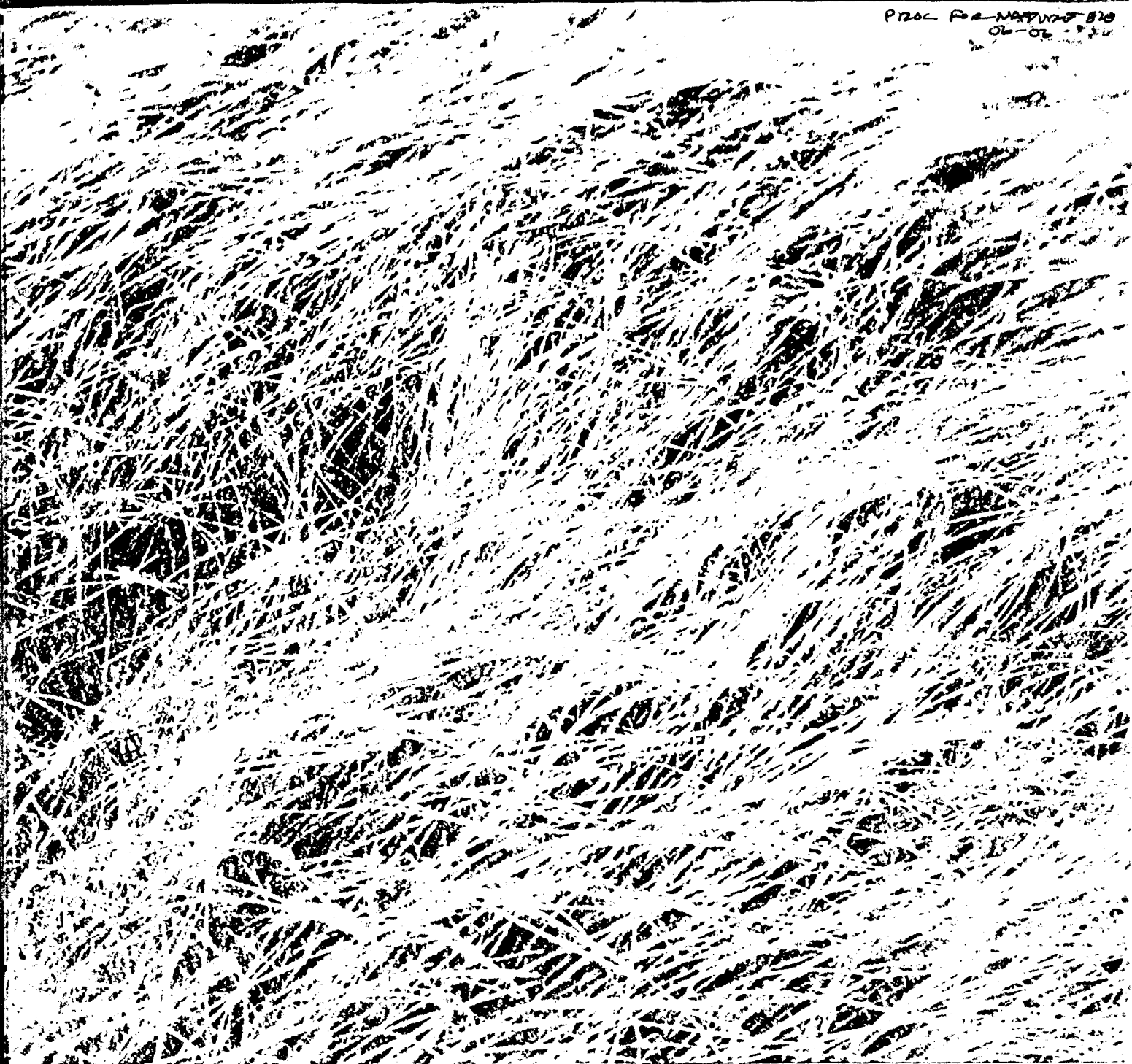




Proceedings and Conclusions of
Workshops on:

**Submerged Aquatic
Vegetation Initiative**
and

**Photosynthetically
Active Radiation**



Special Publication SJ93-SP13

**PROCEEDINGS AND CONCLUSIONS
OF WORKSHOPS ON:
SUBMERGED AQUATIC VEGETATION INITIATIVE
AND
PHOTOSYNTHETICALLY ACTIVE RADIATION**

**Melbourne, Florida
July 16-17, 1992
and
January 7-8, 1993**

Edited by

Lori J. Morris
St. Johns River Water Management District
and
David A. Tomasko
Sarasota Bay National Estuary Program

Sponsored by

Indian River Lagoon National Estuary Program
Melbourne, Florida
St. Johns River Water Management District
Palatka, Florida
1993

SEAGRASS MAPPING IN THE INDIAN RIVER LAGOON

by

Robert W. Virnstein, Ph.D.
St. Johns River Water Management District
P.O. Box 1429
Palatka, FL 32178

The first "layer" of a layered approach is the Lagoon-wide, "big picture" approach. Lagoon-wide seagrass maps provide this big picture.

What follows is a quick overview of the steps taken to map seagrasses in the Indian River Lagoon and uses of these maps. These maps are the initial step in evaluating the status of seagrass in the Lagoon. Such steps include: aerial photographing; ground-truthing; photo-interpreting and delineating of polygons; registering these to a base map; and digitizing these maps into a geographic information system (GIS).

ELEMENTS OF THE MAPPING EFFORT

1. Aerial photos
 - * 9x9 inch, color, infra-red or true-color positives
 - * quad scale, 1:24,000 (1 inch = 2,000 ft)
 - * winter-spring usually offers greatest water clarity
 - * photos every year (proposed)
 - * full mapping effort about every 2 to 3 years
 - * 1986
 - * 1989
 - * 1992
2. Ground-truth, using copies or prints of aerial photos
 - * spot checks, as needed
 - * establish transects
 - * permanent, fixed
 - * or as needed to interpret

3. Photo-interpret
 - * past efforts in 1986 and 1989 – four density classes
 - * <10% coverage
 - * 10-40%
 - * 40-70%
 - * >70%
 - * 1992 – only two classes, narrowed to:
 - * dense, continuous beds
 - * patchy beds
4. Digitize, plot – ARC
5. Trend Analysis – INFO

I emphasize that ground-truthing is an integral and important part of seagrass mapping, as it verifies the interpretation and answers questions raised in the aerial photos. Visual estimates are used in the field.

TRANSECTS AS PART OF THE 1992 MAPPING EFFORT

In addition to simple gross estimates of percent cover to assist photo-interpretation, more rigorous estimates were made along transects starting in 1992. These fixed, permanent transects can then be revisited in subsequent years or seasons.

As part of the 1992 mapping effort, 50 transects were established. These extended roughly perpendicular to shore from the shallowest edge of seagrass out past the deep edge of the seagrass. At a minimum of ten points along the transect, the following parameters were estimated or measured:

- * percent cover
- * species composition and relative abundance
- * algal percent cover
- * canopy height
- * epiphyte abundance (scale of 0-5)

These parameters enhance the interpretation of Lagoon-wide maps. They provide insight into, or more rigorous indicators of:

- * species composition and subsequent changes
- * changes along the depth gradient
- * separation of signatures of algae versus seagrass
- * the correspondence between the densities indicated from the aerial photos and from field measurements

Once the ground-truthing effort has been completed, photo-interpreting, an inexact science, may be completed. As indicated above, four classifications were used in estimating seagrass coverage, from 1986-89. We have now revised our classification scheme to only two categories. Neither of these schemes is perfect. However, we selected the two-category scheme because of the magnitude of the effort, and it appears as if it may be a more repeatable scheme. Once photos are interpreted, we can digitize the maps and continue on to trend analysis.

USES OF LAGOON-WIDE SEAGRASS MAPS

From the point of view of this workshop, the uses of the Lagoon-wide seagrass maps are very important. For example, we can describe large-scale patterns, such as determining how many acres are in a county or segment. We can address trends by county or by segment. If we examine a long stretch of the Lagoon, we see that there is very little seagrass from Cocoa to Grant, compared to most of the rest of the Lagoon.

Appropriate uses of Lagoon-wide maps include:

- * To describe large-scale distribution patterns Lagoon-wide, per county, and per segment
 - * acres of seagrass
 - * percent of bottom with seagrass
- * Determine large-scale changes and trends
 - * overall
 - * per county
 - * per segment
- * Locate "healthy" and "problem" areas
- * Define resource protection areas
- * Relate distribution and changes to various water quality parameters
- * Relate distribution to bathymetry and distribution goals

Lagoon-wide maps are not suitable for:

- * Detecting or describing short-term changes (less than 1 year)
- * Detecting localized impacts
- * Detecting changes in species composition
- * Site-specific permitting
- * Detecting small changes in seagrass distribution. Shifts of less than perhaps 10-50 m can not be reliably detected

Certainly, such maps are only representations. As such they can represent only a few selected features. We choose these features based on the details we need. We must realize the limited scale and precision of these maps when we interpret and use them.

THE TAMPA BAY EXPERIENCE

by

Thomas F. Ries
Southwest Florida Water Management District, SWIM
Tampa Service Office
7601 U.S. Highway 301
Tampa, FL 33637

Thomas Ries is an environmental scientist with the Southwest Florida Water Management District (SWFWMD), SWIM Program, where he works as project manager on seagrass research projects including mapping and trend analysis. Additional projects include restoration of Tampa Bay estuarine habitats via creation of tidal wetlands and research on the limiting light levels for seagrasses. He received his B.S. in biology with a minor in hydrogeology in 1983 and is currently seeking his M.S. in environmental public health at the University of South Florida.

TREND ANALYSIS IN TAMPA BAY

The SWIM Program is completing seagrass mapping on the west coast of Florida, in Tampa Bay. The program has experienced some problems with mapping and as a result the program has been continually revised.

The SWIM Program of SWFWMD wanted to complete seagrass mapping in the Tampa Bay area since the last time seagrasses had been mapped was by the state Department of Natural Resources in 1982. The intent of the program was to update and document seagrass presence, to determine how the ecological system was progressing in terms of the seagrass trend analysis.

In 1988 the program completed the first mapping effort. We wanted to complete the effort with GIS and ARC/INFO to allow the trend analysis to be more easily completed. To accomplish this we hired Geonix, who have monitored a significant number of mapping projects for the government, namely the National Wetlands Inventory for the U.S. Fish and Wildlife Service.

When we mapped in 1988, true color was used because we hoped to gain better depth penetration with color at 1:24,000, with USGS 7.5 minute quads, taken during the winter months when there is good water clarity, at low tide and low wind. We received good photos, not great, but adequate. In categorizing seagrass coverage, Geonix used three categories, dense, sparse, and patchy.

When we went-out in the field to begin our ground-truthing efforts, we realized that the difference between sparse and dense was not what we assumed. Instead, the difference appeared as a characteristic of morphological difference in seagrass species. More specifically, the *Thalassia* spp., with its broad leaves appeared more continuous and dense than other seagrasses (of similar distribution).

Consequently, we narrowed the categories to two for the 1988 mapping effort and future mapping efforts. The drawback is that less information was gained on the maps, but the information was correct. Because we gained less information on our maps, we began to define transects.

In 1990, we wanted to update the seagrass maps in a two-year interval to document any changes. We again used true color for the subsequent overflights. Due to the drought in 1990, water clarity was exceptional, thus we were able to attain some very clear maps. During the same time period the District was mapping land features using color/IR photography at the same scale. By comparing the overlap area we have concluded that true color has superior light penetration, which made it easier to distinguish species. In fact, the 1990 water clarity was so good that we were able to pull out *Caulerpa* spp. (attached algae areas), as defined as a separate signature from SAV.

Due to less information gained overall, we established transects (starting in 1990). Seventy transects were located throughout Tampa Bay. These transects were 1,000 meters long with data points every 100 meters. We collected information on species presence, blade width of species, epiphyte loading, bottom characteristics-hard bottom/soft bottom determination, depth of the water and relative abundance of algae.

Lewis *et al.* (1983) suggested we have had an 80 percent seagrass loss in Tampa Bay since the 1800s. Obviously, we hoped to reverse that trend and we needed to identify what kind of trend in seagrass coverage was occurring.

In 1990, we completed a trend analysis of the entire mapping area for all of Tampa Bay (Table 1). The results are significant and include the percent change

SAVI Section 2: Seagrass Mapping and Assessment

TABLE 1
Total Acreage of Seagrass Beds in the Tampa Bay Area

BOTTOM TYPE	1988 ACRES	1990 ACRES	CHANGE	
			ACRES	PERCENT
Seagrass, Continuous	18577	20182	1605	8.64
Seagrass, Patchy	10040	10750	709	7.06
Attached Algae	0	633	—	—
Seagrass and Algae(Total)	28617	31565	2948	10.3
Tidal Flats /Submerged Shallow Platforms	25097	23699	-1397	-5.57
Beaches	97	881	-10	-10.30
Estuaries, Bay and Gulf	338381	336800	-1581	-0.46
Land	366970	367009	39	0.01
TOTAL	759162	759162	0	0

in acres of seagrass: 1605 in continuous and 709 in patchy.

These numbers represent acres of seagrass percent change in the positive direction for that category. With a closer look, the percent changes offer a better insight into the increases in seagrass coverage.

Table 2 gives an even greater understanding of seagrass increase. Of the 1605 acres, 75 percent was derived from the category of patchy grass beds which grew into continuous coverage. We expected this observation for expanding and healthy seagrass areas. We concluded, that a 27 percent increase of seagrass areas originated from bare bottom. As a result, the 709 acres in Table 1 represents a

significant number of brand new seagrasses in Tampa Bay within a two year period.

Part of this mapping effort was to determine whether the efforts of the SWIM department and other programs are making headway with improving water quality in Tampa Bay. The results seem to indicate that they are effective programs. I must preface these remarks with the fact that we had a significant drought in 1990 and less surface water was entering the Bay thus potentially increasing water clarity.

At this point we need to repeat the mapping to see if this trend is real and will continue through 1992. Also we plan to revisit all our transects on an annual basis to develop site specific information to gauge species changes as an early indicator of the health of the system.

TABLE 2
Cross Tabulation of Seagrass Change Categories
Between 1988 and 1990 in Acres

1988	Seagrass continuous	Seagrass patchy	Attached algae	Beaches	Tidal flats/algae submerged shallow platforms	Estuaries Bay and Gulf	Land	TOTAL
1990 Seagrass continuous	—	2030	0	0	599	244	0	20181
Seagrass patchy	876	—	0	0	1656	991	0	10750
Attached algae	0	0	—	0	632	1	0	633
Beaches	0	0	0	—	23	2	5	88
Tidal flats/submerged shallow platforms	309	647	0	14	—	789	23	23699
Estuaries Bay and Gulf	92	127	0	3	243	—	19	336801
Land	1	0	0	22	36	28	—	367099
TOTAL	18577	10040	0	97	25097	338381	366969	

This is how the program has evolved. We have been lucky to have the same person completing the photo-interpreting over the years. It is very important to enter the field to conduct your initial ground-truthing as soon as possible after shooting the photos.

LITERATURE CITED

Lewis, R.R., M.J. Durako, M.D. Motter, and R.C. Phillips, 1983. Seagrass meadows of Tampa Bay - A Review. In: S.F. Treat, J.L. Simon, R.R. Lewis, and R.L. Whitman, eds. Tampa Bay Area Scientific Information Symposium. Florida Sea Grant Publ. pp 210-246.

ITAL

0181

0750

533

88

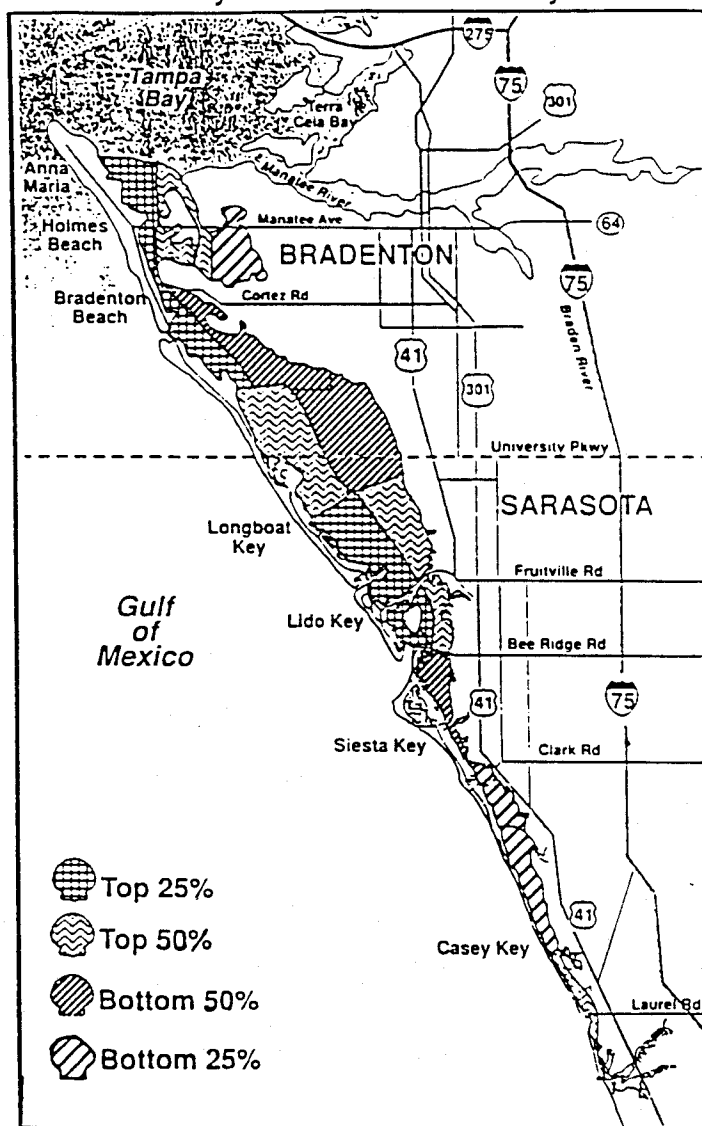
3699

16801

57099

Sarasota Bay, like other parts of Southwest Florida, experiences distinct wet and dry seasons. Approximately 60 percent of the Bay's rainfall occurs during a 5 month period, from June to October (Heyl, 1992). Associated with this seasonality in rainfall, water quality changes dramatically at any given point in the Bay, dependent upon the time of the year (Lowrey, 1992). Therefore, it is important that monitoring programs do not confound seasonal differences in water quality with spatial differences when assessing the relationships that exist between water quality and seagrass distribution.

Figure 1. Relative water clarity index for Sarasota Bay



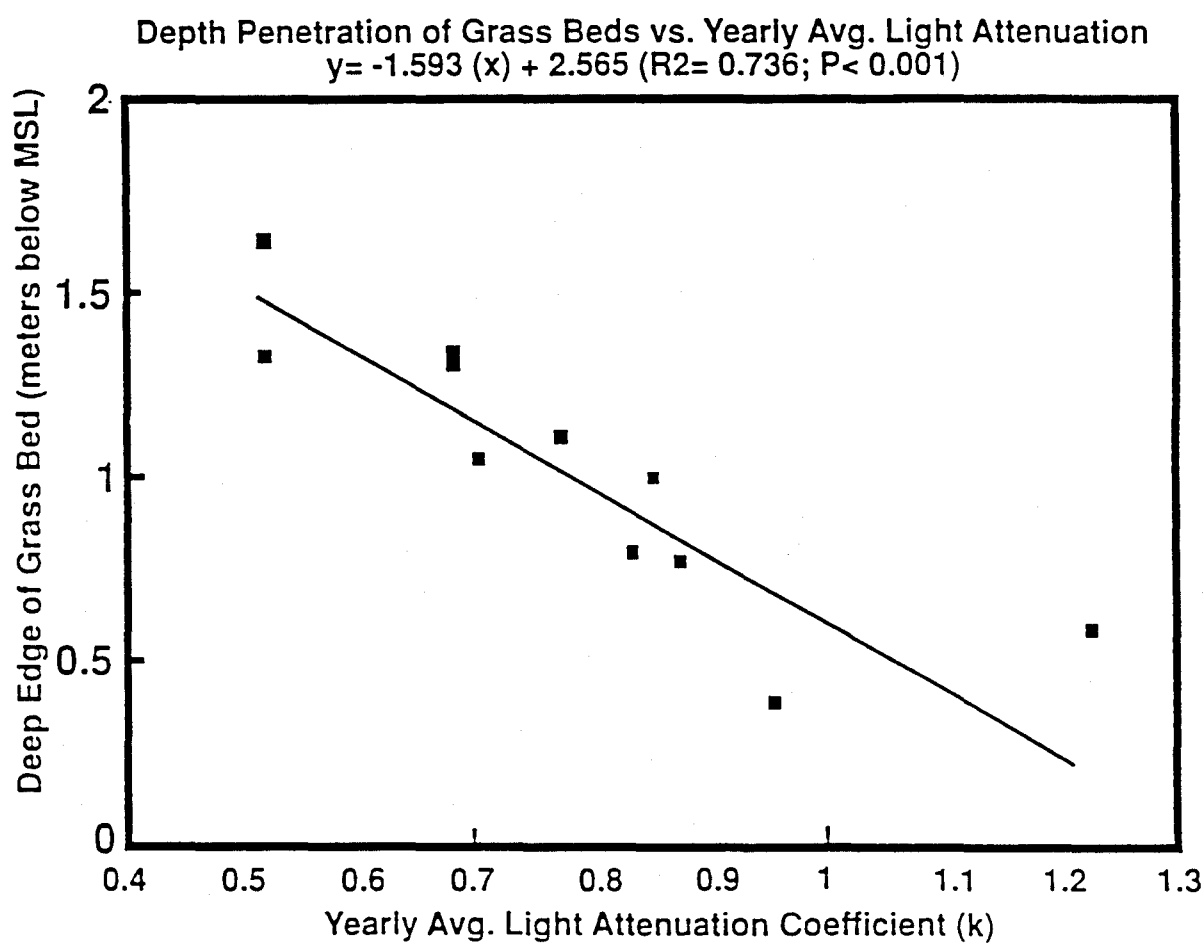
IMPORTANCE OF WATER CLARITY AND VARIOUS LIGHT ATTENUATORS

As can be seen in Figure 1, water clarity in Sarasota Bay varies spatially. Some of the difference in water clarity is attributed to differences in circulation and flushing. Areas closest to passes generally have the best water clarity, and areas in null zones for circulation typically have reduced water clarity. However, exceptions do exist. Roberts Bay, the area just east of Siesta Key, is in the bottom 50 percent of all Bay segments for water clarity, yet it is in the upper 33 percent of all Bay segments in terms of flushing rate (Sheng and Peene, 1992). Also, the area just east of central Longboat Key, which is in the top 50 percent of all Bay segments for water clarity, is in the lower 33 percent of all Bay segments in terms of flushing rate, being located in the null zone between New Pass and Longboat Pass (Sheng and Peene, 1992).

A potential reason for the lack of water clarity in Roberts Bay, despite its thorough flushing, is that Roberts Bay receives the discharge of Phillippi Creek. Phillippi Creek has the largest watershed of any tributary to Sarasota Bay, which contains the majority of the 45,000 septic tanks located in the Sarasota County portion of the Bay watershed (Heyl, 1992). The combination of stormwater and wastewater loads seems to be associated with the elevated Chlorophyll *a* levels found in Roberts Bay (Lowrey, 1992). In contrast, the area east of Longboat Key has no wastewater discharges to the Bay, and the reduced land area is associated with low levels of stormwater runoff (Heyl, 1992).

In order to document that the water quality monitoring program in Sarasota Bay has biological relevance, an attempt was made at correlating the depth to which seagrasses grow in any particular segment to the yearly average light attenuation coefficient for all non-tributary stations within that segment. The results, Figure 2, suggest that the current method of measuring water clarity is a meaningful tool for estimating the depth to which seagrasses can grow in Sarasota Bay. With the shallow bottom slope in Sarasota Bay, dramatic increases in seagrass habitat can be achieved with minimal increases in water clarity. For example, if seagrasses could grow to one more foot of water depth in Little Sarasota Bay (which would require average K values going from 1.26 to 1.07), it is estimated that the amount of seagrass habitat in this area could potentially go from the present 647 acres (Culter, 1992) to a projected total of 1,434 acres (Tomasko *et al.*, 1992).

Figure 2. Depth limits of seagrasses in Sarasota Bay as a function of segment-wide annual average light attenuation coefficients.



However useful it might be to have a relationship between measures of water clarity and the extent of seagrass habitat, such information is of limited use to resource managers. Although it is beneficial to seagrasses and the organisms dependent on them to increase water clarity, the question arises as to how increased water clarity might be brought about. Preliminary data suggest that water clarity in Little Sarasota Bay and Palma Sola Bay is strongly affected by the abundance of dissolved substances ("color"), while water clarity in Roberts Bay seems to be most strongly affected by the abundance of phytoplankton populations, which are themselves limited by the availability of nitrogen (Tomasko *et al.*, 1992; Tomasko, unpubl. data).

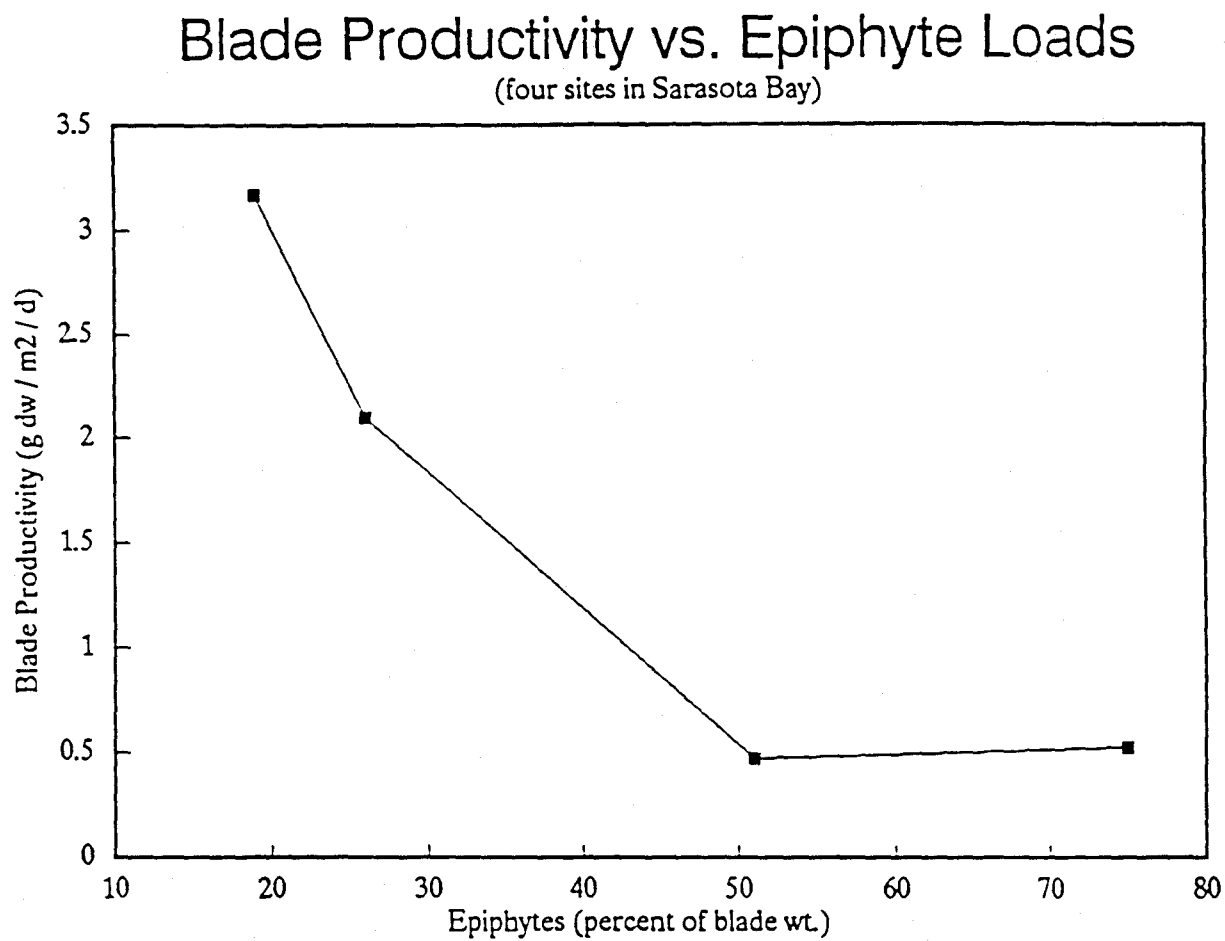
To further aid resource managers in making the appropriate kinds of decisions to increase water clarity, SBNEP is currently funding a project similar to that used in Charlotte Harbor by McPherson and Miller (1987) to determine the relative importance of various light attenuators. With this information, informed decisions can be made regarding the appropriateness of various activities aimed at increasing water clarity.

IMPORTANCE OF EPIPHYTE LOADS

An additional factor to consider when managing water quality for seagrass habitats is the level of epiphyte coverage on the blades of the seagrasses. Previous work in Australia (Silberstein *et al.*, 1986; Neverauskas, 1987), Texas (Dunton, 1990), Denmark (Borum, 1985), and Florida (Tomasko and Lapointe, 1991; Lapointe *et al.*, in press) has illustrated the relationship between increased water column nutrient loads, increased epiphyte abundances, and decreased seagrass productivity and biomass. The primary mechanism reducing seagrass productivity with increased epiphytism is reduced irradiance at the blade level. Shading by epiphytes can reduce irradiance by up to 70 percent (Sand-Jensen, 1977; Silberstein *et al.*, 1986).

Preliminary work in Sarasota Bay (Figure 3) concurs with these other studies, with increased epiphyte abundances being correlated with decreased areal blade productivity. Using the relationship between epiphyte abundance and light reduction determined for *Thalassia testudinum* by Odum (1985), it is estimated that the heaviest epiphyte loads in Sarasota Bay are capable of reducing available light by approximately 32 percent (Tomasko, unpubl. data). As epiphyte abundance increases with increased nutrient loading of the water column

Figure 3. Areal blade productivity of *Thalassia testudinum* versus blade epiphyte loads.



(Dunton, 1990; Tomasko and Lapointe, 1991; Lapointe *et al.*, in press), it is no surprise that the seagrasses with the highest epiphyte levels in Sarasota Bay come from Roberts Bay, which has the highest nutrient loads of any segment of Sarasota Bay (Heyl, 1992).

IMPORTANCE OF RECURRENT HYPOXIA

Despite increased awareness of the importance of seagrasses, most of this concern is centered around the animal usage of these habitats. Therefore, information on the faunal component of seagrass habitats is extremely important. Preliminary studies by SBNEP have recorded recurrent hypoxia (D.O. < 2 ppm) in parts of Sarasota Bay (Figure 4). Despite the importance of D.O. in maintaining healthy animal communities, little information has been collected to accurately measure the degree of hypoxia that can occur in nearshore systems. In Figure 5, which is a rearrangement of the same data in Figure 4, the relation between D.O. and hours after sunrise becomes apparent. As most monitoring programs rely on daytime sampling (water clarity measurements require the sun to be nearly overhead), pre-dawn D.O. sags are not adequately captured.

A SBNEP study by Leverone and Marshall (1992) examined differences in animal communities in seagrass beds of varying status. "Pristine" and "impacted" meadows of both turtle grass (*Thalassia testudinum*) and shoal grass (*Halodule wrightii*) were studied to determine differences in the numbers of fish, shrimp, and crabs between these categories of seagrass meadows (8 sites were used). Elevated abundances of macroalgae and pre-dawn D.O. sags were parameters used to classify a site as impacted. No significant difference could be found between animal communities found in pristine and impacted turtle grass beds. However, impacted shoal grass beds contained far fewer caridean shrimp compared to their pristine counterparts.

Leverone and Marshall (1992) concluded that if water quality degraded to the point that animals were excluded due to recurrent hypoxia, turtle grass would be excluded as well. However, shoal grass could survive in areas of water quality bad enough to kill off particularly vulnerable species, such as caridean shrimp. It appears that turtle grass might be useful as a bio-indicator of good water quality, as it is often replaced by shoal grass in areas of increased nutrient loading (Reyes and Merino, 1991; Tomasko *et al.*, 1992; Lapointe *et al.*, in press).

Figure 4. Dissolved oxygen levels (mg / l) over a seven day period in Little Sarasota Bay.

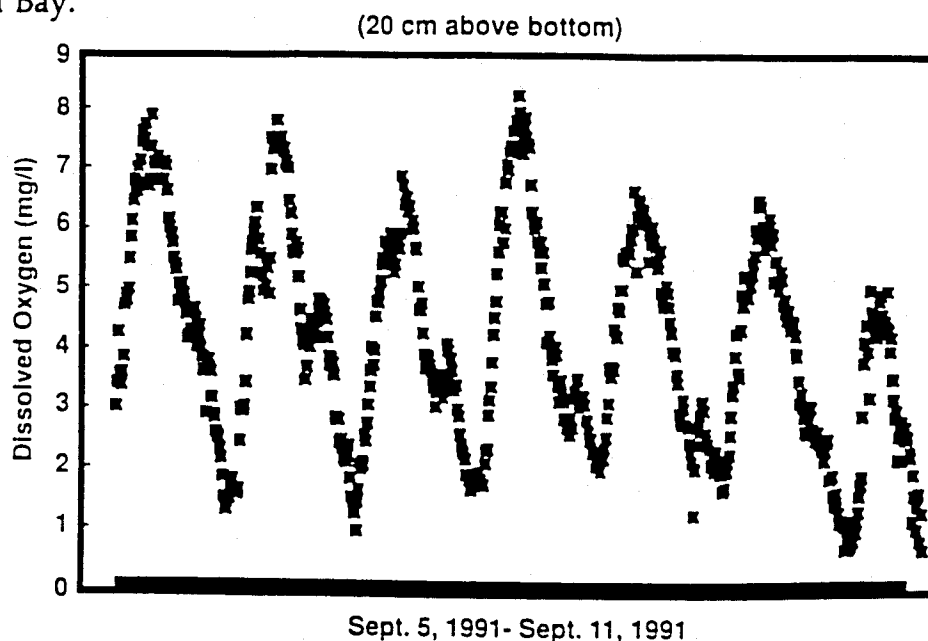
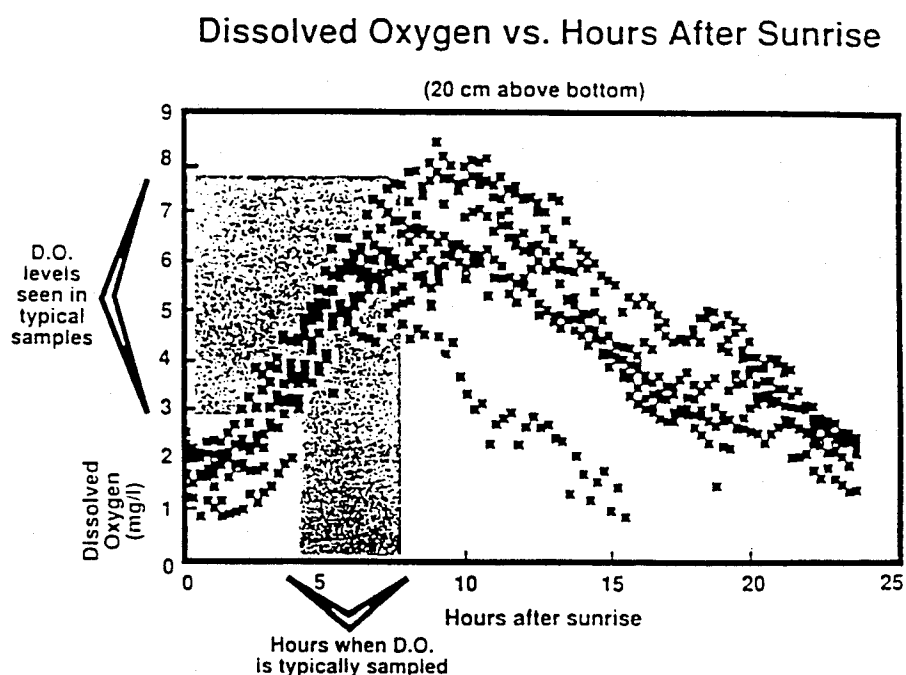


Figure 5. Dissolved oxygen levels (mg / l) versus hours after sunrise. Data are rearranged from Figure 4.



CONCLUSIONS

Through the documentation of the relationship between water clarity and the depth to which seagrasses can grow, it is now possible in Sarasota Bay to predict increases or decreases in seagrass habitat associated with changes in water clarity.

In addition, a study is underway to determine which light attenuators are most important in reducing underwater light, as well as what role epiphyte abundance plays in light attenuation at the blade level. Also, the relationship between nutrient enrichment of the water column, increased epiphyte loads, and decreased seagrass productivity has been documented. This information can be used to depict the benefits expected with implementation of a nutrient load reduction strategy.

Additionally, the relationship between increased abundance of macroalgae, recurrent hypoxia, and a depauperate seagrass fauna has been documented. Several points are then clear as regards the animal usage of seagrass beds: 1) turtle grass seems to be an indicator of good water quality, 2) shoal grass can persist in areas of reduced water quality where specific animals can be excluded, and 3) the limitation of seagrass habitat mapping is that presence does not necessarily equal function.

LITERATURE CITED

- Borum, J. 1985. Development of epiphytic communities on eelgrass (*Zostera marina*) along a nutrient gradient in a Danish estuary. *Mar. Biol.* 87: 211-218.
- Culter, J. 1992. Estuarine bottom assessment. Sarasota Bay National Estuary Program 1992 Framework for Action.
- Dunton, K. 1990. Production ecology of *Ruppia maritima* L. s.l. and *Halodule wrightii* Aschers. in two subtropical estuaries. *J. Exp. Mar. Biol. Ecol.* 143: 147-164.
- Heyl, M. 1992. Point and nonpoint source loading assessment of Sarasota Bay. Sarasota Bay National Estuary Program 1992 Framework for Action.

- Lapointe, B., Tomasko, D., Matzie, W. (in press). Trophic structuring of marine plant communities in the Florida Keys. *Bull. Mar. Sci.*
- Leverone, J., Marshall, M. 1992. Seagrass bed faunal utilization study. Sarasota Bay National Estuary Program.
- Lowrey, S. 1992. Bay water and sediment quality. Sarasota Bay National Estuary Program 1992 Framework for Action.
- McPherson, B., Miller, R. 1987. The vertical attenuation of light in Charlotte Harbor, a shallow, subtropical estuary, south-western Florida. *Est. Coast. Shelf Sci.* 25: 721-737.
- Neverauskas, V. 1987. Accumulation of periphyton biomass on artificial substrates deployed near a sewage sludge outfall in South Australia. *Est. Coast. Shelf Sci.* 25: 509-517.
- Odum, M. 1985. Shading effects of epiphytes on leaves of turtle grass, *Thalassia testudinum* Banks ex Konig. M.A. Thesis. Univ. of Texas at Austin. 79 pp.
- Reyes, E., Merino, M. 1991. Diel dissolved oxygen dynamics and eutrophication in a shallow, well-mixed tropical lagoon (Cancun, Mexico). *Estuaries* 14: 372-381.
- Sand-Jensen, K. 1977. Effect of epiphytes on eelgrass photosynthesis. *Aquat. Bot.* 3: 55-63.
- Sheng, Y.P., Peene, S. 1992. Circulation and its effect on water quality. Sarasota Bay National Estuary Program 1992 Framework for Action.
- Silberstein, K., Chiffings, A., McComb, A. 1986. The loss of seagrass in Cockburn Sound, Western Australia. III. the effect of epiphytes on productivity of *Posidonia australis* Hook. F. *Aquat. Bot.* 24: 355-371.
- Tomasko, D., Lapointe, B. 1991. Productivity and biomass of *Thalassia testudinum* as related to water column nutrient availability and epiphyte levels: field observations and experimental studies. *Mar. Ecol. Prog. Ser.* 75: 9-17.

SAVI Section 2: Seagrass Mapping and Assessment

Tomasko, D., Anderson, M., Clark, P., Culter, J., Dixon, K., Edwards, R., Estevez, E., Heyl, M., Lowrey, S., Sheng, Y.P., Stevely, J. 1992. Technical synthesis of Sarasota Bay. Sarasota Bay National Estuary Program 1992 Framework for Action.

THE FLORIDA STATE-WIDE DISTRIBUTION AND ABUNDANCE

by

Margaret O. Hall, Ph.D
Florida Department of Environmental Protection
FL Marine Research Institute
100 Eighth Ave, SE
St. Petersburg, FL 33701-5095

Dr. Margaret Hall is an Associate Research Scientist with the Florida Department of Environmental Protection, Florida Marine Research Institute in St. Petersburg. Dr. Hall is an estuarine ecologist, with primary interest in seagrass ecosystems. Her recent and on-going research topics include physical impacts to seagrass beds (e.g. reduced light, prop scars), faunal community structure in natural versus restored seagrass systems, influence of drift algae on seagrass fauna, and structural and functional differences in seagrass communities with respect to hydrodynamic energy regime. She is also involved in a study to investigate the genetic and clonal structure of *Spartina alterniflora* populations in Florida.

SEAGRASS MAPPING

The Florida Marine Research Institute (FMRI) currently has a state-wide database for seagrass distribution and abundance. However, the data for some areas are better than for other areas because the quality of aerial photography varies between locations, and much of the information is dated. For some parts of Florida, the most recent data are from the late 1970s or early 1980s. One of the main goals of the Marine Resources GIS program is to continually update this state-wide seagrass database as new aerial photography becomes available. For example, the seagrass maps being generated for the Indian River Lagoon, Tampa Bay, and Sarasota Bay by SWIM and NEP will be used to update the FMRI state-wide database. All seagrass mapping data are in ARC/INFO.

FMRI is also involved in several other projects where seagrass maps are being updated. The first is a cooperative effort between NOAA and FMRI. The goal of this project is to map benthic resources from the Florida Keys to the Dry Tortugas for the Florida Keys National Marine Sanctuary. Not only seagrasses, but also corals, hard bottom areas, and patch reefs will be mapped. These data will

a nautical chart (1:40,000), or preferably aerial photography and a nautical chart to determine location of the prop-scars. It is much easier to pinpoint location when both aerials and nautical charts are available.

Seagrass areas damaged by prop-scars will be outlined on the charts and aerials with polygons by the observer. Polygons will vary in size depending on how large the damaged areas are, but polygons will not be any smaller than one acre. The level of damage in the polygons will also be ranked. Currently, there are three categories of damage: low, moderate, and severe. Prop-scar damage was ranked subjectively for Tampa Bay, but the investigators are now developing a sampling grid which will enable them to quantitatively determine the level of damage. Observers are also videotaping the grass beds to document the various levels of damage. The information on the charts will be digitized into the FMRI's GIS database. There will also be some ground-truthing to verify data collected during overflights. The prop-scar assessment project was begun this June, so the techniques are still being refined. Only Tampa Bay has been completed at this time, but when the study is concluded the report will include state-wide acreage of prop-scar damage and a summary by county.

The mapping project described above will provide general information concerning prop-scar damage to an area, but sometimes more accurate information concerning the level of prop-scar damage in a particular seagrass bed might be required. For example, precise estimates of prop-scar damage may be necessary to get permission to close an area to motorized vessels, or perhaps to monitor recovery from prop-scar damage in a seagrass bed. FMRI recently conducted a study at Weedon Island State Preserve in Tampa Bay to identify the precision of prop-scar damage assessment using aerial photography flown at three different scales including 1:24,000, 1:12,000 and 1:2,400. Precision was assessed by evaluating the amount of information gained or lost between scales. Seven hundred individual prop-scars were delineated using color aerial photography flown at 1:2,400, 104 scars were visible at 1:12,000, and only 5 scars could be detected at 1:24,000. The 1:24,000 aerials were hazy, however, by using aerials from another source flown at the same scale, 78 scars could be identified. This was almost as many prop-scars as were visible at 1:12,000. The investigators concluded that it was possible to assess prop-scar damage at all scales, but information was much more accurate at a larger scale. However, both time and money increase with scale. For example, it takes 20 times as long to interpret the 1:2,400 aerials as the 1:24,000 aerials. Comparatively, there are 46 photos for the 1:2,400 scale and only one photo for 1:24,000. Thus, the scale an investigator

Proceedings and Conclusions—Part I

decides to use to assess damage ultimately depends on the goals and money available for the project.

Dr. Rob
Science
Departm
biology
1975. I
research
currentl
reports,

I wou
Veget
Chesa
drama
unlike

An ar
under
the cu
comm
mana
Bay.
Mana
surro
monit
becau

PERMANENT, FIXED TRANSECTS

by

Robert W. Virnstein, Ph.D.
St. Johns River Water Management District
P.O. Box 1429
Palatka, FL 32178

Permanent, fixed transects can be used as a tool for identifying change at a smaller scale of space and time than Lagoon-wide maps. Lagoon-wide mapping done every 2-3 years is most useful for detecting large-scale changes over time periods of at least a year.

For detecting small-scale changes, permanent, fixed transects might be the best tool. Fixed transects eliminate spatial variability, which could mask temporal changes when sampling in patchy seagrass beds. However, by increasing temporal precision, spatial resolution is lost. Change can thus be detected only along a particular transect or at a particular spot along the transect. But many transects within an area would increase the power of inference within that area.

Permanent transects can offer a precise reference of what is present in a given location at a particular time. For example, suppose a storm or major rain event occurs, and we wish to detect whether this event impacted the seagrasses. We cannot depend on Lagoon-wide maps to determine small changes, such as loss of patches less than one acre, or shifts in the edge of a seagrass bed by a few tens of meters or changes occurring within a few months. As a result, we have to wait at least another year to determine whether changes occurred, and thus are unable to attribute changes in seagrass to particular events. If permanent transects had been sampled previously in the area and an event occurs, we can return to the same transect and determine if any changes have occurred since the previous sampling. We cannot determine any change in a system without taking into account natural variability and repeatedly sampling the same location.

SWIM is starting this transect work in 1993, initially in the Sebastian area. Plans are to have at least 50 permanent transects throughout the Lagoon that would be sampled at least twice a year – summer and winter.

Parameters visually estimated or measured along the transects as part of the Lagoon-wide mapping effort include:

- * seagrass percent cover
- * species composition and percent cover of each species
- * canopy height
- * algae percent cover
- * epiphyte abundance (scale of 0-5)

The permanent transect monitoring includes shoot counts. Estimates or measurements are made every 10 m.

A large part of the initial effort toward implementing these permanent transects is developing the methodology to sample (1) repeatedly along the same line and at the same spots along the line, (2) non-destructively, and (3) rapidly. Permanent status is achieved by marking the transects with a series of stakes driven into the sediment. A measured tape tautly strung between the stakes exactly marks the line. Sampling occurs every 10 m along the line.

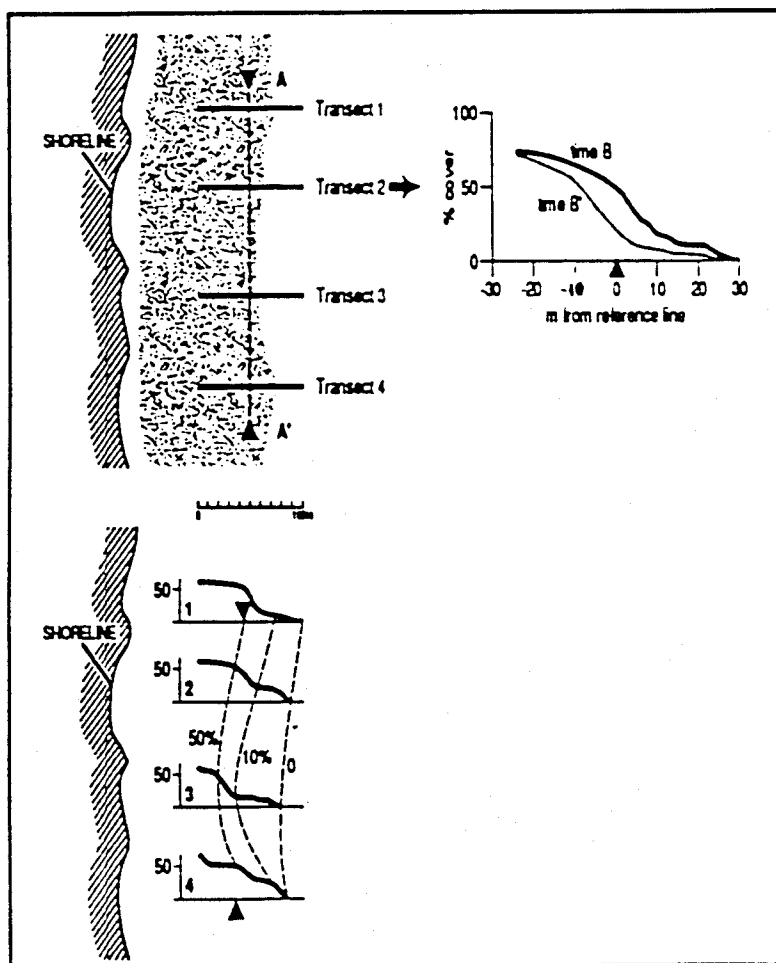
Developing non-destructive rapid techniques has been difficult and is ongoing. Two general approaches are being pursued. One effort is to develop visual estimates of seagrass and epiphyte biomass. To be meaningful, these visual estimates must correspond to quantitative estimates. We are in the initial stages of developing these visual estimates. Such technique development requires taking many samples and measurements over a range of densities to measure the precision and accuracy of the corresponding visual estimates. A photo-reference guide is being developed for matching with field densities.

The second effort is directed toward developing techniques using underwater video. The potential of this method is to serve as the device for collecting the data, the information can be recorded rapidly and inexpensively on tape, and it provides a permanent archival record of the distribution and condition of the seagrass along the transect line.

USES OF PERMANENT, FIXED TRANSECTS

There are two ways to use these transects. A single transect could be used as a unit of measure. We could look at that same transect over and over to gain detail about a particular bed. We could also have several transects across a single bed as in Figure 1. These transects could be sampled at time B and again at time B'.

Figure 1. Illustrating the use of several transects to define the outer edge of a grassbed.



Proceedings and Conclusions—Part I

These several transects could be used to define the contour, e.g. of 10% cover or 50% cover to define changes in the "edge" of the grassbed (Figure 1). Thus, we could use either a single transect or several transects to describe an area.

In summary, permanent, fixed transects can:

1. Aid interpretation of:

- * aerial photos
- * seagrass maps
- * impacts of changes in water quality

2. Detect site-specific changes over time, by:

- * detecting declining areas
- * documenting improvements
- * detecting changes other than simple abundance or presence/absence
 - * growth
 - * species composition
 - * abundance – percent cover, shoot density
 - * canopy height
 - * condition

PHYSIOLOGICAL MEASURES OF SEAGRASS HEALTH

by

David A. Tomasko, Ph.D.
Sarasota Bay National Estuary Program
1550 Ken Thompson Highway
Sarasota, FL 34236

OVERVIEW

The health of seagrasses within a given area, at a given time, can be assessed to some degree by determining the quantities and/or activities of various physiological indicators. Physiological indicators include proximate constituents, pigment levels, indicator enzymes, and stress proteins. In combination with appropriately designed field and/or laboratory studies, information on physiological markers can be very informative and insightful.

PROXIMATE CONSTITUENTS

The relative quantities of chemical constituents of seagrasses can vary with season, water depth, and geographic location (Dawes *et al.*, 1979; Dawes and Lawrence, 1980; Tomasko and Dawes, 1990). In addition, cropping or blade loss can invoke changes in constituent levels (Dawes *et al.*, 1979; Dawes and Lawrence, 1979; Tomasko and Dawes, 1989a, b).

Protein content can vary as a function of sediment nutrient supply, in a manner similar to that of fluctuations in tissue N and tissue P contents mirroring availability of sediment nutrients (Short, 1987; Fourqurean *et al.*, 1992a, b).

Levels of soluble carbohydrates in rhizomes and short shoots track seasonal changes in carbon allocation strategies (Dawes *et al.*, 1979; Tomasko and Dawes, 1990), with levels increasing in times of energy storage, and decreasing when reserves are drawn upon for basic metabolism or rapid growth. Additionally, soluble carbohydrate

Proceedings and Conclusions—Part I

stores are drawn upon when stresses such as light reduction and/or leaf removal are imposed (Dawes *et al.*, 1979; Tomasko and Dawes, 1989a, b; Hall, pers. commun.).

In contrast, levels of lipid, ash, and insoluble carbohydrate vary little as a function of location, season, or other factors. As such, they would not appear to be profitable subjects for investigation.

PIGMENTS

The relationship between decreased light availability and correlative changes in pigment levels and pigment organization is illustrated in Table 1. Of the 12 scenarios examined for reducing available light to seagrasses, 10 found that $P_{\max}$ (the photosynthetic rate at saturating irradiance) declined with decreasing light levels. This relationship persisted whether decreased light was due to increased water depth, seasonal shifts in water clarity, or actual shading of intact plants.

Alpha, the initial slope of the photosynthesis-irradiance (PI) curve, seemed to vary independently of light availability, as did the ratio between chlorophyll *a* and chlorophyll *b*. However, total chlorophyll levels increased with decreased light availability in 8 of the 10 scenarios that examined this relationship.

Consequently, it appears that pigment levels and $P_{\max}$ values might be useful indicators of spatial and/or seasonal differences in light availability. Whether the reason for decreased irradiance is increased water depth, increased distance from a flushing inlet or some other factor, reduced irradiance should manifest itself in lower $P_{\max}$ values and higher blade chlorophyll levels.

INDICATOR ENZYMES

The major indicator enzymes to receive much attention from seagrass researchers are Alcohol Dehydrogenase (ADH), Nitrate Reductase (NR), and various carbon metabolizing enzymes. As light levels decrease, photosynthesis would decrease. Persistent low photosynthetic rates might induce localized rhizosphere anoxia, particularly in organic-rich sediments. As ADH allows for continued metabolism in the absence of available oxygen, ADH has been shown to be a good indicator of root anoxia (Smith *et al.*, 1984). Consequently, ADH activity might be a good stress indicator in areas where reduced light is thought to be co-occurring with degrading

SAVI Section 3: Site-Specific Seagrass Monitoring

Table 1. Responses of the photosynthetic processes of various species of submerged aquatic macrophytes to decreased irradiance. "NA" = no available information. "0" = no change with decreased light. "+" = increase with decreased light. "-" = decrease with decreased light.

<u>Study</u>	<u>Reason for Decreased PAR</u>	<u>Pmax</u>	<u>Alpha</u>	<u>Total Chl</u>	<u>Chl a:b</u>
1	Depth	NA	NA	+	-
2	Depth	-	NA	+	0
2	Shade	0	NA	+	0
3	Season	-	0	+	+
4	Season	-	-	NA	NA
4	Depth	-	-	NA	NA
5	Season	-	0	+	+
5	Depth	-	0	0	0
6	Depth	-	NA	+	-
7	Depth	-	NA	+	-
8	Depth	-	0	0	NA
9	Shade	-	+	+	-

- 1) Wiginton & McMillan, 1979
- 2) Dennison & Alberte, 1985
- 3) Drew, 1978
- 4) Libes, 1986
- 5) Pirc, 1986

- 6) Dennison & Alberte, 1986
- 7) Dennison & Alberte, 1982
- 8) Dawes & Tomasko, 1988
- 9) Goldsborough & Kemp, 1988

water clarity. The activities of enzymes such as sucrose phosphate synthase and sucrose synthase are also good indicators of the rates of source-to-sink carbon transport and carbon transformations (Zimmerman and Alberte, 1990).

In an intriguing series of experiments, both Maier and Pregnall (1990) and Burkholder *et al.* (1992) found evidence that Nitrate Reductase (NR) was an inducible enzyme in seagrass leaves, with increased activities in areas of elevated nitrate loading. As nutrient enrichment of nearshore waters is a major cause of seagrass declines worldwide, NR might be a useful tool for locating areas where significant nitrate enrichment of nearshore waters is occurring. Burkholder *et al.* (1992) argue that nitrate enrichment of nearshore waters in North Carolina is of sufficient magnitude to cause direct mortality of seagrasses through a process that accelerates carbon withdrawal from storage tissues.

STRESS PROTEINS

In agricultural crops such as rice and wheat, stress proteins have received much attention as markers of various physiological insults. Stress proteins are evolutionarily very conservative, and they function to minimize the effects of various agents on degradation of cellular proteins. Factors such as recurrent anoxia, pesticides and heavy metals can induce the formation of stress proteins. Despite the great potential for using stress proteins as molecular markers of degraded habitat quality, no work has been published on the subject of stress proteins in seagrasses.

LITERATURE CITED

- Burkholder, J., Mason, K., Glasgow, H. 1992. Water-column nitrate enrichment promotes decline of eelgrass *Zostera marina*: evidence from seasonal mesocosm experiments. Mar. Ecol. Prog. Ser. 81: 163-178.
- Dawes, C., Lawrence, J. 1979. Effects of blade removal on the proximate composition of the rhizome of the seagrass *Thalassia testudinum* Banks ex Konig. Aquat. Bot. 7: 255-266.

- Dawes, C., Lawrence, J. 1980. Seasonal changes in the proximate composition of the seagrasses *Thalassia testudinum*, *Halodule wrightii*, and *Syringodium filiforme*. *Aquat. Bot.* 8: 371-380.
- Dawes, C., Tomasko, D. 1988. Depth distribution of *Thalassia testudinum* in two meadows on the west coast of Florida; a difference in effect of light availability. *P.S.Z.N.I. Mar. Ecol.* 9: 123-130.
- Dawes, C., Bird, K., Durako, M., Goddard, R., Hoffman, W., McIntosh, R. 1979. Chemical fluctuations due to seasonal and cropping effects on an algal-seagrass community. *Aquat. Bot.* 6: 79-86.
- Dennison, W., Alberte, R. 1982. Photosynthetic responses of *Zostera marina* L. (Eelgrass) to in situ manipulations of light intensity. *Oecologia* 55: 137-144.
- Dennison, W., Alberte, R. 1985. Role of daily light period in the depth distribution of *Zostera marina* (eelgrass). *Mar. Ecol. Prog. Ser.* 25: 51-61.
- Dennison, W., Alberte, R. 1986. Photoadaptation and growth of *Zostera marina* L. (Eelgrass) transplants along a depth gradient. *J. Exp. Mar. Biol. Ecol.* 98: 265-282.
- Drew, E. 1978. Factors effecting photosynthesis and its seasonal variation in the seagrass *Cymodocea nodosa* (Ucria) Archers., and *Posidonia oceanica* L. DeLile in the Mediterranean. *J. Exp. Mar. Biol. Ecol.* 31: 173-194.
- Fourqurean, J., Zieman, J., Powell, G. 1992a. Phosphorus limitation of primary production in Florida Bay: evidence from C:N:P ratios of the dominant seagrass *Thalassia testudinum*. *Limnol. Oceanogr.* 37: 162-171.
- Fourqurean, J., Zieman, J., Powell, G. 1992b. Relationships between porewater nutrients and seagrasses in a subtropical carbonate environment. *Mar. Biol.* 114: 57-65.
- Goldsborough, W., Kemp, M. 1988. Light responses of a submersed macrophyte: implications for survival in turbid tidal waters. *Ecology* 69: 1775-1786.
- Libes, M. 1986. Productivity-irradiance relationship of *Posidonia oceanica* and its epiphytes. *Aquat. Bot.* 26: 285-306.

Proceedings and Conclusions—Part I

- Maier, C., Pregnall, M. 1990. Increased macrophyte nitrate reductase activity as a consequence of groundwater input of nitrate through sandy beaches. *Mar. Biol.* 107: 263-271.
- Pirc, H. 1986. Seasonal aspects of photosynthesis in *Posidonia oceanica*: influence of depth, temperature and light intensity. *Aquat. Bot.* 26: 203-212.
- Short, F. 1987. Effects of sediment nutrients on seagrasses: literature review and mesocosm experiment. *Aquat. Bot.* 27: 41-57.
- Smith, R., Pregnall, M., Alberte, R. 1988. Effects of anaerobiosis on root metabolism of the seagrass *Zostera marina* L. (eelgrass). *Mar. Biol.* 98: 131-141.
- Tomasko, D., Dawes, C. 1989a. Effects of partial defoliation on remaining intact leaves in the seagrass *Thalassia testudinum* Banks ex Konig. *Bot. Mar.* 32: 235-240.
- Tomasko, D., Dawes, C. 1989b. Evidence for physiological integration between shaded and unshaded short shoots of *Thalassia testudinum*. *Mar. Ecol. Prog. Ser.* 54: 299-305.
- Tomasko, D., Dawes, C. 1990. Influences of season and water depth on the clonal biology of the seagrass *Thalassia testudinum*. *Mar. Biol.* 105: 345-351.
- Wiginton, J., McMillan, C. 1979. Chlorophyll composition under controlled light conditions as related to the distribution of seagrasses in Texas and the U.S. Virgin Islands. *Aquat. Bot.* 6: 171-184.
- Zimmerman, R., Smith, R., Alberte, R. 1989. Thermal acclimation and whole plant carbon balance in *Zostera marina* L. (eelgrass). *J. Exp. Mar. Biol. Ecol.* 130: 93-109.
- Zimmerman, R., Reguzzoni, J., Wyllie-Echevarria, S., Josselyn, M., Alberte, R. 1991. Assessment of environmental suitability for growth of *Zostera marina* L. (eelgrass) in San Francisco Bay. *Aquat. Bot.* 39: 353-366.