Seagrass Restoration and Protection in the St. Martins Marsh Aquatic Preserve

NFWF-SHELL MARINE: Award #2009-0046-000
Final Report
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Background

Seagrass meadows are recognized as one of the richest, most productive and most important communities in shallow coastal waters (USFWS 1989). The state and federal waters surrounding Florida support approximately 2.7 million acres of seagrass habitat (Haddad and Sargent, 1994; Sargent et al. 1995), more acreage and diversity of seagrass habitat than anywhere else in the United States. Much of Florida's seagrass habitat occurs in shallow areas that are vulnerable to boat propeller scarring; and Florida vessel registration has grown substantially over the last several decades along with coastal populations. A 1995 report published by the Florida Marine Research Institute (Sargent et al.) quantified the problem of seagrass scarring for the first time statewide in Florida using a consistent methodology and found that boats operating in shallow water were severely scarring, and in some areas completely denuding, seagrass beds throughout the state.

Propeller scarring mechanically injures plants and disturbs substrate. Because the sediment stabilizing rhizomes and roots play a vital role in the growth, anchoring, and nutrition of these grasses, mechanical damage to these components are some of the most severe injuries impacting seagrass meadows (Kenworthy et al., 2000). Scarring can also facilitate the loss of the buried organic material, impacting nutrient and chemical circulation processes of the sediment. This in turn affects the availability of these nutrients to the impacted seagrasses. Lastly, these scars are subject to further deterioration from other natural disturbances such as tidal currents, storms, and biological activity, often resulting in increased size far beyond that of the original injury.

In 2005, The Nature Conservancy along with numerous agency, academic and non-governmental organization (NGO) partners, conducted an assessment of Florida's coastal and marine resources to identify priority areas for focusing conservation attention (Geselbracht et al., 2005). In several of the alternative solutions presented, the Southern Big Bend region of Florida (roughly the Florida Gulf Coast from Cedar Key south to the southern boundary of Hernando County) was identified as a conservation priority area, largely due to the extensive seagrass meadows along this coastline. The Nature Conservancy subsequently adopted the Southern Big Bend Area as a conservation action site. Along this coastline, Sargent et al. (1995) found significant areas of light seagrass scarring with a few modest areas of moderate and severe scarring.

Seagrass scarring can best be prevented through improved boater awareness, and in severe cases, enforcement. Once scarring occurs, seagrass may recolonize the scarred area over time, but depending on the width and depth of the scar and localized currents, this may not happen. Several techniques have been tested to repair scar areas including: temporary placement of bird stakes in the scarred areas to encourage re-growth through enhanced fertilization, and placing sediment-filled tubes in a prop scar to bring the substrate elevation level back to ambient grade increasing seagrass rhizome colonization. There is some evidence from these early studies that success can be influenced by local conditions.

Florida Study Overview

In the Florida portion of this project, a project area was selected along the Southern Big Bend Coast that was shown to have light, moderate, and severe seagrass scarring. This area was located in the St. Martins Marsh Aquatic Preserve (Figure 1). The sediment tube technique was selected for this project because of the karstic nature of the bottom substrate. Bird stakes would not have been a suitable approach because installation would have required drilling into the substrate, likely causing significant additional damage to the seagrass habitat. Table 1 summarizes the activities that were conducted as part of this project and the timeframe in which these activities were completed.

Figure 1. Areas of seagrass scarring in the vicinity of the St. Martins Marsh Aquatic Preserve. Data is from Sargent et al. (1995) and represents information collected from 1991 – 1994.

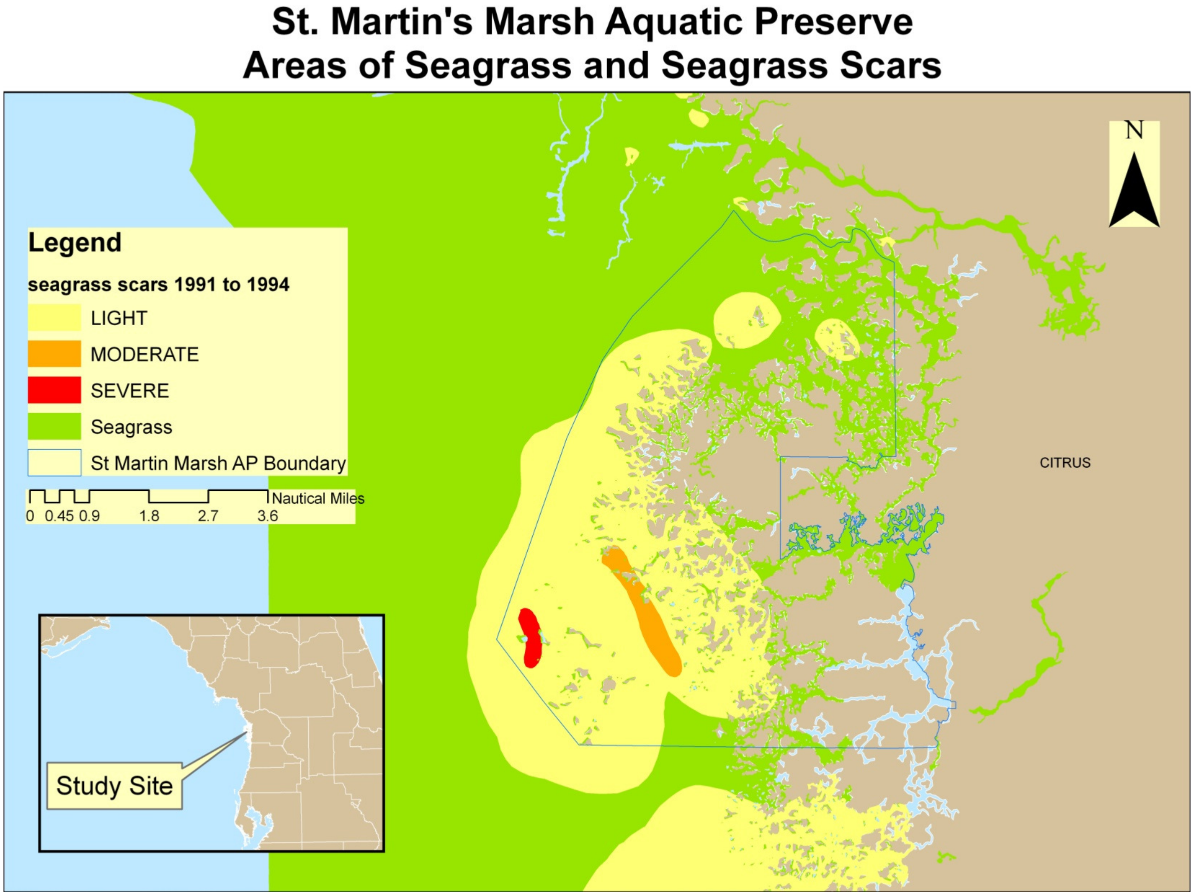


Table 1. Summary of project activities and timeframe of completion.

Project Activity	**Completion Timeframe**
Identified current scar locations for restoration and study controls;	February 2009
Conducted field survey(s) to identify seagrass scar locations suitable for receiving sediment tubes as well as study control sites;	June – July 2009
Conducted the pre-treatment boater behavior survey;	July 2009
Designed, printed, and installed kiosk signs highlighting the importance of seagrass and promoting protection it at 4 local boat launches;	August 2009
Designed educational brochures;	August – October 2009
Obtained approval from the Florida Department of Environmental Protection (DEP) for a Environmental Resource Permit and from the US Army Corps of Engineers for a dredge and fill nationwide permit;	November 2009
Conducted pre-installation conditions survey prior to tube installation.	March 2010
Installed 400 sediment tubes (1 meter in length each) at 13 scar sites.	March – April, 2010
Redesigned brochure to include area map and location of boating channels.	July – August 2010

Printed and distributed 5,000 of the redesigned brochures at the St. Martins Aquatic Preserve Office as well as sporting goods, boating, and sportfishing stores.	August 2010
Conducted the follow up boater behavior survey.	November 2010
Conducted the final site survey	July 2011

Methods and Project Description

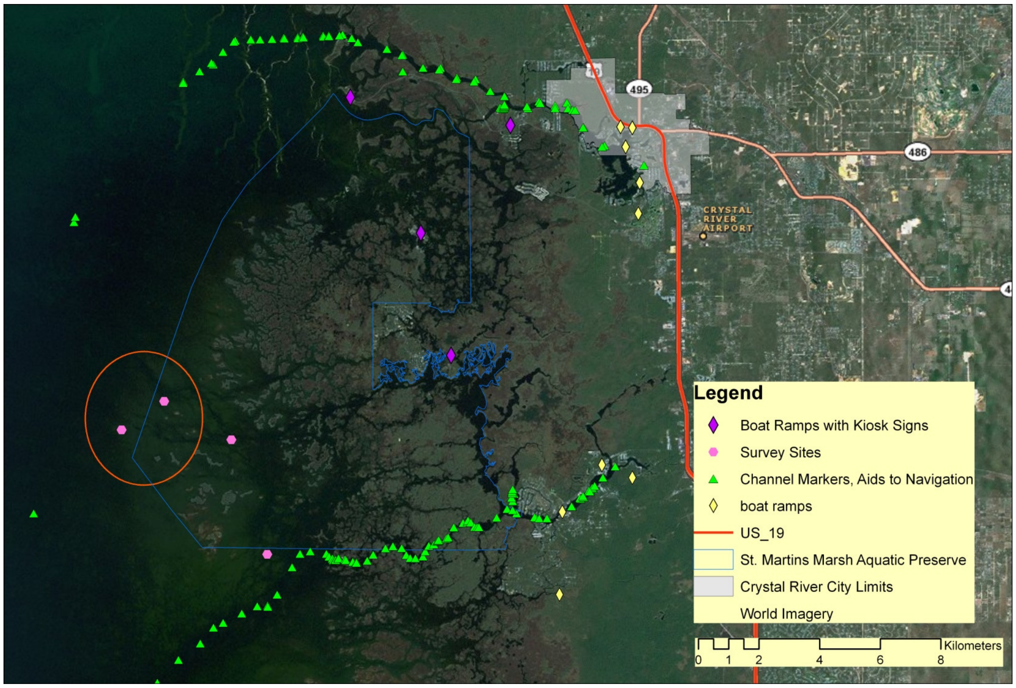
Upon project initiation in February 2009, and prior to obtaining the Florida Department of Environmental Protection's Environmental Resource Permit for installation of the sediment tubes, study design, educational materials (kiosk signs and educational brochures), and design of the pre- and post- boater behavior surveys were established. In July 2009, prior to disseminating and posting educational materials to area boaters on the value of seagrass, the first boater behavior survey was completed.

Boater Behavior Survey Design

The boater behavior survey was designed to determine the effectiveness of a boater education program. Boater behavior was observed during two distinct time periods, one before the implementation of the project's boater education activities, and one after. The boater behavior survey collected information on how boaters traverse through shallow seagrass areas and whether they take actions to avoid damaging seagrass habitat.

Prior to conducting the first boater behavior survey, four randomly selected survey sites were identified (See Figure 2). Two sites were in the general vicinity of the restoration site, one site was slightly outside the restoration site, and one site was removed from the restoration site, but close to a boat channel. While in the field, sample site information was recorded including depth of water, proximity to a navigable channel and/or seagrass bed, and time of day so as to later establish the stage of tide.

Figure 2. Location of boater behavior survey points and boat ramps where educational signs are posted.



Sampling for both pre and post-education program implementation was conducted over two field days, July 10 through July 11, 2009 and September 8 through September 9, 2010. Sampling at each site was conducted for 90 minutes. During the sampling time frame, the following was recorded for each observed boat travelling within 500 meters of sampling site: method of transit (motoring or poling/drifting/trolling), whether the boat appeared to be in the channel, general boat speed (fast or slow), boat size (<10 ft, 10 – 15 ft, 15-20 ft, 20+ ft), and whether the boat appeared to be actively making a scar. The sampling sites remained the same during both sampling periods. A comparison of the proportion of boats motoring through the shallow seagrass areas versus not motoring through shallow seagrass habitat was completed to measure the effectiveness of the educational outreach.

<u>Boater Education</u>

The boater education portion of the project had two components: posting of educational signs at area boat ramps and distributing brochures. Both the signs and brochures contained information about the value of seagrass to natural systems and humans as well as tips and techniques for avoiding propeller scarring of seagrass habitat in shallow waters. The approximately 1 meter by 1 meter kiosk signs (Figure 3) were placed at four boat ramps frequented by boaters accessing the St. Martins Marsh Aquatic Preserve in August 2009. The signs were posted at the following boat ramps:

Ft. Island Beach, 16000 W. Fort Island Trail in Crystal River, Florida;
Ft. Island Trail Park, 12073 W. Fort Island Trail in Crystal River, Florida;
Ozello Park, John Brown Road off CR 494; and
Pirate Cove Boat Ramp at the end of CR 494.

Figure 3. Signs posted at local boat ramps to encourage boaters to operate their boats cautiously so as to avoid damage to shallow seagrass habitat.

In August 2010, 5,000 educational brochures were printed and distributed to the St. Martins Marsh Aquatic Preserve, local marinas, and boating supply shops. The brochures contain a non-navigational map of the St. Martins Marsh Aquatic Preserve, location of seagrass habitat and boat channels, as well as information beyond what was contained on the kiosk signs regarding the value of seagrass habitat, seagrass protection, and proper navigational techniques through shallow seagrass beds (Appendix 1).

Restoration of Seagrass Scars

In early 2009, the project team identified 17 scars with a suitable depth and length for restoration activities. Scars with a minimum depth of 0.33 m and a minimum length of 6 m were selected as restoration and control sites (Figure 4; Table 2). Site locations were recorded with a hand-held GPS.

Figure 4. Location of seagrass scars for restoration and study control.

Table 2. Restoration Site Scar Number and Length in Meters.

Scar Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	total:
Length (m)	41	40	39	22	39	17	59	8	10	19	16	22	10	11	18	13	8	392

In November 2009, the Florida Department of Environmental Protection Environmental Resource Permit and the US Army Corps of Engineers Dredge and Fill Nationwide Permit were issued. A baseline survey was conducted in early March 2010, and no seagrass shoots were observed in the scars to be restored. To maximize the value of the control sites, it was decided to split each project area scar site in half, with one side receiving the sediment tubes and the other half remaining as the control site. At the time of sediment tube installation, a coin was flipped in order to randomly select which side of each scar would serve as the control.

On March 9 through 10 2010, 400 sediment tubes were deployed into the 17 selected seagrass scars. The sediment tubes consisted of 20-centimeter diameter biodegradable cotton tubes of approximately 1 meter in length. Tubes were placed in one half the length of the scar until the tubes achieved ambient grade with the surrounding seagrass bed. See Appendix 2 for photos taken on the day of sediment tube deployment. The contractor, Seagrass Recovery, returned on April 6, 2010 to add an additional 200 sediment tubes to the treated scars, as some settling had occurred and additional tubes were necessary to achieve ambient grade with the surrounding seagrass meadows.

The treated and control areas were monitored two times following deployment of the sediment tubes to observe the extent to which seagrass was recolonizing the treated and untreated scar areas. The first monitoring occurred on November 3, 2010 and the final monitoring occurred on June 9, 2011. Treated and untreated seagrass scars were monitored using the Braun-Blanquet method. This method has proven to be quick, accurate and cost-effective (Fourqurean et al. 2001; Rose et al. 1999). Observations recorded included: seagrass cover, submerged aquatic vegetation (SAV) species presence, and benthic invertebrate presence. Data observations were made using ¼ -meter by 1/4-meter quadrat (quad) randomly spaced along the length of the treated and control scar sites and across its entire width once prior to treatment (sediment tube installation). Surveys were conducted approximately 8 months post-treatment and again just prior to the conclusion of the project. A modified Braun-Blanquet scale was used to establish the percentage of seagrass coverage at treated versus untreated sites. The modified scale used is as follows:

1.0 = less than 5% cover
2.0 = 5-25% cover
3.0 = 25-50% cover
4.0 = 50-75% cover
5.0 = greater than 75% cover

For comparison, seagrass coverage was also measured adjacent to each scar. An individual score was given to seagrass species and green macro algae present within each quad. A paired T-test was applied to compare seagrass coverage between treated and untreated portions of the study sites to estimate the extent to which sediment tubes accelerated and/or improved recolonization by seagrass. For the SAV species assessment, whether or not a particular species of SAV was present inside a quad was recorded, and that value was divided by the total number of quads (n=272).

Results of the Seagrass Restoration and Boater Education Activities

<u>Seagrass Restoration Results – Mid-Project Monitoring</u>

Eight months post treatment, a follow-up survey was conducted on the seventeen prop scars using Braun-Blanquet study method. Due to the sediment type and depth, many of the sediment tubes settled 15-18 cm below ambient grade. Most of the sediment tubes were still intact or in various states of decay at the time of the survey. Both seagrass and macroalgae were present in both treated and control scars. In treated areas, two species of seagrass and six species of algae were present. Two species of seagrass and five species of algae were present at control areas (Table 3). the intact tubes provided an ideal holdfast for macro algae species present. . even so, the occurrence of macroalgae and seagrasses were similar both in the control and treated segments (Table 3). However, a substantial differences between control and treatment areas were seen in the number of monitoring quadrants with no SAV. Approximately 34% of treatment areas versus 62% of control areas had no SAV present. Only six benthic invertebrates were observed during the mid-project survey. Several prop scars had sediment types characterized by sand and shell fragments. When this occurred, the sediment tubes clearly displayed sediment stabilization within the treated sections. In some cases, the control segments were barren and below ambient grade. Most of the propeller scars used for the survey showed less than 5% total SAV coverage. Since most of the sediment tubes had not yet dissolved at the time of the mid-point monitoring, it would have been difficult for any seagrass to grow in treated sections. In this study, one growing season proved to not be enough time to determine the success or failure of the restoration project.

Table 3. Eight Months Post Treatment Monitoring Results - Percent Presence of SAV Species at Treated and Control Areas of Restoration (Scar) Sites.

SAV Species	Treated Area	Control Area
Seagrass Species		
Syringodium filiform	12%	8%
Thalassia testudinum	16%	18%
Macro Algae Species		
Caulerpa cupressoides	14%	6%
Halimeda incrassata	11%	12%
Penicillus capitatus	5%	6%
Penicillus dumetosus	7%	6%
Udotea flabellum	3%	6%
Caulerpa ashmeadii	5%	0%
No SAV	34%	62%

Mid-Project Braun Blanquet Scores

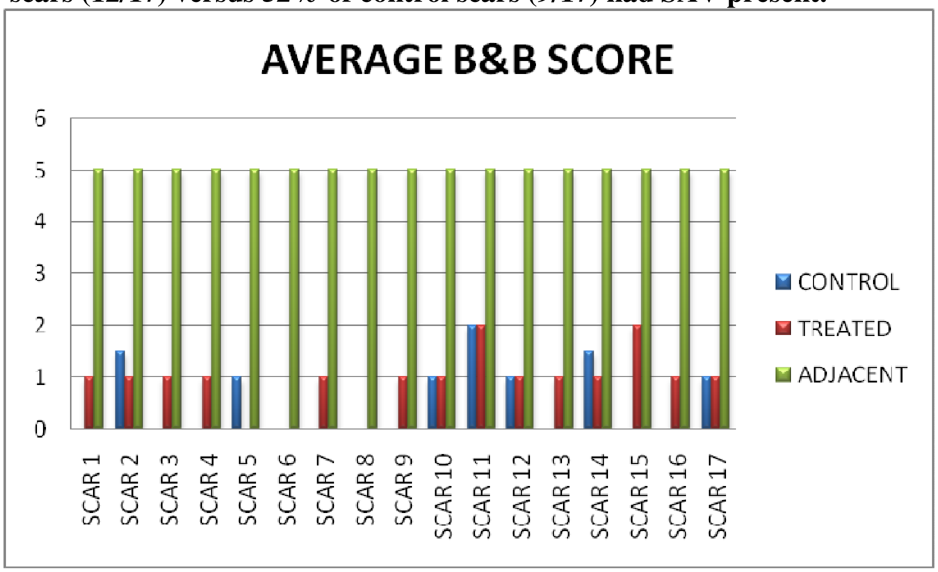
The mean Braun-Blanquet score (seagrass only) differed between the treated and control sites (0.941 versus 0.529), and a paired T-test showed that this difference was significant (Table 4; Figure 5). Appendix 3 provides the full results of the paired T-test.

Table 4. Mid-Project Monitoring - Results of the Braun-Blanquet Survey

	TREATED	CONTROL	ADJACENT
SCAR 1	1	0	5
SCAR 2	1	1.5	5
SCAR 3	1	0	5
SCAR 4	1	0	5
SCAR 5	0	1	5
SCAR 6	0	0	5
SCAR 7	1	0	5
SCAR 8	0	0	5
SCAR 9	1	0	5

SCAR 10	1	1	5
SCAR 11	2	2	5
SCAR 12	1	1	5
SCAR 13	1	0	5
SCAR 14	1	1.5	5
SCAR 15	2	0	5
SCAR 16	1	0	5
SCAR 17	1	1	5
mean	0.941	0.529	5.000

Figure 5. Average Braun-Blanquet Score. Where no score is listed for a treatment or control area, no SAVs were present in monitoring quadrants. Seventy percent of treated scars (12/17) versus 52% of control scars (9/17) had SAV present.



<u>Seagrass Restoration Results – Final Project Monitoring</u>

In the final survey, most of the control sections of the prop scars continued to be scoured and were absent of SAV's (Figure 6). Most sections of the treated prop scars showed varied degrees of success, while some sections remained barren and scoured. It was evident during the final survey that the sections where sediment tubes remained at ambient grade had the greatest success. When the tubes were still intact, if they remained at ambient grade, SAV colonization was up to 75% total coverage (Figure 7). The areas where the sediment tubes sank below grade showed no growth and signs of scouring (Figures 8 and 9). Consequently, these sections also showed evidence of heavy undermining of the adjacent seagrass beds (Figure 10). Overall, the treated portions of the propeller scars showed an increase in seagrass and algae coverage between the first and second survey (Table 5). As with the mid-project monitoring, only a few benthic invertebrates were observed during the final-project survey in the treated scar locations.

Figure 6. Many of the control sections of the prop scars continued to be scoured and lacked any SAV growth.

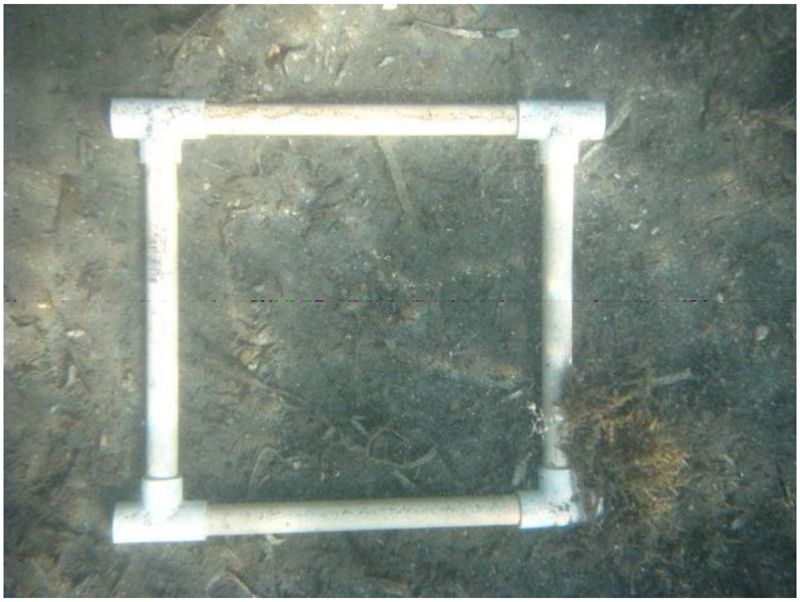


Figure 7. In treated portions of the prop scars, where the sediment tubes remained at ambient grade, SAV and seagrass colonization was observed.

Figure 8. Observed scouring of the tubes when below ambient grade.

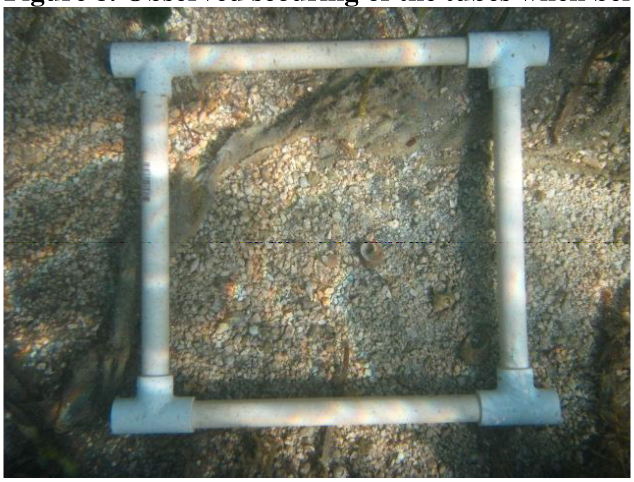


Figure 9. Observed scouring of the tubes when below ambient grade.

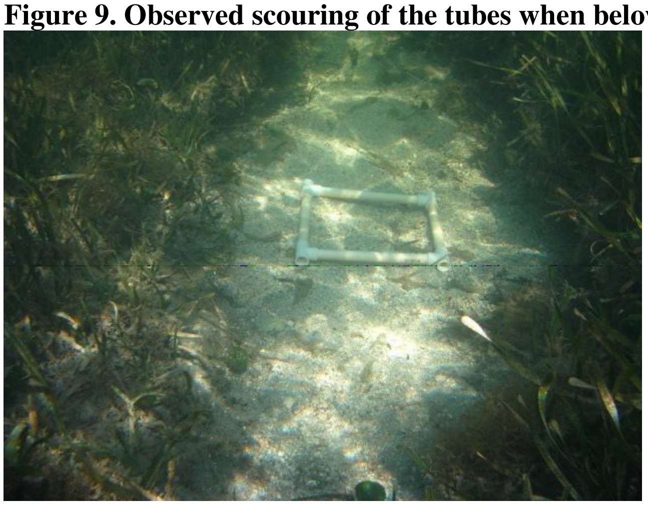


Figure 10. Undermining of seagrass adjacent to test prop scars was evident where sediment tubes sank below the ambient grade.

Table 5. Percent representation of seagrass and other SAVs in treated and control propeller scar monitoring quadrants, mid-project and final surveys.

	Mid-Project	Mid-Project	Final	Final
SAV Species	**Treated**	**Control**	**Treated**	**Control**
Syringodium filiform (SFIL)	12%	8%	22%	15%
Thalassia testudinum (TTES)	16%	18%	21%	15%
Caulerpa cupressoides (CPRO)	14%	6%	13%	4%
Halimeda incrassate (HINC)	11%	12%	12%	4%
Penicillus capitatus (PCAP)	5%	6%	40%	10%
Penicillus dumetosus (PDUM)	7%	6%	0	0
Udotea flabellum (UFLA)	3%	6%	3%	0
Caulerpa ashmeadii (CASH)	5%	0%	1%	0
No SAV	34%	62%	35%	59%

Final Project Braun Blanquet Scores

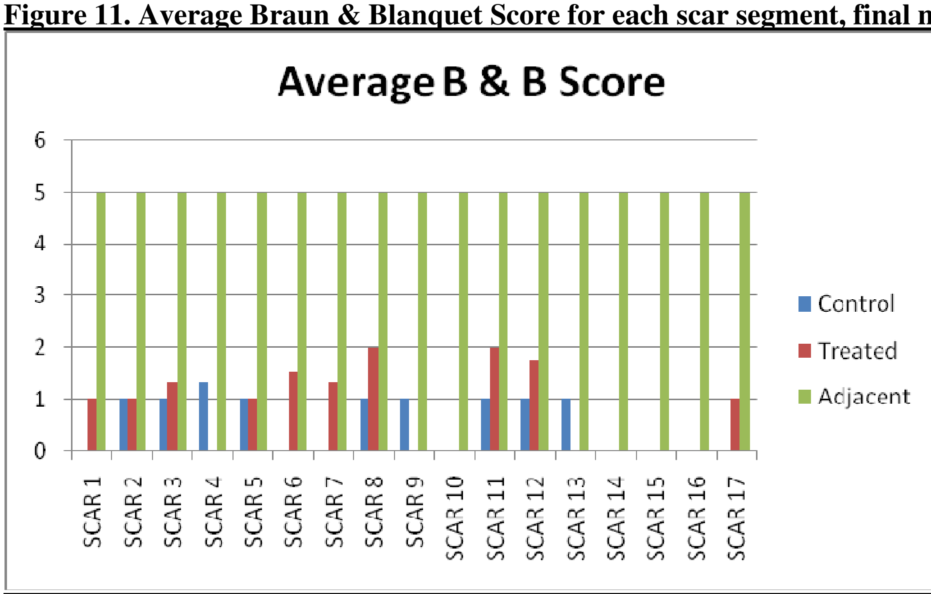
While the mean Braun-Blanquet score differed between the treated and control sites (0.818 versus 0.549; Table 6), a paired T-test showed that this difference was not significant. Appendix 3 provides the full results of the paired T-test. It may be that the difference of when the surveys were conducted (i.e., early in the growing season versus at the end of the growing season) influenced the results. A follow-up survey conducted during the same time of year as the mid-project survey would minimize any growing season differences in project results.

When placed at ambient grade, the tubes clearly stabilized the sediment long enough for SAV colonization. However, where they settled below ambient grade, the tubes may be accelerating the undermining of adjacent seagrass beds. Due to the sediment type and depth, many of the sediment tubes have settled 15 – 18 centimeters below ambient grade. It is recommended in future studies that enough tubes are place in the propeller scars to assure the proper grade is established. An analysis of propeller scar sediment depth is recommended to be completed prior to the placement of the sediment tubes.

Table 6. Final Project Monitoring - Results of the Braun-Blanquet Survey

	TREATED	CONTROL	ADJACENT
SCAR 1	1	0	5
SCAR 2	1	1	5
SCAR 3	1.33	1	5
SCAR 4	0	1.33	5
SCAR 5	1	1	5
SCAR 6	1.5	0	5
SCAR 7	1.33	0	5
SCAR 8	2	1	5
SCAR 9	0	1	5
SCAR 10	0	0	5
SCAR 11	2	1	5
SCAR 12	1.75	1	5
SCAR 13	0	1	5
SCAR 14	0	0	5
SCAR 15	0	0	5
SCAR 16	0	0	5
SCAR 17	1	0	5
mean	0.818	0.549	5.000

Figure 11. Average Braun & Blanquet Score for each scar segment, final monitoring.



Boater Behavior Survey Results

It appears that project boater education activities had an impact on how boaters transited areas in close proximity to the project site. Prior to posting of the kiosk signs and distribution of the brochures, a lower percentage of boaters remained in established channels in areas of shallow seagrass. Prior to the boater education activities, 29% and 38% of boaters transited in an established channel proximate to survey sites "Rest 4" and Rest 1", respectively (Table 8). Although depicted on Figure 2, there is an unofficially marked channel in the vicinity of the restoration area that helps to guide boaters safely through shallow seagrass beds. Following implementation of the boater education activities, 100% of boaters transiting through the sallow seagrass beds in the vicinity of the restoration area stayed within the unofficial channel (Table 8).

Project Outcomes and Indicators

- 17 scars with a total length of approximately 200 meters were filled with sediment tubes. Seagrass was re-established in most of the treated areas with some exceptions. The final survey found that the mean Braun-Blanquet score at the treated areas was slightly less than 1 (0.818), where a score of 1 represents <5% cover; however, some treated areas achieved seagrass cover of up to 75%. A single growing season does not appear to be sufficient for seagrass to re-establish itself in scars treated with sediment tubes. Furthermore, treated scars where the sediment tubes did not achieve ambient grade performed poorly. In these scars, tube elevation should be raised to ambient levels to allow for colonization by adjacent seagrass.

- As with seagrass recolonization of restored scar areas, utilization of treated scar areas by benthic invertebrates is in its early stages and is expected to increase as seagrass continues to fill out the treated scar areas.

- Four educational signs on the value of seagrass and seagrass protection were posted at 4 area boat ramps.

- 5,000 educational brochures providing information on the value of seagrass and seagrass protection as well as a map depicting the location of shallow seagrass areas and boating channels for safe navigation were designed, printed, and distributed at area boating supply stores and public parks.

- Boater awareness, as reflected by better boating practices near the restoration site was achieved.

Table 8. Boater Behavior Survey Summary Results

Monitored Sites	Water Depth (ft)	Boats Observed	Size Range <10 ft	Size Range, 10 - 20 ft	Size Range, 20 - 30 ft	Size, not recorded	Number in/near Channel	Percent in Channel	Motor-ing Fast?	Percent Motoring Fast
Rest 1										
Pre-Survey	0.65	13	2	10	1		5	38%	5	38%
Post Survey	nr	10		8	2		10	100%	8	80%
Rest 4										

Pre-Survey	0.8	14		14			4	29%	8	57%
Post Survey	4	3		3			3	100%	1	33%
Open 2										
Pre-Survey	0.8	6		6			6	100%	4	67%
Post Survey	2	4	1	3			4	100%	3	75%
Sign 2										
Pre-Survey	2.1	7		7			7	100%	4	57%
Post Survey	3	19	1	12	5	1	18	95%	18	95%

(nr = not recorded)

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Appendix 1. Educational Brochure Distributed to Boaters

DID YOU KNOW?

- The waters along Florida's Gulf of Mexico coast contain the most extensive and diverse seagrass meadows in the United States.
- Seagrass meadows rival or exceed most kinds of agriculture in their productivity.
- A single acre of seagrass can produce over 10 tons of leaves per year and can support as many as 40 thousand fish and 50 million invertebrates.
- 70% of Florida's marine recreational fish depend on seagrass communities at some time in their lives.

Photo of Seagrass Prop Scar courtesy of The Nature Conservancy™

SAVE OUR SEAGRASS

- Seagrasses are the basis of marine ecosystems in the Gulf of Mexico. Underwater meadows of seagrass in bays and estuaries serve as valuable nurseries and habitat for many species, including shrimp, crabs and other shellfish, as well as sport fish,such as redfish, and sea trout prized by anglers. Birds, including ducks, shorebirds and wading birds, and sea turtles also depend on thriving seagrasses. The declining quantity and quality of seagrass habitats now represent serious threats to wildlife, recreation and the economy along the Gulf Coast.
- Seagrass meadows around the Suncoast Keys occur in extremely shallow water that may be only inches deep at low tide.
- Seagrass conservation projects are being conducted throughout the Gulf of Mexico and coastal Florida by agencies, non-profit organizations, municipalities and research institutions, to restore seagrass health and raise awareness about the importance of healthy seagrass habitat.

WITH YOUR HELP

- Running boats in shallow waters can damage your boat, as well as destroy seagrass beds. Prop scar damage can take years to recover. Prop scars not only damage the plants, but also destabilize sediments, inhibiting seagrass growth and impacting critical habitat. When you come to shallow water, stop your engine, lift your prop, and pole or troll to your favorite spot.
- This pamphlet provides information to enhance your boating experience in and around the Suncoast Keys, while protecting our valuable marine resources.

The Nature Conservancy
Protecting nature. Preserving life.

NOAA

PROTECTING SEAGRASS

IN AND AROUND THE SUNCOAST KEYS
and the
DEPARTMENT OF ENVIRONMENTAL PROTECTION'S
OFFICE OF COASTAL AND AQUATIC AREAS
ST. MARTINS MARSH AQUATIC PRESERVE

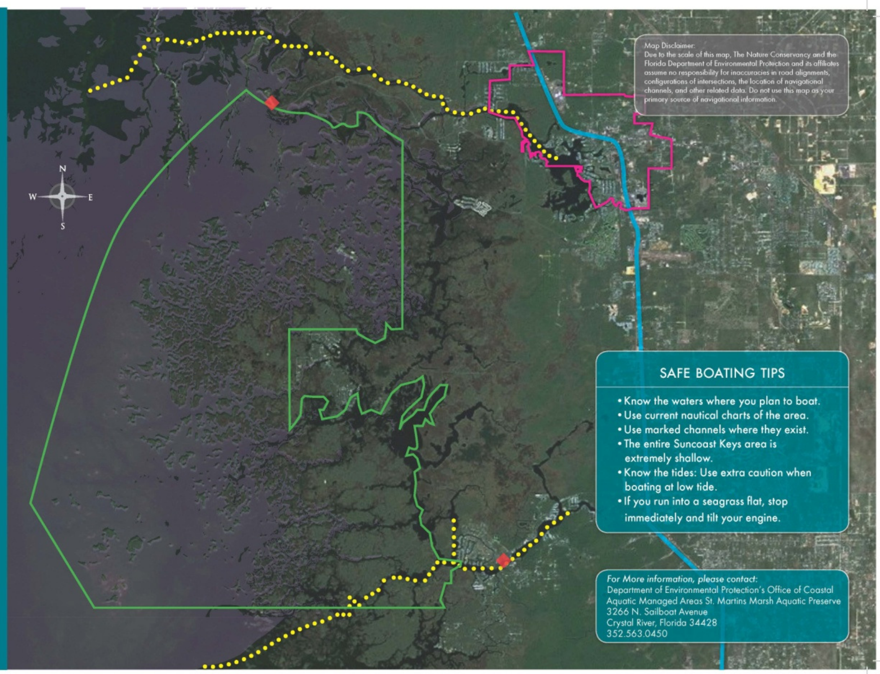
MAP KEY

- This map provides an aerial view of Suncoast Keys/St. Martins March Aquatic Preserve area. The icons are used to identify boat ramps and channels for safe navigation.
- Boaters may encounter restoration projects within shallow seagrass meadows of the Suncoast Keys Area. Is so, do not disturb these areas.
- A number of efforts are underway to expand seagrass conservation efforts in coastal Florida.

Channels
Boat Ramps
US 19
Crystal River
St. Martins Aquatic Marsh Preserve
Areas of Seagrass

BOATER'S ETIQUETTE

- Idle or raise motors when navigating through shallow areas.
- Obey no-motor and no-wake zones.
- Always put your boat in neutral when marine mammals are near and stay at least 100 feet away. Federal law prohibits the enticing, chasing, feeding or touching marine mammals.
- Stash your trash and do not leave fishing line behind. Fishing line can take up to 600 years to biodegrade, and can entangle or be ingested by marine wildlife. Line can also get caught in boat propellers.



Map Disclaimer:
Due to the scale of this map, The Nature Conservancy and the Florida Department of Environmental Protection and its affiliates assume no responsibility for inaccuracies in road alignments, configurations of intersections, the location of navigational channels, and other related data. Do not use this map as your primary source of navigational information.

SAFE BOATING TIPS

- Know the waters where you plan to boat.
- Use current nautical charts of the area.
- Use marked channels where they exist.
- The entire Suncoast Keys area is extremely shallow.
- Know the tides: Use extra caution when boating at low tide.
- If you run into a seagrass flat, stop immediately and tilt your engine.

For More information, please contact:
Department of Environmental Protection's Office of Coastal Aquatic Managed Areas St. Martins Marsh Aquatic Preserve
3266 N. Sailboat Avenue
Crystal River, Florida 34428
352.563.0450

Appendix 2. Photos from Sediment Tube Deployment Day

Appendix 3. Paired T-test Results

Mid-Project Monitoring

P value and statistical significance:

The two-tailed P value equals 0.0437

By conventional criteria, this difference is considered to be statistically significant.

Confidence interval:

The mean of Control minus Treated equals -0.412

95% confidence interval of this difference: From -0.810 to -0.013

Intermediate values used in calculations:

t = 2.1898

df = 16

standard error of difference = 0.188

Review your data:

Group
Control
Treated

Mean
0.529
0.941

SD
0.695
0.556

SEM
0.169
0.135

N
17
17

Final Project Monitoring

P value and statistical significance:

The two-tailed P value equals 0.2034

By conventional criteria, this difference is considered to be not statistically significant.

Confidence interval:

The mean of Control minus Treated equals -0.2694

95% confidence interval of this difference: From -0.7001 to 0.1612

Intermediate values used in calculations:

t = 1.3262
df = 16
standard error of difference = 0.203

Review your data:

Group	Control	Treated
Mean	0.5488	0.8182
SD	0.5390	0.7693
SEM	0.1307	0.1866
N	17	17