



Tampa Bay Estuary Program
Technical Publication # 07-04

FACTORS INFLUENCING SEAGRASS
RECOVERY IN FEATHER SOUND,
TAMPA BAY, FLORIDA

FINAL REPORT

April 2004

Factors Influencing Seagrass Recovery in Feather Sound, Tampa Bay, Florida



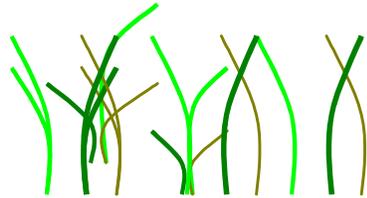
Final Report

April 2004

Submitted to the
Pinellas County Environmental Foundation
by the Feather Sound Seagrass Recovery Workgroup

Contact: Holly Greening, Project Manager
hgreening@tbep.org

Factors Influencing Seagrass Recovery in Feather Sound, Tampa Bay, Florida



Final Report
April 2004

Submitted to the
Pinellas County Environmental Foundation
by the Feather Sound Seagrass
Recovery Workgroup

Contact: Holly Greening, Project Manager
hgreening@tbep.org

Table of Contents:

Title	Page
Project Objective and Teamwork	1
Project Summary	2
Major Findings	3
Principal Investigators and Tasks	4-5
Background:	
Seagrasses in Tampa Bay	6-7
Historical Changes in Seagrass Coverage in Old Tampa Bay	8
Task B:	
b Chlorophyll Levels in Tampa Bay	9
b Water Quality Intensive Monitoring: Primary Hypotheses	10
b Water Quality Intensive Monitoring: Study Parameters	11
b Water Quality Intensive Monitoring: Final Results	12-13
Task C:	
c Seagrass Intensive Monitoring: Seagrass Depth Distribution	14
c Seagrass Intensive Monitoring: Study Parameters	15
c Seagrass Intensive Monitoring: 2002-2003 Results	16
c Seagrass Intensive Monitoring: Depth and Seagrass Loss	17
Task D:	
d Analysis of Historical Patterns of Seagrass Loss and Recovery	18
d Historical Changes in Seagrass Coverage in Feather Sound	19
Task E:	
e Seagrass Productivity and Epiphyte Loads	20
e Bioturbators and Ray Exclusion Devices	21
Task F:	
f Application of a Wave Exposure Model	22
f Flushing Rates in Tampa Bay	23
Task G:	
g Shallow Water Bathymetry and Groundwater Influence	24
Task H:	
h Experimental Seagrass Plantings	25
Task I:	
i Volunteer Patch Monitoring	26
i The Mystery of the Seagrass “Donuts”	27
Next Steps	28
Technical Reports Included on Accompanying CD	29

Project Objective

The Tampa Bay Seagrass Restoration and Recovery Strategy assessed several potential causes and factors that may be hindering successful restoration and recovery of seagrass in identified “problem areas” (i.e., the Feather Sound area) along the western shore of Old Tampa Bay- areas where seagrasses existed in 1950 but are not found now.

Based on these applied research results, projects partners, with input from seagrass scientists and local resource managers, have recommended specific actions needed to further identify the causes of slow seagrass recovery and to encourage seagrass recovery in these areas (potentially totaling approximately 2,000 acres of “restorable” seagrass habitat, or more than 15% of the Tampa Bay Estuary Program restoration goal).

This document is a summary of the findings and recommendations of the Feather Sound Seagrass Recovery Workgroup.



Teamwork: Designing and carrying out an intensive water quality monitoring effort such as the Feather Sound Seagrass Project requires an enormous amount of teamwork, pre-planning, and preparation—before the first sample is ever taken. Quality assurance is also an important component of a scientific research project. Findings and results are only as good as the data supporting them. The scientists involved in this project have spent a considerable amount of time ensuring that the data they collected were accurate and reliable.

Projects were periodically reviewed and modified as part of an adaptive monitoring strategy. For more information on quality assurance or the adaptive monitoring strategy, please see the Appendix section of the technical papers on the accompanying CD.



Project Summary

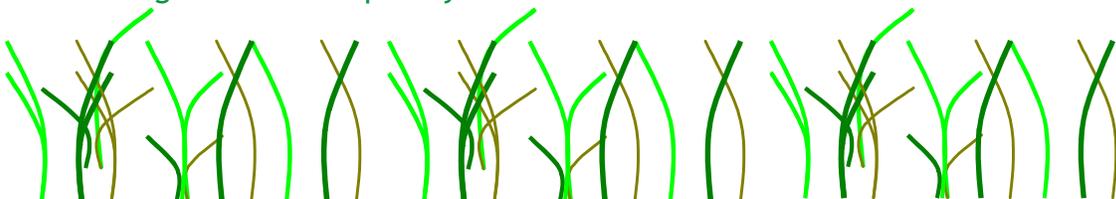
In response to nutrient load reductions and resulting clearer water, seagrasses have expanded significantly in many areas of Tampa Bay since the mid-1980s. However, the recovery rate and expansion of seagrasses in several areas, especially in the Feather Sound region of Old Tampa Bay, have been much slower. This project was designed to examine factors that may be affecting seagrass recovery and growth in the Feather Sound region compared to three other areas of Old Tampa Bay.

Results and observations over the 2002-2003 study period showed that the Feather Sound area had poorer water quality (and thus, less light available for seagrasses) than the rest of the study area. In addition, seagrass loss between 1950 and the present, in the deeper sections of Feather Sound, also indicates degraded water clarity in this area. Although epiphytes (a plant or an animal that lives on the outer surface of another plant) caused significant light reduction (25-32%) in all portions of Old Tampa Bay, light reduction was greatest in Feather Sound in 2003. Volunteer seagrass patches colonized the Feather Sound area in 2001, but many patches died or formed donut-shaped features with dead centers later in 2002. Causes of “donut” formations are currently unknown. Transplanted seagrass survival in Feather Sound was very low; seagrass covered less than 1% of the transplanted plots one year post-planting, compared with as much as 21% cover in other areas of Tampa Bay.

Potential causes of slower seagrass recovery in Feather Sound, as compared to the other Old Tampa Bay study sites, include reduced circulation and slower flushing rates, increased epiphyte loads, high rates of bioturbation (by stingrays and burrowing organisms), and possibly the influence of hydrogen sulfide concentrations. Neither high wave energy nor the inputs of submarine groundwater appear to be major factors responsible for slower seagrass recovery rates in Feather Sound. Chlorophyll *a* concentrations throughout Old Tampa Bay were higher than in other bay segments in 2003; and may have been caused by runoff due to higher rainfall in 2003, or other undetermined factors.

This study suggests that reduced water clarity may be the primary factor in the slow rate of seagrass recovery in Feather Sound. Some recommendations for follow-up research include:

- circulation and flushing scenarios in Feather Sound (including exchange through the Howard Frankland Bridge causeway),
- the effects of bioturbation,
- the role of hydrogen sulfide toxicity,
- the influence of sediment and nutrient loading from local sources on water quality, and
- the development of a model to predict seagrass growth and survival throughout Old Tampa Bay.



Major Findings

Feather Sound Seagrasses

- * Seagrasses have expanded significantly in many areas of Tampa Bay since 1982 in response to clearer water. However, the recovery rate of seagrasses in Feather Sound is much slower.
- * Areas where seagrasses have disappeared since 1950 were significantly deeper (by an average of 0.5 meters) than the areas where seagrasses have survived since 1950. This observation is consistent with other studies, which have shown that poor water clarity limits seagrasses to shallower water depths.
- * Although it may have a significant impact in other parts of Tampa Bay, wave energy is probably not a major factor in the slow recovery rate of seagrasses in Feather Sound.
- * Reduced circulation and slow flushing rates (compared to other areas of the bay) may be factors in the slower seagrass recovery rates in Feather Sound. Reduced circulation and flushing are often associated with poor water clarity and high concentrations of phytoplankton suspended in the water column.
- * In general, epiphytes caused about 32% light reduction on *Thalassia* leaves and 25% light reduction on *Halodule* leaves (thus reducing the ability of the seagrasses to survive and grow).
- * In 2003, light reduction by epiphytes on both *Thalassia* and *Halodule* was greatest in the Feather Sound quadrant.
- * The type of epiphytic organisms changed during the study period. With increasing cloudiness of the water column (greater chlorophyll *a* and turbidity) in 2003, plant-like (light-requiring) epiphytes disappeared and were replaced by particle-filtering animals, such as barnacles and bryozoans.
- * Seagrass depth varied among species and among quadrants. *Halodule* was the deepest growing seagrass species in the Feather Sound quadrant. *Thalassia* and *Syringodium* grew deeper than *Halodule* in the other three quadrants.

Seagrass Transplants and Volunteer Patches

- * Of the three transplant sites in Tampa Bay, Feather Sound had the lowest transplant growth rate (0.9% cover) one year post-planting. Shell Key and Apollo Beach had considerably higher seagrass transplant growth rates (21% and 11% cover, respectively).
- * Sting rays, horseshoe crabs, and small burrowing organisms are abundant in the Feather Sound quadrant and may contribute to seagrass loss. Additional study is required to determine the

impacts of these “bioturbators.”

- * “Volunteer” patches of *Halodule* grass colonized the Feather Sound quadrant in fall 2001 and spring 2002 and expanded rapidly during the summer. In fall 2002 and in 2003, poor water quality limited the growth of patches near Big Island, and seagrass coverage in patches farther from shore (in slightly deeper water) declined significantly.
- * Seagrass in the center of many *Halodule* volunteer patches died in fall 2002, creating “donuts.” Potential causes include bioturbators, hypoxia and sulfide toxicity, clonal senescence, and sediment nutrient depletion. Because volunteer seagrass recruitment is the most promising method to restore seagrasses in Old Tampa Bay, additional study should focus on causes of “donuts” and volunteer patch failure.

Water Quality

- * Scientists suspected that poor water quality was an important reason for seagrass loss in Old Tampa Bay. This study was conducted to determine if water quality was poorer in areas where seagrasses have been lost compared to areas where seagrasses have been stable over time. Water quality measured in 2002-2003 was not significantly different between the areas where seagrasses have been lost since 1950 and the areas where seagrasses have been stable since 1950.
- * The areas where seagrasses have been lost were deeper than the areas where seagrasses have been stable, implicating decreased water clarity as a primary cause of seagrass loss. Approximately 75% of the samples from areas where seagrasses have been lost were deeper than 1.0 meter (mean water). Approximately 75% of the samples from areas where seagrasses have been stable were shallower than 1.0 meter (mean water).
- * The shallow area (<2.0 meters) had significantly higher turbidity and color than the deep area. There was not a significant difference for chlorophyll *a* or light transmittance between the shallow area and the deep area.
- * The Feather Sound quadrant of the study area had significantly poorer water clarity in 2002-2003 than in the other three quadrants (higher chlorophyll *a*, turbidity, and color; and lower transmittance).
- * A significant decline in *Halodule* coverage occurred at sampling sites in the Feather Sound quadrant between 2002 and 2003.

Feather Sound Seagrass Project: Principal Investigators and Tasks

a Program Coordination and Administration: *Organize project objectives and assign lead agencies to tasks.*

- Holly Greening: *Tampa Bay Estuary Program*

b Water Quality Intensive Monitoring: *Determine whether water clarity differences exist in the areas where seagrass growth is limited (i.e., Feather Sound) and areas where seagrasses continue to expand.*

- Mark Flock: *Pinellas County Department of Environmental Management*
- Chris Anastasiou, Dave Tomasko, and Darren Bishop: *Surface Water Improvement and Management Program (SWIM), Southwest Florida Water Management District*
- David Wade: *Janicki Environmental, Inc.*
- Roger Johansson: *City of Tampa, Bay Study Group*
- Eric Lesnett: *Environmental Protection Commission of Hillsborough County*

c Seagrass Intensive Monitoring: *Determine if there are differences in seagrass density, species composition, or abundance between “problem areas” and reference areas, and if the differences are related to water quality.*

- Roger Johansson and Walt Avery: *City of Tampa, Bay Study Group*
- Alice Ketron: *Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute*

d Analysis of Historical Patterns of Seagrass Loss and Recovery: *Use historical maps and photos to determine whether gains and losses of seagrass coverage in study areas are related to patterns of urbanization in Old Tampa Bay.*

- Darlene Saindon, Bill Burkholder, and Paul Carlson: *Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute*
- Dave Tomasko: *SWIM, Southwest Florida Water Management District*

e Seagrass Productivity and Epiphyte Loads: *Determine whether growth rates for seagrasses in “problem areas” are lower than growth rates in more stable areas. Determine the impact (if any) that epiphytes have on seagrass growth in these areas.*

- Laura Yarbrow, Alice Ketron, and Paul Carlson: *Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute*

f Application of Wave Exposure Model, Circulation, and Residuals: *Evaluate the effects of wave energy on seagrass losses in Tampa Bay and whether restoration efforts should include sandbar replacement.*

- Mark Fonseca: *National Oceanic and Atmospheric Administration, Center for Coastal Geology*
- Brad Robbins: *Mote Marine Laboratory*

Feather Sound Seagrass Project: Principal Investigators and Tasks

g Shallow Water Bathymetry and Groundwater Influence: Evaluate the potential effects of groundwater influence on seagrasses in Feather Sound.
- Mark Hanson, Peter Swarzenski, and Mario Fernandez: United States Geological Survey, Center for Coastal Geology

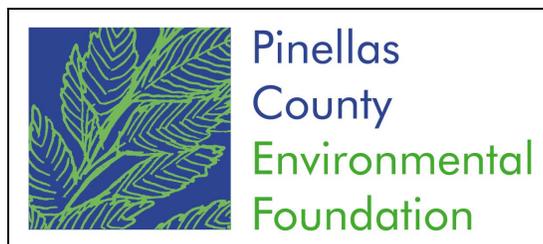
h Experimental Seagrass Plantings: Transplant seagrass into several areas around Tampa Bay and determine whether physical, chemical, or biological factors are limiting recovery of seagrasses in these areas.
- Penny Hall and Paul Carlson: Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute

i Volunteer Patch Monitoring: Monitor the conditions of seagrass patches that appeared during the study period in Feather Sound. This step was added as a task after volunteer patches were identified.
- Paul Carlson, Alice Ketron, and Darlene Saindon: Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute

j Synthesis, Interpretation, and Distribution of Program Results and Recommendations: Synthesize results and recommend the most appropriate strategy for the restoration of seagrasses in Old Tampa Bay. Distribute results to scientists, managers, citizens, and policy makers.
- Lindsay Griffen and Holly Greening: Tampa Bay Estuary Program



BAY STUDY GROUP
WASTEWATER DEPARTMENT
CITY OF TAMPA

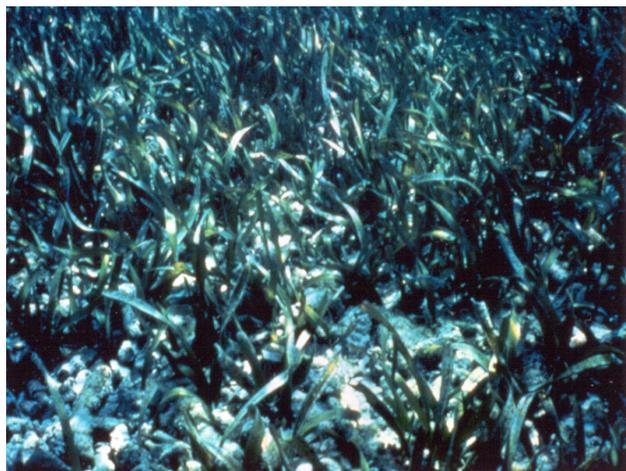


Background: Seagrasses in Tampa Bay

Tampa Bay is home to a multitude of marine species. The mixing of salt water from the Gulf of Mexico and fresh water runoff from the watershed creates a unique environment that supports many plant and animal species. Seagrasses, important marine plants, are a vital part of the bay's ecology and economy.

What are Seagrasses?

Seagrasses are flowering plants that live underwater and are rooted in the marine sediments. They usually grow 1-3 feet tall. They have leaves, flowers, and seeds and some species look similar to terrestrial grasses.



A healthy "meadow" of seagrasses

Tampa Bay seagrasses grow in shallow (less than 6-8 feet) waters. They form "meadows" which are ideal places for fish and other creatures to live, feed, hide, and reproduce.

Although there are seven species of seagrasses found in Florida, the most common species seen in Tampa Bay are:

- ◆ *Halodule wrightii* (shoal grass),
- ◆ *Syringodium filiforme* (manatee grass), and
- ◆ *Thalassia testudinum* (turtle grass).

Why are Seagrasses Important?

Among the ecological and economic services provided by seagrasses:

- ✦ Serve as an important part of the marine food web: food supply for many animals (e.g., crabs, shrimp, fish, sea turtles, and manatees)
- ✦ Provide habitat for commercial and recreational fish species (e.g., snook, red drum, spotted sea trout, and brown shrimp). Some 70% of marine recreational fish depend on seagrass at some time in their lives either as habitat or as a food source
- ✦ Improve water quality by filtering pollutants
- ✦ Produce oxygen
- ✦ Stabilize sediments
- ✦ Dampen wave and current energy



Manatees eat seagrasses and rely on them as their main source of nutrition.

Seagrasses are a cash crop

Much of Florida's economy is based on tourism and on its world-class marine resources. Seagrasses in Tampa Bay and throughout the state help to support a thriving, multi-million dollar recreational fishing industry that attracts resident and out-of-state boaters and anglers. The commercial fishing industry also depends on healthy seagrass meadows to protect and provide habitat for young fish and shellfish, and other marine life.

Background: Seagrasses in Tampa Bay

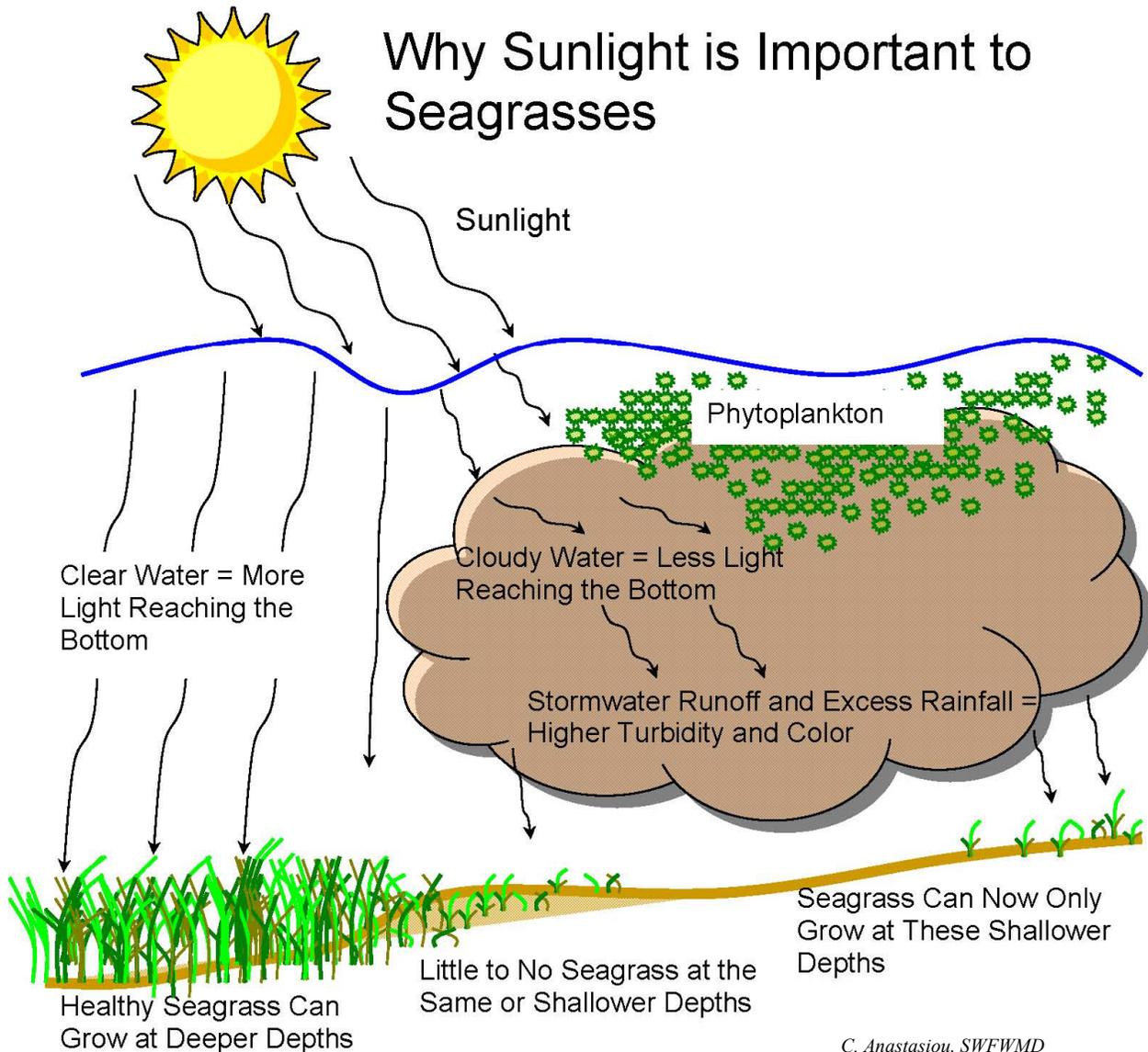
Where do seagrasses grow in Tampa Bay?

Seagrasses are found in many shallow areas of Tampa Bay. Since they have stricter water quality requirements than some other plants (e.g., algae), they are an indicator of healthy water conditions. The distribution of seagrasses in the bay may be due to differences in depth, water clarity, physical disruptions, or wave energy. It is not known why certain areas of the bay do not support seagrasses.

Sources: FMRI Seagrass brochure (2002) and Seagrass Education Toolkit (2004).

Seagrass coverage in Tampa Bay has changed over time.

Factors affecting seagrass growth and acreage may be natural, such as changes in rainfall or a major storm event. Human threats to seagrasses include: degraded water quality (a result of urbanization and many other factors); dredge and fill operations; replacing natural shorelines with constructed seawalls; habitat alterations; and physical impacts by boat propellers. The Feather Sound Seagrass Project will address some of these impacts and their effects on Tampa Bay seagrasses.

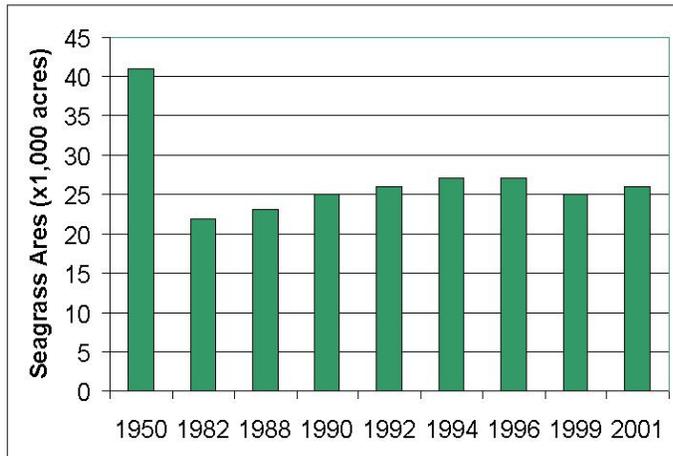
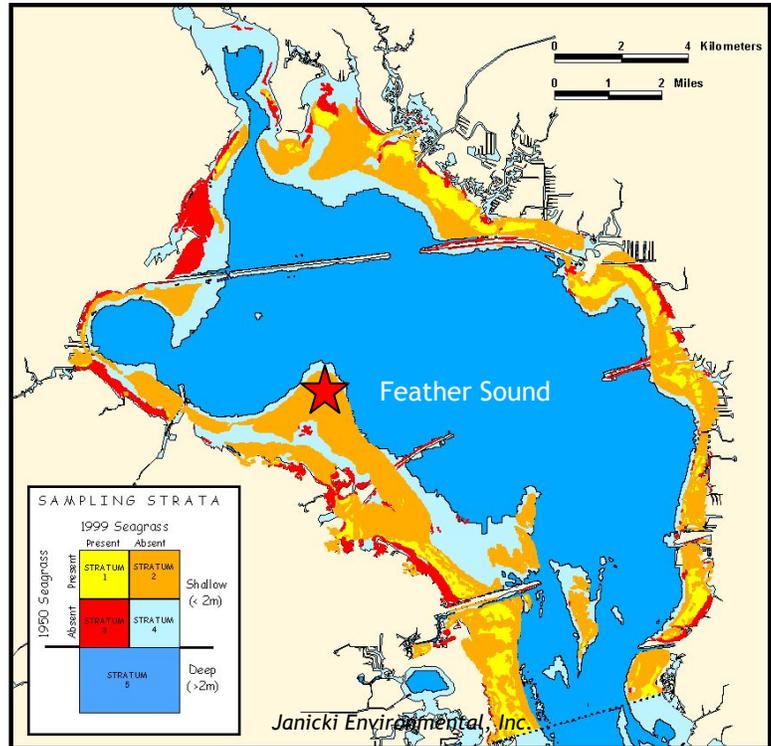


C. Anastasiou, SWFWMD

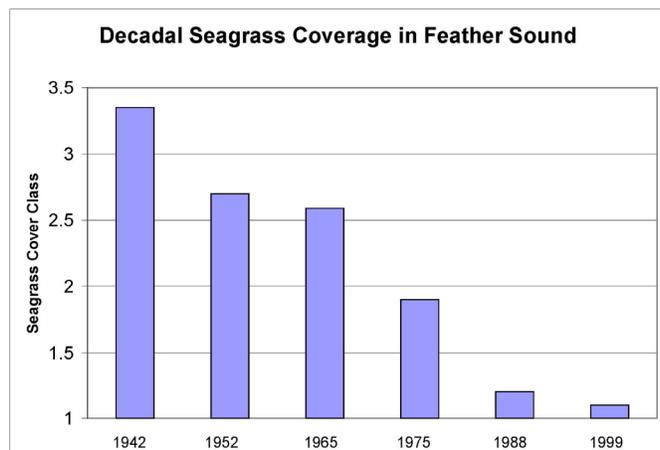
Background: Historical Changes in Seagrass Coverage in Old Tampa Bay

Seagrasses in Tampa Bay have shown an overall decline since the 1950s but are now recovering in many areas of the bay. The areas in **orange** are places in the bay where seagrasses were observed in 1950, but are not present now. Conversely, the **red** areas show seagrass growth that occurs now, but did not occur in the 1950s.

Areas that have not recovered, such as Feather Sound, may be able to support seagrasses in the future if factors affecting recovery can be addressed. The Feather Sound Seagrass Study is helping scientists to understand the conditions that are needed for recovery of seagrasses in these areas.



The efforts of local, state, and regional governments; agencies; industries; and non-profit groups have improved the health of Tampa Bay by controlling pollution sources and educating bay area residents. Consequently, seagrasses are more abundant than they were 20 years ago. However, the baywide seagrass coverage goal of 38,000 acres has not yet been met. Research projects, such as the Feather Sound Seagrass Project, will continue to aid scientists in their understanding of the bay and how best to protect it.



Explanation of Graphs: The top graph shows the bay-wide increase in seagrass coverage since 1982. The losses in 1999 were likely due to the 1997-1998 El Niño rains. *Source: SWFWMD*
The bottom graph shows a steady decline in seagrass coverage in the Feather Sound region. *Source: D. Saindon, Eckerd College*

b Chlorophyll levels in Tampa Bay

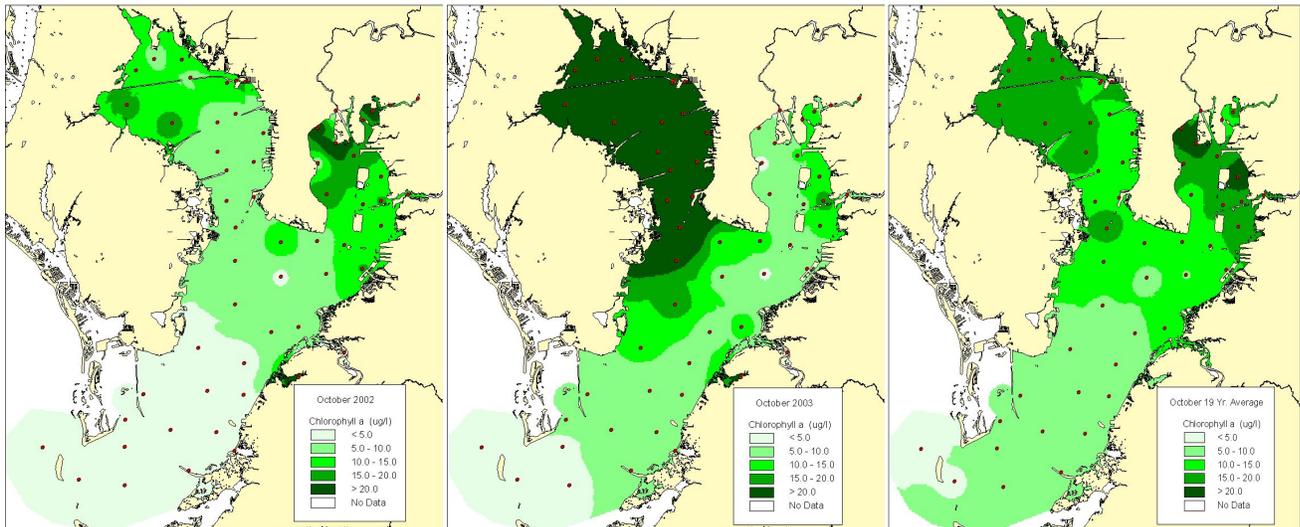
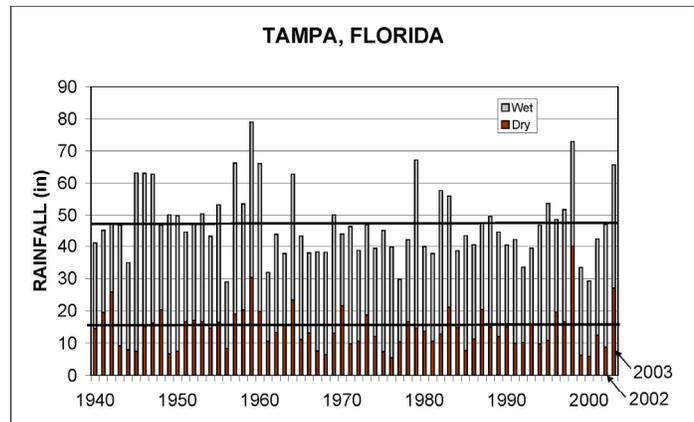
Weather can play an important role in seagrass growth and productivity. As rainfall increases, it washes nutrients and pollutants off roads, lawns, and parking lots into receiving water bodies. Nutrients, such as nitrogen, are utilized by phytoplankton, which can proliferate in these conditions. Phytoplankton compete for light with seagrass species and decrease the light available to seagrasses. Typically, the water quality and clarity decreases in years with heavy precipitation.

Scientists can measure the presence and abundance of phytoplankton by testing for chlorophyll *a*. The green color that is seen in photosynthesizing plants and phytoplankton is a result of chlorophyll *a*. Therefore; chlorophyll *a* concentrations in the water are an indication of phytoplankton biomass.

During the Feather Sound Seagrass Project there was a year with near average rainfall (2002) and a year with heavy rainfall (2003). The following graphs illustrate the differences in chlorophyll *a* concentrations between October 2002, October 2003, and the 19-year average for October chlorophyll *a* concentrations.

Rainfall in 2002 was lower than average in the dry season and average for the wet season. Rainfall in 2003 was significantly higher than the average for both the wet and dry seasons.

Source: P. Carlson, FWC FMRI



Chlorophyll *a* concentrations in Old Tampa Bay in October 2003 were higher than the October 2002 chlorophyll *a* concentrations and higher than the average October chlorophyll *a* concentrations taken over a 19-year time period (1985-2003).

Source: E Lesnett, EPCHC

Bottom Line: Heavy rainfall in 2003 led to increased phytoplankton biomass, as indicated by higher chlorophyll *a* concentrations.



Water Quality Intensive Monitoring: Primary Hypotheses

Because of the importance of adequate water quality to seagrass growth and survival, scientists wanted to determine whether water quality conditions could explain why seagrasses have not recovered in the Feather Sound quadrant. To do this, a series of experiments were designed to test for statistically significant differences in several water quality parameters between specific areas in Old Tampa Bay. The three primary hypotheses are listed below.



A scientist takes a water sample from the Feather Sound region to analyze in the lab.
C. Anastasiou, SWFWMD

Primary Hypotheses:

1. Is water quality different in areas of stable vs. lost seagrasses?

“Lost” refers to seagrasses that were absent in 1990 but were present in 1950s aerial photographs.

2. Is water quality different in deep vs. shallow sites?

3. Is water quality different in west vs. east Old Tampa Bay areas?



Additional data analyses were performed on the Feather Sound (northwest) quadrant after monitoring was completed. This was not one of the primary hypotheses to be examined; however, after reviewing the results, the Principal Investigators noticed that the water quality in the Feather Sound quadrant was poorer and that *Halodule* seagrasses were lost in this quadrant between 2002 and 2003. The final results include statistical tests for the three original hypotheses plus differences between the Feather Sound samples and samples from the other study quadrants.

b Water Quality Intensive Monitoring: Study Parameters

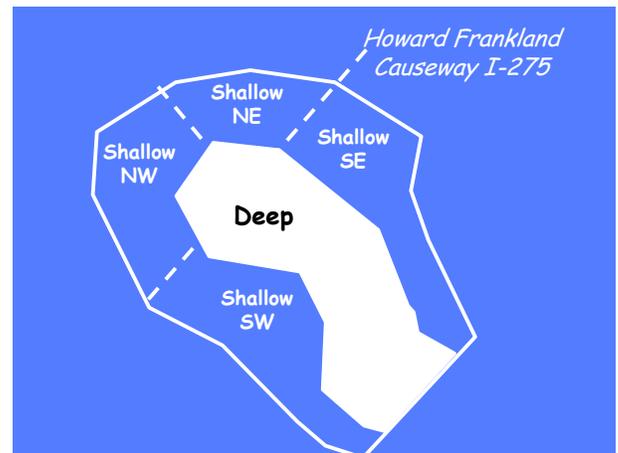
Water quality can be measured by testing several different parameters. The following water quality measurements were included in this study:

1. **Chlorophyll *a***: Indicator of phytoplankton biomass. Phytoplankton also require light for photosynthesis and can reduce light availability for seagrasses. Measured as micrograms per Liter (ug/L).
2. **Turbidity**: Quantity of suspended matter in the water column. Waters with high turbidity have reduced light penetration. Measured as Nephelometric Turbidity Units (NTU).
3. **Color**: Color of the water after the turbidity has been removed. Influenced by the presence of natural metallic ions (iron and manganese), humus and peat materials, decomposing plant materials, and industrial wastes. Measured in Platinum-Cobalt Units (PCU).
4. **Light Attenuation**: Loss of light with depth. Given the symbol K_d .
5. **Transmittance**: Ratio of light gathered by a receiver to the amount originating at the source. Measures the clarity of water. Measured as a percentage of light striking the water surface.

C. Anastasio, SWFWMD

Water quality intensive monitoring occurred in Old Tampa Bay and samples were taken at randomly selected locations. In order to test for water quality differences in Old Tampa Bay, the bay segment was divided into four quadrants: northeast, southeast, northwest, and southwest. In addition, a deep area was defined. This diagram shows the four shallow quadrants and the deep area. Feather Sound is located in the northwest quadrant.

D. Wade, Janicki Environmental, Inc.



Water Quality Samples

700 Samples

617 Shallow ← → 83 Deep

Seagrasses are more abundant in shallow waters due to increased light penetration; therefore, more shallow than deep water samples were needed in order to provide the necessary information about areas capable of supporting seagrasses. Samples were collected between April 2002 and October 2003.

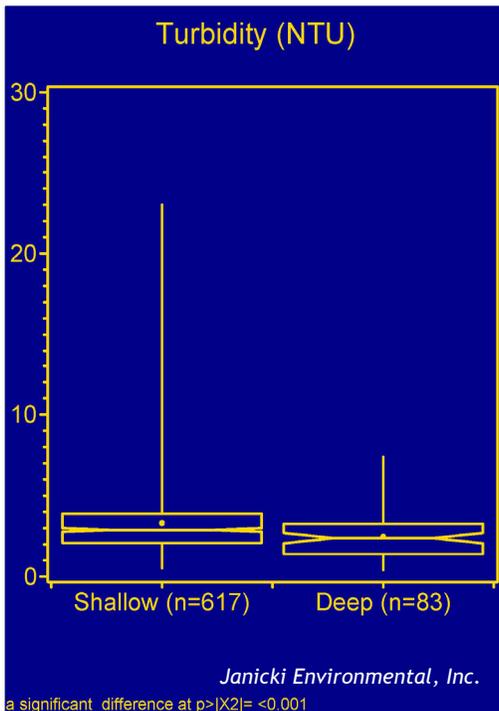
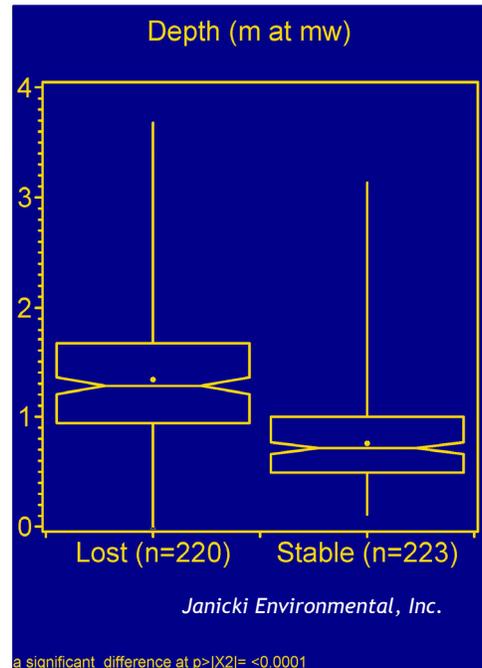


Water Quality Intensive Monitoring: Final Results

Water Quality at Stable vs. Lost Seagrass Sites

- No significant differences in light attenuation factors (chlorophyll *a* and turbidity) between stable and lost sites.
- Color significantly higher in stable sites than in lost sites.
- No significant difference in transmittance between stable and lost sites.
- Lost sites significantly deeper (average 0.5 meters) than stable sites.

The average depth of seagrasses in stable areas at mean water (mw) was 0.8 meters (32 inches). The average depth in lost areas was 1.3 meters at mean water (51 inches).



Shallow vs. Deep Water Quality

- No significant difference in chlorophyll *a* between shallow and deep areas.
- Turbidity significantly higher in shallow areas than in deep areas.
- Color significantly higher in shallow areas than in deep areas.
- No significant difference in transmittance between shallow and deep areas.
- Average depths were 1.2 meters (shallow sites) and 4.1 meters (deep sites).

High turbidity can indicate poor water clarity. The mean turbidity in shallow areas was 3.3 NTU but only 2.5 NTU in deep areas; however, both of these values indicate relatively low turbidity levels.

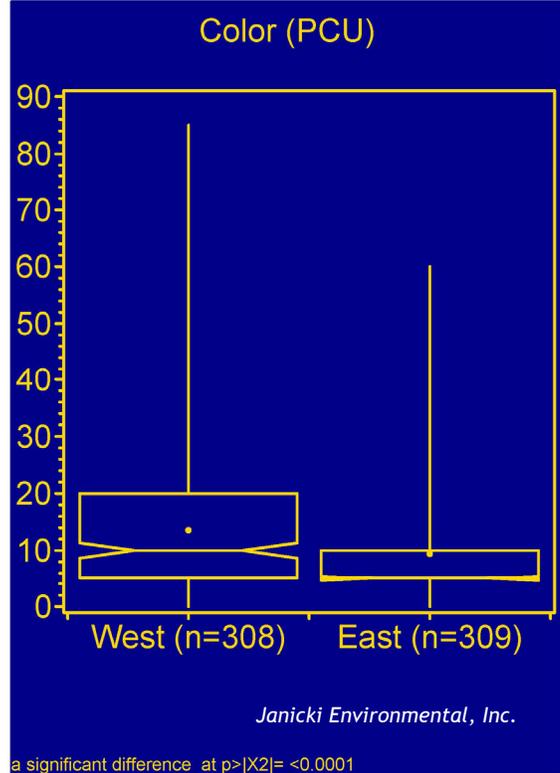
Explanation of Graphs: These graphs are called “box and whisker plots.” The mean (average) value is shown as a point. The boxes around the mean indicate the range between the 25th percentile and the 75th percentile of the data. The horizontal line through the center of each box indicates the best estimate of the median value, and the notches indicate that the true median may be higher or lower as shown with 95% certainty. The sample size is represented as “n.”

b Water Quality Intensive Monitoring: Final Results

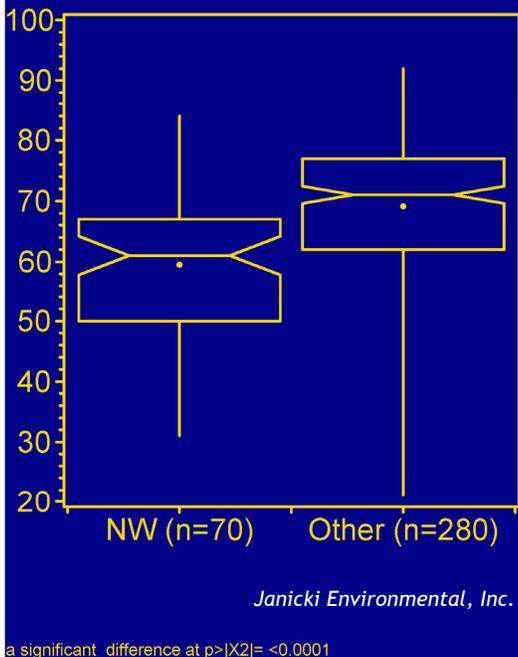
Water Quality at shallow water sites in the western side of Old Tampa Bay vs. eastern side of Old Tampa Bay

- Turbidity and color significantly higher in western shallow sites than in eastern shallow sites.
- Western sites were slightly shallower; however, eastern sites showed more variability in depth. Overall, sample depths were similar.
- Transmittance and chlorophyll *a* values were similar for western and eastern samples.

Waters with higher color have decreased light penetration. The mean color in the western shallow areas was 13.6 PCU. The mean color in the eastern shallow areas was 9.5 PCU.



Transmittance (%)



Water Quality at sites in Feather Sound vs. other study quadrants:

- Chlorophyll *a* significantly higher in the Feather Sound quadrant than in the other three quadrants.
- Turbidity significantly greater in the Feather Sound quadrant than in the other three quadrants.
- Color significantly greater in the Feather Sound quadrant.
- Transmittance significantly less in the Feather Sound quadrant.

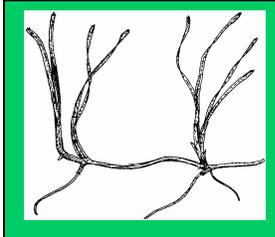
Higher percentages of transmittance indicate better water clarity. The mean transmittance in the Feather Sound quadrant was 60%; in other areas transmittance was higher at 69%.

Bottom Line: Water quality in the Feather Sound quadrant is significantly poorer (with respect to light penetration) than in the other quadrants of the study area.



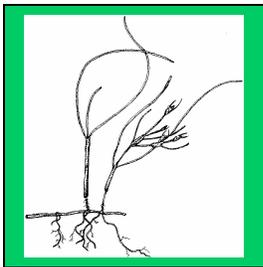
Seagrass Intensive Monitoring: Seagrass Depth Distribution

All seagrass species are not created equal. Just like terrestrial plants, each seagrass species has unique characteristics and requirements. The following list will provide a basic understanding of the three most common seagrass species found in Tampa Bay, including life history traits.



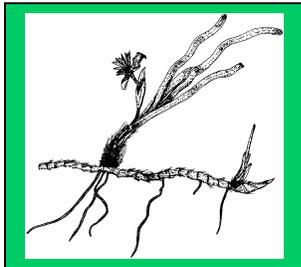
Halodule wrightii (Shoal grass):

- Long, narrow, and thin leaves
- Shallow root system; therefore, has a limited reserve capacity
- Pioneer species-one of the first to colonize an area
- Often found in shallow waters but may also be the deepest growing species in some parts of Tampa Bay



Syringodium filiforme (Manatee grass):

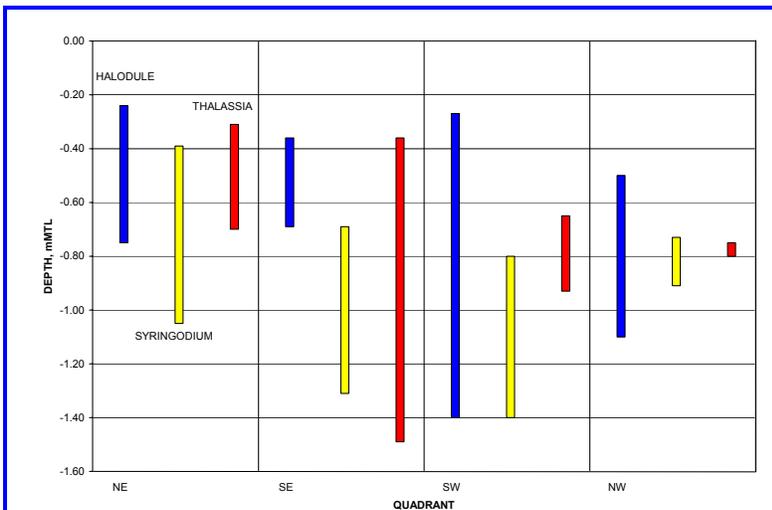
- Long, rigid, and cylindrical leaves
- Roots grow to an intermediate depth
- Least consistent member in colonization sequence
- Widely distributed throughout Tampa Bay-brittle and buoyant leaves are easily broken off and dispersed by wind and currents



Thalassia testudinum (Turtle grass):

- Wide, thick, and straplike leaves
- Deep growing root system with massive rhizomes
- Climax species-the last to colonize an area
- Dominant seagrass species in parts of Tampa Bay, but not abundant in low salinity areas

Source: Zieman and Zieman (1989)



Depth distribution of *Halodule*, *Syringodium*, and *Thalassia* seagrass species in the four study quadrants of Old Tampa Bay.
R. Johansson, City of Tampa, Bay Study Group

Seagrass monitoring revealed that, in the Feather Sound quadrant of Old Tampa Bay, *Halodule* was the deepest growing species. Since *Syringodium* and *Thalassia* are the deepest species in other areas of the bay, this might imply that water clarity is limiting the depth distribution of these two species in this quadrant.



Seagrass Intensive Monitoring: Study Parameters

Seagrasses within the four quadrants of Old Tampa Bay were monitored for changes throughout the 2002-2003 study period. The following characteristics were studied for each species and the results are provided on the following page.

- **Presence:** seagrass species observed at study sites.
- **Abundance:** a visual coverage class rating (Braun Blanquet) using seven categories to classify percent coverage.
- **Short shoot density m^{-2} :** the number of short shoots in one square meter. The scale is from 0 to the highest observed values.
- **Canopy height:** the average blade length - longest and shortest blades are not measured.



This photo depicts a scientist measuring seagrass characteristics, such as canopy height, as part of the monitoring process.

R. Johansson, City of Tampa

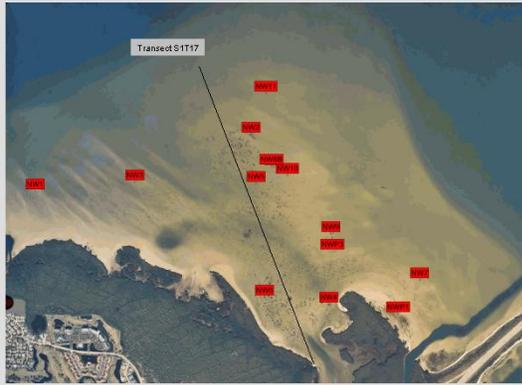
Forty-one sites were selected to monitor: 13 sites in the Feather Sound quadrant, 10 in the southwest quadrant, and 9 in each of the northeast and southeast quadrants. In each quadrant, a permanently fixed transect was also present, which aided scientists in identifying specific sample sites. Sampling occurred in 2002 and 2003. Data from the study were used to determine how the Feather Sound region and its seagrasses differ, if at all, from other areas in the bay that support seagrasses. The following results reflect changes during the two-year study period.

Bottom Line: Seagrasses are generally stable in the southeast, northeast, and southwest quadrants except for the *Halodule* loss that occurred on the offshore face of the longshore bar in the northeast quadrant. **There was significant *Halodule* loss in the Feather Sound quadrant between 2002 and 2003.**



Seagrass Intensive Monitoring: 2002-2003 Results

NW QUADRANT



Feather Sound Quadrant (Northwest)

- *Halodule* presence decreased between 2002 and 2003; remained constant for *Syringodium* and *Thalassia*
- Abundance decreased for all 3 species
- Short shoot density decreased greatly for *Syringodium*; decreased slightly for *Halodule* and *Thalassia*
- Canopy height decreased for all 3 species; greatest change in *Syringodium*

NE QUADRANT



Northeast Quadrant

- Presence remained fairly constant for all three species between 2002 and 2003
- Abundance decreased by 50% for *Syringodium*; remained constant for *Halodule* and *Thalassia*
- Short shoot density decreased by 66% for *Syringodium*; increased slightly for *Halodule* and *Thalassia*
- Canopy height decreased for all 3 species

SW QUADRANT



Southwest Quadrant

- *Syringodium* presence decreased between 2002 and 2003; *Halodule* and *Thalassia* remained constant
- Abundance fairly constant for all 3 species; decreased slightly for *Halodule*
- Short shoot density decreased for *Halodule*; increased for *Syringodium* and *Thalassia*
- Canopy height decreased for all 3 species

SE QUADRANT



Southeast Quadrant

- Presence decreased slightly for *Halodule*; remained constant for *Syringodium* and *Thalassia*
- Abundance increased slightly for *Halodule* and *Syringodium*
- Short shoot density decreased for all 3 species
- Canopy height decreased for all 3 species



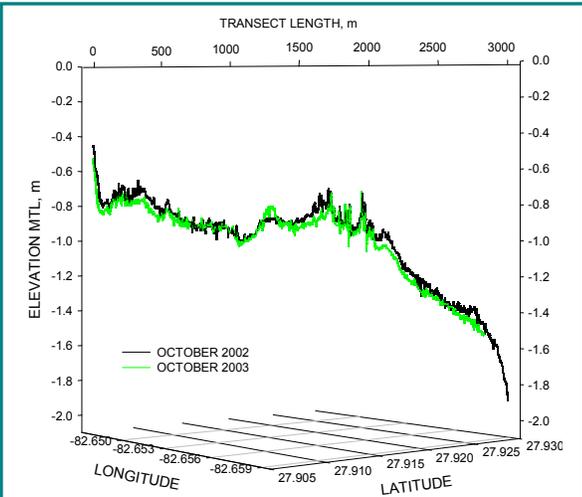
Seagrass Intensive Monitoring: Depth and Seagrass Loss

Depth measurements can be used, along with estimates of light penetration from the water quality study, to determine how much sunlight the seagrass meadows receive. Seagrasses have high light requirements compared to other marine plants and need about 20-25 percent of the sunlight that is available at the water surface to grow and flourish. Estimates of how much light is available for the Old Tampa Bay seagrass meadows have not yet been completed. The depth measurements were also used to determine if the seagrass study areas had been subject to sediment erosion and/or accumulation during the study period. The depth measurements suggested that there were no major sediment shifts during the study period.

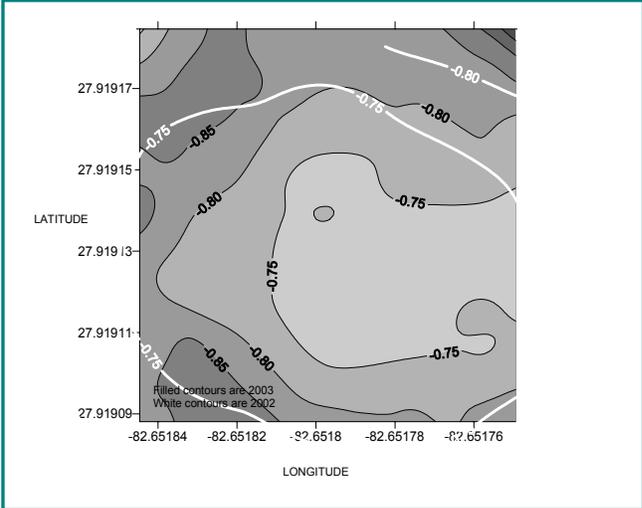
Scientists utilized the transect areas in each of the four quadrants to measure the elevation, depth contours, and mean tidal levels.



This scientist is using a highly accurate satellite-based Global Positioning System (GPS) instrument to measure the elevation at the seagrass sites.



Sediment surface elevations (mMTL) measured in October 2002 and October 2003 at seagrass transect S1T17 (NW quadrant) in Old Tampa Bay.



Sediment surface elevations (mMTL) measured in October 2002 and November 2003 at seagrass study site NW8B in Old Tampa Bay.

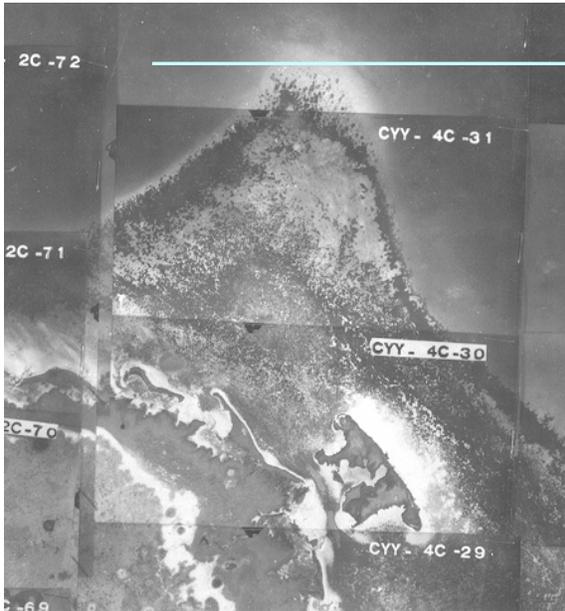
Photos and Graphs: R. Johansson, City of Tampa, Bay Study Group

Bottom Line: There were no major changes in elevation for the transect and seagrass study sites in the Feather Sound quadrant during the two years, even though a loss of seagrass was observed during that time. These data suggest that sediment erosion or accretion might not be principal factors in the loss of seagrasses in the Feather Sound region of Old Tampa Bay.

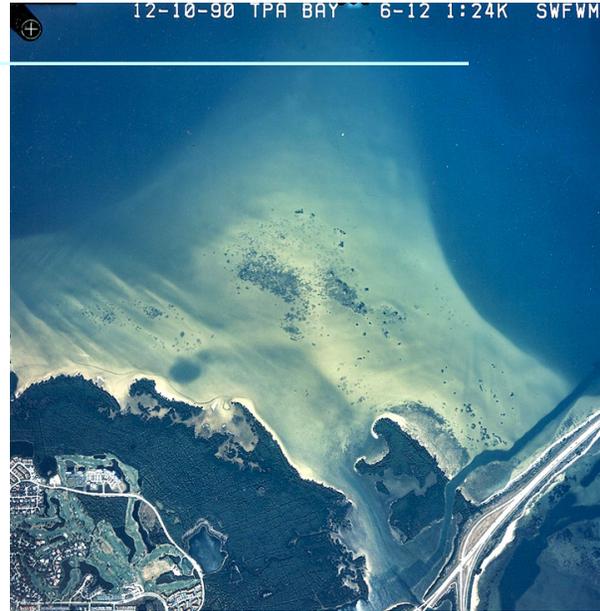


Analysis of Historical Patterns of Seagrass Loss and Recovery

Tampa Bay has changed dramatically over the past century, and even in the past 50 years. Land that was once marsh, mangroves, wetlands, or forests is now subdivisions, shopping centers, highways, or office buildings. The term used to describe the change from natural to industrial/residential areas is “urbanization.”



U.S. Department of Agriculture, Natural Resource Conservation Service

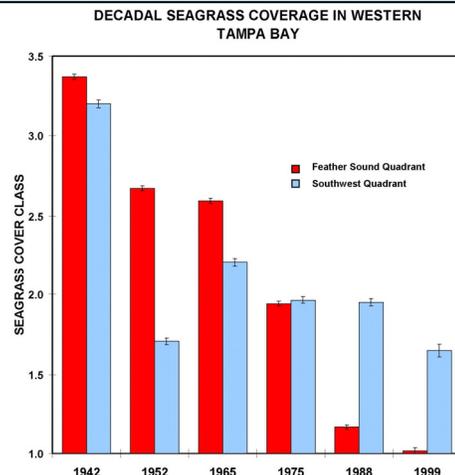


Southwest Florida Water Management District

These aerial photographs depict Feather Sound in 1943 and 1990. The small black dots indicate seagrasses. In 1943, seagrass coverage was very extensive. Today, only a few small patches are present. Houses, roads, and the Howard Frankland Bridge have replaced marshes and mangrove forests in Feather Sound.

Urbanization has been extensively documented as having negative effects on water quality and clarity. One way in which water quality is degraded is through point and non-point pollution sources, such as wastewater treatment plants, industrial facilities, urban stormwater, and agricultural runoff. Although advances in the treatment of point and non-point nutrient sources have improved water quality, urbanization continues to impact Tampa Bay.

Bottom Line: The Feather Sound region, which had poorer water clarity during the study period, supports fewer seagrasses. Also, the deepest areas that support seagrasses in Feather Sound are shallower than in other regions of Old Tampa Bay. This may indicate that poorer water clarity in Feather Sound is limiting seagrasses to shallower areas.



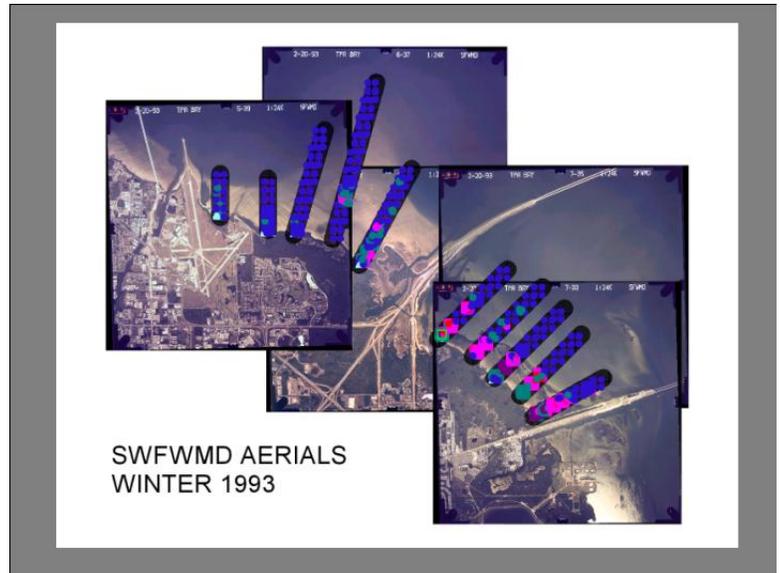
This graph shows that seagrass coverage in Feather Sound has declined steadily since the 1940s, and was most pronounced between 1965 and 1988. Although seagrasses were also lost in the southwest quadrant of Old Tampa Bay between 1942 and 1952, recovery has occurred since the 1960s.

Source: D. Saindon, Eckerd College

d Historical Changes in Seagrass Coverage in Feather Sound

Aerial photographs can be used to analyze historical changes in land use and seagrass coverage. To determine the changes in seagrass coverage in Feather Sound, scientists created mosaics of aerial photographs taken in 1942, 1953, 1965, 1977, 1988, and 1999. Using Geographic Information Systems (GIS) software, they overlaid a rectangular grid over the study area and laid out 10 transects between the St. Petersburg-Clearwater airport and the Gandy Bridge. The transects extended from shore to deep water, and several quadrants composed of 100 - 20 meter by 20 meter cells laid along each transect. Observers classified the seagrass coverage in each cell of each quadrant to determine the changes over time.

Bottom Line: The historical photograph analysis shows incremental seagrass loss each decade in Feather Sound between the 1940s and the 1990s. This is in contrast to increasing seagrass coverage in other areas since the 1980s.



This is an example of a geo-referenced and rectified photo-mosaic of Feather Sound, with seagrass analysis transects overlaid. The colors refer to the seagrass coverage observed in each cell.

- | | |
|----------------|--------------------------|
| ● dense, full | ● dense, partially full |
| ● sparse, full | ● sparse, partially bare |
| ● bare | |

Source: D. Saindon, FWC FMRI and SWFWMD

Halo Formation



“Halos” present at the mouths of several creeks in northern Old Tampa Bay.

Source: SWFWMD

Many freshwater tributaries and man-made flood channels drain into Tampa Bay. At the mouth of some of these channels in northern Old Tampa Bay, a “halo effect” (i.e., an area with no seagrasses) was observed. Scientists hypothesized that the difference in salinity, due to the freshwater inflows, may prevent seagrass growth. As it turns out, there were no readily apparent differences in salinity that would explain the lack of seagrasses. However, scientists noticed that the areas at the mouth of two channels - Rocky Creek and Channel A - were over 1 meter deeper than the surrounding areas, creating a 400 acre-wide delta formation. Aerial photographs show that, historically, seagrasses grew in these areas .



1. Were the areas around Rocky Creek and Channel A always deeper and the seagrasses there more susceptible to die-off? OR

2. Were the areas shallower historically and other events caused the seagrass die-off? If water quality decreased it could have caused a decline in seagrasses. With no seagrass roots to anchor the sediments, the area may have eroded, increasing the depth.

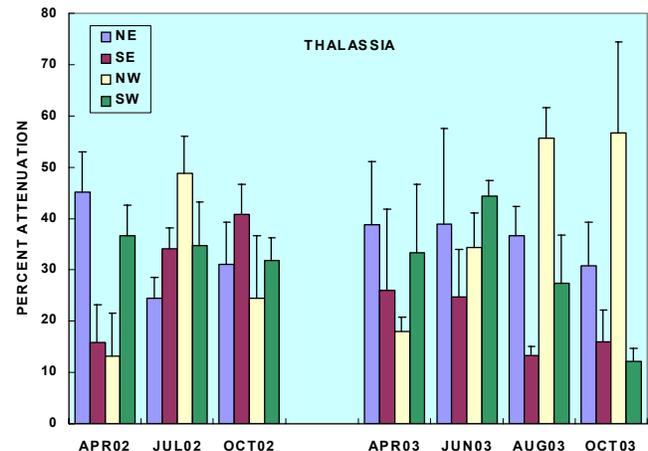
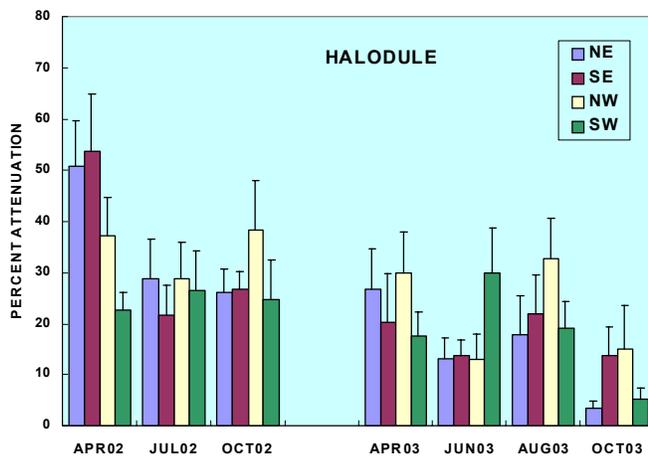
e Seagrass Productivity and Epiphyte Loads

Light reduction by epiphytes growing on the leaves of *Thalassia* and *Halodule* may affect the survival of seagrass beds. An **epiphyte** is a plant or animal that lives and grows on the outer surface of another plant (e.g., moss growing on trees). Epiphytes that grow on seagrass leaves may include algae, barnacles, amphipods, colonial animals like bryozoans and tunicates, and worms. Epiphytes intercept and reduce the light reaching seagrass leaves. This, in turn, may reduce seagrass growth.

In this study, scientists measured the amount and type of epiphytes found on *Thalassia* and *Halodule* leaves and estimated the light reduction caused by epiphytic growth during 2002 and 2003.



This photo depicts epiphytic algae on *Thalassia*.
P. Carlson, FWC FMRI



Results:

- ◆ Epiphytes were measured in all four quadrants of Old Tampa Bay.
- ◆ Epiphytes caused about 32% light attenuation (reduction) on *Thalassia* leaves and about 25% light attenuation on *Halodule* leaves when averaged over the entire study period and study areas.
- ◆ For both *Thalassia* and *Halodule*, epiphyte light attenuation was greatest in the Feather Sound quadrant of the study area in 2003, but not in 2002.
- ◆ In general, the amount of epiphytes on seagrass leaves (epiphyte loads) was greatest in early spring and least in the summer.
- ◆ In the Feather Sound quadrant, epiphyte loads on *Thalassia* and *Halodule* were high during late summer and fall in both 2002 and 2003.
- ◆ Epiphyte taxa changed during the study period. With increasing cloudiness of the water column (greater chlorophyll *a* and turbidity) in 2003, plant-like (light-requiring) epiphytes disappeared and were replaced by particle-filtering animals, such as barnacles and bryozoans.

The graphs illustrate epiphyte light attenuation on *Halodule* and *Thalassia* in each quadrant during 2002 and 2003. Feather Sound is in the northwest quadrant.
L. Yarbro, FWC FMRI



Bioturbators and Ray Exclusion Devices



This photo shows a scientist placing a Ray Exclusion Device over a recently planted seagrass bed in the Feather Sound region.

P. Carlson, FWC, FMRI

There are many events that can impede seagrass growth in newly planted or recovering seagrass beds. A large storm event or a hurricane can destroy both transplanted and stable seagrass beds. Poor water quality may stress seagrasses, making them less resistant to other disturbances. Sometimes, aquatic animals (such as stingrays) can burrow into the sediments and uproot the seagrasses. Other potential “bioturbators” include sediment dwelling worms, ghost shrimp, and snapping shrimp.



Ghost shrimp

Daryl Felder, UL Lafayette

Ray Exclusion Devices (REDs)

In order to eliminate the effects of stingrays (a known bioturbator), scientists utilized a technique dubbed a “Ray Exclusion Device.” Scientists placed REDs (mesh nets) over some of the transplanted seagrasses to keep stingrays out of the growing beds. The experiment was designed to assess the importance of stingrays on transplant failure and to design new restoration techniques.



An Atlantic stingray among *Thalassia*.

Brent Winner, FWC FMRI

Bottom Line: The REDs that stayed buried in the sediment were fairly effective in deterring stingrays; however, if the mesh was exposed, it became an attachment site for algae. Instead of benefiting the seagrasses, some REDs had a negative effect.



Ray pit dug by a stingray in a volunteer *Halodule* seagrass patch in Feather Sound.

P. Carlson, FWC FMRI



Application of a Wave Exposure Model

In some parts of Tampa Bay, wave energy and fetch (the distance in which wind blows over a body of water or land) may be factors in seagrass loss. These factors can be analyzed and predicted using computer modeling.

A wave exposure model is a complex computer program that is used to predict the movement of waves and currents within a selected waterbody. The program allows scientists to create a variety of “wave exposure” scenarios. For example, scientists can include the current distribution of seagrass beds and features, such as bridges and causeways, and can also “add” or “subtract” virtual sand bars to model different wave energy patterns.

A model developed by the National Oceanic and Atmospheric Administration (NOAA) and Mote Marine Laboratory has been applied in Tampa Bay.

Bottom Line: Results of the wave exposure model indicated that wind generated waves are not a major factor in Feather Sound. Although wave action might affect seagrass beds in some areas of Tampa Bay, such as Apollo Beach, the model results indicated that seagrass growth in Feather Sound should not be limited due to wave exposure.

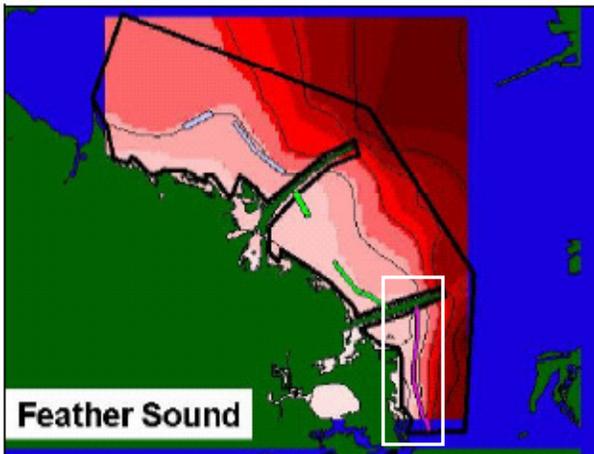


Fig. 1: Relative Exposure Index values and bar locations for Feather Sound. Dark red = high energy while lighter colors = relatively low wave energy. Green bars are present day features. Purple bars in the white boxes represent 1950s features.

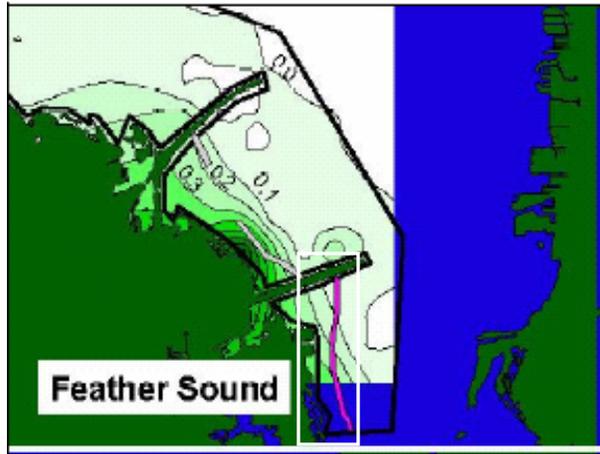


Fig. 2: Probability of seagrass coverage with all bars in place for Feather Sound. The values on the contours or callouts = the probability of seagrass coverage. The values are out of a possible 1.0.
Source: M. Fonseca, NOAA

The purple bars in the white boxes indicate where a sandbar has been lost, south of the current Gandy Bridge Causeway, in Figure 1. Wave energy is reduced closer to the shoreline, as a result of the causeways, bridges, and sand bars. Figure 2 shows the probability of recovering lost seagrass coverage if lost bars are replaced. The probability of an increase in seagrass coverage is highest nearshore, while the probability of an increase in seagrass coverage between and beyond the bridges is nearly zero (0.1 and 0.0). As a comparison, the model results indicated that if lost bars are replaced in “The Kitchen” and “Wolf Branch” regions of Tampa Bay, there is a higher probability (0.8) of increased seagrass coverage.

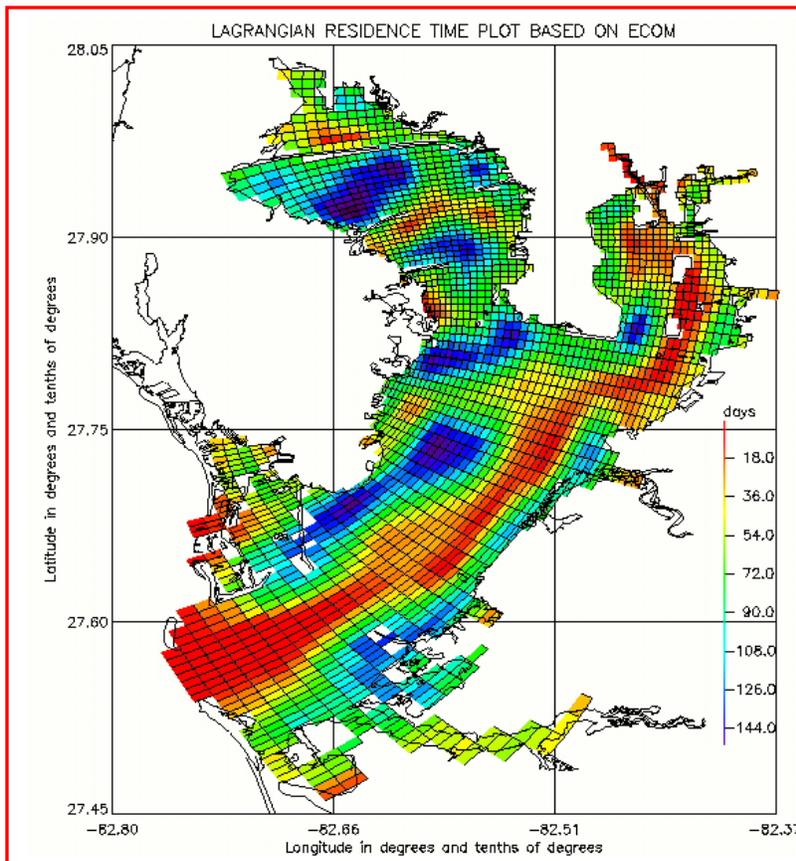


Flushing Rates in Tampa Bay

Circulation patterns and flushing rates can be important factors in water quality. A circulation model was employed that maps the movement of water within the bay and provides an estimate of residence times. The residence time refers to the number of days in which a water mass is contained in a given area. Scientists were particularly interested in the residence time in Feather Sound and whether it was linked to poor water quality.

A region of the bay with good flushing (such as at the mouth of Tampa Bay) may recirculate water every 3-5 days. Pollutants and nutrients in those areas are quickly flushed and diluted. Conversely, the residence time in Feather Sound is among the longest in the entire bay. A conservative estimate of the residence time is 144 days - nearly 4 ½ months!

Scientists are not sure where the water masses in Feather Sound originate nor the reasons for the poor flushing; however, the man-made causeways in Old Tampa Bay may contribute. Wastewater treatment plants and urban watersheds (along with other point and non-point sources) that discharge into the Feather Sound region, increase the nutrient loading. Since nutrient-enriched water resides in the area for so long, there is a higher risk for algal and phytoplankton growth.



In this map of residual circulation, areas with **short residence times** (good flushing rates) are colored **red**. The mouth of Tampa Bay and areas up and into Hillsborough Bay have short residence times of less than 18 days. Regions with **longer residence times** (poor flushing) are colored **blue**. The Feather Sound region, indicated in dark blue/purple, has a residence time of about 144 days.

M. Luther, USF St. Petersburg

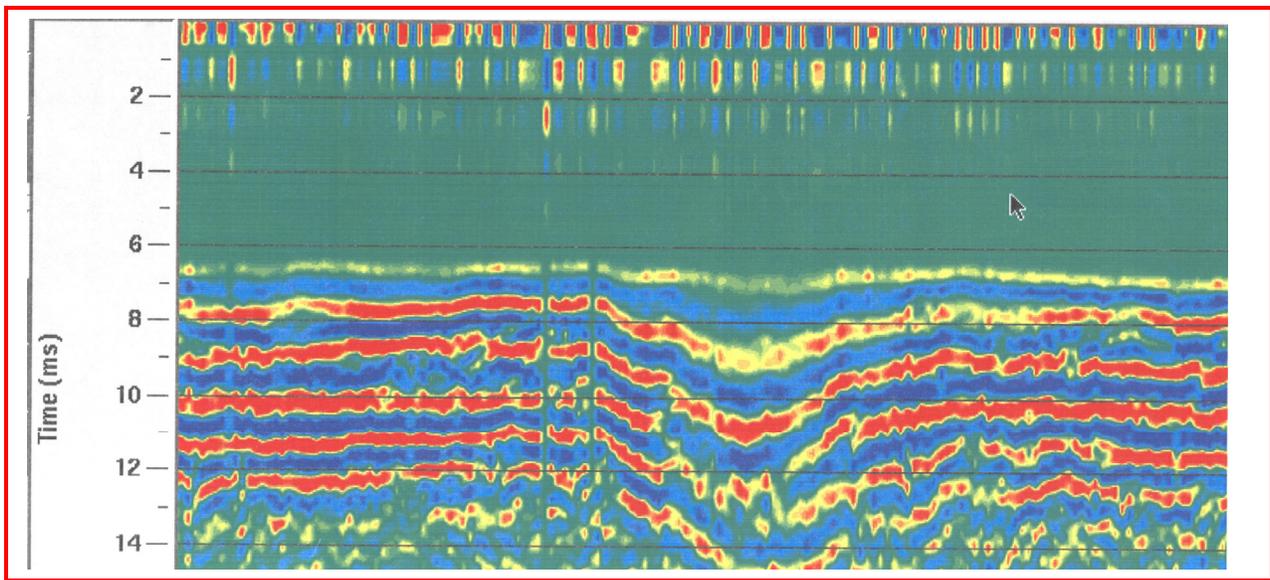
Bottom Line: Poor flushing and high nutrient loading may lead to decreased water quality in Feather Sound.



Shallow Water Bathymetry and Groundwater Influence

The topography of submerged land can vary as much as on dry ground. Features such as underwater volcanoes, mountain ranges, crevices, and even sinkholes are found in many aquatic environments. To detect these features, scientists utilize bathymetry: the practice of measuring the depths of oceans or other water bodies.

Aerial photographs indicated the presence of a depressed feature, possibly a spring or a sinkhole, in Feather Sound. If the feature was connected to an underground freshwater source, it could have an effect on seagrass growth in the surrounding region. Depending on the water quality of the underground source, additional nutrients and contaminants could be delivered to the bay, further inhibiting seagrass growth and restoration efforts.



The depressed area in the seismic photograph is the spring or sinkhole.

P. Swarzenski, USGS

A seismic survey was conducted which verified the presence of a collapsed feature (spring). Seepage meters were also employed to detect possible freshwater inflow by an underground source. Results from the two-year study suggest that there was no discharge from a “spring” at the expected location. However, nutrient and chemical fluxes may be occurring as a result of water flowing between the water column and pore spaces located about 1 meter below the sediment-water interface. The residence time in pore spaces may also be leading to increased sulfide concentrations, which is discussed in Task I- The Mystery of the Seagrass “Donuts.”

Bottom Line: A collapsed feature or “spring” found in the Feather Sound quadrant does not appear to be discharging measurable amounts of groundwater.

h Experimental Seagrass Plantings

One method used for seagrass restoration is planting sprigs or larger units of seagrasses in areas where seagrass no longer exists. In some cases, planting can help “kick start” seagrass recovery, if adequate conditions (such as light availability and sediment type) exist. Just like terrestrial grasses, seagrasses can spread naturally by sending out seeds, or (more commonly for seagrasses in Tampa Bay) by sending out underground stems or rhizomes. Plantings in appropriate locations can help seagrasses recolonize.

Scientists planted seagrasses in 15 plots at three sites in Tampa Bay - Feather Sound, Apollo Beach/TECO, and Shell Key. The purpose was to examine the growth rate of the plantings using several different mechanical and hand planting techniques.



Percent cover of seagrass in transplanted plots one year post-planting:

Shell Key:	21%
Apollo Beach:	11%
Feather Sound:	0.9%

The growth rate at Feather Sound may be due to slightly poorer water quality. Also, the Feather Sound transplant site was deeper than at the other two transplant sites.

Scientists used four different treatment methods (three hand planting and one mechanical) for transplanting, in order to analyze which technique was the most effective for restoration. While hand planted seagrass units were more successful at Shell Key, no method was significantly better among all sites. This photo shows scientists measuring transect lines in preparation for hand planting.

P. Hall, FWC FMRI



Effects of El Niño on Seagrass Transplants

Between fall 2002 and fall 2003, there was a 10.4% decline in seagrass planting survival (affecting all 3 sites) due to El Niño rain events. Increased precipitation and associated stormwater runoff, as well as point source discharges, can lead to higher levels of nutrients and pollution in the bay. It is likely that there would have been greater success at all three sites in the absence of the El Niño event.

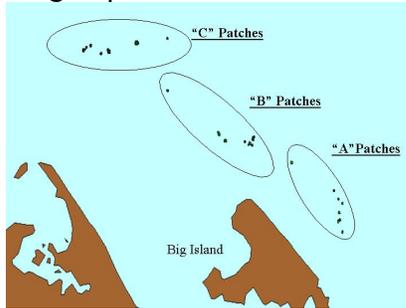
Bottom Line: The location and depth of seagrass transplant sites may be greater factors in the success of restoration efforts than the transplanting method used.



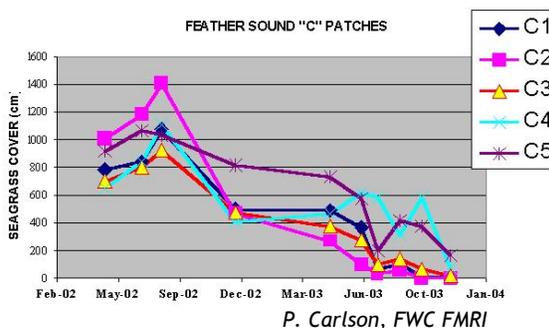
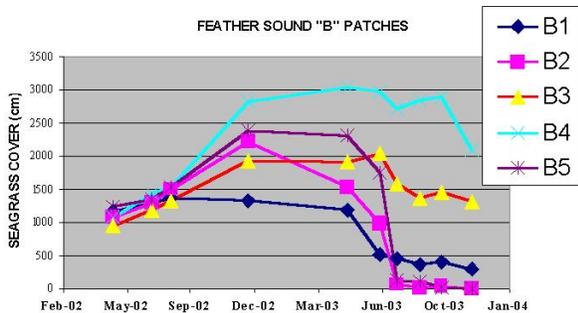
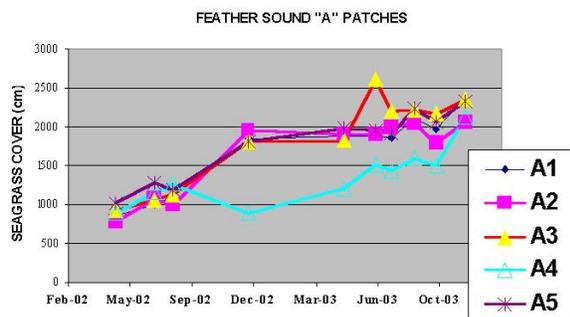
Volunteer Patch Monitoring

In addition to monitoring planted seagrasses, scientists also monitored patches of seagrasses that became established on their own. "Volunteer" patches of *Halodule* grass appeared in the Feather Sound quadrant in fall 2001 and spring 2002 and expanded rapidly. Volunteer patches have a much greater capacity for seagrass recovery than seagrass restoration plantings, so scientists were encouraged to see patches expand and coalesce.

The patches were divided into three groups based on their location: A, B, and C (see diagram). Scientists selected five patches in each of the three groups for monitoring. Patches were surveyed regularly using transect tapes and sophisticated global positioning system (GPS) equipment.



A scientist uses GPS equipment to monitor volunteer patches of seagrass in Feather Sound.
P. Carlson, FWC FMRI



Seagrass dynamics in the monitored patches varied seasonally and among patch groups. *Halodule* grass in the center of many volunteer patches died in fall 2002, creating "donuts" (see The Mystery of the Seagrass "Donuts"). The number of "donuts" and amount of seagrass loss were greatest in the patch group C located northwest of Big Island. Seagrass cover in patch group C began to decline in fall 2002 and continued to decline through 2003. Seagrass cover in most of patch group B increased during the 2002 growing season, leveled off during the winter, and declined precipitously in summer 2003. Seagrass cover increased in patch group A during the 2002 growing season, leveled off during winter and spring 2003, and increased slightly in fall 2003.

Using precision GPS, scientists determined that there were also slight differences in elevation among patch groups. The A, B, and C patch groups had an average elevation of -94 cm, -100 cm, and -107 cm, respectively. As noted earlier, water quality in 2003 was worse than in 2002, and lowered growth rates and/or seagrass losses were noted in all patches in 2003.

Bottom Line: Differences in seagrass growth and loss among the patch groups suggest that, even within the Feather Sound quadrants, there are gradients in water quality. Additionally, although the elevation differences between patch groups are not large, during poor water quality years, such as 2003, the 13 cm difference between the A and C patch groups might be the difference between survival and death for seagrasses.

P. Carlson, FWC FMRI



The Mystery of the Seagrass “Donuts”



P. Carlson, FWC FMRI

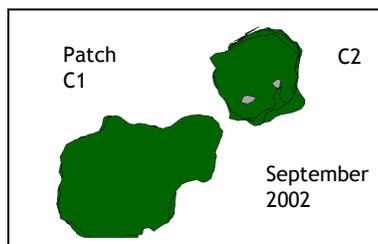
Many volunteer patches of *Halodule* seagrass that became established in fall 2001 and spring 2002 began to die rapidly in late summer and fall 2002. Scientists noticed that the volunteer patches, which started out as solid patches, became bare in the middle, exhibiting a donut-shaped formation. The donut formations occurred quickly, sometimes in less than a month. This picture depicts the seagrass “donuts” that formed near Big Island in Feather Sound. Donut formations in Feather Sound were only noted and studied for *Halodule* seagrass.

Seagrass Donut Formation Hypotheses:

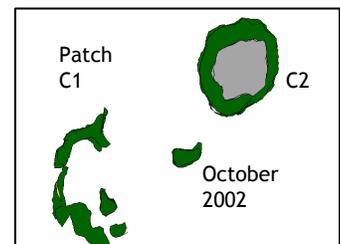
These “donuts” are patches of seagrass that used to be full; however, the seagrass in the middle is beginning to die-off. The amount of seagrass loss varies among patches. There are several hypotheses for this occurrence:

1. “Donuts” may be natural features of colonizing seagrass meadows; however, they may also be symptomatic of problems relating to seagrass recolonization.
2. Bioturbators (i.e. stingrays, horseshoe crabs, and burrowing organisms) may be digging up the middle of patches. Stingrays, in particular, have the capacity to dig up new seagrass patches as they feed or rest on the bottom. However, the rapid formation of “donuts” is not consistent with the normal pattern of damage by stingrays or burrowing organisms.
3. Hypoxia and sulfide toxicity: Hydrogen sulfide, a chemical produced by soil bacteria during anoxic conditions (no oxygen), may be higher in the seagrass beds than in bare sediments, killing seagrasses in the middle of patches. Sulfide may also act synergistically with other stressors to weaken or kill seagrasses.
4. Clonal senescence: Seagrasses grow by extending underground stems called rhizomes, and a seagrass bed is composed of intertwined rhizomes. As the rhizome extends outwards from the center of the bed, some of the older shoots might die, leaving bare spots. Because the growing tips of the rhizomes are oriented outwards, the bare centers of donut patches are not immediately recolonized.
5. Sediment nutrient depletion: As seagrasses recolonize bare sediments, they may deplete the supply of sediment nutrients. The fringe of growing seagrass around the edge of the patch is continuously growing into new sediments, so the patch continues to expand outwards. Seagrasses in the center may run out of necessary nutrients and die.

The *Halodule* seagrass patches that experienced the greatest die-off in Feather Sound (patch group C) were located in deeper water than patch groups A and B. By the end of the study, patch group C had very little seagrass remaining.



Halodule seagrass loss in patch group C, illustrating the donut formation.



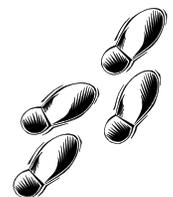
P. Carlson, FWC FMRI

Bottom Line: More research needs to be conducted on why seagrass “donuts” form and on the causes of volunteer patch failure.

Next Steps:

The Feather Sound Seagrass Project has provided Tampa Bay area scientists and managers with important information about seagrass recovery and success in Feather Sound. However, many unanswered questions remain. Additional research is needed to further examine the factors affecting slow seagrass recovery. The scientists involved in this study have suggested these tasks for follow-up research:

- Examine the causes of seagrass transplant failure and factors affecting expansion and mortality of volunteer seagrass patches.
 - o Continue to investigate the causes of donut formations in volunteer patches.
 - o Focus on rhizome growth patterns, nutrient availability, hypoxia, and hydrogen sulfide toxicity.
- Develop a model to predict seagrass survival and growth throughout Old Tampa Bay.
 - o Use water quality data, detailed bathymetry, epiphyte, and seagrass photosynthesis data collected in this study.
 - o Collect additional data for calibrating the model using light monitoring at one or more seagrass site(s) and measurements of seagrass community metabolism data using benthic chambers.
- Continue to study the effects of bioturbators on seagrass beds.
 - o Determine the effects of large and small bioturbators on new seagrass beds in Feather Sound using field measurements and experiments.
- Continue to closely monitor seagrass transects for seagrass bed survival, expansion, contraction, and thinning in the four quadrants of Old Tampa Bay, including bi-annual aerial photography.
 - o Examine the potential for using digital photography and airborne/satellite hyperspectral remote sensing for benthic habitat and water quality mapping.
- Pursue further work on the depth differences between areas where seagrasses have been stable vs. areas where seagrasses have been lost.
 - o Examine the effects of stormwater runoff on seagrass beds and the formation of “halos” around stream mouths.
 - o Further characterize the water quality and depths at the mouths of Rocky Creek and Channel A where “halos” are prominent seagrass features.
 - o Determine the relative impacts of salinity changes, sediment scouring, and nutrient loads on seagrass beds.
- Analyze decadal changes in seagrass coverage in response to major events, such as the construction of the Howard Frankland Bridge.
 - o Construct a timeline of events in Tampa Bay.
- Continue to study circulation effects and whether longer residence time is linked to poorer water quality.
 - o Include exchange scenarios through the Howard Frankland Bridge causeway.
- Investigate the effects of the hydrodynamic regime on water quality and sediment geochemistry in the Feather Sound area.



Technical Reports included on Accompanying CD:

b

Facilitating adaptive monitoring for scientific investigations through quality assurance and data management. D. Bishop and C. Anastasiou, *Surface Water Improvement and Management Program, Southwest Florida Water Management District.*

Old Tampa Bay water quality monitoring network: 2002 and 2003 sampling seasons. Data files and quality assurance reports. C. Anastasiou, D. Tomasko, and D. Bishop, *Surface Water Improvement and Management Program, Southwest Florida Water Management District.*

Old Tampa Bay water quality monitoring network: Field operations manual: Standard operating Procedures (SOP) and quality assurance (QA) plan. C. Anastasiou (Editor), *Surface Water Improvement and Management Program, Southwest Florida Water Management District.*

Using percent transmission for calculating light attenuation in clear shallow waters: A case study in Tampa Bay. C. Anastasiou¹, R. Johansson², W. Avery², D. Tomasko¹, and D. Bishop¹, ¹*Surface Water Improvement and Management Program, Southwest Florida Water Management District*, ²*City of Tampa, Bay Study Group.*

Water quality observations from 2002-2003 probabilistic sampling. D. Wade, *Janicki Environmental, Inc.*

Chlorophyll *a* concentrations in Tampa Bay: October 2002, October 2003, and 19-year October average (1985-2003). E. Lesnett, *Environmental Protection Commission of Hillsborough County.*

c

Seagrass monitoring in Old Tampa Bay. J.O.R. Johansson and W.M. Avery, *City of Tampa, Bay Study Group.*

d

Spatial and temporal changes in submerged aquatic vegetation in Feather Sound, Tampa Bay. D. Saindon, *Eckerd College.*

e

Epiphytes on seagrass in Old Tampa Bay, Florida: Contribution to light attenuation and variation in composition. L. Yarbro, P. Carlson, A. Ketron, D. Saindon, and H. Arnold, *Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute.*

f

Evaluating the effects of offshore sandbars on seagrass recovery and restoration in Tampa Bay through ecological forecasting and hindcasting of exposure to waves. M. Fonseca¹, B. Robbins², P. Whitefield¹, L. Wood¹, and P. Clinton³, ¹*NOAA/NOS Center for Coastal Fisheries and Habitat Research*, ²*Center for Coastal Ecology, Mote Marine Laboratory*, ³*OAQ WED/NHEERL/ORD U.S. EPA*

Submarine ground water discharge to Feather Sound: Aquifer derived sources and mixing of bay waters. J. Martin¹, E. Davis¹, and P. Swarzenski². ¹*University of Florida, Department of Geological Sciences* ²*United States Geological Survey, St. Petersburg, Florida.* (Power Point)

g

Investigating of submarine ground water discharge and nutrient loading to the Feather Sound region of Tampa Bay, Florida. P. Swarzenski, J. Martin, P. Cambell, and E. Davis, *United States Geological Survey, St. Petersburg, Florida.* (Poster)

h

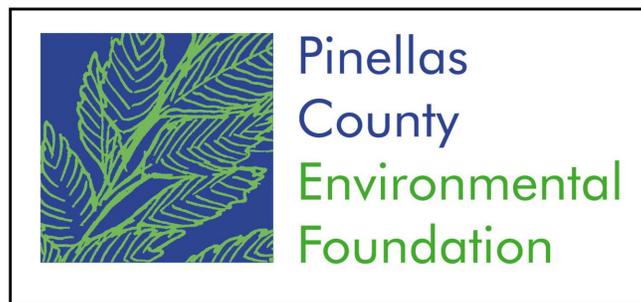
A comparison of mechanical and manual seagrass planting techniques at three sites in Tampa Bay, Florida. M.O. Hall¹, D. Berns¹, P. Carlson¹, K. Ferenc¹, J. Hyniova¹, A. Ketron¹, M. Merello¹, D. Saindon¹, M. Fonseca², and S. Bell³, ¹*Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute*, ²*NOAA/NOS Center for Coastal Fisheries and Habitat Research*, ³*University of South Florida.* (Poster)

i

Dynamics of volunteer seagrass patches at Feather Sound. P. Carlson, D. Saindon, B. Burkholder, A. Ketron, and L. Yarbro, *Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute.*

Feather Sound Seagrass Project funded by a grant from the

Pinellas County Environmental Foundation



BAY STUDY GROUP
WASTEWATER DEPARTMENT
CITY OF TAMPA

