SOUTH ROOSEVELT BOULEVARD SEAWALL RESTORATION PROJECT FIRST ANNUAL SEAGRASS MITIGATION MONITORING REPORT

SFWMD PERMIT NO. 44-00318-P

October 2004

Submitted to the

South Florida Water Management District

on behalf of

The City of Key West
Engineering Services
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1.0 INTRODUCTION

The purpose of this first annual monitoring report is to document the current conditions associated with the compensatory mitigation of impacts related to the South Roosevelt Boulevard Seawall constructed along Cow Key Channel, Key West, Monroe County, Florida.

As required by the South Florida Water Management District (SFWMD) permit (Permit Number 44-00318-P), 10,250 square feet (8,200 linear feet) of propeller scars within the seagrass habitat near Cow Key Channel were to be restored by Misener Marine using biodegradable sediment-filled tubes provided and installed by Seagrass Recovery, Inc. A total of 4,159 biodegradable, sediment-filled tubes were installed to cover an area totaling 10,272.3 square feet. These tubes were intended to provide a surface area flush to surrounding regions for seagrass re-colonization. The tubes were filled with native calcium carbonate sand from the Florida Keys and were installed into 124 propeller scars (see Map 1 Post, Buckley, Schuh & Jernigan (PBS&J), 2004; **Table 1**). The principle behind the usage of the tubes was to provide a "level" area to allow the surrounding seagrasses to re-colonize the non-vegetated sediments in the scars. One to five tubes were positioned across each scar.

2.0 PREVIOUS MONITORING SUMMARY

Post-installation (time-zero) monitoring took place on September 17-18, 2003 and included site locations for the origin and terminus of each repaired propeller scar using a Trimble High Precision Portable GPS unit (PBS&J, 2004). In addition, both photographic and video images were made of the mitigation site. A modified Braun-Blanquet (1932) scale was used in ten $1m^2$ areas to establish a baseline for seagrass coverage.

Seagrasses found in the vicinity of the mitigated scars were turtle grass (*Thalassia testudinium)* or shoal grass (*Halodule wrightii)*. In certain regions, Manatee grass (*Syringodium filiforme)* was also found (PBS&J, 2004). Personal communication with local National Oceanic and Atmospheric Administration (NOAA) experts revealed that this particular site preferentially selects for *Halodule*, possibly due to high-nutrient loads in the water column and sediment bed (S. Meehan and K. Kirsch, *pers. comm.*). Green algae (*Penicillus* spp., *Halimeda* spp. and *Caulerpa setularioides)*, the red alga (*Chordria tenuissima),* and the brown alga (*Dictyota* sp.) were also present at the study site (PBS&J, 2004).

Six-month monitoring took place on April 8-9, 2004 and included the collection of video/photographic images of a representative sample of restored scars (PBS&J, 2004). Video footage of eight scars was obtained. Qualitative observations were recorded for 40% of the individual scars to draw conclusions regarding the general condition of the restored propeller scars. A modified Braun-Blanquet scale (1932) was utilized within 50 of the scars to establish the percentage of seagrass coverage.

Halodule wrightii colonized the majority of the site, and it was surmised that this type of grass would stabilize the bed for later colonization by *Thalassia testudinium* and *Syringodium filiforme*. It was also found that scars surrounded by *Halodule* appeared to recover more quickly than those scars surrounded by other species, however, no significant statistical differences in recruitment/colonization density were determined by ANOVA between samples of *Halodule* and *Thalassia* (PBS&J, 2004).

3.0 SUCCESS CRITERIA

As defined in the SFWMD permit, the success criteria associated with the propeller scar restoration project will be determined utilizing the Braun-Blanquet scale. This scale provides a comparative analysis of seagrass density (i.e., coverage) between the adjacent seagrass beds and the restoration sites. Annual seagrass coverage targets are as follows:

Year One – 15% coverage
Year Two – 25% coverage
Year Three – 55% coverage
Year Four – 75% coverage
Year Five – 95% coverage

Targeted percent coverage for the first four years is lower than what is typically accepted by the Southwest Florida Water Management District (SWFWMD) due to the fact that *Thalassia* is the targeted and anticipated colonizing species, which has a slower growth (and colonizing) rate than other seagrass species.

Monitoring of the mitigation area will be conducted and reports will be submitted to the SFWMD on an annual basis for a period of five (5) years.

4.0 METHODS

The repaired propeller scars in Cow Key Channel were divided into 12 regions, A through L, during time-zero and six-month monitoring studies performed by PBS&J. For this first annual report, that configuration was also adopted (see Map 1, PBS&J, 2004).

One-year monitoring took place on October 12, 13, 14 and 17, 2004. A TopCon Real-Time Kinematic Global Positioning Satellite (RTK-GPS) unit was used to re-locate the origin of 50 scars that were to be assessed. ForeSight DXM and SurveyPro software were used to import the coordinates of the origin and terminus of each repaired scar (**Table 2**). National Geodetic Stations Permanent Identifier (PID) Stations AA0028 (BAYOU), AA1648 (FLGPS MALLOY AZ MK), and AA1644 (FLGPS MALLOY) were used for horizontal/vertical control for relocation of the restored scars. These stations are high-resolution monuments, surveyed by the National Geodetic Survey for high-precision GPS surveys (sub-centimeter accuracy). Stations AA0028 and AA1664 were of Horizontal Order B, +/- 8mm and Station AA1648 was of First Horizontal Order as published by the National Geodetic Survey http://www.ngs.noaa.gov/. Localization of the base-station survey unit with these monuments provided sub-centimeter accuracy for horizontal localization.

The RTK-GPS base station was setup on October 12-13, 2004, for a stakeout survey to allow for the marking of the origin of selected scars to be monitored. The location of the base station was directly west of Cow Key Channel, to the north of Cow Key Bridge. The base station was localized using the three control monuments described previously; one monument was rechecked for horizontal control verification before the stakeout survey commenced. The RTK Rover was mounted onto a personal watercraft (PWC) jet ski for the stakeout survey and the origins of selected scars were programmed as waypoints into the RTK Rover. Travel time and distance from waypoints were monitored from the PWC as the jet ski closed in on the waypoint indicating the horizontal coordinate of the origin of each scar to be monitored. When the PWC was within 10 feet of the waypoint, the RTK Rover was removed from the PWC and a swimmer holding and monitoring the RTK Rover marked the waypoint. When it was within 0.5 feet north and east of the waypoint, the swimmer staked the site with a 24-inch, 0.5-inch O.D. PVC stake. This procedure was repeated for all 50 waypoints on October 12 and 13, 2004 (**Figures 1** and **2**).

On October 14 and 17, 2004, staked scars were surveyed for percent total coverage by submerged vegetation and relative percentages of dominant flora. Up to five scars in regions A through L were randomly selected by a random number generator (MS-EXCEL) using the caveat that each selected scar was at a minimum of 25 feet in length. Results are presented in **Table 2**. Divers for swimming surveys were initially located at the stake denoting the origin of the restored scar. Surveyors swam along the restored scar using computed distances and angles from origin and terminus Florida State Plane coordinates from the PBS&J study.

Distance was denoted by the equation:

$$\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \qquad (1)$$

where x_2 and x_1 are the Easting coordinates for the terminus and origin of surveyed scars, respectively, and y_2 and y_1 are the Northing coordinates for the terminus and origin of the surveyed scar, respectively.

Bearing was denoted by:

$$\text{atan}\left[{(x_2 - x_1)}\big/{(y_2 - y_1)} \right] \qquad (2)$$

or, the arctangent of the distance East over the distance North.

Surveyors reported average percent coverage for the entire length of each scar, which was converted to a modified Braun-Blanquet scale as follows:

0.1 = solitary shoots with small cover
0.5 = few shoots with small cover
1.0 = numerous shoots but less than 5% cover
2.0 = any number of shoots but with 2-25% cover
3.0 = any number of shoots but with 25-30% cover
4.0 = any number of shoots but with 50-75% cover
5.0 = any number of shoots but with >75% cover

The presence of remnant fabric from the sediment-filled tubes, sediment type, relative depth, and relative current strength were noted. Photographs were taken of representative scars in each region.

5.0 RESULTS AND DISCUSSION

Fifty scars were surveyed in Cow Key Channel during October 14-17, 2004. Results from the survey are listed in **Table 3**. Overall seagrass coverage of the scars that were sampled appeared to be exceeding the SFWMD success criteria of 15% coverage for Year One. Both species combined provide 75% seagrass coverage to the scar that was the focus of this monitoring event.

The average Braun-Blanquet ranking for scars supporting both *Halodule* and *Thalassia* growth was 4.32 (st.dev. = 0.82; n=19), for *Halodule* only, the average was 3.5 (st.dev. = 1.22; n=14), and for *Thalassia* only, the average was 2.57 (st.dev = 0.94; n=14). A one-way ANOVA was performed to determine if there were differences in the recruitment levels of seagrasses and the species that had recruited to the restored scars (**Table 4**). The null hypothesis was rejected and found that there are significant differences between recruitment levels and species present.

Based on the average Braun-Blanquet ranking, the highest percent coverage levels for scars were supported by both *Thalassia* and *Halodule* combined with a value of 75%. The percent coverage for *Halodule* only was observed at 40%, and *Thalassia* only was 25% coverage (**Table 4** and **Figures 4** and **5**). Calculating the average of all scars observed combined, the average percent coverage is 38%.

SUMMARY

Groups	Count	Average Braun-Blanquet	Percent Cover
Thalassia and *Halodule*	19	4.32	75
Halodule	14	3.50	40
Thalassia	14	2.57	25
Average		3.40	38

Only four of the 50 scars examined had remnant fabric associated with them; all other scars examined had tubes that had been completely buried or were degraded. Similar to the April 2004 PBS&J study (PBS&J, 2004), the abundance of relatively recent and/or unrestored propeller scars caused great difficulty in the identification of restored scars. Without survey level precision RTK-GPS, it would not have been possible to locate the origin of restored scars. Further, it does appear that new groundings have occurred since April 2004. In any case, the scars that have been monitored for this study were staked with 2-inch height, 0.5-inch O.D. PVC stakes for future reference.

Many of the recovering sites exhibited a mixture of *Thalassia* and various species of *Caulerpa*, such as the region adjacent to scar #2 (**Photograph 1**). Remnant fabric was found at the edges of the scars amongst red algae, such as in scar #10 (**Photographs 2** and **3**). Indications of high nutrients and quiescent waters in Cow Key Channel were depicted along scar #15 where epiphytic grown was found on *Thalassia* (**Photograph 4**). *Halodule* growth was seen across scar #34, indicating quick recovery (**Photograph 5**). Indications of a region of high hydraulic energy were noticed along scar #42 where a sand bed littered with shell fragments indicated strong tidal energy (**Photograph 6**). A mixture of growth of *Thallasia* and *Penicillus* and red algae was seen in scar #56 (**Photograph 7**). Epiphytic growth was seen on *Thalassia* in recovering scar #57. Example of remnant fabrics was found along scars (**Photograph 8**).

Also examined was the correlation between percent coverage and hydraulic energy. Here, sites were given a ranking of 3 if they were deep (little hydraulic friction), had sand and shell beds (fine sediments were winnowed by currents), and exhibited 4+ knot tidal currents (**Table 5**). Sites were given a ranking of 1 if they were shallow (high hydraulic friction), had silty beds, and were quiescent with low tidal flows. Sites exhibiting intermediate characteristics were given a ranking of 2. The correlation coefficient between the Braun-Blanquet scale and the hydraulic energy scale was $r^2 = -0.59$, which indicates that there is a negative correlation between hydraulic energy and recruitment levels, and that parameters relating to hydraulic energy (currents, waves, bottom sediments) may explain up to 59% of the variance of recruitment level data. Here, regions that are shallow and quiescent appear to be more compliant to recovery of seagrasses.

With the difficulty of swimming the transects, it is apparent that seagrass recruitment is inhibited due to the high tidal energy in the channel. It is not uncommon for tidal currents to exceed 4 knots, and on days of sampling, the currents exceeded 7 knots. It was clear that for those regions of the bed that exhibited evidence of scour, no seagrass would recruit to that region. Regions that did have relatively fast-growing *Halodule* were stabilized and relatively resistant to erosion. However, the sediment tubes will aid in holding the bottom sediments in place in regions showing signs of strong tidal energy. The timing of the degradation of the sediment tube fabric may have occurred quickly in these regions, and it is not clear as to whether there was sediment scour around the edges of the tubes. Recruitment may also be related to the distance from the navigation channel as these regions, close to the channel, show low levels of recruitment (**Figure 5**).

In the tidal flats surrounding Cow Key Channel, the useful action of the sediment tubes is not only providing a level surface on which seagrass rhizomes can spread and colonize but also is providing a method of anchoring sediments in a region of high tidal energy, has been exhausted by means of their degradation. For the scars surveyed in this study, the tubes no longer exist and no longer play a useful role as described above. The tubes that had been successfully colonized by either *Halodule* or *Thalassia* while they were intact remain colonized; comparisons between the six-month monitoring report and this Year One report demonstrates steady improvement for restored scars.

6.0 SUMMARY

Overall seagrass coverage of the scars that were sampled appeared to be exceeding the SFWMD success criteria of 15% coverage for Year One. Both species combined provide 75% seagrass coverage to the scar that was the focus of this monitoring event. It is expected that *Halodule* would recruit into restored scars before *Thalassia*, and *Thalassia* will recruit as the ecosystem matures and there are later successions of submerged vegetation. We do recognize that new groundings still occur in the area and that it will be difficult to determine if the tidal flats adjacent to Cow Key Channel will improve on a regional scale.

7.0 REFERENCES

Braun-Blanquet, J. 1932. Plant sociology: the study of plant communities. Reprint 1983 Koeltz Scientific Books. P.O. Box 1360, D-6240 Koeningstein/West Germany.

PBS&J. 2004. South Roosevelt Boulevard seawall restoration project six-month seagrass mitigation monitoring report. Submitted to South Florida Water Management District in Compliance with Permit No. 44-00318-P.

APPENDIX A

TABLES

TABLE 1. GPS COORDINATES FOR SOUTH ROOSEVELT BLVD. RESTORATION

NAD 1983 State Plane Florida East FIPS 0901 Feet				
Scar	***Start X-COORD***	***Start Y-COORD***	***End X-COORD***	***End Y-COORD***
1	408721.78	81816.70	408771.31	81740.45
2	408684.84	81892.45	408702.78	81859.64
3	408662.16	81964.22	408683.06	81928.79
4	408678.59	82005.26	408792.38	81918.64
4	408668.66	82014.51	408673.81	82007.94
5	408817.00	81886.08	408705.47	81843.48
6	408523.03	81954.33	408547.00	81869.62
7	408532.06	81971.00	408530.56	81949.01
8	408536.63	81979.13	408516.09	81961.35
9	408503.84	81969.46	408515.41	81966.47
10	408405.69	82282.77	408498.69	82193.63
11	408438.81	82463.74	408454.03	82439.52
12	408270.53	82586.97	408339.78	82528.38
13	408425.75	82567.43	408438.88	82534.85
14	408449.97	82542.10	408473.09	82502.65
15	408475.88	82514.56	408472.81	82491.11
16	408418.91	82760.95	408389.13	82760.40
17	408405.38	82773.72	408411.56	82759.54
18	408405.97	82765.51	408441.53	82752.59
19	408438.16	82749.23	408432.31	82743.30
20	408429.94	82795.97	408425.47	82763.80
21	408367.97	82890.54	408388.69	82834.14
22	408374.56	82984.86	408400.06	82902.81
23	408383.09	82978.09	408399.81	82922.55
24	408416.78	82968.22	408420.56	82936.36
25	408393.66	83029.45	408366.78	82998.59
26	408400.66	83055.25	408405.47	83029.53
27	408396.34	83073.09	408397.63	83051.41
28	408357.28	83113.88	408359.81	83102.10
29	408370.66	83156.46	408377.72	83126.11
30	408320.84	83235.52	408327.66	83173.38
31	408320.81	83304.54	408320.22	83275.13
32	408285.63	83506.50	408283.22	83380.10
33	408253.72	83504.45	408279.84	83380.51
34	408268.41	83559.08	408275.78	83517.96
35	407760.34	84413.73	407776.06	84378.37
36	407727.47	84522.95	407751.28	84444.48
37	407637.56	84574.22	407676.75	84496.65
38	407689.63	84533.62	407636.06	84522.48
39	407669.41	84610.50	407705.09	84544.33
40	407603.34	84686.48	407672.91	84566.73
41	407607.91	84673.92	407613.59	84659.55
42	407610.75	84676.17	407657.06	84608.16
43	407633.63	84605.44	407664.84	84554.81
44	407597.97	84681.09	407594.59	84662.16
45	407595.50	84699.17	407608.50	84659.35

Table 1. (Continued)				
46	407554.59	84741.66	407560.00	84733.81
46	407560.75	84721.28	407549.78	84694.47
47	407533.31	84771.35	407546.38	84740.02
48	407544.03	84764.77	407572.16	84723.79
49	407554.75	84785.38	407583.34	84745.17
50	407472.00	84902.84	407480.47	84890.86
51	407466.69	84901.88	407494.44	84872.02
51	407482.44	84885.37	407492.13	84870.55
51	407480.44	84886.48	407482.59	84881.70
52	407502.28	84850.80	407514.41	84840.17
53	407434.25	84900.20	407445.75	84883.66
53	407447.66	84880.79	407492.31	84829.95
54	407485.91	84821.65	407490.91	84819.14
54	407476.13	84844.48	407478.75	84838.88
54	407476.34	84837.12	407486.75	84828.95
55	407474.31	84828.00	407493.06	84806.29
56	407447.13	84914.93	407457.28	84904.20
56	407459.03	84902.05	407488.25	84863.96
57	407422.66	84929.02	407451.88	84902.98
58	407392.16	84978.03	407437.66	84933.32
59	407342.91	84968.05	407235.00	84939.30
60	407417.84	85106.38	407475.28	85024.76
61	407356.13	85142.34	407427.03	85063.92
62	407278.03	85290.66	407376.78	85165.86
62	407289.03	85305.09	407310.66	85264.55
63	407277.31	85275.95	407457.41	85071.24
64	407533.63	84786.69	407541.56	84768.88
65	407361.00	85306.20	407388.63	85273.67
66	407293.28	85469.47	407384.28	85275.48
67	407294.31	85435.68	407401.88	85282.30
68	407339.16	85413.70	407372.16	85402.34
69	407265.47	85454.55	407352.28	85309.52
70	407230.06	85533.70	407251.66	85489.53
71	407243.06	85623.32	407243.72	85528.62
72	407331.03	85792.16	407259.56	85585.39
73	407330.06	85727.88	407349.47	85642.15
74	407334.50	85772.70	407340.72	85729.85
75	407174.75	86227.70	407178.81	86219.91
76	407096.47	86307.11	407093.03	86288.78
77	407104.28	86322.73	407124.13	86158.00
78	407150.88	86267.40	407152.97	86236.19
79	407145.13	86226.87	407159.84	86153.93
80	407165.81	86215.84	407181.00	86175.88
81	407133.72	86259.36	407135.00	86247.62
82	407142.53	86177.32	407155.19	86102.62
83	407155.28	86126.89	407157.94	86114.02
83	407154.06	86105.97	407155.72	86092.95
84	407147.22	86090.35	407148.75	86069.64
85	407155.66	86067.01	407153.59	85985.91
86	407167.63	86025.30	407166.72	86002.05
87	407191.00	86109.88	407189.72	86088.17

Table 1. (Continued)				
88	407181.41	86142.98	407185.63	86087.07
89	407224.53	86084.06	407210.50	86034.50
90	407164.69	85969.62	407157.81	85945.94
91	407171.81	85971.73	407160.72	85945.95
92	407146.22	85916.16	407121.78	85807.07
93	407135.06	85884.38	407133.56	85862.67
94	407145.41	85916.51	407136.03	85866.38
95	407133.56	85751.59	407125.91	85690.74
97	407186.00	85679.71	407184.28	85653.49
98	407183.53	85683.08	407153.16	85610.77
99	407103.03	85649.80	407085.94	85605.45
100	407158.63	85199.20	407226.38	85047.98
101	407207.16	85132.72	407198.16	85065.14
102	407205.81	85169.09	407206.78	85147.65
103	407196.19	85183.35	407205.47	85153.35
104	407183.31	85176.17	407209.06	85137.76
105	407186.47	85171.17	407189.28	85144.84
106	407220.84	85141.80	407234.16	85100.46
107	407247.75	85121.38	407232.97	85108.82
108	407233.63	85121.48	407235.75	85106.90
109	407233.59	85133.22	407211.31	85009.58
110	407192.16	85042.53	407214.25	85032.87
111	407222.88	85089.85	407192.94	85046.45
111	407190.31	85041.69	407190.31	85041.69
112	407226.00	85115.11	407222.97	85080.80
113	407220.72	85103.22	407220.91	85098.48
114	407209.69	85089.79	407247.00	85037.28
115	407237.34	85060.04	407204.56	85048.43
116	407213.16	85134.44	407214.81	85131.98
116	407215.69	85129.29	407239.03	85055.20
117	407253.31	85118.05	407271.75	85045.50
118	407275.56	85081.52	407281.38	85074.62
119	407270.16	85062.24	407252.25	85045.79
120	407259.28	85046.76	407261.72	85037.34
121	407241.16	85089.48	407254.84	85074.91
122	407173.88	85000.80	407152.03	84987.88
122	407139.75	84982.21	407084.25	84968.70
123	407115.13	84972.14	407098.25	84968.62
124	407114.66	84970.37	407107.91	84964.66
125	407123.16	84962.09	407095.94	84960.43

TABLE 2. SELECTED SCARS FOR OCTOBER 2004 SURVEY

Scar No.	Northing	Easting	Latitude		Longitude		Length	Bearing
	ft	*ft*	*Deg*		*deg*		*ft*	*deg*
1	81816.700	408721.780	24°33'23.93773"	N	81°44'40.19472"	W	91	147
2	81892.450	408684.840	24°33'24.68614"	N	81°44'40.59923"	W	37	151
3	81964.220	408662.160	24°33'25.39588"	N	81°44'40.84907"	W	41	149
4	82005.260	408678.590	24°33'25.80330"	N	81°44'40.67353"	W	143	127
5	81886.080	408817.000	24°33'24.63011"	N	81°44'39.16747"	W	119	249
6	81954.330	408523.030	24°33'25.29046"	N	81°44'42.35538"	W	88	164
10	82282.770	408405.690	24°33'28.53770"	N	81°44'43.64549"	W	129	134
11	82463.740	408438.810	24°33'30.33217"	N	81°44'43.29737"	W	29	148
12	82586.970	408270.530	24°33'31.54386"	N	81°44'45.12721"	W	91	130
13	82567.430	408425.750	24°33'31.35862"	N	81°44'43.44490"	W	35	158
14	82542.100	408449.970	24°33'31.10900"	N	81°44'43.18109"	W	46	150
15	82514.560	408475.880	24°33'30.83757"	N	81°44'42.89885"	W	24	187
25	83029.450	408393.660	24°33'35.93367"	N	81°44'43.81952"	W	41	221
26	83055.250	408400.660	24°33'36.18962"	N	81°44'43.74522"	W	26	169
29	83156.460	408370.660	24°33'37.19060"	N	81°44'44.07608"	W	31	167
30	83235.520	408320.840	24°33'37.97109"	N	81°44'44.62031"	W	63	174
31	83304.540	408320.810	24°33'38.65480"	N	81°44'44.62468"	W	29	181
32	83506.500	408285.630	24°33'40.65353"	N	81°44'45.01755"	W	126	181
33	83504.450	408253.720	24°33'40.63152"	N	81°44'45.36305"	W	127	168
34	83559.080	408268.410	24°33'41.17347"	N	81°44'45.20715"	W	42	170
35	84413.730	407760.340	24°33'49.61236"	N	81°44'50.76031"	W	39	156
36	84522.950	407727.470	24°33'50.69252"	N	81°44'51.12275"	W	82	163
37	84574.220	407637.560	24°33'51.19557"	N	81°44'52.09961"	W	87	153
39	84610.500	407669.410	24°33'51.55667"	N	81°44'51.75676"	W	75	152
42	84676.170	407610.750	24°33'52.20404"	N	81°44'52.39599"	W	82	146
53	84880.790	407447.660	24°33'54.22224"	N	81°44'54.17451"	W	68	139
55	84828.000	407474.310	24°33'53.70073"	N	81°44'53.88275"	W	29	139
56	84902.050	407459.030	24°33'54.43345"	N	81°44'54.05261"	W	48	143
57	84929.020	407422.660	24°33'54.69866"	N	81°44'54.44814"	W	39	132
58	84978.030	407392.160	24°33'55.18251"	N	81°44'54.78138"	W	64	134
62	85290.660	407278.030	24°33'58.27327"	N	81°44'56.03597"	W	159	142
66	85469.470	407293.280	24°34'00.04538"	N	81°44'55.88132"	W	214	155
67	85435.680	407294.310	24°33'59.71071"	N	81°44'55.86817"	W	187	145
68	85413.700	407339.160	24°33'59.49539"	N	81°44'55.38108"	W	35	109
69	85454.550	407265.470	24°33'59.89609"	N	81°44'56.18166"	W	169	149
73	85727.880	407330.060	24°34'02.60716"	N	81°44'55.49814"	W	88	167
79	86226.870	407145.130	24°34'07.54019"	N	81°44'57.53062"	W	74	169
82	86177.320	407142.530	24°34'07.04921"	N	81°44'57.55587"	W	76	170
85	86067.010	407155.660	24°34'05.95719"	N	81°44'57.40715"	W	81	181
88	86142.980	407181.410	24°34'06.71113"	N	81°44'57.13271"	W	56	176
89	86084.060	407224.530	24°34'06.12979"	N	81°44'56.66217"	W	52	196
92	85916.160	407146.220	24°34'04.46236"	N	81°44'57.50052"	W	112	193
94	85916.510	407145.410	24°34'04.46579"	N	81°44'57.50931"	W	51	191
95	85751.590	407133.560	24°34'02.83145"	N	81°44'57.62795"	W	61	187
98	85683.080	407183.530	24°34'02.15549"	N	81°44'57.08266"	W	78	203
100	85199.200	407158.630	24°33'57.36084"	N	81°44'57.32387"	W	166	156
101	85132.720	407207.160	24°33'56.70491"	N	81°44'56.79430"	W	68	188
109	85133.220	407233.590	24°33'56.71128"	N	81°44'56.50806"	W	126	190
117	85118.050	407253.310	24°33'56.56207"	N	81°44'56.29357"	W	75	166
119	85062.240	407270.160	24°33'56.01012"	N	81°44'56.10777"	W	24	227

TABLE 3. SCAR SURVEY RESULTS; COW KEY CHANNEL, KEY WEST, FLORIDA, OCTOBER 2004

Scar #	Seagrass Recruitment Species	Algal Recruitment Species	Braun-Blanquet Rank (Average)	Notes
1	*Halodule, Thalassia*	*Penicillus, Halimeda, Red Algae*	5	Anemone
2	*Halodule, Thalassia*	*Penicillus*	4	Deep scars - 7 kt current
3	*Halodule, Thalassia*	*Halimeda*	3	Deep scars - 7 kt current
4	*Halodule, Thalassia*		3	Deep scars - 7 kt current
5	*Halodule, Thalassia*		4	
6	*Halodule, Thalassia*	*Penicillus*	5	
10	*Halodule*		5	Very shallow / same as background
11	*Thalassia*	*Penicillus*	3	Deep scar
12	*None*	*Penicillus*	2	
13	*Thalassia*	*Red Algae*	2	Red algae attached to fabric; strong currents
14	*Thalassia*	*Red Algae*	2	Red algae attached to fabric; strong currents
15	*Halodule, Thalassia*	*Epiphytic Algae*	5	
25	*Thalassia*	*Penicillus*	3	
26	*Thalassia*	*Penicillus, Halimeda, Epiphytic Algae*	2	
29	*Thalassia*	*Epiphytic Algae*	2	7 kt current
30	*Halodule, Thalassia*	*Penicillus, Epiphytic Algae*	3	
31	*Halodule*	*Epiphytic Algae*	5	Same as background
32	*Thalassia*	*Penicillus, Epiphytic Algae*	5	Same as background; silty
33	*Halodule, Thalassia*	*Epiphytic Algae*	5	Same as background
34	*Halodule*	*Epiphytic Algae*	5	Same as background
35	*Thalassia*	*Halimeda, Red Algae, Epiphytic Algae*	2	Same as background
36	*Halodule, Thalassia*	*Penicillus, Red Algae, Ephiphytic Algae*	4	Same as background
37	*Thalassia*	*Halimeda*	2	Shell fragments
39	*Halodule*	*Epiphytic Algae*	2	Same as background

TABLE 3. (continued)				
42	*Halodule*		2	Fabric found -- where bags remain there is halodule growth. Scour around bags; shell fragments
53	*Halodule*		4	Fabric found -- where bags remain there is halodule growth. Scour around bags.
55	*Halodule*	*Penicillus, Halimeda, Red Algae*	3	
56	*Halodule*	*Epiphytic Algae, Penicillus*	5	
57	*Thalassia*	*Halimeda*	4	Fabric found; red algae attached to fabric
58	*None*		0.5	Deep scar; covered with shell fragments; strong current; thalassia outside of scar
62	*Halodule, Thalassia*	*Penicillus, Halimeda, Red Algae*	3	Strong current
66	*Halodule, Thalassia*	*Epiphytic Algae*	4	
67	*Halodule*	*Epiphytic Algae*	4	
68	*Halodule*		3	
69	*Halodule*	*Penicillus*	2	
73	*Halodule, Thalassia*	*Halimeda*	5	Mild current; shallow
79	*Halodule*		4	Shallow
82	*Halodule, Thalassia*	*Epiphytic Algae*	5	Shallow; silty
85	*Halodule, Thalassia*	*Epiphytic Algae*	5	Silty
88	*Halodule*	*Penicillus*	2	Long scars to the east and west of site; thalassia to east and west of two scars; Halodule in middle of scars
89	*Halodule, Thalassia*		5	Edge of the channel. Halodule to the shallows. Thalassia in the channel
92	*Halodule, Thalassia*	*Penicillus*	5	Silty;surrounding area dominated by thalassia with epiphytes
94	*Thalassia*	*Epiphytic Algae*	3	Deeper site. Sparse Thalassia in wide sand region; close to channel
95	*Halodule, Thalassia*		5	Deep scar
98	*Thalassia*		2	Deeper site
100	*Halodule, Thalassia*	*Epiphytic Algae*	4	Shallow; quiescent
101	*Thalassia*	*Penicillus*	2	Sandy site; hard bottom
109	*Thalassia*	*Epiphytic Algae*	2	Corals; sponges; hard bottom; turning basin
117	*None*		0.5	Several scars at location; hard bottom
119	*Halodule*	*Halimeda*	3	

TABLE 4. ONE-WAY ANOVA: COMPARE MEANS OF B-B SCALE FOR THALASSIA+HALODULE, HALODULE ONLY, AND THALASSIA ONLY.

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Both Species	19	82	4.315789474	0.67251462
Halodule	14	49	3.5	1.5
Thalassia	14	36	2.571428571	0.879120879

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	24.58318669	2	12.29159335	12.56755556	4.81491E-05	3.209279953
Within Groups	43.03383459	44	0.978041695			
Total	67.61702128	46				

TABLE 5. HYDRAULIC ENERGY RANKING AND SPECIES COMPOSITION

Scar #	Hydraulic Energy 1=quiescent 2=intermediate 3=strong currents	Recruitment Species 1=Thalassia 2=Halodule 3=Thalassia+Halodule	Braun-Blanquet Rank (Average)
1	2	3	5
2	3	3	4
3	3	3	3
4	3	3	3
5	2	3	4
6	2	3	5
10	1	2	5
11	2	1	3
12	2	0	2
13	3	1	2
14	3	1	2
15	2	3	5
25	2	1	3
26	2	1	2
29	3	1	2
30	0	3	3
31	2	2	5
32	1	1	5
33	2	3	5
34	2	2	5
35	2	1	2
36	2	3	4
37	3	1	2
39	2	2	2
42	3	2	2
53	3	2	4
55	2	2	3
56	2	2	5
57	2	1	4
58	3	0	0.5
62	3	3	3
66	2	3	4
67	2	2	4
68	2	2	3
69	2	2	2
73	1	3	5
79	1	2	4
82	1	3	5
85	1	3	5
88	2	2	2
89	3	3	5
92	1	3	5
94	3	1	3
95	2	3	5
98	3	1	2
100	1	3	4
101	3	1	2
109	3	1	2
117	3	0	0.5
119	2	2	3

APPENDIX B

FIGURES

Figure 1. Location of origin of surveyed scars; Aerial of Cow Key Channel.

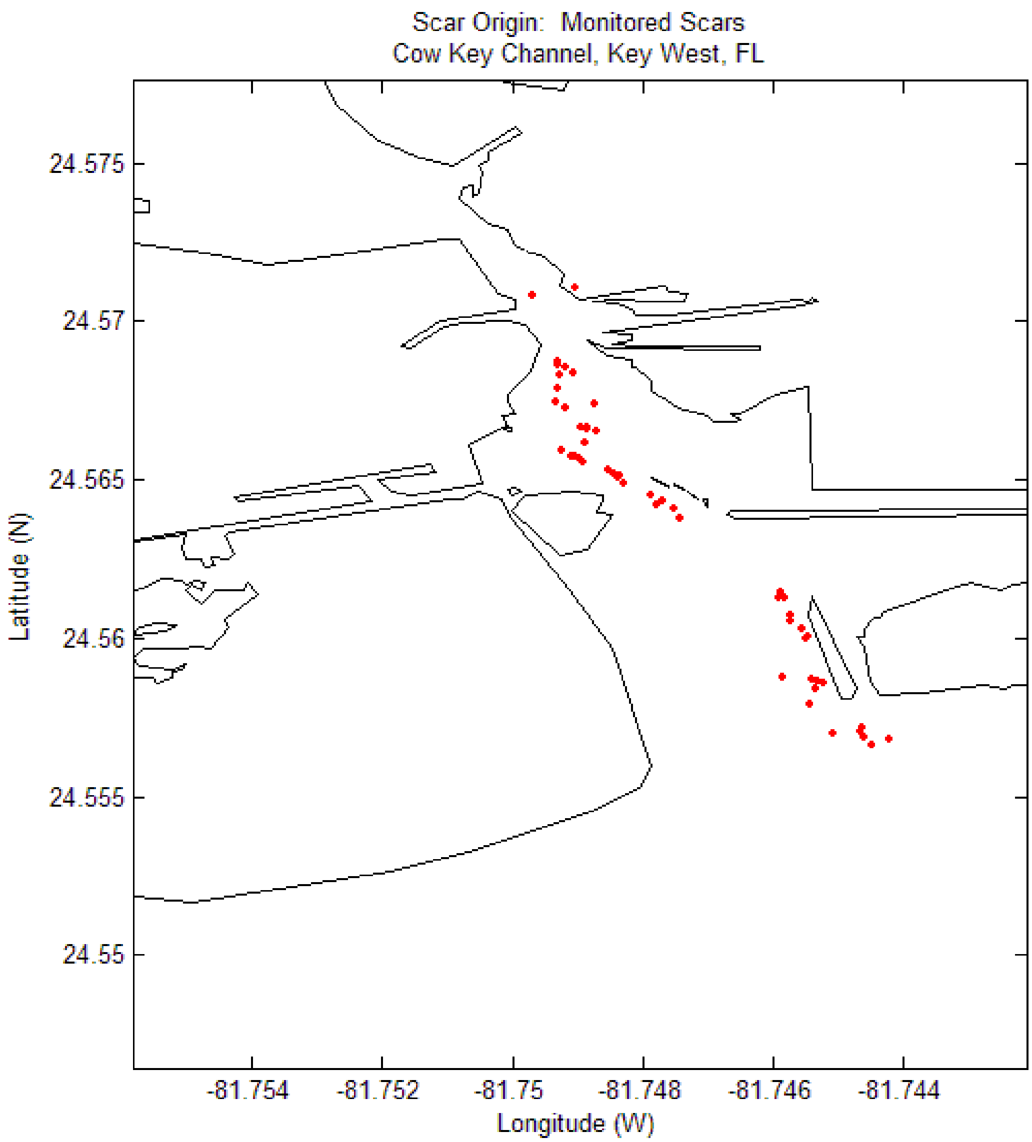


Figure 2. Location of origin of surveyed scars; Latitude and Longitude (decimal degrees).

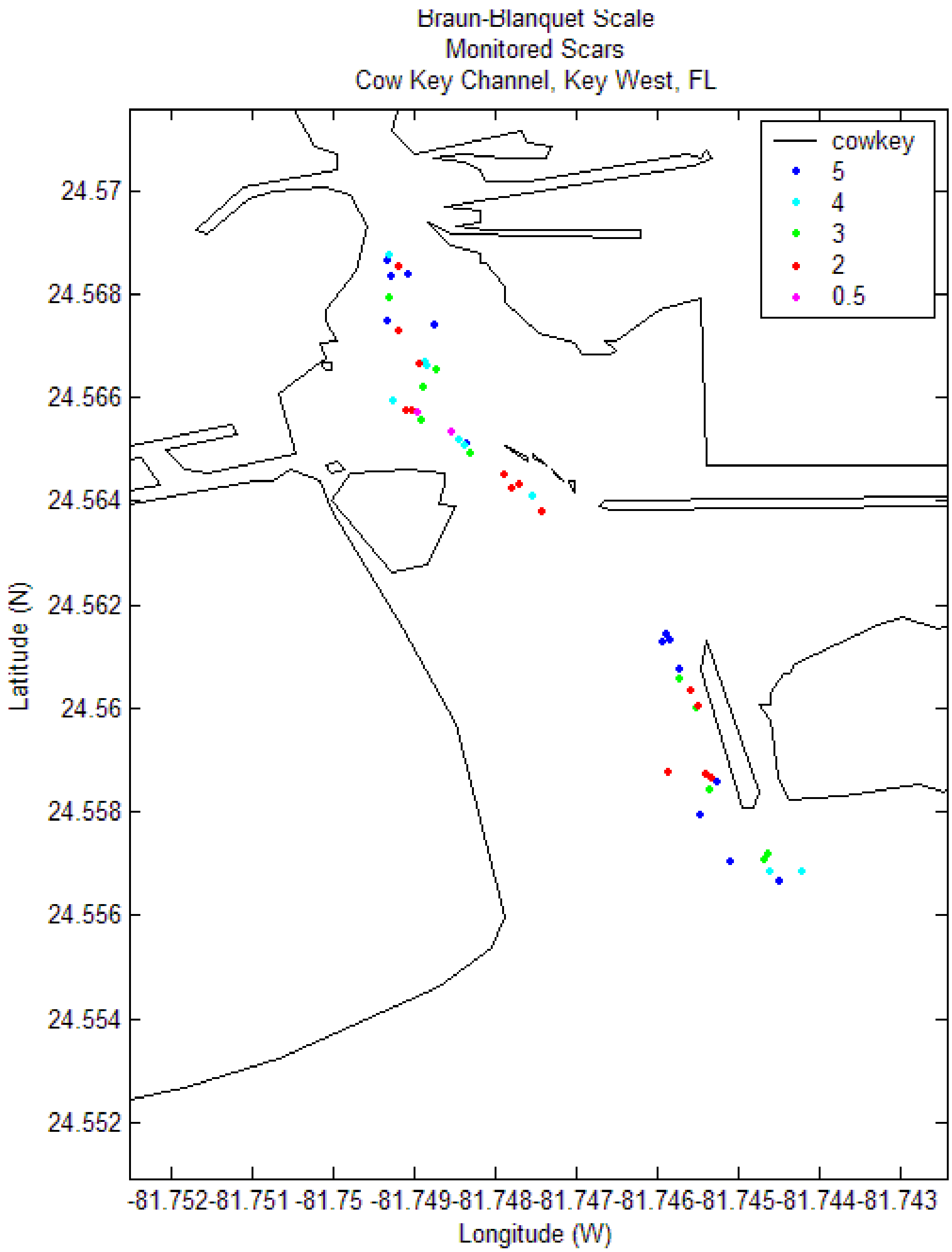


Figure 3. Location of surveyed scars and Braun-Blanquet Scale. Cool colors represent high levels of recovery, warm colors represent poor recovery. Poor recovery appears to be correlated with hydraulic energy and distance from the navigation channel.

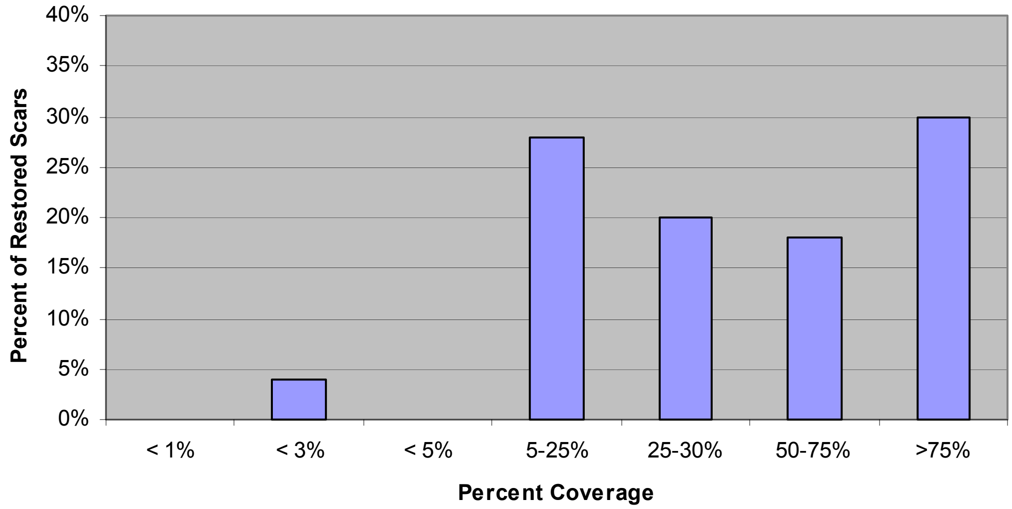


Figure 4. Percent of seagrass coverage based on results of Braun-Blanquet scale for all scars observed.

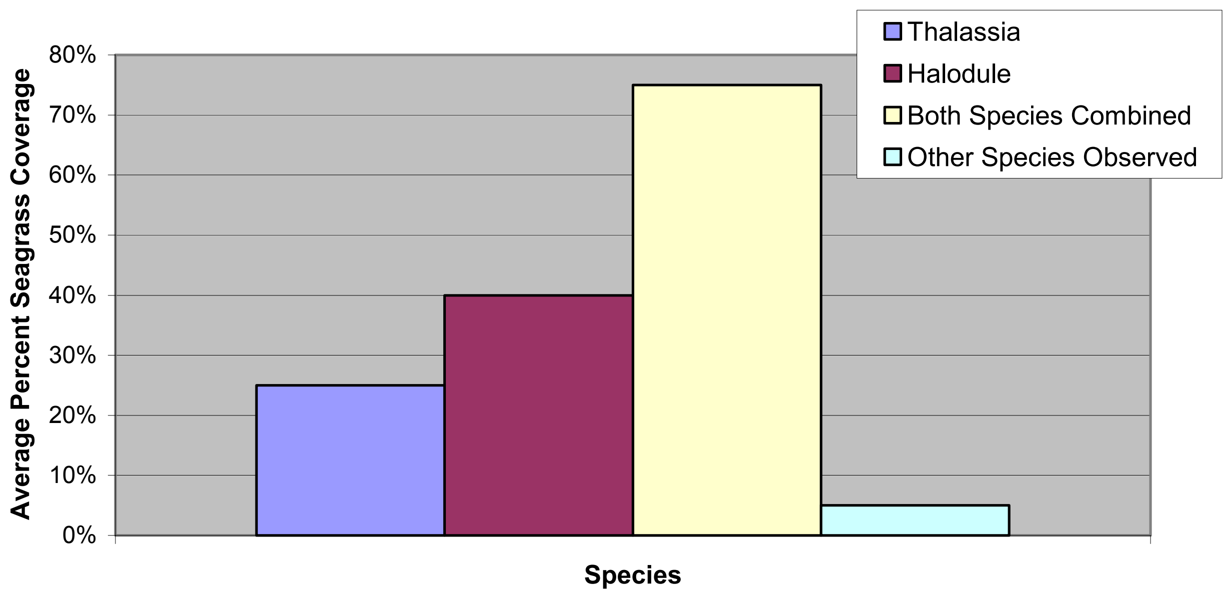
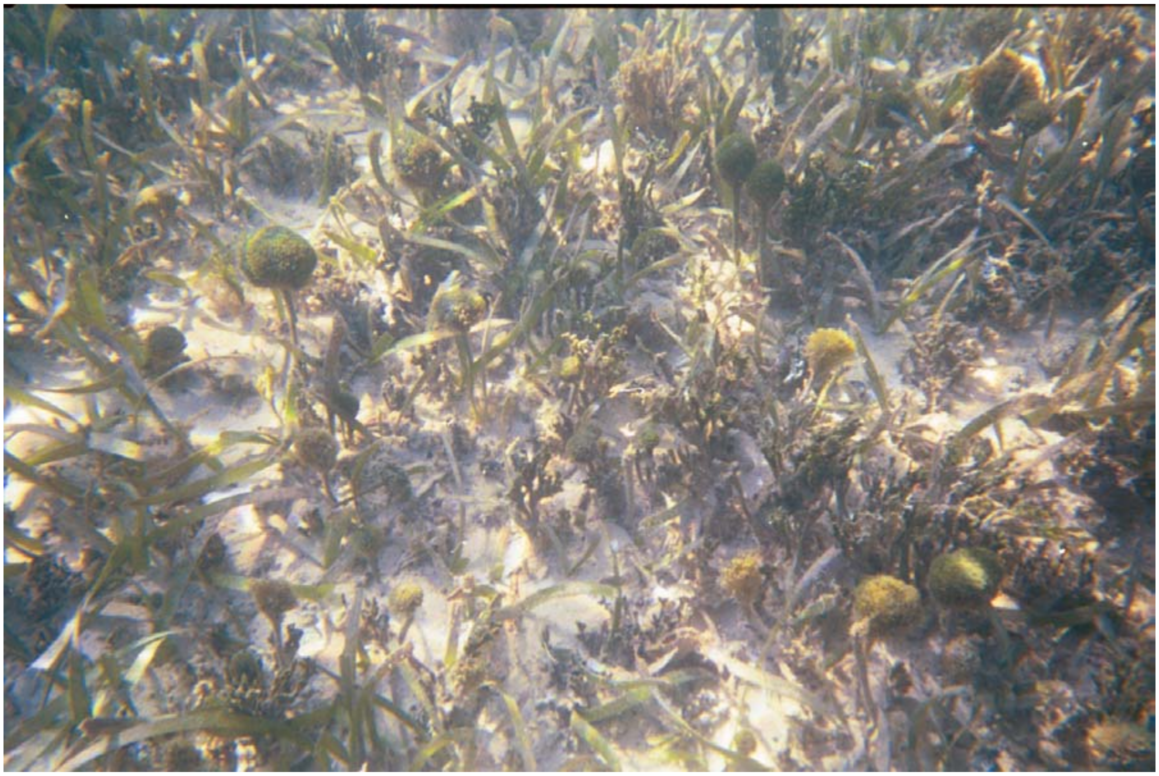


Figure 5. Percent of seagrass coverage based on results of Braun-Blanquet scale for each species.

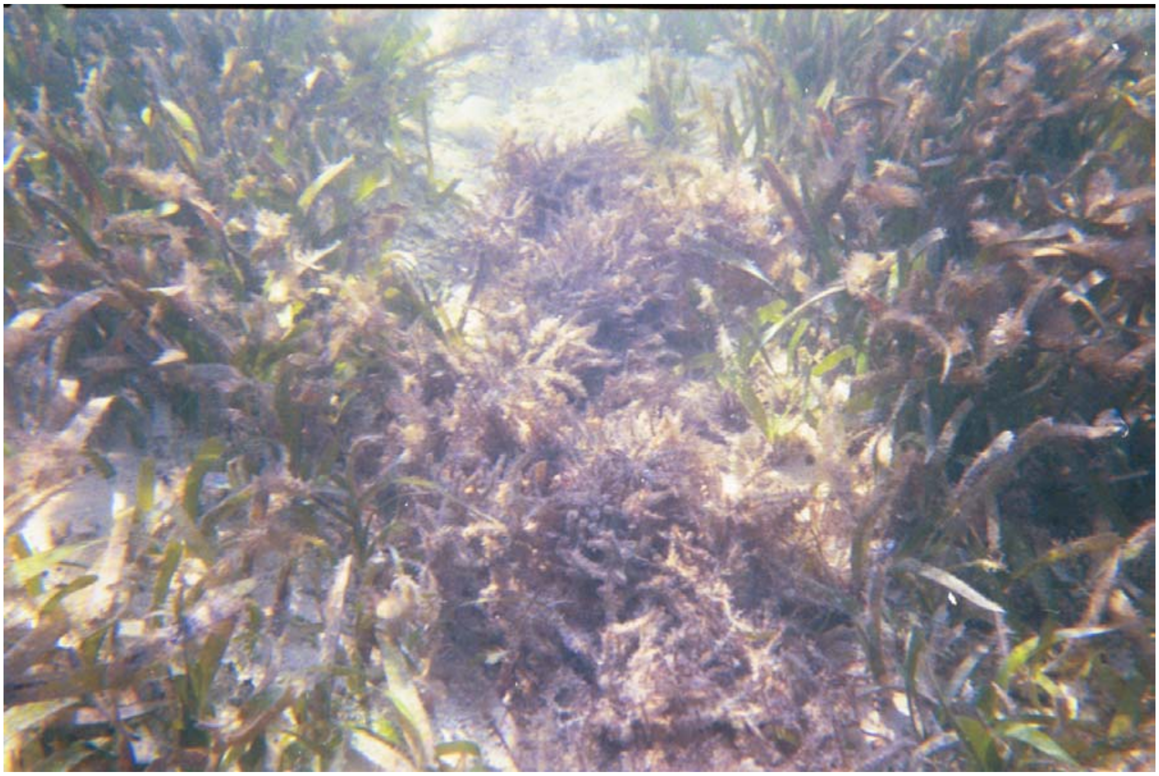
APPENDIX C

PHOTOGRAPHS



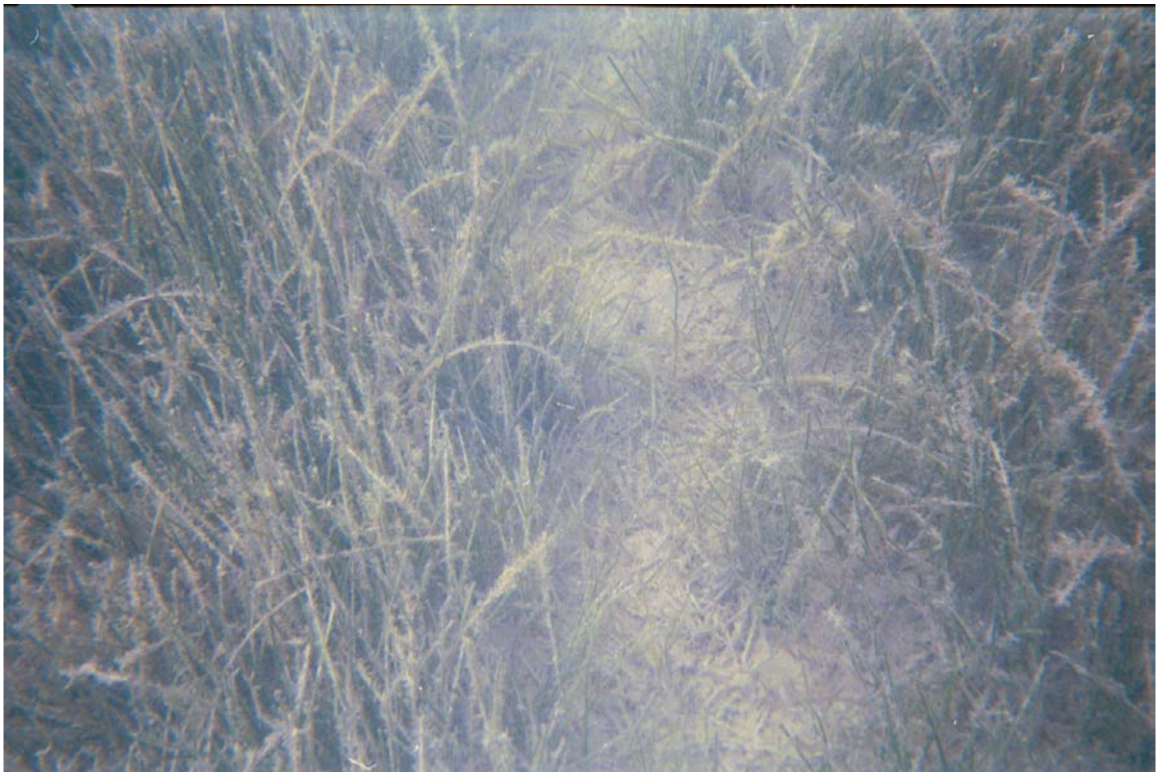
Photograph 1. Scar #2: Mixture of *Thalassia* and *Penicillus* and *Halimeda* algae.

Photograph 2. Scar #13: *Thalassia* shoots, red algae. Remnant fabric was found at edges of this scar.



Photograph 3. Scar #13. Red algae was found in the scar and was entangled in remnant fabric from sediment filled tubes.

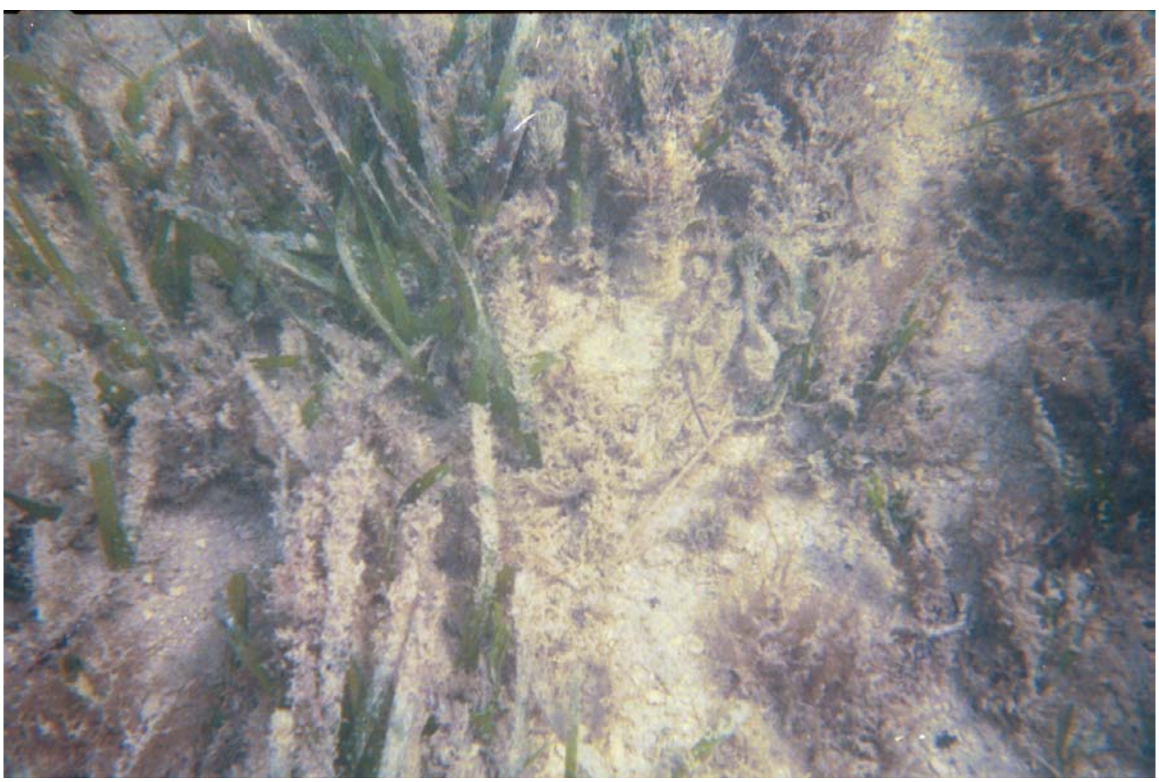
Photograph 4. Scar #29: Epiphytes found on *Thalassia* due to high levels of nutrients in Cow Key Channel.



Photograph 5. Scar #34: *Halodule* recovery across the scar.

Photograph 6. Scar #42: Sand and shell fragments, in addition to poor recovery denote a high hydraulic energy site. Remnants of fabric found at the site.

Photograph 7. Scar #56: Mixture of growth of *Thallasia* and *Penicillus* and red algae in Scar #56.



Photograph 8. Scar #57: Epiphytic growth seen on *Thalassia* in recovering scar. Remnants of fabric found along scar.