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RESTORATION OF SEAGRASS HABITAT IN TAMPA BAY USING LARGE MANATEE GRASS (*SYRINGODIUM FILIFORME*) SOD UNITS AND A DISCUSSION OF PLANTING SITE SEDIMENT ELEVATION DYNAMICS

Prepared for

the Hillsborough County Environmental Recovery Fund
Project 06-02

By

J.O.R. Johansson, W.M. Avery, K.B. Hennenfent and J.J. Pacowta
City of Tampa, Bay Study Group

February 2, 2009

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COVER PHOTO

The cover photo shows the planting area just south of the MacDill AFB in Middle Tampa Bay. The individual planting plots can be seen in the center foreground and the skyline of Tampa can be seen in the background. The picture was taken January 26, 2009.

EXECUTIVE SUMMARY

Extensive losses of seagrass meadows on the off-shore portions of the shallow estuarine shelf in the upper areas of Tampa Bay occurred during the 1960s. Historical records and current observations of areas down-bay suggest that much of the off-shore seagrass losses may have consisted of manatee grass (*Syringodium filiforme*). The primary causes of these seagrass losses apparently resulted from declining water quality and prevalent dredging activities.

Following the off-shore seagrass meadows losses, there also appears to have been substantial erosion of long-shore sandbar formations at the outer deep edge of the shallow estuarine sand shelf in several areas of the bay. These changes suggest that coverage of off-shore grasses, specifically manatee grass, and the presence of long-shore bars may be interdependent. Seagrass meadows are efficient sediment traps and it can be hypothesized that sediment accumulation linked to the off-shore manatee grass meadows may have maintained the long-shore bar systems.

Water quality in Tampa Bay has improved substantially over the last 25 years as a result of anthropogenic oligotrophication. In view of the improvements, the possibility to successfully restore off-shore manatee grass to several areas currently lacking this species became apparent. By selecting an area for seagrass restoration which historically had a prominent long-shore bar present and which presently lacks this feature and manatee grass coverage; it would be possible to test the theory of an interrelationship between off-shore seagrass meadows and the long-shore bars.

A study area that met the objective to test this theory was identified near the MacDill AFB in northern Middle Tampa Bay. About 50 years ago the area had extensive seagrass coverage that extended from the shore to the edge of the estuarine shelf. Recent surveys of the area show that the current seagrass coverage is greatly reduced and that the estuarine shelf lacks a prominent long-shore bar feature.

Approximately 1200, large (0.20m by 0.20m), manatee grass sod units with sediment attached were harvested in the summer of 2006 from a 60ha donor area located in southeastern Old Tampa Bay. The total area of harvested material was about 48m^2. Harvesting methods were designed to minimize impacts to both sediments and seagrass in the area.

The donor material was planted within a few hours of harvesting at the restoration area near the MacDill AFB. The material was placed in six 10m by 20m plots with approximately 200 sods in each. The water depth of the planting plots ranged from about -0.70mLMSL (local mean sea level) to -0.90mLMSL.

Above ground biomass, expressed as short shoot density, canopy height, and area coverage of the planted manatee grass was monitored for two years at approximately six month intervals. In addition, detailed DGPS area mapping of the planted manatee grass was conducted in winter and summer of 2008. The latter measurements included manatee grass

growing within the original 10m by 20m plots and also grass that had expanded beyond the plot perimeters.

In September 2008, two years after plantings, the total manatee grass ground cover was $1340m^2$ (0.33acres). This was a 28 times increase in area cover over the originally planted $48m^2$. All plots showed a substantial increase in area coverage and several of the restored meadows were actively expanding in area coverage at a rate similar to natural growing manatee grass meadows. Further, the per unit area above ground biomass of the restored grass was, in several of the planting plots, similar to, or may have exceeded the biomass of the donor grass at the time of harvest.

Impacts to seagrass and sediments, which were caused by the removal of the seagrass sods in the donor area, were monitored for recovery during the duration of the study. Results show that no visible or measurable impacts from the harvesting activities were evident one year following harvesting.

In addition to the seagrass planting activities, the project also included high resolution kinetic DGPS measurements of sediment elevation within and near the planting plots. These surveys were conducted just prior to planting activities and at approximately six month intervals until summer 2008. The measurements were aimed to determine potential interactions between sediment elevations and the restored seagrass meadows.

The elevation surveys showed that substantial sediment perturbations occurred in the outer-most, and generally deeper, half of the planting area. Changes in sediment elevation in this section ranged from some areas becoming 0.20m deeper, to others becoming 0.25m shallower. The largest elevation changes were associated with the development or movement of several sandbars with amplitudes reaching 0.40m. The large changes in sediment elevations were most likely caused by wave generated turbulence.

The shallower and more near-shore half of the planting area had smaller sediment perturbations. Changes in sediment elevation in this section ranged from some areas becoming 0.15m deeper to others becoming 0.15m shallower. Only relatively small sandbars were present in this area and, consequently, the relief of the area was less uneven than the off-shore half. The near-shore area is located landward of the series of large sandbars in the outer half of the study area and it may have been relatively well shielded from off-shore generated waves.

Final area coverage of the planted manatee grass and its overall condition was generally poorer in the off-shore area than in the more protected near-shore area. The relatively high wave turbulence in the off-shore area may have caused the observed reductions in canopy height; and may also have caused sediment accretion that smothered the grass, erosion that dislodged the grass from the sediment, and potentially high turbidity events that temporarily may have impacted light availability.

The two year study period may not have been sufficiently long to clearly demonstrate a positive relationship between sediment accumulation and the planted manatee grass. Three of the six planting plots showed large expansions in ground cover and had dense and tall manatee grass after two years of growth. However, only one plot in the near-shore area had substantial sediment accretion that may have been associated with the manatee grass.

Measurements of short-term sediment elevation changes between winter and summer of 2008 showed that two plots in the outer-most planting area had sections with substantial sediment losses in which all manatee grass was lost. The "deep" erosion of these areas apparently exceeded the rhizome anchoring depth of the manatee grass. In contrast, a total loss of manatee grass also occurred in an area of one plot where sediments accumulated. This loss of grass appears to have been caused by sediment burial resulting from the movement of a large sandbar.

The final project monitoring results show that the manatee grass transplanting effort was completed successfully. First, the donor site monitoring indicated that disturbances caused by harvesting were fully mitigated within the two year study period. Second, about $1300m^2$ of manatee grass were established in an area previously devoid of this species. Third, at the end of the study period the per unit area above ground biomass of the restored manatee grass in several of the planting plots was similar to, or may have exceeded the biomass of the donor grass at the time of harvest. Finally, several of the restored meadows have been actively expanding in area coverage at a rate similar to natural growing manatee grass meadows.

Although the two year study did not clearly demonstrate a strong relationship between well developed manatee grass meadows and sediment accumulation, several important observations were made of interrelationships between elevation and dynamics of the sediment, and manatee grass growth and survival. The sediment elevation surveys clearly indicated that the off-shore half of the planting area was very dynamic in terms of sediment perturbations and that the near-shore half was less so. These findings assisted in the identification of favorable planting location criteria to be applied in future manatee grass restoration efforts in this area of Tampa Bay.

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INTRODUCTION

The onset of rapidly declining water quality in Tampa Bay in the 1960s, a result of eutrophication and prevalent dredging activities, apparently resulted in extensive losses of seagrass meadows on the off-shore portions of the shallow estuarine shelf in the upper areas of the bay (Lewis et al. 1985; Johansson and Lewis 1992; Lewis et al. 1998). Historical seagrass records of these areas and current observations of similar areas down-bay, which still have thriving off-shore seagrass meadows, suggest that much of the up-bay off-shore seagrass losses that occurred nearly 50 years ago may have consisted of manatee grass (*Syringodium filiforme*) (Phillips 1962; Lewis et al.1985).

There also appears to have been substantial erosion of long-shore sandbar formations following the off-shore seagrass meadows losses (Fonseca et al. 2002). The diminished long-shore bars were located at the outer-most edge of the shallow estuarine sand shelf (Lewis et al. 1985). The bar and seagrass losses suggest that the off-shore grasses and the long-shore bars may have coexisted in a functional association. Seagrass meadows are efficient sediment traps (Koch 2001; Seddon 2004; Boer 2007) and it was hypothesized at the onset of this project that sediment accumulation from the historically well developed off-shore seagrass meadows may have maintained the long-shore bar systems. When the grasses were lost as a result of the causes named above, the potential sediment/seagrass interaction became nonfunctional and the long-shore bars eventually deteriorated as a result of sediment erosion (see Fonseca et al. 2002; Seddon 2004).

Water quality in Tampa Bay has improved substantially over the last 25 years as a result of anthropogenic oligotrophication (Johansson 1991; Johansson and Lewis 1992). In view of the overall bay improvements, and site specific evaluations of current water quality conditions, the possibility to successfully restore off-shore manatee grass to several areas currently lacking such grass became apparent. Further, by selecting an area for manatee seagrass restoration which historically had a prominent long-shore bar present and currently is lacking such a feature, it would also be possible to examine and test the theory of the potential interrelationship between the off-shore seagrass meadows and the long-shore bars.

A suitable study area to address the two objectives of this project was identified near the deep edge of the shallow estuarine shelf near the MacDill AFB in northern Middle Tampa Bay (Figure 1). Aerial photographs from approximately 50 years ago suggest that the selected study area had extensive seagrass coverage that extended from near-shore to the deep edge of a shallow sandbar, located approximately 850m from shore (Figure 2). Recent aerial photography by the Southwest Florida Water Management District in 2002 and fixed seagrass transect information (Avery and Johansson 2005) indicate that current seagrass coverage only extend to about 650m from shore (Figure 2). Further, the outer 100m of the estuarine shelf currently lacks a prominent long-shore bar feature (Johansson pers. obs.); instead, several smaller bars that are parallel to shore occupy the outer area.

A multi-agency work group (see below) implemented a manatee grass restoration project in the selected study area in early summer 2006. Large manatee grass sod units with sediment attached were harvested in southeastern Old Tampa Bay and then transported and planted at the restoration site near the MacDill AFB. Further, extensive measurements of sediment elevations were conducted in the study area during the seagrass transplant project.

The harvesting and planting of the manatee grass sod material was primarily conducted by Tampa Bay Watch staff with help from citizen volunteers and the City of Tampa Bay Study Group (COT-BSG) personnel. Tampa Bay Watch also evaluated the recovery of the seagrass donor sites over the two year study period with assistance from the COT-BSG. The COT-BSG was responsible for quality control of the field activities, periodic progress monitoring of the planted manatee grass and several bathymetric surveys of the planting site. The Coastal Resources Group, Inc. was responsible for securing necessary project permits, and the preparation and submittal of required project progress reports to the permit granters. The Tampa Bay Estuary Program provided oversight and distribution of project funds. Major funding for the project was provided by the Hillsborough County Environmental Pollution Recovery Fund. All project partners provided substantial in-kind contributions.

METHODS

Selection of the Restoration Area

The project area selected for the seagrass restoration and sediment/seagrass interaction studies is located on the shallow estuarine shelf in northern Middle Tampa Bay near Coon Hammock Creek and the MacDill AFB (Figure 1 and 2). The site was selected based on a scientific process which considered water quality conditions, water depth, and estimated photosynthetically active radiation (PAR) availability at the sediment surface. The selection process also included comparisons of those parameters at the restoration site and at other Tampa Bay areas with abundant manatee grass meadows, including the site selected for donor seagrass material.

Harvesting of the Donor Seagrass

Approximately 1200, large (0.20m by 0.20m), manatee grass sod units with sediment attached were harvested during June and July 2006 within a permitted, near 60ha, donor area located in south-eastern Old Tampa Bay (Figure 1 and 3). Large sod units were chosen because prior seagrass restoration efforts in Tampa Bay, and in other areas, have suggested that such material provides a high probability of survival of the planting units (Fonseca 1994; Avery and Johansson 2006; Lewis et al. 2006; Paling et al. 2007).

Harvesting was conducted in a manner designed to minimize impacts to both the sediments and the seagrass of the donor area. Collections of the sod units were spaced over nearly the entire donor area and the removal of individual units were spatially separated by about 3m. Further, harvesting was scheduled during high tides to minimize boat impacts to the area.

The seagrass material was immediately placed in transportation containers following harvesting to ensure that each collected plug was maintained as a near intact unit during handling and transportation (Figure 3). The donor site was located approximately 9km (transportation distance) from the planting site.

Evaluation of the Harvested Manatee Grass

During harvesting of the donor material, 36 manatee grass sod units were randomly selected and examined for: 1) number of apical meristems per unit, 2) number of short shoots per unit, 3) average canopy height, and 4) above and below ground biomass measured as dry weight per m^{-2} (gdwt m^{-2}). All manatee grass blades were carefully scraped of epiphytes; and the seagrass biomass material was dried for twenty-four hours at 102C and cooled prior to weighing.

Planting Technique

The harvested manatee grass was transported by shallow draft boats, kept shaded and wet, and was planted within a few hours of harvesting at the restoration area near the MacDill AFB (Figure 4). The sod units were carefully removed from the transportation containers and planted level with the surrounding sediment by hand on 1m centers at six 10m by 20m sites (Figure 5 and 6). Approximately 200 sods were planted at each site.

The water depth of the six planting plots ranged from about -0.70mLMSL (local mean sea level) to -0.90mLMSL. This depth range was selected because pre-planting estimates of sub surface light conditions at the planting area indicated that more than 25 percent of incident PAR light would reach the deepest planted grass on an annual averaged basis. Similar light availability exists in other areas of Tampa Bay that currently have healthy manatee grass meadows (Johansson 2002), including the donor area. Overall light conditions at the transplant area were, therefore, not expected to limit the survival and growth of the transplanted seagrass material.

Monitoring of the Donor Area

The recovery of seagrass and sediment loss caused by removal of the seagrass sod units in the donor area was monitored at 16 selected donor sites during the duration of the study by Tampa Bay Watch. Monitoring was conducted at the time of sod removal and about six months, one year and two years following removal. Please see Appendices A, B, C, D and E in this report, which include periodic monitoring reports prepared by Kruer (2006; 2007a; 2007b; 2008a; 2008b), for detailed descriptions of donor site monitoring procedures and discussions of monitoring results.

Monitoring of the Planted Manatee Grass

The restoration sites were monitored for survival and growth of the planted manatee grass about every six months since planting, from June 2006 through September 2008. Initially, 10 percent of the seagrass sods units from each planting plot were randomly selected for measurements of: 1) area coverage, 2) percent seagrass coverage within a $1m^{-2}$quadrate reported as Braun Blanquet (1965) class coverage assessments, 3) short shoot density and 4) canopy height. Area coverage was determined by measuring the major and minor axis of the selected sods (Figure 7) and then calculating the area using the ellipse area formula.

Coalition of the planted manatee grass sod units was first noted during the monitoring survey in January 2007. Because of the ongoing coalition, a modified monitoring technique was used for that and subsequent surveys of the manatee grass growing within the perimeter of the planting plots. The new method used 20 randomly placed $1m^{-2}$ quadrates within each planting plot to determine the above listed seagrass characteristics. Further, area coverage of the planted manatee grass for each of the six planting plots was estimated by multiplying the average percent cover from the 20 $1m^{-2}$ placements by the plot area ($200m^{-2}$).

During the January 2008 survey it became evident that the planted manatee grass had expanded outside the perimeter of the 10m by 20m planting plots in several locations. To accurately evaluate the total amount of manatee grass restored to the area during the project, detailed DGPS ground cover area mappings were conducted in January 2008 and September 2008. These measurements included all manatee grass growing within the plot perimeters and also the grass that had expanded beyond the perimeters. Further, the September 2008 survey also included a final measurement of manatee grass short shoot density and canopy height at the six plots.

In addition to the ground level monitoring events, low level helicopter oblique aerial photography of the planting sites was conducted on a near quarterly schedule. These photos were not used for quantitative determinations, but were used to illustrate the overall progress of the planted manatee grass during the course of the study (Figure 8).

Measurements and Monitoring of Sediment Elevation

In addition to seagrass plantings, the project also included high resolution kinetic DGPS sediment elevation measurements (see Johansson 2002) of the six planting sites and a 100m by 300m area encompassing the planting sites. Elevation measurements were conducted just prior to planting activities in summer 2006 and about every six months following transplanting until summer 2008. These measurements were aimed to determine potential sediment elevation dynamics associated with the restored seagrass meadows.

To illustrate measured sediment elevations of the planting area at specific time periods the information from each individual elevation survey was contoured using natural neighbor gridding (Surfer 7, Golden Software, Inc.) and the results were plotted as colored shaded-relief images. Also, to determine and illustrate the overall long-term changes in sediment elevation of the planting area over the two year study period, summer 2006 elevations were subtracted from the summer 2008 elevations, thus providing a new dataset giving positive and negative elevation differences. This dataset was also contoured using natural neighbor gridding. In the resulting tables and figures from these calculations, positive difference corresponds to deepening and negative difference to shallowing.

Further, short-term sediment elevation changes, which occurred in the planting area over a near six month period between winter and summer of 2008, were also calculated and illustrated in a similar manner as the long-term changes that occurred over the two year study period. The shorter time period was of particular interest because it appears to have been an active period for both sediment dynamics and growth of the planted manatee grass.

Measurements of Sediment and Seagrass Interaction

The long-term sediment elevation changes that occurred in the planting area over the two year study period were evaluated against the two year final manatee grass monitoring results. The purpose of the long-term examination was to seek support for the hypothesized interrelationship between sediment accumulation and well developed seagrass meadows.

Specifically, long-term sediment accumulation that occurred within the six 10m by 20m plots, and also within a similar sized area located just shoreward of each planting plot, were first examined and then associated with the final above ground biomass monitoring results obtained in summer 2008. The area located just shoreward of each planting plot was of interest because naturally occurring manatee grass meadows in Tampa Bay, and other seagrass species as well, often have accumulations of sediment, or smaller sandbars, near the shoreward edge of the meadows or just shoreward of the meadow (Johansson and Avery pers. obs.).

The short-term sediment elevation changes that occurred in the planting area during the 6 month period between winter 2008 and summer 2008 were also examined and evaluated against detailed DGPS measurements of manatee grass area expansion or contraction that had occurred in each planting plot over approximately the same time period. It was anticipated that a detailed examination of the short-term period would provide instructive insight on potential interactions between sediment gains and losses and the planted manatee grass coverage.

RESULTS

Evaluation of the Harvested Manatee Grass

The 36 randomly selected manatee grass sod units collected at the donor area were examined for both above and below ground seagrass characteristics. The evaluation showed that mean short shoot counts and canopy height measurements were 3469±1166m^{-2} and 0.39±0.05m, respectively (Figure 9). In addition, the mean apical meristem density was 297±161m^{-2} and the mean above ground and below ground biomass were 99±30gdwt m^{-2} and 207±95gdwt m^{-2}, respectively.

The density and biomass values of the manatee grass harvested in the donor area were similar to those reported elsewhere in Florida. In the Indian River Lagoon, Short et al. (1993) reported a maximum short shoot density of ca 3000m^{-2} and an above and below ground biomass of 87±161gdwt m^{-2} and 103±94gdwt m^{-2}, respectively. Similar results have been reported from Florida Bay (Zieman 1982; Kenworthy and Schwarzchild 1998; Rose et al. 1999) and Tampa Bay (Lewis et al.1985).

Recovery of the Donor Area

Seagrass and sediment recovery at the 16 designated sod unit collection sites in the donor area were initially evaluated by Tampa Bay Watch in August 2007, about one year following the harvest. A detailed discussion of the one year donor site monitoring results is included in Appendix C (Kruer 2007b). Those results indicate that no visible or measurable impacts to manatee grass coverage or sediments were evident at the donor site one year following harvesting. It was concluded that all 16 collection sites had successfully and fully recovered within one year. Additional monitoring events were, however, conducted in November 2007 and July 2008. The results from the later surveys, discussed in Appendix D and E (Kruer 2008a and 2008b), confirmed the one year results.

It was anticipated, prior to harvesting, that the donor sites would recover relatively quickly following the impacts caused by harvesting because; 1) the seagrass meadows in the donor area appeared stable and healthy at the time of harvesting and 2) the harvesting methods were specifically designed to minimize impacts to the surrounding seagrass and sediments. Similar relatively quick recovery of manatee grass donor sites in Florida have been reported by Fonseca et al. (1994).

Growth and Horizontal Expansion Rate of the Planted Manatee Grass

Detailed results of all randomly conducted evaluations of the six manatee grass planting plots, in terms of area coverage, short-shoot density, canopy height and Braun-Blanquet abundance are illustrated and discussed in Appendix B, C, D and E (Kruer 2007a; 2007b; 2008a; 2008b). The two paragraphs below provide a summary of the results from the manatee grass evaluations over the two year study period.

The six manatee grass restoration plots were surveyed in July 2008 for two year progress in area coverage growth following the plantings in summer 2006. This survey utilized the random technique to determine area coverage and seagrass condition within the perimeters of the planting plots. The amount of manatee grass that was originally planted in each of the six plots, in terms of area coverage, was approximately $8m^2$ for each plot, or a total of about $48m^2$. In July 2008, approximately two years following plantings, the total estimated cover from the random surveys within the 20m by 10m perimeter of the six planting plots was estimated at $600m^2$, which equals an overall average of 50% area coverage in the six plots. However, manatee grass coverage among the 6 plots varied greatly, but all plots showed a substantial increase in coverage after two years (Appendix E; Kruer 2008b).

The first evaluation of density and canopy height of the planted manatee grass was conducted in late July 2006. At that time the seagrass at the six restoration plots was relatively dense, on average about 1180short-shoots/m^2, and had a canopy height at about 0.18m. In the July 2008 survey, the respective values for these parameters were about 1229short-shoots/m^2 and 0.36m. Similar to variations in ground cover between the six plots, there were also large variations between plots in these parameters, however, all plots, except Plots 1 and 2, showed substantial increases in these parameters over the two year study period (Appendix E; Kruer 2008b).

In addition to the random surveys, detailed DGPS ground cover area mappings were conducted in January and September 2008. These measurements included all manatee grass growing within the 10m by 20m plot perimeters and also the grass that had expanded beyond the perimeters. Therefore, the mapping effort provided an accurate evaluation of the total amount of manatee grass restored over the two year project period. The final DGPS survey in September 2008 showed that the total manatee grass coverage for the six plots was $1340m^2$ (0.33acres), which equals a 28 times increase in manatee grass cover over the approximately two year study period. There were variations in coverage between the six plots after two years; however, all sites showed a substantial increase (Figure 9).

The September 2008 DGPS mapping survey also included manatee grass short-shoot density and canopy height measurements (Figure 9). The short-shoot measurements showed that all plots had relatively dense grass two years following plantings, but that the values were somewhat lower than that of the harvested material. Canopy height for all six plots, on the other hand, substantially exceeded the height of the grass that was harvested. The two measures of above ground biomass suggest that the restored manatee grass had relatively high biomass and that its above ground biomass per unit area was similar to that found at the donor site.

In addition, the detailed perimeter surveys of the planted manatee grass also showed that the area covered by manatee grass in Plots 5 and 6, the two most near-shore plots, had expanded substantially over the eight month period between January and September 2008. (Figure 10). During the 8 month period, the outer perimeter of the grass in both plots had extended about 1m in most directions. The 1m spreading of the planting plots over this period was equal to a patch edge expansion rate of about 0.004m day^{-1}, or about 1.5m yr^{-1}.

Sediment Elevation of the Planting Plots

The sediment elevation, or water depth at local mean sea level, of the six planting plots ranged from about -0.70mLMSL to -0.90mLMSL at the time of planting. However, there were large elevation changes at several plots over the two year study period as a result of sediment erosion and accretion (Figure 11). A more detailed discussion of elevation changes seen for the individual plots will be provided under the heading "Seagrass and Sediment Interactions" below.

Sediment Elevation Dynamics

Comparisons of sediment elevation measurements from the start of the study in June 2006 to the end in July 2008 show that substantial sediment perturbations occurred in the outer-most, and generally deeper, half of the planting area (Figure 11 and 12). Seagrass Plots 1, 2 and 3 were planted in this area. Changes in sediment elevation in the off-shore area ranged from some areas becoming 0.20m deeper to others becoming 0.25m shallower. The largest elevation changes were associated with the development or movement of sandbars with amplitudes reaching 0.40m. Several sandbars were present throughout the study period in the outer-most section of the planting area. These bars were located parallel with the deep off-shore edge of the shallow estuarine shelf, but were approximately 50m to 100m inshore of the location of the historical prominent off-shore bar.

The shallower and more near-shore half of the planting area had smaller sediment perturbations (Figure 11 and 12). Seagrass Plots 4, 5, and 6 were planted in this area. Changes in sediment elevation in the near-shore area over the two year study period ranged from some areas becoming 0.15m deeper to others becoming 0.15m shallower. Only relatively small sandbars were present in this area during the study period and, consequently, the relief of the area was less uneven than the off-shore half. The near-shore area was located landward of the series of sandbars in the outer half of the study area and may have been relatively well shielded from wave energy (Fonseca et al 2002; Lewis 2002; Dai et al. 2008).

Seagrass and Sediment Interactions

The examination of potential long-term sediment accumulation that may have occurred in the manatee grass planting area as a result of sediment trapping by the planted grass is discussed below. Changes in sediment elevation, or water depth, for each of the six 10m by 20m planting plots, and also the area of similar size located just shoreward of each planting plot, are discussed individually.

Plot 1. The depth of the planted plot increased slightly over the two year study period and the area just shoreward of the plot became slightly shallower (Figure 11 and 13A). The manatee grass coverage and density were, when compared to several other plots, relatively sparse and thin after two years of growth (Figure 9). It is unlikely that the slight sediment accumulation noted in the shoreward area was caused by the planted manatee grass because areas both east and west of the shoreward area, which lacked manatee grass, showed similar sediment accumulation.

Plot 2. The depth of the planted plot increased substantially over the two year study period and the area just shoreward of the plot became substantially shallower (Figure 11 and 13A). The manatee grass coverage and density were, when compared to several other plots, relatively sparse and thin after two years of growth (Figure 9). It is not likely that the planted manatee grass caused the sediment accumulation noted in the shoreward area because areas both east and west of the shoreward area, which lacked manatee grass, had similar sediment accumulation.

Plot 3. The depth of the planted plot changed little over the two year study period; however, the south-east section became substantially deeper (Figure 11 and 13B). It will be shown later that all planted manatee grass was lost in this deepened area. The shoreward area within and just outside the plot became moderately shallower. The manatee grass coverage was relatively sparse after two years of growth when compared to several other plots and the density was relatively low (Figure 9). It is doubtful that the sediment accumulation noted in the shoreward area was caused by the relatively sparse manatee grass, because as with Plots 1 and 2, areas both east and west of the shoreward area had similar or greater sediment accumulation than the shoreward area.

Plot 4. The planted plot became substantially deeper over the two year study period, and the area just shoreward of the plot became slightly deeper (Figure 11 and 13B). The manatee grass coverage and density were both relatively high after two years of growth (Figure 9). However, no sediment accumulation was noted in the shoreward area and it appears that the well developed manatee grass in this planting plot had little or no impact on sediment accumulation.

Plot 5. The planted plot became substantially shallower over the two year study period, and the area just shoreward of the plot became shallower near the edge of the manatee grass coverage (Figure 11 and 13C). The manatee grass in this plot had the highest area coverage, density and canopy height of all plots after two years of growth (Figure 9). Sediment accumulation within the plot was near 0.15m and it was about 0.10m just shoreward of the planted plot. Further, similar sediment accumulations were not seen in areas east and west of the just shoreward area. It is, therefore, reasonable to assume that the extensive, dense and tall manatee grass within the plot had contributed to the noted sediment accumulation both within and just shoreward of the plot.

Plot 6. Both the planted plot and the area just shoreward of the plot had relatively small sediment elevation changes over the two year study period (Figure 11 and 13C). The area just shoreward of the plot appears to have become slightly shallower. The manatee grass in this plot also had high area coverage, density and canopy height after two years of growth (Figure 9). However, the small amount of sediment accumulation just shoreward of the plot was less than the accumulation in an area to the west, which lacked manatee grass. It appears that the well developed manatee grass in this planting plot had little or no impact on sediment accumulation.

Results from the short-term and comprehensive examination of potential manatee grass/sediment interactions that occurred within the six 10m by 20m transplanting plots between January 2008 and summer 2008 will be presented and discussed in the Discussion section of the report.

DISCUSSION

Performance of the Manatee Grass Restoration Effort

The final project monitoring results from the donor area and the restoration area attest to a successful completion of the manatee grass restoration effort. First, the donor site monitoring indicated that disturbances caused to the donor site by harvesting activities were fully mitigated within the two year study period. This was postulated to occur based on results from other harvesting projects conducted in similar stable and healthy seagrass meadows (see Fonseca 1994). Second, the restoration of about 1300m^2 of manatee grass, two years following plantings, in an area previously devoid of this species clearly indicates that the seagrass transplanting portion of the project was successful. Third, at the end of the study period the per unit area above ground biomass of the restored manatee grass in several of the planting plots was similar to, or may have exceeded the biomass of the donor grass at the time of harvest. Finally, several of the restored meadows were actively expanding in area coverage at a rate similar to natural growing manatee grass meadows. Meadow expansions will be discussed further in the following section.

The positive outcome of the restoration project may have been linked to the application of the following techniques and approaches:

1. The efforts to minimize impacts, to the greatest extent possible, to both the sediments and seagrass of the donor area during harvesting most probably aided in the successful and quick recovery of the donor site within the two year study period. The quick recovery was evidenced by a lack of visible or measurable impacts to seagrass coverage and sediments one year following the sod removal.

2. The restoration site was selected based on a scientific selection which considered water quality conditions, water depth and estimates of PAR light availability at the sediment surface. This step also included comparisons of water quality and submarine light conditions between the restoration site and other Tampa Bay areas with abundant manatee grass meadows, including the selected donor area.

3. The donor material was carefully evaluated, collected and handled to ensure high survival rate and growth potential. Further, the relatively large planting units, with the natural sediment matrix attached, contained a substantial amount of intact manatee grass biomass with numerous apical meristems.

4. The harvested manatee grass was kept shaded and wet, and were placed in transportation containers to maintain intactness during handling and transportation. The sod units were handled carefully during planting and were planted, by hand, at the same level as the surrounding sediment to minimize effects of sediment scouring. All harvested material was planted within a few hours of harvesting.

5. Planting occurred during early and mid summer and prior to the onset of the annual rainy period. This time window may have allowed the newly planted manatee grass a brief, but potentially important period of relatively calm weather and good underwater light climate to recover from relocation impacts and to acclimatize to the new environment.

6. Finally, no devices were employed at the planting plots to deter bioturbation or encroachment of drift algae. These tools may at times accomplish their intended purposes (see Fonseca 1994); however, it has also been observed that such devices may interfere with the growth and survival of the planted grass (Johansson pers. obs.). For example, they may disrupt the natural flow of water and sediments at the planted sites, and they may attract both animal and vegetation fouling organisms that can shade or in other ways retard growth. Also, the devices could potentially reduce bioturbation activities that may enhance seagrass recruitment to the area (see Fonseca et al. 2008). As discussed below, bioturbation did not appear to have had a substantial impact on the survival and growth of the unprotected planted manatee grass sods in the current project. Paling et al. (2007) also found that planted seagrass sods had relatively low susceptibility to bioturbation.

Planting Patch Expansions and Anticipated Future Progress of Growth

The measured expansion rate for the patch edge of the planted manatee grass in Plots 5 and 6 was about 1.5m yr^{-1} (Figure 10). This rate is within the 0.5m yr^{-1} to 1.82m yr^{-1} rate that has been reported for horizontal rhizome elongation of manatee grass in a wide range of environments (Marba and Duarte 1998; Kendall et al. 2004; Cabaço et al. 2008). Further, Fonseca et al.(2004; as discussed in Kendall et al. 2004) calculated that edges of naturally growing manatee grass patches in the Florida Keys advanced at 1.23m yr^{-1}, which is within the range of the reported rhizome elongation rate and very similar to the measured rate for edge of patch expansion in the current study.

The measured expansion rate for the edge of the planted manatee grass in Plots 5 and 6 suggests that these plots will coalesce early 2010, assuming that the current rate remains constant. Coalescence may also occur between these plots and Plot 4 in that time frame, however, any further coalescence between plots appears unlikely in the near future due to the greater distance between the remaining plots (Figure 12) and their apparent slow expansion rate.

The most recent area measurements indicate that all plots, except Plots 2 and 3, have developed substantial area coverage and biomass amounts, and could be expected to withstand, at least temporarily, detrimental conditions such as reduced light availability caused by degraded water quality conditions. Plots 2 and 3, experienced losses of area coverage during the last six months of the project and the losses, specifically, in Plot 3 were considerable (Figure 14). The recent losses make the future outlook for these two plots uncertain. Later it will be shown that these plots apparently were established in the most physically dynamic section of the planting area. Forces such as wave turbulence and sediment scouring and accretion, could be expected to be more detrimental to seagrass growth in this dynamic area than in more quiescent areas. Persistent exposure to these forces may cause additional seagrass losses in Plots 2 and 3 and the eventual demise of the planted manatee grass.

Interactions between the Sediment and the Planted Manatee Grass

Seagrasses have been identified as ecosystem engineers because of their ability to change their own environment (Koch 2001). Specifically, their ability to stabilize and accumulate sediments by reducing water currents and turbulence over the meadows is generally recognized to be beneficial to the grass by stimulating growth and decreasing mortality from erosion (see reviews by Koch 2001; Boer 2007). Other important ways the seagrasses may affect their environment are also discussed in those articles.

The manatee grass restoration project addressed the seagrass/sediment interaction process in a two pronged approach. First, sediment elevation changes that occurred in the manatee grass planting area over the two year study period were compared to the two year and final seagrass monitoring results. This step attempted to determine the long-term ability of the planted manatee grass to accumulate sediments within the planting plots or in areas just shoreward of the plots. Second, more short-term seagrass/sediment interactions that occurred over an approximately six to eight month period between January 2008 and summer 2008 were also examined. The purpose of the short-term analysis was to provide insight on the ability of the planted manatee grass to withstand sediment burial and erosion. This period was selected because substantial sediment perturbations occurred in the study area over this period and, further, very detailed information on the planted manatee grass area coverage was available from the surveys conducted in January and September 2008.

Long-term Interactions:

Long-term sediment accumulation within and near the planted manatee grass plots were not readily apparent at most plots, possibly suggesting that the two year study period was not sufficiently long to clearly demonstrate a relationship between well developed manatee grass meadows and sediment accumulation. Four of the six planting plots showed large expansions in ground cover and had dense and tall manatee grass after two years of growth (Figure 9), however, only planting Plot 5 had substantial sediment accretion that may have been associated with the manatee grass (Figure 13C). Sediment accumulation ranging from about 0.10m to 0.15m was measured within Plot 5 and just shoreward of the planted area. Sediment accumulation also occurred near several other plots. It is, however, difficult to associate this latter sediment accumulation with the planted manatee grass because areas near these plots, but outside the expected influence of the manatee grass, also had similar or greater sediment accumulation. Shoal grass (*Halodule wrightii*) was abundant outside most plots, specifically towards the end of the two year study period. However, this species have relatively narrow and short blades and would not be expected to have a large influence on sediment accumulation (see Mellors et al. 2002).

The substantial changes in sediment elevations which occurred in the outer-most, and generally deeper, half of the seagrass restoration area over the two year study period were most likely caused by off-shore generated waves impacting the outer edge of the estuarine shelf. The physical impact of waves in this area may have hindered the planted manatee grass to reach the high densities and area coverage attained by the more near-shore and protected plots (see Fonseca and Bell 1998; Koch 2001; Fonseca et al. 2002; Seddon 2004; Cruz-Palacios et al. 2005). Planting Plots 2 and 3 were located in this dynamic section of the planting area (Figure 12). These plots had the lowest manatee grass area coverage of all plots at the end of the study and also low above ground biomass (Figure 9). Further, both plots became overall deeper over the two year study period with sections of the plots losing up to 0.20m of sediments (Figures 13A and 13B).

The wave generated turbulence present in the outer-most planting area may have caused numerous impacts to the planted manatee grass, including loss of leaf canopy, sediment accretion that smothered the grass, erosion that dislodged the grass from the sediment and also high turbidity events that temporarily may have impacted light availability (see Koch 2001; Kendall et al. 2004; Cabaço et al. 2008). It is unlikely that the relatively low values of above ground biomass and area coverage observed in this dynamic area resulted from bioturbation or man-made local and smaller-scale physical disturbances. In addition, no obvious effects of bioturbation were noted in the very dense and tall manatee grass growing in the more protected plots in the near-shore planting area.

Short-term Interactions:

Short-term seagrass/sediment interactions that occurred between January 2008 and summer 2008 were also apparent in planting Plots 2 and 3 in the outer-most and generally deeper portion of the planting area. During this period, both plots had sections with substantial sediment losses, ranging from about 0.10m to 0.20m, in which all manatee grass was lost (Figure 14). In a comprehensive review of short-term impacts on seagrass from experimental sediment burial and erosion Cabaço et al. (2008) reported that manatee grass suffered 50% mortality at a 0.045m erosion level over 60 days. That level of erosion was greatly exceeded in sections of Plots 2 and 3 where 100% manatee grass loss occurred during the short-term period. Cabaço et al. (2008) also reported that "deep" erosion of 0.10m, which exceeded the anchoring depth of the manatee grass, did not produce a total loss of grass in the laboratory experiments. This unexpected finding may have resulted from the reviewed experiments being of a relatively short duration. Total loss of manatee grass could be expected when the anchoring depth of the grass is exceeded for an extended period; which appeared to have occurred in sections of Plots 2 and 3.

In contrast to the total loss of planted manatee grass in areas of erosion in Plots 2 and 3, a total loss of manatee grass also occurred during the short-term period in a large area of the near-shore portion of Plot 3 where sediment accumulated from about 0.05m to 0.20m. Cabaço et al. (2008) reported that an experimental burial level of 0.10m over 60 days caused 100% mortality of manatee grass. The amount of sediment accretion in Plot 3, where total loss of manatee grass occurred, was similar to or exceeded 0.10m. Therefore, a near $100m^2$ large loss of manatee grass that occurred between January and June/July 2008 in the near-shore section of Plot 3 appears to have been caused by sediment burial. Specifically, the shallowing of the near-shore portion of Plot 3, and the seagrass losses, may have resulted from the apparent movement in the off-shore direction of a large sandbar located between Plots 3 and 4 (Figure 15). There are several similar observations of seagrass burial and losses by migrating sand waves referenced in the literature (see Boer 2007; Cabaço et al. 2008;), including observations from Hillsborough Bay by Avery and Johansson (2006). The near 10m movement of the sand bar in the off-shore direction was unanticipated; however, Backstrom et al. (2008) have reported that storm events which create off-shore-directed water currents on the shallow shelf may transport sand in the off-shore direction.

Considerations for Future Planting Projects

An important finding of the planting project was the identification of an apparent favorable planting location or "sweet spot" for manatee grass restoration in the selected study area. The water depth of Plots 4, 5 and 6, where the highest above ground biomass developed, ranged from about -0.60mLMSL to -1.00mLMSL. This depth range effectively encompassed the depth range of all planted plots. However, Plots 4, 5 and 6 were located in the near-shore half of the planting area and landward of the series of sandbars in the outer half of the study area. As a result, these plots may have been relatively well shielded from off-shore generated waves. The observation that relatively minor sediment perturbations occurred in the near-shore area during the project supports that conclusion. The discovery of the apparent favorable planting location for manatee grass restoration in the study area appears to have resulted from the selection of both appropriate water depth and sufficient protection from wave turbulence.

A second phase project to restore additional manatee grass to the estuarine shelf off the MacDill AFB in Middle Tampa Bay is planned for the spring of 2009. The planned project will utilize and build on lessons learned from the successful completion of the 2006 through 2008 Phase 1 project. The harvesting and planting methodology utilized for the Phase 2 project will essentially remain identical to those used during the first project because of the positive outcome of the first project.

The water depth of the area selected for the Phase 2 manatee grass restoration project ranges from approximately -0.60mLMSL to -0.80mLMSL and is also located shoreward of a series of pronounced off-shore sandbars and should, therefore, be within the envelope of the favorable criteria for successful manatee grass restoration. The new planting area has, as opposed to the initial conditions found at the Phase 1 area, a relatively abundant shoal grass cover. Should the shoal grass persist and still be present when Phase 2 is initiated then the new project will be used to test a method of seagrass habitat community restoration referred to as “compressed succession.” This method accelerates the natural process of succession by planting a higher successional stage seagrass species (in our case manatee grass) within an established meadow of a colonizing species (in our case shoal grass) (see Fonseca et al. 1994; Seddon 2004).

CONCLUSIONS

The manatee grass transplanting project near the MacDill AFB in Middle Tampa Bay, conducted from summer 2006 through summer 2008, was completed successfully. First, the donor site monitoring indicated that disturbances caused to the donor site by harvesting activities were fully mitigated within the two year study period. Second, the restoration of about 1300m^2 of manatee grass, two years following plantings, in an area previously devoid of this species clearly indicates that the seagrass transplanting portion of the project was successful. Third, at the end of the study period the per unit area above ground biomass of the restored manatee grass in several of the planting plots was similar to, or may have exceeded the above ground biomass of the donor grass at the time of harvest. Finally, several of the restored meadows were actively expanding in area coverage at a rate similar to natural growing manatee grass meadows.

Although the two year study did not clearly demonstrate a strong relationship between well developed manatee grass meadows and sediment accumulation, several important observations were made of interrelationships between sediment dynamics and manatee grass growth and survival. Also, the sediment elevation surveys conducted over the two year period clearly indicated that the off-shore half of the planting area was very dynamic in terms of sediment perturbations and that the inshore half was less so. These findings assisted in the identification of favorable planting location criteria to be applied in future manatee grass restoration efforts in this area of Tampa Bay.

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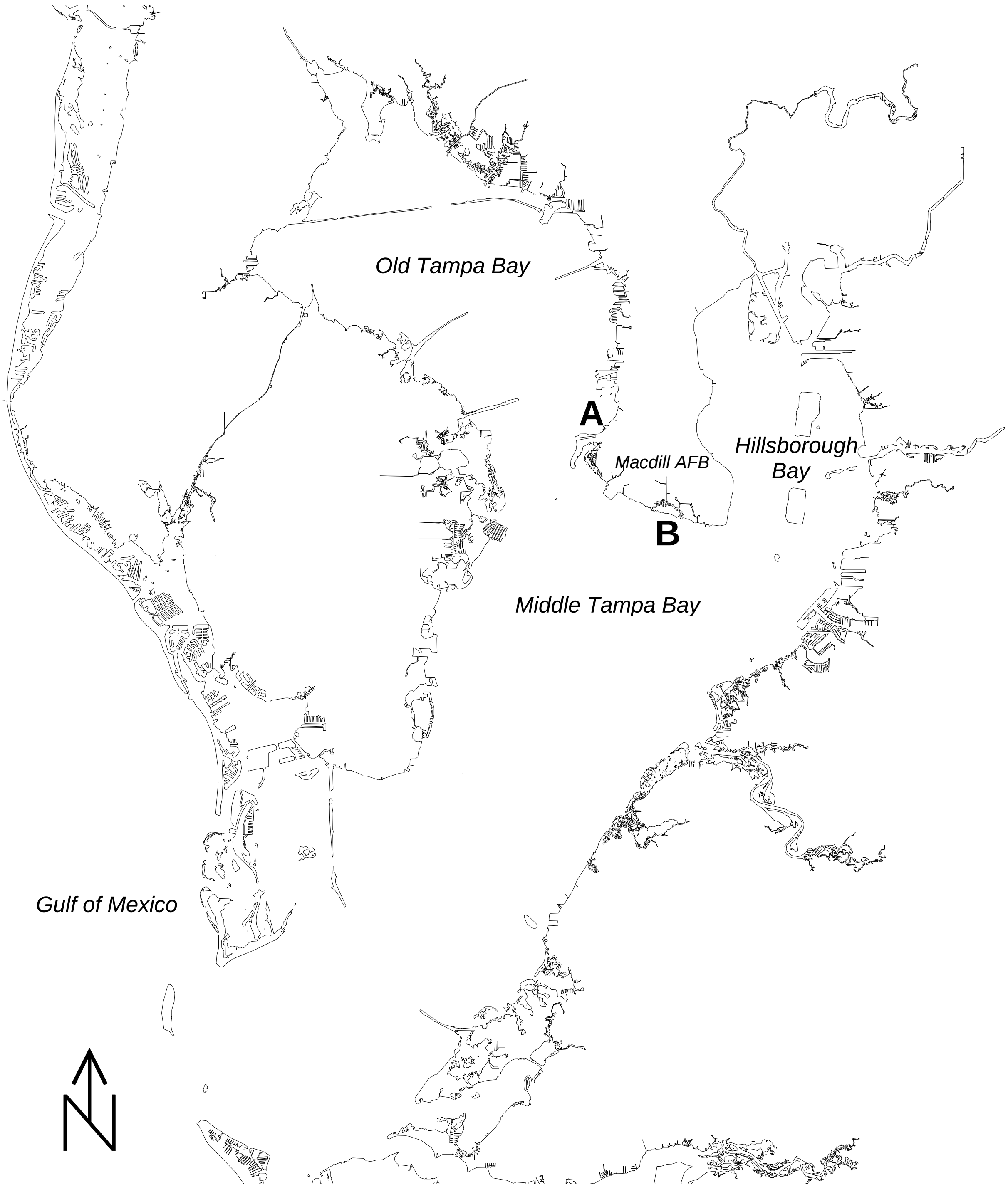

Figure 1. Location of the manatee grass (*Syringodium filiforme*) donor site in eastern Old Tampa Bay (A) and the planting area near MacDill AFB in upper Middle Tampa Bay (B).

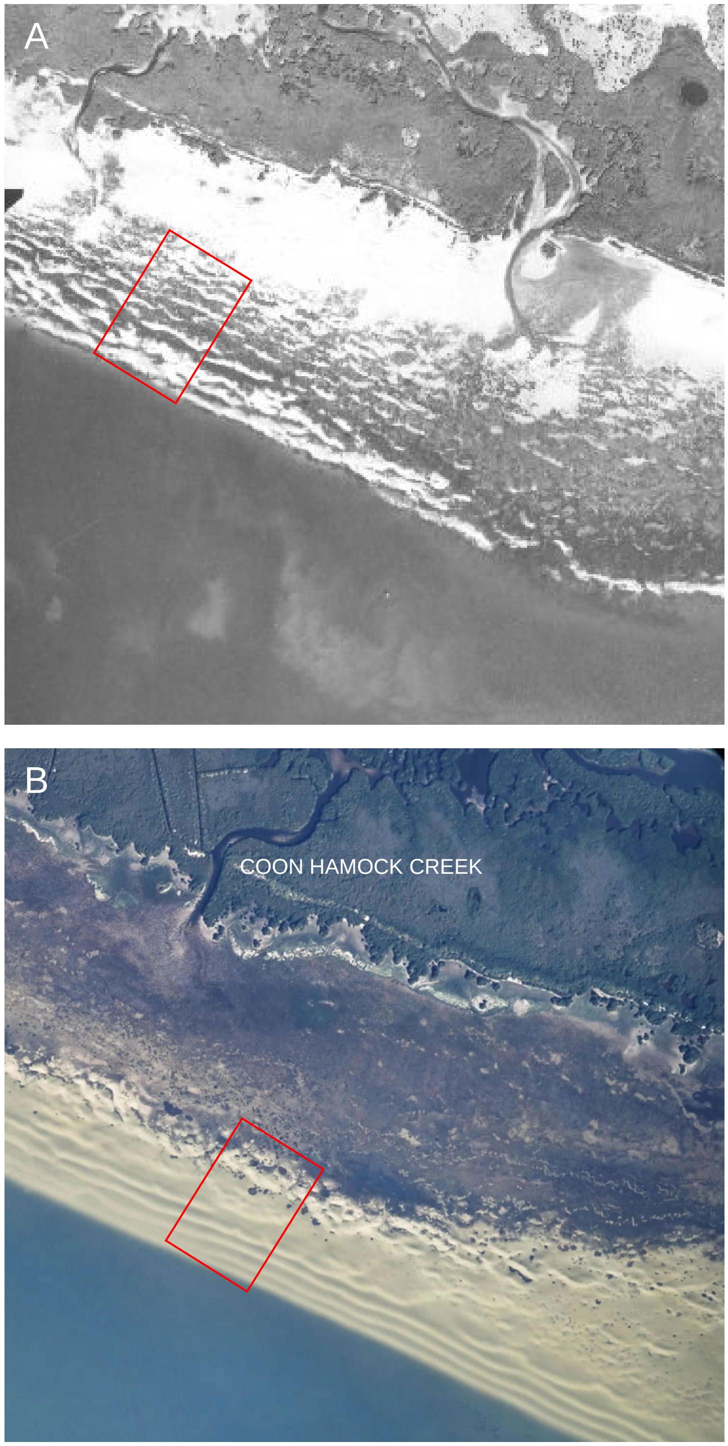

Figure 2. Aerial photographs of the shallow estuarine shelf south of MacDill AFB in Middle Tampa Bay (A-1938 USDA; B-2002 SWFWMD). The rectangles outlined in red show the general area selected for the manatee grass plantings.

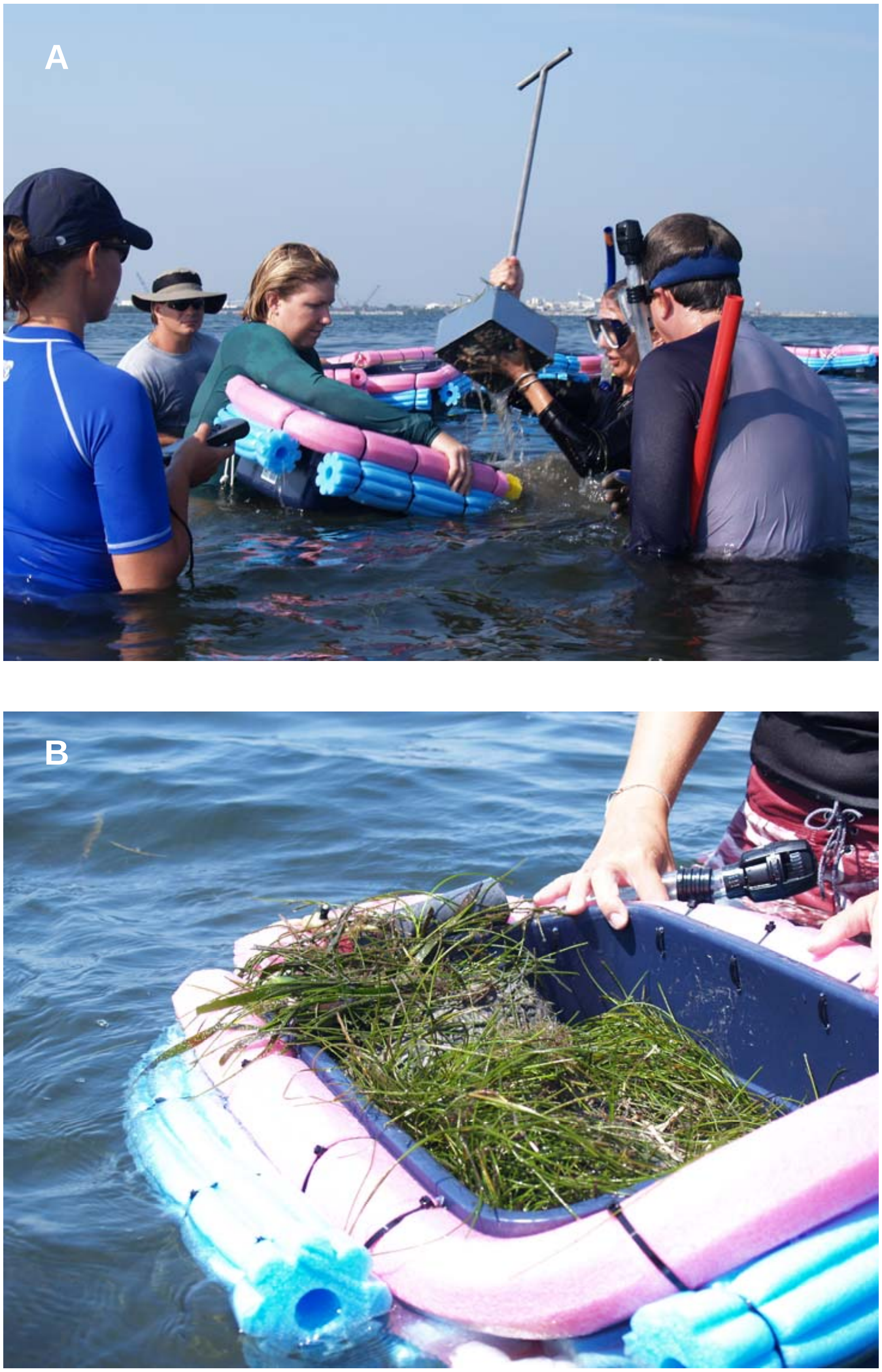

Figure 3. Harvesting of manatee grass sod units, showing (A) stainless steel collection device and WAAS corrected GPS recorder, and (B) sod transportation container.

Figure 4. Location of the six manatee grass planting plots on the estuarine shelf south of MacDill AFB in Middle Tampa Bay. Planting Plot 1 is the most off-shore plot and Plot 6 is the most near-shore plot. Hillsborough Bay is seen in the background.

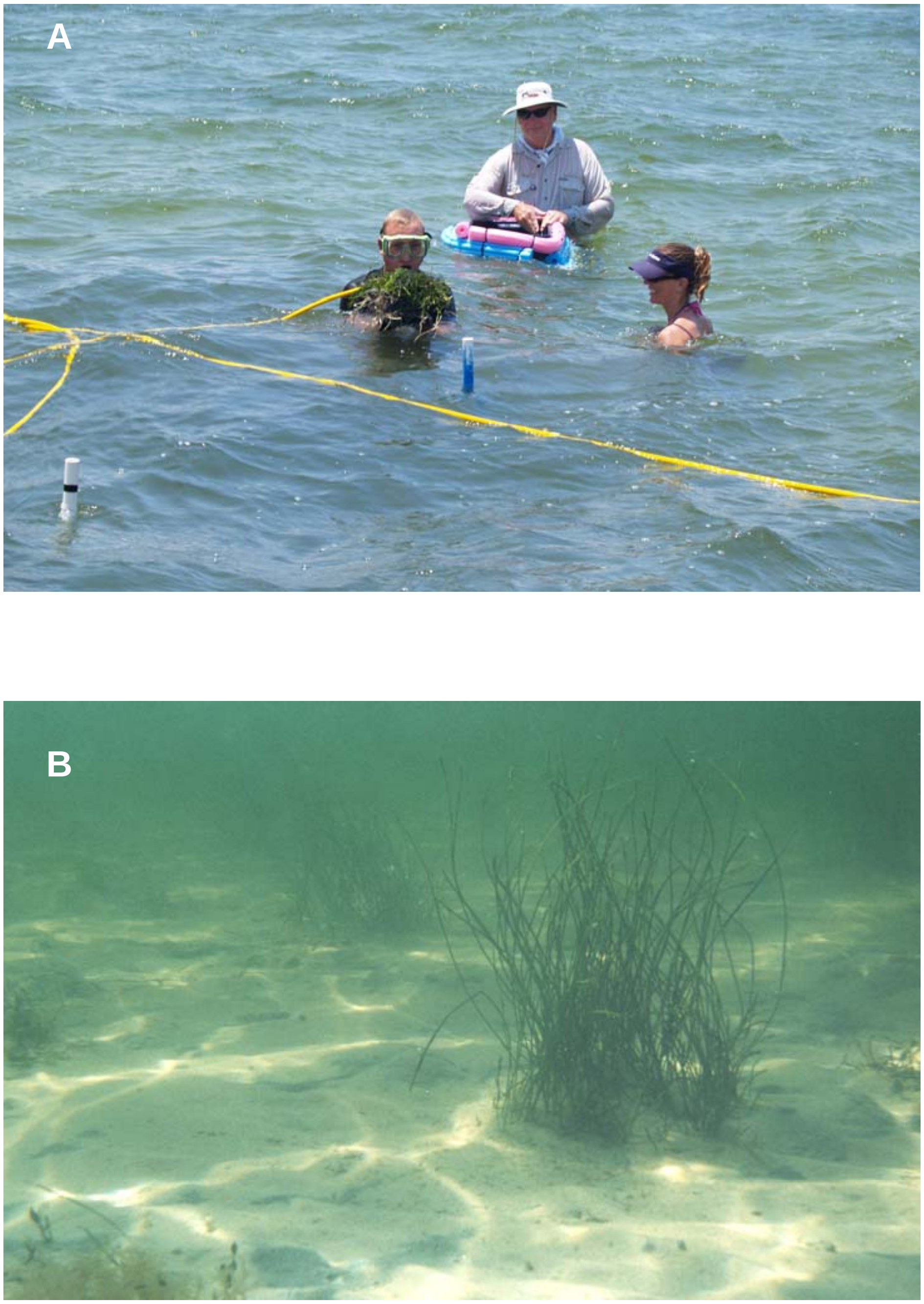

Figure 5. (A) Planting of manatee grass sod units. (B) Underwater photo of a freshly planted unit.

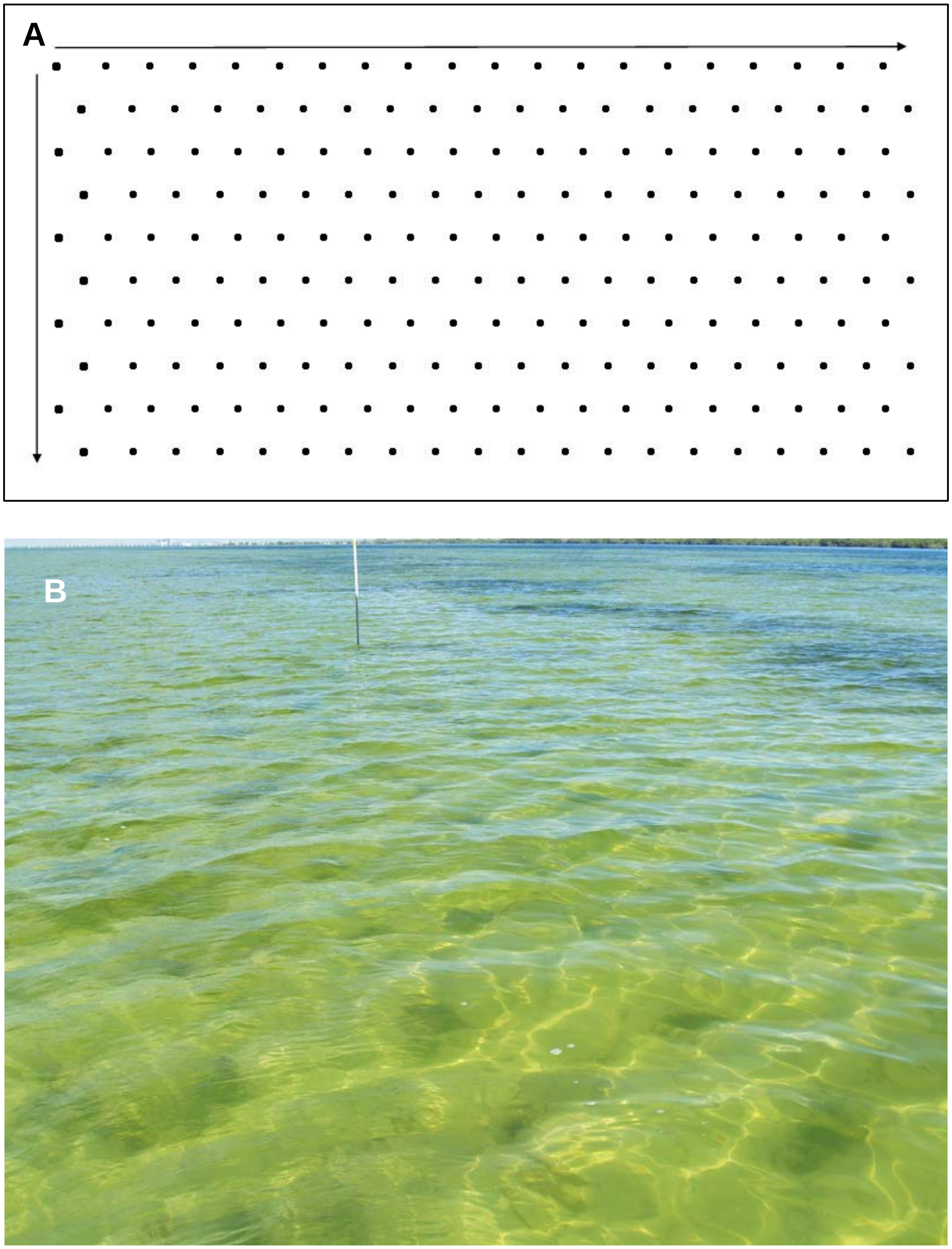

Figure 6. (A) Drawing showing the planting design of the manatee grass sod units used for each of the six planting plots. Planting units were placed on 1m centers in the 10m by 20m plot area. (B) Photo of the freshly planted sod units.

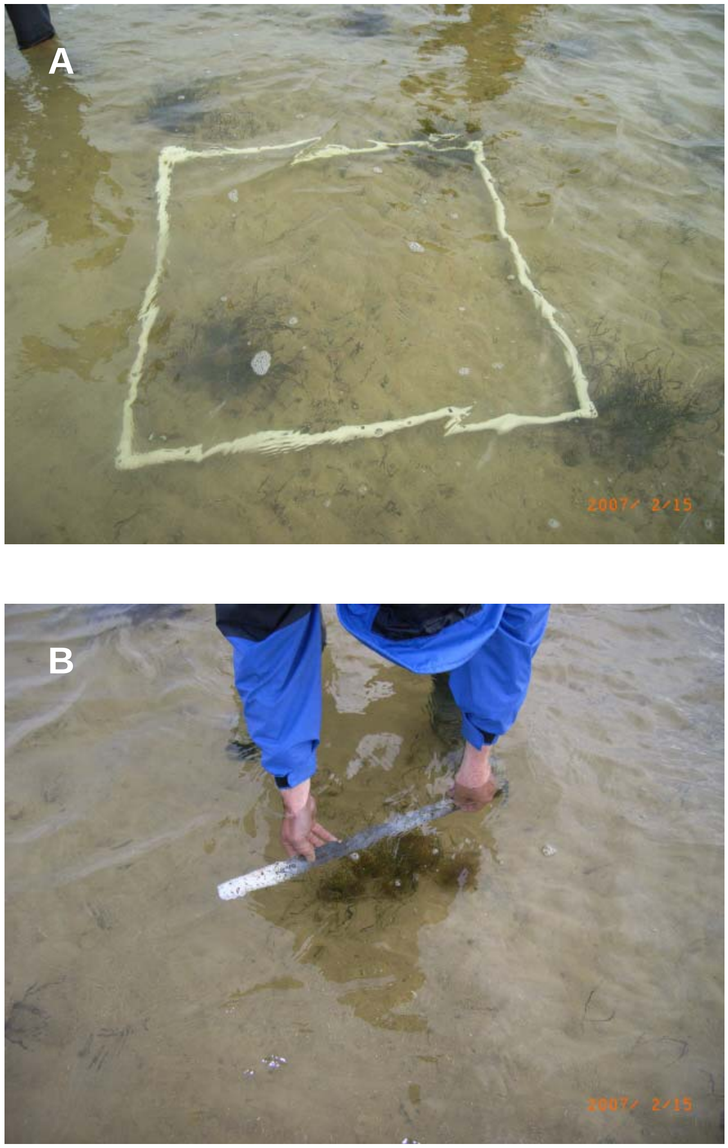

Figure 7. Monitoring of the planted manatee grass sod units. (A) Measurements of percent seagrass coverage and (B) area coverage.

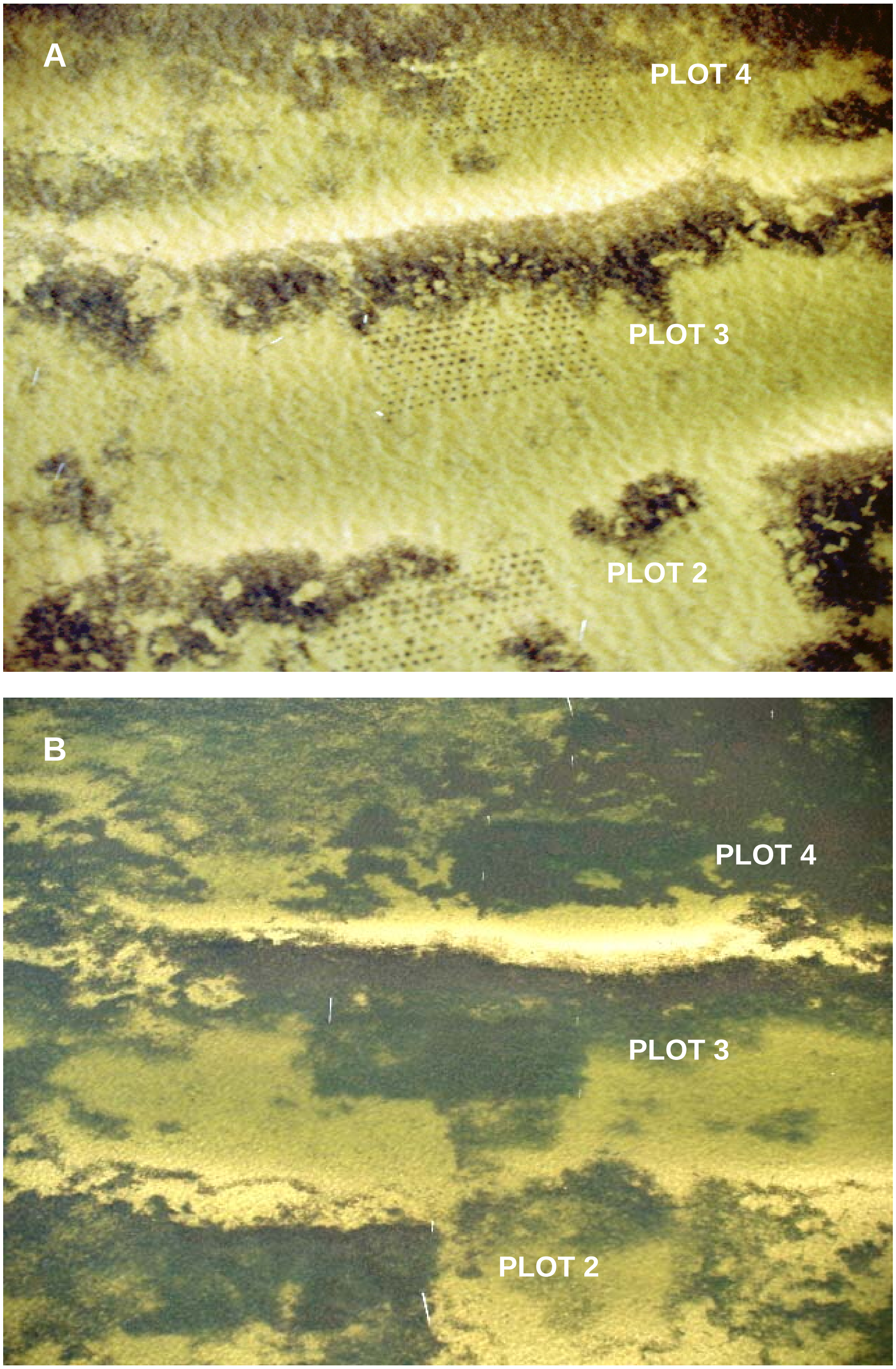

Figure 8. Oblique aerial photographs of planting Plots 2, 3 and 4 taken on (A) November 2006 and (B) November 2007.

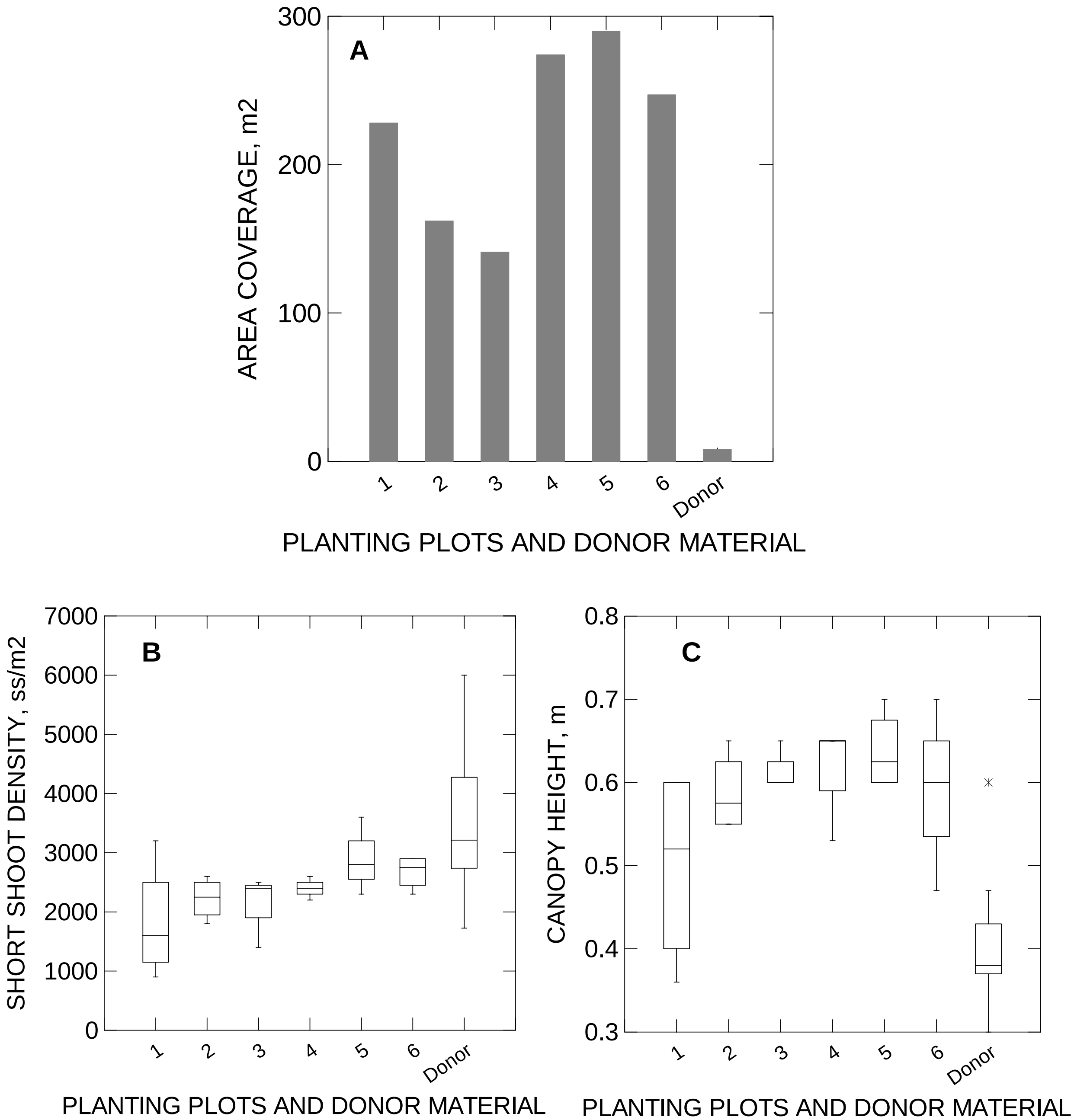

Figure 9. Comparison of results from the September 2008 monitoring of seagrass characteristics for the planted manatee grass at each planting plot and the initial characteristics of the donor material: (A) area coverage (please note that all plots initially had $8m^2$ of total coverage), (B) short shoot density and (C) canopy height.

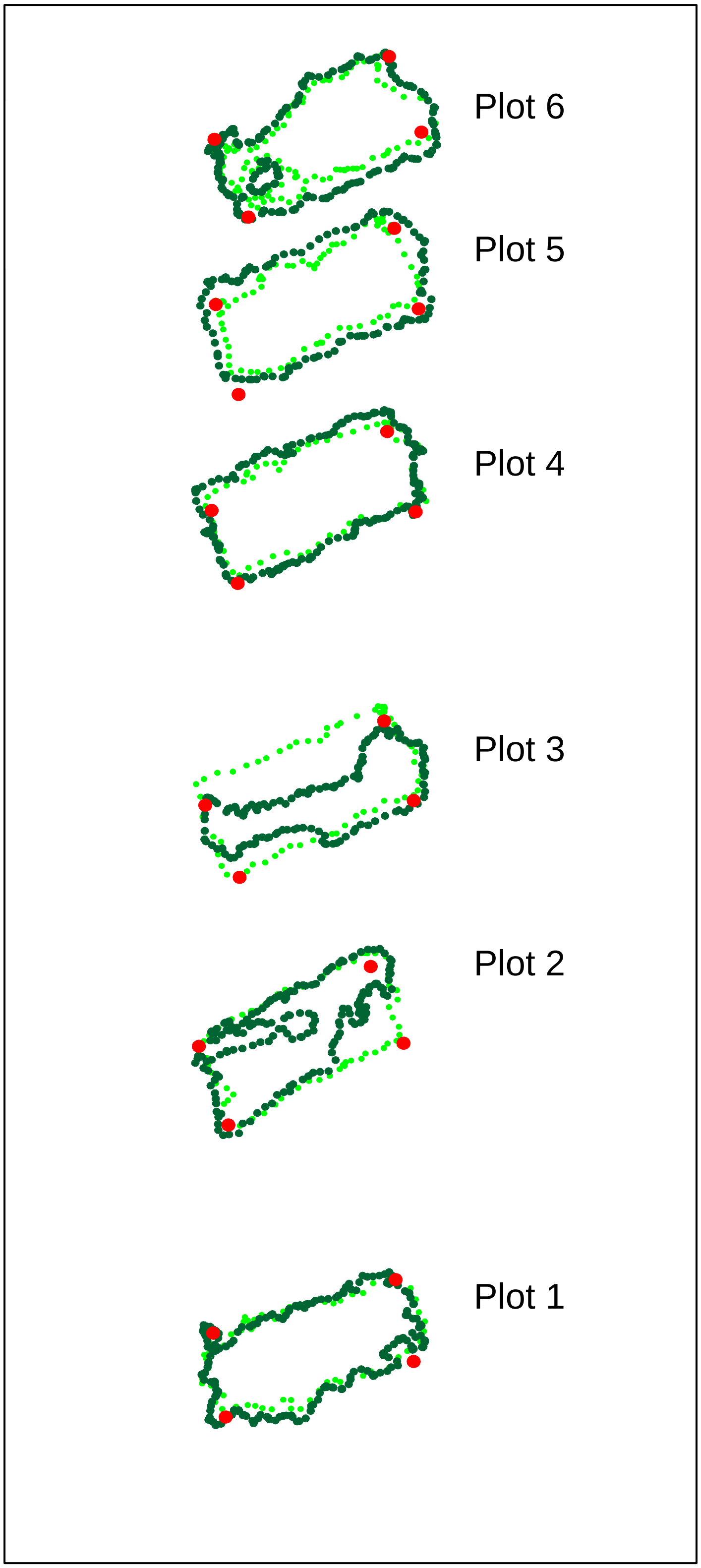

Figure 10. Perimeter surveys of manatee grass area coverage at the six planting plots conducted in January (light green symbols) and September 2008 (dark green symbols). The planting plot corner posts are also shown. The short sides of the plots are 10m.

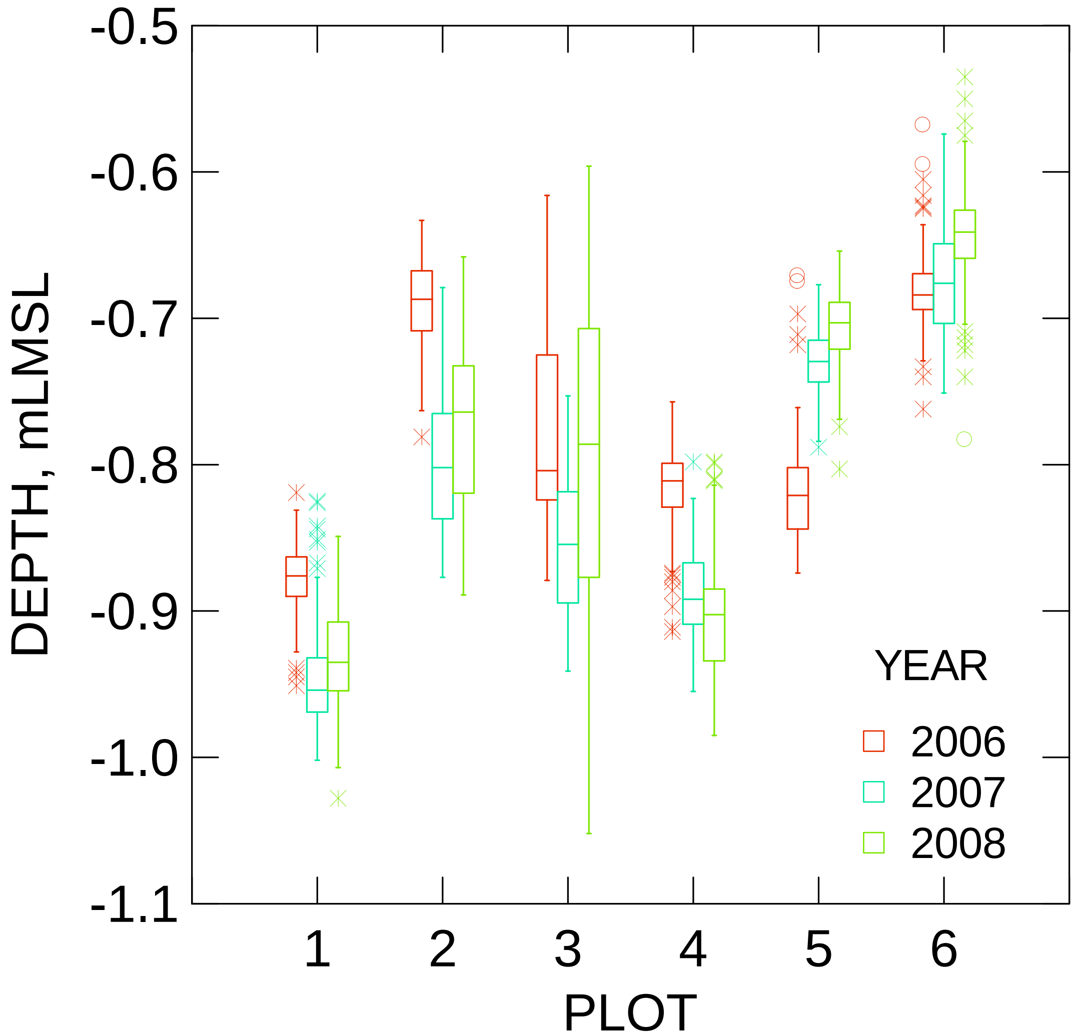

Figure 11. Box and whisker plots of measured sediment elevations (water depth at local mean sea level) within the perimeters of the six planting plots. Surveys were conducted in summer 2006, 2007 and 2008.

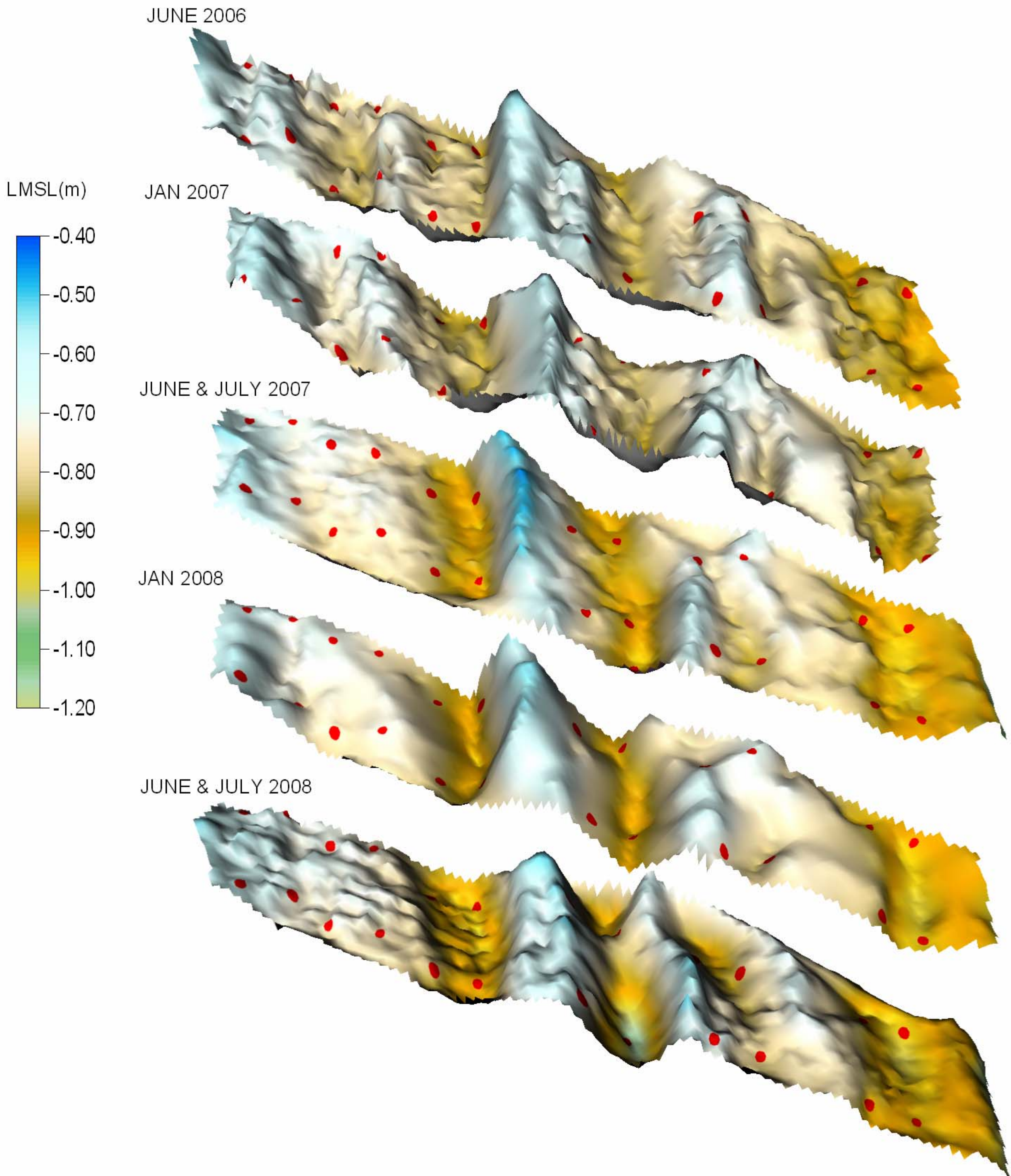

Figure 12. Sediment elevation surface plots showing bathymetry of the planting area at the start of the project and two years later at the end of the project. The red markers show the corners of the six planting plots (Plot 1, the most off-shore plot, is to the right and Plot 6, the most near-shore plot, is to the left).

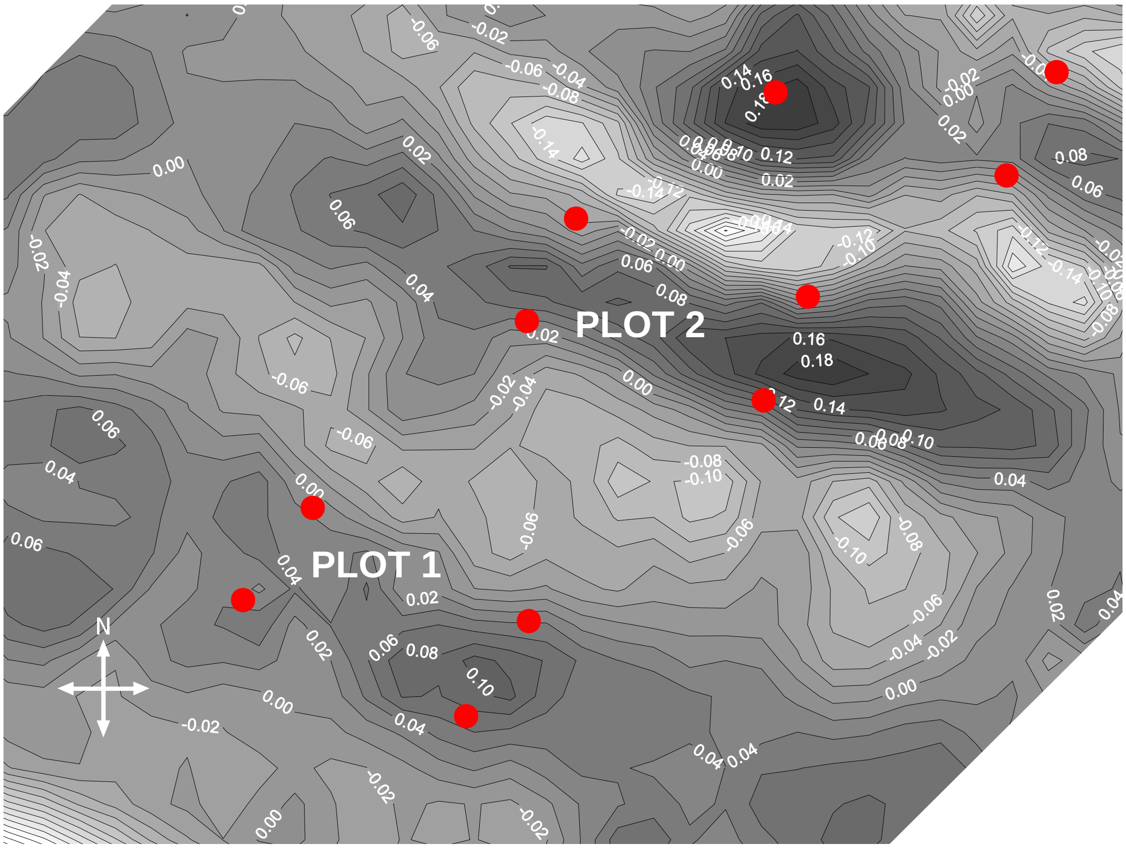

Figure 13A. Contours of sediment elevation change that occurred within and outside planting Plots 1 and 2 over the two year study project. Elevation surveys conducted in summer 2006 and summer 2008 were used for the change analysis. Positive values and dark shading show areas that became deeper, and negative values and light shading indicate areas that became shallower.

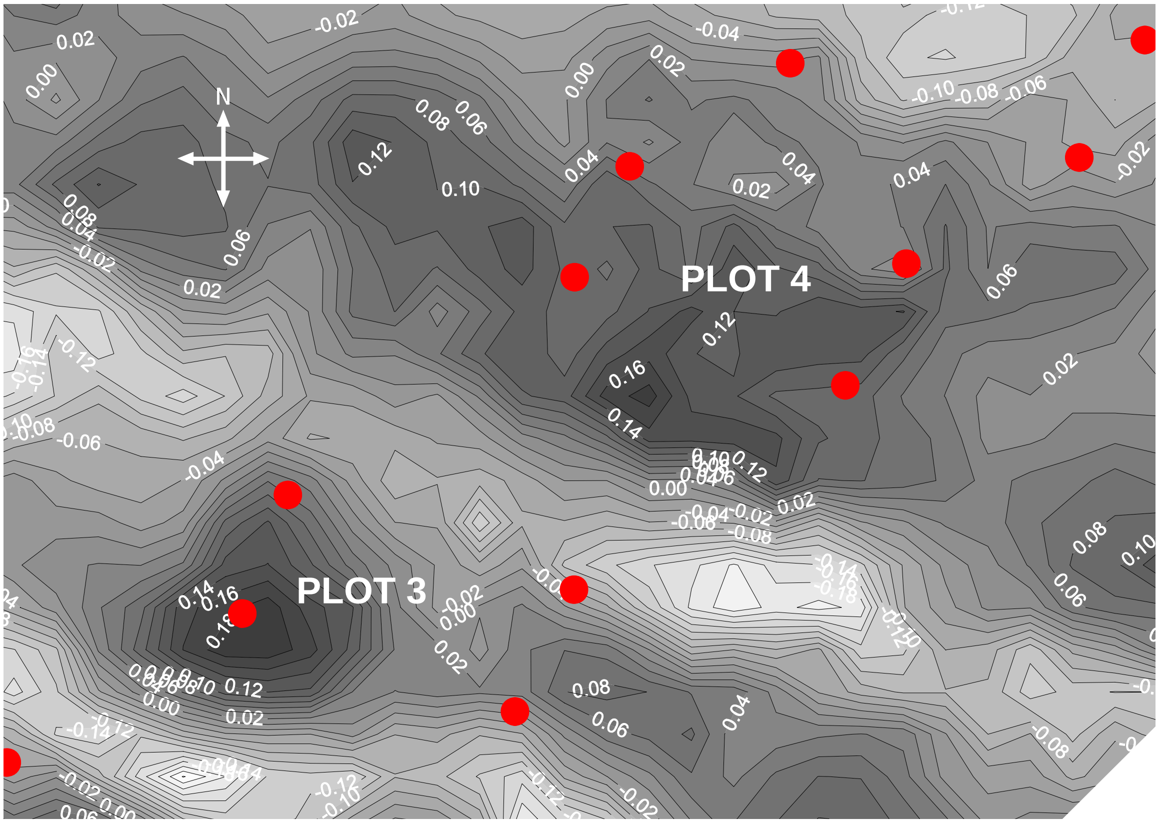

Figure 13B. Contours of sediment elevation change that occurred within and outside planting Plots 3 and 4 over the two year study project. Elevation surveys conducted in summer 2006 and summer 2008 were used for the change analysis. Positive values and dark shading show areas that became deeper, and negative values and light shading indicate areas that became shallower.

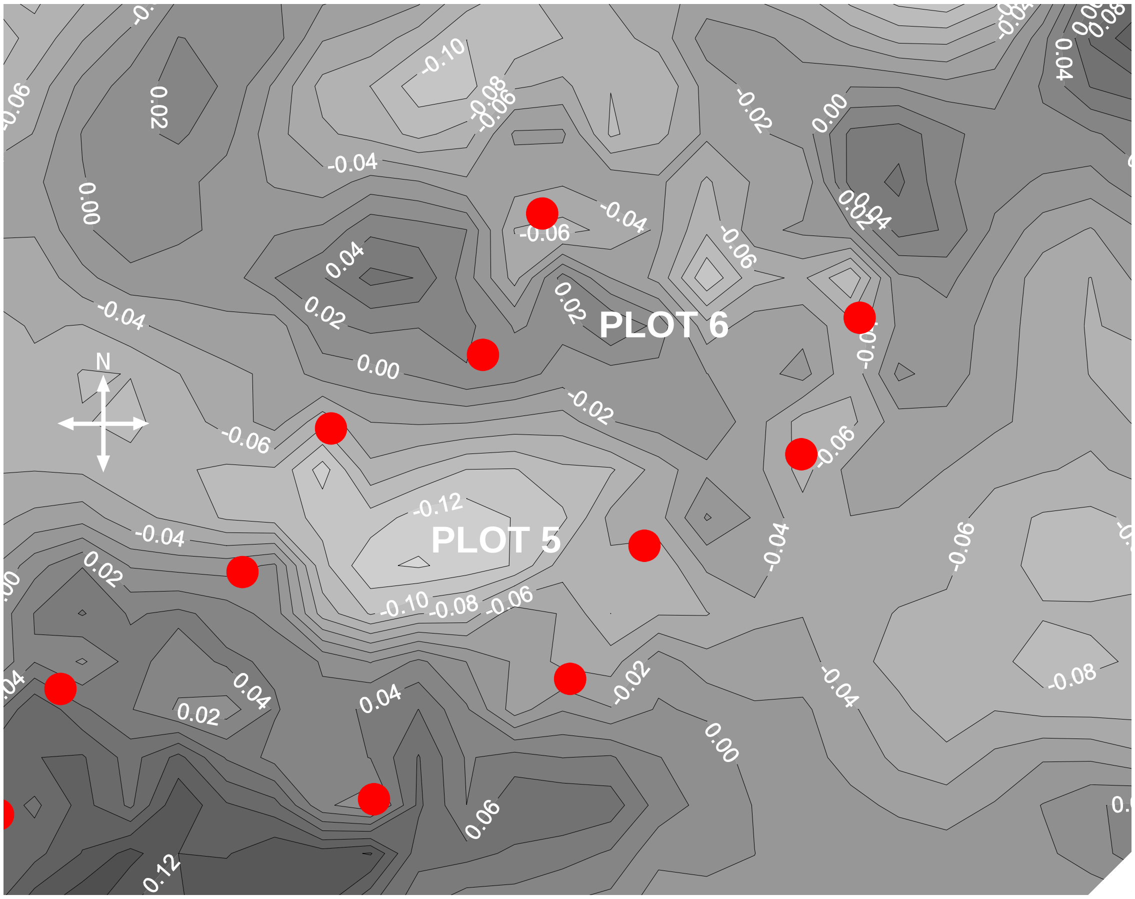

Figure 13C. Contours of sediment elevation change that occurred within and outside planting Plots 5 and 6 over the two year study project. Elevation surveys conducted in summer 2006 and summer 2008 were used for the change analysis. Positive values and dark shading show areas that became deeper, and negative values and light shading indicate areas that became shallower.

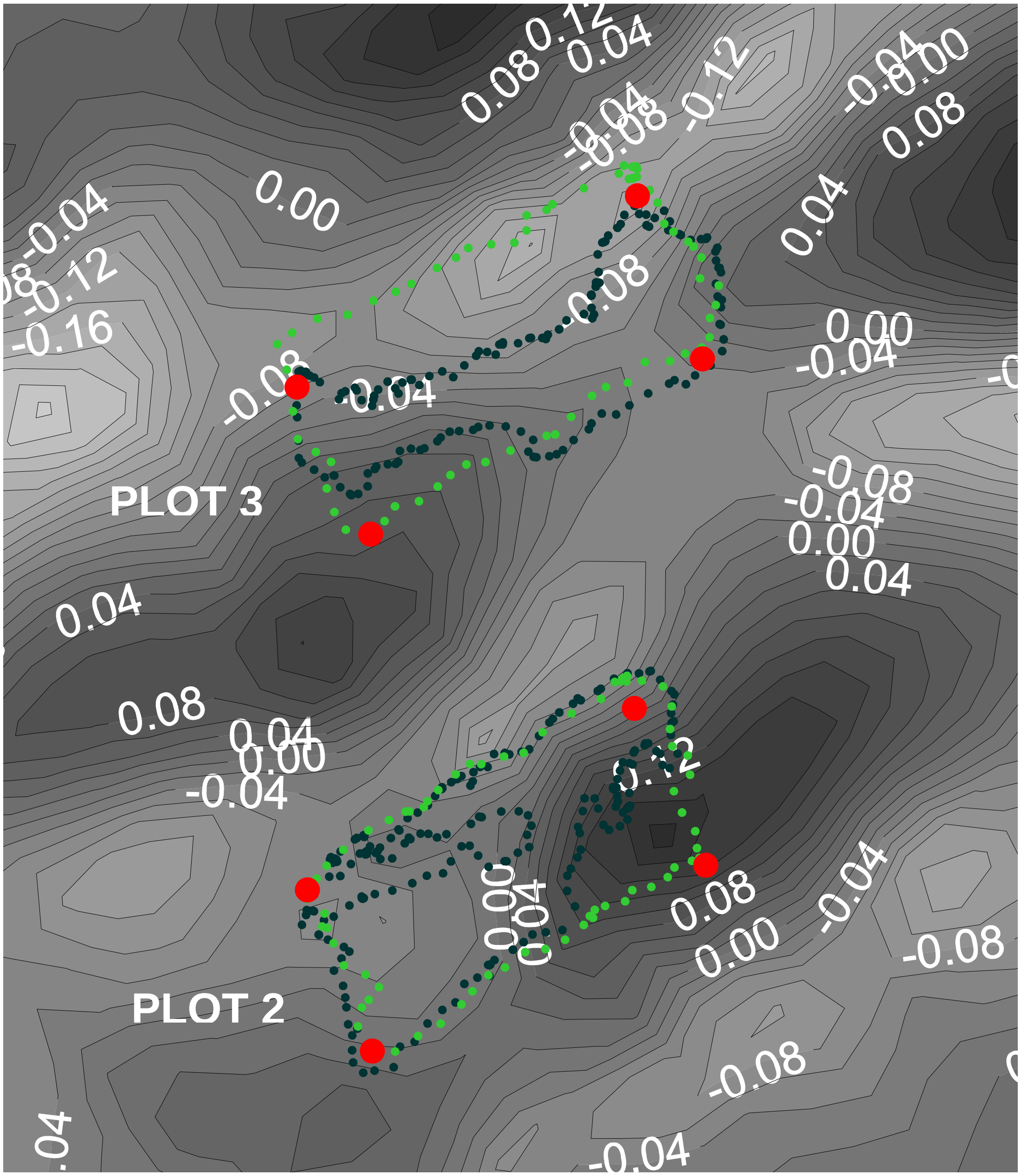

Figure 14. Contours of sediment elevation change that occurred within and near planting Plots 2 and 3 between January 2008 and summer 2008. Positive values and dark shading show areas that became deeper, and negative values and light shading indicate areas that became shallower. Also shown are perimeter surveys of manatee grass area coverage from January 2008 (light green symbols) and September 2008 (dark green symbols). The planting plot corner posts are also shown. The short sides of the plots are 10m.

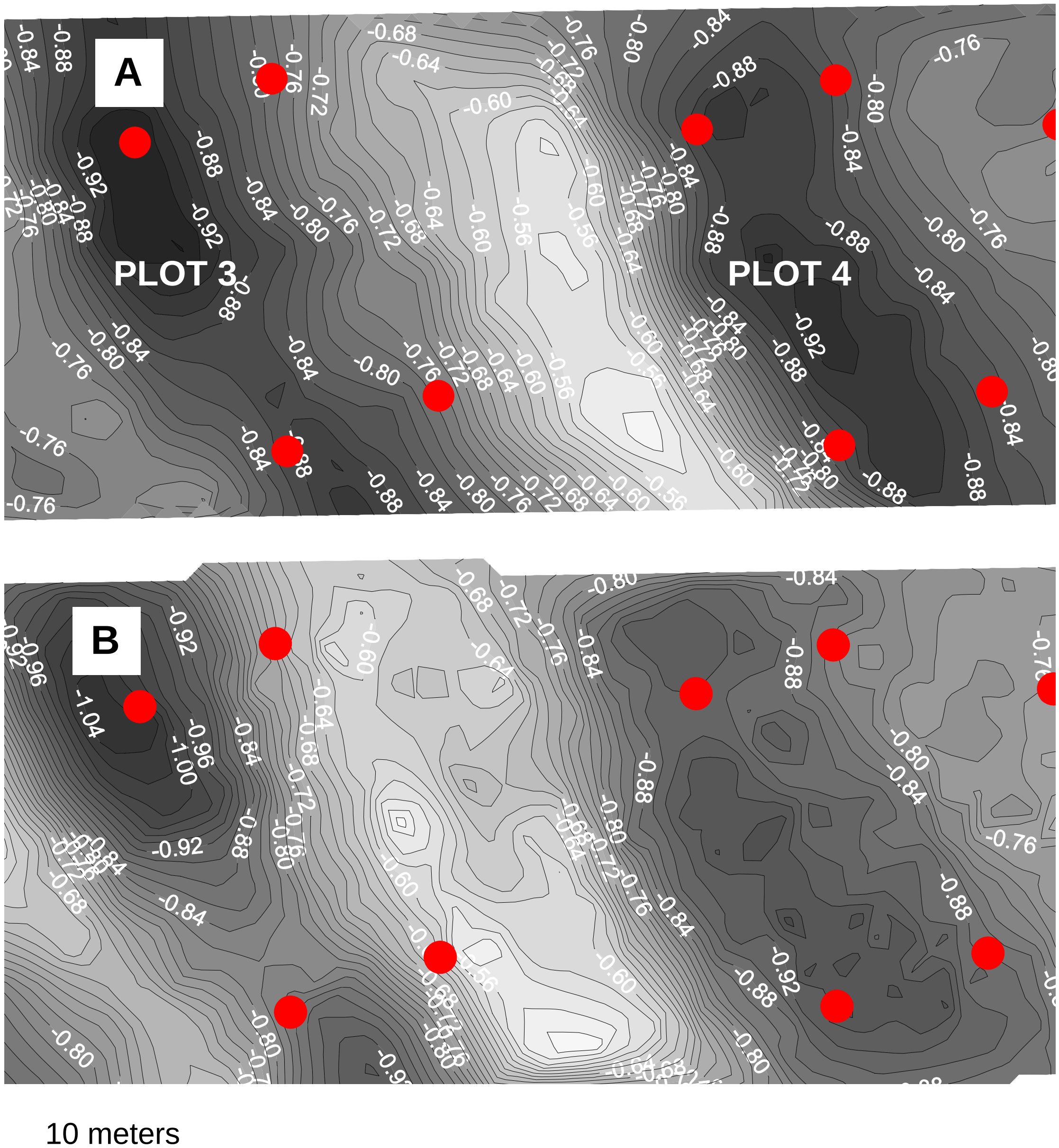

Figure 15. Contour plots showing bathymetry of planting Plots 3 and 4: (A) measurements from January 2008 and (B) measurements from June and July 2008. The red markers show the corners of the two planting plots. Plot 4 is to the right and Plot 3 is to the left. Note the apparent migration of the sandbar between Plots 3 and 4 toward the right, i.e. the off-shore direction. The short sides of the plots are 10m.

APPEDIX A

Kruer 2006

Coastal Resources Group, Inc.
A Florida not-for-profit Corporation

Time Zero Report

Seagrass Transplant and Restoration Project
MacDill Air Force Base, Tampa Bay, FL

August 31, 2006

Monitoring and Reporting Required by Special Conditions 17, 18, 20 and 26 of FDEP Environmental Resource Permit No. 29-0256820-001 Issued to Coastal Resources Group, Inc. on May 3, 2006

Includes Reports and Graphics Prepared by Tampa Bay Watch (Donor Site, page 10) and the City of Tampa Bay Study Group (Transplant Site, page 19)

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Figure 21. Aerial photo of shallow bank off MacDill AFB with location of *Syringodium* (1-6) and *Thalassia* (3T) transplant plots noted. View to north. July 15, 2006 photo by Coastal Resources Group.

Figure 22. Low-level oblique aerial photo of *Syringodium* plots 1 and 2 on July 14, 2006. View to east. Aerial photo by City of Tampa Bay Study Group.

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Figure 24. Low-level oblique aerial photo of *Syringodium* plots 4, 5, and 6 on July 14, 2006. View to east. Aerial photo by City of Tampa Bay Study Group.

Time Zero Report Prepared by Curtis Kruer, Coastal Resources Group, Inc.
August 31, 2006

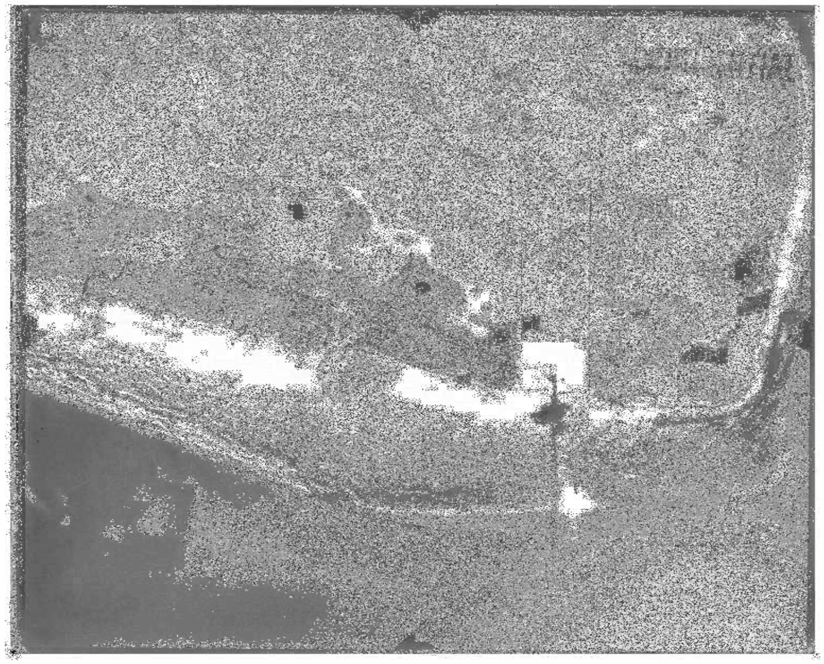


Figure 1. 1938 aerial photo of south shore of MacDill AFB showing longshore bar and seagrass complex on bank.

Figure 2. 2002 aerial photo of south shore of MacDill AFB reflecting changes over time and current lack of longshore bar and seagrass complex on bank.

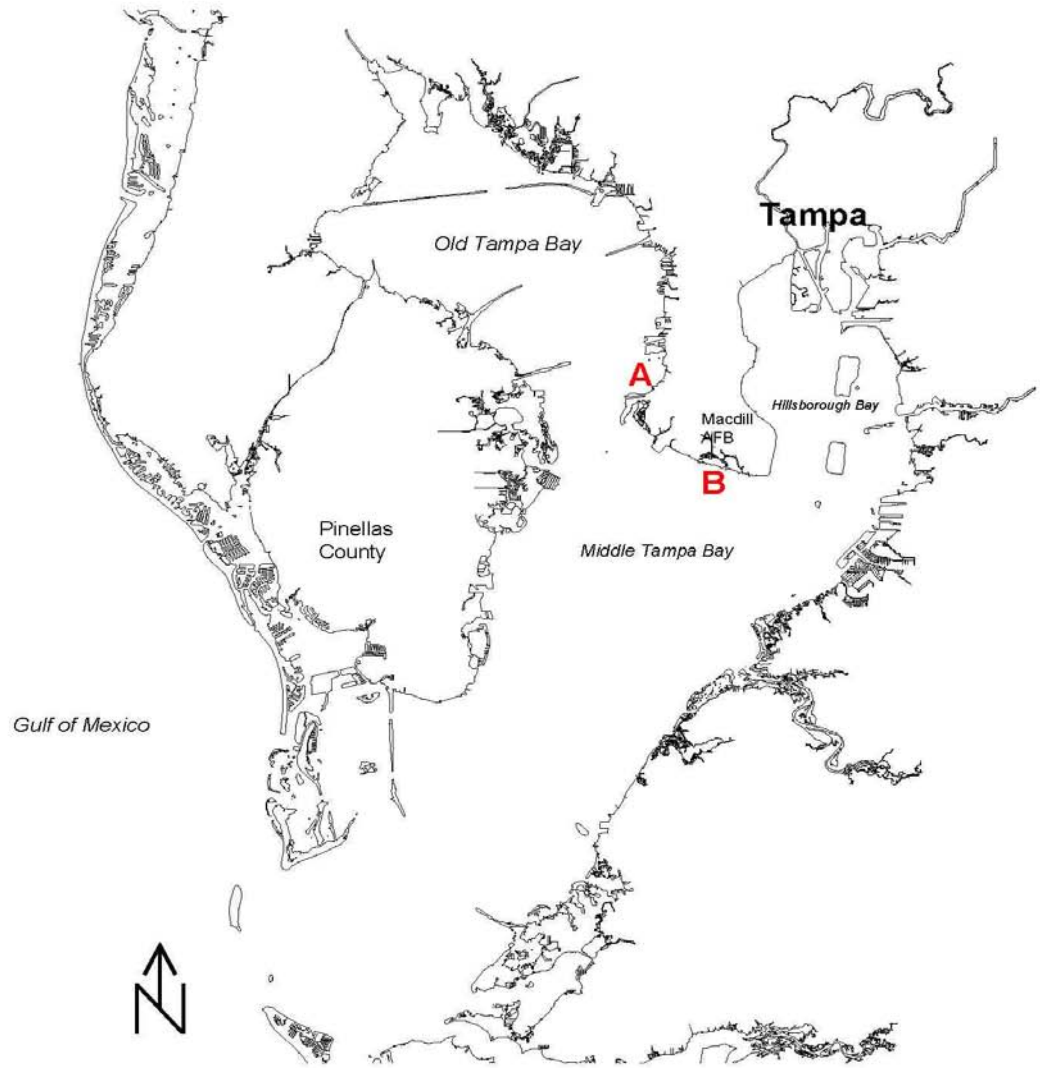


Figure 5. Location of the *Syringodium filiforme* donor site in eastern Old Tampa Bay (A), and the planting area in upper Middle Tampa Bay (B),

Figure 3. General location map showing the *Syringodium* transplant donor site (A) and the *Syringodiu*m transplant site off the south shore of MacDill AFB (B) in Tampa Bay. Adapted from project proposal.

PROPOSED DONOR AREA
WESTINGHOUSE SITE (OTB) TAMPA

Figure 8. 2002 photograph showing the location of the *Syringodium filiforme* donor area (red polygon) with lat/long corner coordinates in eastern Old Tampa Bay. Also shown are the location and bottom elevations of seagrass monitoring transect S1T15.

Figure 4. Donor area utilized for harvesting of 1200 *Syringodium* plugs. Adapted from project proposal.

Figure 5. Example of shallow draft vessel used for transplant work. Containers on bow are used to transport plugs of *Syringodium*.

Figure 6. Methods used to harvest plugs of *Syringodium*.

Figure 7. Methods used to harvest plugs of *Syringodium.*

Figure 8. Methods used to harvest and transport plugs of *Syringodium.*

Figure 9. Methods used to transport plugs of *Syringodium* to the transplant site.

Figure 10. Methods used to transport plugs of *Syringodium* to the transplant site.

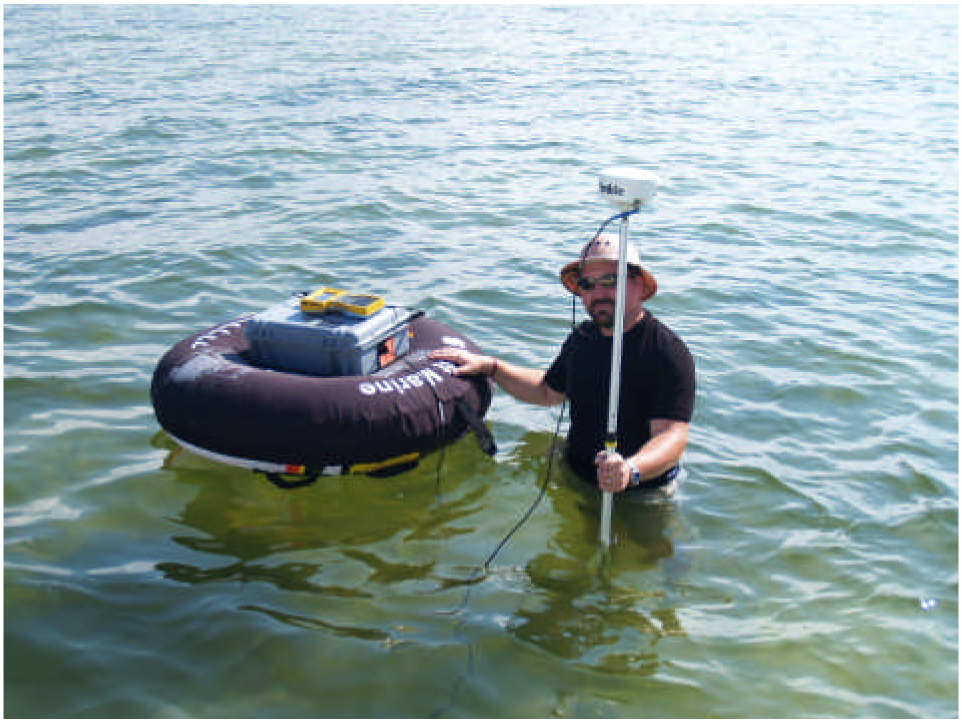


Figure 11. Method used to obtain GPS coordinates of donor plug sites.

Figure 12. Example of plot of early *Syringodium* donor plug harvest sites using GPS coordinates.

Seagrass Monitoring Report
Methods Used
Baseline Monitoring Summary
Provided by Tampa Bay Watch, Inc.

Collection of the donor plugs was accomplished in the approved “Westinghouse Flats” area. Plugs were acquired at a minimum spacing of three (3) meters. Latitude/Longitude reference points were acquired by GPS for each donor plug collected. A Latitude/Longitude reference listing of all donor points and seagrass plugs removed for quality assurance will be provided in the first 30 day monitoring report. The donor unit collection locations will be documented on an aerial photograph of the Westinghouse Flats area to identify specific locations of donor collection for a visual reference.

Four (4) donor plug monitoring sites have been established. At each site a manatee friendly “crab trap” type float was screw anchored into the bay bottom at the middle of the site. On each of the compass headings (north, east, south, and west) a donor plug was removed two (2) meters from the central float. The central marking float and each of the four seagrass donor plugs were referenced by GPS capable of sub meter accuracy. The units were also flagged with small florescent yard flags to ease monitoring efforts. Each of the four donor monitoring sites had four donor plugs harvested, resulting in a total of sixteen donor units to be monitored.

Evaluation of the donor plug monitoring sites will be accomplished in the following manner. Each of the four monitoring sites were visited immediately after construction for baseline monitoring, will be visited again approximately 30 days after construction, approximately six (6) months post construction, one (1) year, and two (2) years post construction. At each of the 16 donor monitoring sites a quarter meter square will be laid over the top of each harvested unit. Percent cover and species diversity will be quantified for Braun-Blanquet (1932) cover-abundance scale and approximate depth of plug hole in centimeters. A second meter square will be centered on the plug hole to measure species diversity and percent cover in the immediate area to quantify any changes.

Seagrass Monitoring Report
Baseline Monitoring Summary
Provided by Tampa Bay Watch, Inc.

The 16 donor monitoring sites were monitored for baseline data on July 14, 2006. Monitoring began with the north plot of the S1 site at 10:00am and concluded with the west plot of the N2 site at 11:36 am. The North monitoring sites, N1 and N2 were established on June 28th, 2006 while the South monitoring sites, S1 and S2 were established on July 13th, 2006. At all 16 of the sites, *Syringodium filiforme* and attached algae were found, while Ruppia was found at 2 sites and *Thalassia testudinum* was found at 2 sites. The abundance of *Syringodium* was typically 76-100% although three of the sixteen sites had lower abundance of 51-75%. Of all 16 sites, the average blade length found was approximately 44 cm with a high of 51 cm and a low of 38 cm. Of all 16 sites monitored, the average shoot density was 29 with a high of 45 and low of 13. The average plug size is 23x21.5 cm with an average depth of 7 cm. The macroalgae *Digenea* was present at all of the North monitoring sites, N1 and N2. Sediment of muddy sand was consistent through all sites. A light density of barnacle spat was found at all monitoring sites.

Seagrass Data for Donor Plugs **Monitoring Date: 7/14/2006** **Provided by Tampa Bay Watch**

Time:10:00 AM to 11:36 AM. **Baseline Data for Time Zero Report**

Species: (AA) Attached Algae (DA) Drift Algae (H) Halodule (HE) Halophila (R) Ruppia (S) Syringodium (T) Thalassia

Abundance: 1=<5% cover, 2=5-25% cover, 3=26-50% cover, 4= 51-75% cover, 5=76-100% cover
Epiphyte Density: 1=clean, 2=light, 3=moderate, 4=heavy Sediment: 1=shelly sand, 2=sand, 3=muddy sand, 4=mud, 5=oyster

Site	Species	Abundance	Blade Length Avg.	Shoot Density	Count Square Size	Epiphyte Type	Epiphyte Density	Sed.	Plug Size	Plug Depth	Water Depth	Comments
S1 North	AA, S	S5	49.33 cm	17	10 square	Barnacle Spat	2	3	29x22 cm	6 cm	90 cm	
S1 East	AA, S, R	S4, R2	36.67 cm	25	10 square	Barnacle Spat	2	3	22x20 cm	11 cm	90 cm	
S1 South	AA, S	S5	33.33 cm	13	10 square	Barnacle Spat	2	3	23x22 cm	9 cm	89 cm	
S1 West	AA, S	S5	42.67 cm	21	10 square	Barnacle Spat	2	3	24x22 cm	8.5 cm	89 cm	
S2 North	AA, S	S5	41.67 cm	16	10 square	Barnacle Spat	2	3	25x22 cm	10 cm	90 cm	
S2 East	AA, S	S5	45.67 cm	19	10 square	Barnacle Spat	2	3	22x21 cm	9 cm	86 cm	
S2 South	AA, S, R	S4, R1	48 cm	21	10 square	Barnacle Spat	2	3	24x21 cm	10 cm	87 cm	
S2 West	AA, S	S5	38 cm	17	10 square	Barnacle Spat	2	3	24x22 cm	9 cm	82 cm	
N1 North	AA, S, T	S4, T2	S48 cm, T39 cm	S21, T2	10 square	Barnacle Spat	2	3	23x21 cm	8 cm	77 cm	
N1 East	AA,S, T	S4, T3	S38 cm, T20 cm	S13, T5	10 square	Barnacle Spat	2	3	23x21 cm	2 cm	78 cm	
N1 South	AA, S	S5	45.33 cm	21	10 square	Barnacle Spat	2	3	22x21 cm	3 cm	76 cm	2 shoots of S in hole
N1 West	AA, S	S5	50.67 cm	35	10 square	Barnacle Spat	2	3	23x20 cm	5 cm	77 cm	
N2 North	AA, S	S5	44.67 cm	28	10 square	Barnacle Spat	2	3	23x22 cm	5 cm	75 cm	3 shoots of S in hole
N2 East	AA, S	S5	48.67 cm	21	10 square	Barnacle Spat	2	3	23x21 cm	6 cm	78 cm	4 shoots of S in hole
N2 South	AA, S	S5	38 cm	45	10 square	Barnacle Spat	2	3	23x21 cm	6 cm	64 cm	2 shoots of S in hole
N2 West	AA, S	S5	47 cm	32	10 square	Barnacle Spat	2	3	23x21 cm	6 cm	70 cm	3 shoots of S in hole
HI			50.67 cm	45					29x22 cm	11 cm	90 cm	
LOW			38 cm	13					22x20 cm	2 cm	70 cm	
AVERAGE			44.335 cm	29					23x21.5 cm	7 cm	81.125	

Notes: Heavy afternoon rains for week prior to monitoring. Tide: mid-incoming. Presence of Digenea at all N1 and N2 sites

Sites S1 and S2 were established on 7/13/2006. Sites N1and N2 were established on 6/28/2006

Transplant Site - MacDill AFB off Coon Hammock Creek

PROPOSED PLANTING SITE AT
SOUTH MACDILL AFB

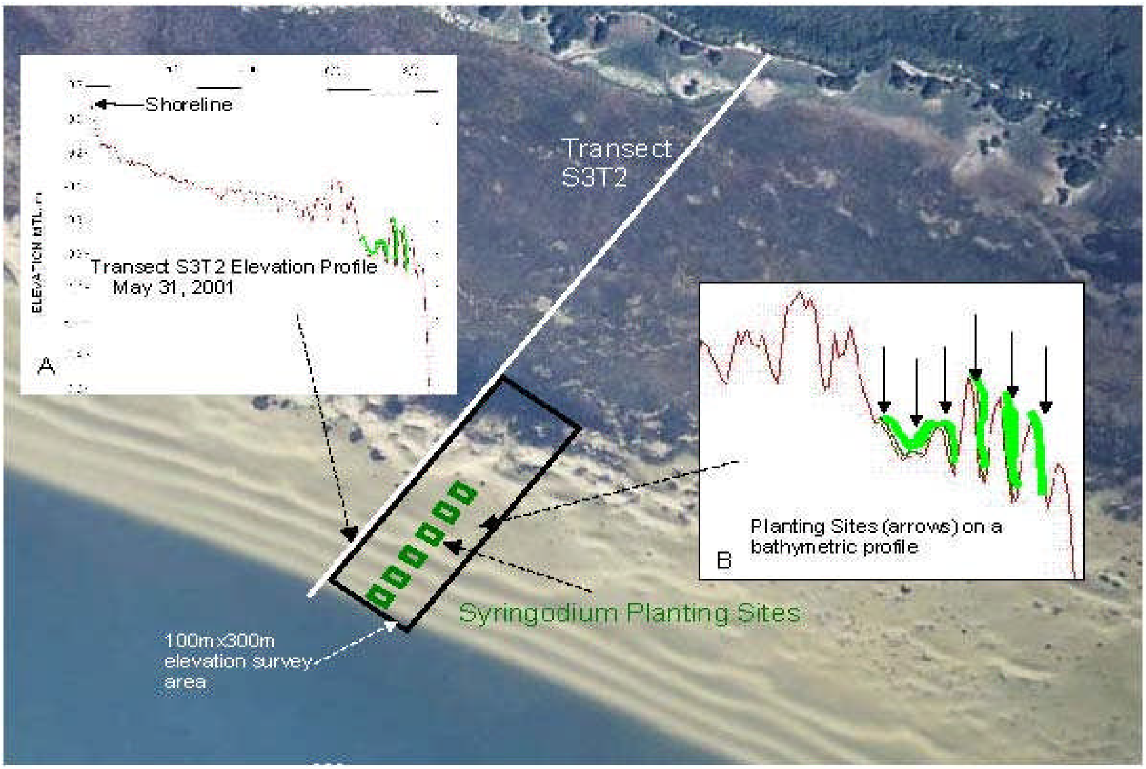


Figure 7. 2002 photograph showing the extent of current seagrass coverage in the proposed planting area. Also shown are the six planting sites within the planting area and the location of the fixed seagrass monitoring transect, S3T2. Further, insert A shows bottom elevations of transect S3T2 and insert B shows detailed bottom elevations of the six planting sites.

Figure 13. General location of originally proposed *Syringodium* planting plots off south shore of MacDill AFB adjacent to long term multi-agency monitoring station Transect S3T2. Adapted from project proposal. X-sections based on 2001 bathymetry.

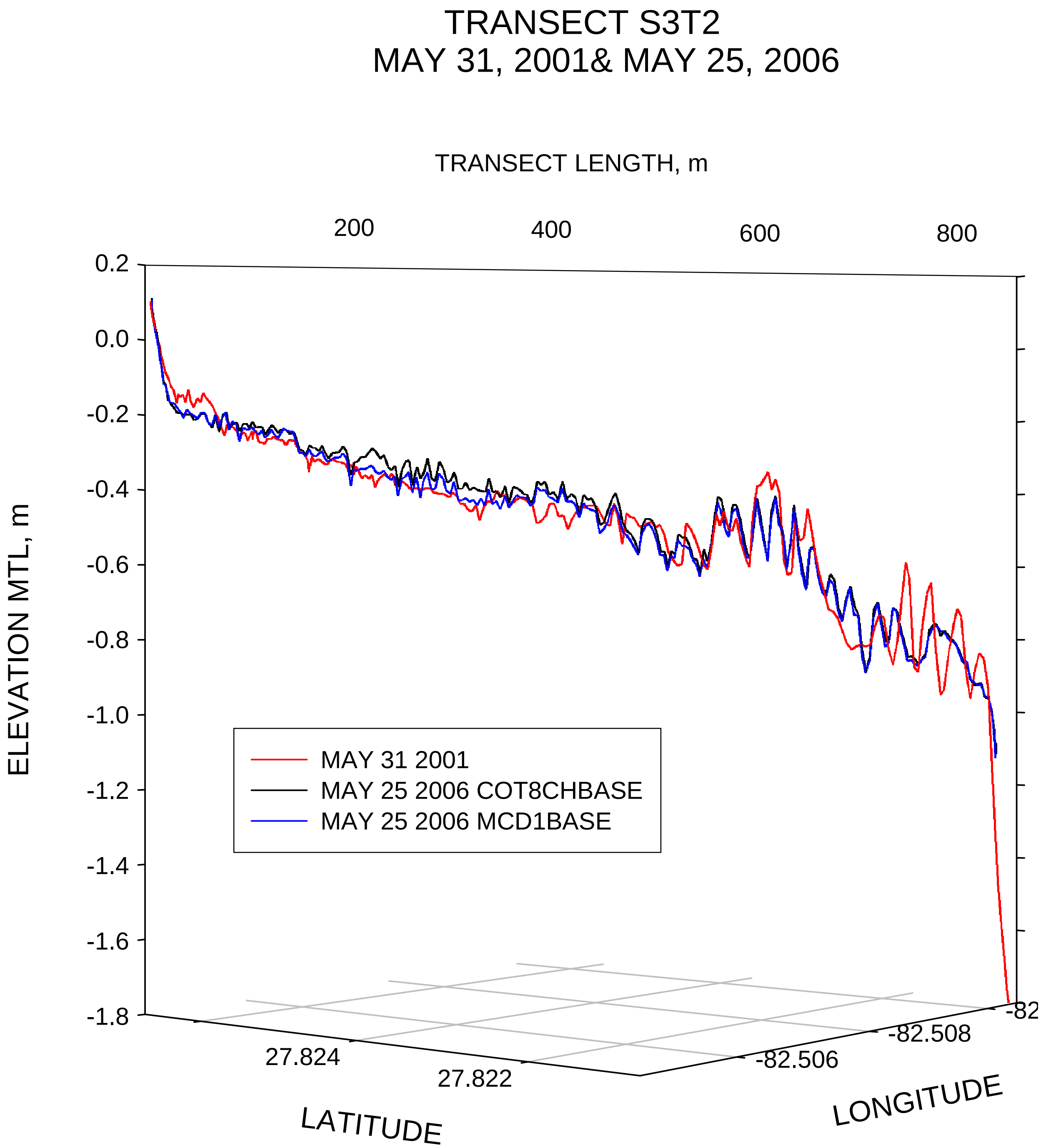


Figure 14. Site bathymetry provided by the City of Tampa Bay Study Group.

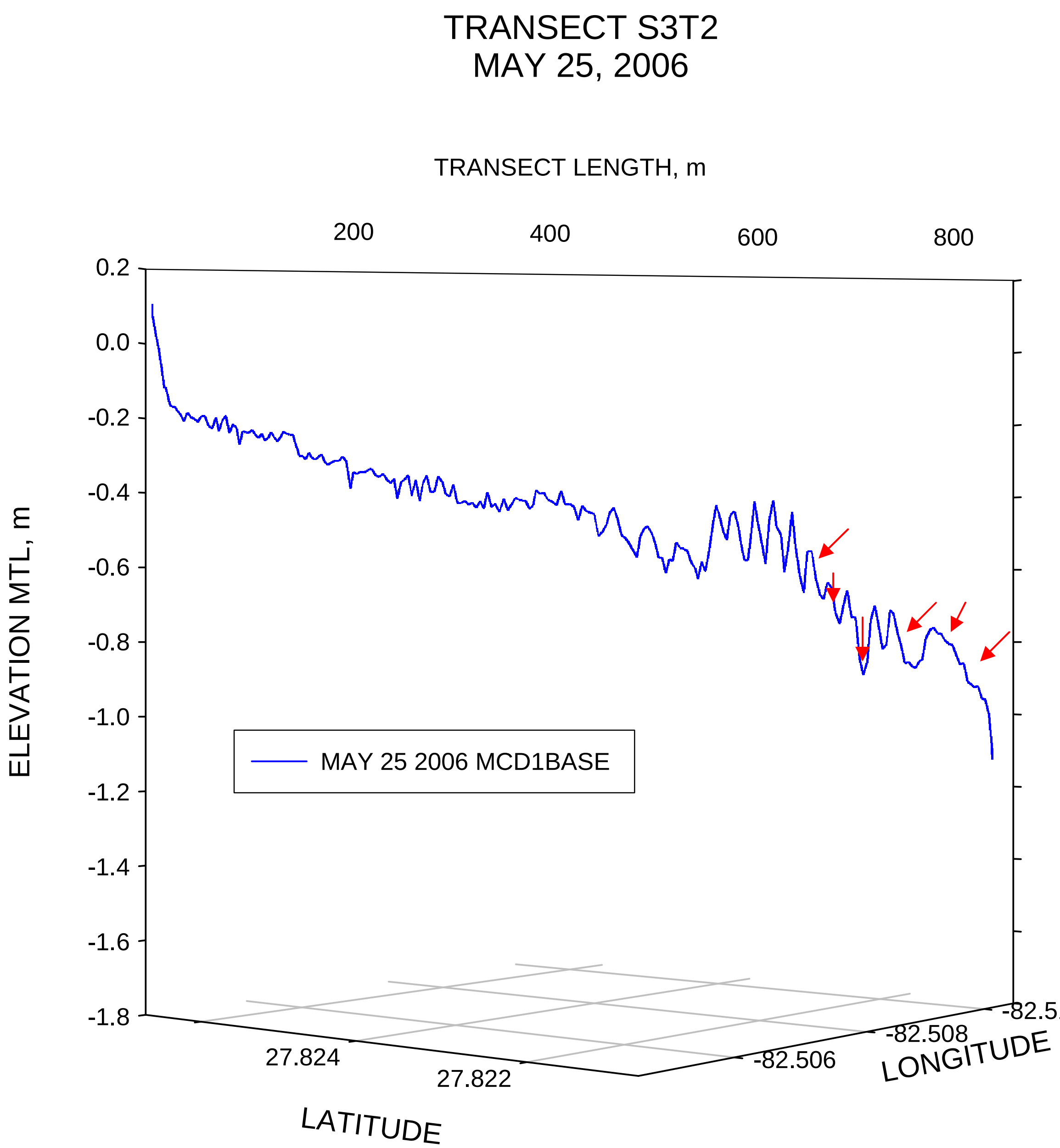


Figure 15. 2005 bathymetry provided by the City of Tampa Bay Study Group with locations of transplant plots approximated.

Figure16. View of *Syringodium* transplant work in progress on June 15, 2006 showing array of plugs on bottom.

Figure 17. Underwater view of installed *Syringodium* plugs on June 15, 2006.

Figure 18. On site method used to assess *Syringodium* plugs.

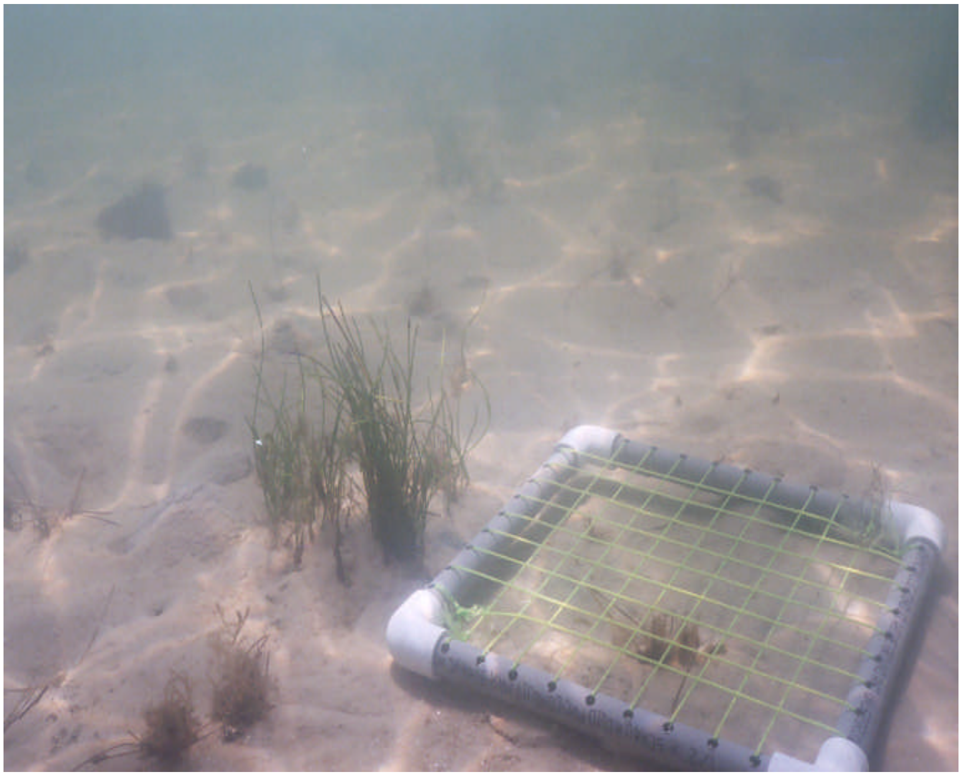


Figure 19. Underwater view of typical *Syringodium* plug and 25 cm x 25 cm quadrat.

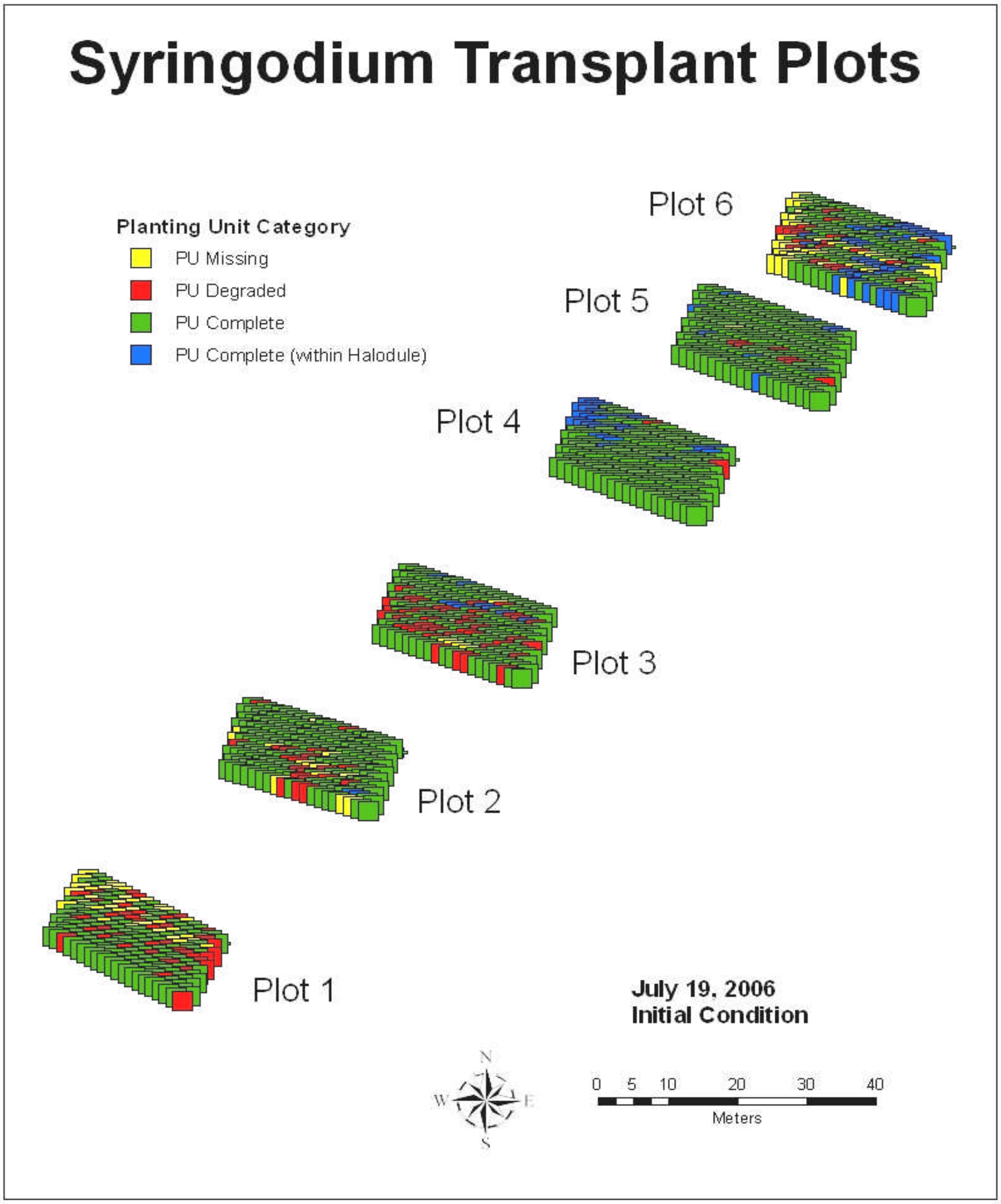


Figure 20. Relative location and initial condition of *Syringodium* transplant plots on shallow bank off MacDill AFB as of July 19, 2006 monitoring event. Graphic provided by Brad Robbins/Mote Marine Lab.

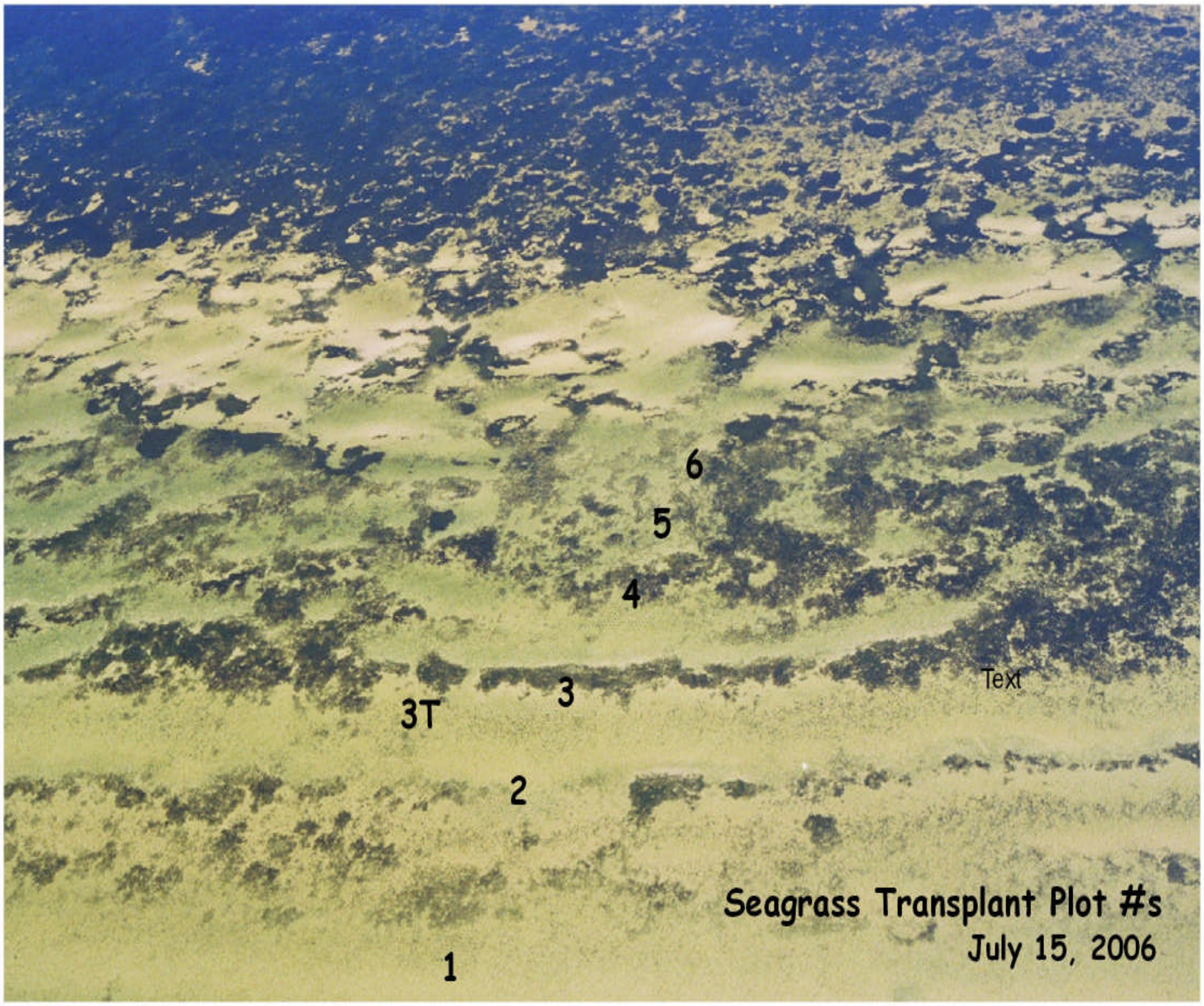


Figure 21. Aerial photo of shallow bank off MacDill AFB with location of *Syringodium* (1-6) and *Thalassia* (3T) transplant plots noted. View to north. Submerged aquatic vegetation visible in the area of the transplant plots is primarily seasonal macroalgae. Aerial photo by Coastal Resources Group.

Data Summary of the *Syringodium filiforme* Transplant Project at Coon Hammock Creek, MacDill AFB for Time Zero Report. Data collected on July 20, 2006. Report and Graphics Prepared by City of Tampa Bay Study Group

Table 1. Completion date for each planting plot.

	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
Completion Date	June 6, 2006	June 19, 2006	June 27, 2006	July 13, 2006	July 14, 2006	June 28, 2006

Table 2. Summary of *S. filiforme* planting unit percent survival and total unit coverage (m^2) based on a ten percent random subsample.

	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Total
S.f unit survival	95%	100%	95%	100%	100%	100%	
S.f total coverage m^{-2}*	9	9.8	12.7	13.1	9.5	8.3	62.4

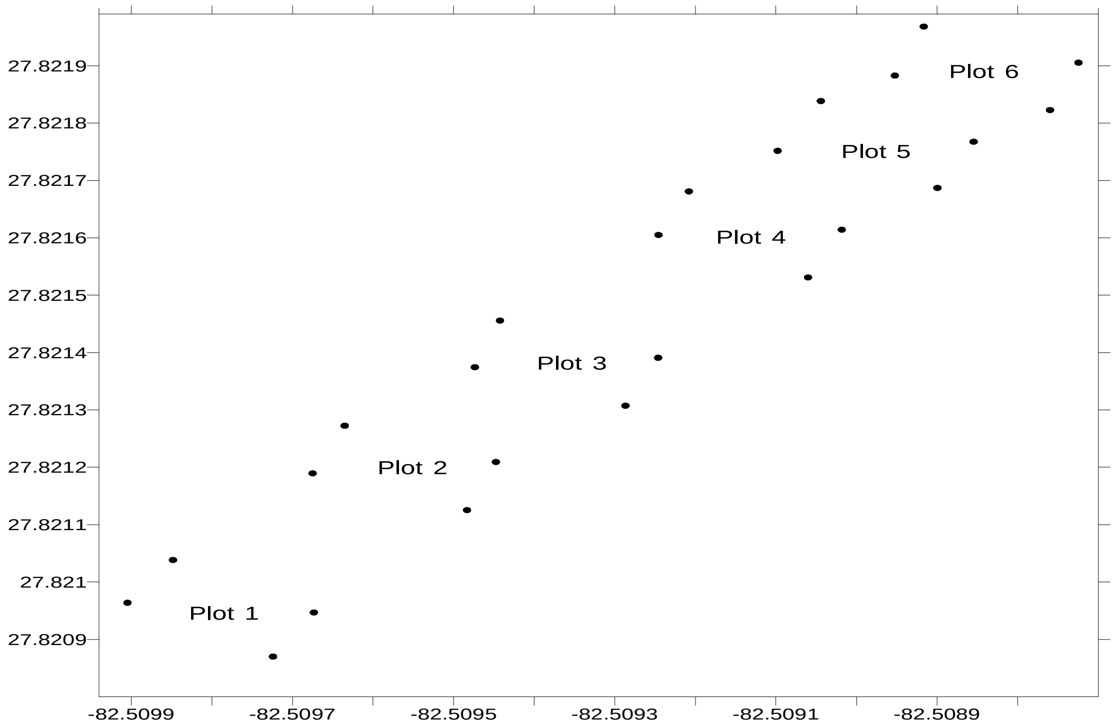
*The size of selected sod units at Time Zero were determined using area = [(length of major axis x width of minor axis)/2) x ∏]. This measurement method will be used for all future sod unit areal coverage estimates.

Table 3. Summary of *S. filiforme* short shoot density m^{-2} (SSD) and canopy height (CH) of the areal coverage reported in Table 2. Data based from measurements of the first ten planting units encountered within random meter square placements.

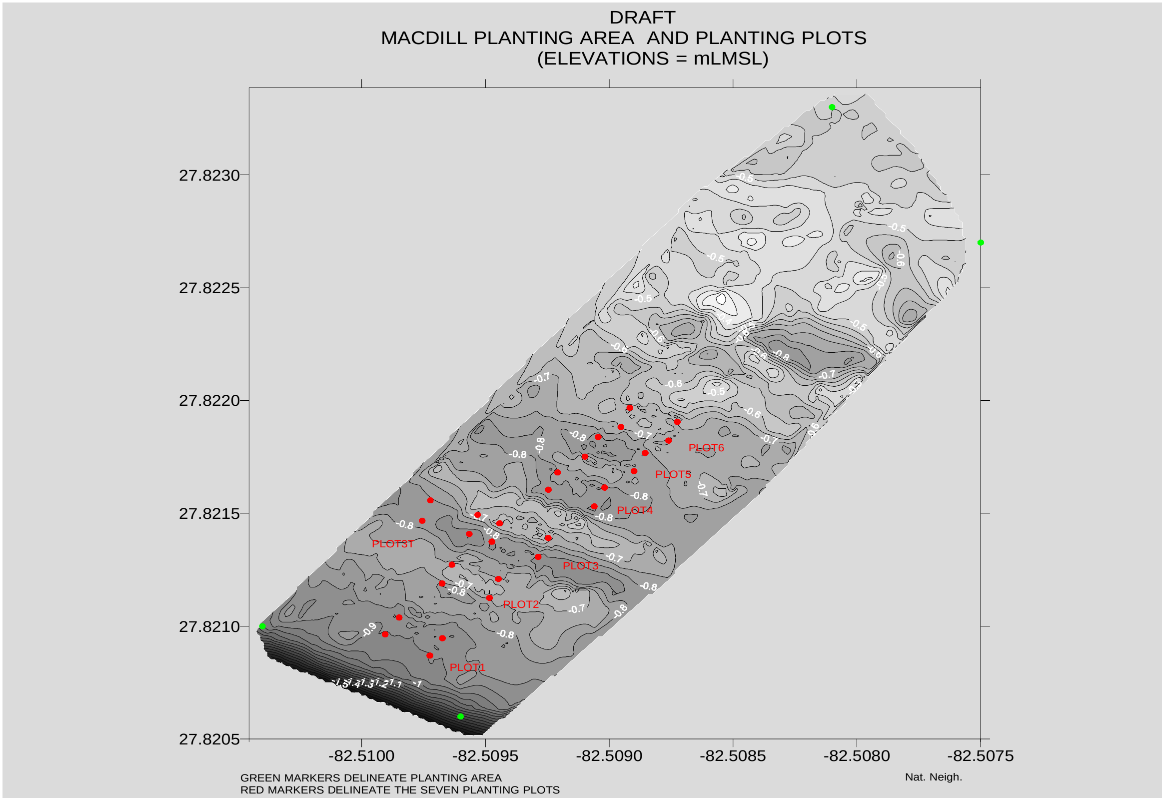
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
SSD	804	1005	1460	1039	1488	874
CH (cm)	18.2	23	19.3	24.5	24.2	22.4

Table 4. Summary of Braun Blanquet class coverage rating (BB) within random meter square
placements in each planting plot on July 20, 2006. Braun Blanquet ratings: 0= absent, 0.5= <1%, 1= 1-5%, 2= 6-25%, 3= 26-50%, 4= 51-75%, 5= >75%.

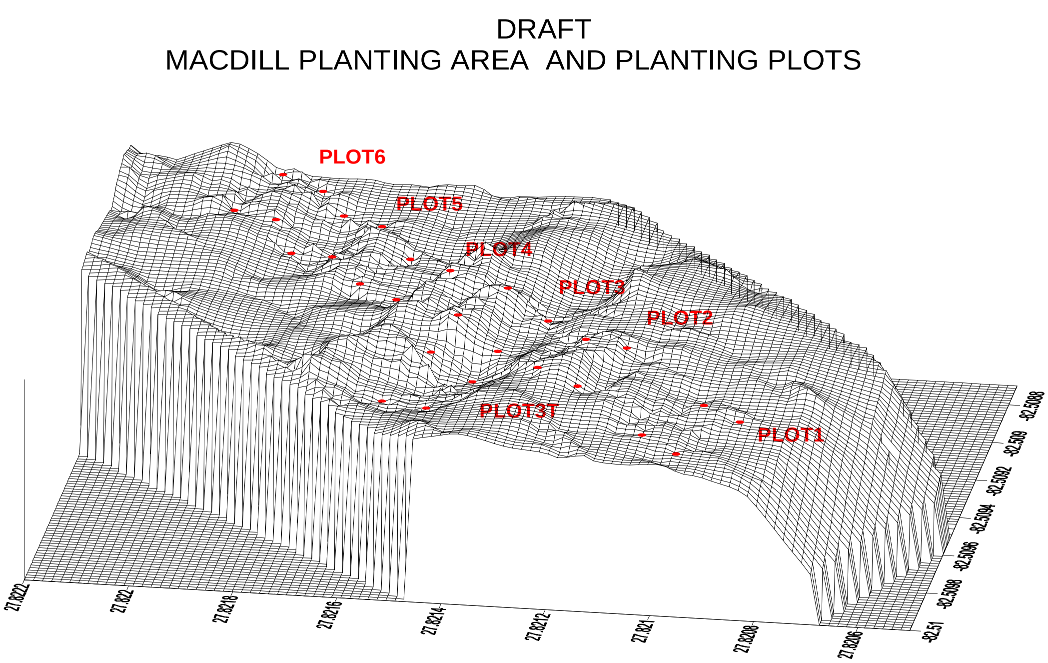
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
H.w BB	0.5	0	0	0.5	2	2
S. f. BB	1	2	1	2	1	1



GPS coordinates of the six planting plots. Produced by the City of Tampa Bay Study Group.



Produced by the City of Tampa Bay Study Group



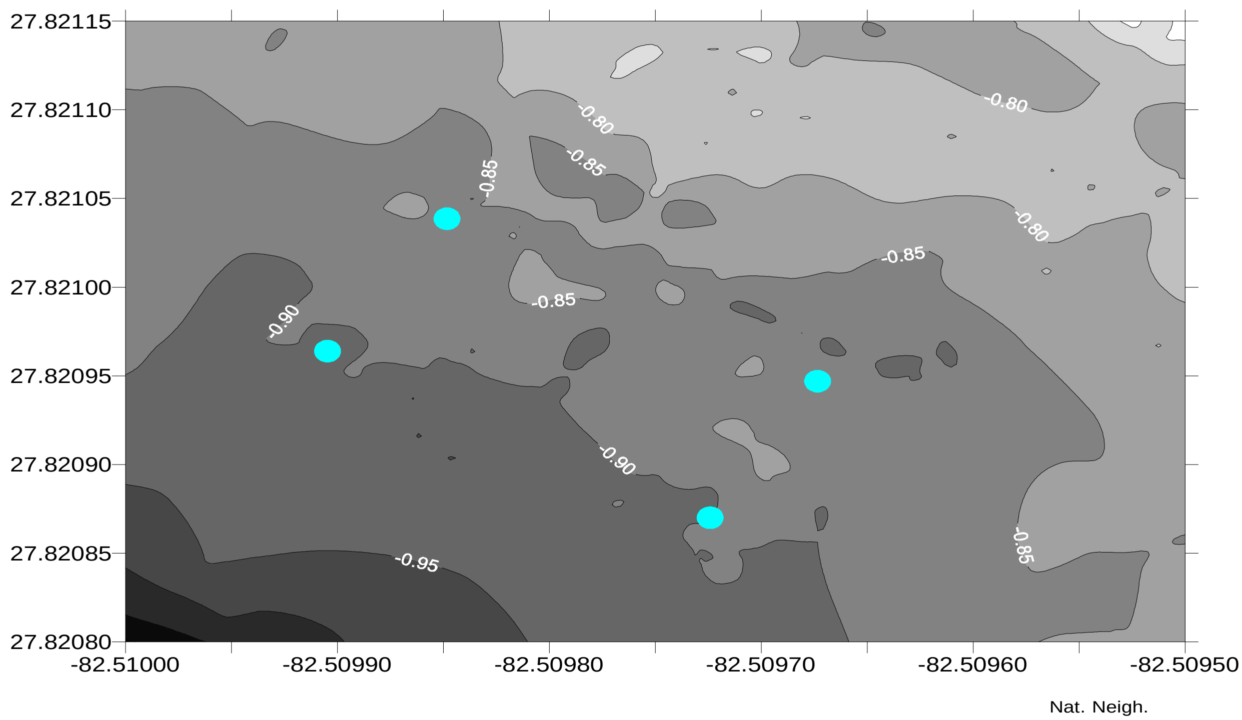
Produced by the City of Tampa Bay Study Group

DRAFT

MACDILL PLANTING AREA AND PLANTING PLOTS

(ELEVATIONS = mLMSL)

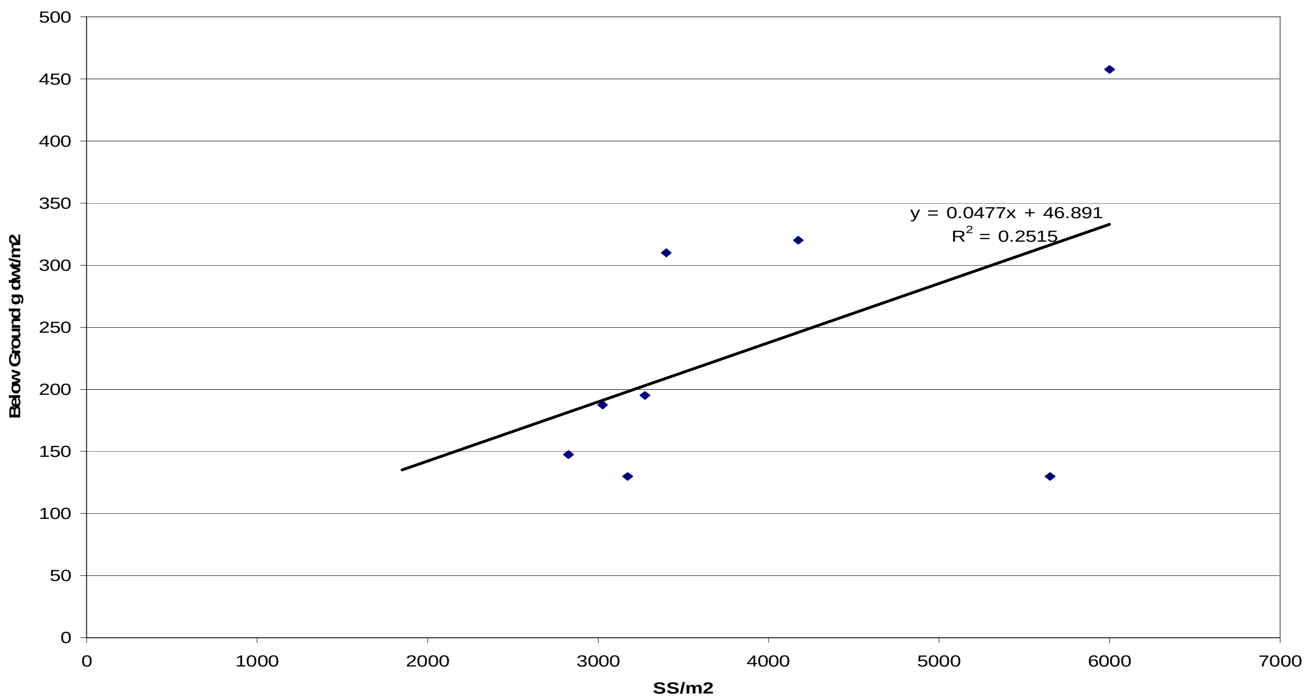
PLOT 1



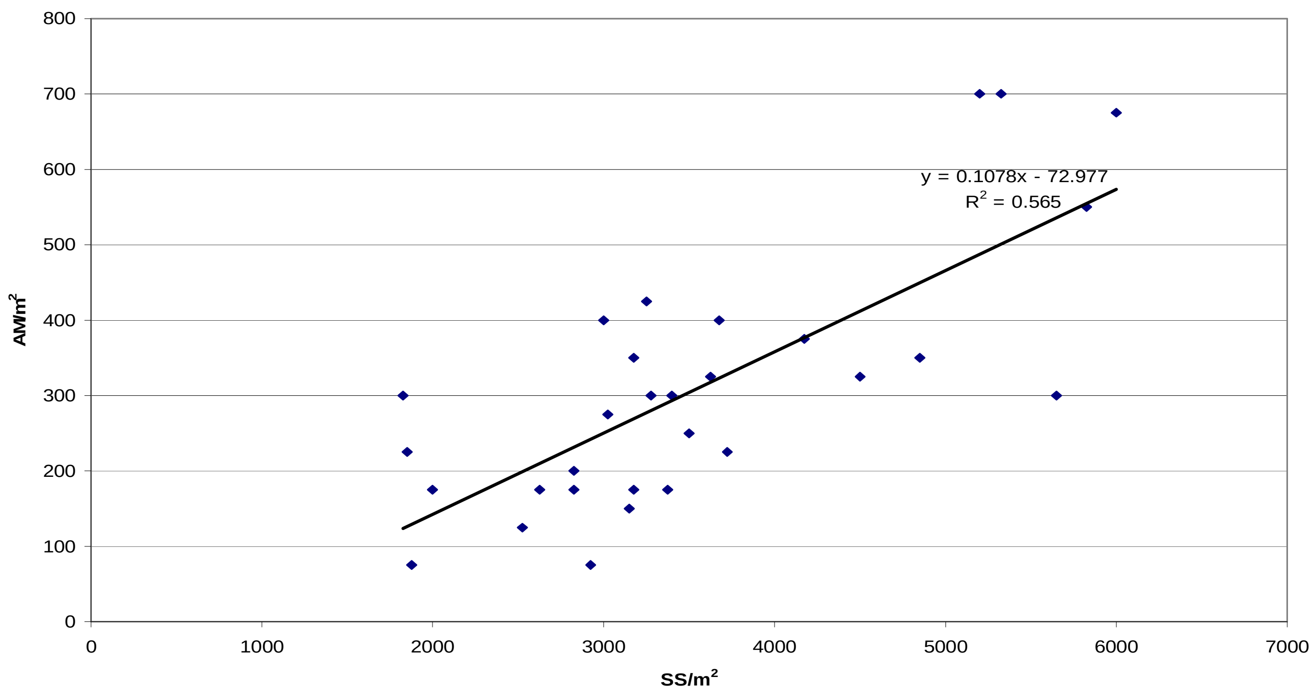
Produced by the City of Tampa Bay Study Group

***Syringodium* Harvest Data - Required Representative Sample**
Data Collected by City of Tampa Bay Study Group

Date	Unit Short Shoot Density	Short Shoot Density/m2	Unit Apical Meristem	Unit Apical Meristem/m2	Ave. Canopy Height (cm)
6/14/2006	121	3025	11	275	30.7
6/14/2006	113	2825	8	200	37.6
6/14/2006	105	2625	7	175	40.1
6/14/2006	126	3150	6	150	42.2
6/14/2006	113	2825	7	175	
6/14/2006	127	3175	7	175	
6/14/2006	131	3275	12	300	
6/15/2006	127	3175	14	350	
6/15/2006	130	3250	17	425	
6/15/2006	240	6000	27	675	
6/19/2006	74	1850	9	225	
6/19/2006	226	5650	12	300	
6/19/2006	167	4175	15	375	
6/19/2006	147	3675	16	400	
6/19/2006	208	5200	28	700	
6/20/2006	136	3400	12	300	
6/20/2006	180	4500	13	325	
6/20/2006	194	4850	14	350	
6/27/2006	73	1825	12	300	37.6
6/27/2006	80	2000	7	175	59.5
6/27/2006	101	2525	5	125	
6/27/2006	149	3725	9	225	
6/27/2006	120	3000	16	400	
6/28/2006	140	3500	10	250	35.7
6/28/2006	135	3375	7	175	46.8
6/28/2006	75	1875	3	75	
6/28/2006	117	2925	3	75	
6/28/2006	233	5825	22	550	
7/5/2006	145	3625	13	325	30.3
7/5/2006	213	5325	28	700	
7/6/2006	100	2500	4	100	36.6
7/6/2006	69	1725	4	100	45.8
7/6/2006	107	2675	12	300	
7/13/2006	112	2800	11	275	38.4
7/13/2006	186	4650	14	350	43.4
7/13/2006	175	4375	12	300	
Average	139	3469	12	297	40.4
StDev	47	1166	6	161	7.6
Minimum	69	1725	3	75	30.3
Maximum	240	6000	28	700	59.5



Donor Site S. filiforme



Produced by the City of Tampa Bay Study Group

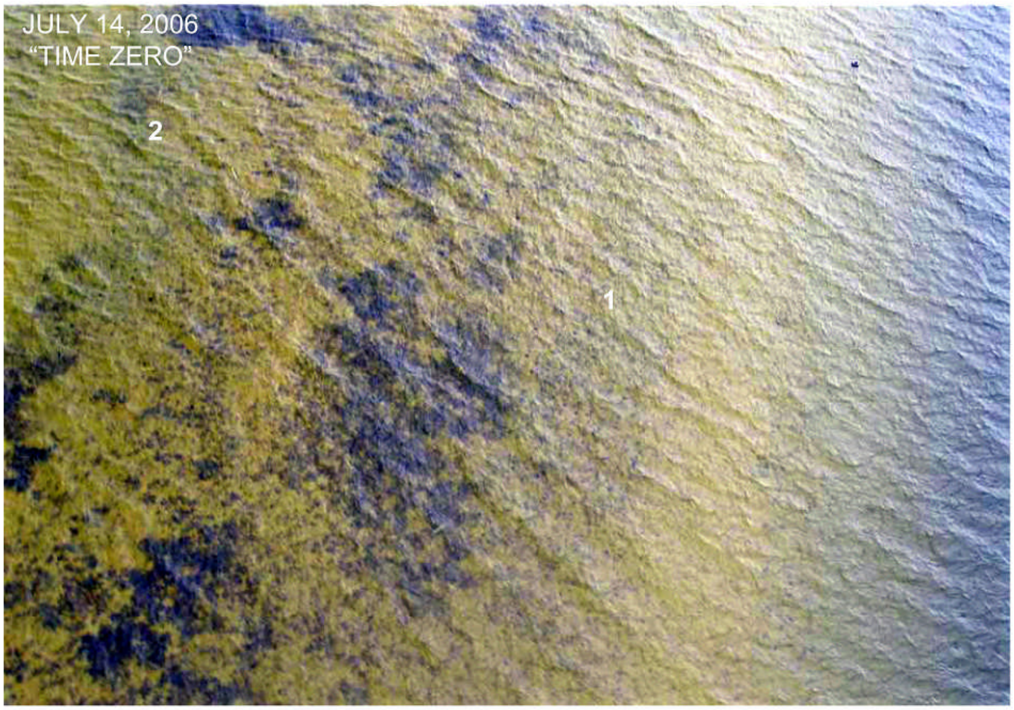


Figure 22. Low-level oblique aerial photo of *Syringodium* plots 1 and 2 on July 14, 2006. View to east. Submerged aquatic vegetation visible in the area of the transplant plots is primarily seasonal macroalgae Aerial photo by City of Tampa Bay Study Group.

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Figure 24. Low-level oblique aerial photo of *Syringodium* plots 4, 5, and 6 on July 14, 2006. View to east. Submerged aquatic vegetation visible in the area of the transplant plots is primarily seasonal macroalgae. Aerial photo by City of Tampa Bay Study Group.

APPENDIX B

Kruer 2007a

Coastal Resources Group, Inc.

A Florida not-for-profit Corporation

Six Month Monitoring Report

Seagrass Transplant and Restoration Project
MacDill Air Force Base, Tampa Bay, FL

March 20, 2007

Monitoring and Reporting Required by Specific Conditions 27 and 28 of
FDEP Environmental Resource Permit No. 29-0256820-001
Issued to Coastal Resources Group, Inc. on May 3, 2006

Includes Reports and Graphics Prepared by
Tampa Bay Watch (Donor Site, pp 2-4) and the
City of Tampa Bay Study Group (Transplant Site, pp 5-18)

Report prepared by:

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Six Month Donor Seagrass Monitoring Summary
FDEP Environmental Resource Permit No. 29-0256820-001
Provided by Tampa Bay Watch, Inc. South Tierra Verde, FL 727-867-8166

Six month donor site seagrass monitoring data was collected at Westinghouse Flats on January 17, 2007 and February 1, 2007. The monitoring buoy was not present at the S1 site on January 17 requiring this site to be resurveyed using sub-meter DGPS on January 30 and monitored on February 1. The tide was low and outgoing with an average depth at the seagrass donor site of 25 cm on January 17 and 30 cm on February 1.

Syringodium filiforme has colonized all donor plug locations with an average short shoot density of 494 per square meter (Table 1). The average blade length is approximately 22 cm (Figure 1). Six month donor site monitoring revealed that all bottom elevations in the plug holes are level with the surrounding sandy bottom; no plug depressions are visible in any of the sixteen donor plugs (Fig 2). The outline of seven plugs holes measuring 20x20 cm are still visible with the remaining nine plugs not visible due to the coalescence of the seagrass. The six month monitoring data shows that the donor site is recovering quickly. The plug holes have filled in with sediment in the first six months and considerable recolonization of *Syringodium filiforme* has occurred.

Table 1. Donor Site 6 Month Data Collected and Reported by Tampa Bay Watch

Species: (S) Syringodium (T) Thalassia
Abundance: 1=<5% cover, 2=5-25% cover, 3=26-50% cover, 4= 51-75% cover, 5=76-100% cover
Donor Sites N1and N2 were established on 6/28/2006, Sites S1 and S2 were established on 7/13/2006.
Tide: low-outgoing.
S1 monitored on 2/1/07, other sites on 1/7/07

Site	Species	Abundance	Blade Length Avg. (cm)	Shoot Density	Count quad size (cm)	Shoot Density/m2
S1 North	S	2	23	6	25	96
S1 East	S	2	23	9	25	144
S1 South	S	2	21	3	25	48
S1 West	S	2	23	13	25	208
S2 North	S, T	S4, T1	28	18	25	288
S2 East	S	4	26	6	25	96
S2 South	S	4	30	7	25	112
S2 West	S	4	27	7	25	112
N1 North	S, T	S2, T3	S24, T23	S4, T8	S10, T25	S400, T800
N1 East	S	3	30	7	10	700
N1 South	S	3	12	8	10	800
N1 West	S, T	S3, T2	S20, T28	S7, T4	S10, T25	S700, T400
N2 North	S	3	13	9	10	900
N2 East	S	3	25	13	10	1300
N2 South	S	4	12	11	10	1100
N2 West	S	3	10	9	10	900
HI		S4, T3	S30, T28			S1300, T800
LOW		S2, T1	S10, T23			S48, T400
AVERAGE		S3, T2	S21.68, T25.5			S494, T600

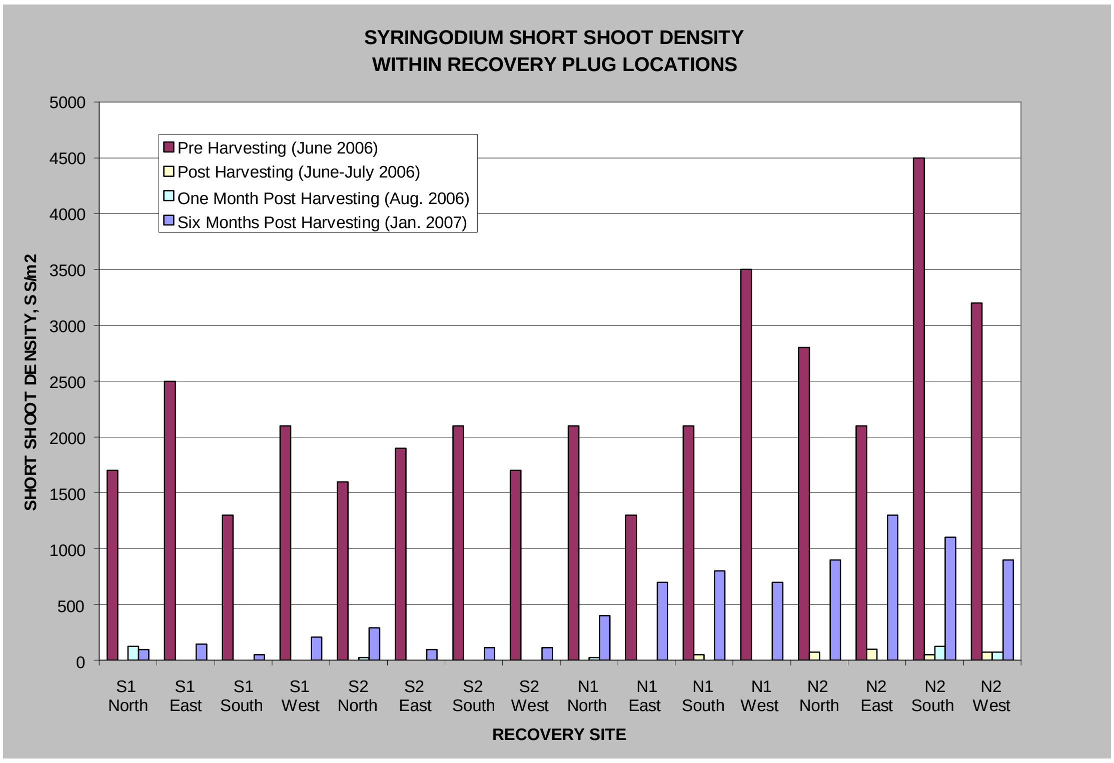


Figure 1. Summary of *Syringodium* recolonization of *Syringodium* donor site.

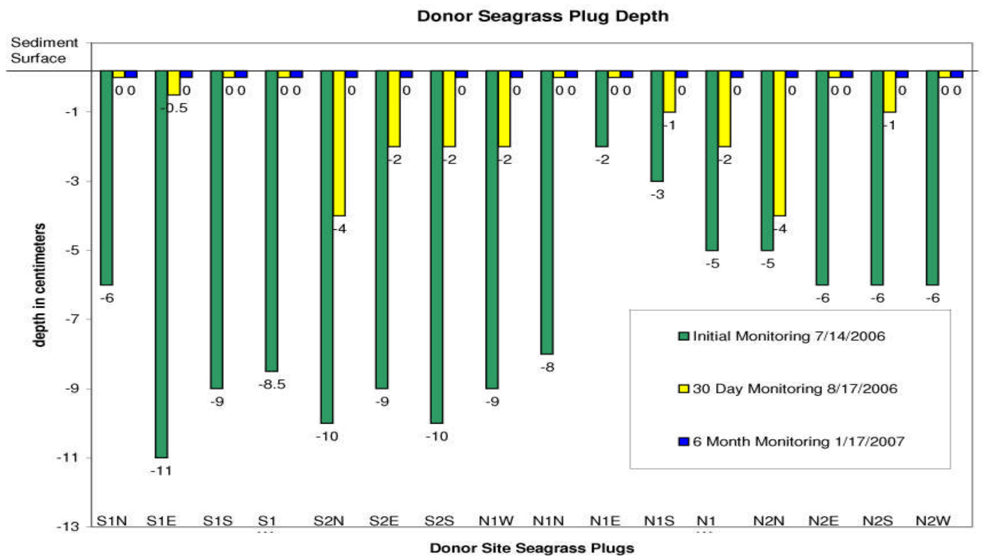


Figure 2. Summary of *Syringodium* donor plug sediment depth changes over time.

Photo 1. Relocation of Site S1 at the *Syringodium* donor area with DGPS by the City of Tampa Bay Study Group.

Data Summary of the *Syringodium filiforme* Transplant Project at Coon Hammock Creek: Time "Six Month" Data Collected January 17, 2007 and February 15, 2007

City of Tampa Bay Study Group
Tampa, FL
813-247-3451

Sampling Summary: Field personnel consisted of Walt Avery, Serra Morrison, Kendall Sanderson, and Chris Sutton. Plot 1-3 assessments on January 17, 2007 started at ca 0900 and ended ca 1100. There was an ebb tide with a calm sea state and partly cloudy conditions. Plot 4-6 assessments on February 15, 2007 started at ca 0800 and ended ca 0930. There was an ebb tide with a light chop sea state and cloudy conditions. A summary of data collected at the 7 individual planting plots (see Time Zero report for this project) follows. Oblique aerial photos of the site were obtained by the COTBSG.

Plot 1

Table 1. Summary of *S. filiforme* total unit coverage (m^2) in Plot 1 based on a ten percent random sub sample that included units measured in rows 8, 12, 14, and 31.

	July 20, 2006	August 17, 2006	January 17, 2007
S.f total coverage m^{-2}*	9	10.5	36

*The size of selected sod units at time "0" were determined using area=[(length of major axis x width of minor axis)/2) x pi]. This measurement method will be used for all future sod unit areal coverage estimates.

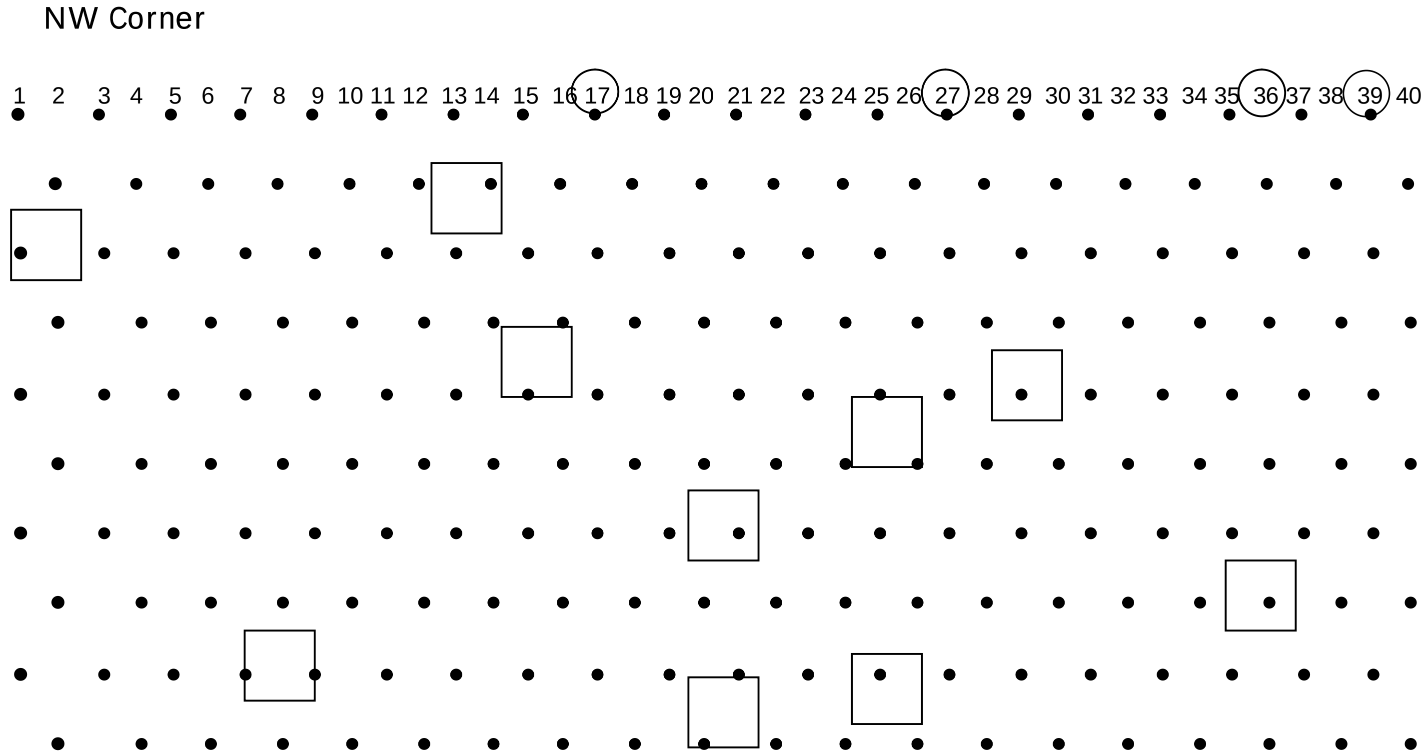
Table 2. Summary of *S. filiforme* short shoot density m^{-2} (SSD) and canopy height (CH) of the areal coverage reported in Table 1. Data based on measurements of the first ten planting units encountered within random meter square placements.

	July 20, 2006	August 17, 2006	January 17, 2007
SSD	804	1238	593
CH (cm)	18.2	25.1	13.6

Table 3. Summary of Braun Blanquet class coverage rating (BB) within random meter square placements in Plot 1. Braun Blanquet ratings: 0= absent, 0.5= <1%, 1= 1-5%, 2= 6-25%, 3= 26-50%, 4= 51-75%, 5= >75%.

	July 20, 2006	August 17, 2006	January 17, 2007
H.w BB	0.5	0.5	0
S. f. BB	1	1	1.5

Figure 1. Schematic of S. *filiforme* monitoring sites in Plot 1 on January 17, 2007. Randomly selected rows for unit size measurements are circled. Squares indicate estimated locations of random meter square placements for Braun Blanquet class coverage ratings. Placements continue until ten S. *filiforme* units are encountered (maximum of twenty placements).



Plot 2

Table 4. Summary of *S. filiforme* total unit coverage (m^2) in Plot 2 based on a ten percent random sub sample that included units measured in rows 1, 2, 15, and 36.

	July 20, 2006	August 17, 2006	January 17, 2007
S.f total coverage m^{-2}*	9.8	9.8	54.5

*The size of selected sod units at time "0" were determined using area=[(length of major axis x width of minor axis)/2) x pi]. This measurement method will be used for all future sod unit areal coverage estimates.

Table 5. Summary of *S. filiforme* short shoot density m^{-2} (SSD) and canopy height (CH) of the areal coverage reported in Table 4. Data based from measurements of the first ten planting units encountered within random meter square placements.

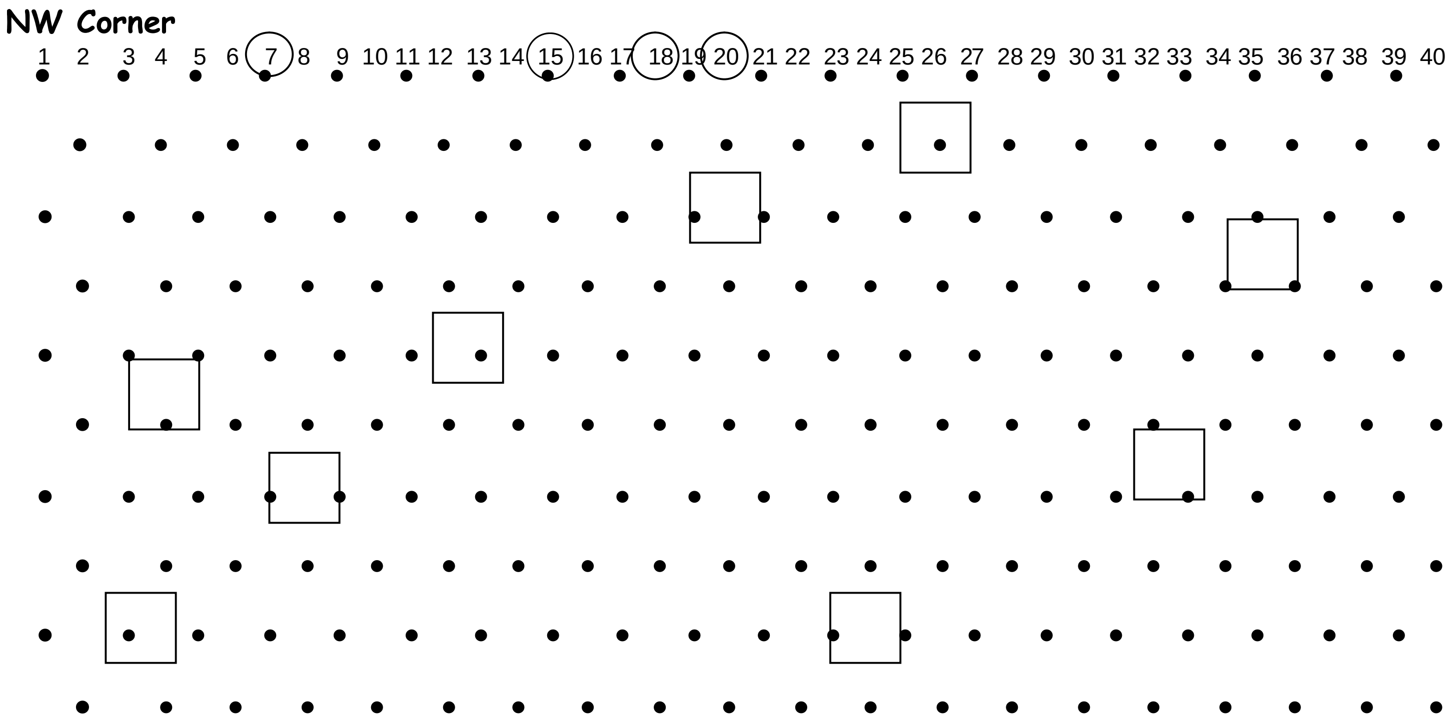
	July 20, 2006	August 17, 2006	January 17, 2007
SSD	1005	1667	966

CH (cm)	23.0	24.8	13.3

Table 6. Summary of Braun Blanquet class coverage rating (BB) within random meter square placements in Plot 2. Braun Blanquet ratings: 0= absent, 0.5= <1%, 1= 1-5%, 2= 6-25%, 3= 26-50%, 4= 51-75%, 5= >75%.

	July 20, 2006	August 17, 2006	January 17, 2007
H.w BB	0	<0.5	0.3
S. f. BB	2	1	1.5

Figure 2. Schematic of S. *filiforme* monitoring sites in Plot 2 on January 17, 2007. Randomly selected rows for unit size measurements are circled. Squares indicate estimated locations of random meter square placements for Braun Blanquet class coverage ratings. Placements continue until ten S. *filiforme* units are encountered (maximum of twenty placements).



Plot 3

Table 7. Summary of *S. filiforme* total unit coverage (m^2) in Plot 3 based on a ten percent random sub sample that included units measured in rows 13, 21, 27, and 36.

	July 20, 2006	August 17, 2006	January 17, 2007
S.f total coverage m^{-2}*	12.7	13.2	71.6

*The size of selected sod units at time “0” were determined using area=[(length of major axis x width of minor axis)/2) x pi]. This measurement method will be used for all future sod unit areal coverage estimates.

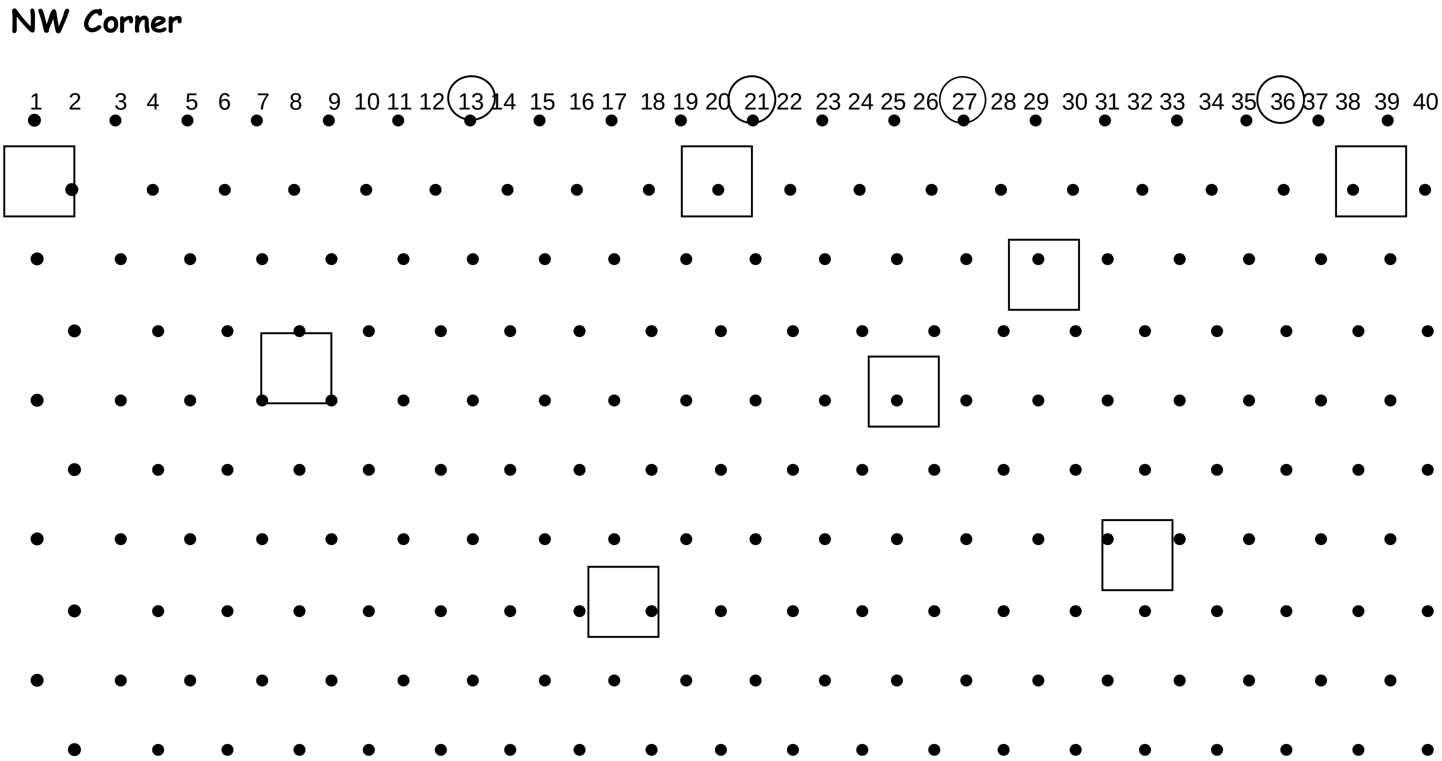
Table 8. Summary of *S. filiforme* short shoot density m^{-2} (SSD) and canopy height (CH) of the areal coverage reported in Table 7. Data based from measurements of the first ten planting units encountered within random meter square placements.

	July 20, 2006	August 17, 2006	January 17, 2007
SSD	1460	1390	1250
CH (cm)	19.3	26.2	16.8

Table 9. Summary of Braun Blanquet class coverage rating (BB) within random meter square placements in Plot 3. Braun Blanquet ratings: 0= absent, 0.5= <1%, 1= 1-5%, 2= 6-25%, 3= 26-50%, 4= 51-75%, 5= >75%.

	July 20, 2006	August 17, 2006	January 17, 2007
H.w BB	0	<0.5	0.3
S. f. BB	1	1	2

Figure 3. Schematic of S. *filiforme* monitoring sites in Plot 3 on January 17, 2007. Randomly selected rows for unit size measurements are circled. Squares indicate estimated locations of random meter square placements for Braun Blanquet class coverage ratings. Placements continue until ten S. *filiforme* units are encountered (maximum of twenty placements).



Plot 4

Table 10. Summary of *S. filiforme* total unit coverage (m^2) in Plot 4 based on a ten percent random sub sample that included units measured in rows 7, 10, 25, and 31.

	July 20, 2006	August 17, 2006	February 15, 2007
S.f total coverage m^{-2}*	13.1	11	34.7

*The size of selected sod units at time "0" were determined using area=[(length of major axis x width of minor axis)/2) x pi]. This measurement method will be used for all future sod unit areal coverage estimates.

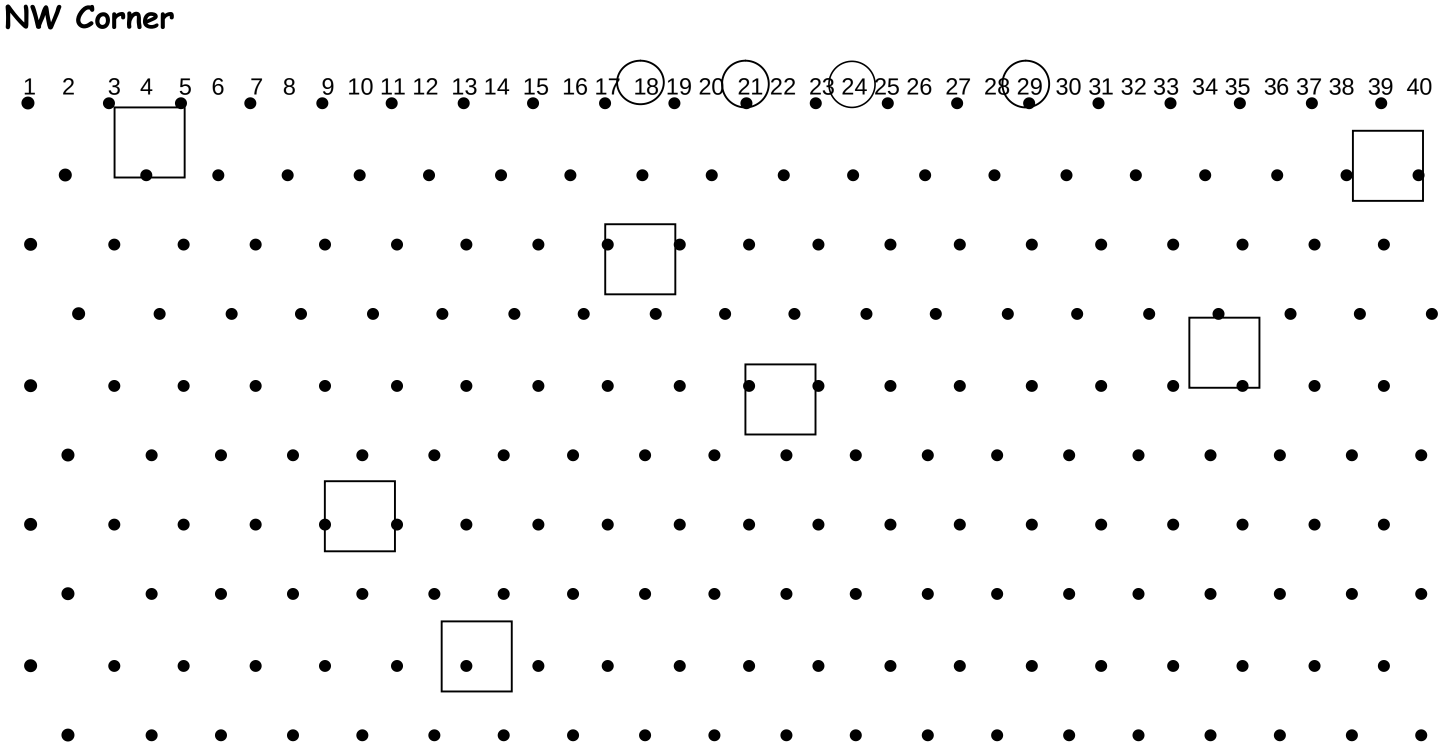
Table 11. Summary of *S. filiforme* short shoot density m^{-2} (SSD) and canopy height (CH) of the areal coverage reported in Table 10. Data based from measurements of the first ten planting units encountered within random meter square placements.

	July 20, 2006	August 17, 2006	February 15, 2007
SSD	1039	1720	1000
CH (cm)	24.5	28.9	15.9

Table 12. Summary of Braun Blanquet class coverage rating (BB) within random meter square placements in Plot 4. Braun Blanquet ratings: 0= absent, 0.5= <1%, 1= 1-5%, 2= 6-25%, 3= 26-50%, 4= 51-75%, 5= >75%.

	July 20, 2006	August 17, 2006	February 15, 2007
H.w BB	0.5	1	0.3
S. f. BB	2	1	2

Figure 4. Schematic of S. *filiforme* monitoring sites in Plot 4 on February 15, 2007. Randomly selected rows for unit size measurements are circled. Squares indicate estimated locations of random meter square placements for Braun Blanquet class coverage ratings. Placements continue until ten S. *filiforme* units are encountered (maximum of twenty placements).



Plot 5

Table 13. Summary of *S. filiforme* total unit coverage (m^2) in Plot 5 based on a ten percent random sub sample that included units measured in rows 7, 14, 15, and 30.

	July 20, 2006	August 17, 2006	February 15, 2007
S.f total coverage m^{-2}*	9.5	3.5	13.7

*The size of selected sod units at time "0" were determined using area=[(length of major axis x width of minor axis)/2) x pi]. This measurement method will be used for all future sod unit areal coverage estimates.

Table 14. Summary of *S. filiforme* short shoot density m^{-2} (SSD) and canopy height (CH) of the areal coverage reported in Table 13. Data based from measurements of the first ten planting units encountered within random meter square placements.

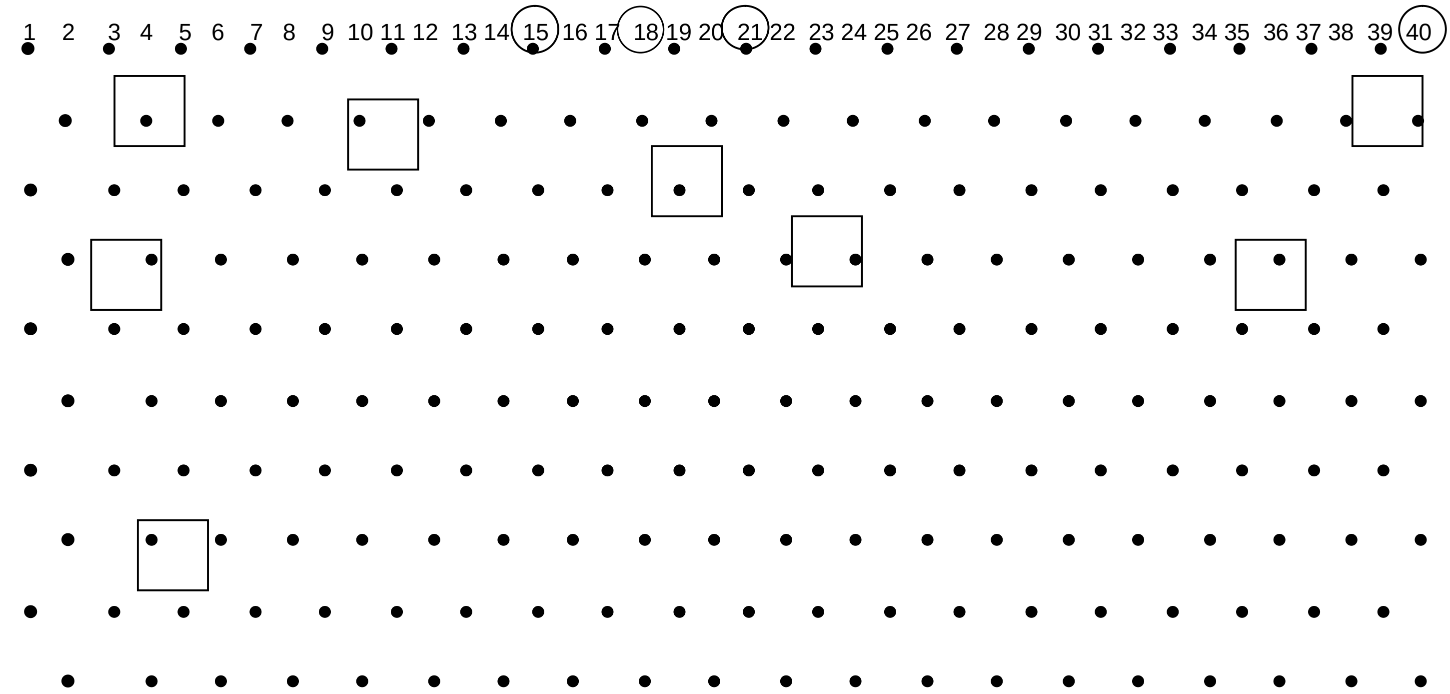
	July 20, 2006	August 17, 2006	February 15, 2007
SSD	1488	629	880
CH (cm)	24.2	21.7	13.7

Table 15. Summary of Braun Blanquet class coverage rating (BB) within random meter square placements in Plot 5. Braun Blanquet ratings: 0= absent, 0.5= <1%, 1= 1-5%, 2= 6-25%, 3= 26-50%, 4= 51-75%, 5= >75%.

	July 20, 2006	August 17, 2006	February 15, 2007
H.w BB	2	3	1.3
S. f. BB	1	<0.5	1.5

Figure 5. Schematic of S. *filiforme* monitoring sites in Plot 5 on February 15, 2007. Randomly selected rows for unit size measurements are circled. Squares indicate estimated locations of random meter square placements for Braun Blanquet class coverage ratings. Placements continue until ten S. *filiforme* units are encountered (maximum of twenty placements).

NW Corner



Plot 6

Table 16. Summary of *S. filiforme* total unit coverage (m^2) in Plot 6 based on a ten percent random sub sample that included units measured in rows 5, 26, 33, and 36.

	July 20, 2006	August 17, 2006	February 15, 2007
S.f total coverage m^{-2}*	8.3	9.9	4.2

*The size of selected sod units at time "0" were determined using area=[(length of major axis x width of minor axis)/2) x pi]. This measurement method will be used for all future sod unit areal coverage estimates.

Table 17. Summary of *S. filiforme* short shoot density m^{-2} (SSD) and canopy height (CH) of the areal coverage reported in Table 16. Data based from measurements of the first ten planting units encountered within random meter square placements.

	July 20, 2006	August 17, 2006	February 15, 2007
SSD	874	1230	941
CH (cm)	22.4	26.9	11.7

Table 18. Summary of Braun Blanquet class coverage rating (BB) within random meter square placements in Plot 6. Braun Blanquet ratings: 0= absent, 0.5= <1%, 1= 1-5%, 2= 6-25%, 3= 26-50%, 4= 51-75%, 5= >75%.

	July 20, 2006	August 17, 2006	February 15, 2007
H.w BB	2	2	1.8
S. f. BB	1	0.5	1.3

Figure 6. Schematic of S. *filiforme* monitoring sites in Plot 6 on February 15, 2007. Randomly selected rows for unit size measurements are circled. Squares indicate estimated locations of random meter square placements for Braun Blanquet class coverage ratings. Placements continue until ten S. *filiforme* units are encountered (maximum of twenty placements).

NW Corner

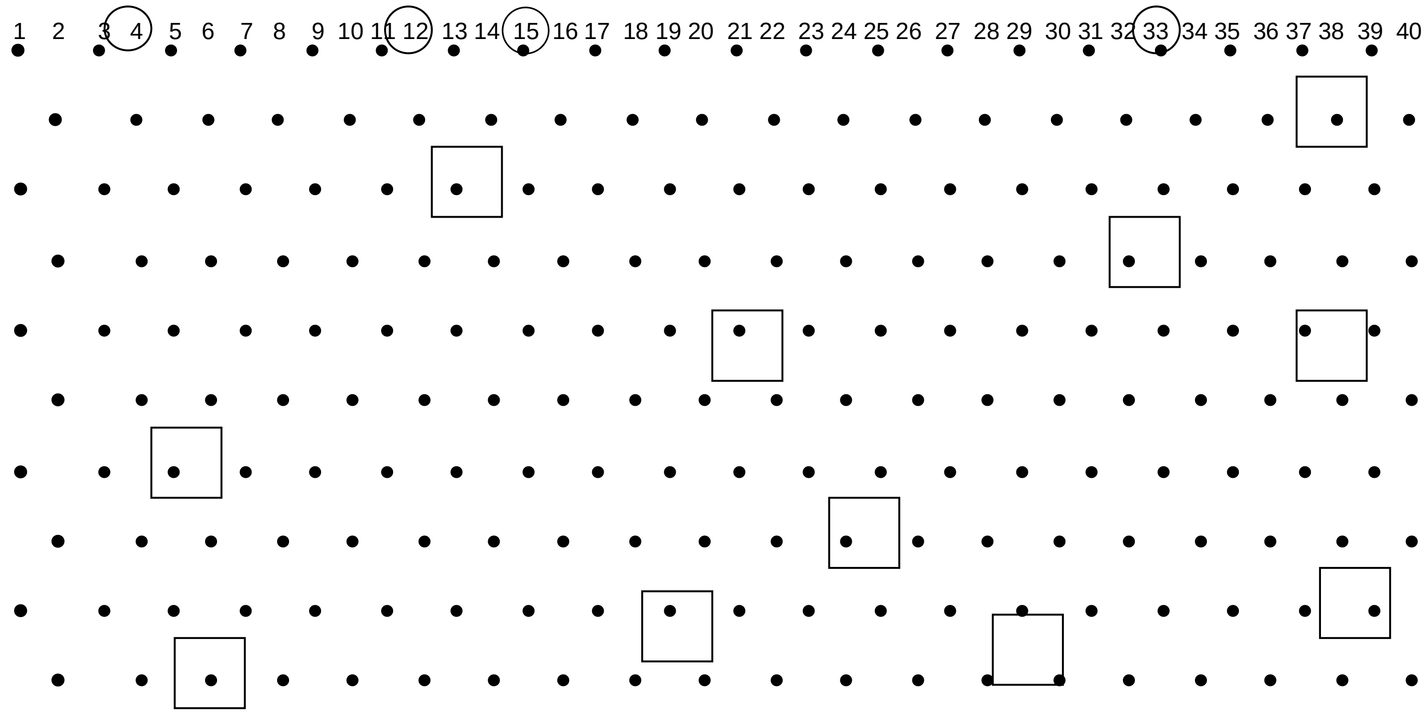


Photo 2. Monitoring station location at *Syringodium* transplant site off MacDill AFB.

Photo 3. Typical *Syringodium* plug in place off MacDill AFB.

Photo 4. Typical array of *Syringodium* planting units off MacDill AFB.

Photo 5. Oblique aerial view of general zone of *Syringodium* transplant plots and the location of historic longshore bars across the flat south of MacDill AFB. View is ca north. Plot 1 is seaward, Plot 6 is landward.

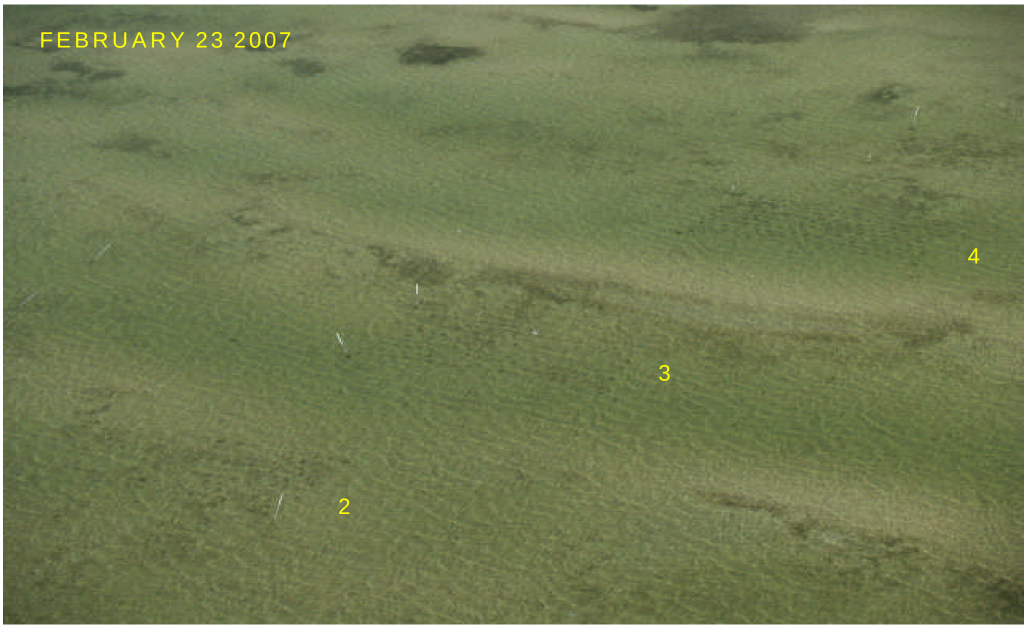


Photo 6. Oblique aerial view of Plots 2, 3 and 4 and remnant longshore bars. View is ca northwest.

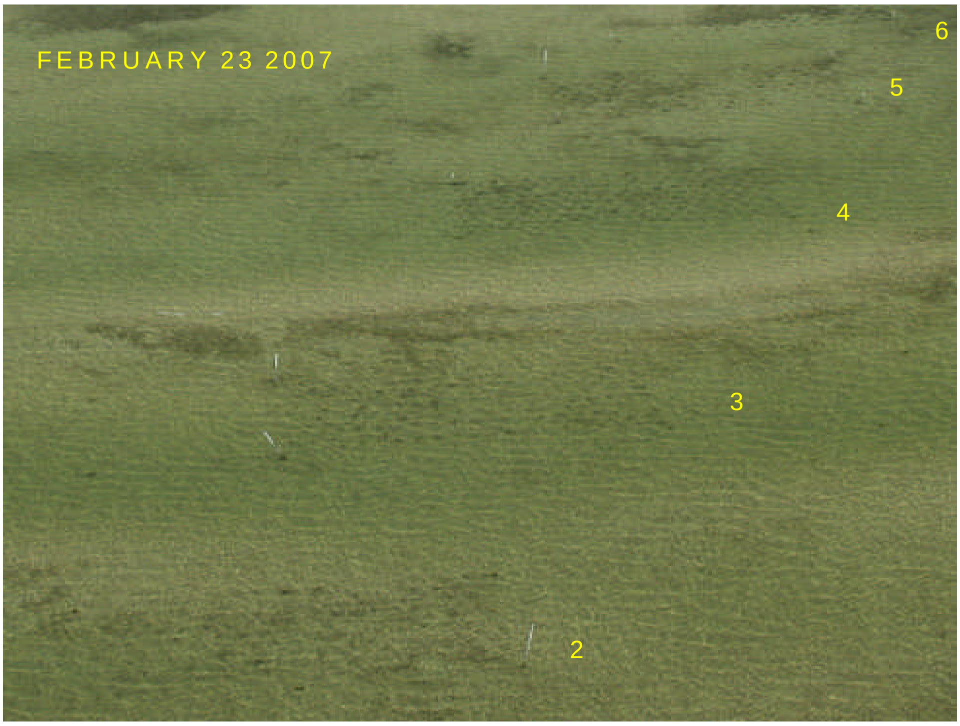


Photo 7. Oblique aerial view of Plots 2 -6 and remnant longshore bars. View is ca northwest.

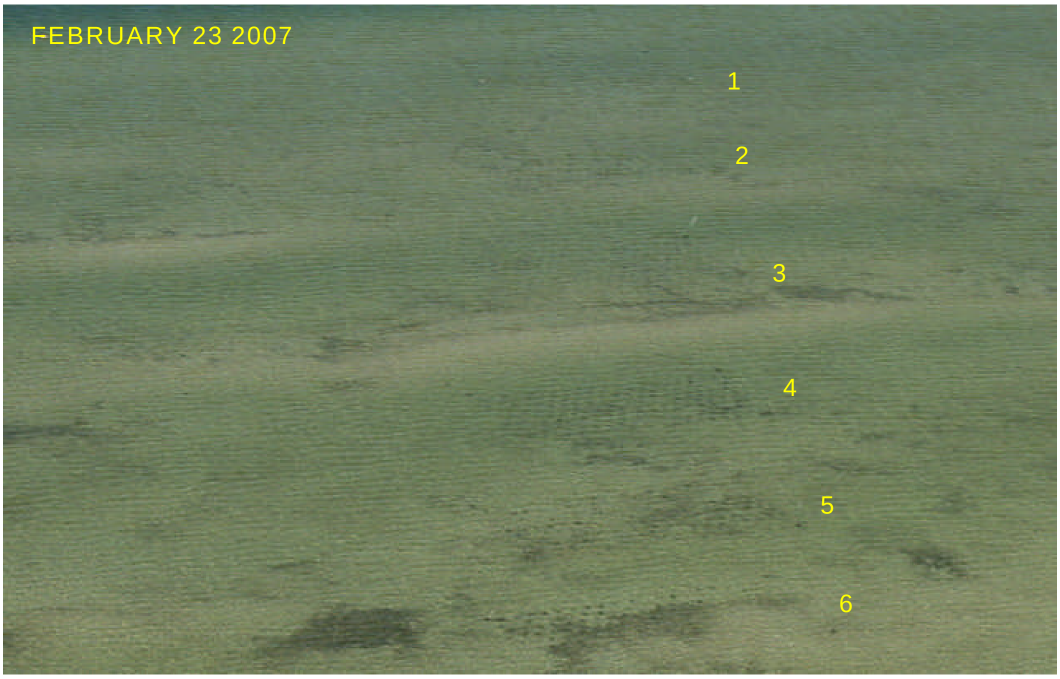


Photo 8. Oblique aerial view of Plots 1-6 and remnant longshore bars. View is ca south.

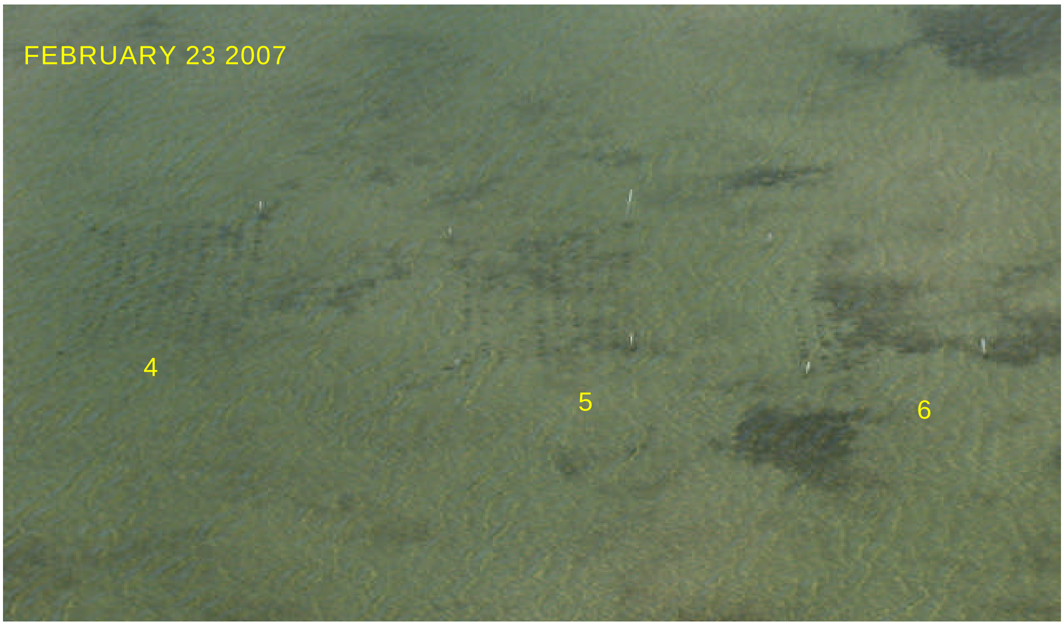


Photo 9. Oblique aerial view of Plots 4, 5, and 6. View is ca west.

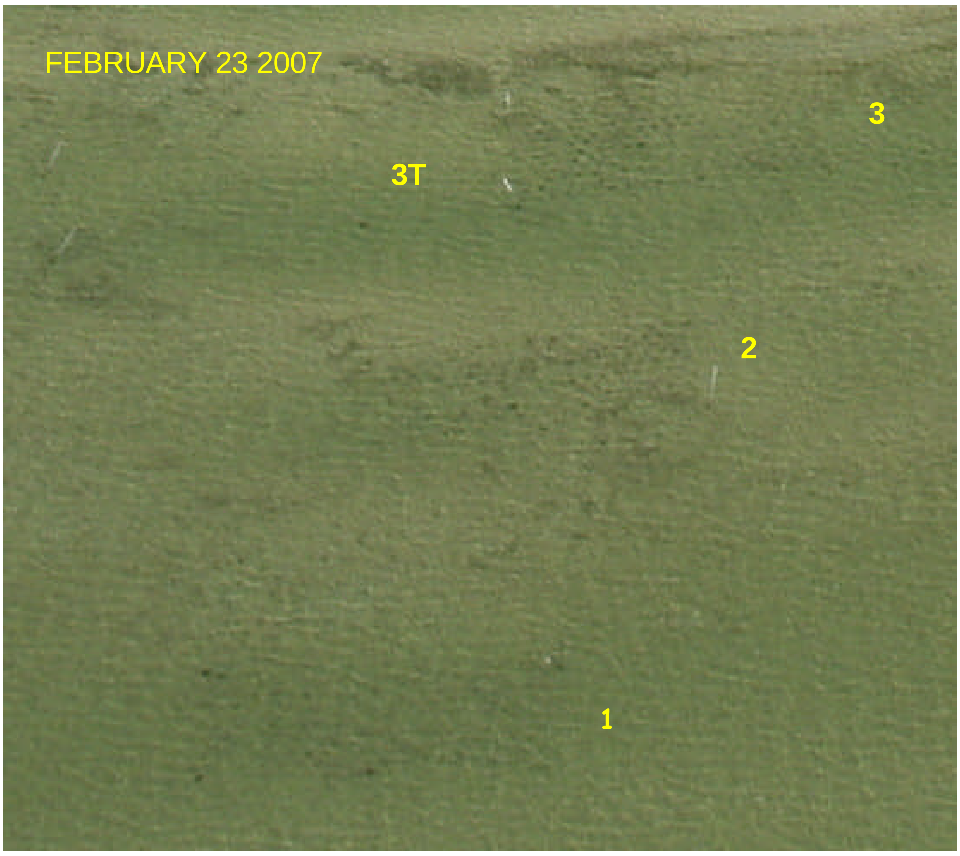


Photo 10. Oblique aerial view of *Syringodium* plots 1, 2 and 3 and *Thalassia* transplant site 3T and remnant longshore bars. View is ca north.

APPENDIX C

Kruer 2007b

Coastal Resources Group, Inc.
A Florida not-for-profit Corporation

Time Zero + One Year Monitoring Report

Seagrass Transplant and Restoration Project
MacDill Air Force Base, Tampa Bay, FL

Monitoring and Reporting Required by Specific Conditions 27 and 28 of
FDEP Environmental Resource Permit No. 29-0256820-001
Issued to Coastal Resources Group, Inc. on May 3, 2006

Includes Reports and Graphics Prepared by
Tampa Bay Watch (Donor Site, pp 3-4) and the
City of Tampa Bay Study Group (Transplant Site, pp 5-21)

Report prepared by:

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August 2007

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Seagrass Monitoring Report Time Zero + One Year Donor Site Monitoring Summary

Submitted by Tampa Bay Watch, Inc.
3000 Pinellas BayWay South
Tierra Verde, FL 33715

The 16 donor monitoring sites were monitored on August 1, 2007 for the 12 month monitoring report. The North monitoring sites, N1 and N2 were established on June 28th, 2006 while the South monitoring sites, S1 and S2 were established on July 13th, 2006. Monitoring began with the north plot of the N1 site at 9:16 a.m. and concluded with the south plot of the S2 site at 10:18 a.m. Overall, all sites looked very good with no apparent donor holes visible. At all 16 of the sites monitored, *Syringodium filiforme* was the dominate seagrass species with *Thalassia testudinum* found at three sites. The average abundance of *Syringodium* was 76-100% coverage. Three sites, not including the reference point, also had 5-25% coverage of *Thalassia testudinum*. The average blade length of all 16 donor sites monitored was approximately 60cm for *Syringodium* with a high of 74cm and a low of 53cm. Of all 16 donor sites monitored, the average shoot density for *Syringodium* was 51 with a high of 75 and low of 39 in the 25cm square.

Reference sites were recorded randomly next to each of the donor plug sites to monitor undisturbed background condition. The measurement was a random toss of the 25cm square one meter from each of the donor plugs. The average blade length of all 16 reference sites monitored was approximately 57cm for *Syringodium* with a high of 73cm and a low of 35cm. Of all 16 reference sites monitored, the average shoot density for *Syringodium* was 47 with a high of 69 and low of 29 in the 25cm square quadrat.

All sites have made a successful recovery. The 16 original donor plug holes are no longer visible. No depth was measurable for any of the 16 plug holes. Both blade length and short shoot density is higher at the donor plug sites than the background reference sites, probably due to the high rate of expansion characteristic of *Syringodium filiforme* during the summertime growing season. Barnacle spat and attached algae were found at all sites. Sandy sediment was consistent through all sites. The next set of monitoring will be conducted at the 24 month interval.

Tampa Bay Watch
Time Zero + One Year field monitoring data from *Syringodium* donor site - August 1, 2007
Species (Spp.): (AA) Attached Algae (DA) Drift Algae (H) *Halodule* (HE) *Halophila* (R) *Ruppia*
(S) Syringodium (T) Thalassia
Abundance: 1=<5% cover, 2=5-25% cover, 3=26-50% cover, 4= 51-75% cover, 5=76-100% cover
Epiphte Density: 1=clean, 2=light, 3=moderate, 4=heavy Sediment (Sed.): 1=shelly sand, 2=sand, 3=muddy sand, 4=mud, 5=oyster
Count square quadrat size = 25 cm x 25 cm,
Tide Low and Incoming
Sites S1 and S2 were established on 7/13/2006. Sites N1and N2 were established on 6/28/2006

Site	Spp.	Abund.	Blade Length Average	Shoot Density	Epiphyte	Epiphyte	
S1 North	S	4	66	41	Type	Density	Sed.
S1 N Ref	S	4	62	44	AA, BS	4,2	2
S1 East	S	4	58	53	AA, BS	4,2	2
S1 E Ref	S	4	49	49	AA, BS	4,2	2
S1 South	S	5	41	41	AA, BS	4,2	2
S1 S Ref	S	5	37	37	AA, BS	4,2	2
S1 West	S	4	53	39	AA, BS	4,2	2
S1 W Ref	S	4	39	29	AA, BS	4,2	2
					AA, BS	4,2	2
S2 North	S	5	53	51			
S2 N Ref	S	5	54	47	AA, BS	4,2	2
S2 East	S	5	55	56	AA, BS	4,2	2
S2 E Ref	S	5	35	49	AA, BS	4,2	2
S2 South	S	5	57	42	AA, BS	4,2	2
S2 S Ref	S	5	53	37	AA, BS	4,2	2
S2 West	S	5	57	46	AA, BS	4,2	2
S2 W Ref	S	5	63	49	AA, BS	4,2	2
					AA, BS	4,2	2
N1 North	S, T	S(5), T(2)	74, 10	S52, T5			
N1 N Ref	S, T	S(5), T(1)	68, 12	S58, T2	AA, BS	2	2
N1 East	S, T	S(5), T(1)	65,11	S53, T4	AA, BS	2	2
N1 E Ref	S, T	S(5), T(1)	64,11	S49, T1	AA, BS	2	2
N1 South	S	5	65	62	AA, BS	2	2
N1 S Ref	S	5	61	67	AA, BS	2	2
N1 West	S	5	65	75	AA, BS	2	2
N1 W Ref	S	5	73	69	AA, BS	2	2
					AA, BS	2	2
N2 North	S	5	61	53			
N2 N Ref	S	5	59	53	AA, BS	2	2
N2 East	S	5	55	49	AA, BS	2	2
N2 E Ref	S	5	53	41	AA, BS	2	2
N2 South	S	5	53	48	AA, BS	2	2
N2 S Ref	S,T	S(5), T(1)	S(53), T(12)	S(36),T(1)	AA, BS	2	2
N2 West	S,T	S(4),T(1)	S(53), T(12)	S(48), T(2)	AA, BS	2	2
N2 W Ref	S	5	42	S(51)	AA, BS	2	2
					AA, BS	2	2

Donor Sites	HI	74	**Donor Sites**		
Blade Length (cm)	LOW	53	Density	HI	1200
	AVERAGE	60	Shoots/m2	LOW	624
				AVERAGE	816
Reference Sites	HI	73	**Ref Sites**		
Blade Length (cm)	LOW	35	Density	HI	1104
	AVERAGE	57	Shoots/m2	LOW	464
				AVERAGE	752

Data Summary of the *Syringodium filiforme* Transplant Project at Coon Hammock Creek: July 5, 2007 - Time Zero + One Year

City of Tampa
Bay Study Group
2700 Maritime Blvd.
Tampa, FL 33605

July 2007

Summary

In the three previous assessments prior to "time one year" on July 5, 2007, random *Syringodium filiforme* planting rows were selected to determine percent survival and planting unit growth. It was noted during the "time six month" assessment that many of the planting units had started to coalesce. Therefore, the methodology for the "time one year" assessment changed to utilizing twenty random meter square placements per 10mx20m planting plot to assess percent composition, short shoot density, and canopy height. Each meter square placement was georeferenced using a Trimble™ GPS unit with submeter accuracy.

Thalassia testudinum was noted in two meter square placements in Plot 3. In addition, one meter square placement in Plot 5 contained the attached alga, *Caulerpa prolifera*. Neither species was present in appreciable biomass and, therefore, were not included in this report.

Plot 1

Table 1. Summary of *S. filiforme* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 1.

	Coverage; m^2	SSD	CH	BB
July 20, 2006	9	804	18.2	1
August 17, 2006	10.5	1238	25.1	1
January 17, 2007	36	593	13.6	1.5
July 5, 2007	21.5	906	19.6	1.7

Table 2. Summary of *H. wrightii* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 1. ND=No Data

	Coverage; m^2	SSD	CH	BB
July 20, 2006	ND	ND	ND	0.5
August 17, 2006	ND	ND	ND	0.5
January 17, 2007	ND	ND	ND	0
July 5, 2007	3	1200	17	0.5

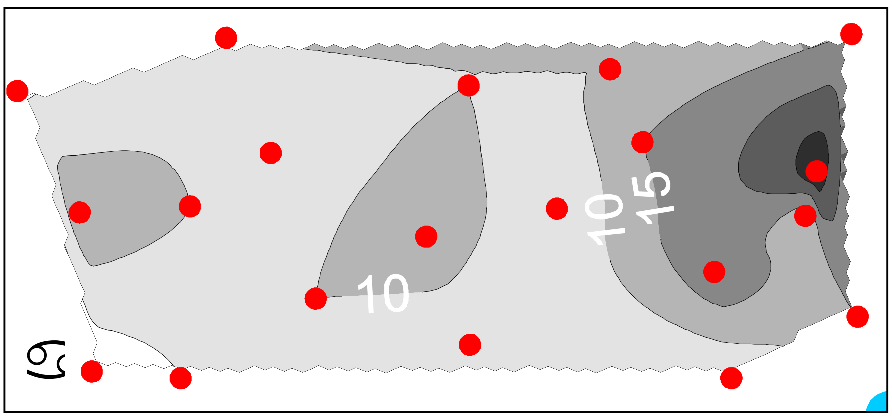


Figure 1. Location of the twenty random meter square placements and distribution of percent *S. filiforme* cover in Plot 1.

Plot 2

Table 3. Summary of *S. filiforme* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 2.

	Coverage; m^2	SSD	CH	BB
July 20, 2006	9.8	1005	23	2
August 17, 2006	9.8	1667	24.8	1
January 17, 2007	54.5	966	13.3	1.5
July 5, 2007	45.6	912	21.3	2.2

Table 4. Summary of *H. wrightii* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 2. ND=No Data

	Coverage; m^2	SSD	CH	BB
July 20, 2006	ND	ND	ND	0
August 17, 2006	ND	ND	ND	<0.5
January 17, 2007	ND	ND	ND	<0.5
July 5, 2007	8.6	1533	17	<0.5

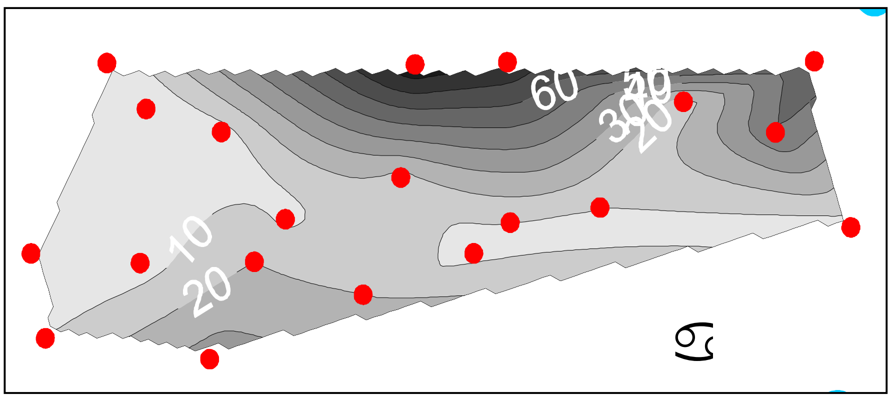


Figure 2. Location of the twenty random meter square placements and distribution of percent *S. filiforme* cover in Plot 2.

Plot 3

Table 5. Summary of *S. filiforme* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 3.

	Coverage; m^2	SSD	CH	BB
July 20, 2006	12.7	1460	19.3	1
August 17, 2006	13.2	1390	26.3	1
January 17, 2007	71.6	1250	16.8	2
July 5, 2007	50.6	1330	23.1	2.4

Table 6. Summary of *H. wrightii* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 3. ND=No Data

	Coverage; m^2	SSD	CH	BB
July 20, 2006	ND	ND	ND	0
August 17, 2006	ND	ND	ND	0
January 17, 2007	ND	ND	ND	<0.5
July 5, 2007	1.8	950	1.3	<0.5

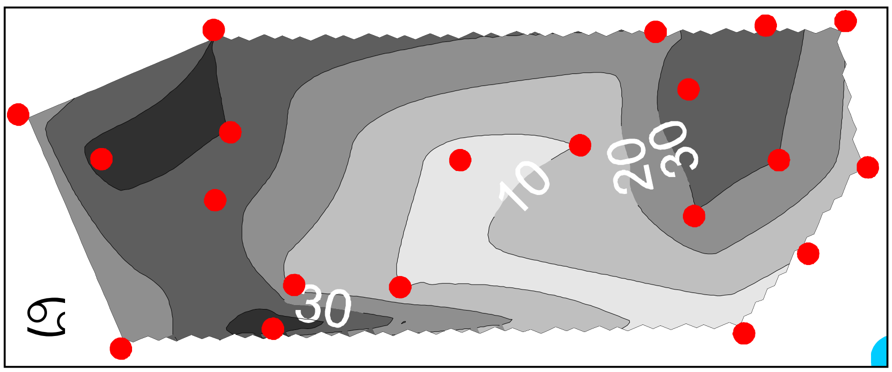


Figure 3. Location of the twenty random meter square placements and distribution of percent *S. filiforme* cover in Plot 3.

Plot 4

Table 7. Summary of *S. filiforme* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 4.

	Coverage; m^2	SSD	CH	BB
July 20, 2006	13.1	1460	19.3	1
August 17, 2006	11	1390	26.3	1
January 17, 2007	34.7	1250	16.8	2
July 5, 2007	34.8	1122	24.3	2.2

Table 8. Summary of *H. wrightii* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 4. ND=No Data

	Coverage; m^2	SSD	CH	BB
July 20, 2006	ND	ND	ND	0.5
August 17, 2006	ND	ND	ND	1
January 17, 2007	ND	ND	ND	<0.5
July 5, 2007	20.2	1125	17.2	1.6

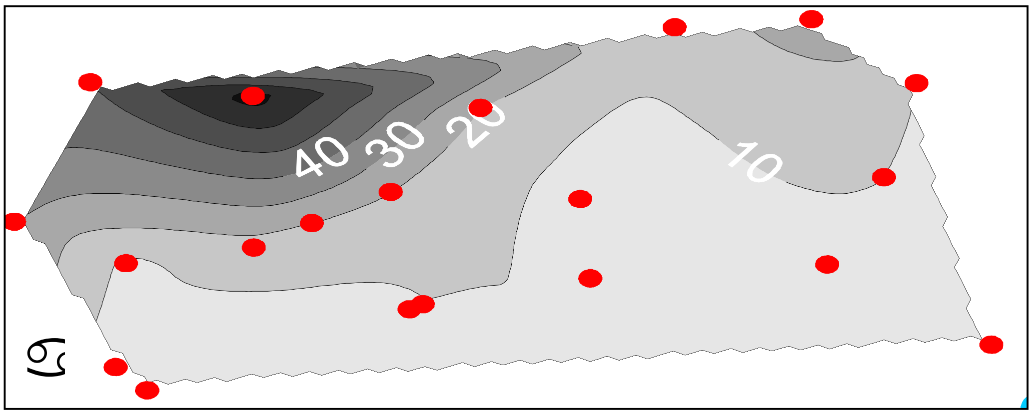


Figure 4. Location of the twenty random meter square placements and distribution of percent *S. filiforme* cover in Plot 4.

Plot 5

Table 9. Summary of *S. filiforme* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 5.

	Coverage; m^2	SSD	CH	BB
July 20, 2006	9.5	1488	24.2	1
August 17, 2006	3.5	629	21.7	<0.5
January 17, 2007	13.7	880	13.7	1.5
July 5, 2007	35.2	1423	27.4	1.9

Table 10. Summary of *H. wrightii* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 5. ND=No Data

	Coverage; m^2	SSD	CH	BB
July 20, 2006	ND	ND	ND	2
August 17, 2006	ND	ND	ND	3
January 17, 2007	ND	ND	ND	1.3
July 5, 2007	70.6	1805	21.8	2.9

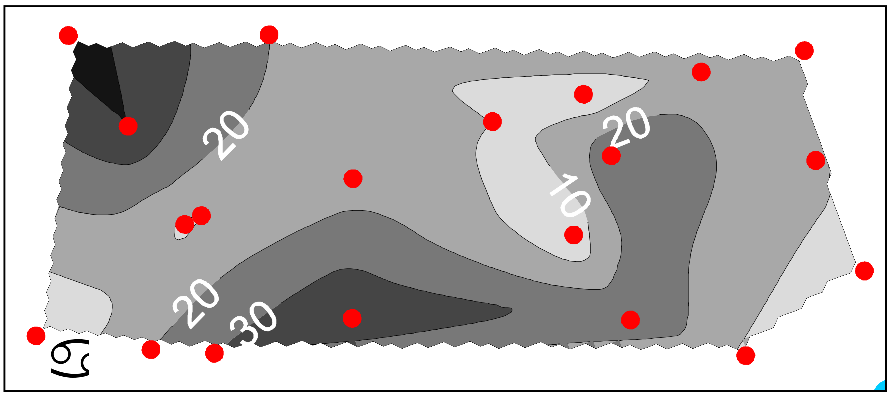


Figure 5. Location of the twenty random meter square placements and distribution of percent *S. filiforme* cover in Plot 5.

Plot 6

Table 11. Summary of *S. filiforme* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 6.

	Coverage; m^2	SSD	CH	BB
July 20, 2006	8.3	874	22.4	1
August 17, 2006	9.9	1230	26.9	0.5
January 17, 2007	4.2	941	11.7	1.3
July 5, 2007	20	1286	27.1	1.0

Table 12. Summary of *H. wrightii* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 6. ND=No Data

	Coverage; m^2	SSD	CH	BB
July 20, 2006	ND	ND	ND	2
August 17, 2006	ND	ND	ND	2
January 17, 2007	ND	ND	ND	1.8
July 5, 2007	59.2	1926	18.2	3

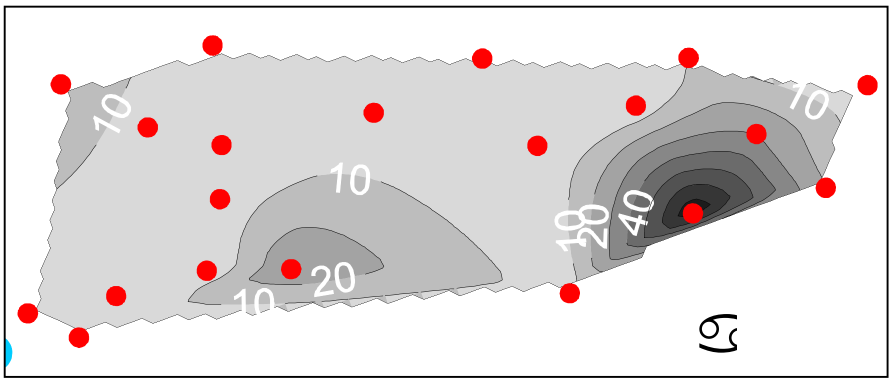
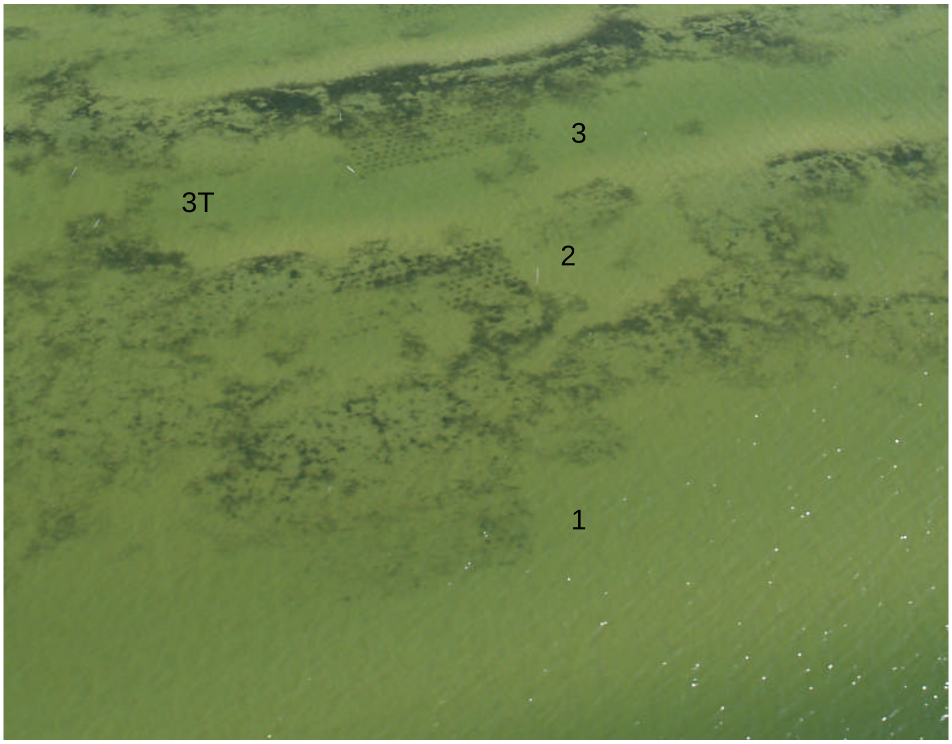


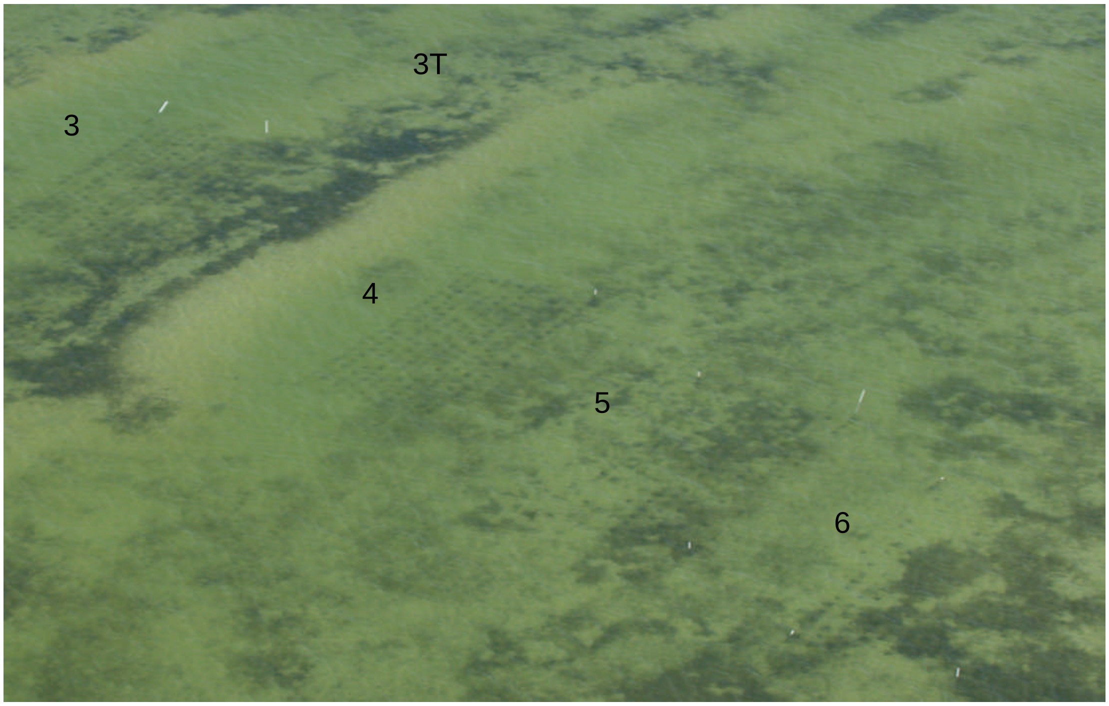
Figure 6. Location of the twenty random meter square placements and distribution of percent *S. filiforme* cover in Plot 6.

May 2, 2007 aerial photos provided by City of Tampa Bay Study Group. Plot #s provided.

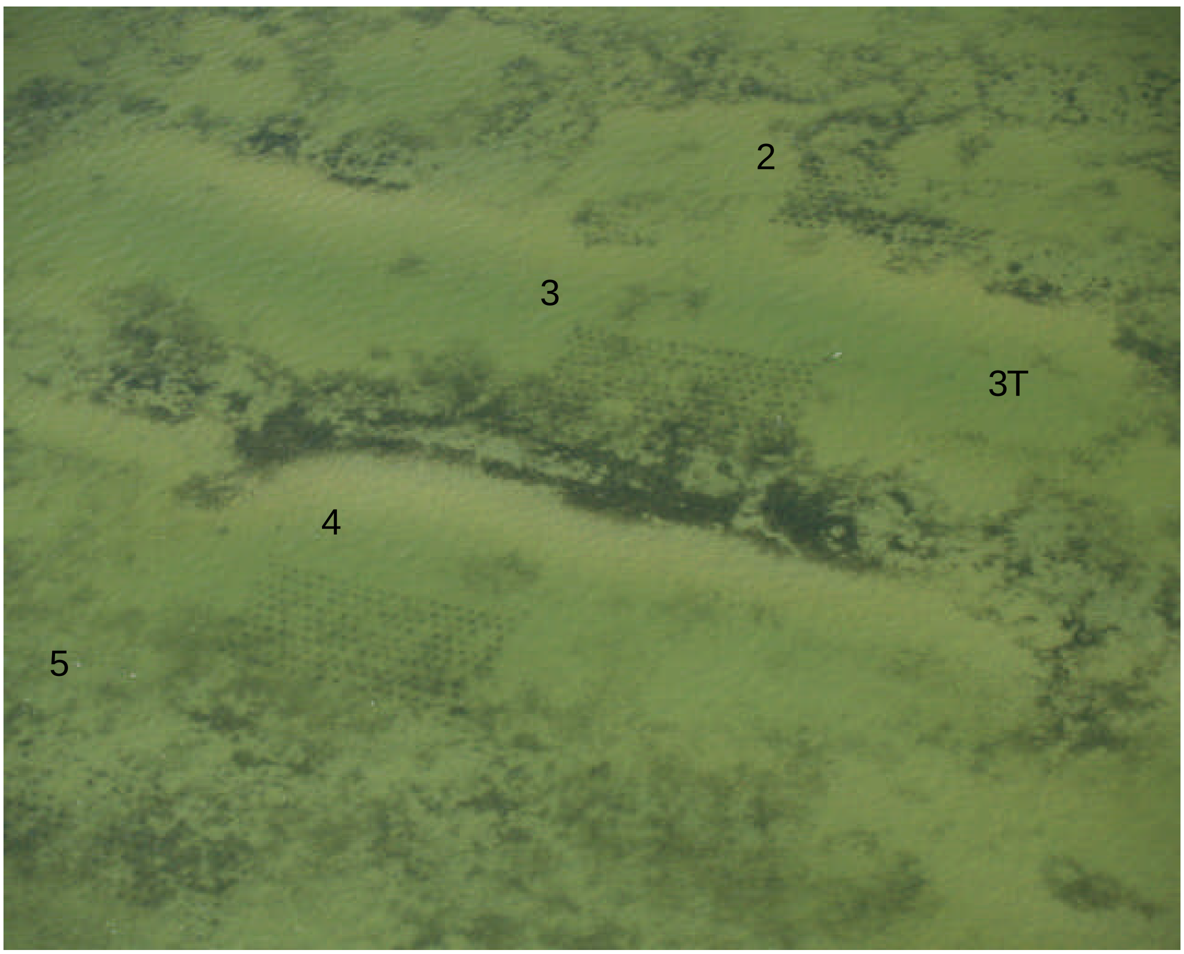
MACDILL MAY 2 2007



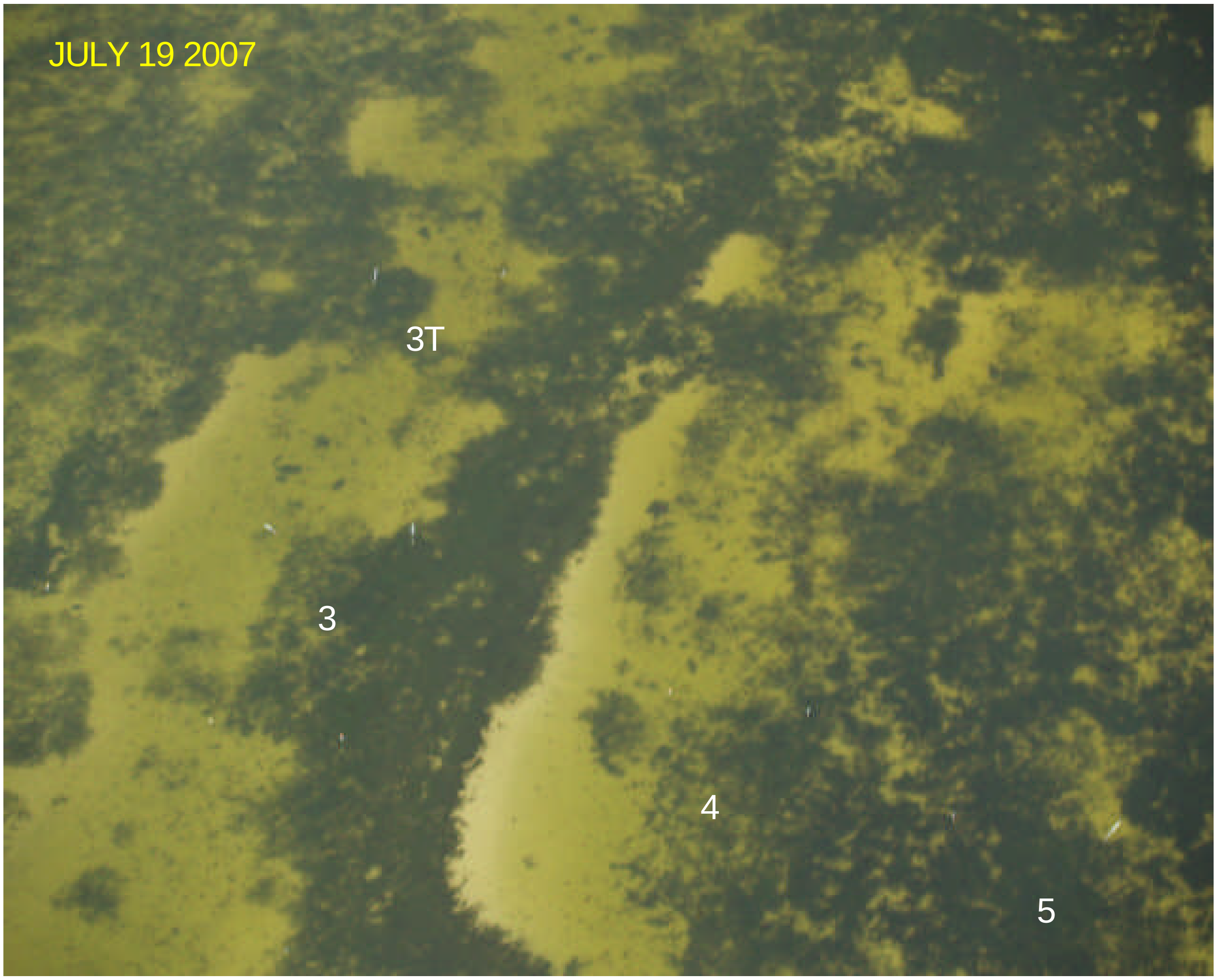
MACDILL MAY 2 2007



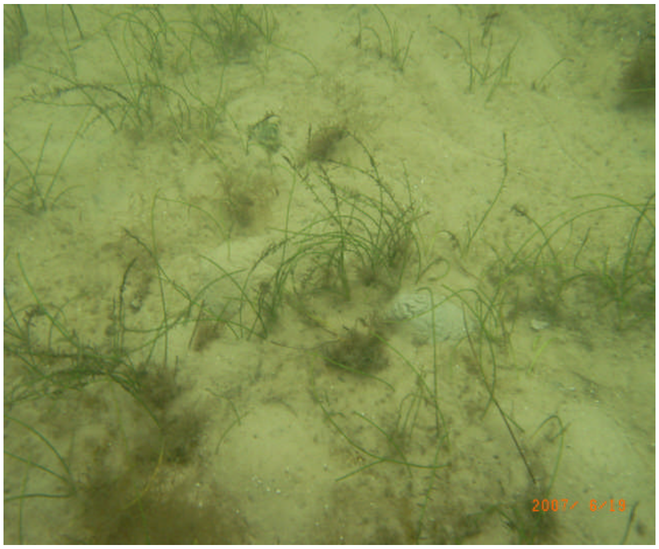
MACDILL MAY 2 2007



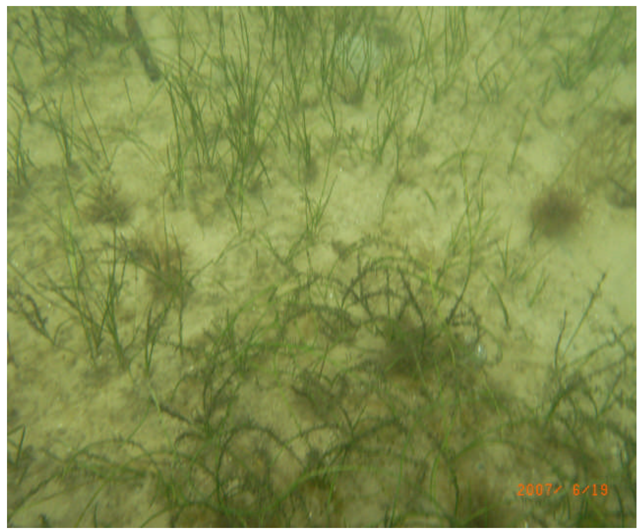
July 19, 2007 aerial photo provided by City of Tampa Bay Study Group. Dark signature is primarily seasonal attached and drift macroalgae.



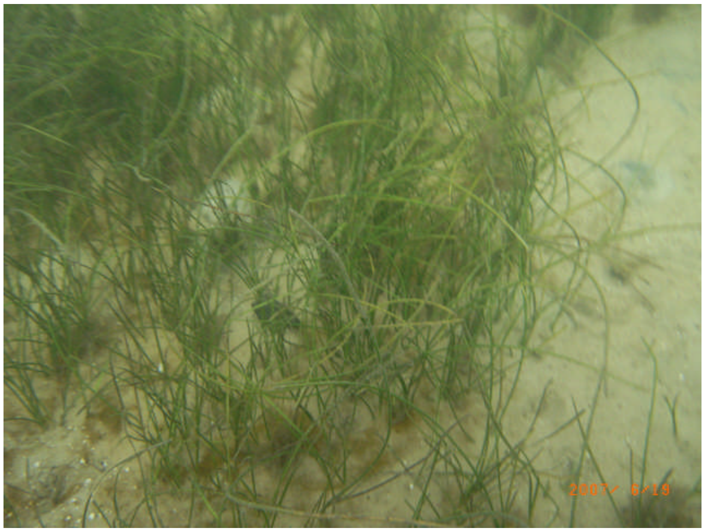
June 19, 2007 - Representative underwater photos of seagrass and macroalgae in planting plots.

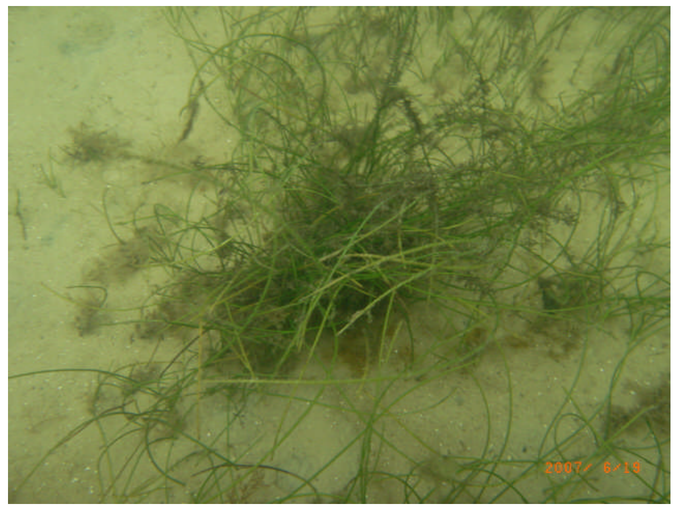


PLOT1

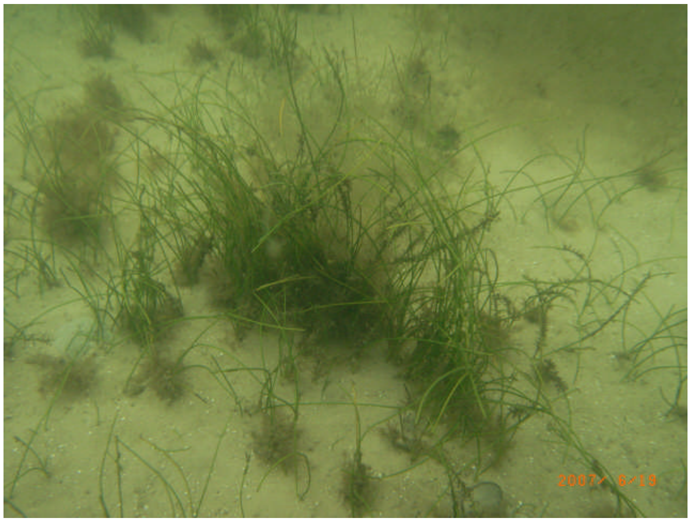


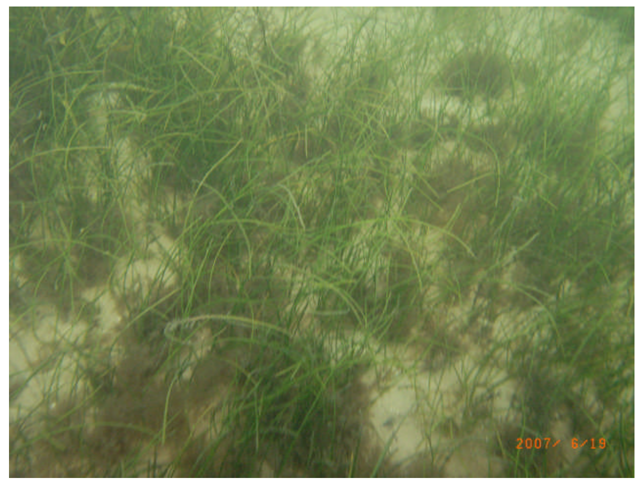
PLOT2

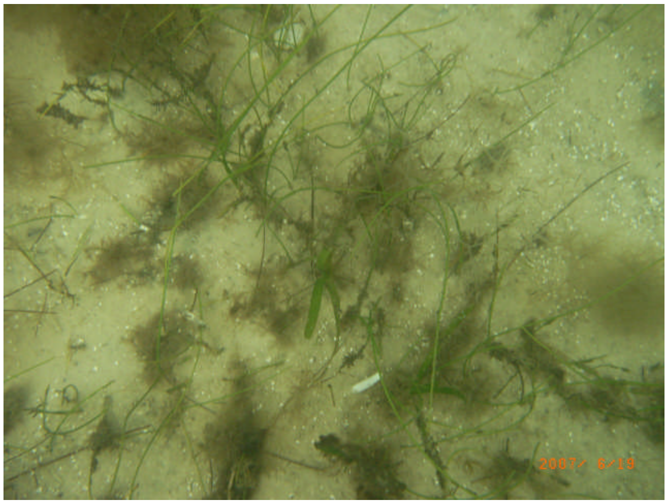




PLOT3

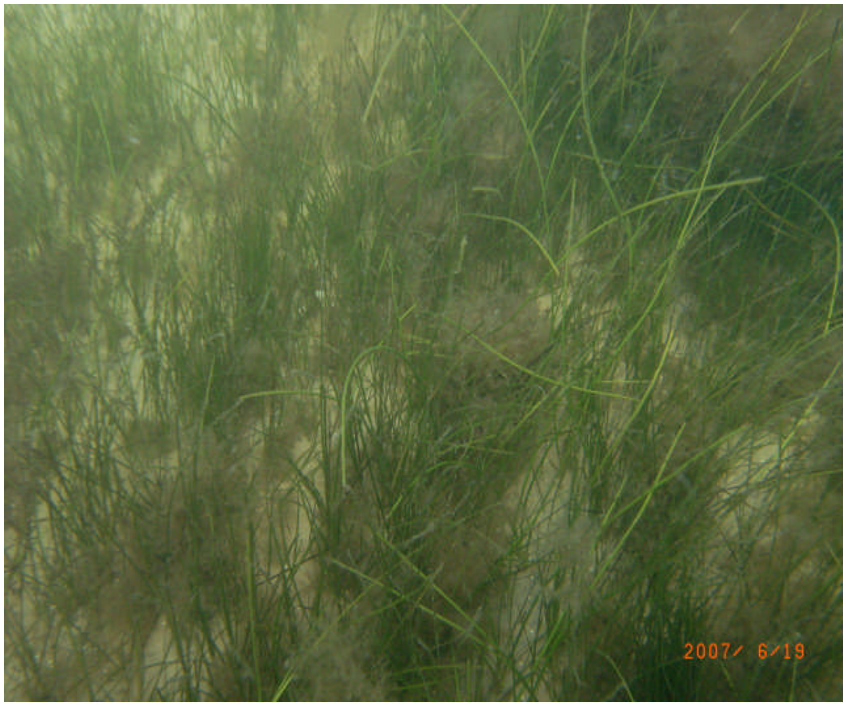


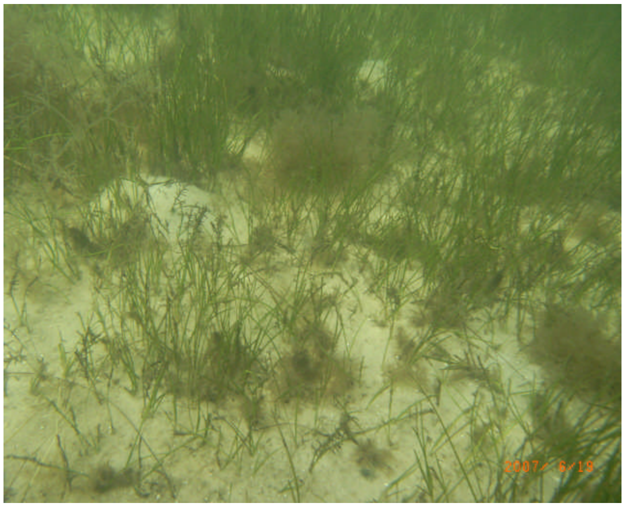




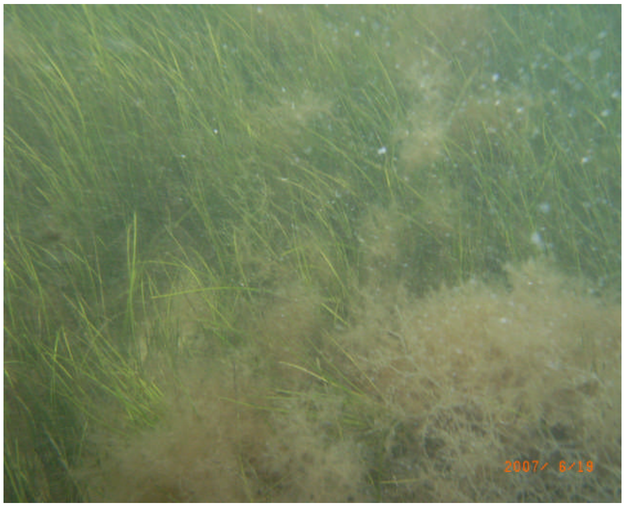
PLOT4

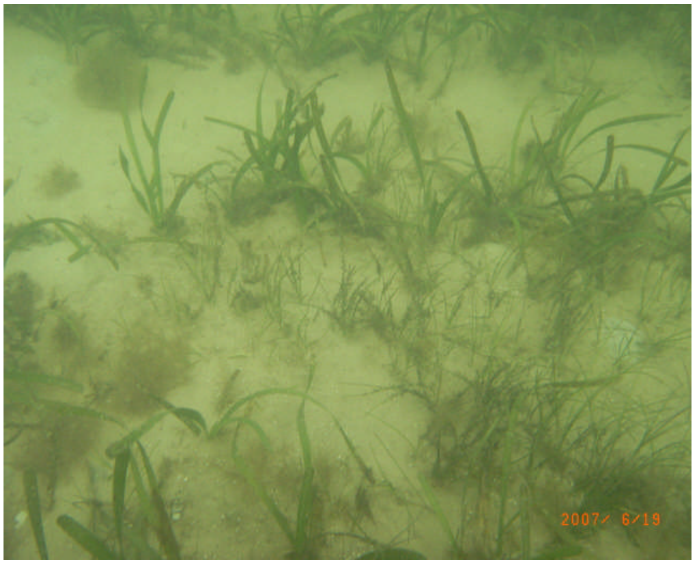
PLOT5





PLOT6





PLOT3T

APPENDIX D

Kruer 2008a

Coastal Resources Group, Inc.
A Florida not-for-profit Corporation

Time Zero + One and 1/2 Year Monitoring Report

Seagrass Transplant and Restoration Project
MacDill Air Force Base, Tampa Bay, FL
Monitoring and Reporting Required by Specific Conditions 27 and 28 of
FDEP Environmental Resource Permit No. 29-0256820-001
Issued to Coastal Resources Group, Inc. on May 3, 2006

Includes Reports and Graphics Prepared by
Tampa Bay Watch (Donor Site, pp 2-3) and the
City of Tampa Bay Study Group (Transplant Site, pp 4-13)

Report Prepared by:

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January 3, 2008

Seagrass Monitoring Report
17 Month Informal Monitoring Summary
Provided by Tampa Bay Watch, Inc.

The donor sites were monitored on November 16, 2007 for an informal 17 month monitoring event by Tampa Bay Watch, Inc. and the City of Tampa Bay Study Group. The North monitoring sites, N1 and N2 were established on June 28th, 2006 while the South monitoring sites, S1 and S2 were established on July 13th, 2006. Overall, all sites looked very good with no apparent visible impact.

Since this was an informal monitoring event, monitoring was not accomplished in the traditional manner. However, this informal event helps to document donor site recovery in between required monitoring events. The unofficial monitoring event was accomplished with two random placements of the meter square set 2m from the center pole directly to the south and to the north. At all 8 of the sites monitored, *Syringodium filiforme* was found. No *Ruppia* was observed at any of the sites. Site N1 had an average of 55% coverage of *Syringodium*. The average shoot density was 10 with an average height of 46.5cm. Site N2 exhibited an average of 45% coverage of *Syringodium*. The observed average shoot density was 11 with and average height of 35cm. Site S1 had both S*yringodium* and *Thalassia testudinum* present with and average density of 70% and 15%. The average shoot density of *Syringodium* was 10.5 and 14 for *Thalassia*. The average height for *Syringodium* was 34cm and 35cm for *Thalassia*. For site S2, the average coverage of *Syringodium* was 27.5%. There was an observed average shoot density of 12 with an average height of 40cm.

Thalassia was found at two of the monitoring sites, but only one site had *Thalassia* in the meter square. The overall average abundance of *Syringodium* was 50% coverage in the meter square. The overall average abundance of *Thalassia* in the meter square was 15%, found only at one reference point. Of all 8 sites monitored, the average blade length found was approximately 39cm for *Syringodium* with a high of 52cm and a low of 30cm. These measurements were taken in the 10cm square. The average blade length of *Thalassia* was 35cm in the 10cm square. Of all 8 sites monitored, the average shoot density for *Syringodium* was 11 plants with a high of 16 and low of 8 in the 10cm square. The average shoot density for *Thalassia* was 14 in the 10cm square.

When compared with data from the previous seagrass monitoring report it is noticeable that the observations are lower than the previous monitoring data across the board. This reflects the winter time dormant stage of the seagrass. Both *Syringodium* and *Thalassia* enter a dormant stage as the water temperatures cool and the days become shorter. This was observed in the smaller shoot density counts as well as the smaller average blade lengths. It is expected that summertime observations will reveal a larger count for both shoot density and average blade length.

None of the 16 plugs were visible at the four locations. No depth was measurable for any of the 16 plugs. The southern most site contained moderate coverage of hydrozoans and bryozoans. Barnacle spat and attached algae were found at all sites. Sandy sediment was consistent through all sites.

Overall, the seagrass seems to have made a full recovery and looks very healthy. An in depth monitoring will be conducted at the required 24 month period that will follow the original monitoring guidelines.

Data Summary of the *Syringodium filiforme* Transplant Project at Coon Hammock Creek on November 26, 2007

Submitted by City of Tampa
Bay Study Group
December 4, 2007

Summary

In previous assessments prior to "time one year" on July 5, 2007, random *Syringodium filiforme* planting rows were selected to determine percent survival and planting unit growth. It was noted during the "time six month" assessment that many of the planting units had started to coalesce. Therefore, the methodology for the "time one year" and subsequent assessments changed to utilizing twenty random meter square placements per 10mx20m planting plot to assess percent composition, short shoot density, and canopy height. Each meter square placement was georeferenced using a Trimble™ DGPS unit with submeter accuracy. The "time eighteen months" assessment was conducted to provide interim data outside of the scheduled FDEP monitoring requirements.

Thalassia testudinum was noted in one meter square placement in Plots 3 and 5. However, this seagrass was not present in appreciable biomass and was not included in this report. The attached alga, *Caulerpa prolifera*, was not present in any meter square placements.

Plot 1

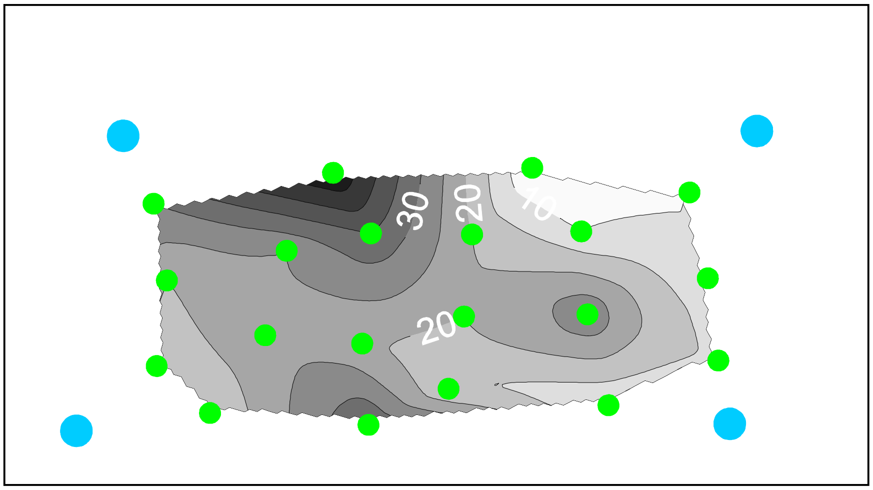
Table 1. Summary of *S. filiforme* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 1.

	Coverage; m2	SSD	CH	BB
July 20, 2006	9	804	18.2	1
August 17, 2006	10.5	1238	25.1	1
January 17, 2007	36	593	13.6	1.5
July 5, 2007	21.5	906	19.6	1.7
November 26, 2007	20.8	660	34.4	2.3

Table 2. Summary of *H. wrightii* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 1. ND=No Data

	Coverage; m2	SSD	CH	BB
July 20, 2006	ND	ND	ND	0.5
August 17, 2006	ND	ND	ND	0.5
January 17, 2007	ND	ND	ND	0
July 5, 2007	3	1200	17	0.5
November 26, 2007	4	1250	28	<0.5

Figure 1. Location of the twenty random meter square placements and distribution of percent *S. filiforme* cover in Plot 1.



Plot 2

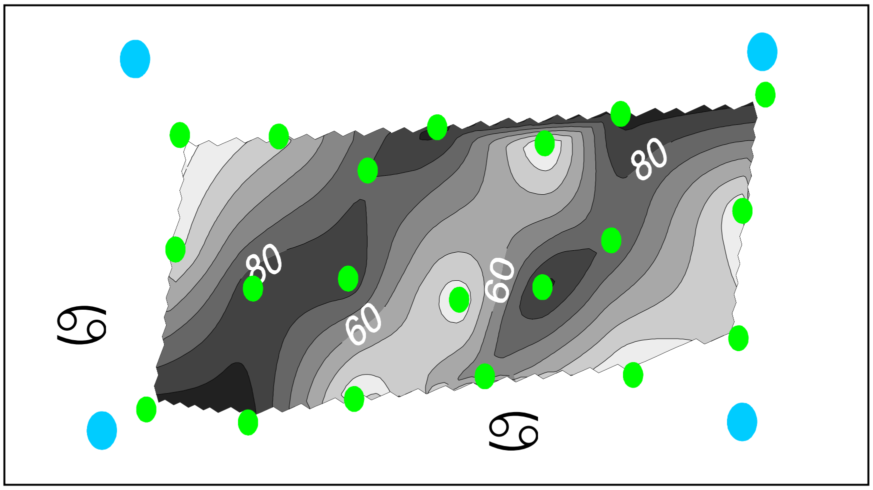
Table 3. Summary of *S. filiforme* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 2.

	Coverage; m2	SSD	CH	BB
July 20, 2006	9.8	1005	23	2
August 17, 2006	9.8	1667	24.8	1
January 17, 2007	54.5	966	13.3	1.5
July 5, 2007	45.6	912	21.3	2.2
November 26, 2007	127	920	43.2	3.9

Table 4. Summary of *H. wrightii* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 2. ND=No Data

	Coverage; m2	SSD	CH	BB
July 20, 2006	ND	ND	ND	0
August 17, 2006	ND	ND	ND	<0.5
January 17, 2007	ND	ND	ND	<0.5
July 5, 2007	8.6	1533	17	<0.5
November 26, 2007	11	500	27.4	1

Figure 2. Location of the twenty random meter square placements and distribution of percent *S. filiforme* cover in Plot 2.



Plot 3

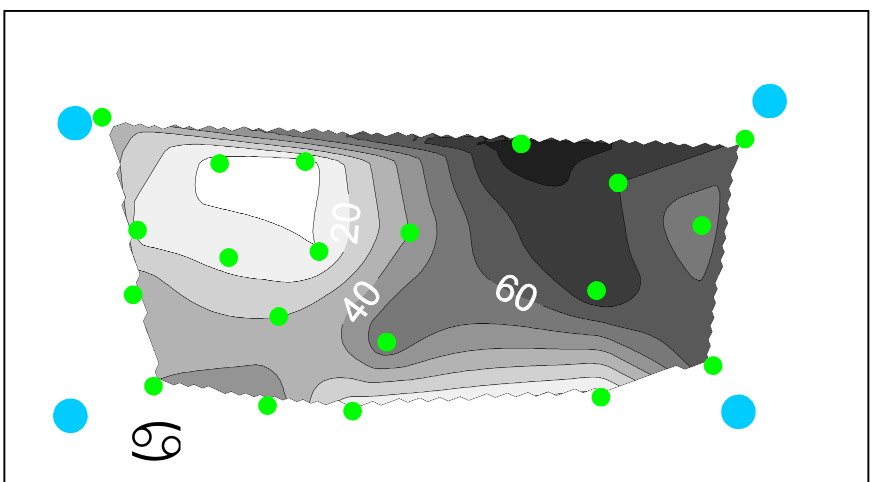
Table 5. Summary of *S. filiforme* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 3.

	Coverage; m2	SSD	CH	BB
July 20, 2006	12.7	1460	19.3	1
August 17, 2006	13.2	1390	26.3	1
January 17, 2007	71.6	1250	16.8	2
July 5, 2007	50.6	1330	23.1	2.4
November 26, 2007	79.5	1495	40.3	3.1

Table 6. Summary of *H. wrightii* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 3. ND=No Data

	Coverage; m2	SSD	CH	BB
July 20, 2006	ND	ND	ND	0
August 17, 2006	ND	ND	ND	0
January 17, 2007	ND	ND	ND	<0.5
July 5, 2007	1.8	950	18.3	<0.5
November 26, 2007	2.6	1000	24	<0.5

Figure 3. Location of the twenty random meter square placements and distribution of percent *S. filiforme* cover in Plot 3.



Plot 4

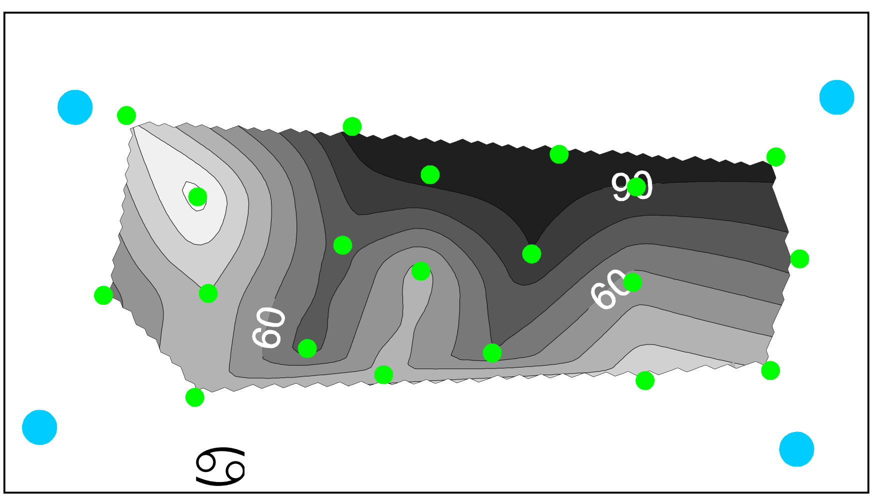
Table 7. Summary of *S. filiforme* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 4.

	Coverage; m2	SSD	CH	BB
July 20, 2006	13.1	1460	19.3	1
August 17, 2006	11	1390	26.3	1
January 17, 2007	34.7	1250	16.8	2
July 5, 2007	34.8	1122	24.3	2.2
November 26, 2007	126	1005	49.2	3.9

Table 8. Summary of *H. wrightii* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 4. ND=No Data

	Coverage; m2	SSD	CH	BB
July 20, 2006	ND	ND	ND	0.5
August 17, 2006	ND	ND	ND	1
January 17, 2007	ND	ND	ND	<0.5
July 5, 2007	20.2	1125	17.2	1.6
November 26, 2007	3.8	150	22	<0.5

Figure 4. Location of the twenty random meter square placements and distribution of percent S. filiforme cover in Plot 4.



Plot 5

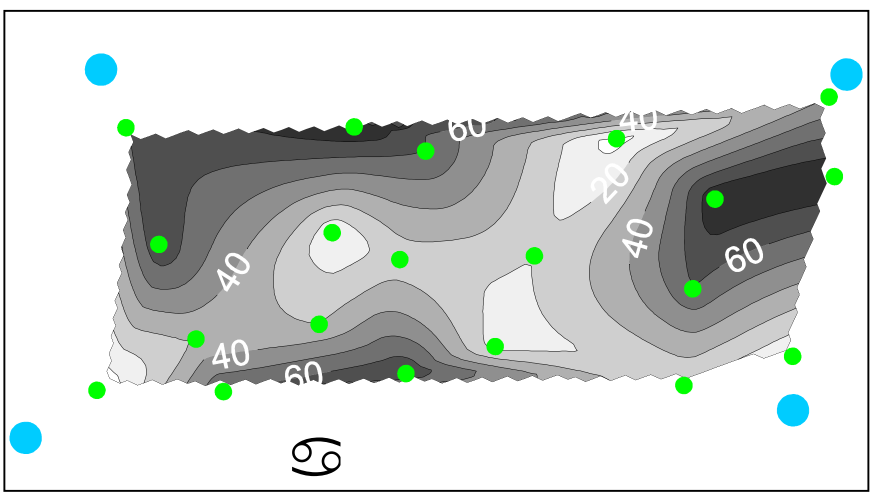
\Table 9. Summary of *S. filiforme* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 5.

	Coverage; m2	SSD	CH	BB
July 20, 2006	9.5	1488	24.2	1
August 17, 2006	3.5	629	21.7	<0.5
January 17, 2007	13.7	880	13.7	1.5
July 5, 2007	35.2	1423	27.4	1.9
November 26, 2007	82.5	1442	46.1	3.1

Table 10. Summary of *H. wrightii* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 5. ND=No Data

	Coverage; m2	SSD	CH	BB
July 20, 2006	ND	ND	ND	2
August 17, 2006	ND	ND	ND	3
January 17, 2007	ND	ND	ND	1.3
July 5, 2007	70.6	1805	21.8	2.9
November 26, 2007	6.2	867	16.1	0.9

Figure 5. Location of the twenty random meter square placements and distribution of percent *S. filiforme* cover in Plot 5.



Plot 6

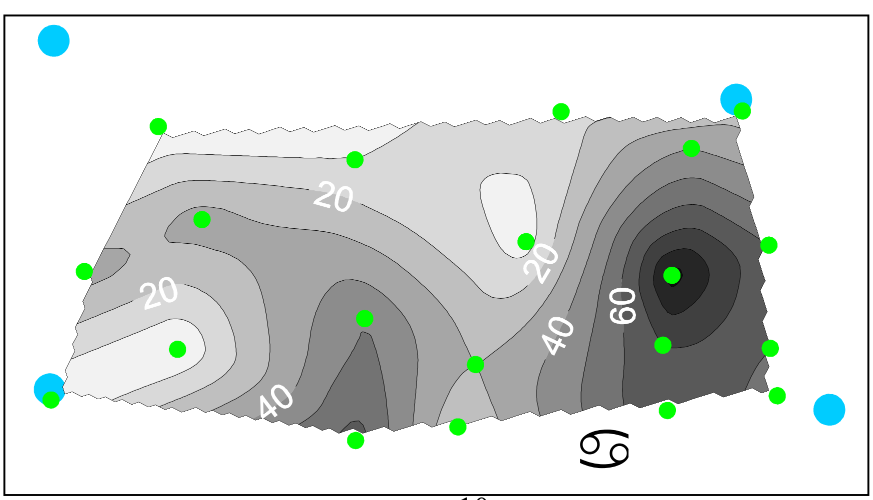
Table 9. Summary of *S. filiforme* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 6.

	Coverage; m2	SSD	CH	BB
July 20, 2006	8.3	874	22.4	1
August 17, 2006	9.9	1230	26.9	0.5
January 17, 2007	4.2	941	11.7	1.3
July 5, 2007	20	1286	27.1	1.0
November 26, 2007	74	1024	42.1	2.7

Table 10. Summary of *H. wrightii* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 6. ND=No Data

	Coverage; m2	SSD	CH	BB
July 20, 2006	ND	ND	ND	2
August 17, 2006	ND	ND	ND	2
January 17, 2007	ND	ND	ND	1.8
July 5, 2007	59.2	1926	18.2	3
November 26, 2007	34.4	1095	25.4	1.5

Figure 6. Location of the twenty random meter square placements and distribution of percent *S. filiforme* cover in Plot 6.



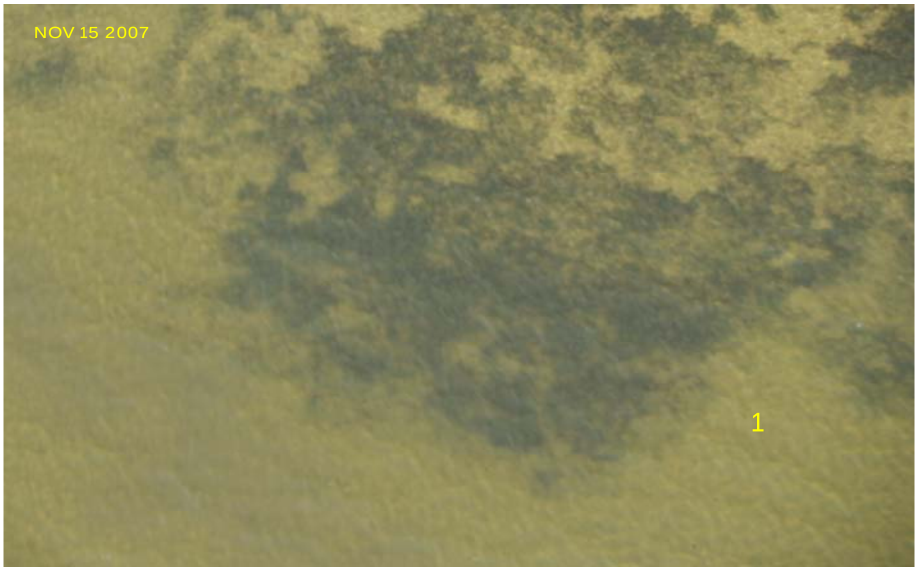


Figure 7. November 15, 2007 low-level aerial of Plot 1. Photo by COTBSG.

Figure 8. November 15, 2007 low-level aerial of Plot 2. Photo by COTBSG.

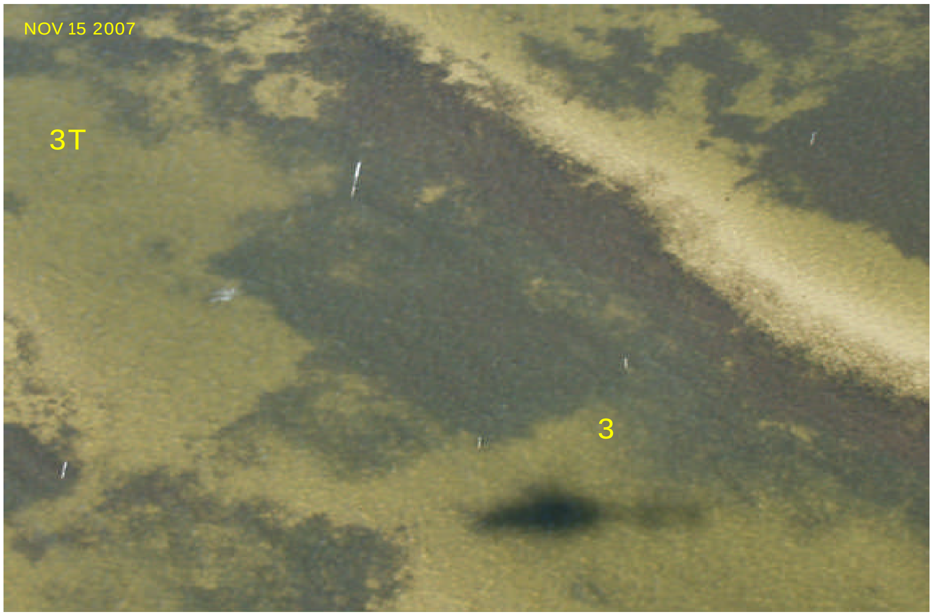


Figure 9. November 15, 2007 low-level aerial of Plots 3 and 3T. Photo by COTBSG.

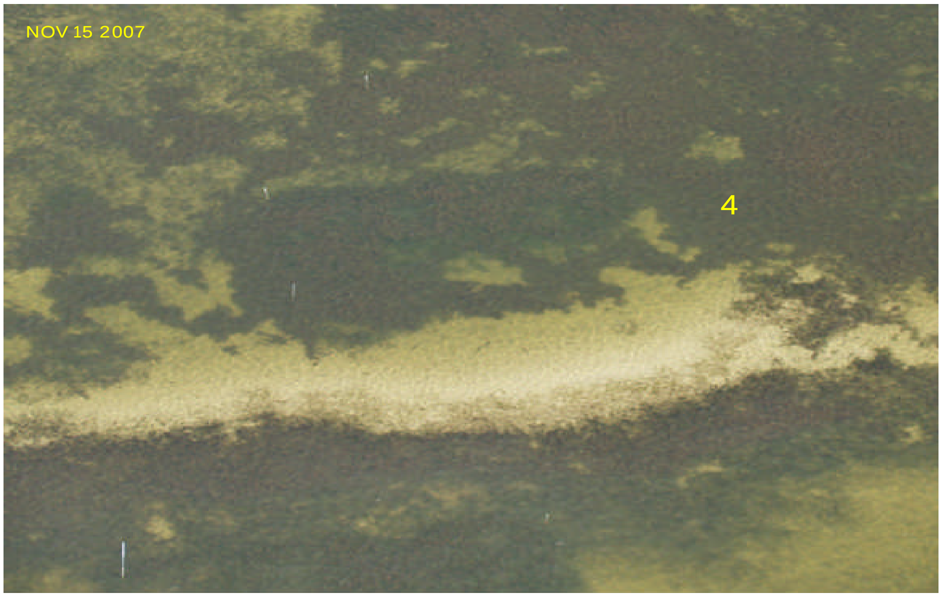


Figure 10. November 15, 2007 low-level aerial of Plot 4. Photo by COTBSG.

Figure 11. November 15, 2007 low-level aerial of Plot 5. Photo by COTBSG.

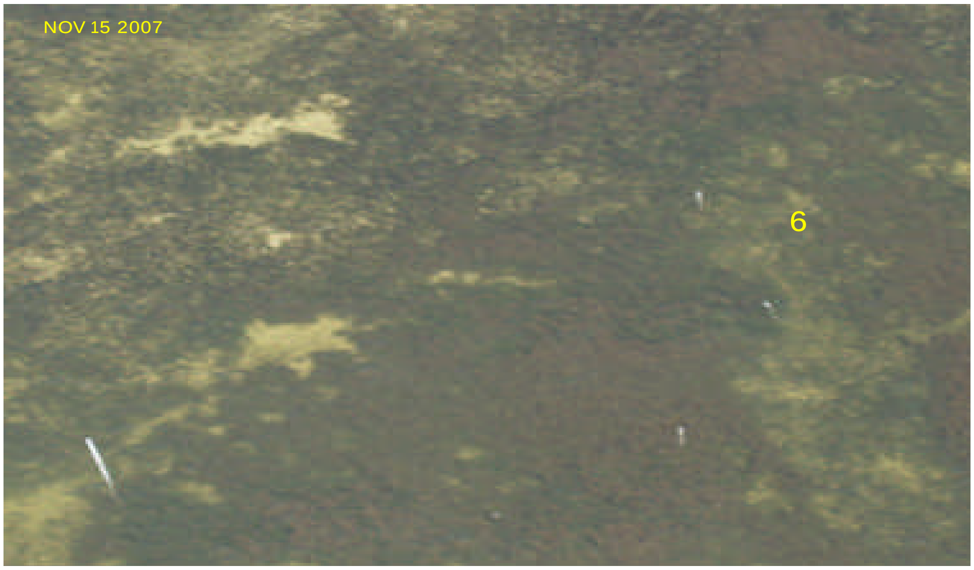


Figure 12. November 15, 2007 low-level aerial of Plot 6. Photo by COTBSG.

APPENDIX E

Kruer 2008b

Coastal Resources Group, Inc.

A Florida not-for-profit Corporation

Time Zero + 2 Year Monitoring Report

Seagrass Transplant and Restoration Project
MacDill Air Force Base, Tampa Bay, FL
Monitoring and Reporting Required by Specific Conditions 27 and 28 of
FDEP Environmental Resource Permit No. 29-0256820-001
Issued to Coastal Resources Group, Inc. on May 3, 2006

Includes Reports and Graphics Prepared by
Tampa Bay Watch (Donor Site, pp 2-4), the
City of Tampa, Bay Study Group (Transplant Site pp 5-11), and Underwater and Aerial Photographs of the Site taken July, 2008 (pp 12-18)

Report Prepared by:

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August 2008

MacDill AFB/Tampa Bay 2006 Seagrass Transplant Project

Seagrass Donor Site Monitoring Report
24 Month Final Monitoring Summary
Provided by Tampa Bay Watch, Inc.

The 16 donor monitoring sites and 16 donor reference points were monitored on July 1, 2008 for the 24 month, final monitoring reference for the FDEP. The North monitoring sites, N1 and N2 were established on June 28th, 2006 while the South monitoring sites, S1 and S2 were established on July 13th, 2006. Monitoring began with the north plot of the S1 site at 9:50am and concluded with the west plot of the N2 site at 11:40am. Overall all sites looked very good with no apparent holes visible. At 15 out of 16 of the sites monitored, *Syringodium filiforme* was found. Ruppia was not found at any of the sites. *Thalassia testudinum* was found at the N1 site and *Halodule wrightii* was found at both the N1 site and the N2 site. The average abundance of *Syringodium* throughout all sites was 51-75%. None of the sites monitored had less than 25% coverage of *Syringodium*. Of all 16 donor sites monitored, the average blade length found was approximately 47 cm for *Syringodium* with a high of 65cm and a low of 18cm. The average blade length found for *Thalassia* was 37cm. Average shoot density for *Syringodium* was 15 shoots in the 10 square with a high of 25 and low of 5 in the 10 square. No depth was measurable for any of the 16 plugs. Barnacle spat and attached algae were found at all sites. Sandy sediment was consistent through all sites.

Reference point data was recorded randomly in the area next to each of the established donor monitoring sites. The measurement was a random toss of the square 1m from each of the donor plugs. Of all 16 reference sites monitored, the average blade length found was approximately 48 cm for *Syringodium* with a high of 60cm and a low of 20cm. The average shoot density for *Syringodium* at the reference sites was 14 shoots with a high of 25 and low of 5 in the 10 square

As reported following the Time Zero + Year One monitoring - all donor sites appear to have made a successful recovery.

Tampa Bay Watch
Seagrass Data **Monitoring Date:** 7/1/2008 Donor Site 24 Month Monitoring DEP Reference

Species: (AA) Attached Algae (DA) Drift Algae (H) Halodule (HE) Halophila (R) Ruppia (S) Syringodium (T) Thalassia

Abundance: 1=<5% cover, 2=5-25% cover, 3=26-50% cover, 4= 51-75% cover, 5=76-100% cover

Epiphyte Density: 1=clean, 2=light, 3=moderate, 4=heavy Sediment: 1=shelly sand, 2=sand, 3=muddy sand, 4=mud, 5=oyster

Notes:

Sites S1 and S2 were established on 7/13/2006. Sites N1and N2 were established on 6/28/2006

Site	Species	Abundance	Blade Length Avg.	Shoot Density	Count square size	Epiphyte Type	Epiphyte Density	Sediment	Plug Size	Plug Depth
N1 North	S/T	S5, T1	S50, T50	S13, T2	10	AA, BS	3	2	N/A	N/A
N1 N Ref	S/T	S3, T3	S50, T21	S5, T3	10	AA, BS	3	2	N/A	N/A
N1 East	S	4	35	13	10	AA	4	2	N/A	N/A
N1 E Ref	S/T	S4, T1	S40, T40	S14, T1	10	AA, BS	4	2	N/A	N/A
N1 South	S	4	35	18	10	AA	3	2	N/A	N/A
N1 S Ref	S	5	50	24	10	AA, BS	3	2	N/A	N/A
N1 West	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A
N1 W Ref	H	3	15	6	10	AA	2	2	N/A	N/A
N2 North	S	3	18	5	10	AA	2	2	N/A	N/A
N2 N Ref	S	3	30	5	10	AA	2	2	N/A	N/A
N2 East	S	4	50	15	10	AA	3	2	N/A	N/A
N2 E Ref	S	3	40	6	10	AA	3	2	N/A	N/A
N2 South	H	1	18	2	10	AA	4	2	N/A	N/A
N2 S Ref	S	3	20	9	10	AA	2	2	N/A	N/A
N2 West	S	4	30	15	10	AA	2	2	N/A	N/A
N2 W Ref	H	4	34	22	10	AA, BS	2	2	N/A	N/A
S1 North	S	5	65	15	10	AA	3	2	N/A	N/A
S1 N Ref	S	4	55	11	10	AA, BS	2	2	N/A	N/A
S1 East	S	3	55	8	10	AA	2	2	N/A	N/A

S1 E Ref	S	4	53	11	10	AA	2	2	N/A	N/A
S1 South	S	5	57	16	10	AA	2	2	N/A	N/A
S1 S Ref	S	5	50	25	10	AA	2	2	N/A	N/A
S1 West	S	4	50	13	10	AA	2	2	N/A	N/A
S1 W Ref	S	4	52	15	10	AA, BS	3	2	N/A	N/A
S2 North	S	5	50	21	10	AA, BS	2	2	N/A	N/A
S2 N Ref	S	4	53	13	10	AA, BS	2	2	N/A	N/A
S2 East	S	5	58	19	10	AA, BS	3	2	N/A	N/A
S2 E Ref	S	4	50	17	10	AA, BS	3	2	N/A	N/A
S2 South	S	5	50	25	10	AA	3	2	N/A	N/A
S2 S Ref	S	5	60	18	10	AA, BS	3	2	N/A	N/A
S2 West	S	4	53	15	10	AA	3	2	N/A	N/A
S2 W Ref	S	5	55	21	10	AA	2	2	N/A	N/A

Average	**41.75**
High	**61**
Low	**13**

City of Tampa
Bay Study Group

Summary

Data Summary of the *Syringodium filiforme* Transplant Project at Coon Hammock Creek (MacDill AFB, Tampa Bay) - monitoring performed on July 7, 2008

In the three previous assessments prior to "time one year" on July 5, 2007, random *Syringodium filiforme* planting rows were selected to determine percent survival and planting unit growth. It was noted during the "time six month" assessment that many of the planting units had started to coalesce. Therefore, the methodology for the "time one year" and subsequent assessments changed to utilizing twenty random meter square placements per 10mx20m planting plot to assess percent composition, short shoot density, and canopy height. Each meter square placement was georeferenced using a Trimble™ GPS unit with submeter accuracy. During July 7, 2008, seventeen meter square placements and nineteen meter square placements were assessed in Plot 3 and 5, respectively.

Thalassia testudinum was noted in one meter square placement in Plots 1 and 5 during this assessment. However, this seagrass was not present in appreciable biomass and was not included in this report. The attached alga, *Caulerpa prolifera*, was not present in any meter square placements.

Plot 1

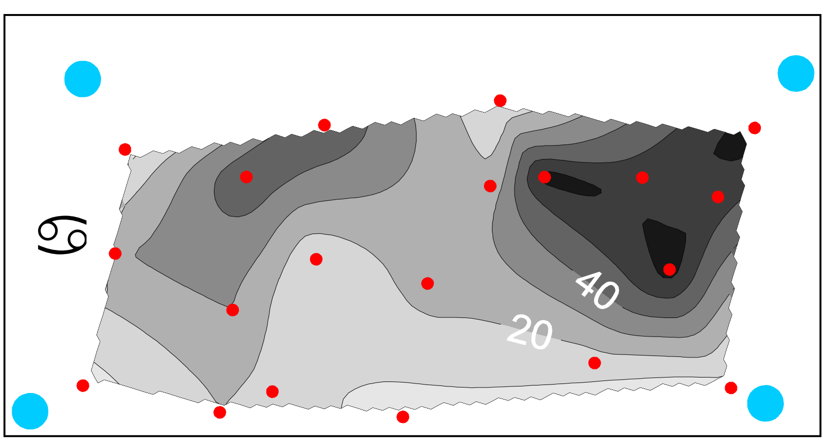
Table 1. Summary of *S. filiforme* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 1.

	Coverage; m^2	SSD	CH	BB
July 20, 2006	9	804	18.2	1.0
August 17, 2006	11	1238	25.1	1.0
January 17, 2007	36	593	13.6	1.5
July 5, 2007	22	906	19.6	1.7
November 26, 2007	69	660	34.4	2.3
July 7, 2008	60	825	17.6	2.4

Table 2. Summary of *H. wrightii* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 1. ND=No Data

	Coverage; m^2	SSD	CH	BB
July 20, 2006	ND	ND	ND	0.5
August 17, 2006	ND	ND	ND	0.5
January 17, 2007	ND	ND	ND	0
July 5, 2007	3	1200	17	0.5
November 26, 2007	4	1250	28.0	<0.5
July 7, 2008	12	1025	15.8	2.2

Figure 3. Location of the twenty random meter square placements and distribution of percent *S. filiforme* cover in Plot 1.



Plot 2

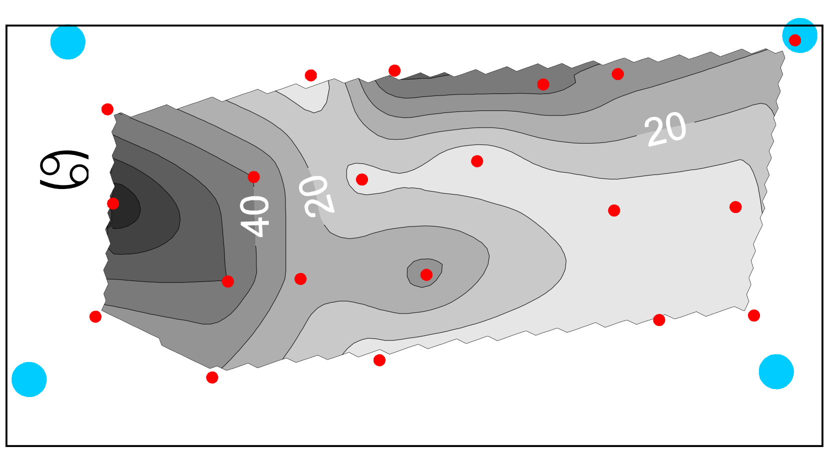
Table 4. Summary of *S. filiforme* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 2.

	Coverage; m^2	SSD	CH	BB
July 20, 2006	10	1005	23.0	2.0
August 17, 2006	10	1667	24.8	1.0
January 17, 2007	55	966	13.3	1.5
July 5, 2007	46	912	21.3	2.2
November 26, 2007	127	920	43.2	3.9
July 7, 2008	51	893	23.6	2.6

Table 5. Summary of *H. wrightii* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 2. ND=No Data

	Coverage; m^2	SSD	CH	BB
July 20, 2006	ND	ND	ND	0
August 17, 2006	ND	ND	ND	<0.5
January 17, 2007	ND	ND	ND	<0.5
July 5, 2007	9	1533	17.0	<0.5
November 26, 2007	11	500	27.4	1.0
July 7, 2008	11	600	13.8	1.5

Figure 6. Location of the twenty random meter square placements and distribution of percent *S. filiforme* cover in Plot 2.



Plot 3

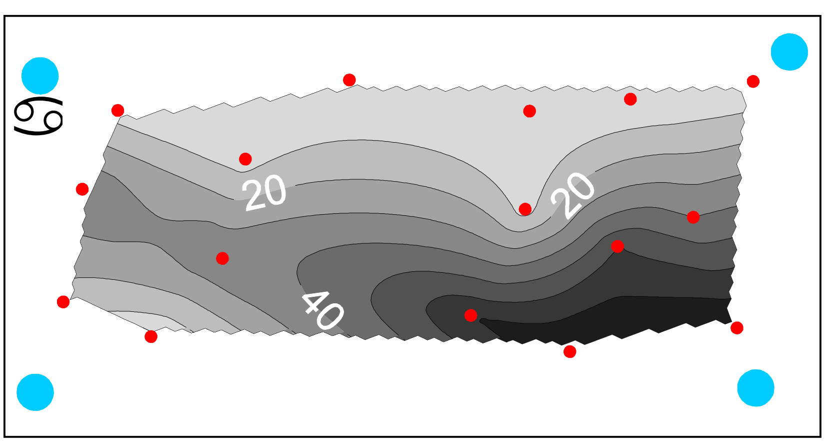
Table 7. Summary of *S. filiforme* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 3.

	Coverage; m^2	SSD	CH	BB
July 20, 2006	13	1460	19.3	1.0
August 17, 2006	13	1390	26.3	1.0
January 17, 2007	72	1250	16.8	2.0
July 5, 2007	51	1330	23.1	2.4
November 26, 2007	80	1495	40.3	3.1
July 7, 2008	55	1550	30.2	2.7

Table 8. Summary of *H. wrightii* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 3. ND=No Data

	Coverage; m^2	SSD	CH	BB
July 20, 2006	ND	ND	ND	0
August 17, 2006	ND	ND	ND	0
January 17, 2007	ND	ND	ND	<0.5
July 5, 2007	2	950	18.3	<0.5
November 26, 2007	3	1000	24.0	<0.5
July 7, 2008	6	1145	19.4	1.2

Figure 9. Location of the seventeen random meter square placements and distribution of percent *S. filiforme* cover in Plot 3.



Plot 4

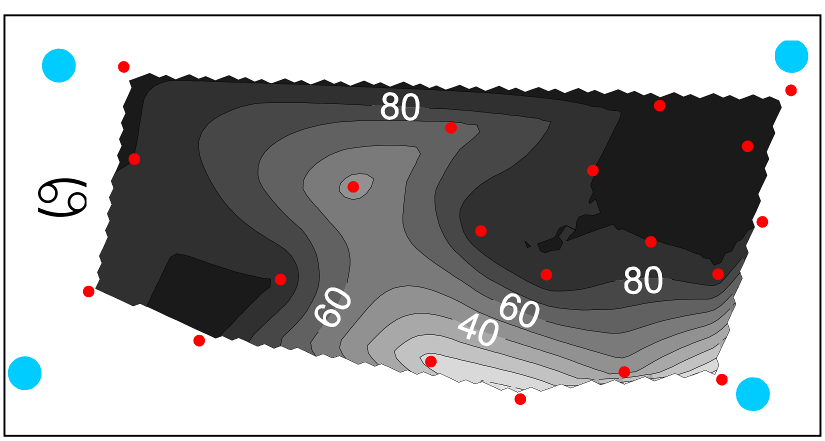
Table 10. Summary of *S. filiforme* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 4.

	Coverage; m^2	SSD	CH	BB
July 20, 2006	13	1039	24.5	1.0
August 17, 2006	11	1390	26.3	1.0
January 17, 2007	35	1250	16.8	2.0
July 5, 2007	35	1122	24.3	2.2
November 26, 2007	126	1005	49.2	3.9
July 7, 2008	145	1695	43.0	4.4

Table 11. Summary of *H. wrightii* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 4. ND=No Data

	Coverage; m^2	SSD	CH	BB
July 20, 2006	ND	ND	ND	0.5
August 17, 2006	ND	ND	ND	1.0
January 17, 2007	ND	ND	ND	<0.5
July 5, 2007	20	1125	17.2	1.6
November 26, 2007	4	150	22.0	<0.5
July 7, 2008	4	200	16.0	1.0

Figure 12. Location of the twenty random meter square placements and distribution of percent *S. filiforme* cover in Plot 4.



Plot 5

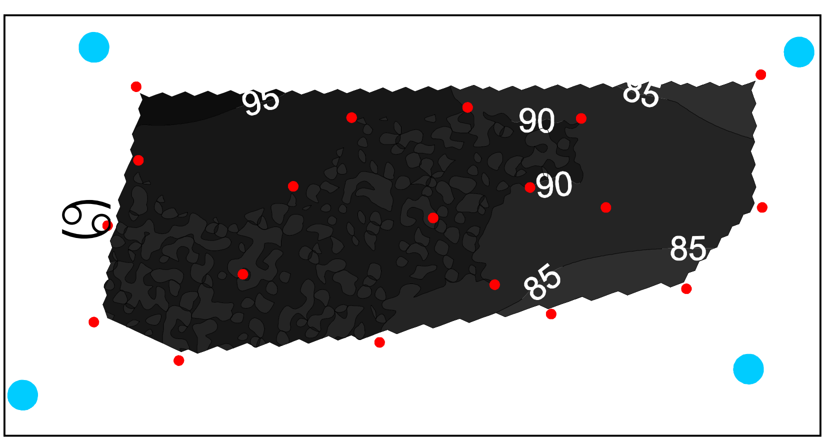
Table 13. Summary of *S. filiforme* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 5.

	Coverage; m^2	SSD	CH	BB
July 20, 2006	10	1488	24.2	1.0
August 17, 2006	4	629	21.7	<0.5
January 17, 2007	14	880	13.7	1.5
July 5, 2007	35	1423	27.4	1.9
November 26, 2007	83	1442	46.1	3.1
July 7, 2008	178	2411	56.7	5.0

Table 14. Summary of *H. wrightii* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 5. ND=No Data

	Coverage; m^2	SSD	CH	BB
July 20, 2006	ND	ND	ND	2.0
August 17, 2006	ND	ND	ND	3.0
January 17, 2007	ND	ND	ND	1.3
July 5, 2007	71	1805	21.8	2.9
November 26, 2007	6	867	16.1	0.9
July 7, 2008	6	1600	24.0	1.0

Figure 15. Location of the nineteen random meter square placements and distribution of percent *S. filiforme* cover in Plot 5.



Plot 6

Table 16. Summary of *S. filiforme* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 6.

	Coverage; m^2	SSD	CH	BB
July 20, 2006	8	874	22.4	1.0
August 17, 2006	10	1230	26.9	0.5
January 17, 2007	4	941	11.7	1.3
July 5, 2007	20	1286	27.1	1.0
November 26, 2007	74	1024	42.1	2.7
July 7, 2008	111	1488	42.8	3.5

Table 17. Summary of *H. wrightii* coverage, average short shoot density (SSD), canopy height (CH), and Braun Blanquet abundance (BB) in Plot 6. ND=No Data

	Coverage; m^2	SSD	CH	BB
July 20, 2006	ND	ND	ND	2.0
August 17, 2006	ND	ND	ND	2.0
January 17, 2007	ND	ND	ND	1.8
July 5, 2007	59	1926	18.2	3.0
November 26, 2007	34	1095	25.4	1.5
July 7, 2008	78	1354	32.2	2.8

Figure 18. Location of the twenty random meter square placements and distribution of percent *S. filiforme* cover in Plot 6.

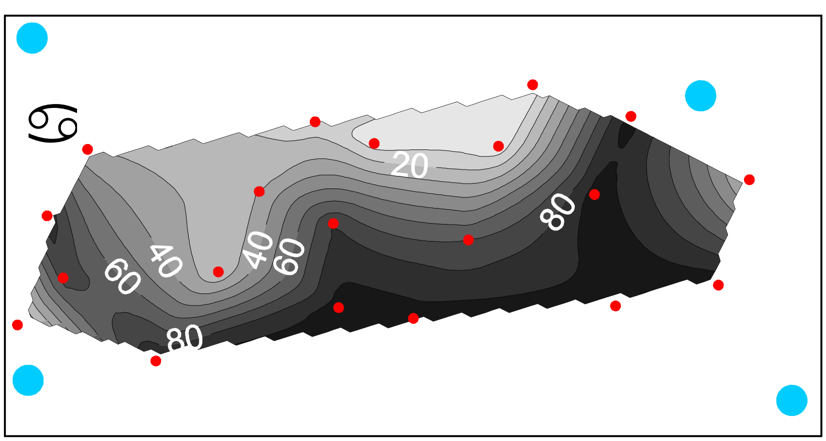


Photo 1. *Thalassia* in Plot 3A. Photo by Coastal Resources Group on July 7, 2008.

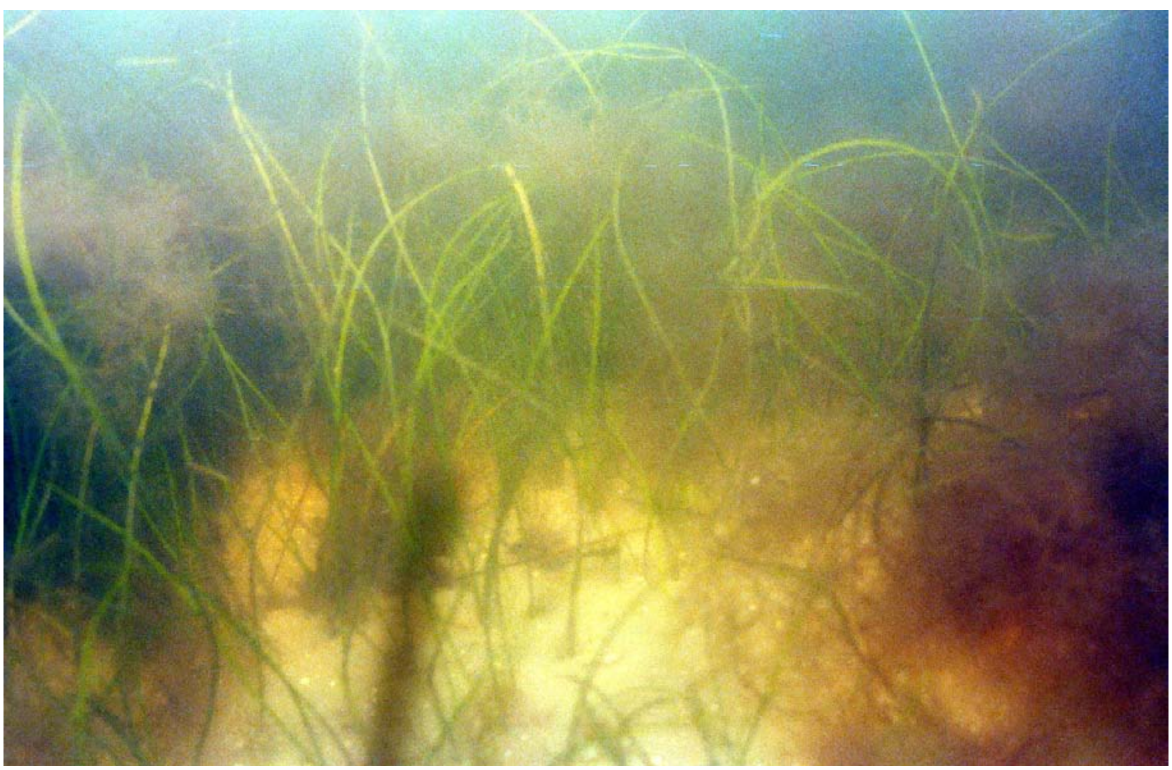


Photo 2. *Syringodium* in Plot 4. Photo by Coastal Resources Group on July 7, 2008.

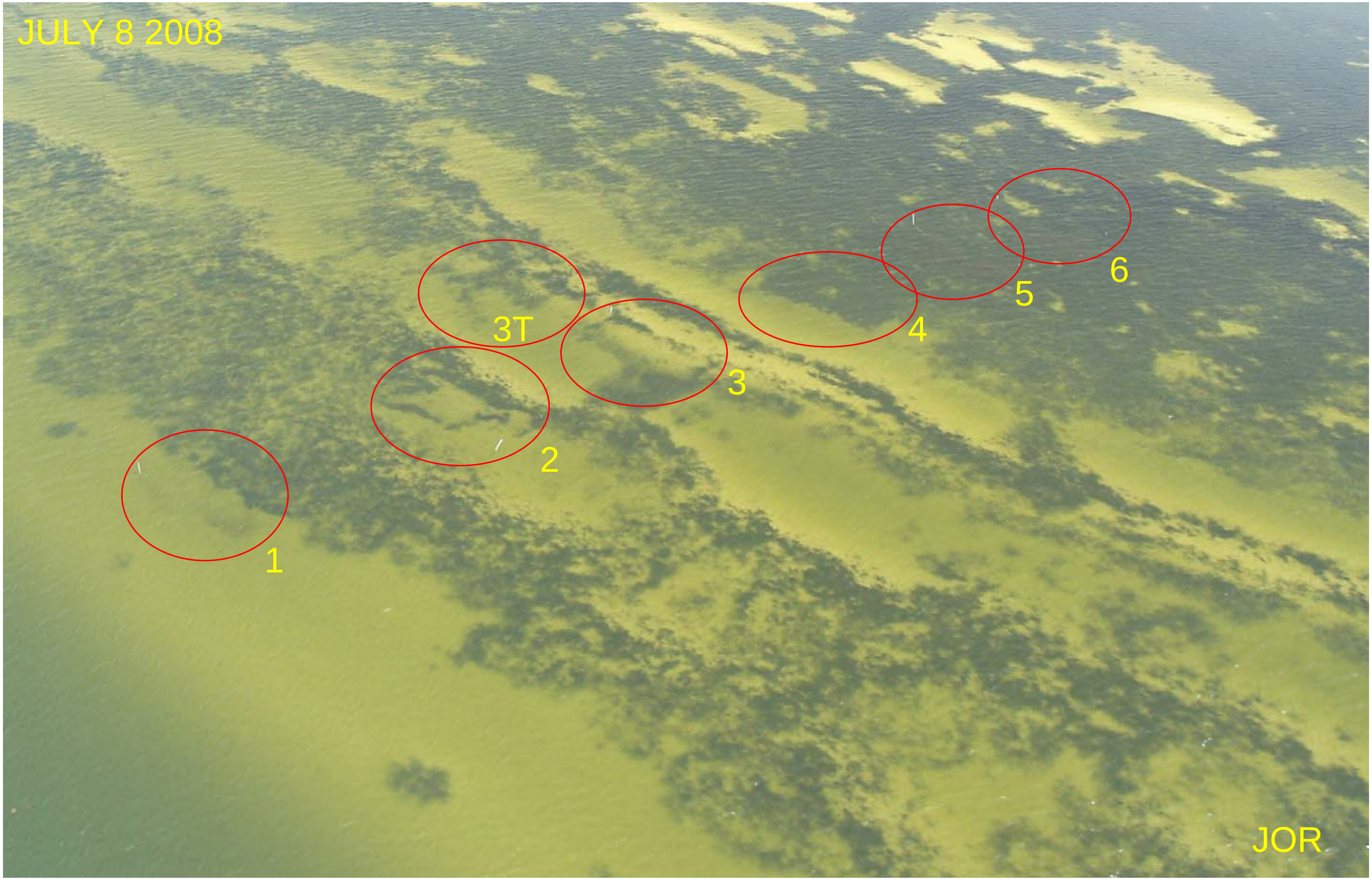
Photo 3. *Syringodium* and macroalgae in Plot 4. Photo by Coastal Resources Group on July 7, 2008.

Aerial Photos of MacDill AFB seagrass transplant site by

Roger Johansson/Chief Biologist/City of Tampa,

Bay Study Group on July 8, 2008

(Numbers indicate various plots where seagrasses were transplanted in 2006)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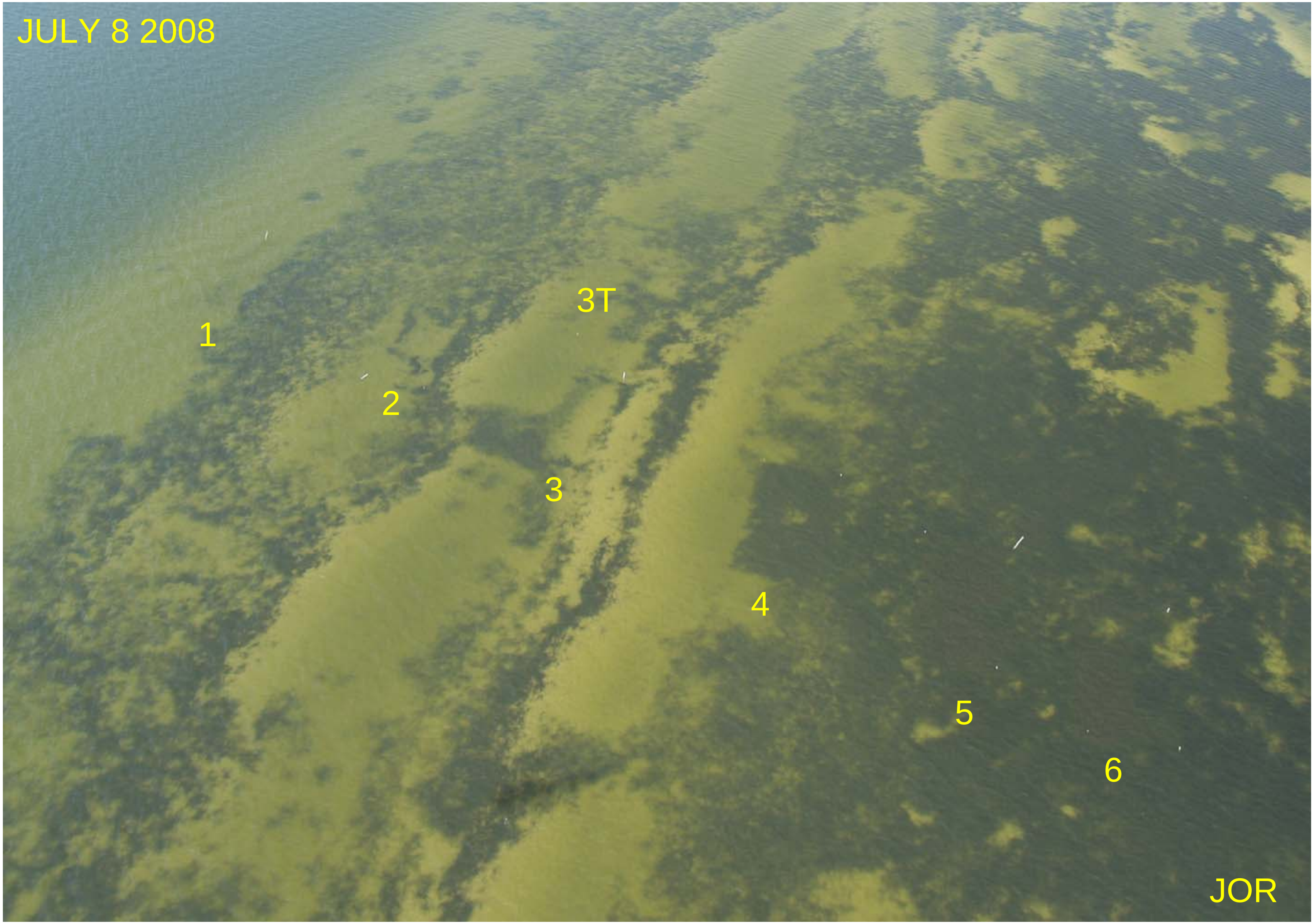
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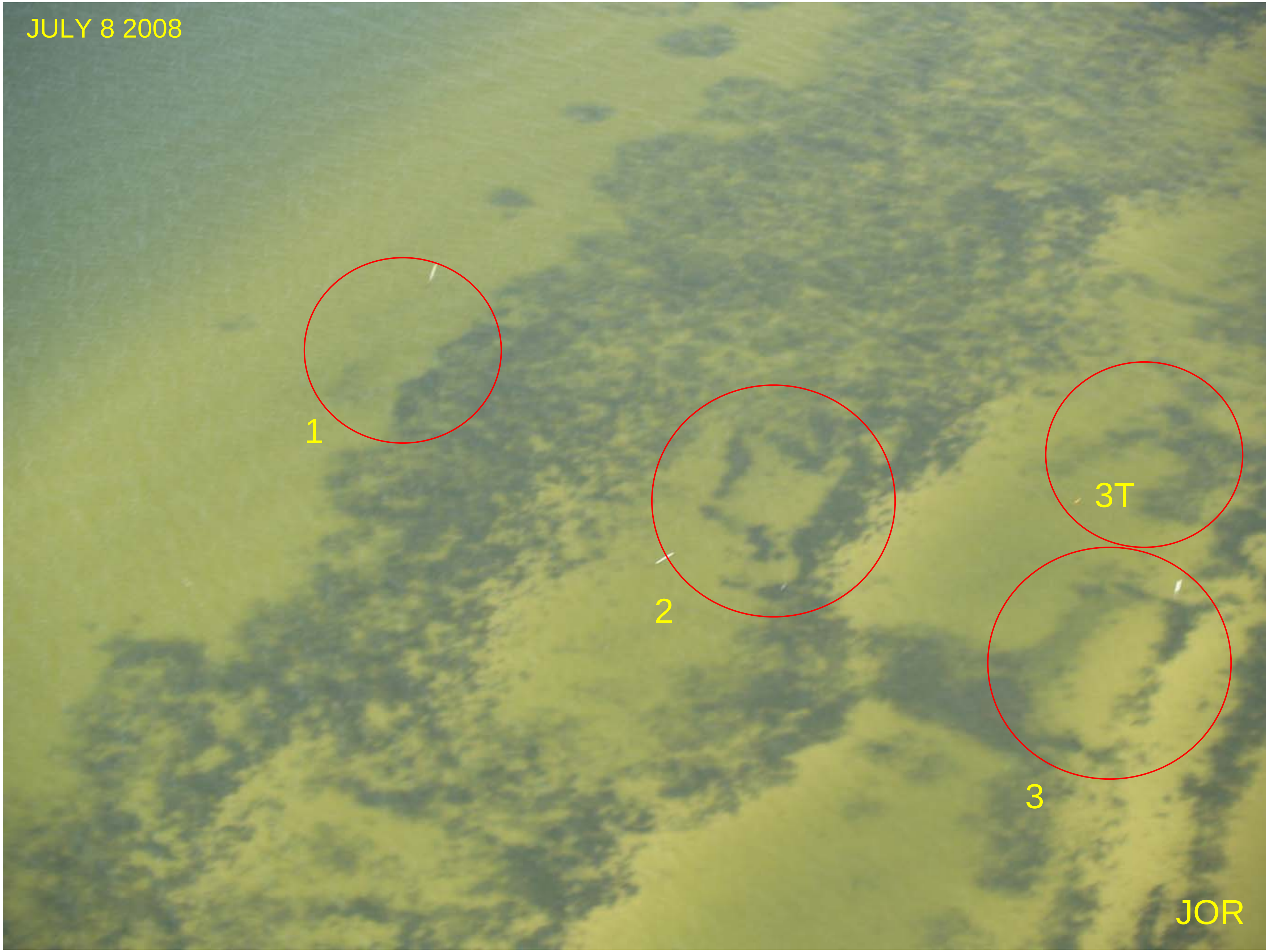
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