave energy. Other characteristics of the hard bottom such as relief and width (of the feature) were not influential in separating species groups. Small scale habitat use was not part of this investigation, but it was observed that molly miller were associated with worm rock along several of the transects.

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SUB-APPENDIX J3

HARDBOTTOM MAPPING AND CLASSIFICATION METHODOLOGY DESCRIPTION

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26 January 2011

Ms. Kimberly Colstad
Coastal Technology Corporation
3625 20th Street
Vero Beach, Florida 32960

Dear Ms. Colstad:

Attached is a description of the remote sensing classification methodology used by CSA International, Inc. (CSA) during the St. Lucie County South Beach, Environmental Services, Task 7: Hardbottom Mapping & Classification. This methodology should accompany the 2010 Hardbottom Classification shapefile provided via email on 18 January 2011.

The objective of the task was to map and classify hardbottom through analysis of 2010 aerials. The map domain extends from FDEP Monument R-77 in St. Lucie County to R-3 in Martin County, and seaward a minimum of 1,000 ft from the existing shoreline. Digital and analog remote sensing techniques were used to map benthic features discernable in the imagery. A total area of 145,970 sq m (36.07 acres or 0.056 sq miles) of was mapped, as shown on the attached figure.

CSA conducted 32 bounce dives on 17 December 2010 within the project area. The photographs and shapefiles associated with the ground-truthing are provided separately within the e-mail containing this document.

If you have any further questions or concerns, please do not hesitate to contact me by phone at 772-219-3049 (direct office) or by e-mail at kvangraafeiland@conshelf.com.

Sincerely,

Keith VanGraafeiland
GIS and Remote Sensing Analyst

Attachments

St. Lucie County South Beach, Environmental Services
Task 7: Hardbottom Mapping & Classification Methodology

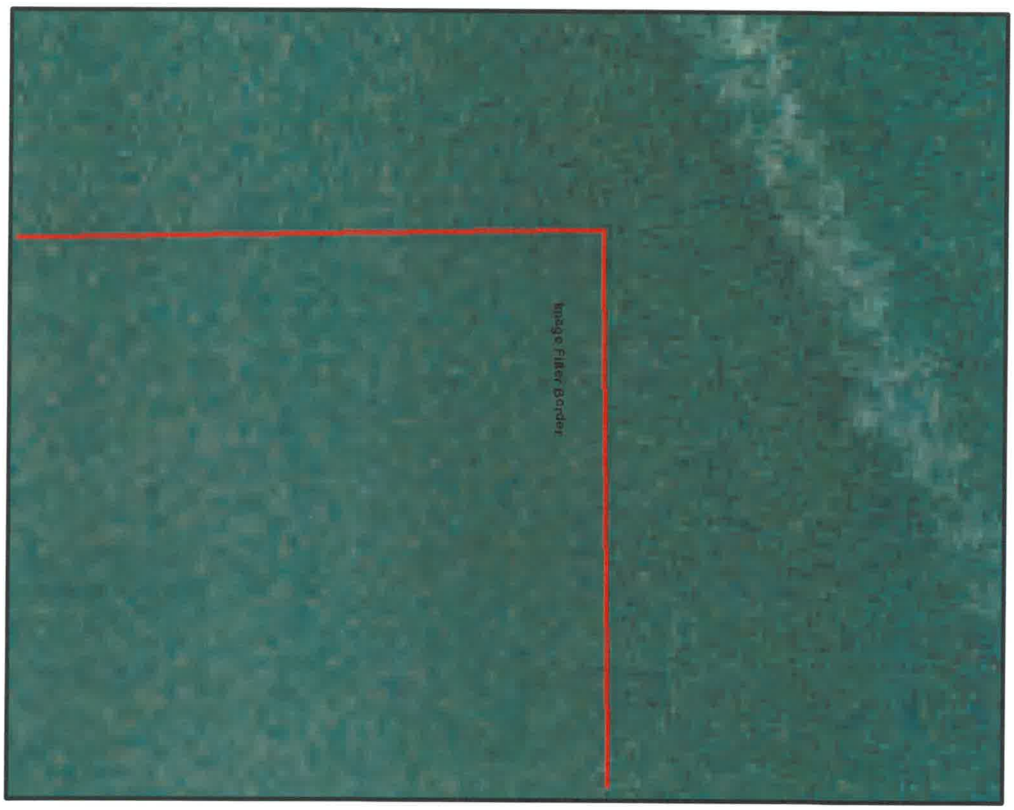
The objective of the task was to map and classify hardbottom through analysis of 2010 aerials to produce binary classified raster data delineating "hardbottom." The map domain extends from FDEP Monument R-77 in St. Lucie County to R-3 in Martin County, and seaward a minimum of 1,000 ft from the existing shoreline. Digital and analog remote sensing techniques were used to map benthic features discernable in the imagery.

Manual and automated techniques for the delineation of benthic hardbottom surfaces were compared for the creation of non-contiguous raster data, as follows:

- High resolution (0.5 ft) aerial photographs were carefully examined for presence of visually identifiable hardbottom features within 1,000 ft of the shoreline.
- To allow ISO data classes to be focused solely on marine data, all terrestrial reflectance data were masked out of the imagery.
- Remaining marine image data were subdivided into "nearshore" and "offshore" areas. to allow for the further separation of spectral characteristics between depth levels. (If all marine pixels [offshore and nearshore] are processed in a single classification, darker non-hardbottom pixels in the offshore areas often will report back with spectral signatures similar to those of nearshore hardbottom pixels.)
- A 64-class unsupervised classification was run on each of 24 separate image areas of interest (AOIs). Separate classification helps to eliminate variations in reflectance and environmental conditions across the entire project area.
- Classification Parameters: 64 Classes; 6 iterations; Convergence threshold = 0.95.
  Diagonal axis: Signature means were computed along a diagonal vector and are evenly distributed within the scaling range for each band.
  3 standard deviation initialization: A higher number of standard deviations initializes more class means in the tails of the distribution. This "reserves" more classes for the darker hardbottom areas that tend to lie near the end of the range of benthic reflectance values.
- Each classification was manually/visually inspected and recoded to identify "hardbottom."
- Recoded binary rasters were then sieved to eliminate any grouping of less than nine contiguous pixels; this eliminates much of the backscatter produced by variations in albedo (the fraction of sunlight reflected back to the sensor) due to minor wave action and other atmospheric effects. Areas of less than 2.25 sq ft (0.5 ft*0.5 ft*9 pixels) were removed from the classification.
- The sieved raters were then converted to vector polygons. All features identified as "hardbottom" during the classification process were output to polygon vector shapefiles.
- The shapefiles were overlaid on the imagery and reviewed. Manual interpretation techniques were then utilized to further delineate the shapefiles using visual observation techniques.

Challenges encountered during the analysis and mapping process included factors affecting visibility and classification accuracy, such as

- high turbidity, wave action, angle, and albedo;
- high cloud shadowing;
- image haze (widespread across image scene);
- lack of infrared spectral bands (useful for marine analyses); and
- blurring caused by post-processing by the aerial imagery provider, resulting in variation within the classification across the image filter border (see example below).



Primary potential sources of error include the following:

- Variable atmospheric conditions affecting visibility and classification accuracy, as previously discussed;
- Photointerpretation errors (digitization) related to poor georeferencing and/or discontinuities of the initial imagery;
- Biases of the interpreters (misidentification or merging of classes);
- Error associated with mapping natural, gradual changes as discrete changes;
- Errors of scale (i.e., when viewed at scales of greater than 1:2500, boundaries may not follow the exact topography of the image terrain); and
- Error associated with re-projection of benthic polygons, or warping of maps when they are imported into other digital map documents.

The primary error sources listed above are the most readily identifiable and perhaps most significant; however, they are only part of a range of all possible error sources.

Conclusions and recommendations include the following:

- A map production scale of 1:2500 or greater is recommended for display of these features;
- Shifting sands in the study area may result in wide variation in hardbottom visibility. Many hardbottom patches are interbedded with sand and non-contiguous. Any hardbottom classification will be largely dependent on marine conditions in the timeframe immediately prior to the acquisition date of the imagery; and
- Acquisition of imagery containing near-infrared spectral bands would improve marine classification efforts.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SUB-APPENDIX J4

SUMMARY OF 2008 AND 2010 HARDBOTTOM MAPPING METHODOLOGY

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MEMORANDUM

To: Kim Colstad and Lois Edwards, Coastal Technology Corporation
From: Keith Spring, Erin Hodel, and Keith VanGraafeiland, CSA International, Inc.
RE: Aerial Imagery Interpretation in Support of the St. Lucie South Beach Project

---

CSA International, Inc. (CSA) utilized the 2008 and 2010 aerial imagery collected during flights flown by Aerial Cartographics of America (ACA) for the St. Lucie County beach re-nourishment project to aid in the interpretation of visually discernible hard bottom features. For both 2008 and 2010 analyses, manual and computer-assisted interpretation techniques were utilized to perform the hard bottom delineation. A separate dataset was created for both 2008 and 2010 hard bottom delineations.

Methodology

Due to the complexity of the nearshore environment, both manual (analog) and computer (digital) classification techniques were utilized, and the processing outputs from both of these techniques were merged, manually manipulated, and reviewed to produce the final dataset for the interpreted hard bottom for each year.

- Manual (analog) processing is subjective and qualitative. This process is intuitive and required the interpreter to apply judgments of field-based observations and knowledge of the environment. Manual techniques were utilized in areas that were visually confusing and could not be easily distinguished due to turbidity, inter-mixing, etc. A manual interpretation scale of 1:500 was determined based on the ability to manually interrogate hard bottom features from the aerial imagery. This scale was utilized to manually digitize and extract hard bottom features from the imagery to align the digitized level of detail (and associated areal calculations) with the detail and effective viewing capabilities of the source aerial data.

- Computer (digital) processing of imagery allows for the quantitative analysis of all spectral bands in imagery simultaneously and for the detection of subtle differences that manual interpretation does not. This process is considered objective and quantitative and provides more consistent results at a finer scale than manual processing.

The combined manual and computer approach is designed to help eliminate the disadvantages associated with each of the interpretation techniques and produce a product that realistically depicts the features of interest, both spatially and visually. This combined approach addresses common manual errors such as undershoots, overshoots, omissions, spikes, and double counting that often overestimate or underestimate areal estimations. The figure below presents combined manual and computer processing (left) and manual only processing (right) results for a visual comparison.

A). Example of combined manual and computer interpretation techniques to generate polygons encompassing hard bottom features (2008 aerial) – 0.078816 acres of hard-bottom.

B). Example of manual-only technique (FDEP) to generate polygons encompassing hard bottom (2008 aerial) – 0.287999 acres of hard bottom.

Aerial photographs represent a single moment in time "capture" of the nearshore environment. Hard bottom interpretations were conducted using the aerial dataset as the primary source of information and other field-collected datasets as secondary datasets. Secondary datasets collected with shorter temporal proximity to aerial collection date were given higher reliability over those datasets collected with longer temporal proximity.

The CSA datasets used to aid in the interpretation include the following:

- 2008 established permanent monitoring transects (3);
- 2009 nearshore hard bottom edge mapping;
- 2009 established permanent monitoring transects (19) and pipeline corridors (6); and
- 2010 bounce dives.

Transect delineation information was overlaid to help interpret locations of hard bottom identified during the field surveys. If transect delineations aligned with the presence of hard bottom in the aerial imagery, the transect delineation information was utilized to help determine the extent of hard bottom if not easily discerned from the image. Nearshore hard bottom edge mapping from 2009 was utilized to help interpret the 2010 imagery using visual inspection. Areas that identified nearshore hard bottom from the 2009 mapping exercise that were not apparent in the 2010 imagery were reassessed to confirm the absence or presence of hard bottom. In areas where the 2009 hard bottom edge did not match the 2010 imagery, there was a significant temporal lag between when the hard bottom edge was mapped (June/July 2009) and when the imagery was collected (October 2011); in this case, the hard bottom was considered to have been covered by sand.

Description of Environment

Nearshore hard bottom features along the St. Lucie South Beach Project Area parallel the shoreline, extending through the intertidal and subtidal zones, and range from relatively wide expanses of pavement-like platforms with ledges to isolated patches of rocks. The ledges typically have exposed vertical faces and overhangs along the shoreward edges. Nearshore hard bottom in this area is ephemeral in nature due to high wave energy and a dynamic sedimentary environment. The majority of hard bottom observed in the project area was partially exposed, having sand veneers of varying depths (CSA, 2010).

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Nearshore hard bottom in portions of the project area are colonized by the sabellariid tube worm, *Phragmatopoma lapidosa* (also known as *P. caudata*), which settle and build reef-like structures from their sand tubes in intertidal and subtidal hard bottom areas (Nelson and Demetriades, 1992; Kirtley, 1994; Drake et al., 2007). These structures are commonly referred to as "worm rock," and are somewhat ephemeral, being negatively impacted by both storm waves and burial by sediments (CSA, 2009). The structure provided by nearshore hard bottom and associated worm rock supports locally moderate to high diversities and abundances of algae, fishes, and invertebrate groups, including sponges, hydroids, mollusks, crustaceans, bryozoans, ascidians, and cnidarians (Kirtley, 1966; Gore et al., 1978; Nelson, 1989; Lindeman and Snyder, 1999; CPE, 2006; CSA, 2010).

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