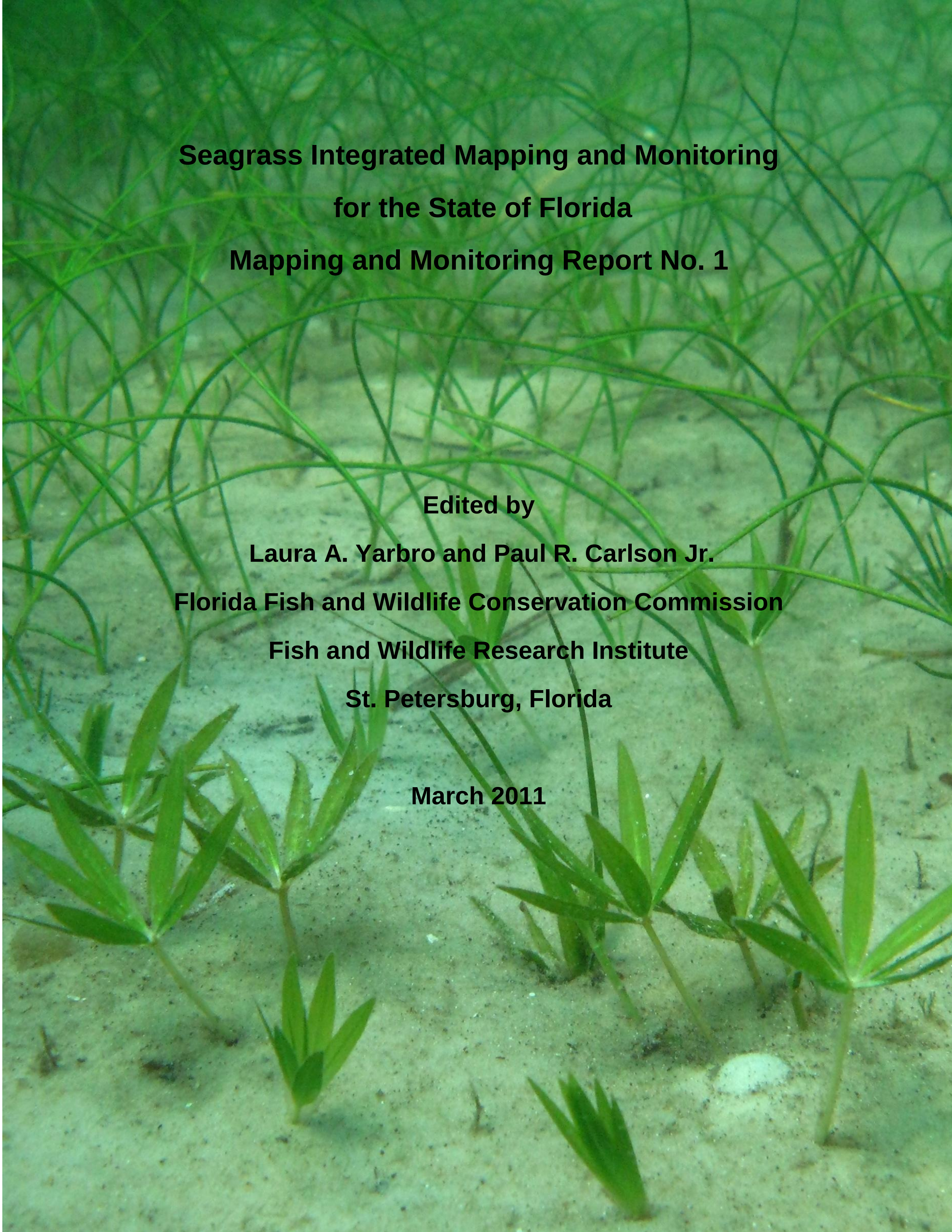

Seagrass Integrated Mapping and Monitoring for the State of Florida

Mapping and Monitoring Report No. 1

Edited by

Laura A. Yarbro and Paul R. Carlson Jr.

Florida Fish and Wildlife Conservation Commission

Fish and Wildlife Research Institute

St. Petersburg, Florida

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Chapter Reports, continued

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Authors, Contributors, and Team Members

Many authors, contributors, collaborators, and Seagrass Integrated Mapping and Monitoring (SIMM) team members made this project possible. SIMM team members from the Florida Fish and Wildlife Research Institute are Paul Carlson, Rene Baumstark, Christi Santi, Dave Palandro, Kathleen O'Keife, Harry Norris, Paul Julian, Makenzie Marsh, and Laura Yarbro. Authors and contributors to each chapter patiently responded to repeated requests for interviews, data, information, figures, text, and editing during the creation of this report. The list of authors and contributors below is arranged in an order similar to that of the chapters, i.e., geographically from the Florida Panhandle to the northern Indian River on Florida's east coast. A number of authors contributed to more than one chapter. In addition to the chapter authors and contributors listed below, Brad Peterson (State University of New York, Long Island campus), Doug Scheidt (Kennedy Space Center), Seth Blitch (Apalachicola National Estuarine Research Reserve), Greg Blanchard (Manatee County), Ben Russell (Northwest Florida Department of Environmental Protection), Cindy Meyer (Pinellas County), Darlene Saindon (University of Florida), Lisa Schwenning and Judy Ashton (Florida Department of Environmental Protection), and Chris Gudeman (formerly of the Fish and Wildlife Commission Division of Habitat Species and Conservation) provided extensive information during telephone interviews in the early phases of this project. Affiliations and contact information for authors and contributors can be found at the end of each chapter.

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This report culminates the successful collaboration of hundreds of people. Some provided data or wrote chapters for this report. Amber Whittle carefully edited the final draft, while Bland Crowder of FWRI and the Community Relations Office of FWC copy edited and produced the final document. Others provided and managed grant funds. Still others laid the groundwork for the Seagrass Integrated Mapping and Monitoring program and similar efforts to collate, summarize, and share data on seagrasses in Florida's coastal waters. Efforts in Tampa Bay and the Indian River Lagoon were especially critical in demonstrating the need for regular assessment of seagrass cover, the link between water quality and the abundance of seagrass, and the effectiveness of seagrass mapping and monitoring in assessing improvements in water quality. Hundreds of scientists and managers participated in those efforts over decades. Regrettably, only the current project participants are listed in individual chapters, but they stand, as does the SIMM team, on the shoulders of those who came before.

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Abstract

This report is the first comprehensive effort of the Seagrass Integrated Mapping and Monitoring (SIMM) program to provide both mapping and monitoring information for seagrasses throughout Florida's coastal waters. We have inventoried mapping and monitoring programs, identified spatial gaps in coverage by these programs, identified emergent metrics of seagrass distribution, abundance, and health, summarized mapping data, and produced this report using contributions of data, graphics, and text from many collaborators. We found that seagrass monitoring programs were collecting data in most of the estuaries and nearshore waters around the state. We have identified 34 active (and 4 inactive) monitoring projects or programs that we hope will be able to collaborate for the monitoring portion of SIMM. Three of the inactive projects are in St. Andrew Bay, the Pensacola Bay region, and the Apalachicola National Estuarine Research Reserve in the Panhandle region. There are planned projects in Choctawhatchee Bay and the Ten Thousand Islands. Along Florida's east coast, seagrasses along the Volusia County coastline are not monitored. A variety of agencies conducts monitoring programs in Florida coastal waters, including the Florida Department of Environmental Protection, the Florida Fish and Wildlife Research Institute, water management districts, counties, cities, universities, colleges, and contractors for military bases.

Monitoring programs measure the presence or absence of seagrasses and document the species composition of seagrass beds. Some include identification and assessment of macroalgae, and most measure seagrass abundance using the Braun-Blanquet scale or percentage cover in replicate quadrats at each site. Sampling methods are basically variations of two types: sampling along transects, often perpendicular to the long axis of seagrass beds, and point sampling, either fixed or varying, random or nonrandom, in design. Most programs conduct field monitoring at least once a year, but the time of year varies between summer and fall. Indicators that can be reported for most seagrass monitoring programs include seagrass (and macroalgal) abundance, species composition and diversity, and depth distribution of seagrass species.

We found that our current statewide set of seagrass maps includes 27 geographic information system datasets based primarily on aerial photography collected from 1992 to 2010. The goal of SIMM is to reduce the mapping cycle time to a minimum of six years for those regions that are not now routinely mapped. The primary indicators derived from mapping projects are seagrass areal coverage and habitat texture (i.e., continuous or patchy). Secondary indicators of seagrass condition and health determined by mapping projects are change analyses of gains and losses in cover and changes in texture determined from analyses of at least two sequential sets of imagery having the same spatial extent. Where successive imagery data sets are available, we have included changes in seagrass acreage.

Based on the most recent mapping data available for each region, we estimate that there are about 2,179,000 acres of seagrass in nearshore Florida waters. Most are located in southern Florida (1,300,000 acres) or in the Big Bend and Springs Coast region (618,000 acres). The

western Panhandle has 39,200 acres of seagrass, and that acreage is in decline. In recent years, seagrass acreage has increased along the west coast of Florida from Pinellas County/Tampa Bay to the Charlotte Harbor region. Seagrass acreage is probably stable in the Florida Keys and Florida Bay and is increasing on the east coast.

Executive Summary

Florida seagrass beds are an extremely valuable natural resource. Approximately 2.2 million acres of seagrass have been mapped in estuarine and nearshore Florida waters (Carlson and Madley 2007), and they provide ecological services worth more than $20 billion a year (Costanza et al. 1997; Orth et al. 2006). Many economically important fish and shellfish species depend on seagrass beds for critical stages of their life history, and seagrasses also play a role in the global carbon cycle, nutrient cycles, sediment stabilization, and the maintenance of coastal biodiversity. Seagrasses provide food and shelter for endangered mammal and turtle species (Orth et al. 2006; Waycott et al. 2009).

Unfortunately, seagrasses are vulnerable to many direct and indirect human impacts, especially eutrophication and other processes that reduce water clarity. Although in some Florida estuaries, concerted efforts to improve water quality have resulted in increases in seagrass coverage, total seagrass coverage in Florida’s coastal waters is less than it was in the 1950s, and coverage is still declining in some areas. The Seagrass Integrated Mapping and Monitoring (SIMM) program was developed to protect and manage seagrass resources in Florida by providing a collaborative vehicle for seagrass mapping, monitoring, and data sharing. Given the budget problems that many agencies are facing, our efforts are directed at leveraging resources as well as decreasing and sharing costs for seagrass mapping and monitoring.

Elements of the SIMM program include: 1) ensuring that all seagrasses in Florida waters are mapped at least every six years; 2) monitoring seagrasses throughout Florida annually; and 3) publishing a comprehensive report every two years that combines site-intensive monitoring data and trends with statewide estimates of seagrass cover and maps showing seagrass gains and losses. This publication is our first such report.

We hope that this report and the SIMM program will inform and support a number of state, federal, and local programs. For example, permitting agencies can now draw on contacts and data available for their area of interest. As we begin to serve data online, stakeholders will be able to download recent mapping and monitoring data on seagrass cover and species composition. Because in many Florida estuaries, seagrass communities represent significant resource management metrics, we hope that SIMM data will also be used by the Florida Department of Environmental Protection (FDEP) and the U.S. Environmental Protection Agency (EPA) to support the Total Maximum Daily Load (TMDL) Program and for the development of numeric nutrient and transparency criteria in Florida estuaries. Reaction to the SIMM concept has been positive; 27 agencies and 39 investigators have drafted chapters or contributed data for this report.

Data collated by the SIMM program have already proved invaluable in the state and federal response to the 2010 Deepwater Horizon oil spill disaster. Because of previous SIMM efforts supported by FDEP, we were able to immediately provide National Oceanic and Atmospheric Agency (NOAA) Natural Resource Damage Assessment (NRDA) staff draft chapters detailing seagrass resources in all Panhandle counties.

Data Collation Methods: The Florida Fish and Wildlife Conservation Commission/Florida Fish and Wildlife Research Institute (FWC/FWRI) are committed to developing, implementing, and maintaining the SIMM program. Our first steps, supported by the FDEP Coastal Zone Management Program, have been the following:

1. An inventory of active mapping and monitoring programs

2. Identification of spatial gaps in mapping and monitoring programs

3. Identification of emergent metrics of seagrass distribution, abundance, and health that can be collated from disparate monitoring programs

4. Production of the first comprehensive mapping and monitoring report using contributions of data, graphics, and text from many collaborators.

We carried out these tasks by:

1. Sifting through active and inactive monitoring program databases

2. Interviewing dozens of scientists, agency employees, consultants, and managers conducting seagrass monitoring programs around the state

3. Reviewing recent and historical seagrass mapping geographic information system (GIS) files and imagery datasets collected across the state.

Current Status of Seagrass Monitoring: We found that seagrass monitoring programs were collecting data in most of the estuaries and nearshore waters in Florida. We have identified 34 active (and 4 inactive) monitoring projects or programs that we hope will be able to collaborate in the monitoring portion of SIMM (see Table ES-1). Three of the inactive projects are in St. Andrew Bay, the Pensacola Bay region, and the Apalachicola National Estuarine Research Reserve (NERR) in the Panhandle region. Another is expected to begin this summer in Choctawhatchee Bay. On Florida's east coast, seagrasses along the Volusia County coastline are not being monitored.

We invited staff from each monitoring program to contribute to a chapter for their area, and for most areas we received excellent summaries, graphics, and data analyses. For a few regions, the editors downloaded monitoring data and produced summaries and graphics. Gaps in monitoring coverage exist in the Panhandle from Perdido Bay to Choctawhatchee Bay, in Waccasassa Bay, the southern Springs Coast, portions of the inshore Ten Thousand Islands, in Volusia County, and for large areas offshore of Florida's Big Bend and the Ten Thousand Islands. Three inactive projects in Pensacola Bay, Santa Rosa Sound, and Apalachicola and Ochlockonee bays could be funded and resumed to fill most of the coverage gap in Panhandle waters. Oil impact sampling is still under way in seagrass beds in the western Panhandle and will probably provide some information where routine monitoring has been lacking. Seagrass monitoring in the Ten Thousand Islands poses a logistical challenge, but we are exploring mapping and monitoring techniques that might work in these remote, sparse seagrass ecosystems in highly turbid waters. A greater challenge exists in monitoring deeper seagrasses offshore in federal waters. However, our overall assessment is that a statewide network of seagrass monitoring programs is feasible and that monitoring results for estuarine and nearshore waters can be collated and reported biennially, if not annually.

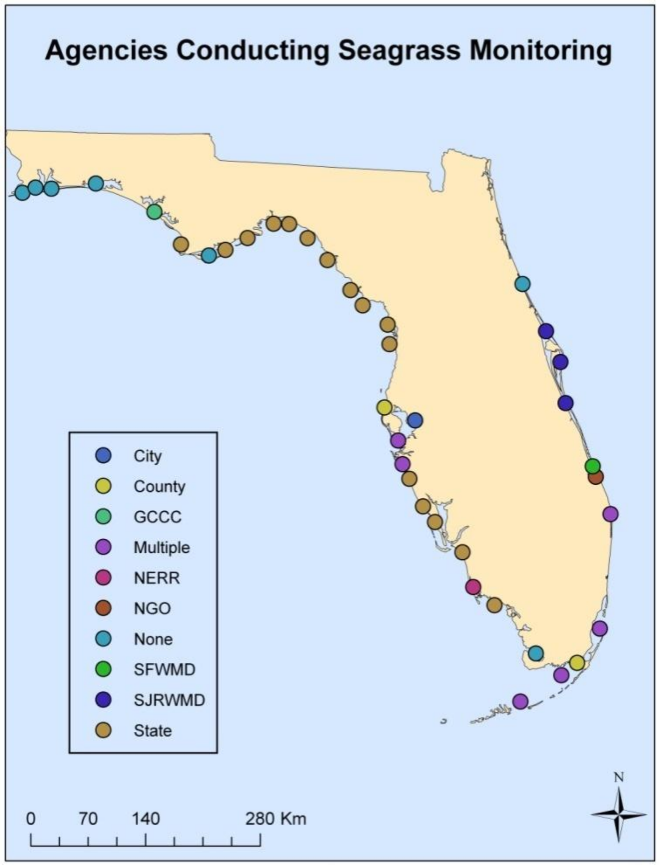


Figure ES-1. Agencies conducting monitoring programs in Florida coastal waters.

A variety of agencies conducts monitoring programs in Florida coastal waters (Table ES-1, Figure ES-1). Of the 38 projects, 19 are carried out by State of Florida staff, primarily from FWC/FWRI and FDEP (Figure ES-1). Five monitoring programs are carried out by county agencies and four by city agencies. Universities or colleges conduct two programs, one in Florida Bay by Florida International University (FIU) and one in St. Andrew Bay by Gulf Coast Community College (GCCC). Seagrasses in coastal areas near Eglin Air Force Base and Cape Canaveral are monitored by federal contractors. The St. Johns River Water Management District (SJRWMD) and the South Florida Water Management District (SFWMD) monitor seagrasses in the Indian River Lagoon and tidal tributaries such as the St. Lucie Estuary. Local governments such as the Loxahatchee River District (Loxahatchee Estuary) and Palm Beach County Environmental Resources Management (Lake Worth Lagoon) also conduct seagrass monitoring. Many projects report to their water management district. A project in Sarasota Bay uses volunteer anglers to report presence or absence of seagrasses.

TABLE ES-1. METRICS USED BY SEAGRASS MONITORING PROGRAMS IN FLORIDA

Estuary or Subregion	Lead Agency	Sampling Frequency	B/B[1] or % Cover	Species Comp[2]	Shoot Counts	Biomass
Perdido Bay	Dauphin Island Sea Laboratory*	Event-driven	Yes	Yes	Yes	Yes
Big Lagoon	Dauphin Island Sea Laboratory*	Event-driven	Yes	Yes	Yes	Yes
Pensacola Bay	Dauphin Island Sea Laboratory*	Event-driven	Yes	Yes	Yes	Yes
Pensacola Bay	Northwest FDEP		Restoration monitoring only			
Santa Rosa Sound	Dauphin Island Sea Laboratory*	Event-driven	Yes	Yes	Yes	Yes
Choctawhatchee Bay	FWRI (2009 only)	Annual	Yes	Yes	No	No
St. Joseph Bay	FWRI	Annual	Yes	Yes	No	No
St. Joseph Bay	FDEP/CAMA	Annual	Yes	Yes	Yes	Yes
St. Andrew Bay	Gulf Coast Community College	Annual	No	Yes	Yes	No
St. Andrew Bay	Northwest FDEP		Restoration monitoring only			
Apalachicola Bay	Apalachicola NERR		Inactive program			
St. Georges Sound	FWC Habitat, Species Conserv.	Annual	Yes	Yes	No	No
Franklin County	FWC Habitat, Species Conserv.	Annual	Yes	Yes	No	No
Ochlockonee Bay	None		None			
St. Marks	FWRI	Annual	Yes	Yes	No	No
St. Marks	FDEP/CAMA	Annual	Yes	Yes	Yes	Yes
Big Bend	FWRI	Annual	Yes	Yes	No	No
Steinhatchee	FDEP/CAMA	Annual	Yes	Yes	Yes	Yes
Cedar Key	FDEP/CAMA	Annually	Yes	Yes	Yes	Yes
Waccasassa Bay	None		None			
St. Martins Marsh	FDEP/CAMA	Annually	Yes	Yes	Yes	Yes
Homosassa	FWRI (2008 only)	Sporadic	Yes	Yes	No	No
Homosassa	FDEP/CAMA	Annually	Yes	Yes	Yes	Yes
Springs Coast	None		None			
Western Pinellas	Pinellas County	Annually	Yes	Yes	Yes	No
Tampa Bay	City of Tampa	Annually	Yes	Yes	Yes	No
Sarasota Bay	Sarasota County	Twice a year	No	Yes	No	No
Sarasota Bay	FDEP/CAMA	Annually	Yes	Yes	No	No
Lemon Bay	Sarasota County	Twice a year	Yes	Yes	No	No
Lemon Bay	FDEP/CAMA	Annually	Yes	Yes	Yes	No
Charlotte Harbor	FDEP/CAMA	Annually	Yes	Yes	Yes	No
Estero Bay	FDEP/CAMA	Twice a year	Yes	Yes	Yes	No
Rookery Bay	Rookery Bay NERR	Inactive	Yes	Yes	Yes	No
Ten Thousand Islands	US Geological Survey/NOAA	Unknown	Yes	Yes	??	??
Florida Bay	FWRI	Twice a year	Yes	Yes	Yes	Yes
Florida Keys NMS	Florida International University	Quarterly	Yes	Yes	No	Some
Biscayne Bay	FWRI, through 2008	Twice a year	Yes	Yes	Yes	Yes
Biscayne Bay	Miami-Dade County	Annually	Yes	Yes	Yes	Yes
Palm Beach	Palm Beach County	Annually	Yes	Yes	Yes	No
South Indian River	South Florida WMD	Bimonthly	Yes	Yes	Yes	No
North Indian River	St. Johns River WMD	Twice a year	Yes	Yes	Yes	No

[1]Braun-Blanquet. [2]composition. *Oil spill–targeted sampling, May 2010

The Tampa Bay, Sarasota Bay, Charlotte Harbor, Florida Bay, Biscayne Bay, and Indian River estuarine systems receive intensive scrutiny from a number of agencies and multiple programs. A large database exists for these systems, often dating back 10 to 20 years. For many systems, monitoring data complement and support frequent, routine seagrass mapping efforts by aiding in interpretation of aerial photographs. Some projects have easily accessible data and websites: FIU's Florida Bay project, the Charlotte Harbor National Estuary Program (CHNEP), and the Tampa Bay Estuary Program (TBEP) are excellent examples.

All monitoring programs measure presence or absence of seagrasses and species composition of seagrass beds. Some include identification and assessment of macroalgae, and most measure seagrass abundance using the Braun-Blanquet scale or percentage cover in replicate quadrats at each site (Table ES-1). Many programs determine shoot counts, and a few collect samples for biomass and morphometric analyses. Some collect optical and nutrient water quality data, and most sample at least once a year, generally during the summer or fall.

Sampling methods are basically variations of two types: transect and point (Figure ES- 2). FDEP Coastal and Marine Assessment (CAMA) programs and programs administered by the Southwest Florida Water Management District (SWFWMD), SJRWMD, and SFWMD use established transects that evaluate the presence or absence of seagrass and the extent of cover by a variation of the Braun-Blanquet procedure. In addition, transects are frequently used in narrow coastal systems where determination of the location of the deep edge of seagrass beds is a high priority. The number and location of transects vary among projects.

Figure ES-2. Seagrass monitoring methods.

Point sampling, either fixed or varying, random or nonrandom, is commonly used in larger systems like Florida Bay, Biscayne Bay, and the Big Bend region. Some coastal regions are monitored by the use of both transect and point sampling (Florida Bay, Biscayne Bay, Tampa Bay, Lake Worth Lagoon, Southern Indian River Lagoon). Many programs are beginning to use probabilistic point sampling.

Most programs conduct field monitoring at least once a year, but the time of year varies between summer and fall. Some programs conduct field monitoring twice a year, in fall and spring or in winter and midsummer. A few programs collect data bimonthly or monthly.

We found that the following indicators can be reported for most seagrass monitoring programs:

1. Seagrass (and macroalgal) abundance

2. Seagrass (and macroalgal) species composition and diversity

3. Depth distribution of seagrass species.

These three indicators can identify changes in seagrass ecosystems due to natural and anthropogenic stressors. For example, the combined impacts of the 2004 and 2005 hurricanes and heavy runoff in winter 2005 resulted in significant losses in seagrass cover, as well as in thinning and changes in species composition in surviving seagrass beds in portions of the Big Bend (Carlson et al. 2010). Although other indicators, such as tissue chemical composition (nitrogen, phosphorus, carbohydrate content, and stable nitrogen isotope ratios) and reproductive effort can be useful, seagrass abundance, species composition, and depth distribution represent the most accessible, cost-effective, and comparable indicators for today's monitoring programs. Possibly more important than the indicators themselves is the comparability of data from year to year and between projects of differing designs, i.e., fixed point and transects versus spatially distributed random sampling points.

Information available from monitoring programs varies across Florida. Each chapter in this report includes a monitoring assessment and data summary, but the intensity and frequency of monitoring, the number of agencies conducting monitoring in an estuary or subregion, and the availability of data and data analysis differ with area. In some chapters monitoring data from two or more agencies may be presented separately and in different ways. Where data are available, we present the most recent assessment of the frequency of occurrence by seagrass species for each estuary.

We combined estuary- or region-specific data on seagrass species from monitoring projects and reported seagrass species composition from telephone interviews to summarize the most common seagrass species found in each estuary or region of coastal Florida (Table ES-2).

Of the seven seagrass species that occur in Florida waters, only widgeon grass (RM; *Ruppia maritima*) was never observed as the most abundant species within a region or estuary. Three species were most abundant in only a few locations: Johnson's seagrass (HJ; *Halophila johnsonii*) in central and southern Lake Worth Lagoon; star grass (HE; *H. engelmannii*) at some locations in Rookery Bay (but also common in other coastal areas along Florida's west coast); and paddle grass (HD: *H. decipiens*) in Naples Bay, Lake Worth Lagoon (along with Johnson's seagrass), and the southern Indian River Lagoon. Paddle grass was observed at other locations in Rookery Bay, in the Florida Keys National Marine Sanctuary, and near the St. Lucie Inlet in the southern Indian River Lagoon. Shoal grass (HW; *Halodule wrightii*) and turtle grass (TT;

Thalassia testudinum) were the most abundant seagrass species at 45% of all the areas surveyed, but only in a few locations did they co-occur in similar abundance. Shoal grass was more frequently most abundant in the Panhandle, along the west coast of Florida from western Pinellas County through Rookery Bay, and along the east coast from the Lake Worth Lagoon through the northern Indian River Lagoon. Turtle grass was most abundant at many locations throughout Florida coastal waters but especially in southern Florida and the Big Bend region. Manatee grass (SF; *Syringodium filiforme*) was most abundant at about 25% of locations in coastal waters and was most often found in the Big Bend region, where it often occurred with turtle grass. Manatee grass was also most abundant along the Gulf side of the Upper Florida Keys and in northern Biscayne Bay, and it occurred with shoal grass at several locations in the Indian River Lagoon.

TABLE ES-2. MOST ABUNDANT SEAGRASS SPECIES FOUND IN FLORIDA ESTUARIES. (HW = *HALODULE WRIGHTII*; TT = *THALASSIA TESTUDINUM;* SF = *SYRINGODIUM FILIFORME*; RM = *RUPPIA MARITIMA*; HE = *HALOPHILA ENGELMANNII*; HD = *HALOPHILA DECIPIENS*; HJ = *HALOPHILA JOHNSONII)*

	Most Abundant Species				Most Abundant Species		
Estuary	**First**	**Second**	**Third**	**Estuary**	**First**	**Second**	**Third**
Perdido Bay	HW			**Sarasota and Lemon Bays**			
Pensacola Bay				Sarasota Bay/Roberts Bay	TT	HW, SF	
Main	none			Little Sarasota/ Blackburn	HW	SF	
Escambia Bay	brackish			Lemon Bay	HW, TT	SF	
East Bay	brackish			**Charlotte Harbor Region**	HW	TT, SF	
Big Lagoon	HW	TT		**Estero Bay**	HW, TT		
Santa Rosa Sound				**Rookery Bay**			
Fort Pickens	HW	TT, SF		Cape Romano	TT, HW, HE	SF, HD	
Gulf Breeze	TT	HW		Johnson Bay	TT, HW, HE	SF, HD	
East	TT			Cocohatchee River	HW		
Choctawhatchee Bay	HW			Naples Bay	HW, HD, HE		
St. Andrew Bay	TT	HW	SF	**Ten Thousand Islands**	TT, SF	HW, HE	
St. Joseph Bay	TT	HW		**Florida Keys NMS**			
Franklin County				Atlantic Upper Keys	TT	SF	
Alligator Harbor	HW	TT		Atlantic Lower Keys	TT	SF	HW
Dog Island	HW	SF	TT	Gulf Upper Keys	SF	TT	HW, HD
St. George Sound	HW			Gulf Lower Keys	TT	SF	
Carabelle River	TT, SF, HW			Tortugas/Marquesas	TT	SF	HW, HD
Lanark River	SF	HW	TT	**Florida Bay**			
Turkey Point	SF	TT	HW	Northeast	TT	HW	
Northern Big Bend				East Central	TT	HW	
Steinhatchee North	TT, SF			North Central	TT	HW	SF
Keaton Beach	SF	TT		South	TT		
Fenholloway	SF	HW, HE	TT	West	TT	SF, HW	
Econfina	SF	TT	HW, HE	**Biscayne Bay**			
Aucilla	TT,SF	HW,HE		Card Sound	TT	HW	
St. Marks	SF	TT		South Biscayne Bay	TT	HW	
				North Biscayne Bay	SF	TT, HW	

Table ES-2. MOST ABUNDANT SEAGRASS SPECIES FOUND IN FLORIDA ESTUARIES. (HW = *HALODULE WRIGHTII*; TT = *THALASSIA TESTUDINUM;* SF = *SYRINGODIUM FILIFORME*; RM = *RUPPIA MARITIMA*; HE = *HALOPHILA ENGELMANNII*; HD = *HALOPHILA DECIPIENS*; HJ = *HALOPHILA JOHNSONII)* (CONTINUED)

	Most Abundant Species				Most Abundant Species		
Estuary	**First**	**Second**	**Third**	**Estuary**	**First**	**Second**	**Third**
Southern Big Bend				**Lake Worth Lagoon**			
Suwannee	TT, SF			North	SF, TT, HW		
Horseshoe East	TT	SF, HW		Central	HJ, HD, HW		
Horseshoe West	TT, SF	HW		South	HJ, HD, HW		
Steinhatchee South	TT	SF	HW	**South Indian River Lagoon**			
Suwannee Sound	SF			IR14-15	HW		
Cedar Keys	TT	SF, HW		IR16-20	HW		
Waccasassa Bay	Unknown			IR21	HW		
Springs Coast				IR22	HW, SF		
St. Martins Keys	TT	SF	HW	IR23	HW, SF		
West Pinellas County				IR24	HD	HW	
St. Joseph Sound	TT	HW		IR25	HD	HW	
Clearwater Harbor	HW	TT		**North Indian River Lagoon**			
Boca Ciega Bay	HW	TT		Mosquito Lagoon	HW	RM, SF	
Tampa Bay				Banana River	HW	RM	
Hillsborough Bay	HW			Melbourne	HW		
Old Tampa Bay	HW			Sebastian Inlet	HW	SF	
Apollo Beach	HW			Vero Beach	HW		
Mid-Bay	TT	SF		Fort Pierce	HW, SF	RM, HJ	
Lower Bay	TT	SF		St. Lucie Inlet	HW, SF	HJ, HD	

Seagrass Mapping Efforts: We found that our current statewide set of seagrass maps included 27 GIS datasets (Figure ES-3; Table ES-3) based primarily on aerial photography collected from 1987 to 2008—21 years! For other estuaries, however (e.g., Indian River Lagoon, Tampa Bay, Sarasota Bay, and Charlotte Harbor) imagery is collected every two years. SIMM's goal is to reduce the mapping cycle time to 10 years at most and ideally to 6 years for coastal areas that do not have a regular mapping program. Imagery datasets collected in the 1980s, 1990s, and early 2000s were acquired with film cameras. More recent imagery has been acquired with digital cameras and so may be georectified and photointerpreted digitally. However, change analyses using older film imagery might require that those datasets be scanned and georeferenced. Interviewees have expressed considerable interest in historical imagery, so we are beginning to collect and scan older aerial photos and we will serve them on the Web.

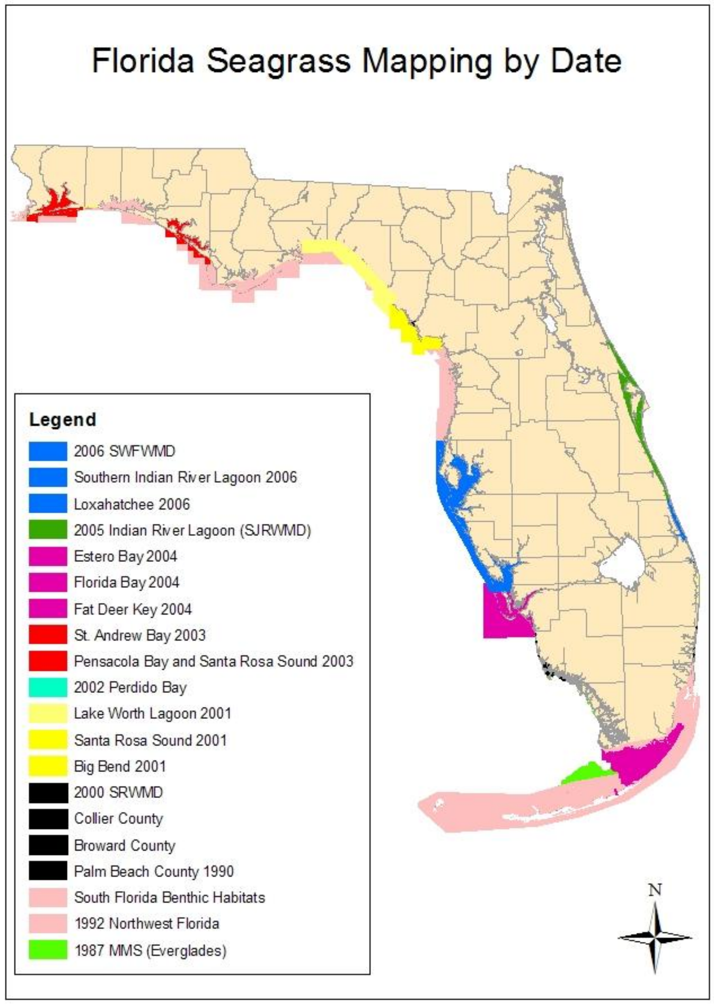


Figure ES-3. Status of seagrass mapping efforts.

The primary indicators derived from mapping projects are seagrass areal coverage (see Table ES-4, below) and habitat texture (whether continuous or patchy; discussed in many of the chapters). However, with improving bathymetry data around the state, broader-scale information on depth distribution of seagrasses might also be obtained from mapping projects. Secondary indicators of seagrass condition and health determined by mapping projects are change analyses of gains and losses in area and changes in texture determined from analyses of at least two sequential sets of imagery. These analyses are useful in a broad context, but they are prone to artifacts, including seasonal changes in seagrass biomass (and, therefore, visual signatures) and differences in water clarity between successive imagery sets. But even with its limitations, mapping allows us to assess seagrass abundance over much larger areas than can be monitored on the ground. We report change analyses where successive mapping data sets with the same spatial extent are available.

TABLE ES-3. SEAGRASS IMAGERY AND MAPPING STATUS FOR FLORIDA

	Imagery Collection		
Estuary	Most Recent	Agency	Most Recent Maps
Perdido Bay	2010	NASA, NOAA	2003
Big Lagoon	2010	NASA, NOAA	2003
Pensacola Bay System	2010	FWC/FWRI, NOAA	2003
Santa Rosa Sound	2010	FWC FWRI	2003
Choctawhatchee Bay	2010	FWC/FWRI SIMM	2003
St. Andrew Bay	2010	GCCC	2003
St. Joseph Bay	2010	FDEP CAMA	2006
Franklin County	2010	FWC/FWRI SIMM	1992
Big Bend Region	2006	FWC/FWRI SIMM	2006
Cedar Keys and Waccasassa	2001	SRWMD	2001
Springs Coast	2007	SWFWMD	2007
Tampa Bay	2010	SWFWMD	2010
Sarasota Bay	2010	SWFWMD	2010
Lemon Bay	2010	SWFWMD	2010
Charlotte Harbor North	2010	SWFWMD	2010
Pine Island Sound	2008	SFWMD	2006
Matlacha Pass	2008	SFWMD	2006
Caloosahatchee Estuary	2008	SFWMD	2006
Estero Bay	2008	SFWMD	2006
Rookery Bay	2009	SFWMD; Rookery Bay NERR	2003/2005
Ten Thousand Islands	2009	SFWMD; Rookery Bay NERR	partial, 2005
Florida Bay	2004	FWC/FWRI SIMM	2004
Gulf Upper Keys	2006	NOAA NCCOS*	1992
Gulf Lower Keys, Marquesas	2006	NOAA NCCOS*	1992
Tortugas	2006	NOAA NCCOS*	1992
Atlantic Lower Keys	2006	NOAA NCCOS*	1992
Atlantic Upper Keys	2006	NOAA NCCOS*	1992
Biscayne Bay	2005	FWC/FWRI SIMM	2005
Lake Worth Lagoon	2009	SFWMD	2007
Southern Indian River Lagoon	2009	SFWMD	2007
Northern Indian River Lagoon	2009	SJRWMD	2007

*NCCOS = National Centers for Coastal Ocean Science

Of the estuaries or subregions of coastal Florida, all have aerial imagery available obtained within the past 10 years, with the oldest imagery being that taken of the Cedar Keys and Waccasassa Bay in 2001 (Table ES-3). However, photointerpretation, mapping, and mapping data have not been developed from the most recent imagery for many locations. In the Panhandle, imagery was collected in 2010 and awaits photointerpretation. The Southwest Florida Water Management District has just released mapping data from imagery collected in 2010 for Tampa Bay south through the northern portions of Charlotte Harbor. In a few cases, imagery was collected but it is not likely that photointerpretation will take place due to large-scale problems with glare or turbidity (Ten Thousand Islands) or insufficient funding (Florida Keys). As a result, for some locations, the most recent mapping data are from the early 1990s (Franklin County, the Florida Keys National Marine Sanctuary); for others, data are not available (Rookery Bay, Ten Thousand Islands). One of the highest priorities of the SIMM program is to acquire or facilitate acquisition of imagery and mapping data for all coastal regions so that no more than six years separates consecutive mapping efforts.

At a recent workshop convened by FDEP, dozens of seagrass scientists also pointed out areas where mapping is prohibitively difficult because of water depth, persistent turbidity, or tannin-stained waters. These areas include the Ten Thousand Islands, Hawk Channel in the Florida Keys, the northeast corner of the Big Bend Region, and portions of several estuaries in the Panhandle. In the immediate short term we will use monitoring data with sufficient density to create point distribution maps for these areas. Acoustic techniques, such as sidescan sonar, have been used successfully to map seagrasses in some areas with turbid or tannin-stained waters (Shirley et al. 2006) and are worthy of continued development.

Areas too deep or too far offshore to map with conventional aerial photography also present a challenge. There are possibly 7 million acres of seagrass habitat in federal waters off Florida, more than three times that mapped in state waters. Areas where the continental shelf is shallow enough for seagrass growth include the Southwest Florida Shelf (the area between Cape Romano and Key West), the Springs Coast (between Anclote Key and Cedar Keys), and the Big Bend proper (from the Suwannee River to Alligator Point). Beds in deeper waters are dominated by paddle grass and star grass, both small plants that are difficult to detect remotely. These areas are important seagrass habitat because they provide migration corridors for species that spend their juvenile stages in estuaries and live offshore as adults. The productivity of these extensive beds (primarily paddle grass) is important in sustaining offshore snapper and grouper fisheries (Kammerstrom et al. 2006).

Off the Springs Coast and Big Bend, the water is so clear that seagrasses may be mapped as far offshore as 20 miles, so satellite imagery may be the most cost-effective way to map seagrasses there. Acquisition of WorldView 2 satellite imagery of the Springs Coast and Big Bend is anticipated in fall 2011. Nevertheless, paddle grass, which is common offshore, is small and has a dubious optical signature in deep water, so mapping these beds in the deeper waters of the Big Bend and the southwest Florida Shelf will be technically challenging.

We have summarized the most recent mapping data for all Florida estuaries or regions and calculated an annual percentage change in seagrass area where two data sets having the same spatial extent were available for a region (Table ES-4). We used percentage annual change as the trend indicator because the time between mapping data sets ranges from 2 to 13 years. However, as the time increases between mapping efforts, trend analysis becomes more general and cannot capture annual variation that could result from natural stressors, such as El Niño weather patterns and tropical cyclones, or short-term anthropogenic factors, such as dredging or changes in boat access. Also, methods of image acquisition and photointerpretation might vary temporally and spatially. More detailed information on methods and seagrass acreage gains and losses is located in each chapter. These data are also summarized on a larger regional basis (Table ES-5; Figure ES-4).

The Panhandle has the lowest acreage of seagrass (39,192 acres, 1.8% of the total), and three estuaries in the Panhandle showed losses greater than 3% per year between 1992 and 2002–03. Santa Rosa Sound and St. Andrew Bay had small annual percentage increases in seagrasses over the same time. As suggested by three years of monitoring data, seagrass acreage in Franklin County coastal waters is probably declining. Photointerpretation of imagery acquired in the fall of 2010 will provide updated information for all Panhandle estuaries.

About 28% (617,921 acres) of Florida seagrasses are found in the area from the northern Big Bend through the Springs Coast (Table ES-5). Change analysis was possible only for the Big Bend regions: Southern Big Bend showed a 1.2% annual loss in seagrass area from 2001 through 2006, while Northern Big Bend showed an annual loss in area of less than 0.1% for the same period, indicating that seagrass cover was stable in that region.

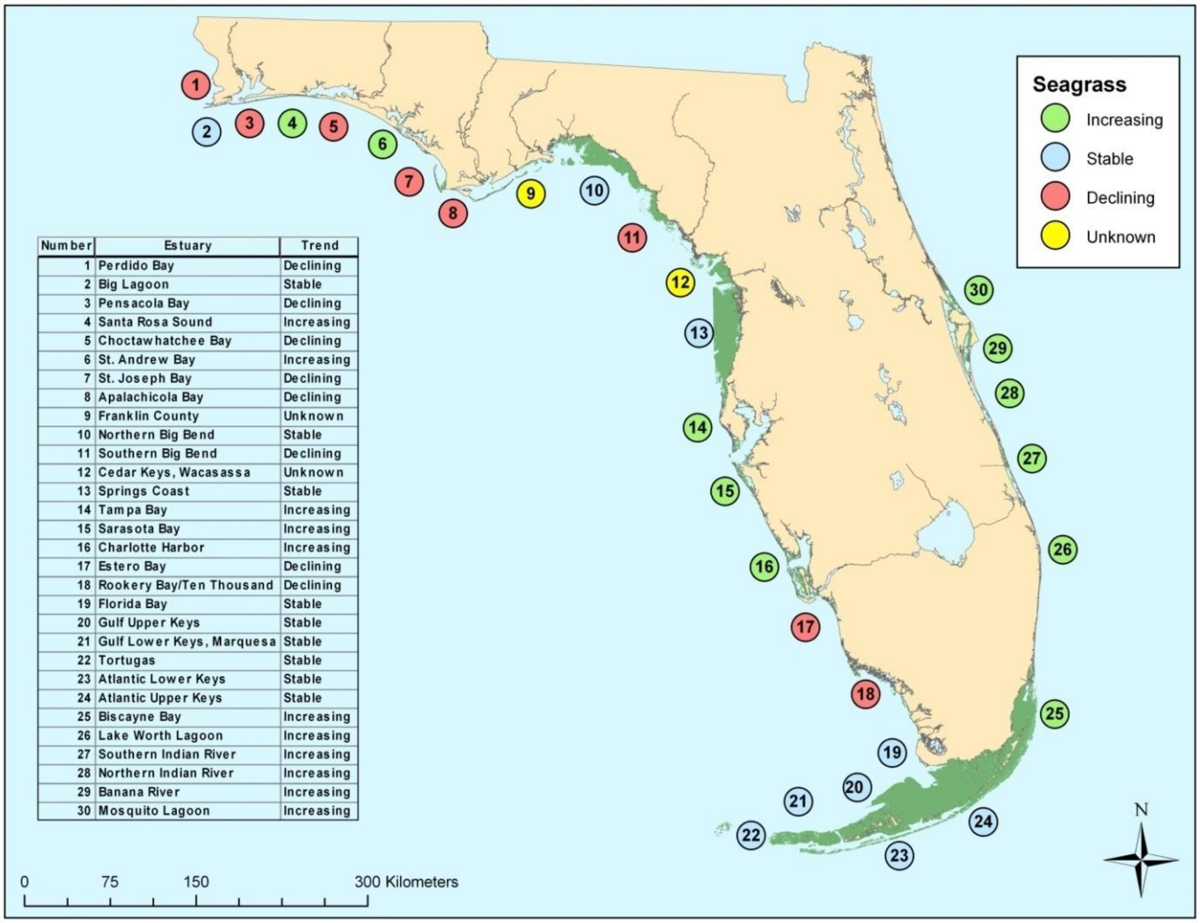
Seagrasses along Florida's southwest coast (from Western Pinellas County through Rookery Bay) cover 137,914 acres or 6.3% of all the seagrass mapped along Florida's coast. We have included 2010 mapping data very recently released by SWFWMD (Kaufman 2011). Substantial seagrass gains have occurred from Western Pinellas County through the Charlotte Harbor region. Estero Bay, on the other hand, lost seagrass acreage between 2004 and 2006 at the annual rate of 1.3%.

More than half of all seagrasses (1,301,936 acres, or 59.7%) in Florida are located in south Florida, including the Florida Keys National Marine Sanctuary, Florida Bay, Biscayne Bay, and adjacent Atlantic waters. Change analyses were possible only for Florida Bay and Biscayne Bay and showed a probably negligible 0.07% annual loss in Florida Bay and small annual gains (0.28%) in Biscayne Bay.

Seagrasses along the east coast of Florida cover 82,182 acres, 3.8% of all seagrasses in Florida waters. Seagrass cover is increasing on the east coast, with large annual increases observed in the Indian River Lagoon—6.7% and 4.7% per year in the southern and northern Indian River Lagoon, respectively.

TABLE ES-4. MAPPING ESTIMATES OF SEAGRASS ACREAGE IN ESTUARINE AND COASTAL WATERS OF FLORIDA

	Mapping data				
	Previous		Most Recent		Change
Estuary/Region	**Year**	**Acres**	**Year**	**Acres**	**(%/yr)**
Perdido Bay	1987	642	2002	125	–5.4
Pensacola Bay System	1992	892	2003	511	–3.9
Big Lagoon	1992	538	2003	544	0.10
Santa Rosa Sound	1992	2,760	2003	3,032	0.90
Choctawhatchee Bay	1992	4,261	2003	2,623	–3.5
St. Andrew Bay	1992	9,832	2003	11,233	1.3
St. Joseph Bay	1993	8,170	2006	6,672	–1.4
Franklin County			1992	14,452	n/a
Northern Big Bend region	2001	149,840	2006	149,140	–0.093
Southern Big Bend region	2001	59,674	2006	56,146	–1.2
Suwannee, Cedar Keys, Waccasassa			2001	33,625	n/a
Springs Coast			2007	379,010	n/a
Western Pinellas County	2006	23,943	2008	25,880	4.0
Tampa Bay	2008	29,647	2010	32,897	5.5
Sarasota Bay	2008	12,641	2010	12,692	0.20
Lemon Bay	2008	2,863	2010	3,039	3.1
Charlotte Harbor region	2004	57,213	2006	58,849	1.4
Estero Bay	2004	3,625	2006	3,529	–1.3
Ten Thousand Islands			n/a	n/a	n/a
Rookery Bay Aquatic Preserve			2003/05	1,028	n/a
Florida Keys National Marine Sanctuary			1992	856,355	n/a
Florida Bay	1992	146,615	2004	145,308	–0.074
Biscayne Bay	1992	153,827	2004/05	159,363	0.28
Atlantic side Biscayne			1992	140,910	n/a
Lake Worth Lagoon	2001	1,647	2007	1,688	0.41
Southern Indian River Lagoon	2005	7,808	2007	8,848	6.7
Northern Indian River Lagoon	2005	65,520	2007	71,646	4.7
Total Seagrass Acreage				**2,179,145**	



Number	Estuary	Trend
1	Perdido Bay	Declining
2	Big Lagoon	Stable
3	Pensacola Bay	Declining
4	Santa Rosa Sound	Increasing
5	Choctawhatchee Bay	Declining
6	St. Andrew Bay	Increasing
7	St. Joseph Bay	Declining
8	Apalachicola Bay	Declining
9	Franklin County	Unknown
10	Northern Big Bend	Stable
11	Southern Big Bend	Declining
12	Cedar Keys, Wacasassa	Unknown
13	Springs Coast	Stable
14	Tampa Bay	Increasing
15	Sarasota Bay	Increasing
16	Charlotte Harbor	Increasing
17	Estero Bay	Declining
18	Rookery Bay/Ten Thousand	Declining
19	Florida Bay	Stable
20	Gulf Upper Keys	Stable
21	Gulf Lower Keys, Marquesa	Stable
22	Tortugas	Stable
23	Atlantic Lower Keys	Stable
24	Atlantic Upper Keys	Stable
25	Biscayne Bay	Increasing
26	Lake Worth Lagoon	Increasing
27	Southern Indian River	Increasing
28	Northern Indian River	Increasing
29	Banana River	Increasing
30	Mosquito Lagoon	Increasing

Figure ES-4. Seagrass cover in Florida coastal waters and trends in seagrass acreage.

Of the 30 systems shown in Figure ES-4, seagrass acreage increased in 11 estuaries or subregions, with especially large increases in western Pinellas County, Tampa Bay, Lemon Bay, and the Indian River Lagoon. Smaller increases were detected in Santa Rosa Sound, St. Andrew Bay, Sarasota Bay, the Charlotte Harbor region, Biscayne Bay, and Lake Worth Lagoon. Acreage of seagrass beds is probably stable in Big Lagoon in western Florida, northern Big Bend, the Florida Keys National Marine Sanctuary, Florida Bay, and the nearshore Atlantic waters adjacent to Biscayne Bay. Change analyses were not available for Franklin County coastal waters, Suwannee Sound, Cedar Keys, Waccasassa Bay, the Springs Coast, Rookery Bay, the Ten Thousand Islands, the Florida Keys National Marine Sanctuary, or the nearshore Atlantic waters near Biscayne Bay.

We anticipate revising change analysis data using more recent mapping data for many areas, and this will strengthen our confidence in the observed trends. Digital color imagery was obtained in fall of 2010 for most of the Florida Panhandle, and photointerpretation and mapping of these images is under way. In addition, satellite imagery of the Big Bend region will be acquired in 2011.

TABLE ES-5. SEAGRASS ACREAGE FOUND IN FIVE COASTAL REGIONS OF FLORIDA

	Seagrass	
Region of Florida	Acres	% of total
Panhandle	39,192	1.8%
Big Bend to Springs	617,921	28.4%
Southwest Florida	137,914	6.3%
South Florida	1,301,936	59.7%
East Coast	82,182	3.8%
Total	**2,179,145**	**100.0%**

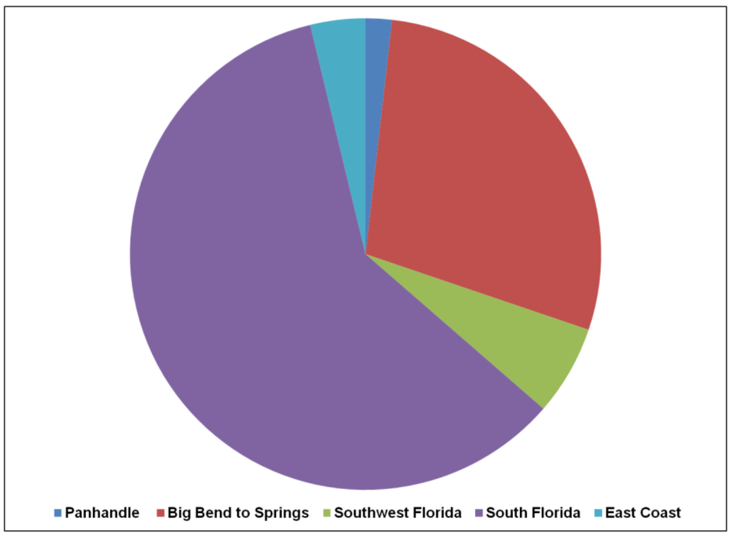


Figure ES-5 Distribution of seagrass acreage in Florida coastal waters.

Core Indicators for Seagrass Monitoring and Mapping: Based on the data and information available to us and from discussions with collaborators, we recommend, for a statewide seagrass mapping and monitoring network, that the following core indicators be used to assess seagrass health and that they be reported regularly to legislators and managers:

Monitoring indicators

1. Seagrass (and macroalgal) abundance

2. Seagrass (and macroalgal) species composition and diversity

3. Depth distribution of seagrass species

Desirable, but optional, monitoring indicators include:

4. Optical water quality measurements (chlorophyll, turbidity, color, total suspended solids, transparency)

5. Reproductive effort (flowering, fruiting, seedling production)

Mapping indicators

6. Seagrass areal coverage and texture

7. Time-series change analyses of areal coverage and texture

The Future of SIMM: Development of the SIMM program has been generously funded by the Florida Department of Environmental Protection Coastal Management Program (CMP). However, the future of SIMM requires a sustained funding source. Increasing budget constraints at state, local, and federal levels require that costs be cut to absolute minimum levels. Recent technological developments and the ability to leverage costs among agencies provide several options for optimizing the use of available funds. Some tasks, such as imagery acquisition, might be less expensive if carried out by a single agency or as a pooled effort among agencies, while monitoring programs will likely be less expensive if carried out locally by partners throughout coastal Florida.

Mapping Costs: In our first annual report (Carlson and Yarbro 2009), we reviewed mapping project costs (Table ES-6), separating imagery acquisition costs from photointerpretation and map production costs. In seven projects carried out from 2004 to 2008, imagery acquisition costs ranged from 6 to 19 cents per acre, with an average cost of 11 cents per acre. Photointerpretation costs for those same projects ranged from 4 to 52 cents per acre, with an average cost of 23 cents per acre. The total combined costs for imagery acquisition and photointerpretation ranged from 11 to 63 cents per acre and averaged 34 cents per acre. Because seagrass beds are surrounded by other habitats on the bottom of estuaries and bays that are included in mapping projects, the total statewide estimate of seagrass area of 2.2 million acres cannot be used to estimate statewide mapping costs. Using an estimate of 4.0 million acres of nearshore bottom habitat, the total cost of mapping seagrass for the entire state of Florida one time using digital aerial imagery and conventional photointerpretation would be about $1.36 million. Spread over a six- year mapping cycle, the annual cost of mapping alone would be $227,000. With staff salary costs added, the total annual cost would be approximately $290,000 for mapping alone.

TABLE ES-6. COMPARISON OF THE COSTS OF IMAGERY ACQUISITION AND MAPPING FOR SEVERAL PROJECTS IN FLORIDA

Project:	Florida Bay SFWMD/FWRI 2004	Biscayne Bay SFWMD/FWRI 2005	Western Everglades 2006	Springs Coast SWFWMD 2005	Tampa Bay SWFWMD 2006	Tampa Bay SWFWMD 2008	Indian River SJRWMD 2007	Average Cost
Area of Study (acres)	815,854	557,222	1,061,091	528,640	1,553,757	1,504,718	224,065	–
Imagery Type	Natural color film	Zeiss DMC digital	Zeiss DMC digital	Leica ADS40	Zeiss DMC digital	Zeiss DMC digital	Zeiss DMC digital	–
Acquisition Cost	$51,066	$55,588	$133,985	$99,946	$97,291	$170,545	$25,380	
Acquisition Cost per acre	$0.06	$0.10	$0.13	$0.19	$0.06	$0.11	$0.11	$0.11
Photointerpretation and Mapping Costs	$107,687	$142,498	$334,963	$170,000	$67,609	$77,346	$116,833	
Photointerpretation and Mapping Cost per acre	$0.13	$0.25	$0.32	$0.32	$0.04	$0.05	$0.52	$0.23
Total Cost	$158,753	$198,086	$468,948	$269,946	$164,900	$247,891	$142,213	
Total Cost per acre	$0.19	$0.35	$0.44	$0.51	$0.11	$0.16	$0.63	$0.34
Mapping: Imagery Cost Ratio	2.1	2.6	2.5	1.7	0.69	0.45	4.6	2.1

Mapping costs can be reduced in three ways: by obtaining imagery for multiple purposes, allowing several agencies or programs to share costs; by using satellite imagery in regions where high spatial resolution is not required; and by using supervised software classification techniques to automate a significant portion of the photointerpretation process.

Cost-sharing for imagery acquisition is highly desirable, but it requires a large amount of coordination, and some partners might not receive imagery that fully meets their needs. For example, photography over land areas for tax assessment or infrastructure mapping is often carried out in winter, when cold fronts provide cloud-free skies. Moreover, long shadows are not desirable, so imagery is generally acquired between 10 a.m. and 2 p.m. For seagrass imagery acquisition, high sun elevation angles at midday can often create unacceptable levels of glare on the water surface, and cold fronts bring high winds that can cause sediment resuspension and turbid conditions. Furthermore, seagrass biomass is generally much lower in winter than in summer, so shallow and sparse seagrass beds might not be visible in winter photography. With patience and communication, however, the needs of all project partners can be met. We have had great success working with aerial photo contractors to acquire seagrass imagery in conjunction with land-area flights for other purposes. Most contractors are able to fly coastal and estuarine flight lines under conditions desirable for seagrass imagery, leaving flight lines over land for windy days and high sun elevation angles. Imagery acquisition costs are still in the vicinity of 12 cents per acre, however, so conventional aerial imagery is best used in areas where high spatial resolution is required.

For larger areas such as Florida's Big Bend, Springs Coast, Biscayne Bay, Florida Bay, and the Florida Keys, satellite imagery can provide a significant cost savings for imagery acquisition. Over the course of SIMM's development, the resolution of satellite imagery has greatly improved and costs have decreased. Resolution, the minimum size of an area that can be discerned by a photointerpreter, of four-band (red, green, blue, and near-infrared) satellite imagery has improved considerably and now approaches 2 m^2. Digital aerial imagery has a resolution of 1 ft^2 which is about 10 times better than that of satellite imagery, but for most seagrass mapping projects where the minimum mapping unit is 0.25 ha, the 2-m^2 resolution of satellite imagery is more than adequate. Satellite imagery has been expensive in the past, but costs are dropping. Using an estimate of 8 cents per acre, a 33% savings over conventional aerial photography can be obtained.

On average, photointerpretation costs twice as much as imagery acquisition, so the ability to automate a portion of the mapping process would also result in significant savings. Using supervised software classification, our goal is to reduce interpretation costs more than 50%, from an average of 23 cents per acre to 10 cents per acre. The uniform density and seamless acquisition of satellite imagery combined with software classification make this goal possible.

Total project costs using satellite imagery and software classification in conjunction with traditional photointerpretation reduces costs from an average of 34 cents per acre to 18 cents per acre, a savings of almost 50%. Statewide mapping costs would drop from $1.4 million to

$740,000. Over a six-year mapping cycle, annual mapping costs and project administration would drop from $290,000 to about $150,000.

Monitoring Costs: The fundamental perspective of SIMM is that seagrass mapping and monitoring are complementary and that both are needed to effectively protect, manage, and restore seagrass resources. Seagrass monitoring can provide information on seagrass density, species composition, and health that cannot be extracted from aerial or satellite imagery. Furthermore, monitoring can be carried out each year, and data can be analyzed within a few months of collection while the turnaround time for mapping data is considerably longer.

The costs of seagrass monitoring depend primarily on logistics and on the indicators measured. Local agencies can monitor seagrass communities in their backyard less expensively than state or federal agency staff traveling long distances from their home offices. Inexpensive and basic indicators are seagrass and macroalgal species composition and abundance. Biomass sampling adds costs for sample collection, storage, and processing. Optical water quality measurements and chemical analysis of seagrass tissue and water samples also raise costs.

Successful seagrass monitoring programs in the Indian River Lagoon, Florida Keys National Marine Sanctuary, Florida Bay, Biscayne Bay, and Big Bend provide a basis for calculating monitoring costs, and, depending on the parameters measured and analyses performed, we estimate that single per-site costs range from $100 to $400. These costs include vehicle and boat maintenance, fuel, travel, salary costs for staff, and analytical costs for chemical indicators. Using a middle estimate of $250 per site and assuming sampling of 2000 sites yearly throughout the state, the annual cost of seagrass monitoring for the entire state will be $500,000. However, the economic value of the ecological services provided by 2.2 million acres of seagrass is approximately $40 billion (Costanza et al. 1997), resulting in an annual cost–benefit ratio of 0.125%

Challenges and Opportunities:

Although it will be challenging to find a stable funding source for SIMM, we are optimistic that the program's value will generate support among participating agencies. As the program continues, we will focus on a number of key tasks:

- <u>Compare monitoring results collected using different sampling designs</u> (fixed points and transects vs. spatially distributed random sampling points). With the assistance of University of Florida staff, we are evaluating the comparability of data collected using fixed-transect, fixed-point, and probabilistic designs. SIMM will deal with this issue as the program develops, with the goal of implementing spatially distributed, random sampling throughout the state.
- <u>Report seagrass status and trends in Florida.</u> By building upon the collaboration established during the creation of this first report and by assisting other monitoring programs logistically or monetarily, we hope to create seagrass monitoring report cards at least every two years.

- Optimize data management, statistical analyses, and Web sharing. Many monitoring programs are uncertain as to how to store and analyze monitoring data. Some data sets are stored in Web-accessible databases; others reside on hard-copy field-data sheets. One of SIMM's near-term goals is to provide data management and analysis support to monitoring programs that need it. In the longer term, we hope to build a Web-accessible database for seagrass monitoring data using our data initially and inviting other agencies to contribute either data or a link to their own Web database.
- Close spatial gaps in monitoring programs. Gaps in program coverage exist in the Panhandle, Springs Coast, Ten Thousand Islands, and Volusia County. Because some programs elsewhere depend on grants, continued statewide seagrass monitoring coverage is dependent on stable funding, and we will continue to explore funding sources and work with other agencies to monitor seagrasses. We are currently assisting FWC, FDEP, the Northwest Florida Water Management District and local agency staff in setting up monitoring programs in Panhandle estuaries.
- Achieve consistency in mapping cycle times. Seagrass mapping cycles range from 2 years to more than 15 years, depending on the estuary or area. Detecting changes in seagrass area and density based on long cycle times has limited value. We have determined that it is highly feasible to link seagrass aerial photography to the triennial aerial photography carried out by the Florida Department of Revenue (FDOR). Narrow water bodies such as the Indian River Lagoon are frequently included in the FDOR imagery acquisition program. A number of issues, such as imagery collection conditions, added costs, and imagery collection schedules, remain to be resolved. In estuaries with two- and three-year mapping cycles, those schedules should be maintained. In estuaries for which no ongoing mapping programs exist, we hope the mapping cycle time will be six years.
- Cut the lag times for seagrass mapping projects. The time between the collection of imagery and the distribution of GIS maps can be as long as five years. Where possible, we will reduce the processing time by finding funds to interpret imagery immediately after collection. In the slightly longer term, mapping costs and turnaround time might be reduced by use of remote sensing and image analysis software for seagrass mapping instead of conventional photointerpretation.
- Address the limitations of conventional aerial photography. Large areas of seagrass habitat important to fisheries in the northeastern Gulf of Mexico cannot be mapped by conventional aerial photography. Gains and losses can occur without our knowledge. We are presently investigating alternative techniques for assessing deep water seagrass beds, such as underwater photography or videography. Other developing technologies include sidescan sonar and hyperspectral imagery.
- Provide data support for management actions. Where degraded water quality has been implicated in seagrass loss or thinning or changes in seagrass species composition, we hope that information from this and future SIMM reports will support opportunities for management actions found in TMDL, Outstanding Florida Waters (OFW), numeric nutrient criteria, and water quality criteria regulations administered by FDEP.

Data Use for Damage Assessment from the 2010 Deepwater Horizon Oil Spill: Release of the final version of this report was delayed because of our involvement in the Natural Resources Damage Assessment (NRDA) of seagrass ecosystems in the northern Gulf of Mexico following the 2010 Deepwater Horizon oil spill. Nevertheless, the final draft chapters and summary information for Florida Panhandle estuaries provided vital information for NOAA's Submerged Aquatic Vegetation Technical Working Group (SAV TWG). SIMM mapping and monitoring information allowed the SAV TWG to design data-acquisition efforts to fill data gaps and to devise statistically defensible sampling designs in the assessment of oiling and resource damage. Extensive and ongoing aerial imagery acquisition associated with damage assessment, and monies provided for the monitoring of Panhandle seagrass beds, might provide mapping and monitoring data for estuaries for which, before the spill, mapping and monitoring programs were not current. However, another consequence related to the oil spill has been potentially destructive impacts to seagrass beds from response activities, such as booming, construction of barriers, and propeller scarring from vessels of opportunity (VOOs). Damage assessment of the direct oiling of seagrass beds and of response activities in Panhandle estuaries will continue at least through 2011. BP and its contractors, as well as federal and state agencies, have used a number of aerial and remote-sensing platforms to collect terabytes of imagery data. We hope some of this imagery and the effort spent to analyze it will realize benefits for future seagrass mapping efforts in Florida.

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Introduction

Florida seagrass beds are an extremely valuable natural resource. Approximately 2.2 million acres of seagrass have been mapped in estuarine and nearshore Florida waters (Table I-1, after Carlson and Madley 2007), Seagrasses provide habitat for fish, shellfish, marine mammals and sea turtles that translate into a value of more than $20 billion each year (Costanza et al. 1997). More seagrass exists in water too deep for conventional mapping, and the total area of seagrasses in Florida's estuarine and coastal waters may be as great as 3 million acres. Many economically important fish and shellfish species depend on seagrass beds for critical stages of their life history**,** and seagrasses also play a role in the global carbon cycle, nutrient cycles, sediment stabilization, and the maintenance of coastal biodiversity and provide food and shelter for endangered mammal and turtle species (Orth et al. 2006; Waycott et al. 2009).

TABLE I-1. ESTIMATES OF MAPPED AND POTENTIAL SEAGRASS AREA IN FLORIDA WATERS (FROM CARLSON AND MADLEY 2007)

	Hectares	Acres
STATEWIDE TOTAL	**913,231**	**2,256,594**
Panhandle	16,942	41,864
Big Bend	247,699	612,064
Gulf Peninsula	43,341	107,096
Atlantic Peninsula	30,132	74,456
South Florida	575,117	1,421,114
POTENTIAL SEAGRASS		
Big Bend	1,415,028	3,496,534
Southwest Florida Shelf	1,433,127	3,541,257

Unfortunately, seagrasses are vulnerable to many direct and indirect human impacts, especially eutrophication and other processes that reduce water clarity (Orth et al. 2006). Although concerted efforts to improve water quality have resulted in increases in seagrass area in some Florida estuaries, the area of seagrasses in some of the state's coastal waters continues to decline (Carlson et al. 2010). In order to identify areas of seagrass loss, to stem and reverse seagrass losses, and to monitor recovery of seagrasses, regular mapping and monitoring of this valuable resource are required.

Until now there has been no coordinated statewide program for the regular assessment of the abundance and health of seagrasses. Seagrasses in some estuaries—Indian River Lagoon, Tampa Bay, Sarasota Bay, and Charlotte Harbor, for example—are regularly mapped every two years by the St. Johns River Water Management District, the Southwest Florida Water Management District, and the South Florida Water Management District, respectively. However, other estuaries and seagrass beds have been mapped using opportunistic grants with no consistent frequency, resulting in gaps of 8–12 years between mapping efforts. The last statewide reporting effort used a collection of seagrass maps produced over a period of 10 years. Comparing data from such disparate mapping projects often requires that the data be reworked into a standard format for computation of area estimates and ignores the potential for significant changes in seagrass cover between start and finish of data collection over such long periods. Comparisons of seagrass cover among regions and analysis of regional trends are also compromised.

Furthermore, when standard photointerpretation methods are used, there is a lag time of 18–36 months between the collection of imagery and the production of seagrass maps in geographic information system (GIS) software. These lags, added to the sometimes lengthy interval between mapping efforts for an area, result in a poor ability to detect seagrass losses quickly and prevent further losses.

To provide more accurate estimates of changes in seagrass area and to provide greater spatial resolution and information on seagrass species composition, the Seagrass Integrated Mapping and Monitoring (SIMM) program integrates seagrass mapping and monitoring across Florida. Monitoring programs provide greater spatial resolution and information on seagrass and algal species composition much faster than do mapping projects alone (Table I-2). Changes in seagrass abundance or species composition can be detected in a few months rather than over several years. Many agencies and groups are monitoring or have monitored seagrasses, and this offers the opportunity to link existing monitoring programs via a reporting network. However, doing so presents several challenges including gaps in spatial coverage, temporal gaps in monitoring data, and identification of key indicators, appropriate field methods, and statistical techniques for analyzing disparate data sets.

TABLE I-2. SEAGRASS MAPPING AND MONITORING ARE COMPLEMENTARY

Characteristic	Mapping	Monitoring
Spatial Coverage	Large: hundreds of km^2	Small: hundreds of m^2
Spatial Resolution	Coarse: 0.2 ha	Fine: 1 m^2
Classification	Coarse: 2−3 categories	Fine: scalar
Species Composition	None	Complete
Revisit Interval	Long: 2−10 years	Short: 6−12 months
Data Lag Time	Long: 12−24 months	Short: 1−2 months

The SIMM program was developed to protect and manage seagrass resources by linking seagrass mapping and monitoring programs across Florida and by filling gaps where necessary. Elements of this program include: 1) mapping of all seagrasses in Florida waters at least every six years for those regions for which a routine mapping program does not exist; 2) monitoring seagrasses throughout Florida annually; and 3) publication of a comprehensive report every two years, combining site-intensive monitoring data and trends with statewide seagrass cover estimates and maps showing seagrass gains and losses.

The Florida Fish and Wildlife Conservation Commission/Fish and Wildlife Research Institute (FWC/FWRI) staff are committed to developing, implementing, and maintaining the SIMM program. Our first steps, supported by the Florida Department of Environmental Protection (FDEP) Coastal Management Program, have been to:

1. Inventory existing mapping and monitoring programs

2. Identify spatial gaps in mapping and monitoring programs

3. Collate and evaluate seagrass monitoring techniques

4. Identify emergent metrics of seagrass distribution, abundance, and health that can be obtained from disparate monitoring programs

5. Analyze seagrass phenology and the seasonal climatology of water clarity to determine the optimal times for mapping seagrass in Florida coastal waters

6. Develop an online imagery database (Marine Resources Aerial Imagery Database [MRAID]) to serve imagery for seagrass mapping projects

7. Carry out seagrass monitoring and mapping in areas for which our inventory identified gaps

8. Evaluate the feasibility of using satellite imagery instead of conventional aerial photography in seagrass mapping

9. Develop collaboration with the Florida Department of Revenue to add seagrass aerial imagery to scheduled land imagery collection in coastal counties

As the SIMM program continues, we will leverage resources among local, state, and federal agencies to make seagrass mapping and monitoring programs effective while saving money on imagery acquisition, photointerpretation, mapping, and monitoring costs. Ultimately, we hope to make all seagrass mapping and monitoring data accessible on the Web. SIMM program data provide or could provide:

1. Baseline data against which natural and human-caused disasters could be evaluated
2. Background data for permitting efforts in general and the Uniform Mitigation Assessment Method (UMAM) of FDEP in particular
3. Quantitative data to support Total Maximum Daily Load (TMDL) efforts and Basin Management Action Plans (BMAP) in estuaries

4. Quantitative metrics for developing and monitoring the effectiveness of numeric nutrient criteria and numeric transparency criteria.

History and vision of the SIMM program: The roots of the SIMM program extend back to the 1970s when the importance of seagrass habitat and its dependence on water quality were recognized in Tampa Bay and other estuaries. The Florida Water Resources Act of 1972 established five water management districts across the state to manage water resources. Citizen initiatives resulted in the funding of advanced wastewater treatment and control of point-source pollution in Tampa Bay and other Florida estuaries. But by the mid-1980s it was apparent that nonpoint-source pollution also played an important role in estuarine eutrophication and seagrass loss. In 1987 the Florida Legislature created the Surface Water Improvement and Management Program (SWIM) to reduce nonpoint-source pollution in Florida waters. Three water management districts—St. Johns River Water Management District (SJRWMD), South Florida Water Management District (SFWMD), and Southwest Florida Water Management District (SWFWMD)—began mapping seagrasses in estuaries within their jurisdictional waters. The first seagrass maps for the Indian River Lagoon were produced in 1987 by SJRWMD and SFWMD. SWFWMD began seagrass mapping from Tampa Bay through northern Charlotte Harbor in 1988 and has continued mapping every two years. When the Tampa Bay National Estuary Program was established in 1991, seagrasses were designated as critical habitat, seagrass restoration goals were set, water quality goals were established to support seagrass recovery, and the SWFWMD biennial seagrass maps became the primary means of assessing seagrass gains and losses in Tampa Bay, Sarasota Bay, Lemon Bay, and northern Charlotte Harbor. The efforts in Tampa Bay and the Indian River lagoon were critical in demonstrating the need for regular assessment of seagrass cover and the effectiveness of seagrass mapping.

The roots of seagrass monitoring and probabilistic sampling also extend back to the 1980s. The U.S. Environmental Protection Agency established the Environmental Monitoring and Assessment Program (EMAP) in the late 1980s in an effort to move beyond point-source-discharge monitoring. EMAP's initial vision was to "monitor the condition of the Nation's ecological resources, to evaluate the cumulative success of current policies and programs, and to identify emerging problems before they become widespread or irreversible" (Messer et al. 1991). Over 20 years of operation, EMAP has developed and validated two concepts that are key to any ecological assessment: 1) the success of ecological monitoring depends on development of reliable, scientifically defensible indicators for measuring ecological health, integrity, and change, and 2) the success of ecological monitoring depends on logistically feasible and statistically valid sampling designs capable of quantifying error, bias, and predictive value (USEPA 1997). Seagrass scientists have taken to heart EMAP's emphasis on reliable indicators of community health, and many have also adopted the spatially distributed random-sampling (SDRS) design that EMAP developed. The advantages of the SDRS design are 1) that it prevents clumping of sample points by distributing them in an array of tessellated hexagons laid over the study area while 2) locating sampling points randomly within each hexagon, permitting the use of parametric statistics. The first seagrass monitoring programs to adopt the EMAP probabilistic sampling strategy were the FWRI seagrass monitoring program in Florida

Bay and Florida International University's monitoring program for the newly created Florida Keys National Marine Sanctuary.

In light of the groundswell of interest in seagrass monitoring and the development of practical sampling designs, in June 2000 Ken Haddad, director of Florida FWRI, held a workshop on seagrass mapping and monitoring with the purpose of fostering collaboration among all agencies carrying out seagrass mapping and monitoring in the state. FWRI staff prepared an inventory of seagrass mapping and monitoring programs for the workshop. This inventory showed that mapping projects were carried out at different intervals and depended heavily on the availability of grant funds and that methodologies varied among monitoring programs.

The 2000 workshop led to the development of the Florida Seagrass Conservation Information System (SCIS; http://research.myfwc.com/seagrass/), an online database of seagrass mapping and monitoring projects hosted on the FWRI website (http://myfwc.com/research/). Almost 200 seagrass-related projects were logged into the SCIS database from 2000 through 2003. Projects included mapping and monitoring efforts as well as projects addressing restoration, education, tissue culture, and boating impacts. The workshop also led to the publication of the *Seagrass Managers Toolbox,* an effort carried out by Gerald Morrison, Ronald Phillips, and Bill Sargent.

Also in 2000, Gil McRae, now director of FWRI, received a five-year grant from EPA to develop a probabilistic monitoring program for Florida estuarine and coastal waters. The Inshore Monitoring and Assessment Program (IMAP) incorporated two important elements: spatially distributed random sampling (SDRS) and nondestructive visual estimation of seagrass abundance. Over the course of the IMAP program, seagrass and macroalgal species composition and abundance were measured at more than 500 sites around the state, demonstrating the inferential power of spatially distributed random sampling designs. In 2002 FWRI investigators Paul Carlson and Laura Yarbro and Suwannee River Water Management District staff (Rob Mattson and Louis Mantini) began a collaborative mapping and monitoring program for Florida's Big Bend Region using the SDRS design. In 2004, Carlson supervised the collection of aerial imagery of Florida Bay to serve as a benchmark dataset against which changes resulting from the Comprehensive Everglades Restoration Program (CERP) might be measured. In 2005, Kevin Madley of FWRI supervised collection of a similar imagery set for Biscayne Bay.

Finally, in 2007, Larry Handley, Diane Altsman, and Richard DeMay produced a report titled *Seagrass Status and Trends in the Northern Gulf of Mexico: 1940–2002* (Handley et al. 2007). This report described seagrass mapping data for 15 estuarine and lagoonal systems from Texas to Florida and serves as the structural model for the SIMM report.

For the report by Handley et al., Carlson and Madley summarized recent trends in seagrass cover in estuaries of Florida's west coast (Carlson and Madley 2007). They reported that, of 13 estuaries and nearshore seagrass beds assessed for the status and trends effort, eight reported seagrass losses over the preceding decade, three reported gains, and two had insufficient mapping data to allow reliable assessment. The need for a coordinated statewide seagrass mapping and monitoring program was obvious, and the FDEP Coastal Management Program

(CMP) provided start-up funds for the development of the SIMM program. With FDEP-CMP funds over the past three years we interviewed staff and collected data from more than 30 mapping and monitoring programs across Florida. These programs vary considerably in their resources and scope, but all the participants see the value of contributing their information to this statewide effort. Because this report is a preliminary synthesis of seagrass mapping and monitoring data contributed by many individuals and agencies, there are bound to be errors and omissions. However, this report will be issued every two years and will provide an opportunity to continuously correct and improve our assessments.

How this report was put together:

Development of the SIMM program at the Fish and Wildlife Research Institute began in 2007 with information gathering about the agencies, researchers, and programs addressing the health and acreage of seagrasses in the coastal waters of Florida. Telephone interviews followed so that we could become acquainted with our collaborators and learn what was being done by scientists and managers involved in assessing seagrass status and trends. Then we began gathering data and information to produce a chapter for each region or estuary along the coast of Florida. This effort allowed us to pursue the long-term goals of SIMM, which include 1) providing a snapshot of seagrass conditions in a statewide report issued annually, with contributions from researchers and managers; 2) establishing a statewide program of routine mapping occurring at least every six years and annual monitoring for all of Florida's seagrass ecosystems by partnering with the many agencies and researchers who work on seagrass ecosystems; and 3) eliminating gaps in monitoring and mapping, through collaboration and funding where possible.

This first report compiles available information on seagrasses and any omissions or gaps are the responsibility of the editors. For each region or estuary, we asked our contributors to provide text, graphics, tables, and any other materials they thought appropriate for this report. As a result, some chapters are organized slightly differently from others, some chapters have a great deal of information while regions receiving less scrutiny have less, and each chapter has a different flavor and emphasis, depending on the status of seagrasses and their stressors. There is overlap among chapters in the Pensacola and Charlotte Harbor regions. For these chapters this may reflect jurisdictional and research boundaries of different organizations whose staff contributed information, or it may result from editorial decisions for which we are solely responsible. We hope that readers and contributors will continue to provide us with additional and updated information so that we might provide a more accurate report in the next edition. In the future, we also hope to include in each chapter 1) more information on management priorities and actions; 2) information on nutrient and optical water quality where such data are available; and 3) summaries of seagrass species occurrence and distribution. We have limited information for a few subregions along Florida's coastline for which no monitoring and mapping program is now under way; these gaps include the Ten Thousand Islands region in southwest Florida and Apalachicola and Ochlockonee bays in the Panhandle. Aerial photography of seagrasses in the Panhandle was completed in late 2010 and we anticipate acquiring imagery for the Ten Thousand Islands in 2011. We anticipate expanding or including chapters on these regions as part of our next edition. As we prepare to publish this report, damage assessment from the 2010 Deepwater Horizon oil spill continues, and the next edition will include the information available on oil spill impacts.

This report is organized to provide information to a wide range of readers. Each chapter provides information on an estuary or subregion of Florida coastal waters, and the chapters are in geographical order, beginning in the western Panhandle and ending with the northern Indian River Lagoon on Florida's east coast. Beneath the title of each chapter are listed the names of the primary contacts and information providers for that estuary or subregion. Contact information (e-mail addresses and telephone numbers) for these contributors is provided at the end of the chapter. A thumbnail map at the top of the first page of each chapter shows the location of the estuary or subregion along the coast of Florida. Within each chapter, content includes a concise and general overall assessment and color-coded "report card" of seagrass status, as well as a map of the distribution of seagrass beds in the estuary or subregion, created using the latest available mapping product.

The report card graphic provides a general assessment of the health of seagrasses and the nature and extent of stressors. The colored boxes convey the following:

■ **Green**—Healthy, improving, stable conditions

■ **Yellow—**Declining, some stress present, some threats to ecosystem health

■ **Orange—**Measureable declines, moderate stressors or declines in seagrass cover

■ **Red**—Large negative changes in seagrass health and stressors, either acutely over a short period of time, or chronically over a period of years.

A reader wanting a quick snapshot of seagrass ecosystem status within a particular estuary or region could use the general assessment and the first status graphic presented on the first page of each chapter.

Following this summary information, the geographic extent covered by the chapter is outlined, followed by a map showing the most recent seagrass coverage, if available, and a brief list of mapping, monitoring, management, and restoration recommendations. We then provide more in-depth information on the status and trends of seagrasses, including another color-coded graphic addressing seagrass status indicators, such as cover, bed texture, species composition, and overall status, and seagrass stress indicators, such as water clarity, nutrients, phytoplankton, propeller scarring, and natural and anthropogenic events. The information in this status graphic varies from chapter to chapter and reflects differences in seagrass ecosystems and stressors among Florida estuaries and coastal waters.

Using mapping data from the two most recent mapping efforts (where available) having the same areal extent, we provide data on the overall acreage of seagrasses and changes in areal cover, along with a short discussion of what factors might be effecting these changes. In some chapters, acreages and change analysis are broken down by location within the estuary or bay, or by the texture (continuous or patchy) of seagrass beds. Using information, graphics, and tables provided by our contributors, we provide an assessment from ongoing monitoring programs. Our contributors articulated mapping, monitoring, management and restoration recommendations, and these are discussed in greater detail than outlined at the beginning of the chapter. We provide information on how the most recent mapping and monitoring data and aerial imagery were obtained and analyzed and where the imagery, maps, and data may be accessed. Any pertinent technical or scientific reports or peer-reviewed publications are listed, along with general references, websites, and additional information.

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Florida Seagrass Integrated Mapping and Monitoring Program

Summary Report for Perdido Bay

Contacts: Ken Heck and Dorothy Byron, Dauphin Island Sea Laboratory, and Shelley Alexander, Northwest Florida Department of Environmental Protection (Monitoring)

General Assessment: Seagrasses in Perdido Bay are primarily shoal grass (*Halodule wrightii*) and diminished in area 80% between 1987 and 2002. In 2002 approximately 125 acres of seagrass remained. The 2004 storm season showed few short-term effects on seagrasses. The Deepwater Horizon oil spill affected the bay, particularly near the inlet on the eastern side.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover		Declining	82% loss, 1987-2002
Water clarity			No information

Geographic Extent: Perdido Bay is the westernmost estuary of the Florida Panhandle and is located inside the barrier bar adjacent to the Gulf of Mexico. The study area begins at the Alabama–Florida state line to the west, extends east to Sunset Pass, and wraps around to include Kees Bayou and Russell Bayou along the northern section of the bay.

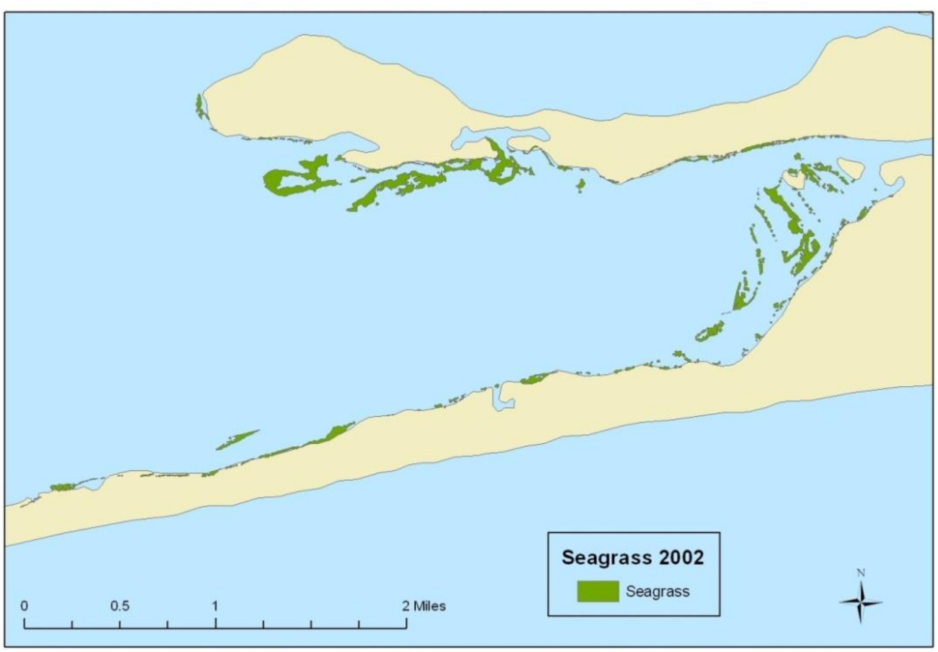

Figure 1. Seagrass map of Perdido Bay.

Mapping and Monitoring Recommendations

• As part of damage assessment of the Deepwater Horizon oil spill, high-resolution aerial photography was acquired for the entire northern Gulf coast in October 2010. Photointerpretation of the imagery is under way, and the new mapping data will be used to conduct change analysis and assessment of seagrass trends.

• A monitoring program should be implemented to evaluate seagrass beds annually.

Management and Restoration Recommendations

• Damage that resulted from the Deepwater Horizon oil spill should be evaluated.

• If necessary, a restoration plan should be drafted and implemented.

• Seagrass beds in high-use areas should be monitored for propeller scarring.

Summary Assessment: Mapping data from 1987 and 2002 show large-scale losses (80%) of seagrasses in Perdido Bay (Table 1)**.** In 2002, only 125 acres of seagrass were mapped, and most of the beds were composed of shoal grass. A study of the short-term effects of the 2004 hurricane season found that seagrasses tolerated these storms well.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover		**Declining**	80% loss, 1987-2002
Seagrass meadow texture		**Stable?**	
Seagrass species composition		**Variable**	Runoff from storms
Overall seagrass trends		**Declining**	

Seagrass Stressors	Intensity	Impact	Explanation
Water clarity			
Nutrients			
Phytoplankton			
Natural events			Hurricanes; 2010 El Niño
Propeller scarring			

Seagrass Mapping Assessment: Most of the seagrass beds surveyed in 1987 had disappeared by 2002. Interpretation of aerial photography acquired in 2010 will evaluate current trends in seagrass cover.

TABLE 1. SEAGRASS ACREAGE IN PERDIDO BAY IN 1987 AND 2002

1987	2002	Change	% Change
642	125	−517	−80.5

Monitoring Assessment: No monitoring program is in place. Some seagrass transplant sites are monitored by the Northwest Florida Department of Environmental Protection (NW FDEP).

Mapping and Monitoring Recommendations

- An annual monitoring program should be established.
- Aerial imagery of seagrass beds should be routinely acquired and photointerpreted.

Management and Restoration Recommendations

- Damage that resulted from the Deepwater Horizon oil spill should be evaluated.
- If necessary, a restoration plan should be drafted and implemented.
- Seagrass beds in high-use areas should be monitored for propeller scarring.

Mapping Data and Imagery: In 2002, the Mobile Bay National Estuary Program surveyed submerged aquatic vegetation (SAV) using photointerpreted and ground-truthed aerial imagery, producing a map of SAV habitat.

Monitoring Data: No routine monitoring program has been established, but the NW FDEP continues to monitor seagrass transplant sites in the bay.

Deepwater Horizon Oil Spill Addendum: The mouth of Perdido Bay and some areas in the eastern portion of the bay received repeated onslaughts of weathered oil, mousse, tar paddies, and tar balls during summer 2010. In particular, a location just inside and to the west of the inlet has persistent submerged oil (Shelley Alexander, personal communication). Perdido Bay, along with Pensacola Bay and Santa Rosa Sound, continues to be evaluated for impacts of the oil spill, and beaches and shores along these bays are closely monitored for oil-related materials and are subject to clean-up operations.

Pertinent Reports and Scientific Publications

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Contacts

Monitoring:

Ken Heck and Dottie Byron, Dauphin Island Sea Laboratory, 251-861-2141, kheck@disl.org and dbyron@disl.org.

Shelley Alexander, Northwest Florida office of the Department of Environmental Protection, 850-983-5359, Shelley.alexander@dep.state.fl.us.

Florida Seagrass Integrated Mapping and Monitoring Program

Summary Report for Pensacola Bay and Santa Rosa Sound

Contacts: Michael Lewis, U.S. Environmental Protection Agency, Gulf Breeze, Florida (Monitoring and Mapping)

General Assessment: Between 1950 and 1980, about 95% of seagrass habitat was lost in this coastal region of the far western Panhandle of Florida. In 2003, mapped seagrass covered 511 acres in the Pensacola Bay System and 3,032 acres in Santa Rosa Sound. Seagrass mapping data from 1992 and 2003 show a loss of seagrass acreage of about 43% in the Pensacola Bay System and a gain of almost 10% in Santa Rosa Sound. During recent surveys, seasonal hypoxia was found to affect as much as 25% of the bottom area. Portions of the bay, particularly those in the vicinity of Pensacola Pass and Gulf Breeze, were repeatedly exposed to Deepwater Horizon oil product during summer 2010. Damage assessment is ongoing.

Seagrass Status and Stresses	Status	Trend	Assessment, Causes
Seagrass cover		Declining	Losses, hypoxia
Seasonal hypoxia		Continuing	Natural phenomena

Geographic Extent: The Pensacola Bay System is located in the western Florida Panhandle. It includes Escambia Bay, East Bay, and Pensacola Bay. Santa Rosa Sound is the lagoon south of the Pensacola Bay System.

Mapping and Monitoring Recommendations

- Implement a regular monitoring program.
- Photointerpret and map photographs taken to evaluate effects of the Deepwater Horizon oil spill. High-resolution aerial photography was obtained in October 2010. Photointerpretation is under way, and the new mapping data will be used to conduct change analysis and assessment of seagrass trends.

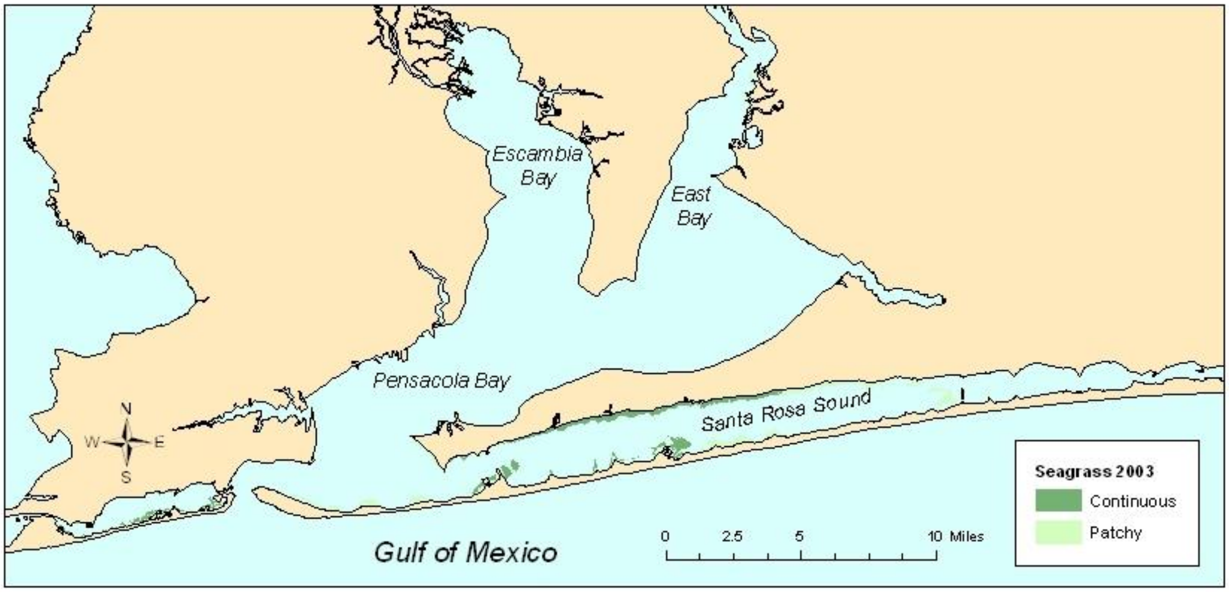

Figure 1. Seagrass cover in Pensacola Bay and Santa Rosa Sound, 2003.

Management and Restoration Recommendations

• Assess the extent and effects of seasonal hypoxia and the long-term effects of salinity changes in the upper regions of the Pensacola Bay System.

• Evaluate injury to seagrasses caused by to the 2010 Deepwater Horizon oil spill and plan restoration.

Summary Assessment: Significant losses in seagrass acreage have occurred in the past 60 years. Between 1992 and 2003, the Pensacola Bay System lost approximately 43% of its seagrass area, while seagrass area in Santa Rosa Sound increased almost 10%. However, significant species changes occurred in Escambia Bay because higher salinities eliminated beds of American eelgrass (*Vallisneria americana*) and widgeon grass (*Ruppia maritima*). Seagrass beds in Santa Rosa Sound are dominated by turtle grass (*Thalassia testudinum*) and with some shoal grass (*Halodule wrightii*) present, but beds appear stunted and sparse. Seasonal hypoxia, with resulting elevated levels of sediment sulfides, is considered a contributing factor to ongoing losses and poor seagrass bed texture.

The decline in seagrass acreage between 1950 and 1980 has been attributed to poor water quality due to industrial pollution and perhaps harbor dredging (Olinger et al. 1975). However, since 2000 water clarity has been relatively high, and nutrient concentrations and chlorophyll levels have been low. Koch (2001) reported that seagrasses were absent from many locations where light was sufficient for their growth.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover		Declining	Losses, hypoxia
Seagrass meadow texture		Poor growth	Mortality, stunted, sparse
Seagrass species composition		Little change	Salinity changes, high sulfide levels
Overall seagrass trends		Declining	Salinity changes, high sulfide levels
Seagrass Stressors	**Intensity**	**Impact**	**Explanation**
Water clarity		Some improvement	Poor in some areas
Nutrients		Good	Low levels, little runoff
Phytoplankton		Good	Low levels
Natural events		N/A	
Propeller scarring		N/A	
Seasonal hypoxia		Continuing	High sulfide levels

Seagrass Mapping Assessment: Between 1992 and 2003, total seagrass cover for the Pensacola Bay System declined 43%, from 894 to 511 acres, all in the upper reaches of Escambia Bay and East Bay, primarily due to increased salinity (Table 1). Losses in the upper system were partly offset by a gain of 91 acres in southern Pensacola Bay. Between 1992 and 2003, seagrass beds in Santa Rosa Sound increased by 272 acres, to 3,032 acres, an increase of almost 10%. These beds are composed primarily of turtle grass along with some shoal grass, but seagrasses are sparse and stunted.

TABLE 1. ACREAGE OF SEAGRASS HABITAT AREA (ACRES)

Basin	1992	2003	Change	% Change
Total Pensacola Bay System	**892**	**511**	**−381**	**−43**
Escambia Bay	440	111	−329	−75
East Bay	170	27.2	−143	−84
Pensacola Bay	282	373	91	32
Santa Rosa Sound	**2,760**	**3,032**	**272**	**9.9**

Monitoring Assessment: Routine monitoring is not being conducted in this region. The City of Gulf Breeze has contracted Heather Reed, of Ecological Consulting Services Inc., to conduct seagrass restoration and follow-up monitoring near Deadman's Island in Pensacola Bay.

Mapping and Monitoring Recommendations

- Implement a routine monitoring program.

- Obtain aerial photography and mapping data, particularly for evaluation of impacts of the 2004–05 hurricanes and the 2010 Deepwater Horizon oil spill.

Management and Restoration Recommendations

- Assess the extent and effects of seasonal hypoxia and the long-term effects of salinity changes in the upper regions of the Pensacola Bay System.

- Evaluate nutrient levels and inputs, particularly since any additional stress due to increased light attenuation or excessive nutrients could exacerbate seagrass losses.

- Assess damage due to the 2010 Deepwater Horizon oil spill; plan and carry out restoration as needed.

Mapping Data and Imagery: Seagrass acreage data from photointerpretation of aerial imagery were obtained from the U.S. Geological Survey National Wetlands Research Center, Lafayette, Louisiana.

Monitoring Data: None are available.

2010 Deepwater Horizon Oil Spill Addendum: Oil and oil product from the spill impacted Pensacola Bay beginning in mid-June 2010 and continued through most of July. Portions of the bay near Pensacola Pass, the Gulf Breeze shoreline areas, Barrancas Beach, and Fort Pickens Park received oil impacts. In addition, certain responses to the spill, such as booming and vessel use, may have damaged seagrass beds, particularly those near the Pass.

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Contacts

Mapping: Michael Lewis, U.S. Environmental Protection Agency, Gulf Ecology Division, Gulf Breeze, Florida, 850-934-9382, lewis.michael@epa.gov.

Monitoring (and 2010 Deepwater Horizon oiling information): Heather Reed, Ecological Consulting Services Inc., Pensacola, Florida, 850-417-7008, hreed@ecoconsultingservices.com.

Florida Seagrass Integrated Mapping and Monitoring Program

Summary Report for Santa Rosa Sound and Big Lagoon

Contacts: Amy Baldwin Moss, Florida Department of Environmental Protection, Northwest District (Monitoring and Mapping)

General Assessment: Seagrass beds in Santa Rosa Sound and Big Lagoon appear stable in area. In 2003, mapping from aerial photography found 3,032 acres of seagrass in Santa Rosa Sound and 543 acres in Big Lagoon. Seagrass beds in southern Santa Rosa Sound/Big Lagoon [along the Gulf Islands National Seashore (GINS)] are prone to sediment burial from unconsolidated sand carried in from nearby barrier islands. In 2009, the Florida Department of Environmental Protection's (FDEP) Ecosystem Restoration Program (ERS) found that as much as 9 cm of sand had been deposited (timeframe unknown) on monitored transplanted plots adjacent to Johnson's Beach (GINS). The FDEP ERS maintains in the area an active seagrass salvage program that relocates seagrasses about to be destroyed by marine construction to areas in which seagrasses are in need of restoration. Areas of Big Lagoon and Santa Rosa Sound near Pensacola Pass were repeatedly exposed to oil product from the Deepwater Horizon spill during the summer of 2010. Damage assessment of seagrass beds is ongoing.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover		Stable	
Water clarity		Good	
Nutrients		Good	Low levels, little runoff
Phytoplankton		Good	Low levels
Propeller scarring			

Geographic Extent: Big Lagoon covers approximately 18 sq. mi. and connects Perdido and Pensacola bays. Santa Rosa Sound is east of Big Lagoon and is approximately 27,160 acres in area. It connects Choctawhatchee Bay to the east and Pensacola Bay to the west. Big Lagoon and Santa Rosa Sound are separated by Pensacola Pass, which is open to the Gulf of Mexico. County political boundaries separate Big Lagoon in Escambia County and Santa Rosa Sound in Santa Rosa and Okaloosa counties.

Figure 1. Seagrass cover in Santa Rosa Sound, 2003.

Figure 2. Seagrass cover in Big Lagoon, 2003.

Mapping and Monitoring Recommendations

• Establish an annual monitoring program to assess changes in nutrient loads in northern Santa Rosa Sound, which receives urban runoff.

Management and Restoration Recommendations

• Assess the relationship between development pressures and storm runoff, scarring, sedimentation, and construction activities.

• Restore hurricane-related sediment-burial areas along the southern shoreline of Santa Rosa Sound (off Pensacola Beach).

• Restore vegetation of adjoining nonvegetated dune areas on the barrier islands.

• Continue assessing damage from the 2010 Deepwater Horizon oil spill, and initiate restoration program.

Summary Assessment: Seagrass beds in Santa Rosa Sound and Big Lagoon are considered stable, based on the limited information available.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover		Stable	
Seagrass meadow texture		Stable	
Seagrass species composition		Stable	
Overall seagrass trends		Stable	
Seagrass Stressors	**Intensity**	**Impact**	**Explanation**
Water clarity		Good	Improving
Nutrients		Good	Low levels, little runoff
Phytoplankton		Good	Low levels
Natural events		Possible	Hurricanes
Propeller scarring			

Seagrass Mapping Assessment: Based on mapping data from aerial photography in 1992 and 2003, the area of seagrass beds in Santa Rosa Sound and Big Lagoon has increased. In 1992, there were 2,760 acres of seagrass in Santa Rosa Sound; by 2003 acreage had increased to 3,032 acres, or 9.9% (Table 1). In 1992, Big Lagoon had 537 acres of seagrass; in 2003, 543 acres were mapped, an increase of 6 acres, or 1%.

TABLE 1. SEAGRASS ACREAGE IN SANTA ROSA SOUND AND BIG LAGOON IN 1992 AND 2003

	1992	2003	Change	% Change
Santa Rosa Sound				
Total	2,760	3,032	272	9.9%
Big Lagoon				
Continuous	372	401	29	7.9%
Patchy	166	143	−23	−13.7%
Total	538	544	7	1.3%

Monitoring Assessment: There is no monitoring program at present, but Paul Carlson collected field and seagrass percentage cover data from portions of Big Lagoon and Santa Rosa Sound in June 2010 as part of the baseline sampling effort associated with the Deepwater Horizon oil spill. This sampling effort targeted seagrass beds near the Pensacola inlet, which are parallel to the northern and southern shores of these bays. Therefore, seagrass beds in western Big Lagoon and eastern Santa Rosa Sound were not evaluated. Turtle grass (*Thalassia testudinum*) was the most common species of seagrass in eastern Big Lagoon, and shoal grass (*Halodule wrightii*) was the most common species at the Fort Pickens and Gulf Breeze sites in Santa Rosa Sound near the Pensacola inlet. Manatee grass (*Syringodium filiforme*) was the least common at all three sites; however, drift red algae were present in 15–45% of all sampling locations.

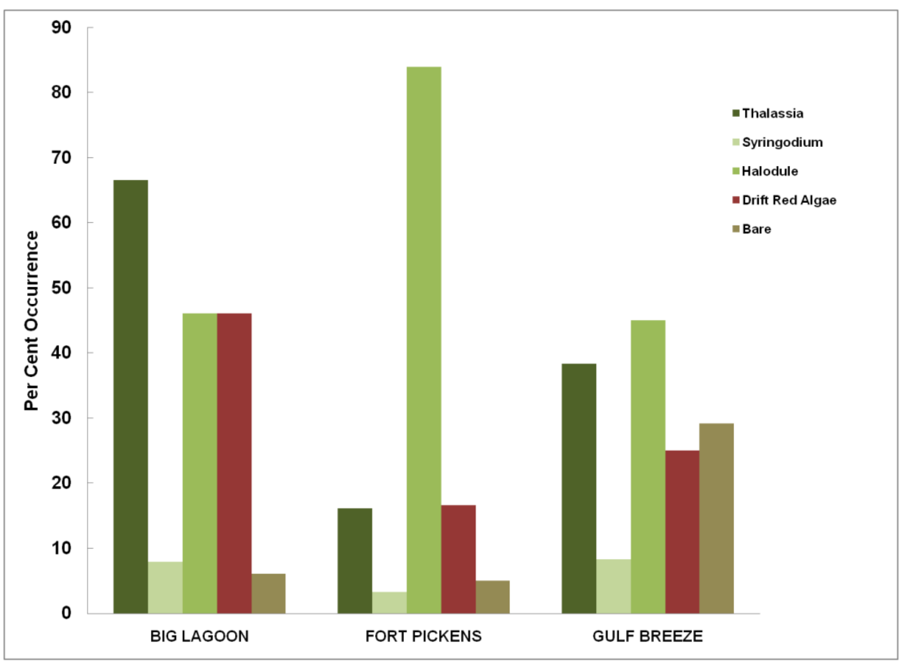

Figure 3. Percentage occurrence of seagrasses in Big Lagoon and near Fort Pickens and Gulf Breeze in Santa Rosa Sound, June 2010.

Mapping and Monitoring Recommendations

• Implement a routine monitoring program, which is acutely needed in light of oil impacts from the 2010 Deepwater Horizon spill. Monitoring data were collected from 1999–2001 to produce a seagrass management plan, and some monitoring was conducted in 2002 as well.

• Photointerpret aerial photography acquired in 2009 and 2010 to update seagrass maps and acreage estimates.

Management and Restoration Recommendations

• Address potential increases in nutrients in coastal waters and sources of nutrients.

• Minimize propeller scarring and conduct restoration efforts in areas with the greatest impacts.
• Address sedimentation from unconsolidated sand on adjacent GINS barrier island areas through vegetative restoration of dunes.

• Continue assessment of damage from the 2010 Deepwater Horizon oil spill, especially for seagrass beds near Pensacola Pass (Fort Pickens, south shore of Gulf Breeze, Robertson Island).

Mapping Data and Imagery: Seagrass data were derived from interpretation of color infrared photography taken in 2003. These images were mapped at 1:12,000 scale on hard copies that were rectified to U.S. Geological Survey (USGS) digital orthophoto quarter quadrangle base maps and were digitized at the USGS National Wetlands Research Center (NWRC). The seagrass beds were classified according to a USGS NWRC-derived classification scheme based on the Coastal Change Analysis Project (C-CAP) Coastal Land Cover Classification system of the National Oceanic and Atmospheric Administration. In assessing damage from the 2010 Deepwater Horizon oil spill, high-resolution aerial photography of the entire northern Gulf coast was obtained in October 2010. This area will be reflown in April 2011.

Monitoring Data: Project specific monitoring in 1999–2001 and 2002; no current monitoring program.

2010 Deepwater Horizon Oil Spill Addendum: Portions of western Santa Rosa Sound were affected by weathered oil entering Pensacola Pass during the summer of 2010. The southern and western shores of Gulf Breeze were oiled several times. The far eastern portions of Big Lagoon also received oil, particularly those near Robertson Island. Assessment of the impacts is ongoing.

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Seagrass Management Plan for Big Lagoon and Santa Rosa Sound, GulfBase.org: http://www.gulfbase.org/project/view.php?pid=smpfblasrs, accessed March 2011.

Contacts

Mapping and Monitoring: Amy Baldwin Moss, Florida Department of Environmental Protection, Northwest District, 850-595-8300, amy.baldwin@dep.state.fl.us.

2010 Deepwater Horizon Oil Spill Information: Heather Reed, Ecological Consulting Services Inc., Pensacola, Florida, 850-417-7008, hreed@ecoconsultingservices.com.

Florida Seagrass Integrated Mapping and Monitoring Program

Summary Report for Choctawhatchee Bay

Contacts: Alison McDowell, Choctawhatchee Bay Alliance, Northwest Florida State College, and Paul Carlson, Fish and Wildlife Research Institute (Monitoring); Larry Handley, U.S. Geological Survey (Mapping); and Shelley Alexander, Florida Department of Environmental Protection (Management)

General Assessment: In 1992, seagrasses covered 4,261 acres in Choctawhatchee Bay. In 2003, total seagrass cover had decreased to 2,623 acres, a loss of 38%. In 2003, only 2% of the bay's total bottom area of 133,300 acres was covered with seagrass. Of the seagrass mapped in Choctawhatchee Bay in 1992, 83% was located in the western bay. In 2003, that percentage was even greater. No seagrass was observed in the eastern segment during mapping in 2003. In 1992, the submerged aquatic vegetation (SAV) in the eastern segment was largely composed of brackish species—widgeon grass (*Ruppia maritima*) and tape grass (*Vallisneria americana*)—and these species are vulnerable to fluctuations in salinity and turbidity related to rainfall and runoff. Heavy winter rainfall in 2009 caused significant animal mortality and also may have affected seagrasses. Heavy rainfall also occurred in fall 2009 and winter 2010, associated with an El Niño.

Seagrass Status and Stresses	Status	Trend	Assessment, Causes
Seagrass cover		Declining	Losses, storm runoff
Water clarity		Declining?	
Natural events		Impacts	Hurricanes, El Niño
Propeller scarring		Negligible	Little impact

Geographic Extent: The eastern half of Choctawhatchee Bay is in Walton County, and the western half is in Okaloosa County. The bay is divided by bridges into three segments: the western segment, which lies west of the U.S. 293 bridge crossing the middle of the bay; the eastern segment, which lies east of the SR331 bridge; and the middle segment, which lies between the two bridges. Roughly 75% of the seagrass mapped in Choctawhatchee Bay in 1992 was located in the western segment.

Mapping and Monitoring Recommendations

• Continue the regular monitoring program begun in 2009 by the Fish and Wildlife Research Institute (FWRI).

• Photointerpret aerial photographs of seagrass acquired in spring 2010 and, as part of oil spill damage assessment, in October 2010. Photointerpretation and mapping of the spring 2010 photography began in early 2011.

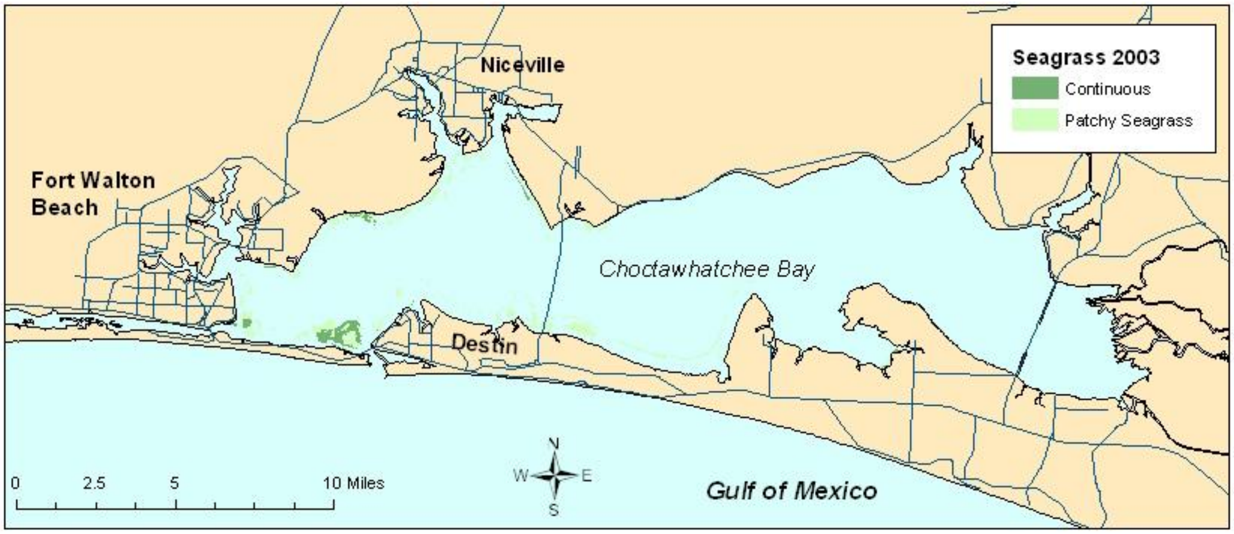

Figure 1. Seagrass cover in Choctawhatchee Bay, 2003.

Management and Restoration Recommendations

• Continue to monitor water quality in the bay and in rivers and streams contributing runoff to the bay.

• Work with regional and state agencies to evaluate and institute controls of quantity and quality of storm runoff entering the bay.

Summary Assessment: Based on seagrass data from 1992 and 2003, 38% of seagrass beds were lost from Choctawhatchee Bay during this 11-year period, and most of the remaining seagrass beds are located in the western bay. Losses in the western portions of the bay are attributed to hurricane and storm overwash and high wave energy. Submerged aquatic vegetation species mapped in 1992 in the eastern bay grow in brackish regions and are sensitive to variations in salinity and to storm runoff. In addition, increased colored dissolved organic matter (CDOM) in stream runoff has reduced water clarity and continues to contribute to seagrass losses in the eastern bay. Heavy rainfall associated with the 2009–10 El Niño may have resulted in further reductions in seagrass cover in this system.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover		Declining	Losses, storm runoff
Seagrass meadow texture		Declining?	
Seagrass species composition		Significant change	Salinity changes
Overall seagrass trends		Declining	Salinity changes, storm runoff
Seagrass Stressors	**Intensity**	**Impact**	**Explanation**
Water clarity		Declining?	Storm runoff
Nutrients		Good	
Phytoplankton		Good	Low levels
Natural events		Impacts	Hurricanes, El Niño
Propeller scarring		Negligible	Little impact

Seagrass Mapping Assessment: Seagrass acreage decreased from 1992 through 2003, especially in the eastern portions of the bay, where freshwater runoff caused almost complete losses of the brackish-water widgeon grass and tape grass (Table 1). Impacts from hurricanes and El Niño may continue this trend.

TABLE 1.SEAGRASS ACREAGE IN CHOCTAWHATCHEE BAY IN 1992 AND 2003

1992	2003	Change	% Change
4,261	2,623	−1,638	−38.4

Monitoring Assessment: Monitoring was begun in summer 2009. Where seagrass is present, shoal grass (*Halodule wrightii*) is the most abundant seagrass in Choctawhatchee Bay. Turtle grass (*Thalassia testudinum*) occurs at a few sites near the western end of the bay and at the entrance to Santa Rosa Sound. In 2009, 493 0.25-m^2 quadrats were evaluated for the presence of seagrasses. Of those, 76% were bare, and shoal grass was found in the remaining 24%. As shown in Figure 2, below, seagrass, for the most part, is limited to the western half of Choctawhatchee Bay. This pattern of distribution could be related to a strong, corresponding gradient in water clarity. Seagrasses are also limited to shallow water in Choctawhatchee Bay. We found shoal grass near many locations for which seagrass was mapped in 2003, and we did not find seagrass where it was not mapped in 2003. There is one large continuous seagrass bed immediately inside the inlet at Destin and another at the west end of the bay along the Intracoastal Waterway entrance to Santa Rosa Sound. Other beds within the bay are very patchy.

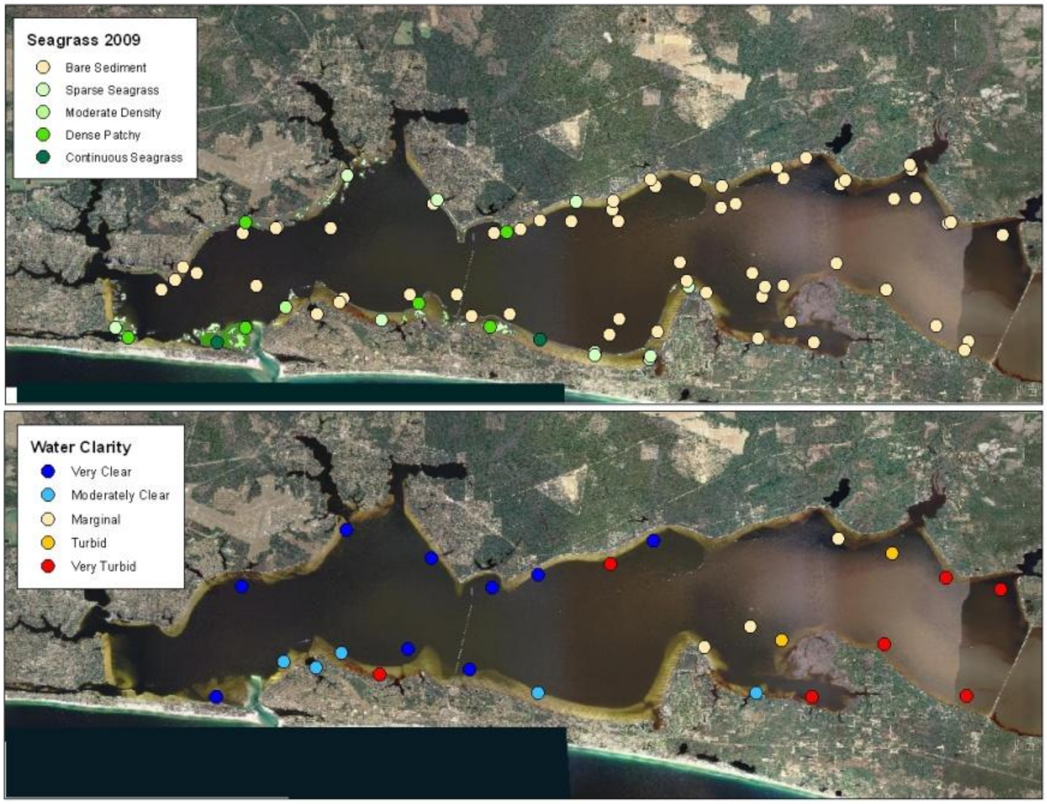

Figure 2. Location of seagrasses and water clarity in Choctawhatchee Bay, 2009.

Mapping and Monitoring Recommendations

• Continue the monitoring program begun in the summer of 2009.

• Photointerpret spring 2010 imagery for mapping to evaluate impacts of the 2004–05 hurricanes and the 2009–10 El Niño.

Management and Restoration Recommendations

• Assess the effects of storm-related reductions in salinity and increases in CDOM on survival of brackish-water seagrass in the eastern bay.

Mapping Data and Imagery: Seagrass data were derived from interpretation of color infrared photography taken in 2003. These images were mapped at 1:12,000 scale, rectified to U.S. Geological Survey (USGS) digital orthophoto quarter quadrangle base maps, and digitized at the USGS National Wetlands Research Center (NWRC). The seagrass beds were classified according to a USGS NWRC-derived classification scheme based on the Coastwatch Change Analysis Project Coastal Land Cover Classification system of the National Oceanic and Atmospheric Administration.

Monitoring Data: Monitoring was initiated in summer 2009 by FWRI staff, and data are available by contacting Paul Carlson.

2010 Deepwater Horizon Oil Spill Addendum: Fortunately, Choctawhatchee Bay was not directly affected by oil or oil products from the spill, except for occasional tar balls washing into the inlet of the bay. However, as in all estuaries along the northern Gulf coast, response activities were extensive, and impacts from oil containment booms and vessels are being evaluated.

Pertinent Reports and Scientific Publications

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Seagrass Habitat in the Northern Gulf of Mexico: http://gulfsci.usgs.gov/gom_ims/pdf/pubs_gom.pdf.

Choctawhatchee Basin Alliance, http://www.basinalliance.org/, accessed March 2011.

Proposed Nutrient Criteria for Choctawhatchee Bay, by Ashley O'Neal, FDEP: http://www.dep.state.fl.us/water/wqssp/nutrients/docs/estuarine/tallahassee/choctawhatchee_bay_082410.pdf, accessed March 2011.

Seagrass Restoration Data and Maps, Northwest District FDEP: http://www.dep.state.fl.us/northwest/ecosys/section/seagrassmaps.htm, accessed March 2011.

Contacts

Mapping: Larry Handley, Ph.D., U.S. Geological Survey National Wetland Research Center, Lafayette, Louisiana, 318-266-8691, larry_handley@usgs.gov.

Monitoring: Alison McDowell, Choctawhatchee Basin Alliance, 850-729-6423, mcdowel2@nwfstatecollege.edu; Shelley Alexander, Florida Department of Environmental Protection, 850-983-5359; shelley.alexander@dep.state.fl.us.

Management: Shelley Alexander (see above)

Florida Seagrass Integrated Mapping and Monitoring Program

Summary Report for St. Andrew Bay

Contacts: Linda Fitzhugh, Gulf Coast Community College (Monitoring); Larry Handley, U.S. Geological Survey (Mapping); and Shelley Alexander, Florida Department of Environmental Protection (Management)

General Assessment: In 2003, seagrasses covered 11,232 acres in St. Andrew Bay, and between 1992 and 2003 seagrass acreage increased 14%. Cover increased throughout the bay, but the greatest areal and fractional increases occurred in West Bay (585 acres, 30%). Based on aerial photos taken in 1953 and 1992, however, West Bay lost 49% of its seagrasses, or 1,853 acres over a 49 year period. Heavy winter rainfall in 2009 caused significant animal mortality and may also have affected seagrasses. Heavy rainfall associated with an El Niño event also occurred in fall 2009 and winter 2010.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover		Increasing	Throughout bay
Water clarity		Variable	
Nutrients		Variable	Low levels, except West Bay
Phytoplankton		Variable	Low levels, except West Bay
Propeller scarring		Significant	All shallow areas

Geographic Extent: St. Andrew Bay is located in Bay County in the Florida Panhandle. It consists of five segments: West Bay, North Bay, St. Andrew Bay proper, East Bay, and St. Andrew Sound.

Figure 1. Seagrass cover in St. Andrew Bay, 2003.

Mapping and Monitoring Recommendations

• Interpret aerial photography completed in spring 2010 and high-resolution aerial images obtained in October 2010 as part of damage assessment following the 2010 Deepwater Horizon oil spill. Photointerpretation of the spring 2010 imagery began in 2011.

• Continue and expand seagrass and water-quality monitoring. Monitoring occurs in the fall in two main areas of the bay: St. Andrew Bay (SAB), behind Shell Island, and in West Bay Bowl (WBBOWL), below the Intracoastal Waterway. Five permanent transects are sampled in SAB, and four permanent transects are sampled in WBBOWL. The St. Andrew Bay Resource Management Association also has three permanent transects in West Bay Arm (WBARM), two between Crooked and Burnt Mill creeks and a third on the opposite side of the bay, and annual monitoring will eventually incorporate these stations. Most of the sites in SAB and WBBOWL have been monitored since 2000. Water quality has been monitored in the entire St. Andrew Bay system since 1990, and data analysis comparing the water quality of WBBOWL, WBARM, and SAB has been completed. Increasing the number of permanent transects in the St. Andrew Bay system would help determine the impacts of upland development on this pristine ecosystem. Upland development in the West Bay watershed will be substantial in the next several decades as approximately 35,000 acres of forest and wetlands are converted to residential, commercial, and industrial use.

Management and Restoration Recommendations

• Assess changes in nutrient loads in WBBOWL once wastewater effluent is removed (scheduled for winter of 2010).

• Assess changes in seagrass coverage in West Bay, especially WBARM, with the completion of the new international airport. The drainage system of the new airport feeds into Crooked and Burnt Mill creeks.

• Facilitate a joint project between the St. Andrew Bay Resource Management Association and the Florida Department of Environmental Protection, Pensacola office, to study transplantation into WBBOWL of seagrasses salvaged from dock construction sites.

• Continue assessment of damage to seagrass beds, particularly those located near the inlet to the Gulf of Mexico, as a result of the response (booming, barrier construction, vessel transits) to the 2010 Deepwater Horizon oil spill. This work is being done by the National Oceanic and Atmospheric Administration (NOAA).

Seagrass Status Indicators	**Status**	**Trend**	**Assessment, Causes**
Seagrass cover		Increasing	Throughout bay
Seagrass meadow texture		Stable	Hurricanes, tropical storms
Seagrass species composition		Stable	Changing over time
Overall seagrass trends		Increasing	Possible winter storm impacts
Seagrass Stressors	**Intensity**	**Impact**	**Explanation**
Water clarity		Variable	
Nutrients		Variable	Low levels, except West Bay
Phytoplankton		Variable	Low levels, except West Bay
Natural events		Possible	Winter rains
Propeller scarring		Significant	All shallow areas

Summary Assessment: Based on data gathered in 1992 and 2003, seagrasses increased in cover in St. Andrew Bay (Table 1). However, tropical storms in 2004 and 2005 and increasing watershed development may have impacted seagrasses since the last mapping effort. In particular, the West Bay may be most vulnerable to increasing nutrient inputs due to changes in watershed use and ensuing phytoplankton blooms. Propeller scarring is extensive in all shallow areas in the bay system.

Seagrass Mapping Assessment: Seagrass beds in St. Andrew Bay expanded during the period from 1992 to 2003, with most of the increase creating continuous beds (2,205 acres). Patchy seagrass beds, however, decreased in size (804 acres). On a percentage basis, the greatest increase occurred in West Bay, and continuous beds increased by 1,495 acres. Areas showing the least change in seagrass were North Bay and St. Andrew Sound. In East Bay in particular, mapping data indicate that about half of the continuous beds in 1992 were patchy in 2003. Aerial photography scheduled for 2010 will provide an update on seagrass acreage and the effects of the storms of 2004 and 2005 and increasing development on seagrasses.

TABLE 1. SEAGRASS ACREAGE IN ST. ANDREW BAY IN 1992 and 2003

	East Bay	North Bay	St. Andrew Sound	St. Andrew Bay	West Bay	**Total**
2003						
Continuous	960	1,638	247	1,862	1722	6,429
Patchy	1,763	338	690	1,197	815	4,803
All seagrass	2,724	1,975	937	3,060	2,537	**11,232**
1992						
Continuous	1,631	988	54	1,324	227	4,224
Patchy	890	877	857	1,258	1,725	5,607
All seagrass	2,521	1,866	912	2,582	1,952	**9,832**
Percentage change 1992–2003	8.1%	5.9%	2.7%	18.5%	30.0%	**14.2%**

Monitoring Assessment: Monitoring occurs in the fall in two main areas of the bay: St. Andrew Bay (SAB), behind Shell Island, and in West Bay Bowl (WBBOWL), below the Intracoastal Waterway. Five permanent transects are sampled in SAB; four permanent transects are sampled in WBBOWL. The St. Andrew Bay Resource Management Association also has three permanent transects in West Bay Arm (WBARM), two between Crooked and Burnt Mill creeks and a third on the opposite side of the bay, and annual monitoring will eventually incorporate these stations. Most of the sites in SAB and WBBOWL have been monitored since 2000. Water quality has been monitored in the entire St. Andrew Bay system since 1990, and data analysis comparing the water quality of WBBOWL, WBARM, and SAB has been completed. Increasing the number of permanent transects in the St. Andrew Bay system will help determine the impact of upland development on this pristine ecosystem. Upland development in the West Bay watershed will be substantial in the next several decades as approximately 35,000 acres of forest and wetlands will be converted to residential, commercial, and industrial use.

Mapping and Monitoring Recommendations

• Increase the number of transects in the monitoring program.

• Photointerpret spring 2010 aerial photography and map seagrass beds, particularly to evaluate impacts of upland development.

Management and Restoration Recommendations

• Evaluate nutrient levels and inputs, particularly since any additional stress due to increased light attenuation or excessive nutrients could exacerbate seagrass losses.

• Continue assessment of damage due to response efforts from the 2010 Deepwater Horizon oil spill.

Mapping Data and Imagery: Seagrass data were derived from interpretation of color infrared photography taken in 2003. These images were mapped at 1:12,000 scale as hard copies that were rectified to U.S. Geological Survey (USGS) digital orthophoto quarter quadrangle base maps and were digitized at the USGS National Wetlands Research Center (NWRC). The seagrass beds were classified according to a USGS NWRC-derived classification scheme based on the Coastwatch Change Analysis Project Coastal Land Cover Classification system of NOAA.

Monitoring Data: St. Andrew Bay Seagrass Monitoring, Report by Linda Fitzhugh, February 2010.

2010 Deepwater Horizon Oil Spill Addendum: St. Andrew Bay was not directly impacted by the oil spill, but certain responses to the spill, including placement and removal of booms, the partial construction of a corrugated metal barrier across the inlet to the Gulf of Mexico, and vessel activities, may have impacted seagrass beds, particularly near the inlet. Damage assessment is ongoing.

Pertinent Reports and Scientific Publications

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St. Andrew Aquatic Preserve: http://www.dep.state.fl.us/coastal/sites/standrews/info.htm, accessed March 2011.

St. Andrew Bay Resource Management Association Inc.: http://www.sabrma.org/baywatch.html, accessed March 2011.

The St. Andrew Bay Watershed, Northwest Florida Water Management District: http://www.nwfwmd.state.fl.us/pubs/big_picture/st_andrew_bay.pdf, accessed March 2011.

Watershed Database and Mapping Projects/St. Andrew Bay (Florida) NOAA Office of Response and Restoration: http://response.restoration.noaa.gov/book_shelf/117_StAndrew_508.pdf, accessed March 2011.

Contacts

Mapping: Larry Handley, U.S. Geological Survey National Wetland Research Center, Lafayette, Louisiana, 318-266-8691, Larry_Handley@usgs.gov.

Monitoring: Linda Fitzhugh, Gulf Coast Community College, Panama City, Florida, 850-769-1551, ext. 2863, lfitzhugh@gulfcoast.edu.

Management: Shelley Alexander, Northwest Florida Department of Environmental Protection, 850-983-5359, shelley.alexander@dep.state.fl.us.

Florida Seagrass Integrated Mapping and Monitoring Program

Summary Report for St. Joseph Bay

Contacts: Kim Wren, Florida Department of Environmental Protection, Coastal and Marine Assessment (Monitoring and Mapping)

General Assessment: Seagrasses covered 6,672 acres in St. Joseph Bay in 2006, based on hyperspectral imagery acquired at that time. Seagrass cover and species composition appear to be stable in St. Joseph Bay, but there are questions about declines observed when aerial imagery from 1992 and 1995 are compared with the 2006 hyperspectral imagery. This difference may be related to the use of better technology and measurement techniques or to deteriorating water quality. Baseline hyperspectral imagery collected in 2006 has proved to be an important resource management tool, and this survey should be repeated to evaluate changes in the amount and condition of the bay's submerged habitats.

Collection of high-resolution imagery in 2010–11 will allow Coastal and Marine Assessment (CAMA) staff to monitor changes in physical and biological conditions over the four to five years since the most recent survey and to detect any effects of declining water quality. CAMA staff will overlay the images from 2006 and 2010 to analyze changes in seagrass species, coverage, depth, propeller scarring, and water quality. The newly acquired imagery will allow staff to identify areas in the bay where increased management emphasis under the 2008 management plan may be necessary.

Increased propeller scarring is also evident in St. Joseph Bay.

Seagrass Status and Stresses	Status	Trend	Assessment, Causes
Seagrass cover		Declining	Losses, 1995–2006
Water clarity		Improving	Affected by runoff, storms
Natural events		Minimal impact	Hurricanes
Propeller scarring		Extensive	

Geographic Extent: St. Joseph Bay is located in the central Florida Panhandle in Gulf County (Figure 1). The bay is bounded on the eastern shoreline by the city of Port St. Joe and St. Joseph Bay State Buffer Preserve lands and on the west by the St. Joseph Peninsula and St. Joseph Peninsula State Park. The total surface area of the bay at mean high water is approximately 43,872 acres (Hemming et al. 2002).

Mapping and Monitoring Recommendations

• Acquire coastal imagery using the Worldview satellite and compare it with hyperspectral imagery collected in 2006.

• Continue annual on-ground monitoring and mapping efforts with more focus on deeper (> 3 ft) areas. A regular monitoring program has been ongoing since 2002. Monitoring has evolved from five fixed-transect sites to 25 fixed-point stations. Monitoring four 1-m^2 quadrats at each station results in the analysis and mapping of 100 stations in the bay.

Management and Restoration Recommendations

• Assess the effects of development pressures on storm runoff.

• Decrease propeller scarring.

Summary Assessment: Seagrass cover and species composition in St. Joseph Bay are stable; however, propeller scarring has increased in the southern portion of the bay (Figure 2). Monthly nutrient monitoring at seven sites in the bay has also indicated increased nitrogen in the bay which may be the cause of increased algal growth and epiphyte coverage on seagrass blades.

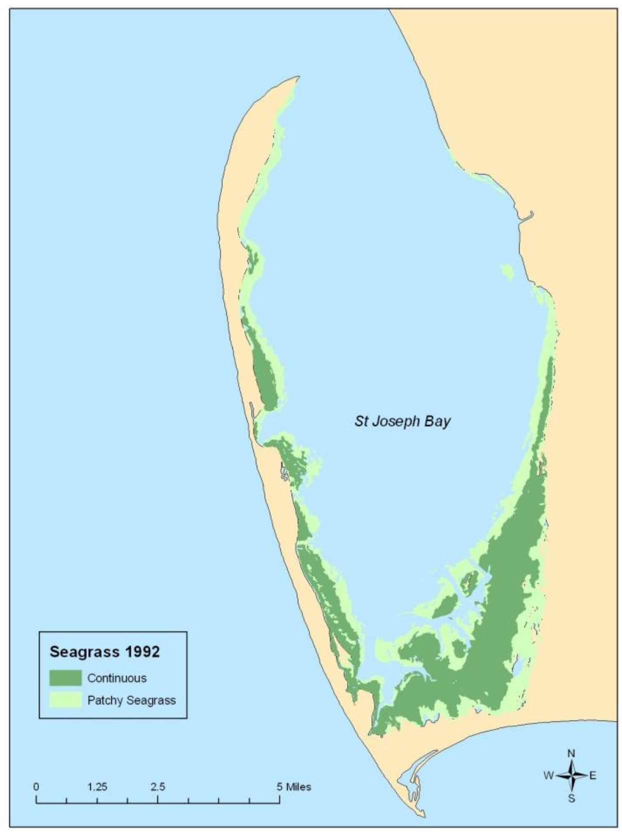

Figure 1. Seagrass cover in St. Joseph Bay, 1992.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover		Declining	Losses, 1995–2006
Seagrass meadow texture		Stable	
Seagrass species composition		Stable	
Overall seagrass trends		Declining	Epiphyte loading, scarring
Seagrass Stressors	**Intensity**	**Impact**	**Explanation**
Water clarity		Improving	Affected by runoff, storms
Nutrients		Relatively low	Affected by runoff, storms
Phytoplankton		Relatively low	Affected by runoff, storms
Natural events		Minimal impact	Hurricanes
Propeller scarring		Extensive	

Seagrass Mapping Assessment: Seagrass acreage in St. Joseph Bay appears to have decreased between 1992 and 2006, from 9,740 acres to 6,672 acres (Table 1); however, the acreage estimates are based on data collected using two methods. In 1992 and 1993, cover estimates were made using aerial photography; in 2006, hyperspectral imagery was interpreted to estimate seagrass cover. Hyperspectral imagery collected in 2010 will provide another assessment of trends. In 1992–93, about half of all seagrass beds (4,840 acres) exhibited propeller scarring (Figure 2). By 2006, scarred areas had been reduced to 1,900 acres, but moderately scarred areas had increased by 900 acres.

TABLE 1. SEAGRASS ACREAGE IN ST. JOSEPH BAY IN 1992, 1993, AND 2006

Category	1992	1993	2006	Change 1993--2006	Percent Change
All seagrass	9,740	8,170	6,672	−1,498	−18.3
Lightly scarred		4,200	448	−3,752	−89.3
Moderately scarred		530	1,430	900	170
Severely scarred		110	21	−89	−80.9

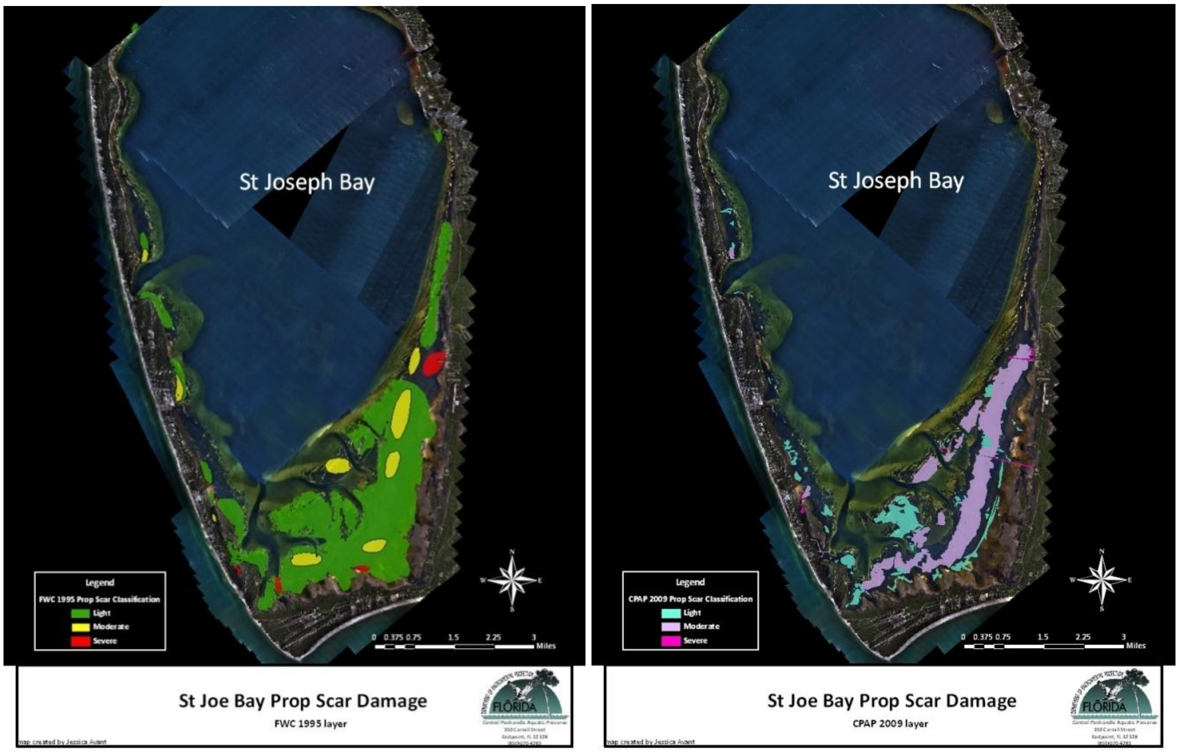

Figure 2. Hyperspectral imagery interpreted to show propeller scarring in 1992 and 2006.

Monitoring Assessment: St. Joseph Bay seagrass beds were monitored by Florida Department of Environmental Protection (FDEP) CAMA staff twice a year from 2002 through 2008 at fixed locations (Figure 3). Since 2009, seagrass monitoring has been conducted annually. In recent years, seagrass beds appear stable in size and species composition. Turtle grass (*Thalassia testudinum*) is the dominant species found in the bay and occurs at depths to 9 ft. Manatee grass (*Syringodium filiforme*) occurs frequently with turtle grass and is predominantly located in areas along the eastern shoreline of the bay. Epiphyte loads on seagrass blades are increasing, presumably due to increasing nutrients in the water column, and propeller scarring continues to affect seagrass beds.

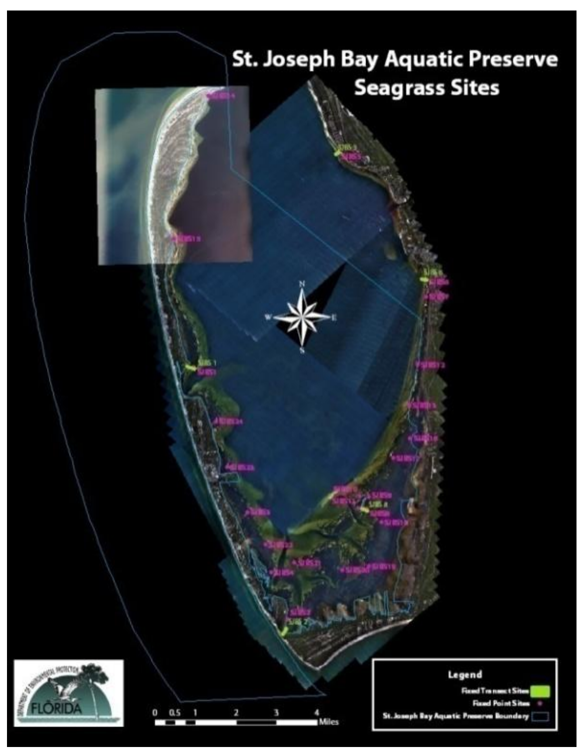

Figure 3. Seagrass monitoring sites in St. Joseph Bay.

Mapping and Monitoring Recommendations

• Continue annual on-ground monitoring.

• Regularly obtain satellite imagery and mapping data to assess changes in habitat.

• Secure assistance with data analysis, including comparing transect data with fixed-point data.

• Analyze hyperspectral imagery to determine the extent of patchy seagrass vs. continuous seagrass.

• Assess propeller scarring from 2010 satellite imagery.

Management and Restoration Recommendations

• Address potential increases in nutrients in the bay and determine nutrient sources.

• Minimize propeller scarring and investigate funding opportunities for restoration efforts in areas with the most damage.

Mapping Data and Imagery: In 1992, seagrass distribution for the Gulf Coast of Florida from Anclote Key to the Alabama–Florida line was interpreted from natural color aerial photographs (1:24,000 scale). The joint National Wetlands Research Center/National Oceanic and Atmospheric Administration seagrass mapping protocol was used, and the abundance of seagrasses in St. Joseph Bay was estimated at 9,740 acres. Sargent et al. (1995) used the 1992 and 1993 aerial photography of St. Joseph Bay to estimate the total area of seagrass beds in the bay. Habitat coverage was estimated at 8,170 acres; of this, 4,200 acres were lightly scarred, 530 acres were moderately scarred, and 110 acres were severely scarred. Overall, 4,840 acres of habitat showed some amount of propeller scarring. In the fall of 2006, a hyperspectral spectroradiometer with high resolution was used to acquire imagery of the bay. Areal extent, abundance and productivity of seagrass meadows, as well as shallow-water (< 2 m) bathymetry were quantified and mapped using a combination of algorithms and models. Seagrass beds were distinguished from surrounding sand and optically deep water using unique reflectance characteristics in the near infrared. Retrieved bathymetry and modeled water-column optical properties were then used to estimate the absolute reflectance of seagrass. Statistical relationships between reflectance, leaf area index, and biomass were then used to calculate total seagrass productivity in St. Joseph Bay. The areal extent of seagrass in the bay was estimated to be 27 km^2, or 6,672 acres, which is 17% of the total footprint of the bay.

Between 1993 and 2006, St. Joseph Bay lost approximately 6 km^2 (1,498 acres) of seagrass habitat. This might be due to deterioration of water quality or could reflect differences in measurement techniques, i.e., radiometrically calibrated images vs. aerial photographs where darker areas of sand could be identified as seagrass, the spatial resolution of the hyperspectral sensor as compared with aerial photography, or errors in calculating areas by drawing polygons around beds of identified seagrass. There may also be interannual variability in seagrass growth that is not measured because aerial surveys are not performed annually.

Monitoring Data: Seagrasses have been monitored in St. Joseph Bay each year since 2002 by FDEP CAMA staff. Seagrass and macroalgal cover are estimated by species for four quadrats at 25 fixed sites throughout the bay (Figure 3). Other data collected include canopy height, epiphyte coverage and type, sediment type, other organisms present, biomass samples (taken occasionally), epiphyte samples for laboratory analysis, underwater photographs or video, and depth. Water quality parameters include dissolved oxygen, temperature, salinity, pH, turbidity, Secchi depth, and light attenuation.

2010 Deepwater Horizon Addendum: While oil and oil products from the 2010 spill did not directly affect St. Joseph Bay, booms were placed across the opening on the north side of the bay during the incident, and seagrass may have been damaged by booms and vessels.

Pertinent Reports and Scientific Publications

Preserve staff is analyzing seagrass data for the Central Panhandle Aquatic Preserves (Alligator Harbor, Apalachicola Bay, and St. Joseph Bay). Plans include the development of a seagrass technical report for the area as well as a *State of the Coast* report for CAMA.

HEMMING, J. M., M. BRIM, and R. B. JARVIS. 2002. Survey of dioxin and furan compounds in sediments of Florida Panhandle bay systems. U.S. Fish and Wildlife Service Publication number PCFO-EC 02-01, Panama City, Florida. 92 p.

PETERSON, B. J., and K. L. HECK JR. 2001. Positive interactions between suspension-feeding bivalves and seagrass—a facultative mutualism. Marine Ecology Progress Series 213: 143–155.

SARGENT, F. J., T. J. LEARY, D. W. CREWZ, and C. R. KRUER. 1995. Scarring of Florida's seagrasses: assessment and management options. Florida Marine Research Institute Technical Report TR-1, Florida Department of Environmental Protection, St. Petersburg, Florida. 37 p. + appendices.

General References and Additional Information

Central Panhandle Aquatic Preserves:
http://www.dep.state.fl.us/water/wqssp/nutrients/docs/estuarine/apalachicola/st_joe_bay_overview.pdf, accessed March 2011.

Resource database for Gulf of Mexico research: St. Joseph Bay:
http://www.gulfbase.org/bay/view.php?bid=sjb, accessed March 2011.

St. Joseph Bay Aquatic Preserve management plan, September 2008 through August 2018:
http://www.dep.state.fl.us/COASTAL/sites/stjoseph/pub/StJosephBay_2008.pdf, accessed March 2011.

St. Joseph Bay Aquatic Preserve:
http://www.dep.state.fl.us/COASTAL/sites/stjoseph/science/seagrass.htm, accessed March 2011.

Contacts: Mapping and Monitoring: Kim Wren, Florida Department of Environmental Protection, Coastal and Marine Assessment, 850-670-4783, ext. 104, kim.wren@dep.state.fl.us.

Florida Seagrass Integrated Mapping and Monitoring Program

Summary Report for Franklin County Coastal Waters

Contacts: Ron Mezich and Kent Smith, Habitat Species Conservation, Fish and Wildlife Conservation Commission (Monitoring); Paul Carlson, Fish and Wildlife Research Institute, Fish and Wildlife Conservation Commission (Mapping)

General Assessment: The most recent seagrass mapping effort in the coastal waters of the Florida Panhandle's Franklin County was completed from aerial photography taken in 1992. At that time, Franklin County waters contained approximately 14,450 acres of seagrass, almost half of which was located near Dog Island Reef (Figure 1). The size of seagrass beds appears to be decreasing, but species composition remains fairly stable. However, increasing development within the watershed raises concerns about decreasing water clarity and quality. Some areas are affected by propeller scarring, and epiphyte loading on seagrass blades is quite heavy in some locations. Runoff from the Ochlockonee and Apalachicola rivers contributes considerable freshwater, color, and turbidity to this region during stormy periods. Excessive runoff from the 2009–10 El Niño may have had impacts on seagrasses.

Seagrass Status and Stresses	Status	Trend	Assessment, Causes
Seagrass cover		Stable	
Water clarity		Good	Affected by runoff, storms
Natural events		Minimal impact	2004, 2005 hurricanes
Propeller scarring		Localized	

Geographic Extent: Franklin County coastal waters extend from Alligator Harbor in the east to St. Georges Sound, ending at the causeway on the western side of St. Georges Island, and include St. Vincent Sound, Apalachicola Bay, St. Georges Sound, Dog Island Reef, and Alligator Harbor and shoal.

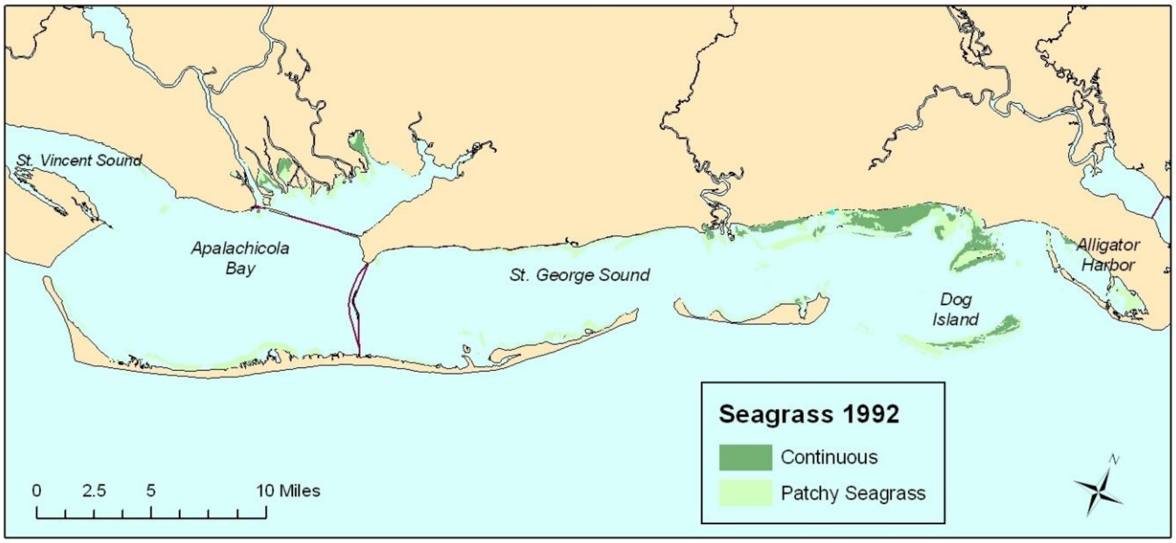

Figure 1. Seagrass cover in Franklin County coastal waters, 1992.

Mapping and Monitoring Recommendations

• Continue seagrass monitoring. Fish and Wildlife Conservation Commission (FWC) staff have monitored seagrasses each summer since 2006.

• Photointerpret the high-resolution aerial photography obtained in October 2010 as part of damage assessment following the Deepwater Horizon oil spill.

Management and Restoration Recommendations

• Assess the effects of development on storm runoff.

• Decrease propeller scarring.

Summary Assessment: In 1992, Franklin County coastal waters contained 14,452 acres of seagrass, with 6,937 acres found at Dog Island Reef, 3,562 acres in St. Georges Sound, 3,146 acres in Apalachicola Bay, 755 acres in Alligator Harbor and associated shoal, and 52 acres in St. Vincent Sound (Table 1). Aerial photography was completed in 2010. Monitoring assessment indicates that, overall, seagrass coverage is decreasing, except near Dog Island Reef. Optical water quality measurements indicate that water clarity is declining, probably a result of storm runoff from heavy to extreme winter rain events in 2008 and 2009.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover		Declining	Runoff, nutrients
Seagrass meadow texture		Fairly stable	No significant changes
Seagrass species composition		Fairly stable	No significant changes
Overall seagrass trends		Declining	Potential nutrient impacts
Seagrass Stressors	**Intensity**	**Impact**	**Explanation**
Water clarity		Declining	Affected by runoff, storms
Nutrients		Increasing	Affected by runoff, storms
Phytoplankton		Increasing	Affected by runoff, storms
Natural events		Minimal impact	2004, 2005 hurricanes
Propeller scarring		Localized	

Seagrass Mapping Assessment: See the summary above. Mapping of photography obtained in 2010 should provide trend and change data.

TABLE 1. SEAGRASS ACREAGE IN FRANKLIN COUNTY COASTAL WATERS IN 1992

St. Vincent Sound	52
Apalachicola Bay	3,146
St. George Sound	3,562
Dog Island Reef	6,937
Alligator Harbor and Shoal	755
Total	**14,452**

Monitoring Assessment: Annual monitoring has been conducted during the summer since 2006. Seagrass beds are decreasing in size but stable in species composition. Epiphyte loads on seagrass blades are increasing, presumably due to increasing nutrients in the water column. Propeller scarring continues to affect seagrass beds. In 2009, seagrasses were least abundant in Alligator Harbor and near St. Georges Island, where more than 80% of the quadrats surveyed were bare of seagrasses (Figure 2). In waters near St. Georges Island, shoal grass (*Halodule wrightii*) was the only seagrass observed, and it was the only seagrass species found in every subregion of Franklin County coastal waters. In the other six subregions, manatee grass (*Syringodium filiforme*) occurred in 5–45% of the quadrats surveyed, and turtle grass (*Thalassia testudinum*) occurred in 7–33% of quadrats surveyed.

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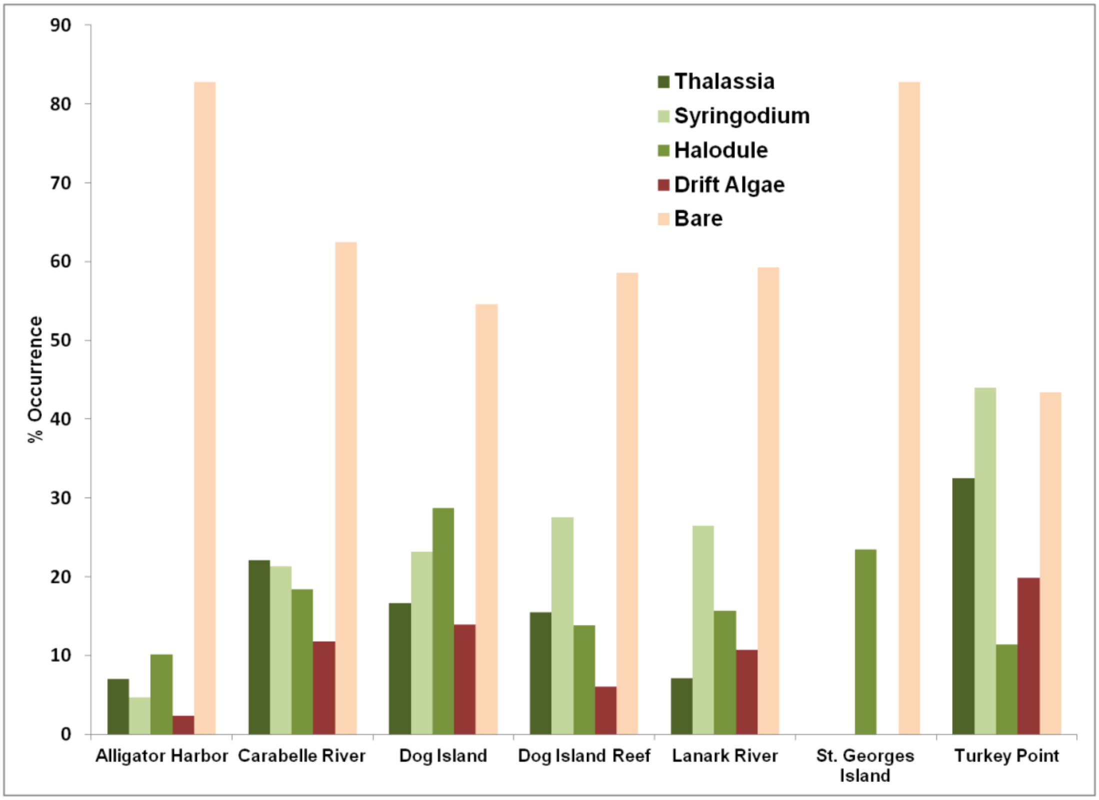

Figure 2. Occurrence of seagrasses and drift algae in quadrats evaluated in subregions of Franklin County coastal waters, 2009.

Mapping and Monitoring Recommendations

• Continue annual routine monitoring program.

• Obtain aerial photography and mapping data on a regular schedule.

• Photointerpret high-resolution aerial photography obtained in October 2010 as part of damage assessment following the Deepwater Horizon oil spill.

Management and Restoration Recommendations

• Address potential increases in nutrients in coastal waters and determine the sources of nutrients.

• Evaluate effects of winter storm runoff from the Apalachicola and Ochlockonee rivers on available light during the following spring.

• Minimize propeller scarring and conduct restoration efforts in highly impacted areas.

Mapping Data and Imagery: The northwest Florida seagrass mapping data set, using imagery obtained in December 1992 and early 1993, was created by the U.S. Geological Survey (USGS) Biological Resources Division at the National Wetlands Research Center in Lafayette, Louisiana. The study area was from Anclote Key to Perdido Bay on the Alabama–Florida state line and includes the coastal waters of Franklin County. Imagery was natural color at 1:24,000 scale. Aerial photographs were interpreted and delineated by USGS, then transferred to a base map using a zoom transfer scope. The maps were digitized into ArcInfo software. Photointerpretation of imagery acquired in 2010 is under way.

Monitoring Data: Since 2006, a spatially distributed, random sampling design has been used to monitor seagrasses in each of seven subregions of Franklin County coastal waters during the summer. At each sampling site, seagrass cover is estimated using a modification of the Braun-Blanquet technique. Species composition of seagrasses and macroalgae and optical water quality parameters (light attenuation, color, turbidity, total suspended solids, chlorophyll-a concentrations) are measured as well. For more information, contact Ron Mezich, FWC Habitat and Species Conservation, or Paul Carlson at the Fish and Wildlife Research Institute.

2010 Deepwater Horizon Oil Spill Addendum: While this region of the northern Gulf coast did not receive direct impacts from the oil spill, extensive response efforts (booms, vessel activity) may have affected seagrass beds.

Pertinent Reports and Scientific Publications

CHANTON, J., and F. G. LEWIS. 2002. Examination of coupling between primary and secondary production in a river-dominated estuary: Apalachicola Bay, Florida, U.S.A. Limnology and Oceanography 47: 683–697.

HAYS, C. G. 2005. Effect of nutrient availability, grazer assemblage and seagrass source population on the interaction between *Thalassia testudinum* (turtle grass) and its algal epiphytes. Journal of Experimental Marine Biology and Ecology 314: 53–68.

General References and Additional Information

Central Panhandle Aquatic Preserves:
http://www.dep.state.fl.us/water/wqssp/nutrients/docs/estuarine/apalachicola/st_joe_bay_overview.pdf, accessed March 2011.

Contacts

Mapping: Paul Carlson, Fish and Wildlife Research Institute, Florida Fish and Wildlife Conservation Commission, 727-896-8626; paul.carlson@myfwc.com.

Monitoring: Ron Mezich, FWC Habitat and Species Conservation, 850-922-4330, ron.mezich@myfwc.com; Kent Smith, FWC Habitat and Species Conservation, 850-922-4330, kent.smith@myfwc.com.

Florida Seagrass Integrated Mapping and Monitoring Program

Summary Report for Northern Big Bend Region

Contacts: Laura Yarbro (Monitoring) and Paul Carlson (Mapping), Fish and Wildlife Research Institute, Florida Fish and Wildlife Conservation Commission

General Assessment: The northern Big Bend region contained 149,140 acres of seagrass in 2006. Seagrass cover in northern Big Bend is stable, although slight declines were noted between the St. Marks and Ochlockonee rivers. Seagrass species composition also appears to be stable. Fragmentation of continuous seagrass beds into patchy beds is cause for concern. Stressors include nutrients, phytoplankton, and turbidity. These stressors were elevated after the 2004 and 2005 hurricane seasons, but they have returned to background levels. Heavy propeller scarring is evident around the St. Marks River mouth, Keaton Beach, and Steinhatchee but is minimal elsewhere.

Seagrass Status and Stresses	Status	Trend	Assessment, Causes
Seagrass cover		Fairly stable	Slight gains, 2001–06
Water clarity		Good	Affected by runoff, storms
Natural events		Minimal impact	2004, 2005 hurricanes
Propeller scarring		Localized	St. Marks, Keaton Beach

Geographic Extent: This region extends from the mouth of the Ochlockonee River in the west (shown at far left, Figure 1) to the mouth of the Steinhatchee River in the southeast (right, Figure 1). Dark and light green polygons show the extent of mapped continuous and patchy seagrass, respectively. Seagrass beds extend a considerable distance into deeper water but are not shown in Figure 1.

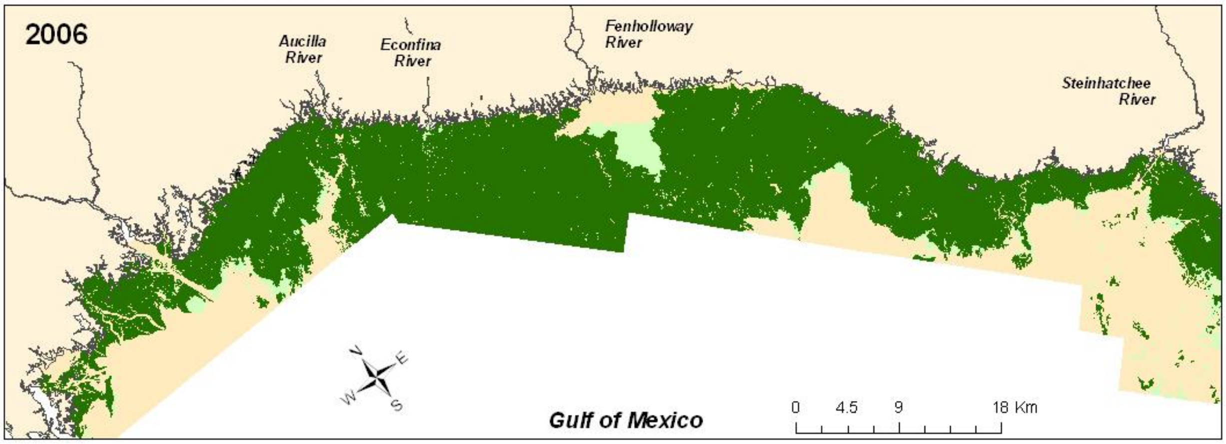

Figure 1. Seagrass cover in the northern Big Bend, 2006.

Mapping and Monitoring Recommendations

• Map and monitor seagrasses in water too deep for conventional aerial photography.

• Map the entire region again in 2011–12.

• Continue annual on-ground monitoring.

• Establish a monitoring program near the mouth of the Ochlockonee River.

• Monitor the effects of improved quality of freshwater discharged from the Fenholloway River on seagrass beds located offshore.

Management and Restoration Recommendation

• Assess changes in nutrient loads in Ochlockonee, St. Marks, Aucilla, Econfina, Fenholloway, and Steinhatchee rivers.

Summary Assessment: Seagrass cover in northern Big Bend is stable, although slight losses were noted between the St. Marks and Ochlockonee rivers. Seagrass species composition also appears to be stable. However, mapping data suggest that as much as 2,720 acres of continuous seagrass beds converted to patchy beds between 2001 and 2006, which is cause for concern. Stressors include nutrients, phytoplankton, and turbidity; increases in these water quality parameters decrease light available to seagrass beds. These stressors were elevated after the 2004 and 2005 hurricane seasons, but they returned to background levels. After the extreme storm events of the 2009–10 winter, phytoplankton and turbidity were still elevated in

July 2010, especially in the Econfina subregion. Heavy propeller scarring is evident around the St. Marks River mouth, Keaton Beach, and Steinhatchee but is minimal elsewhere.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover		Fairly stable	Slight gains, 2001–06
Seagrass meadow texture		Fragmenting	St. Marks, Steinhatchee
Seagrass species composition		Fairly stable	No significant changes
Overall seagrass trends		Fairly stable	Potential nutrient impacts
Seagrass Stressors	**Intensity**	**Impact**	**Explanation**
Water clarity		Relatively low	Affected by runoff, storms
Nutrients		Relatively low	Affected by runoff, storms
Phytoplankton		Relatively low	Affected by runoff, storms
Natural events		Minimal impact	2004, 2005 Hurricanes
Propeller scarring		Localized	St. Marks, Keaton Beach

Seagrass Mapping Assessment: Between 2001 and 2006, total seagrass cover for northern Big Bend (excluding the area immediately offshore of the mouth of the Fenholloway River) declined from 149,840 acres to 149,140 acres, a decrease of 700 acres, or 0.5% (Table 1). This represents a loss of 840 acres near the Ochlockonee River and marginal gains elsewhere in the region. Most (95%) of the seagrass beds in the northern Big Bend are large and continuous. However, during this five-year period patchy seagrass area increased 61%, from 4,490 acres to 7,210 acres, as continuous seagrass area declined by 3,420 acres (2.3%), from 145,350 acres to 141,930 acres. Fragmentation of beds is cause for concern, especially in the St. Marks East and Steinhatchee North subregions. However, some of the fragmentation may have resulted from the 2004 and 2005 hurricanes.

The 2001 and 2006 mapping efforts did not extend far enough offshore to capture the deep edge of seagrass beds in the northern Big Bend. Furthermore, there are extensive, but sparse, beds of paddle grass (*Halophila decipiens*) offshore that cannot be mapped with conventional aerial photography. These beds probably serve as a bridge for grouper and other important fish and shellfish species as they migrate inshore and offshore.

TABLE 1. SEAGRASS ACREAGE IN NORTHERN BIG BEND IN 2001 AND 2006

Habitat Type	St. Marks West	St. Marks East	Aucilla	Econfina	Keaton Beach	Stein* North	All Regions
Acres in 2001							
Patchy	230	760	920	140	1,220	1,220	4,490
Continuous	15,710	15,610	24,550	28,510	38,080	22,890	145,350
All seagrass	15,940	16,370	25,470	28,650	39,300	24,110	**149,840**
Acres in 2006							
Patchy	1,180	1,780	1,150	280	1,220	1,600	7,210
Continuous	13,920	14,630	24,360	28,390	38,100	22,530	141,930
All seagrass	15,100	16,410	25,510	28,670	39,320	24,130	**149,140**
Change 2001–06							
Patchy	950	1,020	230	140	0	380	2,720
Continuous	−1,790	−980	−190	−120	20	−360	−3,420
All seagrass	−840	40	40	20	20	20	**−700**

*Steinhatchee

Monitoring Assessment: Big Bend seagrass beds are monitored each summer by Fish and Wildlife Commission (FWC) staff and collaborators. The number of samples each year has varied between 450 and 600, so results in Table 2 are expressed as the percentage of samples in which each seagrass species was found.

TABLE 2. OCCURRENCE (%) OF SEAGRASS SPECIES IN NORTHERN BIG BEND

Year	No Seagrass	Star Grass	Shoal Grass	Manatee Grass	Turtle Grass	Widgeon Grass	Drift Algae
2004	17.9	8.7	29	55.2	35.7	4.8	34.5
2005	13.1	7.5	30.3	50.3	46.7	0.3	15.8
2008	23.5	15.4	17.3	56.4	33.7	0	29.2
2009	23.5	10.0	15.0	61.0	42.7	0.9	17.4

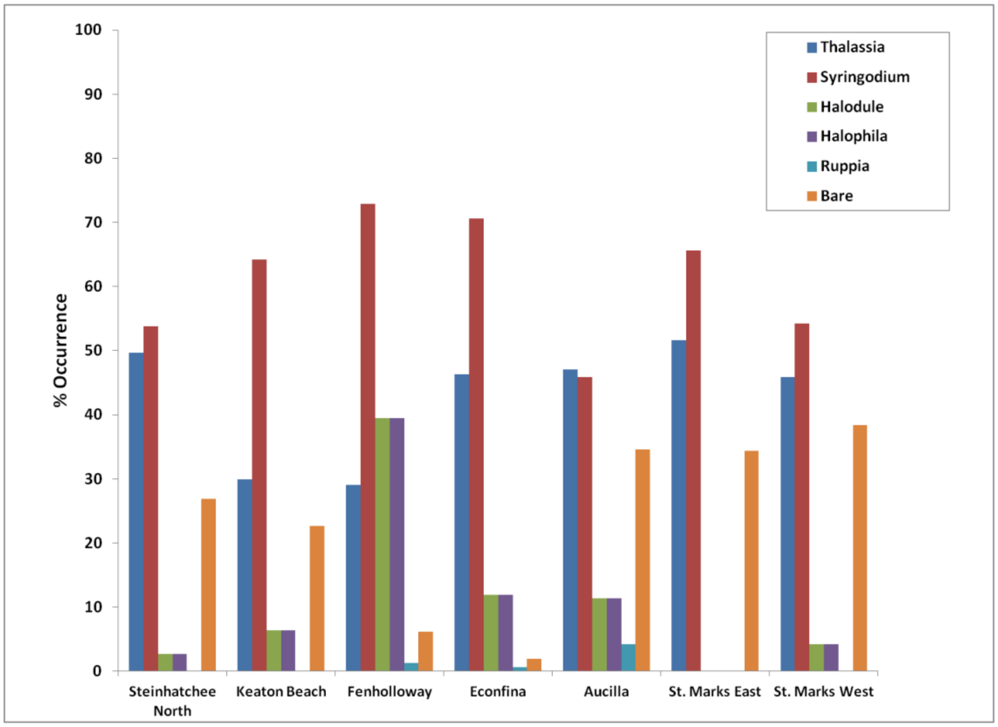

Figure 2. Percentage occurrence of seagrass species in the subregions of northern Big Bend, 2009.

Manatee grass (*Syringodium filiforme*) occurs at more sampling locations than turtle grass (*Thalassia testudinum*), but the two species frequently occur together (Table 2). Both of these seagrasses increased in occurrence in 2009 above levels observed in the previous five years. The number of sampling locations with shoal grass (*Halodule wrightii*) appears to have declined over the past five years—a potentially disturbing trend because 1) shoal grass often occurs at the deep edge of seagrass beds, and 2) it is subject to light stress if water clarity deteriorates. Star grass (*Halophila engelmannii*) occurred in 7.5–15% of all sampling locations from 2004 through 2009. The occurrence of widgeon grass (*Ruppia maritima*) dropped off sharply from 5% in 2004 and has remained at low levels since. The number of samples with no seagrass increased between 2005 and 2008 and remained unchanged in 2009 (23.5%). It is unclear whether this seagrass loss will continue. However, in 2009, drift red macroalgae occurred at nearly 2005 levels (17.4% of sites evaluated), down from 29% in 2008.

In 2009, seagrasses were present in more than 70% of sampling locations, with greatest occurrence in the Fenholloway and Econfina subregions (Figure 2). Manatee grass occurred more than 50% of the time at all subregions except Aucilla. Turtle grass was the second most abundant seagrass at all sites except Fenholloway, where turtle grass and star grass were equally abundant and occurred at nearly 40% of the sites. Shoal grass and star grass were found more frequently in Fenholloway and Econfina than in other areas of the northern Big

Bend. The Aucilla and St. Marks subregions had the greatest occurrence (> 30%) of bare quadrats.

Mapping and Monitoring Recommendations

- Map and monitor seagrasses in water too deep for conventional aerial photography.
- Acquire imagery and map the entire region again in 2011–12.
- Continue annual on-ground monitoring, especially near Ochlockonee River.
- Monitor the effects of improved water quality in the Fenholloway River discharge on offshore areas.

Management and Restoration Recommendation

- Assess changes, if any, in nutrient loads in Ochlockonee, St. Marks, Aucilla, Econfina, Fenholloway and Steinhatchee rivers.

Mapping Data and Imagery: In 2001, natural color aerial photography of the Big Bend region was flown at 1:24,000 scale for the Suwannee River Water Management District (SRWMD) by U.S. Imaging. The location of the original negatives is not known, but copies are housed at SRWMD headquarters in Live Oak, Florida. Benthic habitats were classified and mapped from this dataset by Avineon Inc. using the Florida Land Use Cover Classification System (Florida Department of Transportation, 1999). ArcMap shapefiles of benthic habitats are distributed on the Fish and Wildlife Research Institute (FWRI) Marine Resources Geographic Information System (MRGIS) website (http://ocean.floridamarine.org/mrgis/). In 2006, the Florida Department of Transportation acquired digital aerial imagery of Big Bend seagrass beds taken with a Zeiss DMC digital camera. Digital 3-band color imagery is available from Paul Carlson, FWRI, and from the Marine Resources Aerial Imagery Database (MRAID) website (http://myfwc.com/research/gis/data-maps/marine/mraid/). Benthic habitats were classified and mapped from 2006 imagery by Photoscience Inc. (Contact: Richard Eastlake). ArcMap shapefiles of benthic habitats based on the 2006 imagery are also distributed on the FWRI MRGIS website.

Monitoring Data: Seagrass monitoring has been conducted in the northern Big Bend each summer since 2002 by FWC staff and collaborators. Seagrass and macroalgal cover are estimated by species for 8–10 0.25 m^2 quadrats at approximately 120 spatially distributed, randomly selected sites throughout the region. Optical water quality measurements (light attenuation, turbidity, color, total suspended solids, and chlorophyll-a concentration) are made at every site as well.

2010 Deepwater Horizon Oil Spill Addendum: While the northern Big Bend was spared impacts from oil and oil products from the 2010 oil spill, response activities, including placement of booms and heightened vessel activity, occurred in the St. Marks subregion. Damage assessment is under way.

Pertinent Reports and Scientific Publications

CARLSON, P. R., L. A. YARBRO, K. K. KAUFMAN, and R. A. MATTSON. 2010. Vulnerability and resilience of west Florida seagrass communities to hurricane impacts. Hydrobiologia 649: 39–53.

DAWES, C. J., R. C. PHILLIPS, and G. MORRISON. 2004. Seagrass communities of the Gulf coast of Florida: status and ecology. Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute and the Tampa Bay Estuary Program. St. Petersburg, Florida. iv + 74 p.

http://www.sarasota.wateratlas.usf.edu/upload/documents/Seagrass-Communities-Status-and-Ecology.pdf, accessed March 2011.

HALE, J. A., T. K. FRAZER, D. A. TOMASKO, and M. O. HALL. 2004. Changes in the distribution of seagrass species along Florida's central Gulf coast: Iverson and Bittaker revisited. Estuaries and Coasts 27: 36–43.

HAMMERSTROM, K. K., W. J. KENWORTHY, M. S. FONSECA, and P. E. WHITFIELD. 2006. Seed bank, biomass, and productivity of *Halophila decipiens,* a deep water seagrass on the west Florida continental shelf. Aquatic Botany 84: 110–120.

IVERSON, R. L., and H. F. BITTAKER. 1986. Seagrass distribution and abundance in eastern Gulf of Mexico coastal waters. Estuarine, Coastal and Shelf Science 22: 577–602.

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MATTSON, R. A., T. K. FRAZER, J. HALE, S. BLITCH, and L. AHIJEVYCH. 2007. Florida Big Bend. Pp. 171–188 *in* L. Handley et al., eds. Seagrass status and trends in the northern Gulf of Mexico, 1940–2002. United States Geological Survey Scientific Investigations Report 2006-5287 and U.S. Environmental Protection Agency 855-R-04-003, Washington, D.C. 267 p.

General References and Additional Information

Big Bend Seagrasses Aquatic Preserve:
http://www.dep.state.fl.us/coastal/sites/bigbend/info.htm, accessed March 2011.

Faunal Communities in Seagrass Meadows:
http://www.marinelab.fsu.edu/faculty/seagrass.aspx, accessed March 2011.

Contacts

Mapping: Paul Carlson, Florida Fish and Wildlife Research Institute, 727-896-8626, paul.carlson@fwc.state.fl.us.

Monitoring: Laura Yarbro, Florida Fish and Wildlife Research Institute, 727-896-8626, laura.yarbro@fwc.state.fl.us.

Florida Seagrass Integrated Mapping and Monitoring Program

Summary Report for Southern Big Bend Region

Contacts: Laura Yarbro (Monitoring) and Paul Carlson (Mapping),
Florida Fish and Wildlife Research Institute, Fish and Wildlife Conservation Commission

General Assessment: Seagrass cover in the southern Big Bend region declined between 2001 and 2006, and historical change analyses indicate that losses have been occurring for more than 25 years. In 2006, seagrasses covered 56,146 acres, mostly as continuous beds (44,109 acres). Between 2001 and 2006, the southern Big Bend experienced a net loss of about 3,500 acres (6%) of its seagrass, which reflects the deterioration of 7,100 acres of continuous beds into only 3,600 acres of patchy beds. Most seagrass beds are located in the Steinhatchee and Horseshoe West subregions, and declines were greatest in the Horseshoe West subregion.

Seagrass Status and Stresses	Status	Trend	Assessment, Causes
Seagrass cover		Declining	Significant losses, 2001–06
Water clarity		Poor	Affected by runoff, storms
Natural events		Serious impact	2004, 2005 hurricanes
Propeller scarring		Localized	Horseshoe Beach

Geographic Extent: This region extends from the mouth of the Suwannee River north to the mouth of the Steinhatchee River (Figure 1). Dark and light green polygons show extent of mapped continuous and patchy seagrass, respectively. Seagrass beds also extend a considerable distance into deeper water, where conventional mapping techniques cannot be used; these deepwater beds are not shown in Figure 1.

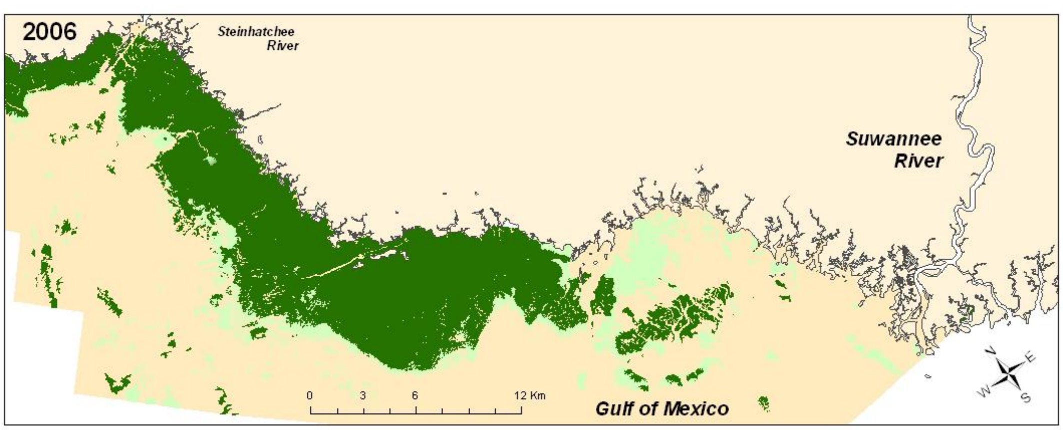

Figure 1. Seagrass cover in the southern Big Bend region in 2006.

Mapping and Monitoring Recommendations

• Map and monitor seagrasses in water too deep for conventional aerial photography.

• Acquire imagery and map the entire region again in 2011–12.

• Continue annual on-ground monitoring from the mouth of the Suwannee River to the mouth of the Steinhatchee River.

• Implement regular water quality monitoring.

Management and Restoration Recommendations

• Assess changes in nutrient loads in the Suwannee River, and evaluate the effects of changing coastal optical water quality on the extent and location of seagrass beds.

• Assess potential impacts of herbicides used for control of hardwood species in pine plantations.

Summary Assessment: Seagrass cover in the southern Big Bend declined significantly between 2001 and 2006 (Table 1). Mapping data from 1984 suggest that seagrass loss has been occurring for more than 25 years. Conversion of continuous seagrass beds to patchy beds is also cause for concern. Stressors include nutrients, phytoplankton, and turbidity associated with runoff from the Suwannee River, and these stressors, in turn, increase light attenuation in the water column. Impacts of river discharge extend as far as 40 km north and west of the river mouth and probably contribute to the observed decrease in acreage and species occurrence between the northern and southern Big Bend regions. Seagrass species shifts attributable to light stress have also been observed.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover		Declining	Significant losses, 2001–06
Seagrass meadow texture		Fragmenting	Steinhatchee, Horseshoe West
Seagrass species composition		Declining	Less manatee, shoal grass
Overall Seagrass Trends		Declining	Storms, runoff impacts
Seagrass Stressors	**Intensity**	**Impact**	**Explanation**
Water clarity		Poor	Affected by runoff, storms
Nutrients		Relatively high	Affected by runoff, storms
Phytoplankton		Relatively high	Affected by runoff, storms
Natural events		Serious impact	2004, 2005 hurricanes
Propeller scarring		Localized	Horseshoe Beach

Seagrass Mapping Assessment: Between 2001 and 2006, total seagrass cover for the southern Big Bend region decreased from 59,674 acres to 56,146 acres, or 5.9% (Table 1). However, continuous seagrass cover decreased 14%, from 51,244 to 44,109 acres. Some of the bed fragmentation might have resulted from the 2004 and 2005 hurricanes. Most (84%) of the region's seagrass beds occur in the Steinhatchee South and Horseshoe West subregions, and the least extensive beds (973 acres) are found near the mouth of the Suwannee River. Between 2001 and 2006, most of the seagrass losses occurred in the Horseshoe West subregion, but the Suwannee subregion had small gains (126 acres). Water clarity, however, may affect mapping accuracy in coastal waters near the mouth of the Suwannee River. Extensive, but sparse, beds of paddle grass (*Halophila decipiens*) offshore cannot be mapped with conventional aerial photography. These beds probably serve as a corridor for grouper and other important fish and shellfish species as they migrate inshore and offshore.

TABLE 1. SEAGRASS ACREAGE IN SOUTHERN BIG BEND IN 2001 AND 2006

Habitat Type	Steinhatchee South	Horseshoe West	Horseshoe East	Suwannee	Total
Acres in 2001					
Patchy	2,500	4,468	1,070	390	8,428
Continuous	20,840	22,893	7,054	457	51,244
All seagrass	23,341	27,361	8,124	848	**59,674**
Acres in 2006					
Patchy	3,429	2,919	4,850	839	12,037
Continuous	20,101	20,991	2,883	134	44,109
All seagrass	23,530	23,910	7,733	973	**56,146**
Change 2001–06					
Patchy	929	−1,549	3,780	449	3,609
Continuous	−739	−1,902	−4,171	−323	−7,135
All seagrass	190	−3,451	−391	126	**−3,528**

Monitoring Assessment: Big Bend's seagrass beds are monitored each year by Fish and Wildlife Conservation Commission (FWC) staff and collaborators. The number of samples each year has varied between 450 and 600, so the results shown in Table 2 are expressed as the percentage of the total number of sample locations at which each seagrass species was found. Since 2004, the average occurrence of bare bottom has ranged from 40% to 50% of sample locations throughout the southern Big Bend. This is twice the frequency of bare bottom found in the northern Big Bend. The most commonly occurring seagrasses are turtle grass (*Thalassia testudinum*) and manatee grass (*Syringodium filiforme*), and occurrence of these two species dropped 21–24% after the storms of 2004 and 2005. Shoal grass (*Halodule wrightii*), however, decreased sharply in occurrence in 2005 and has not recovered. Star grass (*Halophila engelmannii*), on the other hand, has increased in occurrence, albeit only slightly, since 2005. The occurrence of drift red macroalgae dropped sharply between 2004 and 2005 and has also remained low. Compared with those at the northern Big Bend, all seagrass species except turtle grass and drift macroalgae occurred half as frequently in the southern Big Bend region. The difference in occurrence between regions for turtle grass was less and may reflect less light stress because of the shallow depths at which turtle grass grows.

TABLE 2. OCCURRENCE (%) OF SEAGRASS SPECIES IN SOUTHERN BIG BEND

Year	No Seagrass	Star Grass	Shoal Grass	Manatee Grass	Turtle Grass	Widgeon Grass	Drift Algae
2004	44.4	1.7	11.2	32.8	32.5	2.2	28.1
2005	40	0.4	6.6	36.3	43	0	6.5
2008	48.5	6.8	5.8	27.5	34.1	0	10.3
2009	49.5	3.4	5.7	28.4	35.4	0.5	8.4

In 2009, nearly 90% of all sample locations were bare in the Suwannee subregion, and the percentage of bare sample locations dropped off sharply along the south-to-north gradient (Figure 2). Seagrasses occurred in more than 70% of sampling locations in the Horseshoe West and Steinhatchee South subregions. Turtle grass was the most common seagrass in all subregions and occurred most frequently in Horseshoe West and Steinhatchee South. Manatee grass was the second most common seagrass species and often occurred with turtle grass. Both the occurrence and diversity of seagrasses increased with distance from the mouth of the Suwannee River.

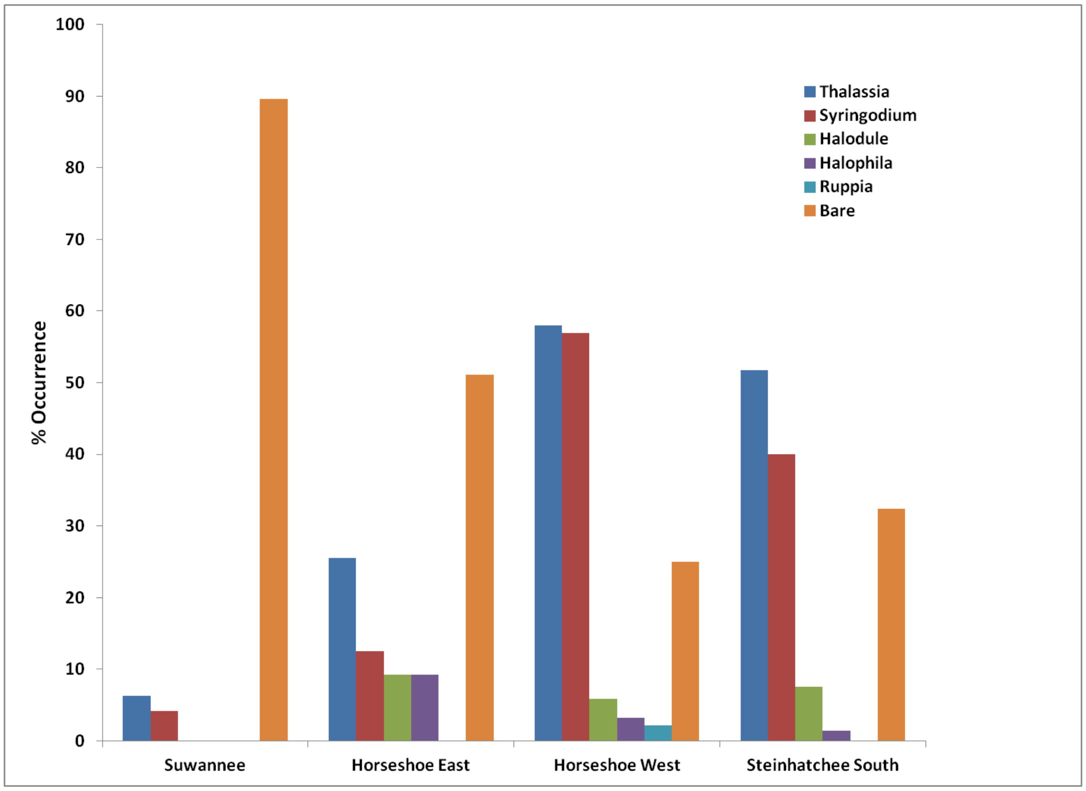

Figure 2. Percentage occurrence of seagrass species in the subregions of southern Big Bend, 2009.

Mapping and Monitoring Recommendations

• Map and monitor seagrasses in water too deep for conventional aerial photography.

• Acquire imagery and map the entire region again in 2011–12.

• Continue annual on-ground monitoring, especially near the Suwannee River.

Management and Restoration Recommendation

• Assess the effects of Suwannee River discharge on seagrass beds.

Mapping Data and Imagery: In 2001, natural color aerial photography of the entire Big Bend region was flown at 1:24,000 scale for the Suwannee River Water Management District (SRWMD) by U.S. Imaging. Location of the original negatives is uncertain, but copies of diapositives are housed at SRWMD headquarters in Live Oak, Florida. Benthic habitats were classified and mapped by Avineon Inc. using the Florida Land Use Cover Classification System (from the Florida Department of Transportation, 1999). ArcMap shapefiles of benthic habitats are distributed on the Fish and Wildlife Research Institute (FWRI) Marine Resources Geographic Information System (MRGIS) website (http://ocean.floridamarine.org/mrgis/). In 2006, the Florida Department of Transportation acquired digital aerial imagery of Big Bend seagrass beds taken with a Zeiss DMC digital camera. Digital 3-band color imagery is available from Paul Carlson, FWRI, and from the Marine Resources Aerial Imagery Database (MRAID) website (http://myfwc.com/research/gis/data-maps/marine/mraid/). Benthic habitats were classified and mapped from the 2006 imagery by Photoscience Inc. ArcMap shapefiles of benthic habitats based on the 2006 imagery are also distributed on the FWRI MRGIS website.

Monitoring Data: Seagrass monitoring has been conducted in the northern Big Bend region each summer since 2002 by FWC staff and collaborators. Seagrass and macroalgal cover are estimated by species for 8–10 0.25-m^2 quadrats at approximately 120 spatially distributed, randomly selected sites throughout the region. Optical water quality measurements (light attenuation, turbidity, color, total suspended solids, and chlorophyll-a concentration) are made at every site as well.

Pertinent Reports and Scientific Publications

CARLSON, P. R., L. A. YARBRO, K. K. KAUFMAN, and R. A. MATTSON. 2010. Vulnerability and resilience of west Florida seagrass communities to hurricane impacts. Hydrobiologia 649: 39–53.

DAWES, C. J., R. C. PHILLIPS, and G. MORRISON. 2004. Seagrass communities of the Gulf coast of Florida: status and ecology. Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute and the Tampa Bay Estuary Program. St. Petersburg, Florida, iv + 74 p. http://www.sarasota.wateratlas.usf.edu/upload /documents/Seagrass-Communities-Status-and-Ecology.pdf, accessed March 2011.

HALE, J. A., T. K. FRAZER, D. A. TOMASKO, and M. O. HALL. 2004. Changes in the distribution of seagrass species along Florida's central Gulf coast: Iverson and Bittaker revisited. Estuaries and Coasts 27: 36–43.

HAMMERSTROM, K. K., W. J. KENWORTHY, M. S. FONSECA, and P. E. WHITFIELD. 2006. Seed bank, biomass, and productivity of *Halophila decipiens,* a deep water seagrass on the west Florida continental shelf. Aquatic Botany 84: 110–120.

IVERSON, R. L., and H. F. BITTAKER. 1986. Seagrass distribution and abundance in eastern Gulf of Mexico coastal waters. Estuarine, Coastal and Shelf Science 22: 577–602.

MATTSON, R. A. 2000. Seagrass ecosystem characteristics and research and management needs in the Florida Big Bend. Pp. 259-277 *in* Bortone, S. A. (ed.) Seagrasses: monitoring, ecology, physiology, and management, Boca Raton, Florida. 318 p.

MATTSON, R. A., T. K. FRAZER, J. HALE, S. BLITCH, and L. AHIJEVYCH. 2007. Florida Big Bend. Pp. 171–188 *in* L. Handley et al., eds. Seagrass status and trends in the northern Gulf of Mexico, 1940–2002. United States Geological Survey Scientific Investigations Report 2006-5287 and U.S. Environmental Protection Agency 855-R-04-003, Washington, D.C. 267 p.

General References and Additional Information

Big Bend Seagrasses Aquatic Preserve:
http://www.dep.state.fl.us/coastal/sites/bigbend/info.htm, accessed March 2011.

Faunal Communities in Seagrass Meadows:
http://www.marinelab.fsu.edu/faculty/seagrass.aspx, accessed March 2011.

Contacts

Mapping: Paul Carlson, Florida Fish and Wildlife Research Institute, 727-896-8626, paul.carlson@fwc.state.fl.us.

Monitoring: Laura Yarbro, Florida Fish and Wildlife Research Institute, 727-896-8626, laura.yarbro@fwc.state.fl.us.

Melissa Charbonneau (for Steinhatchee area), Big Bend Seagrasses Aquatic Preserve, 352-563-0450, melissa.charbonneau@dep.state.fl.us.

Florida Seagrass Integrated Mapping and Monitoring Program

Summary Report for Suwannee Sound, Cedar Keys, and Waccasassa Bay Region

Contacts: Melissa Charbonneau, Florida Department of Environmental Protection, Coastal and Marine Assessment (Monitoring), and Paul Carlson, Fish and Wildlife Research Institute, Fish and Wildlife Conservation Commission (Mapping)

General Assessment: In 2001, 33,625 acres of seagrasses were mapped in Suwannee Sound, Cedar Keys, and Waccasassa Bay with 72% of the seagrass beds occurring in Waccasassa Bay (24,184 acres). Suwannee Sound had 1,652 acres of seagrasses, located along the offshore reef west and south of the mouth of the Suwannee River. In the Cedar Keys region, 7,789 acres of seagrass were mapped. Of the total seagrass area, 72%, or 24,296 acres, were continuous beds. Seagrass cover in the Cedar Key region appears to be stable. Seagrass species composition also appears to be stable. However, conversion of continuous seagrass beds to patchy beds is cause for concern. Stressors include nutrients, phytoplankton, and turbidity, which reduce water clarity. These stressors were elevated after the 2004 and 2005 hurricane seasons, but they have returned to background levels. Localized, direct impacts from propeller scarring are evident in this region, especially between North Key and Seahorse Key in the Cedar Keys. Less information is available for Suwannee Sound and Waccasassa Bay.

Seagrass Status and Stresses	Status	Trend	Assessment, Causes
Seagrass cover		Decreasing	River impacts in Suwannee
Water clarity		Variable	Poor in Suwannee Sound
Natural events		Minimal impact	2009–10 El Niño, tropical storms
Propeller scarring		Localized	Cedar Keys area

Geographic Extent: This region extends south from the mouth of the Suwannee River to just south of the mouth of the Waccasassa River. Seagrasses are limited to the offshore reef near the mouth of the Suwannee but become much more common south and east of the Cedar Keys. This area is characterized by a mixture of hard bottom, reefs, sands, and seagrass beds.

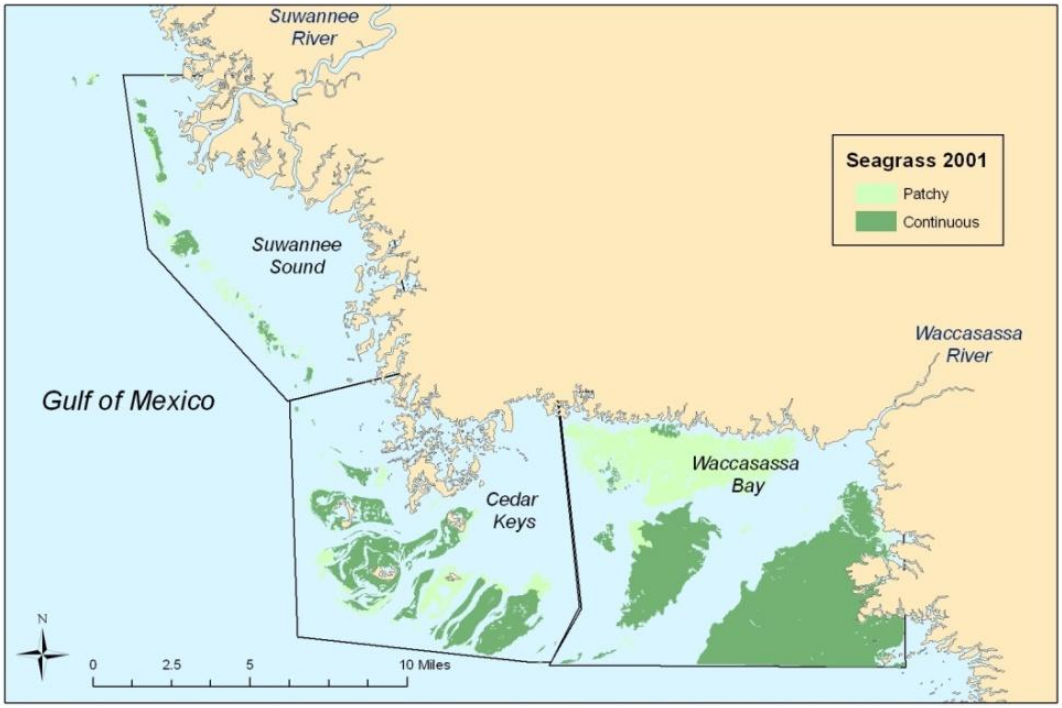

Figure 1. Seagrass cover in Suwannee Sound, Cedar Keys, and Waccasassa Bay, 2001.

Mapping and Monitoring Recommendations

• Establish a seagrass monitoring program in the Waccasassa Bay estuary and in Suwannee Sound.

• Acquire and map aerial or satellite imagery of seagrass beds in 2011–12 in the Cedar Keys and Waccasassa Bay subregions, where poor optical properties of the water have prevented photointerpretation of recently collected imagery.

Management and Restoration Recommendations

• Reduce nutrient levels in the Suwannee River. This will partly address the negative impacts of river discharge, but episodic high runoff associated with tropical storms and El Niño events will continue to affect seagrasses in this region.

• Survey and evaluate propeller scarring in the Cedar Keys region and develop a proactive program for reducing impacts. The current strategy includes distribution of and publicity about the new boater guide for the Nature Coast region to increase boaters' awareness of seagrass beds in the region. FDEP staff have posted at public boat ramps signs advising boaters of penalties for the propeller scarring of seagrass beds. Law enforcement will educate the public for a year before it begins to issue citations for scarring by boaters.

Summary Assessment: Nutrients and poor water clarity in the highly colored and turbid discharge from the Suwannee River continue to impact seagrass beds close to the mouth of the river. Seagrass beds are very limited in Suwannee Sound and occur mostly near the reef offshore and to the south of the river mouth. In recent years turbidity and resulting light attenuation have made it impossible to map seagrasses near Cedar Key and in Waccasassa Bay and might also be causing seagrass losses. However, without mapping data or a monitoring program, the status of seagrasses in Waccasassa Bay cannot be assessed.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover		Decreasing	River impacts in Suwannee
Seagrass meadow texture		Unknown	
Seagrass species composition		Stable	
Overall seagrass trends		Fairly stable	Potential nutrient impacts
Seagrass Stressors	**Intensity**	**Impact**	**Assessment, Causes**
Water clarity		Variable	Poor in Suwannee Sound
Nutrients		Variable	High near Suwannee River
Phytoplankton		Relatively low	
Natural events		Minimal impact	2009–10 El Niño, tropical storms
Propeller scarring		Localized	Cedar Keys area

Seagrass Mapping Assessment: Based on aerial photography obtained in 2001, most of the seagrasses in this region are found in continuous beds, with nearly 75% of all seagrass acreage found in Waccasassa Bay (Table 1). Suwannee Sound has the smallest area of seagrasses (1,652 acres), but more than half the beds (905 acres) are continuous. Seagrasses in the Cedar Keys (7,789 acres) are also predominantly found in continuous beds (79%).

TABLE 1. SEAGRASS ACREAGE IN SUWANNEE SOUND, CEDAR KEYS, AND WACCASASSA BAY IN 2001

Habitat Type	Suwannee Sound	Cedar Keys	Waccasassa Bay	All Regions
Patchy	747	1,643	6,939	9,329
Continuous	905	6,146	17,245	24,296
All Seagrass	**1,652**	**7,789**	**24,184**	**33,625**

Monitoring Assessment: Staff of the Big Bend Seagrasses Aquatic Preserve have been monitoring seagrass beds at 25 sites in the Cedar Keys area since 2006 using fixed transects and Braun-Blanquet assessment of 1-m^2 quadrats. Turtle grass (*Thalassia testudinum*) is usually the most common seagrass species found near Cedar Key, but in September 2006, shoal grass (*Halodule wrightii*) was most common and occurred in more than 50% of the quadrats (Figure 2). Manatee grass (*Syringodium filiforme*) and star grass (*Halophila engelmannii*) occurred less frequently among quadrats but were present to some extent during every sampling effort. Very few quadrats in Cedar Key were bare of seagrass. Evaluation of total seagrass cover (all species) by Braun-Blanquet score indicates a decline in seagrass density near Cedar Key from 2006 through 2009 (Figure 3).

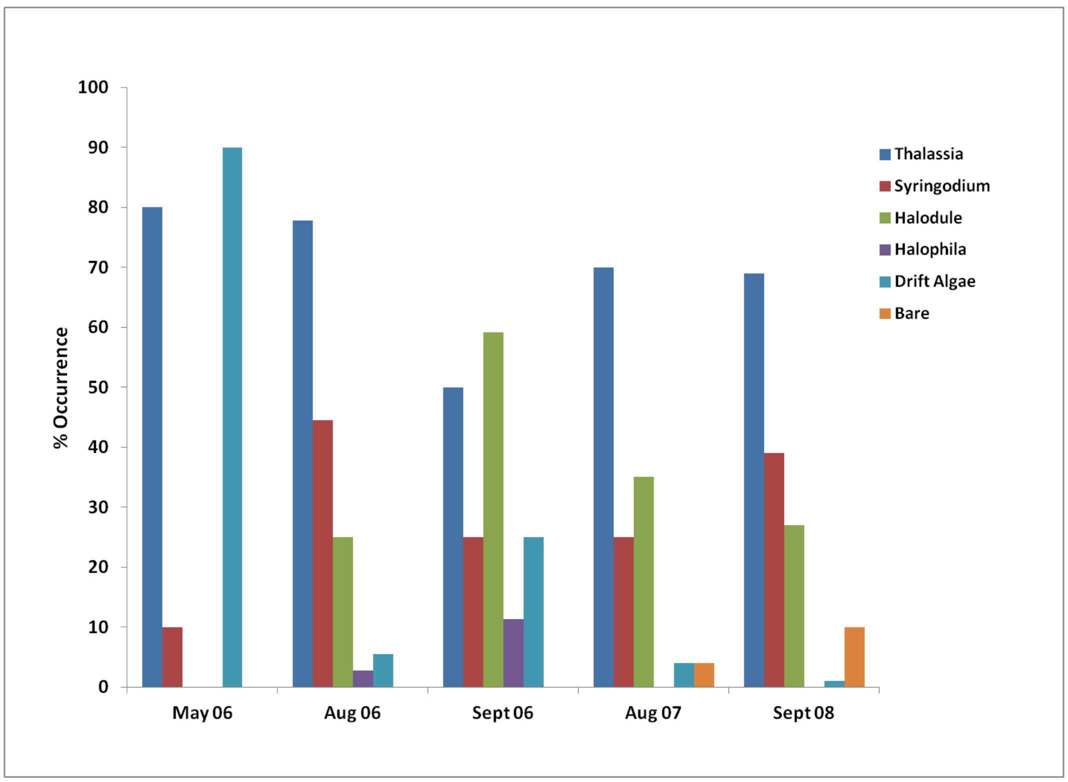

Figure 2. Percentage occurrence of seagrasses and drift algae in the Cedar Key subregion, May 2006–September 2008.

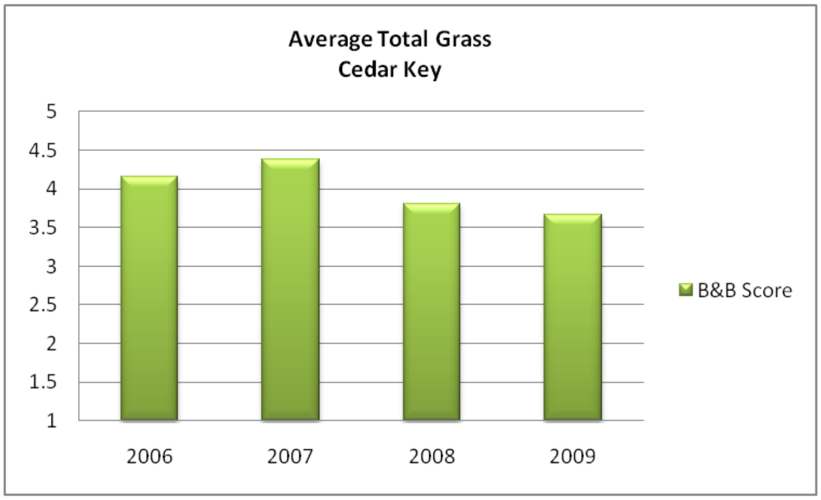

Figure 3. Mean seagrass cover (using Braun-Blanquet scores) in the Cedar Key subregion, 2006–2009.

Mapping and Monitoring Recommendations

• Photograph and map this region in 2011–12. Continue to map seagrasses every 5–6 years.

• Continue the monitoring program in the Cedar Key subregion and expand it to include Suwannee Sound and Waccasassa Bay.

Management and Restoration Recommendations

• Continue efforts to reduce propeller scarring of seagrass beds near the Cedar Key subregion.

• Acquire imagery and map Waccasassa Bay to allow trend analysis.

• Continue to assess impacts from river runoff to seagrasses near the mouth of the Suwannee River.

Mapping Data and Imagery: Seagrass data were photointerpreted from 2001 natural color aerial photography acquired at 1:24,000 scale and classified using the South Florida Water Management District modified Florida Land Use Cover Classification System (FLUCCS, from the Department of Transportation, 1999). Features were stereoscopically interpreted from the aero-triangulated aerial photography, and vector data were compiled using analytical stereoplotters. Extensive field reconnaissance and seagrass bed monitoring were conducted to resolve classification and boundary problems encountered during photointerpretation. The minimum mapping unit for classification was 0.5 acre.

Monitoring Data: Data are available for the Cedar Key subregion from staff of the Big Bend Seagrasses Aquatic Preserve, Melissa Charbonneau, manager. No monitoring program is in place for Waccasassa Bay or Suwannee Sound.

Pertinent Reports and Scientific Publications

JACKSON, J. B., and D. J. NEMETH. 2007. A new method to describe seagrass habitat sampled during fisheries-independent monitoring. Estuaries and Coasts 30: 171–178.

MATTSON, R. A. 2000. Seagrass ecosystem characteristics and research and management needs in the Florida Big Bend. Pp. 259-277 *in*: Bortone, S. A. (ed.) Seagrasses: Monitoring, ecology, physiology, and management, Boca Raton, Florida. 318 p.

General References and Additional Information:

Big Bend Seagrasses Aquatic Preserve: http://www.dep.state.fl.us/coastal/sites/bigbend/, accessed March 2011.

Resource Database for Gulf of Mexico Research: Suwannee River: http://www.gulfbase.org/bay/view.php?bid=suwaneeriver, accessed March 2011.

Contacts

Mapping: Paul Carlson, Fish and Wildlife Research Institute, 727-896-8626; paul.carlson@myfwc.com .

Monitoring: Melissa Charbonneau, Florida Department of Environmental Protection, Coastal and Marine Assessment, 352-563-0450, Melissa.charbonneau@dep.state.fl.us.

Florida Seagrass Integrated Mapping and Monitoring Program

Summary Report for Springs Coast

Contacts: Melissa Charbonneau, Florida Department of Environmental Protection, Coastal and Aquatic Managed Areas (Monitoring); and Keith Kolasa, Southwest Florida Water Management District (Mapping)

General Assessment: The Springs Coast region contained 379,010 acres of seagrass in 2007. Seagrass cover in the Springs Coast region appears to be stable or increasing slightly, based on a rough comparison between data collected in 1999 and 2007. Seagrass species composition also appears to be stable. Conversion of continuous seagrass beds to patchy beds is a cause for concern. Stressors include nutrients, phytoplankton, and turbidity which in turn affect light available to seagrasses. These were elevated after the 2004 and 2005 hurricane seasons, but they have returned to background levels. Heavy propeller scarring is evident around the mouth of Pithlachascotee River, St. Martins marker shoal (10 nmi off Pasco County), and Anclote Key, but is less extensive elsewhere.

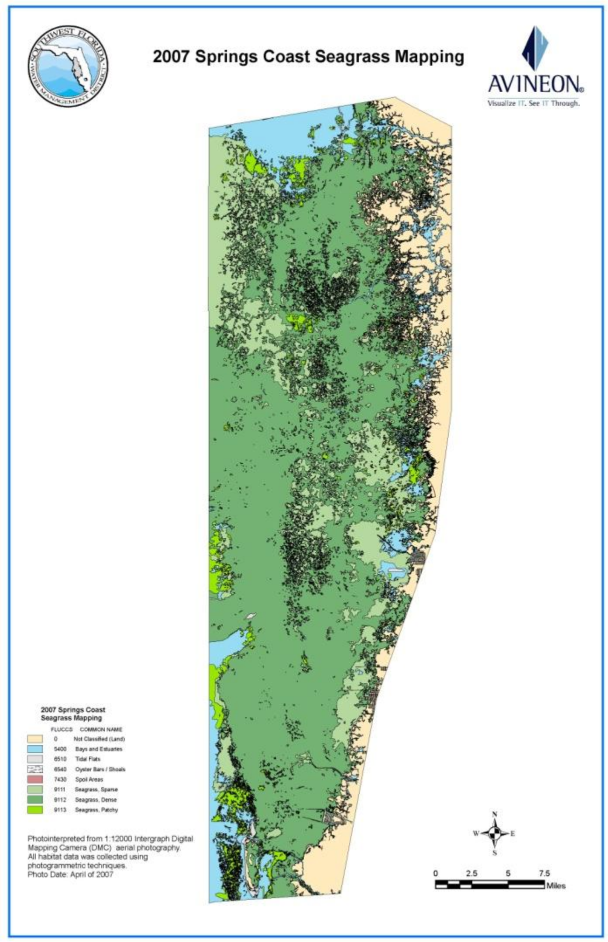

Figure 1. Seagrass cover along the Springs Coast, 2007.

Geographic Extent: The Springs Coast extends from the mouth of the Crystal River south to Anclote Key, with a total project area of 494,403 acres. In Figure 1, dark green areas show extent of mapped continuous seagrass beds, and light green and bright green areas show locations of sparse and patchy seagrass, respectively. Seagrass beds extend a considerable distance beyond the mapped area into deeper water.

Seagrass Status and Stresses	Status	Trend	Assessment, Causes
Seagrass cover		Increasing	Steady gains
Water clarity		Good	Affected by runoff, storms
Natural events		Minimal impact	1998 El Niño, 2004, 2005 hurricanes
Propeller scarring		Localized	Anclote Key, Pithlachascotee River

Mapping and Monitoring Recommendations

• Map and monitor seagrasses in water too deep for conventional aerial photography.

• Acquire imagery and map the entire region again in 2011–12.

• Continue the monitoring program in the St. Martins Keys area (south of the mouth of the Crystal River through Homosassa Bay) by staff of the Florida Department of Environmental Protection (FDEP) Coastal and Managed Areas (CAMA)

• Continue water quality monitoring of the Homosassa, Pithlachascotee, Crystal, Weeki Wachee, and Withlacoochee rivers, their associated estuaries, and adjacent coastal marine waters.

• Investigate mapping techniques needed for monitoring trends in the expansion of drift macroalgae and its associated impacts on seagrass communities.

Management and Restoration Recommendations

• Monitor the impact of propeller scarring, with the goal of developing a proactive strategy for reducing impacts.

• Identify which seagrass beds around the St. Martins Keys are most prone to impacts from improper boat navigation and develop a boater's guide for this shallow-water region.

• Use the recently completed boater's guide for the St. Joseph Bay region (which includes Anclote Key) to improve boater education and awareness of seagrass beds around Anclote Key and to reduce propeller scarring.

Summary Assessment: Seagrass cover in the Springs Coast appears stable, with a similar total area of seagrass mapped between 2007 and 1999, when the same project boundary is used (Table 1). Seagrass species composition also appears to be stable. Conversion of continuous seagrass beds to patchy beds is cause for concern. Stressors include increased nutrients, phytoplankton, and turbidity. These were elevated after the 1998 El Niño event and the 2004 and 2005 hurricane seasons, but they have returned to background levels. Heavy propeller scarring is evident around the mouth of the Pithlachascotee River, St. Martins marker shoal, and Anclote Key but is less evident elsewhere.

Seagrass Status Indicators	**Status**	**Trend**	**Assessment, Causes**
Seagrass cover		Fairly stable	Slight gains, 1999–2007
Seagrass meadow texture			
Seagrass species composition		Fairly stable	No significant changes
Overall seagrass trends		Fairly stable	Potential nutrient impacts
Seagrass Stressors	**Intensity**	**Impact**	**Explanation**
Water clarity		Good	Affected by runoff, storms
Nutrients		Relatively low	Affected by runoff, storms
Phytoplankton		Relatively low	Affected by runoff, storms
Natural events		Minimal impact	1998 El Niño; 2004, 2005 hurricanes
Propeller scarring		Localized	Anclote Key, Pithlachascotee River

Seagrass Mapping Assessment: Total seagrass cover for the Springs Coast region in 2007 was 379,010 acres (77% of the total 494,402 acres mapped), with dense seagrass comprising 272,772 acres, medium to sparse seagrass comprising 87,393 acres, and patchy seagrass comprising 18,850 acres (Table 1).

TABLE 1. SEAGRASS ACREAGE IN THE SPRINGS COAST REGION IN 2007

Habitat Type	Anclote–Pithlachascotee	Aripeka–Hernando Beach	Weeki Wachee–Chassahowitzka	Homosassa–Crystal River	All Regions
Patchy	5,903	4,138	4,401	4,408	18,850
Continuous	40,422	94,316	137,526	87,896	360,160
All seagrass	46,325	98,454	141,927	92,304	**379,010**

A comparison of the seagrass coverage in 2007 to that in 1999 was completed using the footprint of the 1999 mapping area as the common base. A smaller project area was mapped in 1999 with only the nearshore region included. Although different sets of habitat categories and techniques were used between the 2007 and 1999 projects, a similar total area of seagrass coverage was found, with 229,000 acres of seagrass mapped in 1999 and 226,500 acres mapped in 2007 (Table 2).

TABLE 2. ACRES OF SEAGRASS ALONG THE SPRINGS COAST, 1999 AND 2007

Habitat Type	1999	2007
Dense	71,000	155,500
Sparse	44,000	58,000
Medium	114,000	Not used
Patchy	Not used	13,000
All Seagrass	**229,000**	**226,500**

The 1999 and 2007 mapping efforts in this region did not extend far enough offshore to capture the deep edge of seagrass beds. Furthermore, there are extensive, but sparse, beds of paddle grass (*Halophila decipiens*) offshore that cannot be mapped with conventional aerial photography. These beds probably serve as a bridge for groupers and other important fish and shellfish species during migration inshore or offshore.

Monitoring Assessment: Since 1997, FDEP staff have monitored 25 sites in the St. Martins Keys area each summer. Data are reported as percentage occurrence of seagrass in 100 randomly placed quadrats (Figure 2). For 2004, 2005, and 2008, turtle grass (*Thalassia testudinum*) was most common, found in 70–84% of quadrats (Table 3). Manatee grass (*Syringodium filiforme*) and shoal grass (*Halodule wrightii*) followed, with percentage occurrence ranging from 41% to 48% for manatee grass and from 24% to 39% for shoal grass. Star grass (*Halophila engelmannii*) and widgeon grass (*Ruppia maritima*) were found in fewer than 10% of quadrats. For the period 1997--2009, the occurrence of turtle grass and manatee grass is increasing, while the occurrence of shoal grass has decreased sharply in the most recent sampling efforts.

TABLE 3. OCCURRENCE (%) OF SEAGRASS SPECIES IN THE ST. MARTINS KEYS AREA

Year	No Seagrass	Star Grass	Shoal Grass	Manatee Grass	Turtle Grass	Widgeon Grass	Drift Algae
2004	0	9	39	41	81	2	25
2005	0	5	31	42	84	9	35
2008	3	2	24	48	70	4	7

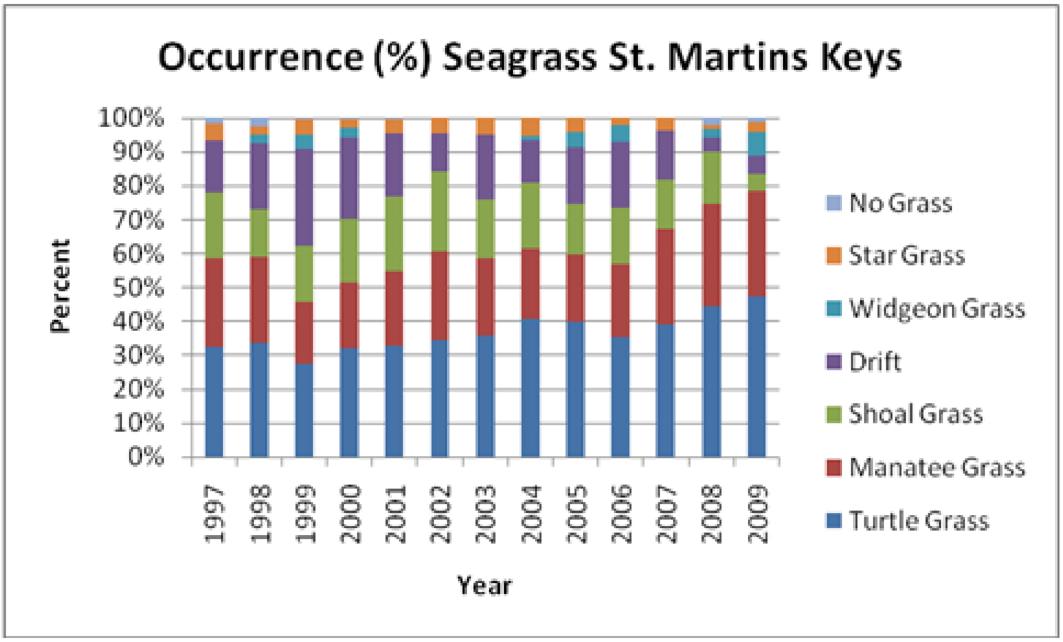

Figure 2. Occurrence of seagrass species in the St. Martins Keys, 1997–2009.

Mapping and Monitoring Recommendations

• Map and monitor seagrasses in water too deep for conventional aerial photography.

• Acquire imagery and map the entire region again in 2011–12.

• Continue seagrass monitoring program and continue water quality monitoring of the coastal rivers (Homosassa, Pithlachascotee, Crystal, Weeki Wachee, and Withlacoochee) and their associated estuaries, as well as coastal marine waters.

• Investigate mapping techniques needed to monitor trends in the expansion of drift macroalgae and its impacts to seagrass communities.

• Continue water quality monitoring programs such as Project Coast (Southwest Florida Water Management District and University of Florida) to assess changes in nutrient loads in the Homosassa, Pithlachascotee, Crystal River, Weeki Wachee, and Withlacoochee rivers.

Management and Restoration Recommendations

• Monitor propeller scarring impacts within the St. Martins marker shoal (1,500-acre shallow-water offshore seagrass bed located 9 nmi offshore of Pasco County) toward development of a proactive strategy for reducing further impacts.

• Use the recently completed boater's guide for the St. Joseph Bay region (including Anclote Key) to improve boater education and awareness of seagrass beds around Anclote Key.

• Identify the seagrass beds around the St. Martins Keys prone to impacts from improper boat navigation and develop a boater's guide for this shallow-water region.

Mapping Data and Imagery: In April 2007, digital aerial imagery of the Springs Coast region was flown at 1:12,000 scale for the Florida Wildlife Research Institute (FWRI) and the Southwest Florida Water Management District (SWFWMD). The imagery was collected using a Z/I Digital Mapping Camera (DMC) with position determined using airborne GPS procedures and an Applanix Inertial Measurement Unit (IMU).

Benthic habitats were classified and mapped from this dataset by Avineon Inc., using the Florida Land Use Cover Classification System. ArcMap shapefiles of benthic habitats are distributed on the Geographic Information Systems database at SWFWMD and are available upon request. The digital imagery is available from FWRI from the Marine Resources Aerial Imagery Database (MRAID) (http://myfwc.com/research/gis/data-maps/marine/mraid/).

Monitoring Data: FDEP staff have conducted annual seagrass surveys in the St. Martins Keys region of the Springs Coast since 1997. Staff use 1-m^2 quadrats to survey 25 fixed-position sites. Species composition and percentage cover for seagrass and macroalgae are estimated using four randomly placed quadrats at each site, totaling 100 samples.

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Florida Department of Environmental Protection, Florida's Water: http://www.protectingourwater.org/watersheds/map/springs_coast/, accessed March 2011.

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Contacts

Mapping: Keith Kolasa, Southwest Florida Water Management District, 800-423-1476, ext. 4236, Keith.Kolasa@swfwmd.state.fl.us.

Monitoring: Melissa Charbonneau, Big Bend Seagrasses Aquatic Preserve and St. Martins Marsh Aquatic Preserve, 352-563-0450, Melissa.Charbonneau@dep.state.fl.us.

Florida Seagrass Integrated Mapping and Monitoring Program

Summary Report for Western Pinellas County

Contacts: Melissa Harrison, Pinellas County Environmental Management (Monitoring), and Kristen Kaufman, Southwest Florida Water Management District (Mapping)

General Assessment: In 2008, 25,880 acres of seagrass were mapped in Boca Ciega Bay, Clearwater Sound, and St. Joseph's Sound, with St. Joseph's Sound accounting for almost 50% of the mapped acreage. Between 2006 and 2008, seagrass acreage increased 8.1% for the entire region, but seagrass area in Boca Ciega Bay decreased 504 acres, or 5.6%. Many seagrass beds in this urban county are greatly affected by storm runoff. In addition, propeller scarring affects seagrass beds in some areas. Water quality is affected by storm runoff and large-scale events such as El Niño.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover		Increasing	All areas except Boca Ciega Bay
Water clarity		Locally poor	Boca Ciega Bay
Nutrients		Increasing	Storm runoff
Phytoplankton		Variable	Low levels
Propeller scarring		Regional	Near high-use areas

Geographic Extent: This region includes the shallow waters of Boca Ciega Bay, Clearwater Harbor, Shell Key, and St. Joseph's Sound along the Gulf coast of Pinellas County.

Mapping and Monitoring Recommendations

• Continue annual monitoring formerly conducted by the Pinellas County Department of Environmental Management.

• Continue biennial imagery acquisition and interpretation.

Management and Restoration Recommendations

• Reduce storm runoff into Boca Ciega Bay.

• Decrease propeller scarring in areas of greatest boat use.

Summary Assessment: Seagrass beds in western Pinellas County are increasing in size in all areas except Boca Ciega Bay based on mapping data from 2006 and 2008. Acreage increased in St. Joseph's Sound by 20% during this two-year period. All coastal waters receive storm runoff from the highly urban Pinellas peninsula, and this poses a threat to water clarity and quality. Propeller scarring, especially in areas of greatest boat use near the Intracoastal Waterway, continues to fragment seagrass beds.

Seagrass Mapping Assessment: In the coastal waters of western Pinellas County, almost half the seagrass beds are found in St. Joseph's Sound in the northwestern portion of this region (Figure 1). Seagrass acreage increased 20%, or 2,093 acres, in St. Joseph's Sound between 2006 and 2008 (Table 1). Seagrass beds also increased in size in Clearwater Sound during the same period, by about 8%. However, Boca Ciega Bay lost 504 acres between 2006 and 2008, a 5.6% decline.

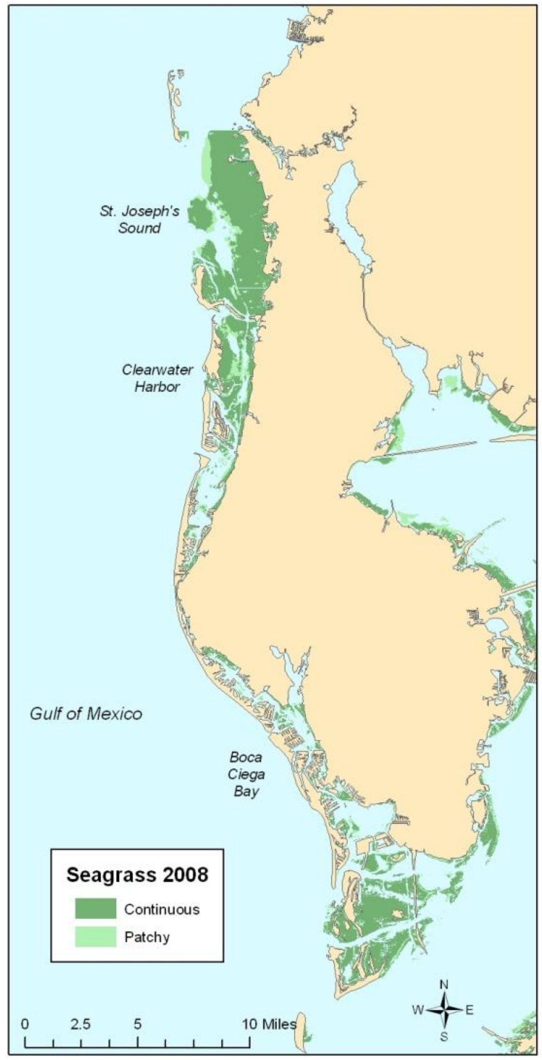

Figure 1. Seagrass cover in Western Pinellas County, 2008.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover		Increasing	All areas except Boca Ciega Bay
Seagrass meadow texture		Stable	
Seagrass species composition		Stable	
Overall seagrass trends		Stable	Urban runoff is a concern
Seagrass Stressors	**Intensity**	**Impact**	**Explanation**
Water clarity		Locally poor	Boca Ciega Bay
Nutrients		Increasing	Storm runoff
Phytoplankton		Variable	Low levels
Natural events		Low	El Niño
Propeller scarring		Regional	Near high-use areas

Monitoring Assessment: Seagrass assessment and monitoring suggest that seagrass beds are stable in Boca Ciega Bay, Clearwater Harbor, and St. Joseph's Sound. Seagrass species include shoal grass (*Halodule wrightii*), manatee grass (*Syringodium filiforme*), and turtle grass (*Thalassia testudinum*). Some transects showed a temporary decrease in density from 2004 to 2005, most likely an effect of tropical storms (Meyer and Hammer Levy 2008).

TABLE 1. WESTERN PINELLAS COUNTY SEAGRASS ACREAGE IN 2006 AND 2008

Bay Segment	2006	2008	Change	% Change
Clearwater North	3,522	3,784	262	7
Clearwater South	914	1,000	86	9
St. Joseph's Sound	10,546	12,639	2,093	20
Boca Ciega Bay	8,961	8,457	−504	−6
Total	**23,943**	**25,880**	**1,937**	**8.1**

Mapping Data and Imagery: The Southwest Florida Water Management District (SWFWMD) has acquired aerial imagery of submerged aquatic vegetation in the Tampa Bay region every two years since 1988. The most recent set of photographs was acquired in 2010. In 2006 and 2008, seagrass imagery was photointerpreted from 1:24,000 scale natural color aerial photography and classified using the SWFWMD modified Florida Land Use Cover Classification System. The minimum mapping unit for classification was 0.5 acre.

Monitoring Data: Seagrass beds are monitored as part of a regional program administered by the Tampa Bay Estuary Program. Seagrass cover is evaluated by the Braun-Blanquet method using quadrats located along fixed transects. There are 11 fixed transects in Boca Ciega Bay and 14 in Clearwater Harbor and St. Joseph Sound. Staff of the Pinellas County Department of Environmental Management have been responsible for field assessment each fall, and their data are reported to the Tampa Bay Estuary Program.

Pertinent Reports and Scientific Publications

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Surveys Show Record Gains for Tampa Bay Seagrasses (January 21, 2011), Tampa Bay Estuary Program: http://www.tbep.org/news/whatsnew.shtml , accessed March 2011.

Contacts

Mapping: Kris Kaufman, Southwest Florida Water Management District, 813-985-7481, Kristen.kaufman@swfwmd.state.fl.us.

Monitoring: Melissa Harrison, Pinellas County Department of Environmental Management, 727-464-4425, mharrison@co.pinellas.fl.us.

Florida Seagrass Integrated Mapping and Monitoring Program

Summary Report for Tampa Bay

Contacts: Walt Avery (retired), City of Tampa, and Ed Sherwood, Tampa Bay Estuary Program (Monitoring); Kristen Kaufman, Southwest Florida Water Management District (Mapping)

General Assessment: Seagrasses covered 29,647 acres of Tampa Bay in 2008. Seagrass acreage has increased steadily since 1999, up 4.8%, or 1,350 acres, from 2006 to 2008, with the greatest gains in Middle Tampa Bay and modest gains in Hillsborough Bay and Old Tampa Bay. Some of these gains were offset by a loss of 1,010 acres of seagrass in the lower subregions of Tampa Bay. Seagrass species composition also appears to be stable. Stressors include diminished light availability, which results from frequently elevated phytoplankton and turbidity. A continuing effort to reduce nitrogen inputs and thus limit phytoplankton productivity is challenged by nonpoint sources from the highly urban watershed. Runoff resulting from the 1997–98 El Niño in particular fueled phytoplankton blooms and resulted in losses of slightly more than 2,000 acres of seagrass. With improving water quality, seagrass cover had rebounded to pre–El Niño levels by 2004.

Seagrass Status and Stresses	Status	Trend	Assessment, Causes
Seagrass cover		Increasing	Steady gains
Water clarity		Improving	Affected by runoff, storms
Natural events		Minimal impact	1997–98 El Niño
Propeller scarring		Extensive	

Geographic Extent: This region extends from the mouth of Tampa Bay north and includes the tidal portions of the Manatee River, Terra Ceia Bay, and Boca Ciega Bay. Boca Ciega Bay runs between the Pinellas peninsula and the barrier islands along the Gulf of Mexico.

Mapping and Monitoring Recommendations

• Continue biennial imagery acquisition and mapping. The most recent mapping effort occurred in 2008, and the most recent aerial photography was acquired in 2010.

• Continue seagrass monitoring completed annually or quarterly by several agencies, including the Southwest Florida Water Management District (SWFWMD), Pinellas County, Manatee County, the City of Tampa, the Florida Department of Environmental Protection, and the Fish and Wildlife Research Institute.

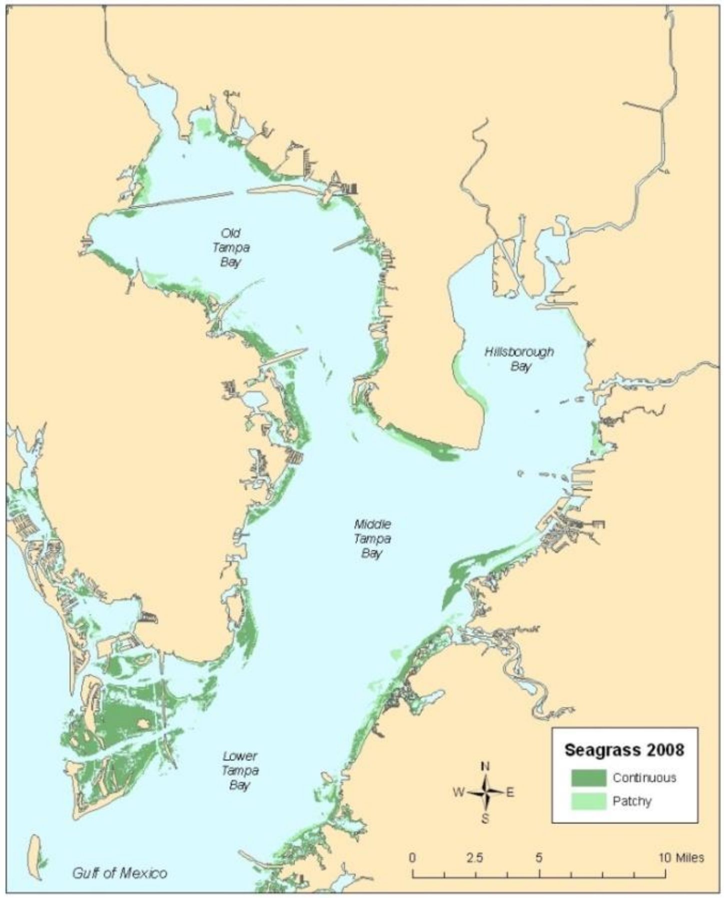

Figure 1. Seagrass cover in Tampa Bay, 2008.

Management and Restoration Recommendations

• Continue reducing nitrogen in runoff to limit phytoplankton productivity.

• Focus on trouble areas where seagrass cover is not increasing.

• Continue efforts to reduce propeller scarring.

Summary Assessment: Seagrass cover in Tampa Bay is steadily increasing in area. Seagrass species composition and meadow texture appear to be stable. Stressors include light limitation, phytoplankton, turbidity, and propeller scarring. Heavy runoff resulting from El Niño events elevates phytoplankton levels and reduces light availability to seagrasses.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover		Increasing	Steady gains
Seagrass meadow texture		Stable	No significant changes
Seagrass species composition		Stable	No significant changes
Overall seagrass trends		Improving	Improving water quality

Seagrass Stressors	Intensity	Impact	Explanation
Water clarity		Improving	Affected by runoff, storms
Nutrients		Relatively low	Affected by runoff, storms
Phytoplankton		Medium	Affected by runoff, storms
Natural events		Minimal impact	1997–98 El Niño
Propeller scarring		Extensive	

Seagrass Mapping Assessment: Between 2006 and 2008, total seagrass cover for Tampa Bay increased by 1,349 acres, from 28,300 acres to 29,650 acres, or 4.8% (Table 1). Most of this increase occurred in Middle Tampa Bay, with small losses occurring in lower portions of the bay. Some of the losses might be due to differences in map interpretation, because turbidity in waters in the southern bay often obscures the bottom in aerial photographs. On a percentage basis, Hillsborough Bay had the greatest gain in seagrass cover, a 95% increase between 2006 and 2008. Seagrass cover increased 7.3% in Old Tampa Bay and 31% in Middle Tampa Bay. The restoration goal for Tampa Bay is a total of 40,400 acres, the estimated seagrass area in 1950. At press time, the Tampa Bay Estuary Program released 2010 mapping data for Tampa Bay: 32,897 acres, an increase of 3,250 acres (11%) since 2008.

TABLE 1. SEAGRASS ACREAGE IN TAMPA BAY

Segment	1950	1982	1996	1999	2004	2006	2008	Change 2006−08
Hillsborough Bay	2,300	0	193	192	566	415	810	395
Old Tampa Bay	10,700	5,943	5,763	4,395	4,636	5,434	5,829	395
Middle Tampa Bay	9,600	4,042	5,541	5,639	6,269	5,089	6,659	1,570
Lower Tampa Bay	6,100	5,016	6,381	5,847	6,319	6,578	6,322	−256
Boca Ciega Bay	10,800	5,770	7,699	7,464	7,731	8,961	8,457	−504
Terra Ceia Bay	700	751	973	929	1,055	1,007	932	−75
Manatee River	200	131	366	375	448	814	638	−176
Total	**40,400**	**21,653**	**26,916**	**24,841**	**27,024**	**28,299**	**29,647**	**1,349**

Monitoring Assessment: Tampa Bay seagrass beds are monitored by the Tampa Bay Interagency Seagrass Monitoring Program with participants assessing an average of 1,550 1-m × 1-m quadrats annually. Results are expressed as the percentage frequency of occurrence for each seagrass species.

Shoal grass (*Halodule wrightii*) is the dominant Tampa Bay species, found in all Tampa Bay subregions (Table 2). Turtle grass (*Thalassia testudinum*), the dominant lower Tampa Bay species, and manatee grass (*Syringodium filiforme*) are also common. The frequency of occurrence of shoal grass and manatee grass increased during 1998–2008; however, turtle grass has remained relatively stable, with slight interannual variations. An alga, *Caulerpa* sp., has been a major contributor to Tampa Bay submerged aquatic vegetation (SAV), especially in the upper portions of Tampa Bay. The number of quadrats having no seagrasses has steadily decreased, from 50% in 1999 to almost 38% in 2008.

TABLE 2. PERCENTAGE FREQUENCY OF OCCURRENCE OF SEAGRASS SPECIES AND *CAULERPA* SPP. IN TAMPA BAY

Year	Bare	Star Grass	Shoal Grass	Manatee Grass	Turtle Grass	Widgeon Grass	*Caulerpa* Alga
1998	49.3	0.0	33.9	4.7	18.4	1.9	1.7
1999	50.4	0.5	35.7	4.9	17.8	0.1	1.7
2000	50.5	0.4	31.0	7.5	18.5	0.8	1.5
2001	47.1	0.2	34.6	7.0	17.3	0.3	2.3
2002	44.1	0.1	38.2	9.0	14.8	0.6	3.2
2003	46.7	0.0	32.0	9.7	19.4	2.0	2.6
2004	46.7	0.3	34.7	9.7	15.4	2.4	4.6
2005	36.0	0.3	39.7	10.6	16.7	5.5	9.6
2006	39.7	0.2	37.7	12.4	18.2	1.5	2.5
2007	36.9	0.1	37.5	12.3	19.0	0.7	4.6
2008	38.3	0.2	39.7	12.5	16.8	0.2	6.0

Mapping and Monitoring Recommendations

- Continue biennial mapping and the annual monitoring program.
- Evaluate methods for comparing cover data obtained using transects with data collected at fixed sampling points.

Management and Restoration Recommendations

• Continue improvement in water quality and light transmission to the bay bottom.

• Increase control of nonpoint-source pollution.

• Remediate and prevent propeller scarring.

Mapping Data and Imagery: SWFWMD has obtained aerial imagery of SAV communities within Tampa Bay every two years since 1988. The most recent set of photographs was obtained in 2010. In 2008, seagrass imagery was photointerpreted from 1:24,000 scale natural color aerial photography and classified using the SWFWMD modified Florida Land Use Cover Classification System. The minimum mapping unit for classification was 0.5 acre.

Monitoring Data: Seagrasses have been monitored in the Tampa Bay region annually since 1986 by regional agency staff and collaborators. The monitoring program is coordinated by the Tampa Bay Estuary Program. Seagrass and macroalgal cover are estimated by species annually in 1,550 quadrats located every 10–25 m on approximately 62 transects and quarterly at 21 fixed locations. These sampling locations are distributed throughout the bay.

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Contacts

Mapping: Kris Kaufman, Surface Water Improvement and Management Program, Southwest Florida Water Management District, 813-985-7481; Kristen.kaufman@swfwmd.state.fl.us.

Monitoring: Walt Avery (retired from the City of Tampa), wmave@msn.com; Ed Sherwood, Tampa Bay Estuary Program, 727-893-2765, esherwood@tbep.org.

Florida Seagrass Integrated Mapping and Monitoring Program

Summary Report for Sarasota Bay and Lemon Bay

Contacts: Jon Perry, Sarasota County, Judy Ashton and Melynda Brown, Florida Department of Environmental Protection (Monitoring); Kristen Kaufman, Southwest Florida Water Management District (Mapping); Jay Leverone, Sarasota Bay Estuary Program, and Judy Ott, Charlotte Harbor National Estuary Program (Resource Management Coordination)

General Assessment: In 2008, seagrass covered 12,641 acres in Sarasota Bay and 2,863 acres in Lemon Bay. Acreage has been steadily increasing since 1999. Between 2006 and 2008, seagrasses increased 28%, or 2,787 acres, in Sarasota Bay and 5.5%, or 149 acres, in Lemon Bay. The greatest gains occurred in Upper Sarasota Bay in Manatee County (1,844 acres), with smaller gains in Sarasota Bay in Sarasota County (850 acres). These gains were offset by a loss of 104 acres of seagrass in Roberts Bay and Blackburn Bay. Seagrass species composition appears to be stable. Stressors include light availability, which is limited in turn by occasionally elevated phytoplankton and turbidity. Seagrass acreage in Sarasota Bay now exceeds the estimated coverage in 1950. Seagrass-based water quality targets have been developed for both bays based on seagrass light requirements, depth at deep edge, and recent or historical acreage.

Seagrass Status and Stresses	Status	Trend	Assessment, Causes
Seagrass cover		Increasing	Large gains, 2006–08
Water clarity		Good	Affected by runoff, storms
Natural events		Minimal impact	2004, 2005 hurricanes
Propeller scarring		Localized	

Geographic Extent: Greater Sarasota Bay extends from Anna Maria Sound in Manatee County south through Blackburn Bay and includes Roberts and Little Sarasota bays. Seagrass resources of Greater Sarasota Bay are managed by the Sarasota Bay Estuary Program. Lemon Bay begins south of Venice and extends south into Charlotte County. Lemon Bay, along with Lyons, Dona and Roberts bays (coastal Venice) are managed by the Charlotte Harbor National Estuary Program (CHNEP). Lemon Bay is also managed as a Florida Aquatic Preserve.

Figure 1. Seagrass cover in Sarasota Bay and Lemon Bay, 2008.

Mapping and Monitoring Recommendations

• Continue to map seagrass cover every two years to evaluate trends in seagrass acreage.

• Continue to monitor changes in species composition, abundance, and deep edge, conducted by several agencies, including the Southwest Florida Water Management District (SWFWMD), Manatee County, Sarasota County, CHNEP, and Florida Department of Environmental Protection (FDEP).

• Update the 2003 propeller scarring map of Lemon Bay prepared for CHNEP by Sargent et al. (2005) to assess trends in scarring and recovery. Assess scarring in Sarasota Bay using similar methods.

Management and Restoration Recommendations

• Evaluate water quality and light attenuation annually using region-specific models and tools available as part of regional Comprehensive Conservation and Management Plans. For more accurate assessment and management, bay waters are divided into segments having generally homogeneous water quality and seagrass conditions. Sarasota Bay is divided into several subestuaries, including Palma Sola Bay (Upper Sarasota Bay), Roberts Bay, Little Sarasota Bay, and Blackburn Bay (Figure 2), while the Lemon Bay region is divided into Upper and Lower Lemon bays (Figure 3). Within each segment, water quality results are evaluated together with seagrass mapping and monitoring data every two years.

• Assess development pressures on storm runoff.

• Continue efforts to reduce propeller scarring.

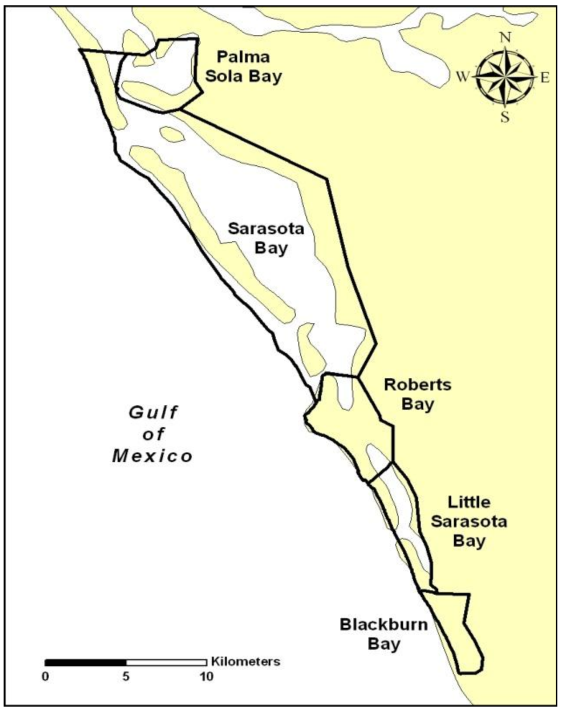

Figure 2. Estuary segments of Sarasota Bay used in seagrass and water quality data analyses.

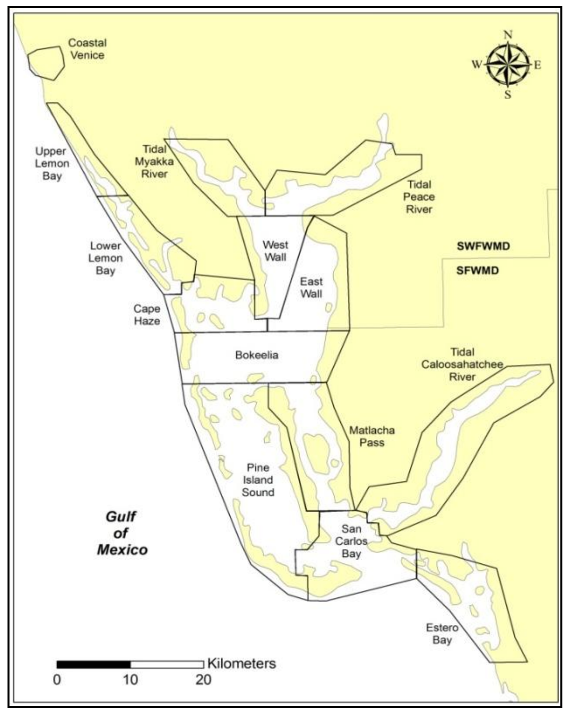

Figure 3. Estuary segments of Lemon Bay and Charlotte Harbor used in seagrass and water quality data analyses.

Summary Assessment: Seagrass cover in Sarasota Bay and Lemon Bay increased during the past four to five years (Table 1). Seagrass species composition and meadow texture appear stable. Stressors include light limitation and propeller scarring. Seagrass cover decreased by 1,085 acres in 1999, following the 1997–98 El Niño. However, optical water quality has improved since then, and increases in seagrass acreage were observed in 2006. Seagrass acreage in Sarasota Bay mapped in 2008 (12,641 acres) exceeded by 29% the target of 9,797 acres. At the same time, steady increases in the extent of continuous seagrass beds have been observed (State of the Bay 2010, Sarasota Bay Estuary Program). Seagrasses in Lemon Bay increased by 149 acres between 2006 and 2008, with 2,863 acres mapped in 2008.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover		Increasing	Large gains, 2006–08
Seagrass meadow texture		Fairly stable	No significant changes
Seagrass species composition		Fairly stable	No significant changes
Overall seagrass trends		Improving	Potential nutrient impacts
Seagrass Stressors	**Intensity**	**Impact**	**Explanation**
Water clarity		Good	Affected by runoff, storms
Nutrients		Relatively low	Affected by runoff, storms
Phytoplankton		Relatively low	Affected by runoff, storms
Natural events		Minimal impact	2004, 2005 hurricanes
Propeller scarring		Localized	

Seagrass Mapping Assessment: Between 2006 and 2008, total seagrass cover for the Sarasota Bay region increased by 2,787 acres, from 9,854 acres to 12,641 acres, an increase of 28% (Table 1). Most of the increase occurred in Upper Sarasota Bay in Manatee County (1,844 acres). Seagrasses cover small areas in Roberts Bay and Blackburn Bay, and these subregions lost 25 and 79 acres, respectively, from 2006 to 2008. Seagrass acreage in the Sarasota Bay region in 2008 exceeded the target acreage, based on estimates of cover in 1950, by 2,844 acres, or 29%. Seagrass acreage in Lemon Bay increased 5.5%, or 149 acres, between 2006 and 2008, from 2,714 acres to 2,863 acres.

TABLE 1. SEAGRASS ACREAGE IN SARASOTA BAY AND LEMON BAY

Segment	1988	1996	1999	2004	2006	2008	Change 2006–08
Upper Sarasota Bay–Manatee Co.	5,469	6,278	5,714	5,493	5,829	7,673	1,844
Upper Sarasota Bay–Sarasota Co.	1,909	2,578	2,060	2,153	2,637	3,487	850
Roberts Bay	331	358	330	368	324	299	−25
Little Sarasota Bay	532	717	770	762	640	837	197
Blackburn Bay	410	401	373	468	424	345	−79
Total Acres in Sarasota Bay	**8,651**	**10,332**	**9,247**	**9,244**	**9,854**	**12,641**	**2,787**
Lemon Bay					2,714	2,863	149

Monitoring Assessment: Seagrass beds throughout this region are stable or increasing in area for the most part. Recent seagrass losses observed in Roberts Bay near Venice coincided with a dramatic increase in the cover of the green attached alga *Caulerpa prolifera.* Turtle grass (*Thalassia testudinum*) is most common in Sarasota Bay, and shoal grass (*Halodule wrightii*) is dominant in Roberts Bay, Little Sarasota Bay, and Blackburn Bay to the south (Figure 4). In Lemon Bay, shoal grass is the most common seagrass in the northern reaches, and turtle grass is most common in the southern portion. The average deep edge of seagrass beds in Lemon Bay varied by location and year from 1999 to 2006, ranging from 1.4 m to 1.6 m, based on FDEP transect data.

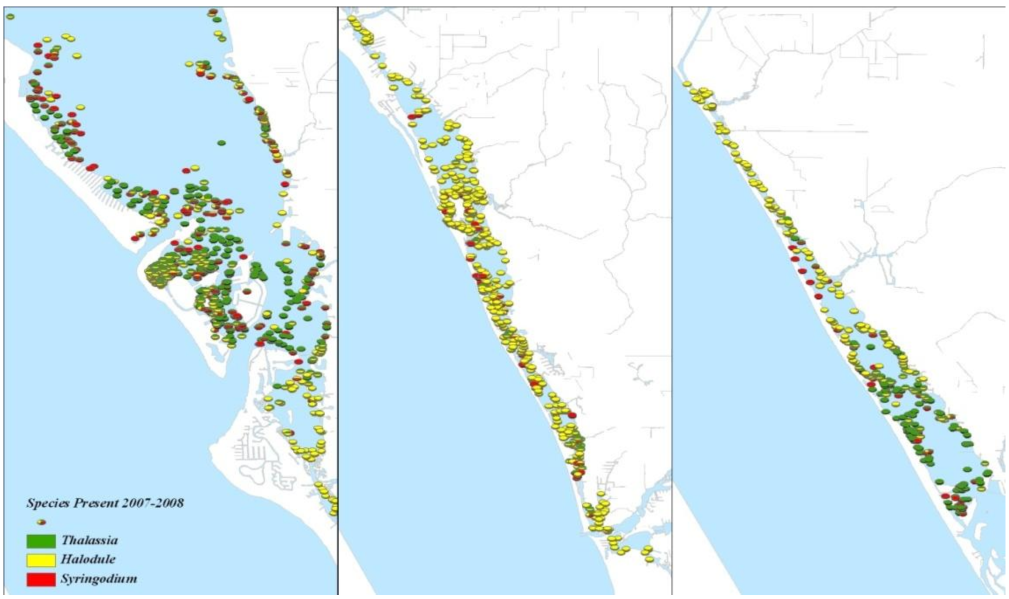

Figure 4. Occurrence of seagrass in Sarasota Bay and Roberts Bay (left), Little Sarasota Bay and Blackburn Bay (middle), and Lemon Bay (right). (Data from the Sarasota County monitoring program.)

Management and Restoration Assessment: Seagrass acreage targets for each segment of Sarasota Bay and Lemon Bay were established by the Sarasota Bay Estuary Program (SBEP) and the CHNEP, respectively, using the maximum historical extent and interannual variability of seagrass cover. In turn, seagrass target acreages were used to establish water quality targets for each estuarine segment. Using aerial photography, persistence of seagrass locations (Figure 5) and historical acreages were determined for Dona, Roberts, and Lemon bays. Seagrass targets for Sarasota Bay are: Palm Sola, 1,031 acres; Sarasota Bay, 7,269 acres; Roberts Bay, 348 acres; Little Sarasota Bay, 702 acres; and Blackburn Bay, 447 acres. For Lemon Bay, seagrass targets are: Dona/Roberts Bay, 110 acres; Upper Lemon Bay, 1,010 acres; and Lower Lemon Bay, 2,880 acres, for a total of 4,000 acres. Progress toward seagrass and water quality targets will be evaluated annually.

Other management goals include continual improvement of water quality and light transmission to the bay bottom, increasing control of nonpoint-source pollution, assessment of the impacts of diverting freshwater from tributaries into Roberts Bay, and remediation and prevention of propeller scarring.

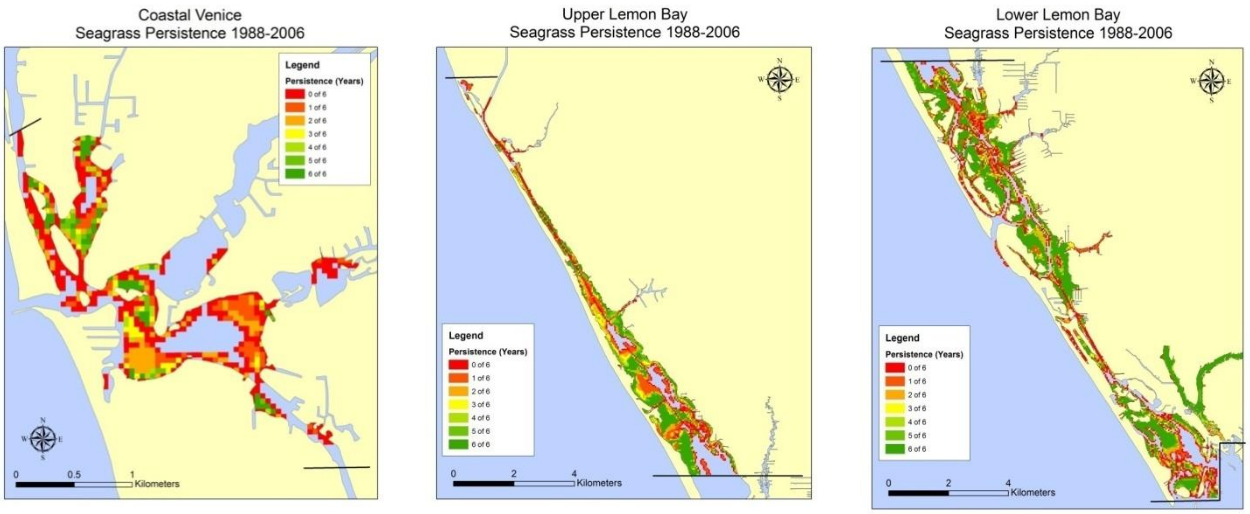

Figure 5. Persistence of seagrass locations in Dona/Roberts and Lemon bays, 1988–2006.

Mapping and Monitoring Recommendations

• Continue biennial mapping and the twice-yearly monitoring program.

• Update the 2003 propeller scarring maps of Lemon Bay produced by Sargent et al. (2005), and produce scarring maps for Sarasota Bay.

Management and Restoration Recommendations

• Evaluate water quality and light attenuation annually using available region-specific models and tools.

• Twice a year, compare water quality and seagrass maps and monitoring data to assess progress in meeting seagrass acreage targets.

• Continue efforts to reduce propeller scarring.

Mapping Data and Imagery: SWFWMD has acquired aerial imagery in Sarasota Bay and Lemon Bay every two years since 1988. The most recent set of photographs was obtained in

2010. In 2008, seagrass imagery was photointerpreted from 1:24,000 scale natural color aerial photography and classified using the SWFWMD modified Florida Land Use Cover Classification System. The minimum mapping unit for classification was 0.5 acre.

Monitoring Data: Seagrass monitoring has been conducted in the Sarasota Bay region annually in the fall since 1999 by FDEP staff. In Lemon Bay, seagrasses have been monitored since 2001 in the fall in a program coordinated by CHNEP. Both monitoring programs evaluate seagrasses along established transects, and seagrass and macroalgal cover are estimated by species. In addition, both programs assess epiphyte loads, seagrass blade length, and sediment quality. Sarasota County staff coordinate a twice-yearly (August and February) monitoring program using volunteers from the fishing community.

Pertinent Reports and Scientific Publications

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FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION CHARLOTTE HARBOR AQUATIC PRESERVES. 2007. Seagrass annual data summary from the Charlotte Harbor & Estero Bay Aquatic Preserves Seagrass Transect Monitoring Program, 1999–2006. Prepared by Celia Stearns. 50 p. http://www.dep.state.fl.us/coastal/sites/charlotte/research/Seagrass_Data_Summary.pdf, accessed March 2011.

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Sarasota County Wateratlas: http://maps.wateratlas.usf.edu/sarasota/index.asp; accessed March 2011.

The Charlotte Harbor National Estuary Program: http://www.chnep.org/, accessed March 2011.

Contacts

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Monitoring: Jon Perry, Sarasota County, 941-861-0984, jsperry@scgov.net; Judy Ashton, FDEP Southwest District, 813-632-7600, judy.ashton@dep.state.fl.us; Mindy Brown, Charlotte Harbor Aquatic Preserves, 941-575-5861, melynda.a.brown@dep.state.fl.us.

Resource Management Coordination: Judy Ott, Charlotte Harbor National Estuary Program, 239-338-2556, jott@swfrpc.org; Jay Leverone, Sarasota Bay Estuary program, 941-955-8085, jay@sarasotabay.org.

Florida Seagrass Integrated Mapping and Monitoring Program

Summary Report for Charlotte Harbor, Cape Haze, Pine Island Sound, and Matlacha Pass

Contacts: Heather Stafford and Melynda Brown, Charlotte Harbor Aquatic Preserves, Florida Department of Environmental Protection (Monitoring); Kristen Kaufman, Southwest Florida Water Management District, and Peter Doering, South Florida Water Management District (Mapping); Judy Ott, Charlotte Harbor National Estuary Program (Resource Management Coordination)

General Assessment: Seagrass acreage in Charlotte Harbor, Cape Haze, Pine Island Sound, and Matlacha Pass has been stable or increasing in recent years (Figures 1 and 2). Acreage has increased since 2004, with recovery from the 2004/2005 hurricanes. In 2004, 57,213 acres were mapped throughout the region, and in 2006, 58,849 acres were mapped, an increase of 1,636 acres, or 2.9%. Seagrass-based water quality targets have been developed throughout the Charlotte Harbor region based on seagrass light requirements, water depth at the deep edge of seagrass beds, and acreage. Human development, with the resulting impacts of increasing nutrients and turbidity in coastal waters, is a threat to seagrass beds. Propeller scarring continues to impact seagrass beds throughout this region; beds in Pine Island Sound and Matlacha Pass in Lee County have experienced the most severe damage. In these two regions, 21,507 acres of seagrass beds have been scarred by propellers.

Seagrass Status and Stresses	Status	Trend	Assessment, Causes
Seagrass cover	Green	Increasing	Improved since 2004–05
Water clarity	Yellow	Local declines	Affected by runoff, storms
Natural events	Yellow	Moderate impact	2004, 2005 hurricanes
Propeller scarring	Red	Increasing	Increased boating

Geographic Extent: This chapter includes Charlotte Harbor, Gasparilla Sound, Cape Haze, Pine Island Sound, Matlacha Pass, San Carlos Bay, and the tidal Caloosahatchee and Peace rivers. The region is managed through both the Aquatic Preserve Program of the Florida Department of Environmental Protection (FDEP) and the Charlotte Harbor National Estuary Program (CHNEP). The Gasparilla Sound/Charlotte Harbor Aquatic Preserves extend from the tidal Peace and Myakka rivers through Lemon Bay to Pine Island Sound and Matlacha Pass. The CHNEP includes these estuaries, plus Lemon Bay to the north, all of Charlotte Harbor, and Estero Bay to the south. In addition, the northern estuaries of this region (those in Charlotte and Sarasota counties, including Lemon Bay, Upper Charlotte Harbor, Peace River, Myakka River, Gasparilla Sound, and Cape Haze) fall within the jurisdiction of the Southwest Florida Water Management District. The southern estuaries (in Lee County, including Lower Charlotte Harbor, Pine Island Sound, Matlacha Pass, San Carlos Bay, and the tidal Caloosahatchee River) are within the jurisdiction of South Florida Water Management District.

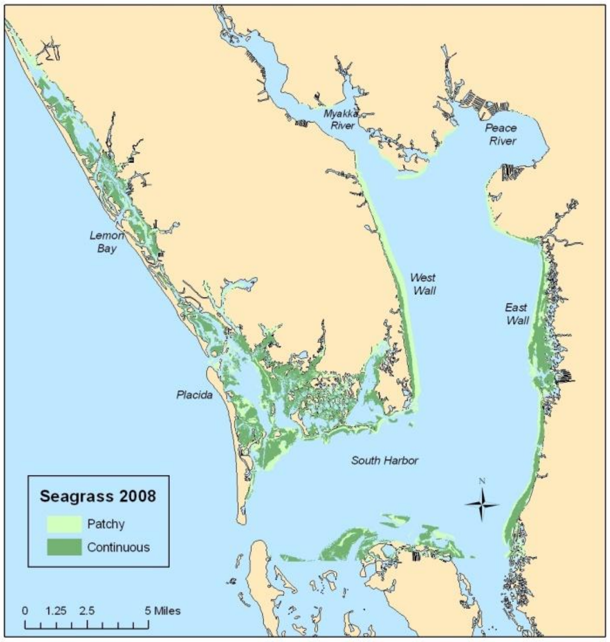

Figure 1. Seagrass in northern Charlotte Harbor, 2008.

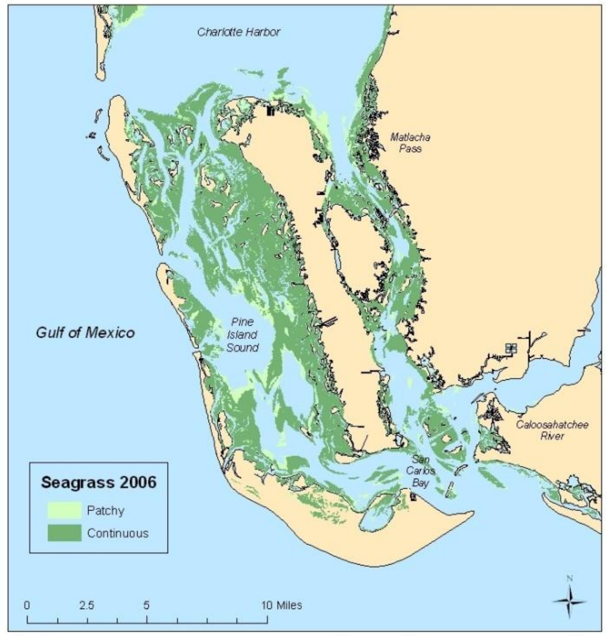

Figure 2. Seagrass in southern Charlotte Harbor, 2008.

Mapping and Monitoring Recommendations

• Continue biennial aerial photography, photointerpretation, and mapping by the Southwest Florida Water Management District (SWFWMD) for northern Charlotte Harbor and by South Florida Water Management District (SFWMD) for southern Charlotte Harbor to evaluate trends in seagrass acreage.

• Continue annual fall monitoring by staff of the Gasparilla Sound/Charlotte Harbor Aquatic Preserves to evaluate changes in species composition, abundance, and water depth at the deep edge of seagrass beds.

• Update the map of propeller scarring in Charlotte Harbor (Sargent et al. 2005) to assess trends in scarring and recovery.

Management and Restoration Recommendations

• As part of the regional management plan, evaluate water quality and light attenuation annually using available region-specific models and tools. For more accurate assessment and management, bay waters are divided into segments having generally homogeneous water quality and seagrass conditions (Figure 3). Within each segment, water quality results are compared with seagrass mapping and monitoring data on a biennial basis.

• Assess effects of development on storm runoff.

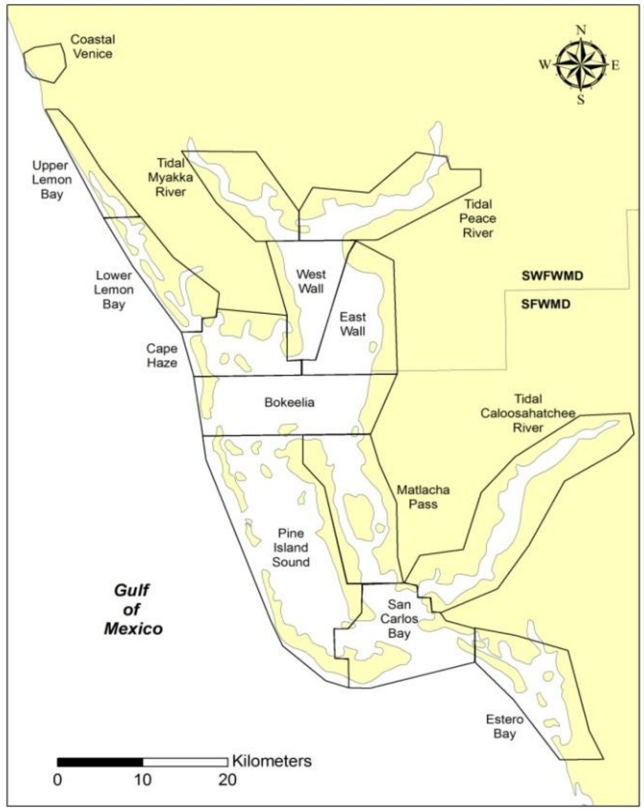

Figure 3. Estuary segments used for seagrass water quality analyses.

• Implement a region-wide program with the goal of decreasing propeller scarring and evaluate the effectiveness of the No Internal Combustion Motor Zones in Pine Island Sound and Matlacha Pass and the Pole and Troll zone near Blind Pass, once they are in place.

Summary Assessment: Overall, seagrass acreage has declined from historical levels due to development and dredge-and-fill operations in coastal waters. More recently, seagrass acreage has been recovering, despite episodic runoff from hurricanes and tropical storms in 2004. From 2004 to 2006, seagrass acreage throughout the subestuaries of the Charlotte Harbor region increased from 57,213 acres to 58,849 acres, or 2.9%. However, monitoring studies indicate that seagrass meadow texture and species composition vary, especially between subestuaries. Overall, the abundance of shoal grass (*Halodule wrightii*) and turtle grass (*Thalassia testudinum*) is probably declining, and the number of monitored quadrats that are devoid of seagrasses has increased. Factors that affect water clarity, such as turbidity, color, and chlorophyll-a concentration, are a concern in some subestuaries and watersheds. Propeller scarring is present throughout the study area and is particularly severe in Pine Island Sound and Matlacha Pass, where 44% of the 21,507 propeller-scarred acres are classified as severely impacted.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover		Increasing	Runoff, nutrients
Seagrass meadow texture		Changing	Increasing bare areas
Seagrass species composition		Fairly stable	Increase in shoal grass
Overall seagrass trends		Improving	Drought before 2010
Seagrass Stressors	**Intensity**	**Impact**	**Explanation**
Water clarity		Local declines	Affected by runoff, storms
Nutrients		Increasing	Affected by runoff, storms
Phytoplankton		Increasing	Affected by runoff, storms
Natural events		Moderate impact	2004, 2005 hurricanes
Propeller scarring		Increasing	Increased boating

Seagrass Mapping Assessment: From 2004 to 2006, seagrass acreage increased by 1,636 acres throughout the Charlotte Harbor region (Table 1). In Upper Charlotte Harbor, seagrass cover increased in all estuary segments except the Cape Haze area, which lost 553 acres of seagrass (a 7.4% loss). The largest percentage gains occurred along the West Wall of Charlotte Harbor and in the tidal portions of the Myakka and Peace rivers. In 2006, there were 16,650 acres of seagrass in the northern segments. In 2006, the Lower Charlotte Harbor estuary segments contained almost 2.5 times as many acres of seagrass as Upper Charlotte Harbor, and most of this acreage was in Pine Island Sound. All estuary segments in Lower Charlotte Harbor had gains in seagrass area between 2004 and 2006, and these gains (1,494 acres), which occurred mostly in Pine Island Sound, accounted for 91% of the increase in seagrass acreage for the entire Charlotte Harbor region.

TABLE 1. SEAGRASS ACREAGE IN THE CHARLOTTE HARBOR REGION

	1999	2004	2006	Change 2004–06	% Change 2004–06
A. Upper Charlotte Harbor (SWFWMD)					
Tidal Myakka River	539	331	375	44	13.3
Tidal Peace River	302	295	341	46	15.6
West Wall	1,993	1,784	2,121	337	18.9
East Wall	3,587	3,275	3,382	107	3.3
Cape Haze	6,709	7,464	6,911	−553	−7.4
Bokeelia	3,101	3,359	3,520	161	4.8
Total	16,231	16,508	16,650	142	0.9
B. Lower Charlotte Harbor (SFWMD)					
Pine Island Sound	25,941	28,034	29,204	1,170	4.2
Matlacha Pass	6,055	7,479	7,619	140	1.9
San Carlos Bay	3,709	5,192	5,376	184	3.5
Total	35,705	40,705	42,199	1,494	3.7
C. Total Charlotte Harbor Region					
	51,936	57,213	58,849	1,636	2.9

Monitoring Assessment: Monitoring has been conducted each fall since 1999 using 50 fixed transects. Evaluation of data from 1999 through 2009 suggests that, overall, seagrass beds are increasing or stable in size and in species composition (Table 2), with no changes in depth distribution (data not shown). Six species of seagrass are found in the Charlotte Harbor region: turtle grass (*T. testudinum*), shoal grass (*H. wrightii*), and manatee grass (*Syringodium filiforme*) are the most common, and widgeon grass (*Ruppia maritima*), paddle grass (*Halophila decipiens*), and star grass (*H. engelmannii*) are ephemeral. From 1999 to 2005, the abundance of shoal grass, turtle grass, and manatee grass declined, based on Braun-Blanquet quadrat assessments. At the same time, the number of bare quadrats increased from 10% to 24%. Greenawalt-Boswell et al. (2006) also found a significant increase in the number of quadrats having no seagrass. After 2005, shoal grass rebounded in percentage occurrence, and the fraction of bare quadrats decreased. However, the percentage abundance of turtle grass and

TABLE 2. PERCENTAGE OCCURRENCE OF SEAGRASS SPECIES IN QUADRATS WITHIN THE CHARLOTTE HARBOR AQUATIC PRESERVES AREA

Year	No Seagrass	Shoal Grass	Turtle Grass	Manatee Grass	Widgeon Grass	Star Grass
1999	10	46.5	31.5	9.2	1.9	0.8
2000	11.9	47.8	30.4	9.3	0.7	0
2001	16.2	40.5	32	9.5	1.4	0.4
2002	15.5	44.5	31.7	8.3	0	0
2003	19.9	41.3	29.9	8.9	0	0
2004	19.9	41.6	30.1	8.4	0	0
2005	24.3	41	26.5	8.2	0	0
2006	20.3	44.5	27.2	7.9	0	0
2007	15.8	47.4	26.8	9.3	0	0.7
2008	16	47	25.4	8.7	2.8	0
2009	12.5	51.2	27.5	8.8	0	0

manatee grass has remained near 2005 levels. Within the Charlotte Harbor region, Greenawalt-Boswell et al. (2006) found net losses of seagrasses in the Peace River, Myakka River, and North Charlotte Harbor. Pine Island Sound, San Carlos Bay, and Matlacha Pass were stable in seagrass cover, while Southern Charlotte Harbor and Gasparilla Sound had increases.

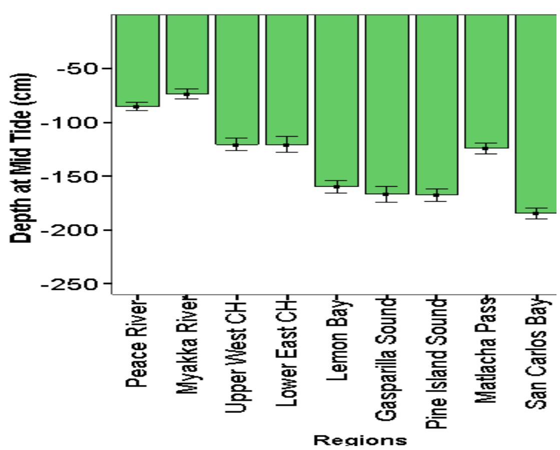

Figure 4. Average deep edge of seagrass growth.

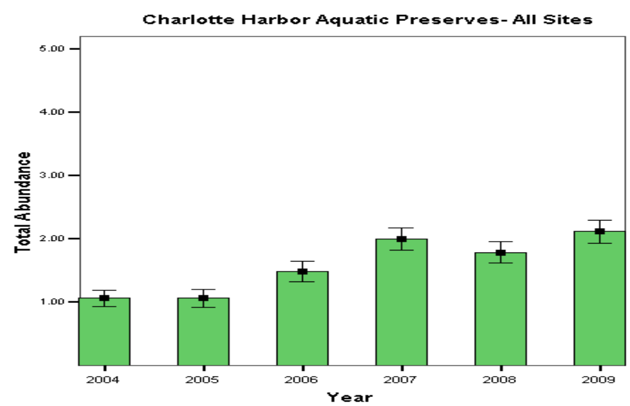

Figure 5. Mean total abundance of all seagrasses in the Charlotte Harbor Aquatic Preserves, reported by Braun-Blanquet score, 1999-2006.

The average water depth at the deep edge of seagrass beds varied by subestuary based on FDEP transect monitoring data from 1999 to 2006, ranging from approximately 70 cm in the Myakka River to 180 cm in San Carlos Bay (Figure 4). Mean total abundance of all seagrasses in the Charlotte Harbor region has steadily increased since 2005 (Figure 5). Propeller scarring in Pine Island Sound, increased nutrient inputs due to watershed development, and increases in the amount of suspended particles in the water continue to impact seagrass beds.

Management and Restoration Assessment: Seagrass acreage targets for each subestuary of Charlotte Harbor (Table 3) were established by CHNEP, using the maximum historical extent and inter-annual variability of seagrass cover. In turn, seagrass target acreages were used to establish water quality targets for each estuarine segment (CHNEP 2009). Based on aerial photography, persistence of seagrass locations and acreage was determined for each estuary segment. An example is shown in Figure 6 for Pine Island Sound.

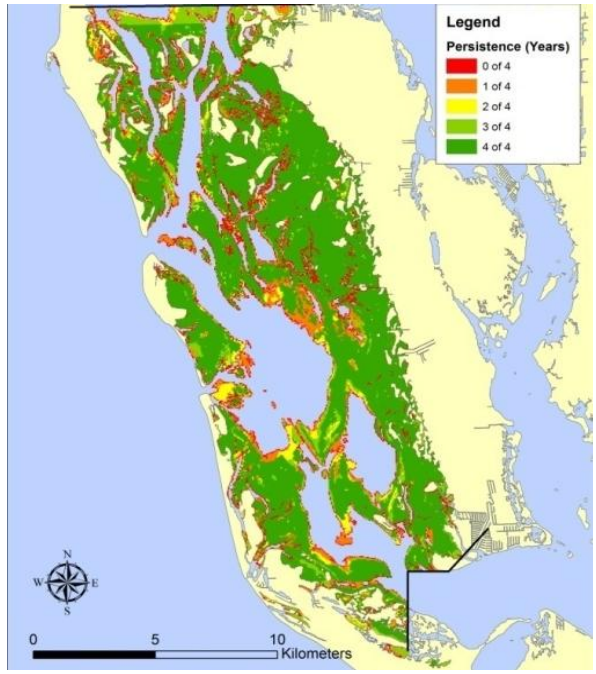

Figure 6. Persistence of seagrass locations from 1999-2006 in Pine Island Sound.

TABLE 3. SEAGRASS PROTECTION AND RESTORATION TARGETS FOR THE CHARLOTTE HARBOR REGION

Estuarine Segment	Target (acres)
Tidal Peace and Myakka rivers	1,430
Charlotte Harbor	9,350
Cape Haze	7,000
Pine Island Sound	26,840
Matlacha Pass	9,320
San Carlos Bay	4,370
Tidal Caloosahatchee River	90
Total	**58,400**

Mapping and Monitoring Recommendations

• Continue biennial mapping and annual monitoring programs.

• Update the 2003 propeller scarring maps of Charlotte Harbor produced by Sargent et al. (2005) to assess trends in scarring and to evaluate areas where severe propeller scarring continues.

Management and Restoration Recommendations

• Evaluate water quality and light attenuation annually using available region-specific models and tools.

• Address levels of nutrient inputs, and identify sources of nutrients and other factors that reduce water clarity.

• Minimize propeller scarring and evaluate the effectiveness of the No Internal Combustion Motor Zones in Pine Island Sound and Matlacha Pass and the Pole and Troll zone near Blind Pass, once they are in place.

Mapping Data and Imagery: SWFWMD is responsible for mapping seagrasses in the northern portion of the Charlotte Harbor Aquatic Preserves, and aerial photography is obtained every two years. In 2008, seagrass imagery was photointerpreted from 1:24,000 scale natural color aerial photography and classified using the SWFWMD modified Florida Land Use Cover Classification System (FLUCCS). The minimum mapping unit for classification was 0.5 acre. Lower Charlotte Harbor, Pine Island Sound, Matlacha Pass, and the Caloosahatchee Estuary are under the jurisdiction of SFWMD. For these subregions, seagrass data were photointerpreted from 2006 1:24,000 scale natural color aerial photography and classified using SFWMD modified FLUCCS. Features were stereoscopically interpreted from the aero-triangulated aerial photography, and vector data were compiled using digital stereo plotters. The minimum mapping unit for classification was 0.5 acre.

Monitoring Data: Seagrass beds in the Charlotte Harbor Aquatic Preserves are monitored each fall using 50 transects from shore to deep edge. Total abundance and species abundance are assessed in 1 m × 1 m quadrats using the Braun-Blanquet method (1: < 5%, 2: 6–25%, 3: 26–50%, 4: 51–75%, 5: 76–100%). Shoot counts, blade lengths, and epiphyte loading on seagrass blades are evaluated as well. Data summaries and reports are available on the Charlotte Harbor Aquatic Preserves website:
(http://www.dep.state.fl.us/coastal/sites/charlotte/research/Seagrass_Data_Summary.pdf).

Pertinent Reports and Scientific Publications

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Contacts

Monitoring: Heather Stafford or Melynda Brown, Charlotte Harbor Aquatic Preserves, Florida Department of Environmental Protection, 941-575-5861, heather.stafford@dep.state.fl.us, melynda.a.brown@dep.state.fl.us.

Mapping: Kris Kaufmann, Surface Water Improvement and Management Program, Southwest Florida Water Management District, 813-985-7481, Kristen.Kaufman@swfwmd.state.fl.us; Peter Doering, South Florida Water Management District 561-682-2772, pdoering@sfwmd.gov.

Resource Management Coordination: Judy Ott, Charlotte Harbor National Estuary Program, 239-338-2556, jott@swfrpc.org.

Florida Seagrass Integrated Mapping and Monitoring Program

Summary Report for Estero Bay

Contacts: Stephanie Erickson, Estero Bay Aquatic Preserve, Florida Department of Environmental Protection (Monitoring); Peter Doering, South Florida Water Management District (Mapping); Judy Ott, Charlotte Harbor National Estuary Program (Resource Management Coordination)

General Assessment: In 2006, there were 3,529 acres of seagrass in Estero Bay, a 2.6% decrease since 2004. Between 2007 and 2009, density of seagrass shoots also decreased slightly. Long-term abundance of turtle grass (*Thalassia testudinum*) and shoal grass (*Halodule wrightii*) is stable, with expected seasonal fluctuations, but occurrence of manatee grass (*Syringodium filiforme*), paddle grass (*Halophila decipiens*), and star grass (*H. engelmannii*) varies from year to year. Recently, widgeon grass (*Ruppia maritima*) has been observed in the central portion of the bay near New Pass (Schmid 2009). Seasonal increases in the abundance of macroalgae decrease light availability to seagrasses and can diminish seagrass productivity. Seagrass-based water quality targets have been developed for Estero Bay based on seagrass light requirements, bed depth at deep edge, and historical acreage. Development with the resulting impacts of increasing nutrients and turbidity in coastal waters threatens seagrass beds. Propeller scarring continues to impact seagrasses in the bay.

Seagrass Status and Stresses	Status	Trend	Assessment, Causes
Seagrass cover		Declining	Runoff, turbidity
Water clarity		Impacted	Runoff, turbidity
Natural events		Minimal impact	2004, 2005 hurricanes
Propeller scarring		Significant	Baywide

Geographic Extent: Estero Bay extends from south of Matanzas Pass to Bonita Beach Road in Lee County. There are extensive seagrass beds in the central region of the bay, particularly along the eastern shoreline. Estero Bay is managed by the Estero Bay Aquatic Preserve and as part of the Charlotte Harbor National Estuary Program (CHNEP) and is in the jurisdiction of the South Florida Water Management District (SFWMD).

Mapping and Monitoring Recommendations

• Continue biennial aerial photography, photointerpretation, and mapping by the SFWMD.

• Continue monitoring seagrasses twice a year by Estero Bay Aquatic Preserves staff.

• Update the map of propeller scarring in Estero Bay (Sargent et al. 2005) to assess trends in scarring and recovery.

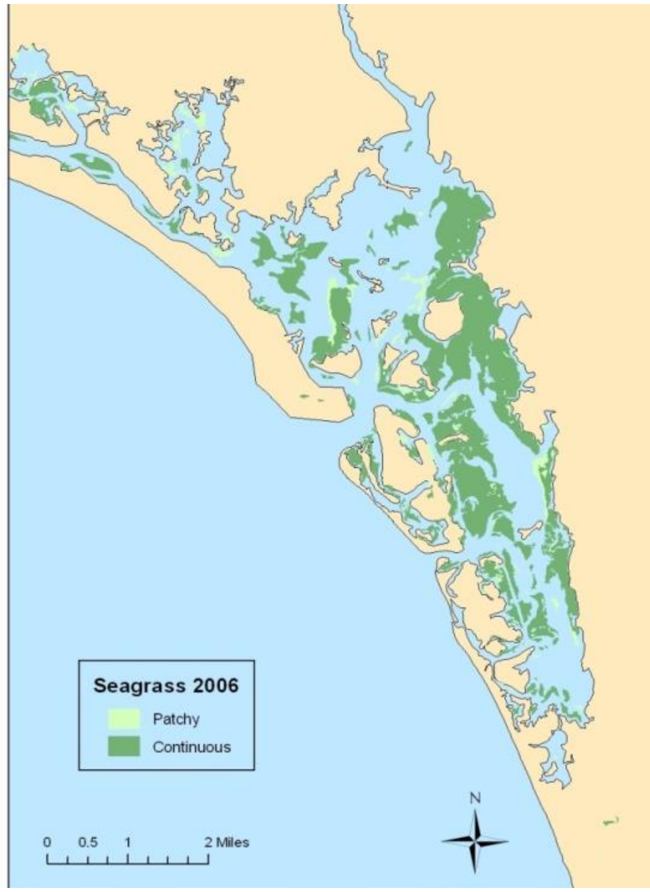

Figure 1. Seagrass cover in Estero Bay, 2006.

Management and Restoration Recommendations

• Continue to evaluate water quality and light attenuation of Estero Bay waters. Estero Bay is managed as one of several regions in the Charlotte Harbor National Estuary Program (Figure 2). Under the regional management plan, water quality and light attenuation of bay waters are evaluated annually using available region-specific models and tools. These water quality data are compared biennially to seagrass maps and monitoring data.

• Increase efforts to eliminate propeller scarring

• Increase efforts to minimize urban runoff and turbidity.

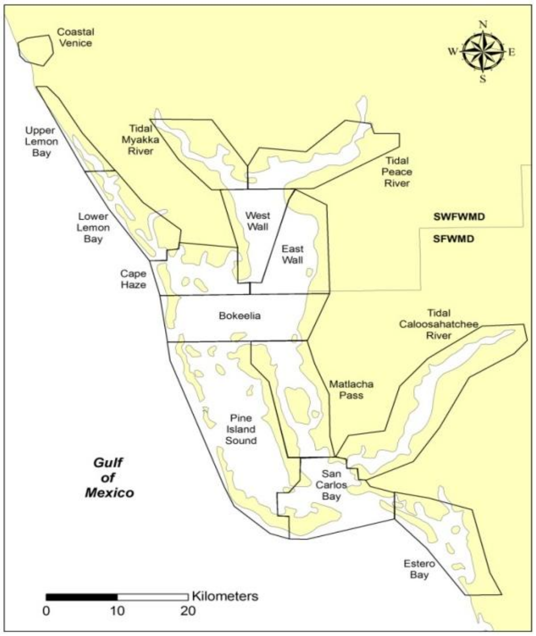

Figure 2. Estuary segments used for seagrass and water quality analyses.

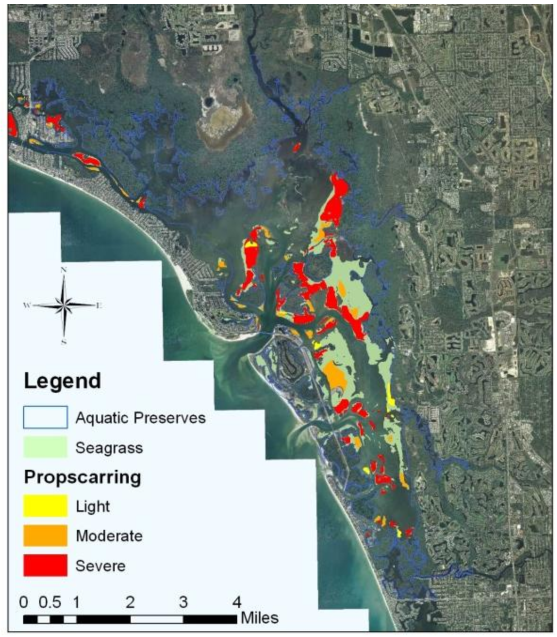

Figure 3. Estuary segments used for seagrass beds affected by propeller scarring in Estero Bay.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover		Declining	Runoff, turbidity
Seagrass meadow texture		Fairly stable	No significant changes
Seagrass species composition		Fairly stable	Shoal grass, turtle grass
Overall seagrass trends		Declining	Water clarity, macroalgae
Seagrass Stressors	**Intensity**	**Impact**	**Explanation**
Water clarity		Impacted	Turbidity, runoff
Nutrients		Impacted	Affected by runoff, storms
Phytoplankton		Local impacts	Affected by runoff, storms
Natural events		Minimal impact	2004, 2005 hurricanes
Propeller scarring		Significant	Baywide

Summary Assessment: Seagrass acreage decreased 2.6% from 2004 to 2006, and losses may have resulted from short-term impacts of the 2004–05 storm seasons (Table 1). Photointerpretation of 2008 aerial photography will provide data that will allow better assessment of storm effects and recovery. Monitoring data indicate that seagrass bed texture and species composition are stable over the long term, with shoal grass and turtle grass most common. Occurrence of star grass, paddle grass, and manatee grass are variable. Propeller scarring remains a significant concern throughout the bay (see Figure 3).

Seagrass Mapping Assessment: Seagrass acreage in Estero Bay decreased by 96 acres, or 2.6%, from 2004 to 2006 (Table 1). Photointerpretation of 2008 aerial photography will provide updated information.

TABLE 1. ACREAGE OF SEAGRASSES IN ESTERO BAY

2004	2006	Change	% Change
3,625	3,529	−96	−2.6

Monitoring Assessment: Staff of the Florida Department of Environmental Protection (FDEP) Estero Bay Aquatic Preserves have monitored seagrasses twice a year since 2002. Since 2006, species composition and abundance have varied by season and year, with abundance greater in summer (Figure 4). Over the past two years, total species abundance within seagrass beds during the summer monitoring period has declined slightly. The average deep edge of seagrass also varied by year, ranging from about 120 cm in 2003 and prior to the severe storm seasons of 2004–05 to 75 cm in 2006. (Figure 5). Turbidity due to resuspension of bottom sediments in this very shallow system continues to affect water clarity, as do seasonal increases in macroalgae.

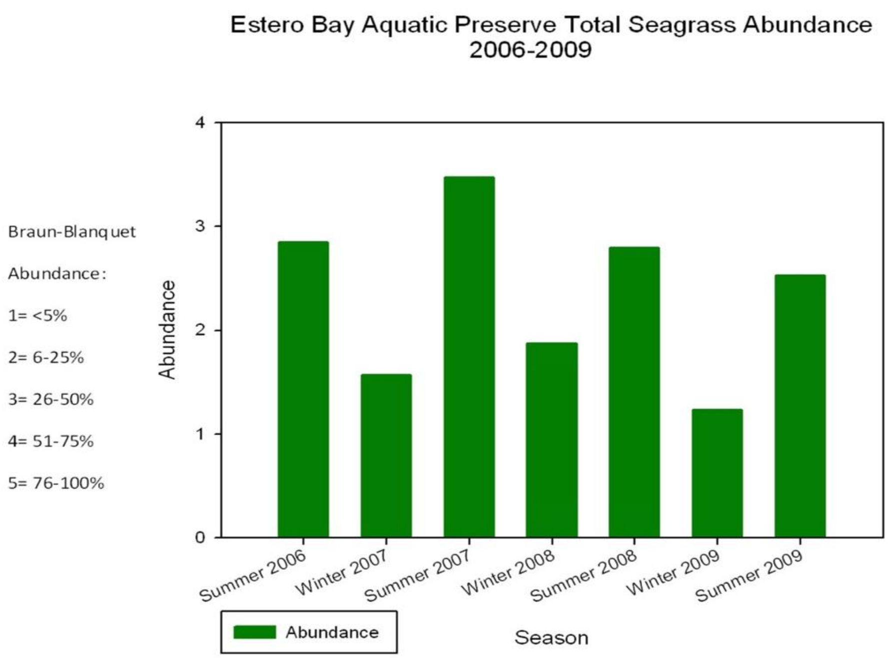

Figure 4. Seagrass abundance in Estero Bay, based on Braun-Blanquet scores.

Management and Restoration Assessment: Propeller scarring is a significant problem in Estero Bay and No Internal Combustion Motor Zones were recently established (Figure 6). A restoration target of 3,660 acres for Estero Bay was established by the CHNEP, using the maximum historical extent and interannual variability of seagrass cover. In turn, the seagrass target acreage was used to establish water quality targets for the bay (CHNEP 2009). Using aerial photography, persistence of seagrass locations and acreage were determined for each estuary segment (Figure 7).

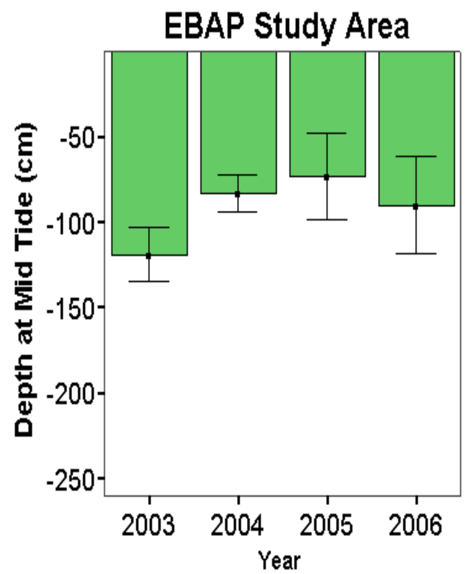

Figure 5. Average depth of the deep edge of seagrass beds in Estero Bay.

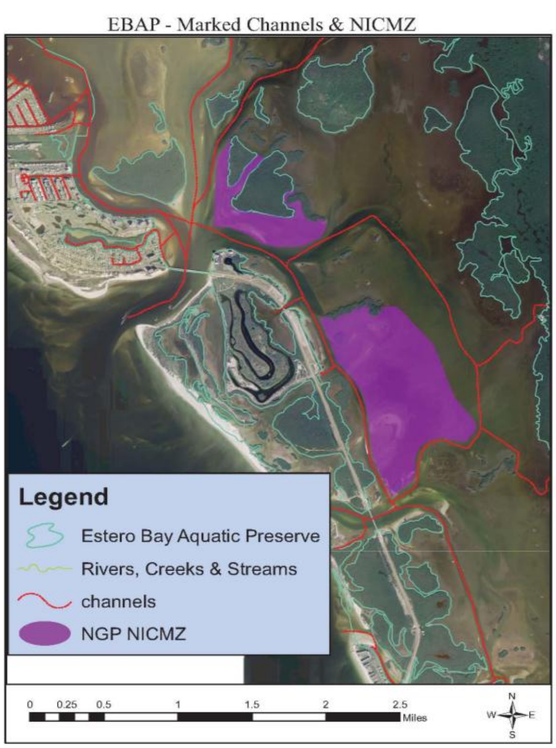

Figure 6. Location of no internal combustion motor zones in Estero Bay.

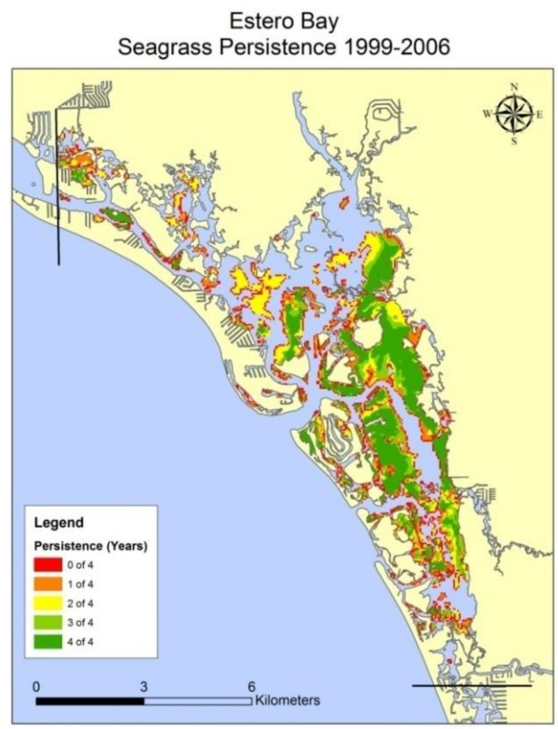

Figure 7. Persistence of seagrass locations in Estero Bay, 1999-2006.

Mapping and Monitoring Recommendations

• Continue monitoring by the Estero Bay Aquatic Preserves and biennial mapping by SFWMD.

• Update the 2003 FWRI propeller scarring maps of Estero Bay produced by Sargent et al. (2005) to assess trends in scarring and evaluate areas where propeller scarring remains severe.

Management and Restoration Recommendations

• Repair areas with propeller scarring, and eliminate or minimize new impacts.

• Evaluate the effectiveness of the No Internal Combustion Motor Zones near Big Carlos Pass and New Pass once they have been implemented.

• Minimize impacts of storm runoff.

• Evaluate progress toward seagrass and water quality targets annually.

• Address potential increases and determine the sources of nutrients and other factors that contribute to decreased water clarity.

Mapping Data and Imagery: Seagrass mapping data were acquired from photointerpretation of 1:24000 scale natural color aerial photography taken in 2006 and then classified using the SFWMD modified Florida Land Use Cover Classification System. Features were stereoscopically interpreted from the aero-triangulated aerial photography, and vector data were compiled using digital stereoplotters. The minimum mapping unit for classification was 0.5 acre.

Monitoring Data: Seagrass beds are monitored twice a year by staff of the Estero Bay Aquatic Preserves in coordination with the Charlotte Harbor Aquatic Preserves monitoring program. Seagrasses are evaluated along five transects, where species composition, species abundance, total seagrass abundance, blade length, shoot counts, and epiphyte loading are assessed. Other recorded parameters include sediment type, water depth, dissolved oxygen (DO), Secchi depth, salinity, and water temperature. Data summaries and reports are available through the Charlotte Harbor Aquatic Preserves website (http://www.dep.state.fl.us/coastal/sites/charlotte/research/seagrass.htm).

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Contacts

Monitoring: Stephanie Erickson, Florida Department of Environmental Protection, 239-463-3240, Stephanie.erickson@dep.state.fl.us; Keith Kibbey, Lee County, kibbey.ka@leegov.org.

Mapping: Peter Doering, South Florida Water Management District, 561-682-2772, pdoering@sfwmd.gov.

Resource Management Coordination: Judy Ott, Charlotte Harbor National Estuary Program, 239-338-2556; jott@swfrpc.org.

Florida Seagrass Integrated Mapping and Monitoring Program

Summary Report for Rookery Bay National Estuarine Research Reserve

Contacts: Victoria Vazquez and Jill Schmid, Rookery Bay National Estuarine Research Reserve (Monitoring and Mapping); Katie Laakkonen, City of Naples (Monitoring)

General Assessment: Approximately 1,028 acres of seagrass have been mapped using sidescan sonar within the Rookery Bay National Estuarine Research Reserve. The most extensive seagrass bed within the reserve is located on the Cape Romano shoals (680 acres) in the Ten Thousand Islands. Other regions in the reserve exhibit mostly patchy beds. Recently, seagrass beds appear to be declining. Research and monitoring are under way to determine causes of the decline and to determine whether seagrass beds are declining throughout the reserve.

Seagrass Status and Stresses	Status	Trend	Assessment, Causes
Seagrass cover		Declining	Undetermined cause
Water clarity		Poor	High to low turbidity

Geographic Extent: The research reserve includes coastal waters in Collier County from Gordon Pass, south of Naples, through the Ten Thousand Islands where the reserve borders Everglades National Park. The reserve has also been involved in monitoring efforts in the Cocohatchee River located in the Delnor-Wiggins State Park, north of the reserve. The turbid waters in the reserve and the patchiness of the seagrass there make mapping of submerged habitat difficult. Therefore, current locations of seagrass beds have not been well identified and need to be reassessed.

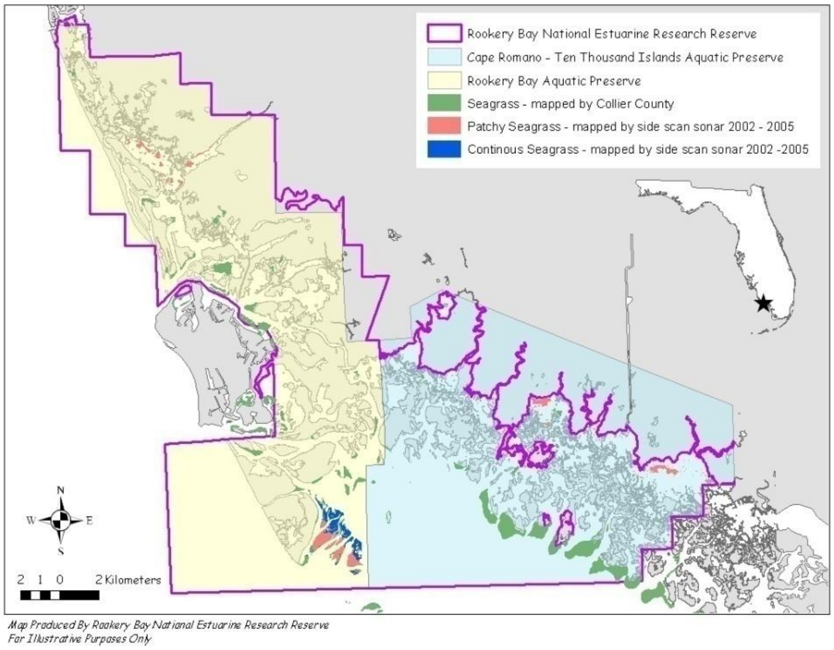

Figure 1. Seagrass cover in the Rookery Bay National Research Reserve, 2002-2005.

Mapping and Monitoring Recommendations

• Remap and analyze changes in areas where seagrass was documented in the 1980s by Collier County and in the area near Cape Romano.

• Map areas along the Ten Thousand Islands so that changes can be detected after hydrologic restoration efforts.

• Expand monitoring efforts to include measurement of nutrients, light attenuation, and sediment accumulation rates.

Management and Restoration Recommendations

• Reduce propeller scarring.

• Determine which factors contribute to the seagrass decline.

Summary Assessment: Recent monitoring assessments suggest that seagrass cover is declining on Cape Romano shoals, the location of the most extensive seagrass beds in Rookery Bay Reserve. However, seagrass species do not appear to be changing. Water clarity is highly variable due to changing turbidity from suspended particles. Nutrients and phytoplankton are usually low in Rookery Bay but increase in response to storm runoff. Propeller scarring is localized near Cape Romano, but burial of seagrass beds by sedimentation or shifting sands is of concern at Cape Romano, Johnson Bay, and Cocohatchee River.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover		Declining	Losses, 2007–09
Seagrass meadow texture		Sparse	
Seagrass species composition		Stable	
Overall seagrass trends		Declining?	Unknown extent
Seagrass Stressors	**Intensity**	**Impact**	**Explanation**
Water clarity		Poor	High turbidity
Nutrients		Relatively low	Affected by runoff, storms
Phytoplankton		Relatively low	Affected by runoff, storms
Natural events		Minimal impact	Hurricane Wilma, 2005
Propeller scarring		Localized	Cape Romano
Sedimentation/shifting sand		Localized	Ongoing

Seagrass Mapping Assessment: During 2002–05, several areas within the reserve were mapped using sidescan sonar. The only area with continuous seagrass was the Cape Romano seagrass bed (345 acres); the remaining areas all had patchy seagrass beds (Table 1). Extensive propeller scars were also mapped at Cape Romano. Recently, reserve staff members have observed a decrease in seagrass coverage. Additional sidescan sonar mapping is needed for change analysis.

TABLE 1. SEAGRASS ACREAGE IN THE ROOKERY BAY AQUATIC PRESERVE, 2003-2005

Seagrass Beds	Henderson Creek	Hall Bay	Rookery Bay	Cape Romano	Pumpkin Bay	Faka Union Bay	Fakahatchee Bay	Total
Patchy	41	31	95	335	80	0	101	683
Continuous	0	0	0	345	0	0	0	345
Total	41	31	95	680	80	0	101	1,028

Monitoring Assessment: Seagrass beds near Cape Romano are declining and impacted by propeller scarring. Turtle grass (*Thalassia testudinum*), shoal grass (*Halodule wrightii*), and star grass (*Halophila engelmannii*) were the dominant species at the Cape Romano and Johnson Bay sites. Manatee grass (*Syringodium filiforme*) and paddle grass (*Halophila decipiens*) also occurred at low levels at Cape Romano and Johnson Bay. Shoal grass was the only seagrass species observed at the Cocohatchee River site. Channel markers were installed in 2008 by Collier County Coastal Zone Management in an effort to minimize boating impacts. A sand bar in Johnson Bay is shifting, to the detriment of seagrass coverage. Seagrass in Cocohatchee River is declining. The City of Naples monitors seagrass beds in three locations in Naples Bay. These beds consist of sparse patches of shoal grass, paddle grass, and star grass.

Mapping Data and Imagery: Sidescan sonar data were collected and interpreted by Stan Locker of the University of South Florida, College of Marine Science, during 2002–05. In 2003, aerial photography of coastal southwest Florida was collected at a 1:24,000 scale by the South Florida Water Management District and georeferenced by reserve staff. In 2005, aerial photography of the Cape Romano shoals was collected by U.S. Imaging Inc. (Bartow, FL) at a 1:24,000 scale and georeferenced by reserve staff. This effort was done in conjunction with the collection of sidescan sonar data to compare the accuracy of the two seagrass mapping techniques.

Monitoring Data: Several areas within the reserve have been monitored annually or quarterly using a fixed-transect modified Braun-Blanquet methodology. Johnson Bay was monitored from 2000 to 2009, Cape Romano from 1998 to 2005, and Cocohatchee River from 2001 to 2003 and in 2005 and has been monitored since 2007. Plans are under way to resume monitoring at Cape Romano. A graduate student is comparing seagrasses at Cape Romano and Round Key, and results of this study will help determine which factors are leading to seagrass losses. In Naples Bay, seagrass beds have been monitored along five transects in spring and fall since 2006; measurements include water depth, seagrass species, abundance (Braun-Blanquet), blade length, total percentage cover, epiphyte density, sediment type, shoot density, light attenuation, and water quality parameters.

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Contacts

Mapping and monitoring: Victoria Vazquez, Research Coordinator, 239-417-6310, ext 402, Victoria.vazquez@dep.state.fl.us; and Jill Schmid, GIS Specialist, Rookery Bay National Estuarine Research Reserve, 239-417-6310, ext. 406, jill.schmid@dep.state.fl.us.

Monitoring: Katie Laakkonen, City of Naples, 239-213-7122, klaakkonen@naplesgov.com.

Florida Seagrass Integrated Mapping and Monitoring Program

Summary Report for the Ten Thousand Islands

Contacts: Victoria Vazquez and Jill Schmid, Rookery Bay National Estuarine Research Reserve (Mapping and Monitoring), Paul Carlson, Florida Fish and Wildlife Research Institute (Mapping)

General Assessment: With the exception of beds in the Cape Romano area, seagrasses in the Ten Thousand Islands region of southwest Florida are difficult to assess. Overlying waters remain turbid and darkly colored most of the year, preventing remote sensing of seagrasses, and the remoteness of the area has slowed monitoring efforts. However, aerial photography in 2009 produced imagery that will allow seagrass mapping of approximately 60% of the region. A monitoring program is also being developed. Seagrasses are generally sparse but include turtle grass (*Thalassia testudinum*), shoal grass (*Halodule wrightii*), and star grass (*Halophila engelmannii*).

Seagrass Status and Stresses	Status	Trend	Assessment, Causes
Seagrass cover		Very sparse	Runoff, turbidity
Water clarity		Poor	Runoff, turbidity
Natural events		Moderate	2004, 2005 hurricanes
Propeller scarring		Localized	Cape Romano

Geographic Extent: The Ten Thousand Islands is a shallow coastal region off Collier and Monroe counties, on Florida's far southwest coast (Figure 1). The region gets its name from the many islands and mangrove marshes that extend from the mainland. Coastal waters receive drainage from the Big Cypress and Everglades areas through the Turner and Chatham rivers, as well as the Faka Union canal.

Figure 1. Turbidity in the Ten Thousand Islands following Hurricane Wilma in 2005 (Ikonos satellite imagery).

Mapping and Monitoring Recommendations

• Supplement aerial imagery flown in 2006 and 2009, and develop a mosaic map from these sources. Seagrasses of the nearshore Cape Romano region were mapped by sidescan sonar in 2003–05. Seagrass beds in the Ten Thousand Islands need to be mapped again, but nearly constant high turbidity makes use of traditional aerial photography and mapping techniques difficult.

• Evaluate alternative mapping techniques, such as underwater videography.

• Continue development of projects for evaluating seagrass cover, optical water quality conditions, and forage available for manatees. This work has been undertaken by several investigators (Daniel Sloane, U.S. Geological Survey, Jud Kenworthy, National Oceanographic and Atmospheric Administration, Penny Hall and Paul Carlson, Fish and Wildlife Research Institute)

• Implement a monitoring program for identification of seagrass beds that uses a spatially distributed, random sampling design (Figure 3).

Management and Restoration Recommendations

- Investigate causes of ongoing turbidity.
- Assess water quality impacts on seagrasses of water entering the estuary from canals.

Summary Assessment: Seagrass maps produced by sidescan sonar in 2003–05 show 680 acres of seagrass near Cape Romano; half of it existed as continuous beds (Shirley et al. 2006). A mapping project for the entire Ten Thousand Island region is under way using imagery from several sources, and this product will fill a large data gap. Monitoring assessments of nearshore Cape Romano seagrasses by staff of the Rookery Bay National Estuarine Research Reserve (NERR) from 1998 to 2005 indicated that seagrass beds were declining and had been scarred by propellers. Turtle grass, shoal grass, and star grass were dominant species. A preliminary monitoring effort in October 2010 by Fish and Wildlife Research Institute (FWRI) staff showed that seagrasses were very sparse. Species included turtle grass, manatee grass (*Syringodium filiforme*), and star grass. A monitoring program will be implemented in 2011 to evaluate seagrass cover, species composition, and optical water quality.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover		Very sparse	Runoff, turbidity
Seagrass meadow texture		Fairly stable	
Seagrass species composition		Fairly stable	Turtle, manatee, shoal, star grasses
Overall seagrass trends		Declining??	Water clarity
Seagrass Stressors	**Intensity**	**Impact**	**Explanation**
Water clarity		Poor	Turbidity, runoff
Nutrients		Impacted	Canals, runoff, storms
Phytoplankton		Impacted	Canals, runoff, storms
Natural events		Moderate	2004, 2005 hurricanes
Propeller scarring		Localized	Cape Romano

Seagrass Mapping Assessment: Sidescan sonar measured 680 acres of seagrass in the nearshore Cape Romano area in 2003–05. Figure 2 shows the area of the two sets of imagery to be used for mapping seagrass in the Ten Thousand Islands. The area of the 2009 imagery is shown in blue, and the area of the 2006 imagery is shown in red. The bold black line indicates the northwestern boundary of Everglades National Park. Supplemental collections of imagery for seagrass mapping will be obtained by using the Worldview 2 satellite in 2011.

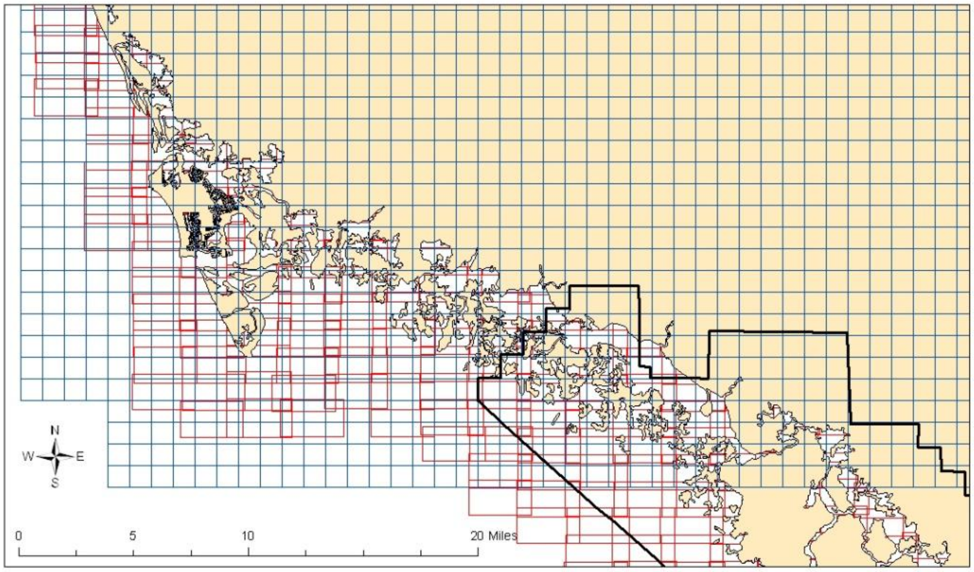

Figure 2. Imagery data sets for the Ten Thousand Islands, 2006 and 2009.

Monitoring Assessment: Monitoring data from 1998–2005 indicated that seagrass beds near Cape Romano were in decline and had been scarred by propellers. Turtle grass, shoal grass, and star grass were common species near Cape Romano. A preliminary field effort in October 2010 provided limited information on seagrass cover (cover was generally very sparse), optical water quality, and seagrass species present. Turtle grass, manatee grass, shoal grass, and star grass were observed but were of very sparse density. Turbidities were high, but color and chlorophyll-a values were low.

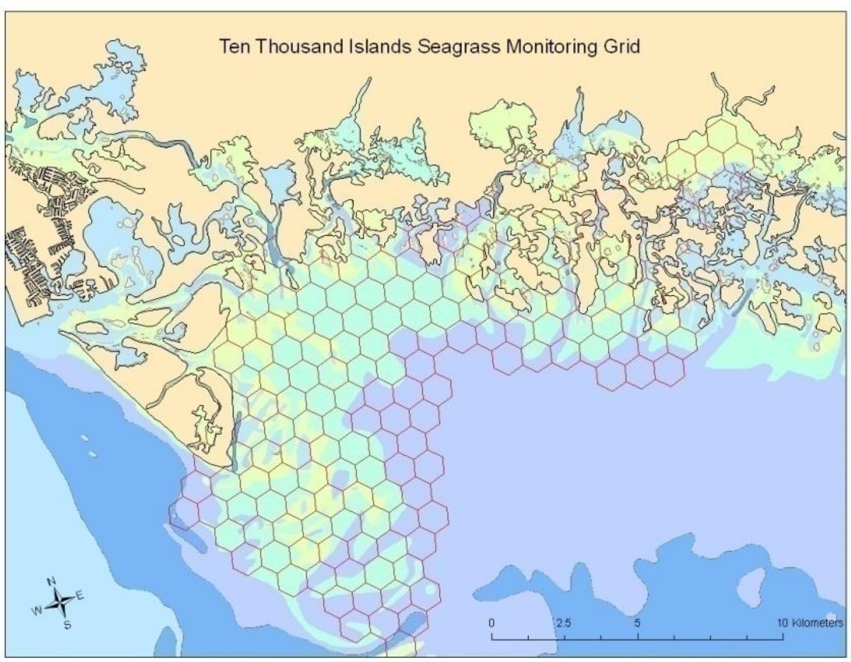

Figure 3. Proposed seagrass monitoring grid for the Ten Thousand Islands.

Mapping Data and Imagery: Sidescan sonar data were collected and interpreted by Stan Locker of the University of South Florida College of Marine Science during 2002–05 to produce seagrass maps for the nearshore Cape Romano area. Imagery interpretation and acquisition are ongoing.

Monitoring Data: Seagrasses near Cape Romano were monitored annually or quarterly from 1998 to 2005 by staff of the Rookery Bay NERR using a fixed-transect modified Braun-Blanquet methodology. Paul Carlson (FWRI) began reconnaissance sampling for development of a seagrass monitoring program in the Ten Thousand Islands in spring 2011. We anticipate that Everglades National Park and Rookery Bay NERR staff will collaborate in the monitoring effort, and our initial project will sample a 1-km^2 grid extending from Cape Romano and the Everglades City/Chokoloskee area. At a randomly chosen sampling point within each grid cell, we will determine seagrass and macroalgal cover and abundance in eight quadrats. We will also measure optical water quality parameters (turbidity, color, chlorophyll-a, and light extinction coefficients) at a subset of 30 sites that will be chosen to achieve representative coverage.

Pertinent Reports and Scientific Publications

BOYER, J. N. 2006. Shifting N and P limitation along a north-south gradient of mangrove estuaries in South Florida. Hydrobiologia 569: 167–177.

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MAIE, N., J. N. BOYER, C. YANG, and R. JAFFE. 2006. Spatial, geomorphological, and seasonal variability of CDOM in estuaries of the Florida Coastal Everglades. Hydrobiologia 569: 135–150.

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Rookery Bay and Cape Romano—Ten Thousand Islands Aquatic Preserves: http://www.dep.state.fl.us/coastal/sites/caperomano/, accessed March 2011.

Rookery Bay National Estuarine Research Reserve: http://www.rookerybay.org/, accessed March 2011.

Contacts

Mapping and Monitoring: Victoria Vazquez, Research Coordinator, Rookery Bay National Estuarine Research Reserve, 239-417-6310, ext 402, Victoria.vazquez@dep.state.fl.us, and Jill Schmid, GIS Specialist, Rookery Bay National Estuarine Research Reserve, 239-417-6310, ext. 406, jill.schmid@dep.state.fl.us.

Mapping: Paul Carlson, Florida Fish and Wildlife Conservation Commission, 727-896-8626, paul.carlson@myfwc.com.

Florida Seagrass Integrated Mapping and Monitoring Program

Summary Report for the Florida Keys National Marine Sanctuary

Contacts: Jim Fourqurean, Florida International University (Monitoring);
Paul Carlson, Florida Fish and Wildlife Conservation Commission (Mapping)

General Assessment: The Florida Keys National Marine Sanctuary (FKNMS) includes some of the largest expanses of seagrasses in Florida coastal waters. In 1992, 856,360 acres of seagrass habitat was mapped in the sanctuary (Figure 1). Seagrass beds covered 131,620 acres on the Atlantic side of the Upper Keys and 144,875 acres on the Atlantic side of the Lower Keys. On the Gulf of Mexico side, seagrasses covered 115,860 acres near the Upper Keys and 453,000 acres near the Lower Keys and the Marquesas Keys; 11,000 acres of seagrasses surrounded the Dry Tortugas. Seagrass cover in the Florida Keys National Marine Sanctuary is probably stable, but significant changes in seagrass species composition continue in many locations in response to alterations in water quality.

Seagrass Status and Stressors	Status	Trend	Assessment, Causes
Seagrass cover		Stable	
Water clarity		Locally poor	Phytoplankton blooms
Nutrients		Increasing?	
Phytoplankton		Increasing?	
Propeller scarring		Local	Near high-use areas

Geographic Extent: The Florida National Marine Sanctuary includes the waters adjacent to the Florida Keys from Key Largo to Key West and out to the Dry Tortugas.

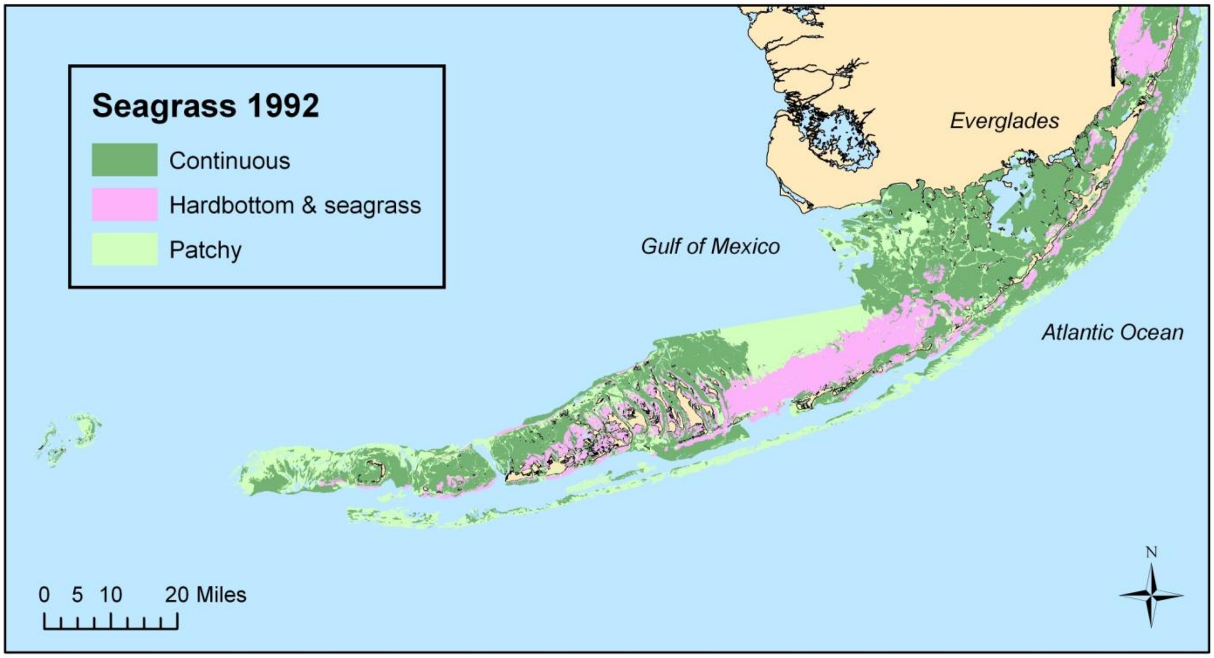

Figure 1. Seagrasses in the Florida Keys National Marine Sanctuary, 1992.

Mapping and Monitoring Recommendations

• Map the 2004 aerial photography.

• Obtain new aerial imagery.

• Continue the long-term monitoring program by staff from the Florida International University.

Management and Restoration Recommendations

• Continue to assess changes in seagrass beds associated with changing nutrient conditions in the water column.

Summary Assessment: Seagrass cover in the FKNMS is probably stable, but photointerpretation of 2004 aerial photography is needed to confirm this. Despite generally stable acreage, the texture and species composition of seagrass beds continue to change in response to changing water quality. Nutrient content in seagrass tissues indicates that more nutrients are available to these ecosystems. Increased nutrient availability in the past 20 years is altering the relative abundance and dominance of seagrasses and macroalgae. Where nutrients have been elevated for some time, long-term increases in phytoplankton populations have been observed, which increases light attenuation in the water column and thus harms seagrass beds.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover		Stable	
Seagrass meadow texture		Some changes	Species changes
Seagrass species composition		Changing	Water quality
Overall seagrass trends		Changing	Altered water quality
Seagrass Stressors	**Intensity**	**Impact**	**Explanation**
Water clarity		Locally poor	Phytoplankton blooms
Nutrients		Increasing?	Northeastern region
Phytoplankton		Increasing?	Northeastern region
Natural events		Low	Hurricanes
Propeller scarring		Local	Near high-use areas

Seagrass Mapping Assessment: Photointerpretation of aerial photography taken in 1992 showed that approximately 856,300 acres of seagrasses covered shallow bottom of the sanctuary from the Upper Keys to the Dry Tortugas (Table 1). Seagrass beds on the Gulf of Mexico side of the Lower Keys accounted for 52% of the total acreage in the sanctuary. Imagery is available from 2004, and photointerpretation is under way.

TABLE 1.SEAGRASS ACREAGE IN THE FLORIDA KEYS NATIONAL MARINE SANCTUARY IN 1992

	Upper Keys	Lower Keys	Tortugas	Total
Atlantic Ocean side	131,620	144,875		276,495
Gulf of Mexico side	115,860	453,000		568,860
Total	247,480	597,875	11,000	856,355

Monitoring Assessment: Florida Keys seagrass beds are monitored annually by staff of Florida International University (FIU) and collaborators. Using 2004 data from the FIU database, we calculated the frequency of occurrence of seagrasses in subregions of FKNMS (Figure 2). Turtle grass (*Thalassia testudinum*) occurred at 80% of sampling locations in seagrass beds along the Atlantic side of the Upper Keys and was first or second in abundance in the other subregions. Manatee grass (*Syringodium filiforme*) was also common and was the most abundant species along the Gulf side of the Upper Keys. Shoal grass (*Halodule wrightii*) and paddle grass (*Halophila decipiens*) were less common but were found in all subregions.

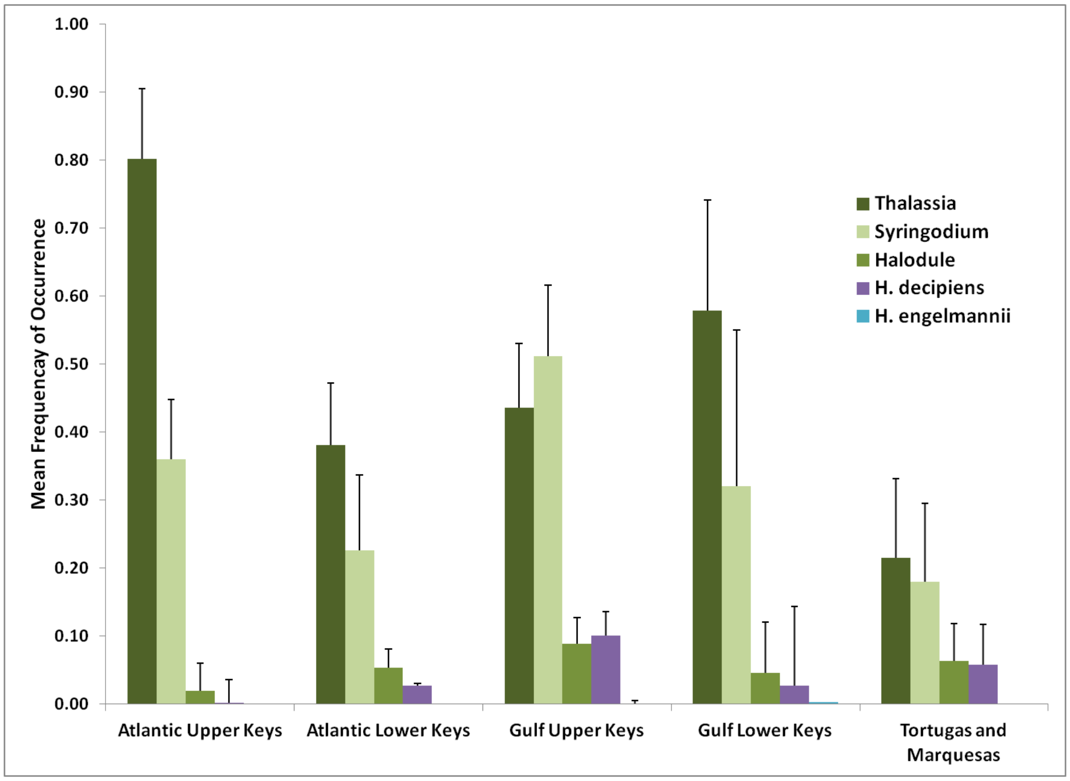

Figure 2. Mean (plus two standard error) frequency of occurrence of seagrasses in the FKNMS in 2004 (data from FKNMS/FIU database).

Mapping and Monitoring Recommendations

• Photointerpret 2004 aerial photography.

• Acquire and photointerpret new imagery.

Management and Restoration Recommendations

• Continue assessment of the effects of nutrient enrichment on seagrass ecosystems.

Mapping Data and Imagery: The South Florida Geographic Information System benthic habitat data set includes areal extent of seagrass beds, interpreted from 1:48,000 scale natural color aerial photography taken in 1992. The FKNMS photography was digitized by a photogrammetrist and stereo analytical plotters made available by the National Oceanographic and Atmospheric Administration. IKONOS satellite imagery from 2006 is being interpreted.

Monitoring Data: Seagrass monitoring has been conducted in the FKNMS quarterly and annually since 1996. Summary reports and monitoring data are available on the FIU FKNMS Seagrass website (http://serc.fiu.edu/seagrass/!CDreport/DataHome.htm).

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General References and Additional Information

Florida Keys National Marine Sanctuary Seagrass Status and Trends Monitoring Data: http://serc.fiu.edu/seagrass/!CDreport/DataHome.htm, accessed March 2011.

Contacts

Mapping: Paul Carlson, Florida Fish and Wildlife Research Institute, 727-896-8626; paul.carlson@fwc.state.fl.us.

Monitoring: Jim Fourqurean, Florida International University, 305-348-4084; jim.fourqurean@fiu.edu.

Florida Seagrass Integrated Mapping and Monitoring Program

Summary Report for Florida Bay

Contacts: Penny Hall (Monitoring) and Paul Carlson (Mapping), Florida Fish and Wildlife Research Institute

General Assessment: In 2004, approximately 145,300 acres of seagrass were mapped in Florida Bay (Figure 1). Seagrass area decreased slightly since 1992 when 146,600 acres of seagrass were mapped. Seagrass cover in western Florida Bay suffered significant losses in the late 1980s and early 1990s as the result of a massive, apparently natural die-off. Seagrasses appear to have recovered from this event, based on data from the most recent (2004) imagery. In 2005, Hurricanes Katrina and Wilma passed directly over Florida Bay with serious impacts on mangroves and aboveground communities. Seagrasses, however, appear to have been less affected. Thick phytoplankton blooms occurred in the eastern basins in 2007 and 2008, but they abated in 2009.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover and species		Fairly stable	
Water clarity		Local	Phytoplankton blooms (eastern bay)
Nutrients		Good	
Phytoplankton		Variable	High in eastern bay
Propeller scarring		Local	Within Everglades Park

Geographic Extent: Florida Bay lies at the southern end of the Florida peninsula. The total area of Florida Bay within the boundaries of Everglades National Park is approximately 395,000 acres, or 615 sq. mi.

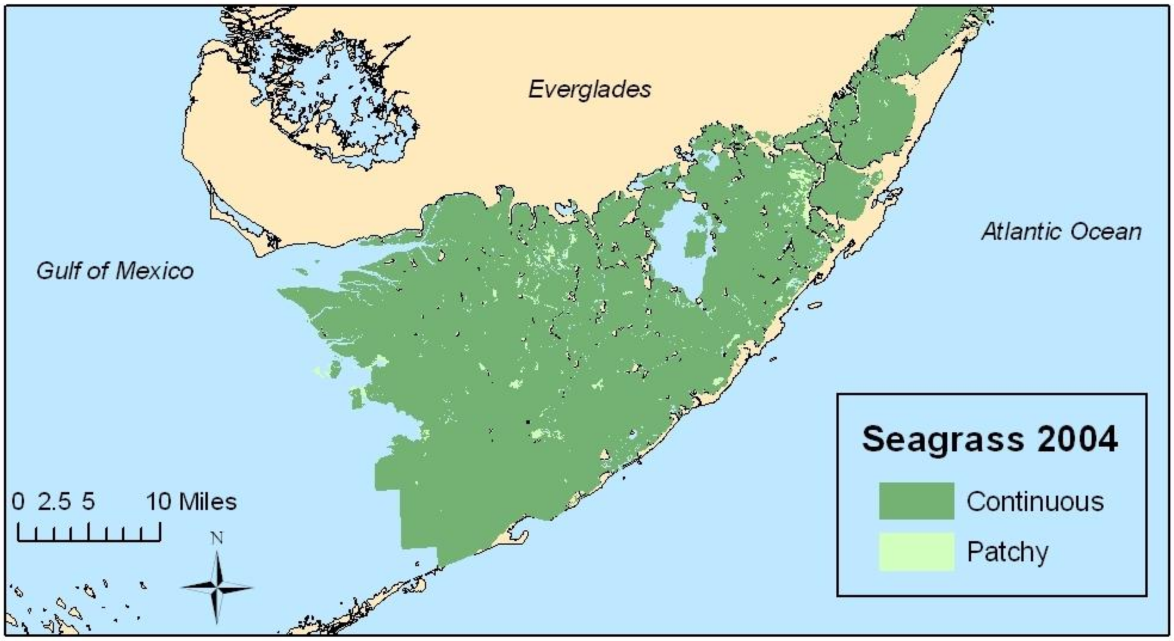

Figure 1. Seagrass cover in Florida Bay, 2004. The blue area in the middle of the Bay was uninterpretable because of suspended sediment.

Mapping and Monitoring Recommendations

• Continue aerial photography and mapping of the north half of Florida Bay at least every 5 years and the entire bay every 10 years.

• Continue twice-yearly on-ground monitoring.

Management and Restoration Recommendations

• Continue the program initiated by Everglades National Park staff to reduce propeller scarring in the park.

• Continue monitoring programs for collection of data that will allow prediction of the impacts of changing hydrology due to planned restoration of the Everglades.

Summary Assessment: Seagrass beds are generally stable across Florida Bay in terms of both acreage and species composition. Persistent phytoplankton blooms in the northeastern portion of the bay may be affecting seagrasses, particularly turtle grass (*Thalassia testudinum*). Recent hurricanes (for example, Wilma in 2005) had minimal impact on seagrass beds in the bay. Propeller scarring of shallow banks near boat channels in Everglades National Park affects some seagrass beds.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover		Stable	
Seagrass meadow texture		Stable	
Seagrass species composition		Stable	
Overall seagrass trends		Stable	Phytoplankton blooms
Seagrass Stressors	**Intensity**	**Impact**	**Explanation**
Water clarity		Local	Northeastern bay
Nutrients		Good	
Phytoplankton		Variable	High in eastern bay
Natural events		Low	Hurricanes
Propeller scarring		Local	Within Everglades Park

Seagrass Mapping Assessment: Mapping assessments from interpretation of aerial photography have shown little change in total seagrass area in Florida Bay. In 1992, 146,615 acres of seagrass covered Florida Bay, and in 2004, 145,308 acres of seagrass were mapped, a loss of 1,307 acres, or 0.9%.

Monitoring Assessment: As part of the Florida Bay Fisheries Habitat Assessment Program (FHAP), staff of the Florida Fish and Wildlife Research Institute (FWRI) monitor seagrass ecosystems twice a year, in May and October. This monitoring program has been under way since 1996. Throughout Florida Bay, turtle grass is the dominant seagrass, occurring in at least 75% of the sampling locations in all subregions of the bay. In 2005, abundance of turtle grass exceeded 80% in all regions of Florida Bay (Figure 2); in 2008, turtle grass abundance had dropped to 75% in the northeastern bay, perhaps reflecting effects of an ongoing phytoplankton bloom there. Shoal grass (*Halodule wrightii*) was the second most abundant seagrass and was most abundant in the north central bay and the western bay in both 2005 and 2008. Manatee grass (*Syringodium filiforme*) was abundant only in the western bay. In 2008, star grass (*Halophila engelmannii*) was found in the north central bay but was absent across the bay in 2005. The occurrence of bare sampling locations was greatest in the northeastern bay and showed a sharp increase from 2.5% to 10% between 2005 and 2008 in the south region of Florida Bay.

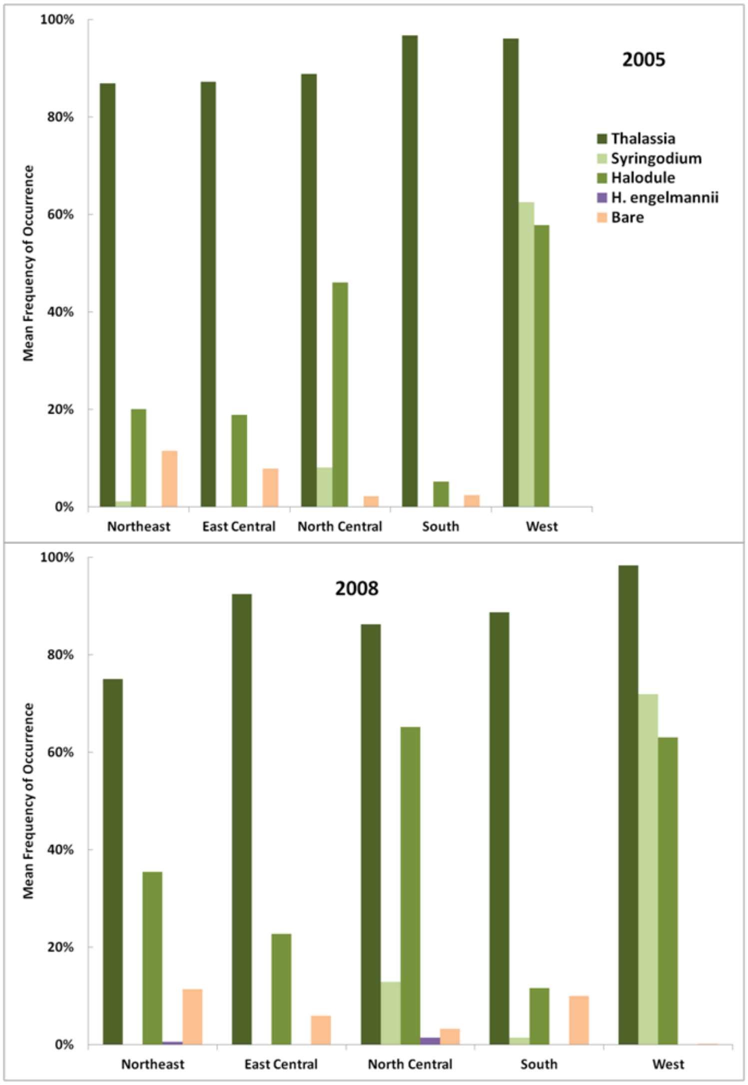

Figure 2. Mean frequency of occurrence of seagrasses in Florida Bay, 2005 and 2008 (data from FWRI FHAP).

Seagrass abundance information obtained during monitoring in 2009 demonstrates the predominance of turtle grass in Florida Bay (Figure 3) and its greater abundance in western portions of the bay. Shoal grass was less abundant in the western bay in 2009 compared with earlier years and showed its greatest abundance in the north central bay (Rankin Lake and Whipray Basin) and in areas near the Keys in the northeastern bay (Barnes and Blackwater sounds). Manatee grass was much less common than turtle grass or shoal grass and was most abundant in the western bay in 2005, 2008, and 2009.

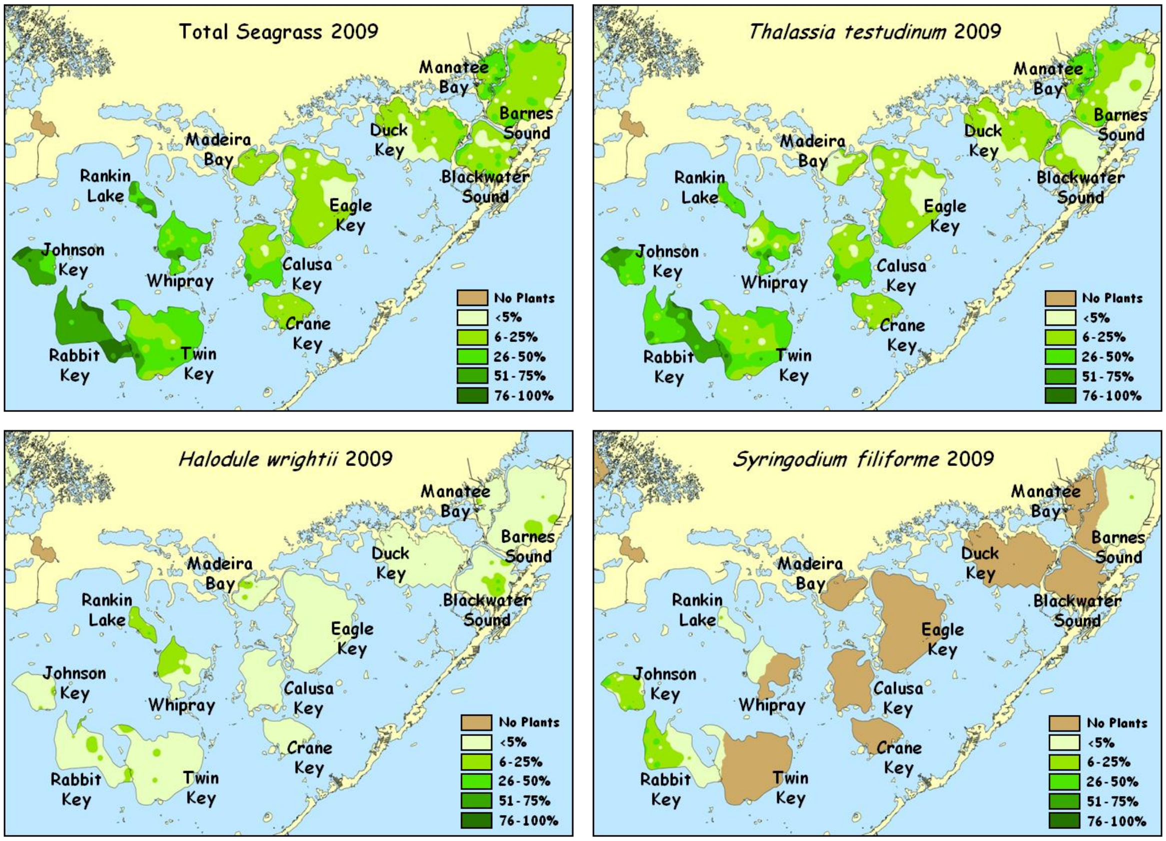

Figure 3. Abundance of seagrass species across Florida Bay, 2009 (data from FHAP).

Mapping and Monitoring Recommendations

• Acquire aerial photography or satellite imagery of the northern half of the bay every 5 years and the entire bay every 10 years.

• Continue FHAP and Florida International University monitoring programs to assess long-term changes and provide background information before the planned hydrologic restoration of the Everglades.

Management and Restoration Recommendations

• Evaluate potential impacts of changing hydrology due to Everglades restoration.

• Assess nutrient inputs from increasing development in the Florida Keys.

• Mitigate and minimize propeller scarring on banks adjacent to channels in the Everglades National Park.

Mapping Data and Imagery: The South Florida Water Management District (SFWMD) acquired aerial photography in the spring of 2004, and images were photointerpreted and ground-truthed. Benthic habitats were defined using the Habitat Classification Categories for Florida Bay Benthic Habitat Mapping—2004/2005, Version 3-23-05.

Monitoring Data: Monitoring data are available from the Florida Bay Fisheries Habitat Assessment Program (FWRI, Penny Hall), funded by SFWMD; and the Florida Keys National Marine Sanctuary Seagrass Status and Trends Monitoring Data (Florida International University, James Fourqurean).

Pertinent Reports and Scientific Publications

HACKNEY, J. W., and M. J. DURAKO. 2004. Size-frequency patterns of morphometric characteristics of the seagrass *Thalassia testudinum* reflect environmental variability. Ecological Indicators 4: 55–71.

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MADDEN, C. J., D. T. RUDNICK, A. A. MCDONALD, K. M. CUNNIFF, and J. W. FOURQUREAN. 2009. Ecological indicators for assessing and communicating seagrass status and trends in Florida Bay. Ecological Indicators 9(6, Supplement 1): S68–S82.

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2010 Everglades Seagrass Workshop, Everglades National Park, http://www.nps.gov/ever/naturescience/2010seagrassworkshop.htm, accessed March 2011.

Contacts

Monitoring: Penny Hall, Florida Fish and Wildlife Research Institute, 727-896-8626; penny.hall@myfwc.com, and James Fourqurean, Florida International University, 305-348-4084; jim.fourqurean@fiu.edu.

Mapping: Paul Carlson, Florida Fish and Wildlife Research Institute, 727-896-8626; paul.carlson@myfwc.com.

Florida Seagrass Integrated Mapping and Monitoring Program

Summary Report for Biscayne Bay

Contacts: Steve Blair and Chris Avila, Miami–Dade County Department of Environmental Resource Management, Penny Hall, Fish and Wildlife Research Institute, and Pamela Sweeney, Biscayne Bay Aquatic Preserves (Monitoring); Paul Carlson, Fish and Wildlife Research Institute (Mapping)

General Assessment: Seagrasses cover extensive areas (159,363 acres, from aerial photography acquired in 2004 and 2005) in the Biscayne Bay region (Figure 1). Mapping data from 1992 indicate that seagrass beds in the adjacent nearshore Atlantic Ocean accounted for an additional 104,910 acres. Most of the seagrass acreage in the Biscayne Bay region (120,756 acres) occurs in Biscayne Bay proper, as continuous beds. Turtle grass (*Thalassia testudinum*) is the dominant seagrass species in Card Sound and southern Biscayne Bay, while northern Biscayne Bay has more diverse seagrass beds, the most common species being manatee grass (*Syringodium filiforme*).

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover and species		Stable	Cover is increasing
Water clarity		Good	
Nutrients		Good	
Phytoplankton		Variable	High in Card Sound
Propeller scarring		Local	Near high-use areas

Geographic Extent: The Biscayne Bay region includes North Biscayne Bay, Biscayne Bay proper, Card Sound, and Barnes Sound and extends from the Oleta River north of Miami Beach on the east coast of Florida south through Biscayne National Park, Card Sound, and Barnes Sound to the U.S. Highway 1 bridge to the Keys.

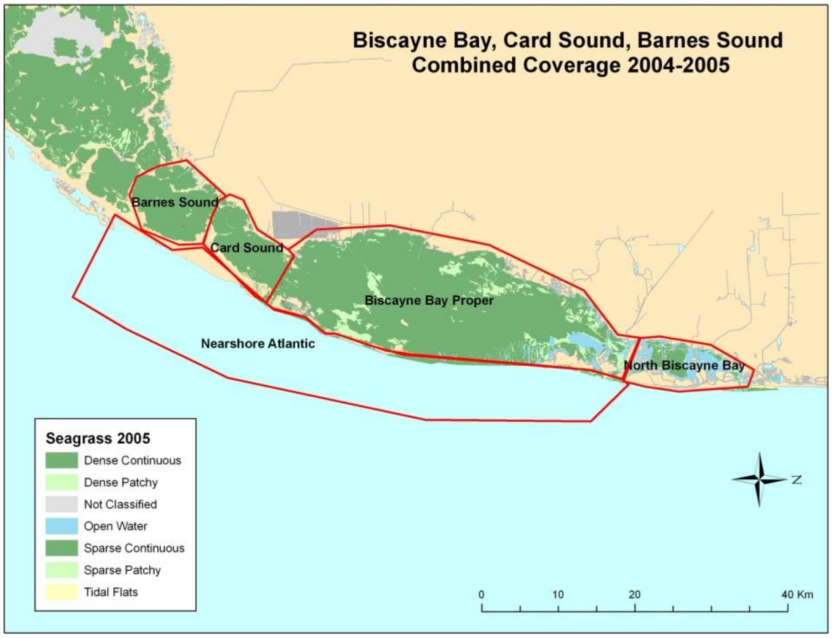

Figure 1. Seagrass cover in the Biscayne Bay region, from photography collected in 2004 and 2005.

Mapping and Monitoring Recommendations

• Map the region’s seagrass every six years.

• Continue and expand seagrass-monitoring programs. Monitoring has been conducted by staff of several agencies. The Fisheries Habitat Assessment Program (FHAP) of the Fish and Wildlife Research Institute (FWRI) conducted monitoring twice a year from 2005 through 2009 at randomly selected sampling points. Staff of the Miami–Dade County Department of Environmental Resource Management (Miami–Dade DERM) sample 100 probabilistic randomly chosen sites and 12 nonrandom fixed sites each June.

Management and Restoration Recommendations

• Evaluate the response of seagrass beds to anticipated hydrological changes associated with restoration of the Everglades.

• Evaluate nutrient loading from land runoff, the greatest threat to seagrass health in Biscayne Bay.

• Continue to monitor phytoplankton populations in Card Sound, where they have been elevated.

Summary Assessment: Seagrass cover is extensive (159,363 acres) in the Biscayne Bay region and increased in area in all subregions of the bay from 1992 to 2005 except North Biscayne Bay, which lost 660 acres, or 11% (Table 1). Species composition is generally stable. Comparison of monitoring data from 2005 and 2007 (see Figure 2) showed few differences between years. However, there are substantial differences in seagrass species composition among the regions of Biscayne Bay. Turtle grass (*T. testudinum*) dominates beds in Card Sound and southern Biscayne Bay, while in northern Biscayne Bay seagrass beds are more diverse, with manatee grass (*S. filiforme*) occurring most frequently. The proportion of bay bottom that is bare also increases from south to north. Nutrient loading from the watershed, changing hydrologic regimes, and boating are likely stressors to seagrass beds.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover		Stable	Cover is increasing
Seagrass meadow texture		Stable	
Seagrass species composition		Stable	
Overall seagrass trends		Stable	Urban runoff
Seagrass Stressors	**Intensity**	**Impact**	**Explanation**
Water clarity		Good	
Nutrients		Good	
Phytoplankton		Variable	High in Card Sound
Natural events		Low	Hurricanes
Propeller scarring		Local	Near high-use areas

Seagrass Mapping Assessment: Mapping of aerial photography acquired in 2004 and 2005 showed that seagrasses covered 159,363 acres in the Biscayne Bay region and that most of the acreage (120,756 acres, or 76%) was found in Biscayne Bay proper (Table 1). The classification system used for seagrass cover from the 1992 imagery differed from that for the 2004–05 imagery sets. Change analysis between 1992 and 2004–05, therefore, is useful only for total seagrass area. We conducted change analysis in ArcMap software, using identical polygons or spatial extents for 1992 and 2004–05 for the Biscayne Bay region. Cover was least in North Biscayne Bay (5,208 acres) and had decreased from the 5,868 acres mapped in 1992. Barnes and Card sounds showed small increases in seagrass acreage in 2004, with seagrass covering 18,793 and 14,606 acres that year, respectively. Overall, seagrasses increased by 5,536 acres, or 3.60%, between 1992 and 2004–05. In 2004–05, 92% of seagrass beds in the Biscayne Bay region were classified as continuous seagrass. In addition, in 1992, 104,910 acres of seagrass were mapped along the margin of the nearshore Atlantic Ocean outside the boundaries of Biscayne Bay.

TABLE 1. SEAGRASS ACREAGE IN THE BISCAYNE BAY REGION IN 1992 AND 2004–2005

A. Acreage in 1992						
Habitat Type	Barnes Sound	Card Sound	Biscayne Bay Proper	Northern Bay	Biscayne Bay Total	Nearshore Atlantic
Continuous seagrass	14,733	11,672	56,464	3,846	86,715	79,296
Hardbottom/seagrass	3,107	1,634	42,842	0	47,583	7,605
Patchy seagrass	795	1,106	15,606	2,022	19,529	18,009
All seagrass	18,635	14,412	114,912	5,868	153,827	104,910

B. Acreage in 2004–2005						
Year Imagery Acquired:	2004	2004	2005	2005	2004–05	
Habitat Type	Barnes Sound	Card Sound	Biscayne Bay Proper	Northern Bay	Biscayne Bay Total	Nearshore Atlantic
Continuous seagrass	18,479	14,388	109,440	4,277	146,584	n/a
Patchy seagrass	314	218	11,316	931	12,779	n/a
All seagrass	18,793	14,606	120,756	5,208	159,363	n/a

C. Change in acreage for all seagrass					
	2004	2004	2005	2005	2004–05
	Barnes Sound	Card Sound	Biscayne Bay Proper	Northern Bay	Biscayne Bay Total
Acres	158	194	5,844	−660	5,536
% Change	0.85%	1.35%	5.09%	−11.2%	3.60%

Monitoring Assessment: The Fisheries Habitat Assessment Program (FHAP), supervised by Penny Hall, monitored seagrasses in Biscayne Bay twice a year from 2005 through 2009. Monitoring assessments were conducted each May and October using fixed sampling points and Braun-Blanquet assessment of 0.25-m^2 quadrats. In 2005 and in 2007 (see Figure 2, below), turtle grass occurred most frequently in Card Sound and southern Biscayne Bay (> 80% frequency of occurrence). Manatee grass occurred most frequently in northern Biscayne Bay during both years (52–57% frequency of occurrence). Shoal grass (*Halodule wrightii*) occurred in all segments of Biscayne Bay but generally at < 30% frequency of occurrence. The number of bare quadrats increased from south to north and was > 20% frequency of occurrence in northern Biscayne Bay in 2007, where seagrass cover decreased from 1992 to 2005. Significant changes in species distributions or occurrence were not observed between the two years.

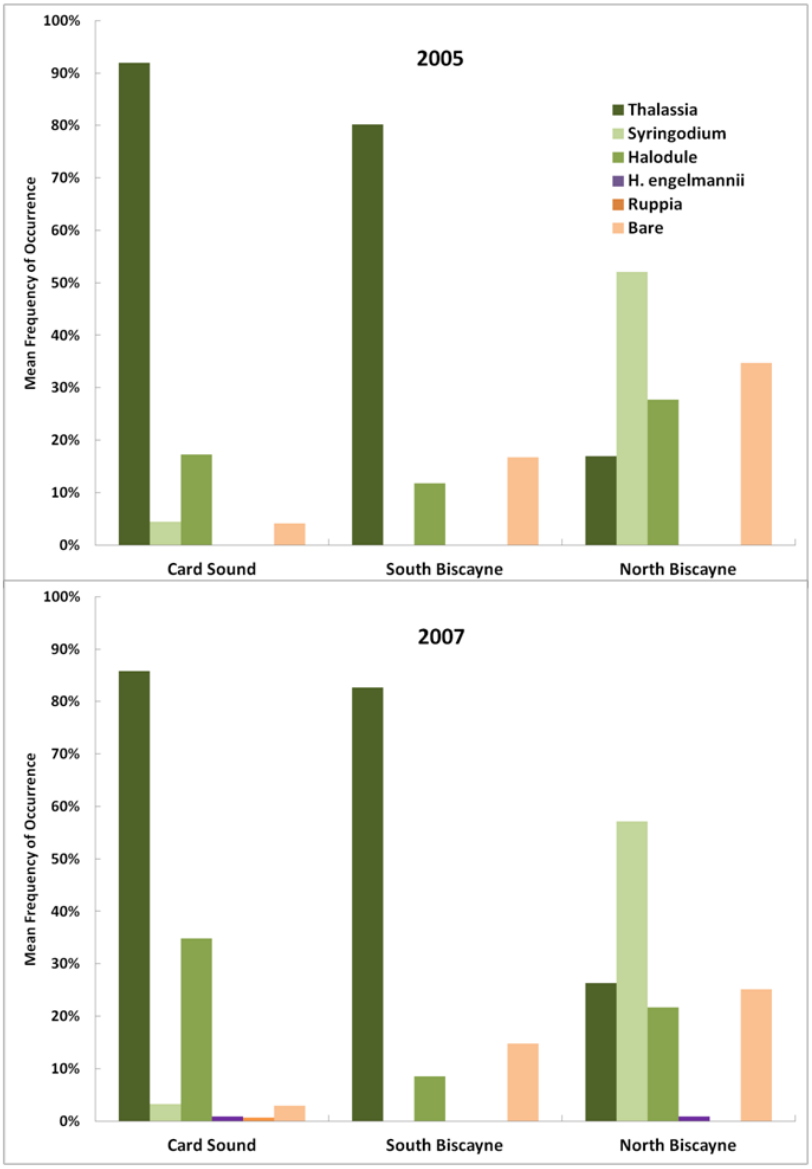

Figure 2. Mean frequency of occurrence of seagrasses in Biscayne Bay, 2005 and 2007 (data from FHAP/FWRI).

Mapping and Monitoring Recommendations

• Acquire and interpret new imagery every six years.

• Continue and expand monitoring programs.

Management and Restoration Recommendations

• Evaluate the response of seagrass beds to anticipated hydrological changes associated with restoration of the Everglades.

• Evaluate nutrient loading from land runoff, the greatest threat to seagrass health in Biscayne Bay.

• Continue to monitor phytoplankton populations in Card Sound, where they have been elevated.

Mapping Data and Imagery: Aerial imagery acquired in 1992 is part of the GIS data set of benthic habitats of South Florida archived at the Fish and Wildlife Research Institute. The presence of seagrass beds, classified as either continuous beds, mixed hard bottom and seagrass, or patchy seagrass, was interpreted from 1:48,000 scale natural color aerial photography. The photographs were digitized by Greenhorne and O'Mara (West Palm Beach, FL) using stereo analytical plotters. Imagery acquired in 2004 and 2005 was interpreted by PhotoScience Inc.(St. Petersburg, FL) using a modified Florida Land Use Cover Classification System in which seagrasses were classified as continuous or patchy in extent. ArcMap shape files of benthic habitats are distributed on the Fish and Wildlife Research Institute (FWRI) Marine Resources Geographic Information System (MRGIS) website (http://ocean.floridamarine.org/mrgis/).

Monitoring Data: Data summaries of monitoring programs are available from the Fisheries Habitat Assessment Program (FWRI, Penny Hall), funded by the South Florida Water Management District for 2005 through 2009 and from the Miami-Dade Department of Environmental Resource Management.

Pertinent Reports and Scientific Publications

LIRMAN, D., and W. P. CROPPER. 2003. The influence of salinity on seagrass growth, survivorship, and distribution within Biscayne Bay, Florida: field, experimental, and modeling studies. Estuaries and Coasts 26: 131–141.

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Miami–Dade County Department of Environmental Resource Management: http://www.miamidade.gov/derm; accessed March 2011.

Biscayne Bay Aquatic Preserve: http://www.dep.state.fl.us/coastal/sites/biscayne/info.htm; accessed March 2011.

Biscayne National Park: http://www.nps.gov/bisc/index.htm; accessed March 2011.

South Florida Information Access: http://sofia.usgs.gov/virtual_tour/biscaynebay/index.html; accessed March 2011.

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Florida Seagrass Integrated Mapping and Monitoring Program

Summary Report for Lake Worth Lagoon

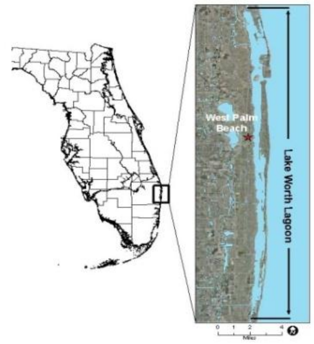

Figure 1: Location of Lake Worth Lagoon, Palm Beach County, Florida

Contacts: Paul Davis and Eric Anderson; Palm Beach County Department of Environmental Resource Management (Mapping and Monitoring)

General Assessment: Based on interpretation of aerial photographs, seagrass cover in Lake Worth Lagoon (LWL) between 2001 and 2007 was generally stable, with a slight increase in 2007. Approximately 1,688 acres of seagrass were mapped in the lagoon in 2007. Most of the increase can be attributed to greater areas of patchy seagrass beds throughout the lagoon. Most of the seagrass (65%) is found in North LWL near Singer Island in Riviera Beach. The dominant species in North LWL are manatee grass (*Syringodium filiforme*), turtle grass (*Thalassia testudinum*), and shoal grass (*Halodule wrightii*). The least coverage by seagrasses occurs in the central (12%) and southern (23%) portions of the lagoon; dominant species are Johnson's seagrass (*Halophila johnsonii*), paddle grass (*H. decipiens*), and shoal grass. Seagrass species composition also appears to be stable in all sections of the lagoon. Annual transect monitoring indicated decreases in cover and density after the 2004, 2005, and 2006 hurricanes. Record high levels of seagrass cover and density were noted in 2007, but slight decreases were observed in 2008 and 2009. Stressors include nutrients, suspended sediments, and turbidity associated with stormwater discharges from three major canals (C-51, West Palm Beach Canal; C-16, Boynton Canal; and C-17, Earman River). Freshwater discharge was elevated after the 2004, 2005, and 2006 hurricanes, but they have returned to background levels. Minor propeller scarring is evident around South Lake Worth (Boynton) Inlet and Lake Worth (Palm Beach) Inlet but is minimal elsewhere.

Seagrass Status and Stresses	Status	Trend	Assessment, Causes
Seagrass cover		Stable?	Little change, 2001–07
Water clarity		Declining	Affected by runoff, storms
Nutrients, turbidity		Increasing	Affected by runoff, storms

Mapping and Monitoring Recommendations

• Map and monitor seagrasses in areas where conventional aerial photography is not effective (where water is too deep, visibility through the water column is poor, and diminutive species such as paddle grass and Johnson's seagrass are dominant).

• Collect aerial photography for the entire region again in 2011–12.

• Continue annual fixed-transect monitoring.

• Evaluate the effectiveness of patch scale monitoring and continue if effective.

Management and Restoration Recommendations

• Assess proposed changes in freshwater discharges, nutrient loads, and sediment loads from the canals that empty into LWL.

• Evaluate nutrient and suspended sediment loading from the agricultural areas (L8 basin) and identify the most cost-effective management options.

Summary Assessment: Seagrass acreage in Lake Worth Lagoon remained relatively stable between 2001 and 2007, although some increases in patchy cover were observed (Table 1). From 1990 to 2001, 484 acres of seagrass, or 23%, were apparently lost, but different mapping methods were used in the 1990 assessment, which may account for some of this difference. Annual fixed transect monitoring has shown fluctuations in seagrass cover over the nine years of the project: years of poor water quality due to increased freshwater releases (2004, 2005, and 2006) coincided with

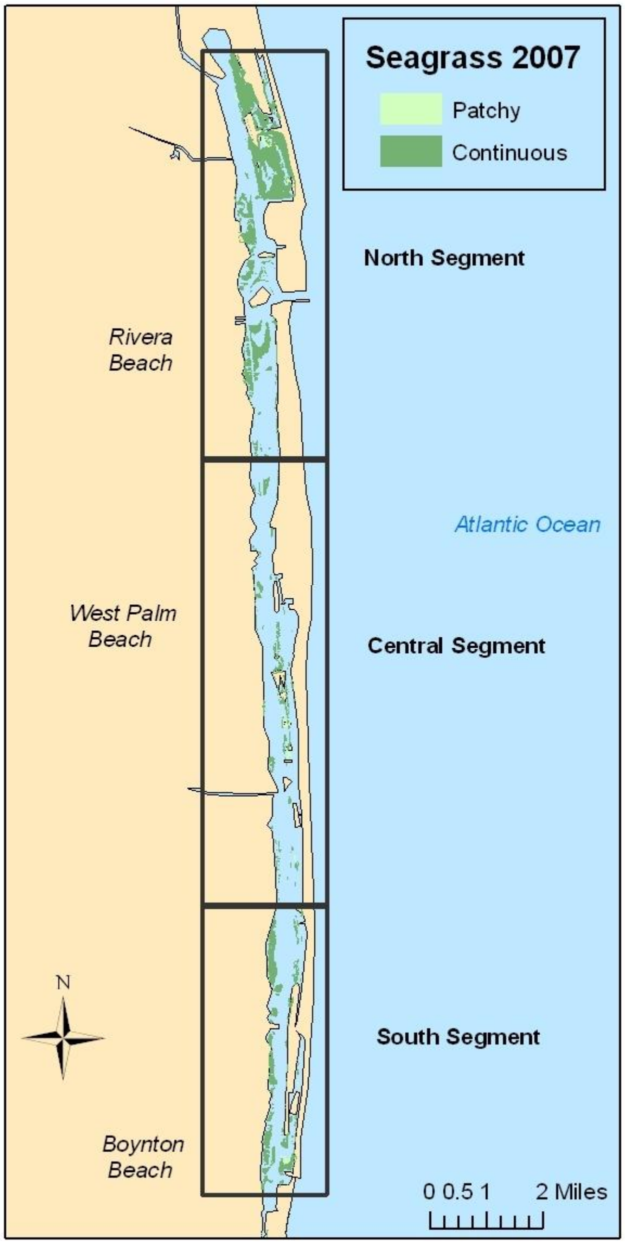

Figure 2. Seagrass beds in Lake Worth Lagoon, 2007.

widespread reductions in seagrass cover. Monitoring programs documented increases in seagrasses in 2001, 2002, 2007, 2008, and 2009, when water quality was better.

However, it is very difficult to provide an accurate estimate of seagrass habitat within the lagoon because of poor water quality, limited visibility through the water column, and the very small size and limited optical signature of Johnson's seagrass and paddle grass. Stressors include increased freshwater inputs to the lagoon, nutrients, sedimentation, turbidity, and phytoplankton blooms associated with runoff from urban stormwater and the regional canal discharges. Impacts of regional canal discharges extend throughout the Lagoon but are most severe in the central portions adjacent to the C-51 canal. The hurricanes of 2004, 2005, and 2006 also affected seagrass beds.

Seagrass Mapping Assessment: Between 2001 and 2007, total seagrass cover for the LWL region increased from 1,647 acres to 1,688 acres, or 2.5% (Table 1). The majority of the increase resulted from a greater area of patchy seagrass beds throughout the lagoon. Seagrass cover varies throughout the lagoon, with the most seagrass found in the northern end (65%), compared with 12% in the central segment and 23% in the southern segment. Comparing the 2001 maps to the 2007 maps revealed a 59-acre decrease in seagrass cover in the northern segment, a 9-acre increase in the central segment, and a 91-acre increase in the southern segment. The results are considered an underestimate of seagrass cover because areas of the lagoon have poor visibility and the tiny and thus difficult to assess Johnson's seagrass and paddle grass are dominant. As a result, mapping efforts may not have accurately identified seagrass cover. Mapping efforts identified only seagrass beds that were 0.25 acre or more in size and were designed to detect large-scale changes.

Seagrass Status Indicators	**Status**	**Trend**	**Assessment, Causes**
Seagrass abundance		Stable	Slight increase, 2001–07
Seagrass species composition		Poor	
Overall seagrass trends		Stable	Stormwater runoff impacts
Seagrass Stressors	**Intensity**	**Impact**	**Explanation**
Water clarity		Poor	Affected by runoff, storms
Nutrients		Relatively high	Affected by runoff, storms
Phytoplankton		Relatively high	Affected by runoff, storms
Natural events		Serious impacts	2004-06 hurricanes
Propeller scarring		Localized	Near inlets

TABLE 1. SEAGRASS ACREAGE IN LAKE WORTH LAGOON

	Regions of Lagoon			
Habitat type	North	Central	South	Total
2001				
Patchy	13	1	0	14
Continuous	1,136	195	302	1,633
All seagrass	1,149	196	302	1,647
2007				
Patchy	21	21	10	52
Continuous	1,069	184	383	1,636
All seagrass	1,090	205	393	1,688
Change 2001-2007				
Patchy	8	20	10	38
Continuous	−67	−11	81	3
All seagrass	−59	9	91	41
Percent change	−5.1%	4.6%	30.1%	2.5%

Monitoring Assessment: In 2000, the Palm Beach County Department of Environmental Resource Management (PBC DERM) initiated a long-term seagrass monitoring program that included the establishment and annual assessment of nine fixed transects throughout LWL (Figure 3). With improving water quality and clarity, seagrasses are expected to grow at greater depths or to increase in density and diversity. To test this hypothesis, transects were located in areas where the lagoon bottom increased in depth by 1–2 ft. within 50–100 ft. of the edge of an existing seagrass bed. The first five years of surveys showed fluctuations in seagrass cover with no obvious pattern of increase or decrease—until the hurricanes of 2004. The survey conducted in June 2005 and 2006 showed a major decrease in seagrass cover in most areas of the lagoon. This loss is believed to be the result of increased turbidity and suspended sediments caused by runoff from the hurricanes and discharges from Lake Okeechobee, as well as burial and scour from wave action. Areas suffering the least severe impact were shallow sites and sites closer to inlets, where water quality was least affected. The 2007 survey reported record highs in terms of total number of sampling locations at which seagrass was observed and of percentage cover at the sampling locations. The 2007, 2008, and 2009 surveys documented not only increases in seagrass cover but also the expansion of beds into deeper water.

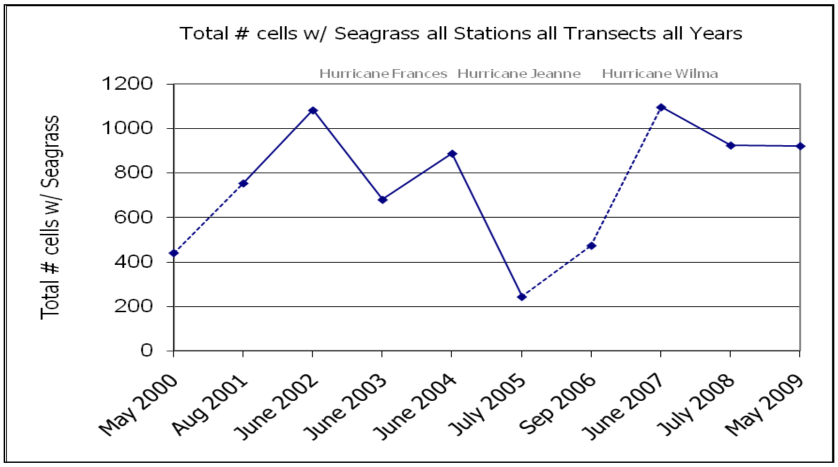

Figure 3. Seagrass occurrence along monitoring transects, 2000–09. In 2000, the project consisted of only five transects (15 stations). In 2001–05 and 2007–09, it consisted of nine transects (27 stations). In 2006, poor water clarity allowed for the monitoring of only 4 transects (12 stations). In 2006, the number shown is the average of 2005 and 2007 values.

Management and Restoration Recommendations

• Assess proposed changes in freshwater discharges, nutrient loads, and sediment loads from the canals that empty into LWL.

• Evaluate nutrient and suspended sediment loading from the agricultural areas (L8 basin), and identify the most cost-effective management options.

Mapping Data and Imagery: In 2001 and 2007, natural color aerial photography of the Lake Worth Lagoon region was flown at 1:10,000 scale for Palm Beach County by U.S. Imaging (Bartow, FL). The original negatives and copies of diapositives are housed at PBC DERM. Benthic habitats were classified and mapped from this dataset by Avineon Inc. (Clearwater, FL) using the Florida Land Use Cover Classification System. ArcMap shape files of benthic habitats are available on the Fish and Wildlife Research Institute Marine Resources Geographic Information System (MRGIS) website (http://ocean.floridamarine.org/mrgis/) or by contacting PBC DERM.

Monitoring Data: A variety of groups and agencies monitors seagrass in the Lake Worth Lagoon (Table 2). Since 2000, PBC DERM has been monitoring seagrass annually along nine transects (27 stations) throughout LWL with the Fixed Transect Monitoring Project (FTMP). Since 2006 the Fish and Wildlife Research Institute (FWRI) and the National Oceanic and Atmospheric Administration (NOAA) have been monitoring Johnson's seagrass (*H. johnsonii)* at 8 locations and 33 stations in the lagoon for the *H. johnsonii* Recover Team. And in 2009, the

South Florida Water Management District (SFWMD) and the U.S. Army Corps of Engineers (USACOE) began bimonthly monitoring at five locations (with 30 stations at each) for the Comprehensive Everglades Restoration Plan (CERP)/Restoration, Coordination and Verification (RECOVER) Seagrass Monitoring Section.

TABLE 2. MONITORING PROGRAMS IN LAKE WORTH LAGOON

Program	Agency	Frequency	Number of locations	Number of stations per location	Annual total of stations
LWL FTMP	PBC DERM	Annually	9	3	27
Johnson's Recovery	FWRI/NOAA	Annually	9	33	297
CERP/ RECOVER	SFWMD/ USACOE	Bimonthly	5	30	900

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PALM BEACH COUNTY DEPARTMENT OF ENVIRONMENTAL RESOURCES MANAGEMENT IN CONJUNCTION WITH DAMES AND MOORE. 1990. Lake Worth Lagoon natural resources inventory and resource enhancement study, West Palm Beach, Florida. 226 p.

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Florida Seagrass Integrated Mapping and Monitoring Program

Summary Report for the Southern Indian River Lagoon

Contact: Becky Robbins, South Florida Water Management District (Mapping and Monitoring); Bud Howard and Lorene Bachmann, WildPine Ecological Laboratory, Loxahatchee River District (Mapping and Monitoring), and Penny Hall, Fish and Wildlife Research Institute (Monitoring)

General Assessment: Seagrass cover in Southern Indian River Lagoon (SIRL) increased between 1999 (7,808 acres) and 2007 (8,848 acres). However, SIRL seagrasses, particularly in the vicinity of the St. Lucie River, experienced significant impacts from hurricanes and associated freshwater discharges in 2004 and 2005. Impacts included decreases in cover and density and, to a lesser extent, burial by shifting bottom sediments. Seagrass status is improving, as documented by increases in mapped acreage, recruitment into areas left bare following the hurricanes, and transition from the diminutive Johnson's seagrass (*Halophila johnsonii*) and paddle grass (*Halophila decipiens*) to the more robust, canopy-forming shoal grass (*Halodule wrightii*) and manatee grass (*Syringodium filiforme*). A 13% increase in mapped seagrass acreage occurred from 2005 to 2007, probably the result of continued post-hurricane recovery and drought, which encouraged more favorable salinities and increased water clarity.

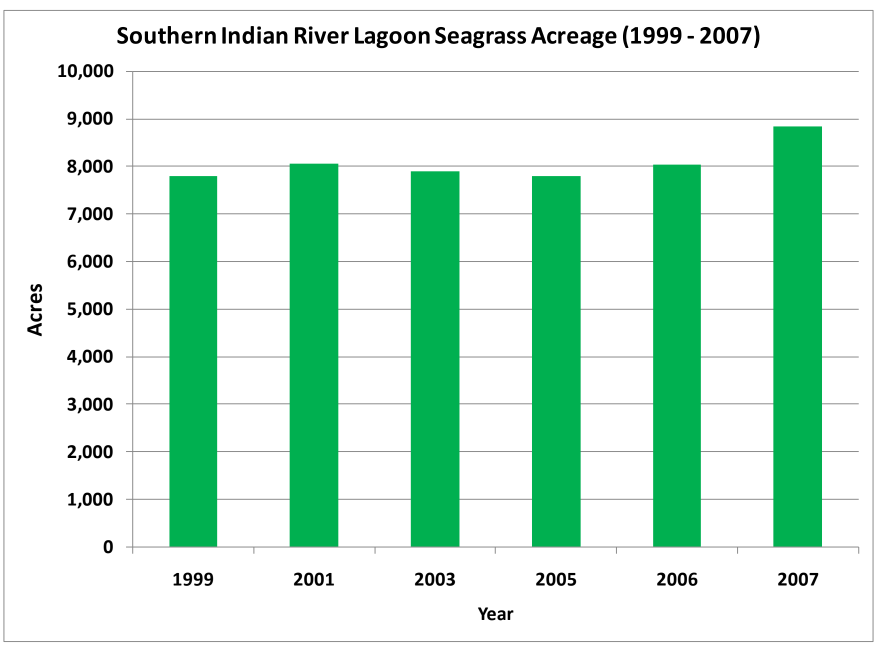


Figure 1. Seagrass cover in the southern Indian River Lagoon, 1999-2007.

Seagrass Status and Stresses	Status	Trend	Assessment, Causes
Seagrass cover		Increasing	Recovery following hurricane impacts; favorable salinities and improved water clarity due to drought conditions
Water clarity		Improving	Apparent decline in total suspended solids , chlorophyll-a, and color, 1992–2008; recent improvements probably tied to drought conditions
Natural events		Significant localized impacts (vicinity of St. Lucie Inlet); recovery under way	2004, 2005 hurricanes

Geographic Extent: The SIRL lies along the east coast of Florida from the St. Lucie/Indian River County line south to Jupiter Inlet. The IRL Surface Water Improvement and Management Plan (SWIM) identified 26 seagrass management units, or segments, throughout the lagoon (Steward et al., 2003). Five of the segments (22–26) lie within the SIRL; segment 22 is between the Indian River County line and the Fort Pierce Inlet, segments 23 and 24 are located between the Fort Pierce Inlet and the St. Lucie Inlet, and segments 25 and 26 occur between the St. Lucie Inlet and Jupiter Inlet. IRL SWIM efforts focus on improving water quality to restore and protect seagrasses. Therefore, the SIRL seagrass segment boundaries primarily follow the boundaries of five water quality zones (areas of relatively homogeneous water quality). Other factors, such as physical configuration and land use in the area, also support this segmentation scheme.

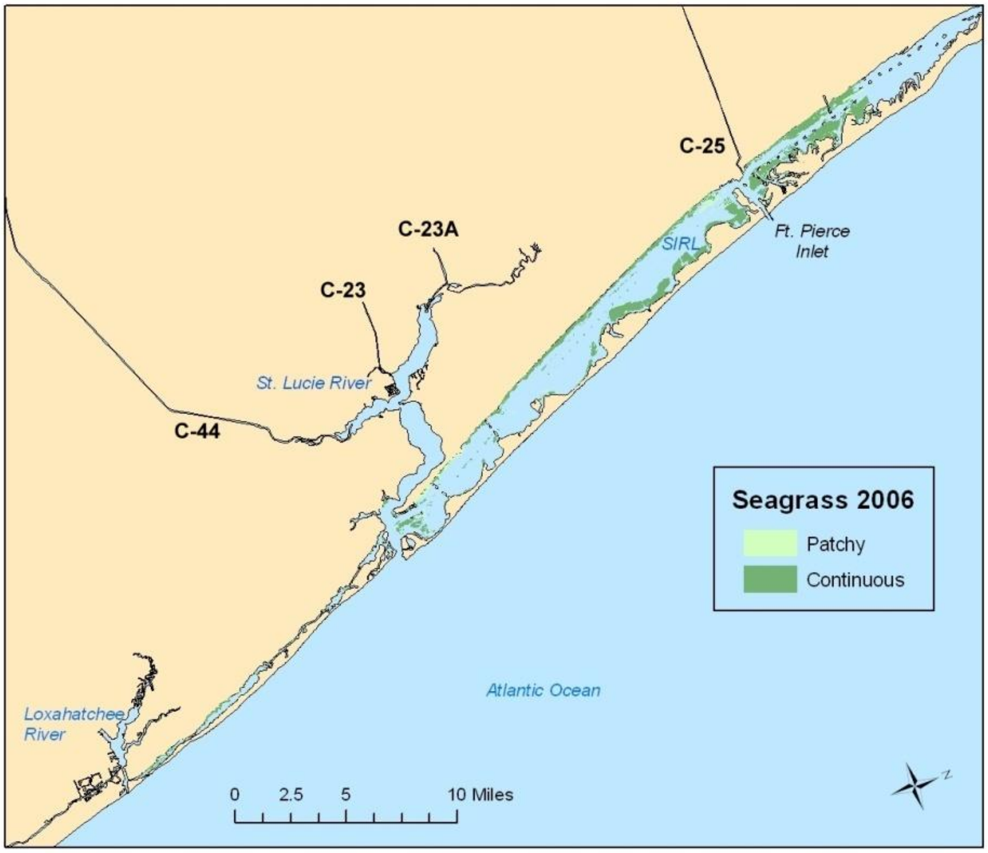


Figure 2. Location of seagrass beds in the southern Indian River lagoon, 2006.

Mapping and Monitoring Recommendations

• Implement landscape-scale seagrass mapping projects and patch-scale, species-specific mapping and monitoring. Landscape-scale seagrass maps, based on aerial photographs and ground-truthing, have been produced for the SIRL every two to three years since 1986. These maps provide an overall understanding of changes in seagrass cover and distribution. However, they do not provide information about seagrass species distribution. Understanding seagrass species distribution is important for water management, because seagrass species found in the SIRL have species-specific salinity tolerance thresholds (Irlandi 2006). Species shifts may occur as a result of restoration projects, and these changes cannot be detected from aerial photographs.

Management and Restoration Recommendations

• Improve management of water discharges from the watersheds surrounding the SIRL. The largest tributaries of the SIRL are the St. Lucie River/Estuary and the C-25 canal, which discharges near the Fort Pierce Inlet. Managing the quality, quantity, and timing of these releases is needed for seagrass restoration in the St. Lucie Estuary and SIRL.

• Restore natural water flows and improve water quality in the watershed. These efforts are part of the Comprehensive Everglades Restoration Plan (CERP), which is tasked with improving water delivery to tributaries.

Summary Assessment: Seagrass cover in the SIRL is increasing. Seagrass species composition and meadow texture are recovering in areas affected by hurricanes. Major stressors include light limitation and salinity extremes.

Seagrass Status Indicators	Status	Trend	Assessment, Causes
Seagrass cover		Increasing	Recovery following hurricane impacts; favorable salinities and improved water clarity due to drought
Seagrass meadow texture		Improving	Recovery following hurricane impacts, colonization of bare bottom, and species shifts from diminutive to more robust (canopy-forming) species
Seagrass species composition		Improving	In areas impacted by hurricanes, bare areas were first typically colonized by *Halophila* spp. and continue to trend toward canopy-forming species
Overall seagrass trends		Improving	Improving water clarity
Seagrass Stressors	**Intensity**	**Impact**	**Explanation**
Water clarity		Improving	Affected by runoff, storms
Nutrients		Relatively low	Affected by runoff, storms
Phytoplankton		Relatively low	Affected by runoff, storms
Natural events		Localized impacts	Hurricanes

Seagrass Mapping Assessment: Robbins and Conrad (2001) provide a detailed analysis of SIRL seagrass map data from 1986 to 1999. A detailed change analysis for subsequent data (through 2009) is being done by the South Florida Water Management District (SFWMD) and is expected to be completed in 2010. Because trends observed for the SIRL as a whole may not reflect seagrass trends for individual segments, the 2010 evaluation will look in detail at changes in acreage and distribution by lagoon segment. In general, the acreage of dense seagrass decreased in most segments following the 2004–05 hurricanes. All segments showed an increase in overall cover from 2005 to 2007 except segment 26, in which no appreciable change was noted (Table 1). The increase in acreage from 2005 through 2007 is probably due to a combination of post-hurricane recovery and drought, which provided favorable salinities and clear water. The portion of the SIRL most affected by water management practices is the area that receives discharges from the St. Lucie Estuary. Accordingly, seagrasses in the portion of the lagoon adjacent to the estuary mouth were mapped to the species level (using detailed ground-truthing and GPS technology) in 2007–08 (Avineon 2008). Species-specific maps have been produced for the St. Lucie Estuary for 1997 (URS Greiner Woodward Clyde, 1999) and 2007 (Ibis Environmental Inc., 2007).

TABLE 1.SEAGRASS ACREAGE IN THE SOUTHERN INDIAN RIVER LAGOON SYSTEM

Segment	1940	1992	1996	1999	2003	2005	2007	Change 2005–07
Segment 22	764	2,310	2,649	2,978	2,910	2,806	2,978	172
Segment 23	3,244	4,273	5,187	2,856	3,238	3,335	4,081	746
Segment 24	2,754	1,513	1,589	1,520	1,342	1,189	1,299	110
Segment 25	358	413	136	134	167	156	172	16
Segment 26	548	365	303	320	234	322	318	−4
Total	7,668	8,874	9,864	7,808	7,891	7,808	8,848	1,040

Monitoring Assessment: Monitoring provides species-specific information for assessing SIRL seagrass resources. Preliminary results of monthly transect monitoring and a new method of bi-monthly patch-quadrat monitoring indicate that sites near the mouth of the St. Lucie River

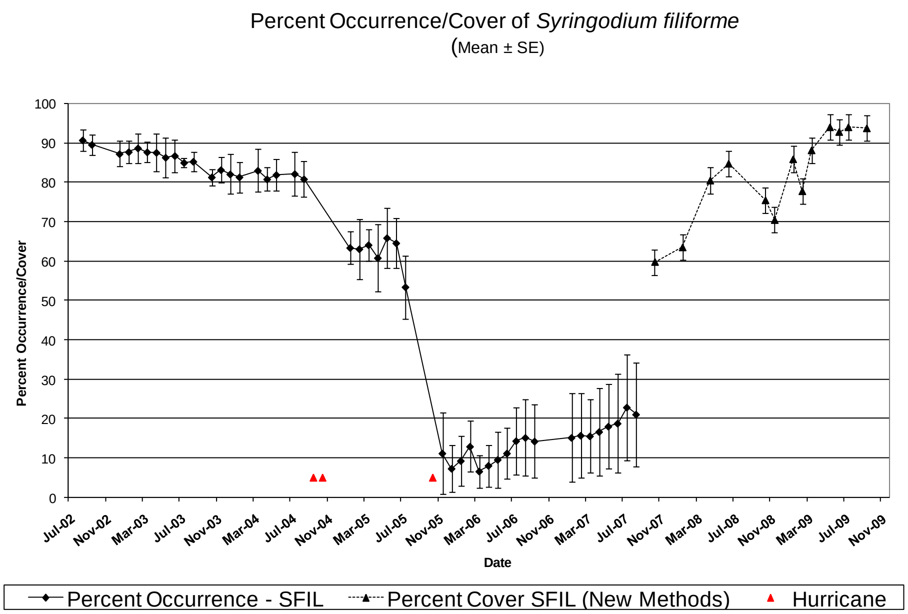
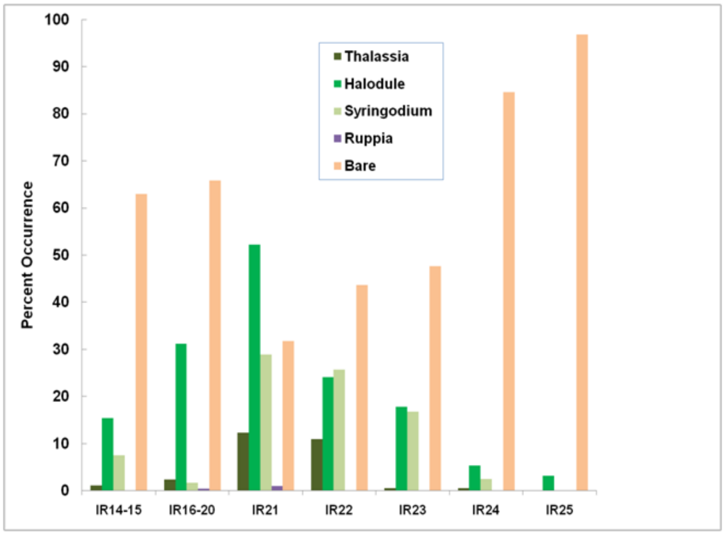


Figure 3. Percentage occurrence of manatee grass (*S. filiforme*) in the southern Indian River Lagoon, 2002—2009.

previously dominated by manatee grass were significantly affected (grasses lost or eliminated) following the 2004 and 2005 hurricanes. Recovery toward pre-hurricane conditions is being documented by monitoring. An example of the hurricane impacts and recovery process is shown in Figure 3 for a SIRL monitoring site located near the influence of the St. Lucie River. Additional data analysis by the SFWMD is planned for completion in 2010. Using probabilistic, post-2004 hurricane monitoring data collected in 2005 by Penny Hall's team at the Fish and Wildlife Research Institute, we examined the frequency of occurrence of seagrass species by estuarine segment in the southern Indian River Lagoon (Figure 4). Seagrasses were found in 3–68% of the quadrats, and overall, shoal grass was the most common species. In segments 22 and 23, shoal grass and manatee grass were equally common. From segment 21 south, the number of bare quadrats increased sharply, with more than 96% of quadrats in segment 25 having no seagrass. *Halophila* spp. were much less common, and of these, *H. decipiens* (paddle grass) was most commonly observed and occurred in 26% of quadrats in segment 23. The threatened *H. johnsonii* (Johnson's seagrass) was most frequent in segments 14 and 15, south of the SIRL.

Mapping and Monitoring Recommendations

- Continue landscape-scale mapping from aerial photographs or ground recording every two to three years.
- Continue bimonthly patch-scale monitoring.
- Continue biannual transect monitoring.
- Continue data evaluation.



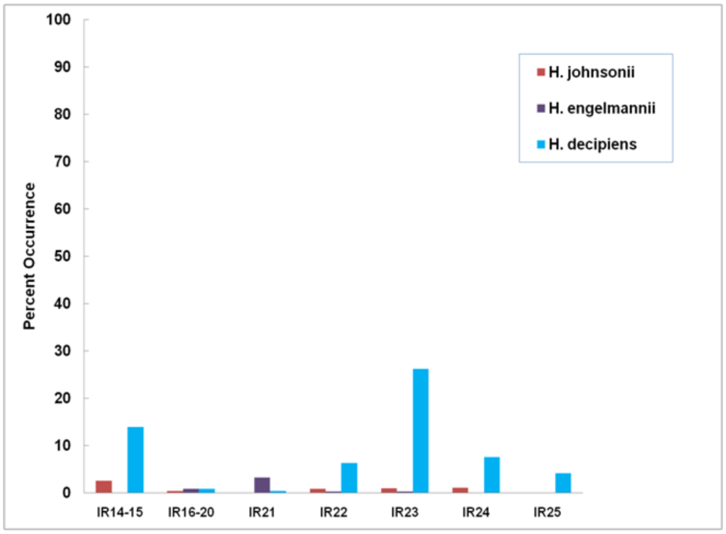


Figure 4. Occurrence of seagrass species by estuarine segment in the SIRL and Lake Worth Lagoon, 2005. (Data from FWRI, Penny Hall, 2005).

Management and Restoration Recommendations

• Continue to fund state and federal IRL restoration programs. Florida's SWIM Program, the U.S. Environmental Protection Agency National Estuary Program, and the U.S. Army Corps of Engineers' CERP Restoration Coordination and Verification (RECOVER) Monitoring and Assessment Plan (MAP) have identified seagrass ecosystems as critical habitats in the SIRL and have committed substantial resources toward restoration and protection.

Mapping Data and Imagery: The SWIM Plan directs the St. Johns River Water Management District (SJRWMD) and SFWMD to map seagrasses in the IRL at two- to three-year intervals. Accordingly, SIRL seagrass maps have been prepared for the following years: 1986 (partial), 1989 (partial), 1992, 1994, 1996, 1999, 2001, 2003, 2005, 2006, 2007, and 2009. SIRL seagrass mapping is based on interpretation of 1:24,000 and 1:10,000 aerial photographs by an outside contractor. In most cases, features on the aerial photographs were identified by means of photointerpretation keys and ground-truthing. Features are classified according to SJRWMD/SFWMD modified Florida Land Use Cover Classification System codes. Interpretation of aerial photographs and subsequent stereoscopic analysis of digital images were used to delineate the features and transfer the polygons into GIS data. An accuracy assessment report has been provided for the later surveys (since 1999). Species-specific, landscape-scale mapping of the Loxahatchee River Estuary was conducted by the Loxahatchee River District for SFWMD in 2007 and 2010 using 9m^2 quadrats and GPS.

Monitoring Data: Seagrass monitoring using transect methods has been conducted in the SIRL Lagoon twice a year (in winter and summer) since 1994 by regional agency staff and collaborators. The monitoring program is coordinated by the SJRWMD. Seagrass and macroalgal cover are estimated in 1-m^2 quadrats located every 5–10 m along 18 transects. A new (since 2007) seagrass patch-quadrat monitoring methodology is being used bimonthly at 10 sites within the SIRL and is coordinated by the SFWMD. The new method includes haphazardly deploying 30 1-m^2 quadrats within specified boundaries. Percentage occurrence of seagrass species and macroalgal functional groups are determined within 25 subsections of the large quadrats. Additionally, seagrass canopy height is measured and quadrat location is recorded. Water quality monitoring has been conducted in the SIRL by the SFWMD since 1990. From October 1990 through July 1999, 40 stations were monitored quarterly. Beginning in January 2000, water quality stations were established along seagrass transects, and monitoring frequency was increased to seven times a year.

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Contacts

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Bud Howard and Lorene Bachmann, WildPine Ecological Laboratory, Loxahatchee River District, 561-747-5700, Bud.Howard@loxahatcheeriver.org, Lorene.Bachman@loxahatcheeriver.org.

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Florida Seagrass Integrated Mapping and Monitoring Program

Summary Report for the Northern Indian River Lagoon System

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General Assessment: Seagrass area in the Northern Indian River Lagoon (NIRL) system has been increasing steadily since 1996. In 2007, mapping estimated a total of 71,646 acres of seagrass in the NIRL, an increase of about 9% over 2005. The increase is the result of depth-limit expansion of seagrasses, which appears to be a response to modest increases in light availability (reduction in light attenuation since 1997). Seagrass species composition and bed texture (patchiness) have been generally stable throughout the system. However, despite the expansion of seagrass area, percentage cover (seagrass density) has decreased, most markedly during 2004–05 in the southern NIRL following the 2004 hurricanes, probably as a result of persistently low salinity. Propeller scarring is not a widespread problem, but it is extensive in the south-central Mosquito Lagoon and, to a lesser degree, near the Sebastian Inlet. Seagrass recovery is occurring in both locations: in the Mosquito Lagoon due to new troll/no-motor zones and near the Sebastian Inlet because of improved channel marking.

TABLE 1. SUMMARY OF SEAGRASS STATUS, TRENDS, AND POSSIBLE CAUSES

Seagrass Status Indicator	Status	Trend	Assessment, Possible Causes
Seagrass acreage		Recent increases	Steady depth-limit expansion due to increased light availability
Species composition		Stable with intermittent localized impacts	Salinity variability
Seagrass density		Recent decreases	Frequent, prolonged reductions in salinity
Seagrass Stressor	**Status**	**Trend**	**Assessment, Possible Causes**
Light limitation (turbidity)		Modest improvements	Droughts, point-source reductions
Salinity		Localized impacts	Frequent, heavy stream discharges (interbasin, urban, etc.)
Propeller scarring		Localized impacts with improving conditions	Motor boat regulations

Geographic Extent: The NIRL system includes three sub-lagoons, Mosquito Lagoon, Banana River Lagoon, and Indian River Lagoon (Figure 1), extending 110 miles (177 km) from Ponce de Leon Inlet in northern Mosquito Lagoon to the southern Indian River County line.

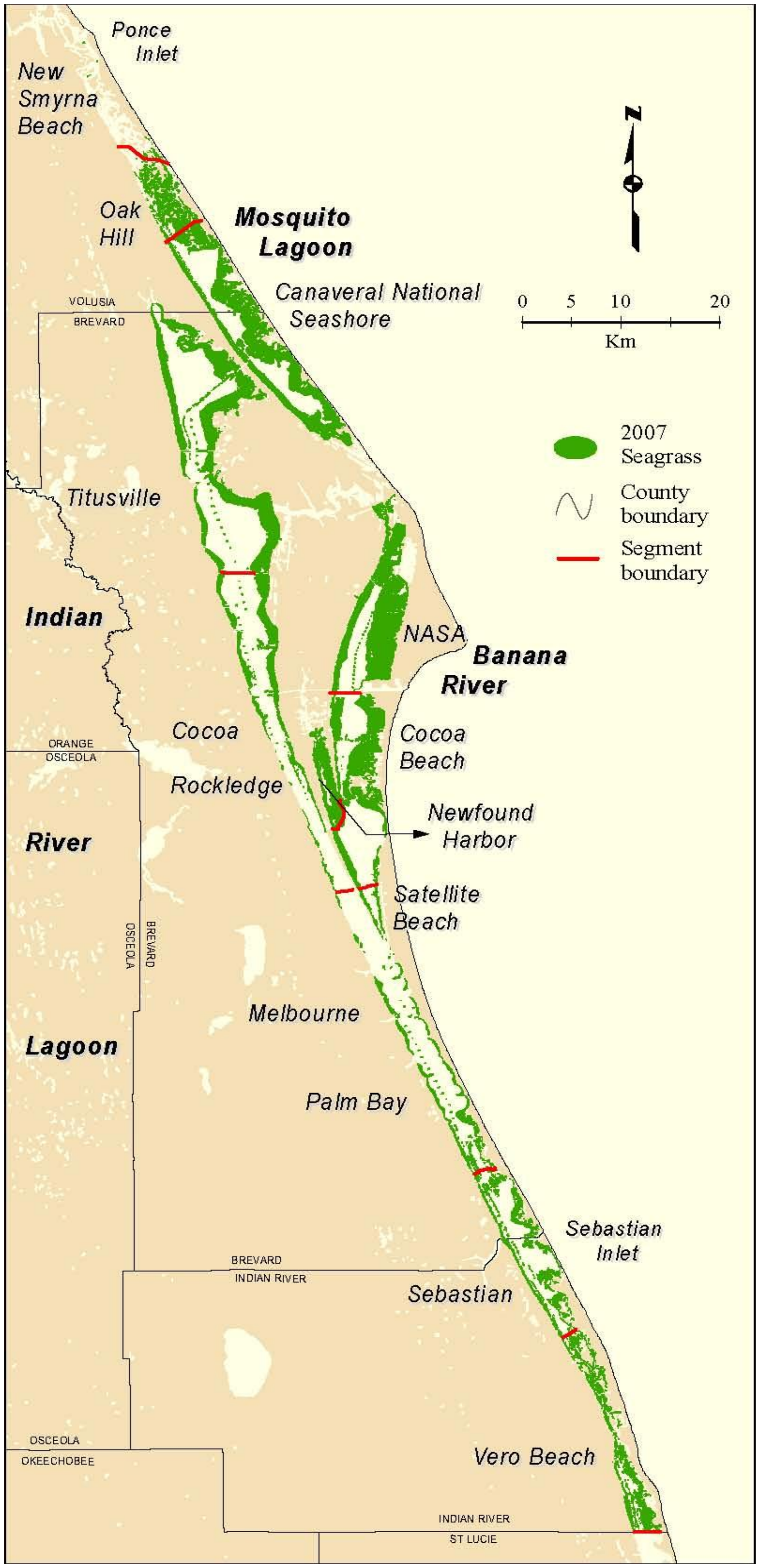

Figure 1. Seagrass beds in the northern Indian River Lagoon system.

Mapping and Monitoring Recommendations

• Continue mapping seagrass acreage. Mapping is done approximately every two years; the most recent (2009) mapping effort is under way. The entire NIRL system is scheduled to be mapped again in 2011.

• Continue seagrass monitoring program. Monitoring has been conducted each winter and summer for 15 years by the St. Johns River Water Management District (SJRWMD), with selected stations monitored monthly during the last 4 years.

• Continue water quality monitoring, which has been implemented to assess potential stressors, including attenuators of light (turbidity/total suspended solids [TSS]), monthly near seagrass monitoring locations. Water quality monitoring has been ongoing since 1989. Information from the combined seagrass and water quality monitoring programs provides a rich data set of historical importance that has assisted in addressing management goals, including the establishment of seagrass depth-limit targets and total maximum daily loads (TMDLs) of total nitrogen and total phosphorus for rivers and canals discharging into the NIRL.

• Improve spatial and temporal monitoring as needed to meet changing resource management goals by periodically reviewing monitoring programs. These reviews will include evaluation of our ability to detect change at appropriate spatial resolutions.

Management and Restoration Recommendations

• Continue coordination of state and federal Indian River Lagoon restoration programs. Florida's Surface Water Improvement and Management Program (SWIM), the U.S. Environmental Protection Agency National Estuary Program, and the U.S. Army Corps of Engineers' North Indian River Lagoon Feasibility Study have identified seagrass as critical habitat in this system and have committed substantial resources toward its restoration and protection.

• Determine water quality benchmarks (e.g., nutrient, TSS, transparency, and salinity levels) concomitant with seagrass depth limits, acreage, and seagrass density targets. Establishment of such restoration targets provides the basis for specific pollutant load reduction goals (e.g., TSS) and TMDLs (nutrients), which, in turn, are applied toward the development of design details for watershed runoff storage and treatment facilities and other remediation strategies (U.S. Army Corps of Engineers and SJRWMD 2002; Steward et al. 2003). The targets will also be used to gauge multiyear trends in seagrass coverage and the effects of management actions on those trends.

The establishment of seagrass depth-limit targets by Steward et al. (2005) provides an example of a management strategy. A segment that achieves its light-at-depth target will have attained a water transparency condition equivalent to or better than that segment's historical best, based on historical seagrass coverage maps and water transparency models. If transparency targets are achieved but seagrass area and depth-limit targets are not met, then factors other than light may be influencing the depth limit of seagrasses and should be investigated.

• Continue to evaluate propeller scarring in affected areas of the NIRL using ground observations and aerial photography to locate scars, using the management strategy of Schaub et al. (2009). New photointerpretation tools have been developed to measure severity of scarring. Troll/no-motor zones have been established to encourage seagrass-bed recovery in the most damaged locations. Continuation of aerial surveys will help in assessing restoration success and management potential for additional areas as needed.

Summary Assessment: Table 2 and Figure 2 depict the steady increase in seagrass area since 1996, probably a consequence of modest decreases in average light attenuation, or K_d (especially in Banana River Lagoon: K_d('90–'96) = 1.02; K_d('97–'07) = 0.91; and southern NIRL from Sebastian through Vero Beach: K_d('90–'96) = 1.31, K_d('97–'07) = 1.17). In 2007, seagrasses covered 71,646 acres, and most of the acreage (55,906 acres, or 78%) was located from Titusville north through the southern Mosquito Lagoon (Canaveral segment) and in the Banana River Lagoon (Table 2). The 2007 coverage represents 82% of available lagoon bottom that could support seagrass (Steward et al. 2005). Heavy turbid runoff caused by a quick succession of hurricanes in 2004 promoted substantial decreases in seagrass area in the fall and winter of 2004–05, with most of the loss occurring in the Rockledge to Melbourne reach. However, recovery was complete by the next growing season. In contrast, the systemwide average density of seagrass has decreased in recent years and is below the pre-2005 average (Figure 2). This decline is believed to be the result of persistently low salinities (< 20 ppt), primarily in the central reaches of the NIRL.

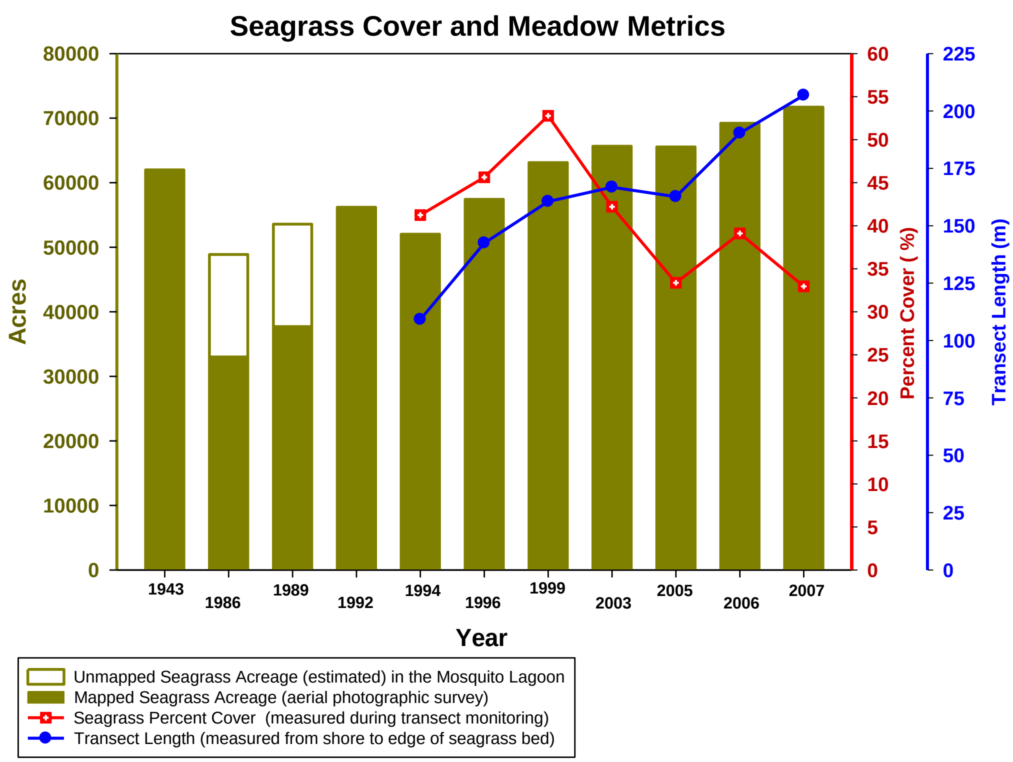

Figure 2**.** Average seagrass area (total acres) in the NIRL per mapping year; average percentage coverage (bed density) along the transect; and the corresponding average length of monitoring transects to the seagrass deep edge.

TABLE 2. MAPPED SEAGRASS AREA (ACRES) IN THE NORTHERN INDIAN RIVER LAGOON USING AERIAL PHOTOGRAPHY

Segment	1943	1992	1996	1999	2003	2005	2007	Change '07–'05	Area Target
Mosquito Lagoon–New Smyrna	822	330	19	59	67	72	94	22	1,003
Mosquito Lagoon–Oak Hill	2,974	2,668	2,350	2,810	2,736	2,760	2,765	5	3,427
Mosquito Lagoon–Canaveral	14,511	13,326	13,459	13,339	13,460	13,362	13,964	602	15,926
Banana River–NASA	6,719	9,824	9,962	10,479	11,861	11,843	12,182	339	11,767
Banana River–Port Canaveral	1,975	1,837	1,909	2,239	2,315	2,153	3,061	908	2,592
Banana River–Cocoa Beach	4,497	4,578	3,406	4,663	4,328	4,495	5,384	889	5,448
Banana River–Newfound Harbor	2,795	1,374	1,287	2,280	2,530	2,439	2,926	487	2,834
Banana River–Satellite Beach	406	173	159	210	221	219	458	239	531
NIRL–Titusville	14,035	14,961	14,399	13,938	14,516	14,556	15,072	516	19,274
NIRL–Cocoa/Rockledge	5,404	2,167	3,085	4,816	4,914	4,855	5,016	161	7,596
NIRL–Melbourne/Palm Bay	3,633	705	1,913	2,563	2,774	2,757	3,134	377	4,183
NIRL–Sebastian	1,325	2,671	3,500	3,165	3,306	3,409	3,783	374	4,776
NIRL–Vero Beach	3,047	1,558	1,950	2,523	2,586	2,600	3,807	1,207	4,082
Total	62,143	56,172	57,398	63,084	65,614	65,520	71,646	6,126	83,439

Note: green high-lighted acreages have exceeded area targets.

TABLE 3. AVERAGE DEPTH (M) OF SEAGRASS DEEP EDGE BY NIRL SEGMENT

Segment	1943	1992	1996	1999	2003	2005	2007	Change 2005–07	Depth Target
Mosquito Lagoon–New Smyrna	1.39	1.29	NA	NA	NA	0.5	0.49	−0.01	NA
Mosquito Lagoon–Oak Hill	**0.84**	0.71	0.68	0.71	0.71	0.62	0.62	0	0.8
Mosquito Lagoon–Canaveral	1.14	0.87	0.93	0.87	0.9	0.87	0.9	+0.03	1.3
Banana River–NASA	1.02	1.48	1.32	1.54	1.67	1.69	**1.81**	+0.12	1.8
Banana River–Port Canaveral/ Cocoa Beach	1.39	1.11	1.11	1.14	1.11	1.11	1.26	+0.15	1.6
Banana River–Newfound Harbor	1.39	1.02	0.96	1.51	1.51	1.51	1.55	+0.04	1.6
Banana River–Satellite Beach	1.23	1.26	0.93	1.07	1.02	0.99	1.23	+0.24	1.4
NIRL–Titusville	1.17	1.14	1.26	1.05	1.17	1.08	1.23	+0.15	1.6
NIRL–Cocoa/Rockledge	1.2	0.93	1.11	1.29	1.29	1.29	1.35	+0.06	1.5
NIRL–Melbourne/Palm Bay	1.29	1.05	1.26	1.26	1.32	1.29	1.42	+0.13	1.5
NIRL–Sebastian	0.91	1.15	1.21	1.18	1.18	1.21	1.27	+0.06	1.3
NIRL–Vero Beach	1.15	0.88	1.03	1.12	1.15	1.18	1.27	+0.09	1.3

Note: Depths highlighted in green have exceeded area targets.

Seagrass Mapping Assessment: Between 2005 and 2007, total seagrass area increased 9.3%. All segments showed an increase (Table 2), with the greatest gains in the Banana River Lagoon (2,862 acres) and in the Vero Beach reach of the NIRL (1,207 acres). Systemwide seagrass area in 2007 exceeded the 1943 estimate by 9,503 acres. However, since 1943, Mosquito Lagoon has lost nearly 1,500 acres of seagrass, mostly in its northernmost segments (near New Smyrna Beach). Seagrass area in the Sebastian segment has almost tripled since 1943, primarily a consequence of the permanent opening at Sebastian Inlet, which has been maintained since 1948. The northern half of Banana River Lagoon is close to meeting its multiyear area and depth-limit targets (Table 2 and Table 3). If the 2009 mapping data support this trend, and if high seagrass densities are maintained, then this segment (which is in waters under control of the National Aeronautics and Space Administration)) may be the first segment in the NIRL system to be considered restored. In order for a segment to be considered restored with respect to areal seagrass cover, it must achieve its area target in at least four out of seven mapping years. Sebastian and Vero Beach were the only other segments to attain their depth-limit targets in 2007 (Table 3).

Monitoring Assessment: As shown with mapped areas (acreage and deep-edge depths), transect lengths (the distance from shore edge to deep edge) are increasing in many locations. (Figure 2). Unfortunately, as seagrass beds expand, they are decreasing in percentage cover (bed density). This is particularly evident in the Melbourne/Palm Bay reach, which has experienced persistent periods (up to one year) of low salinity (< 20 ppt).

Mapping Data and Imagery: The SWIM Plan directs the SJRWMD and South Florida Water Management District (SFWMD) to map seagrasses in the IRL at two- to three-year intervals. Accordingly, in addition to the 1943 maps, IRL seagrass maps have been prepared for the following years: 1986, 1989, 1992, 1994, 1996, 1999, 2001 (partial), 2003, 2005, 2006, and 2007. Seagrass mapping is based on interpretation by an outside contractor of 1:24,000 (and to a lesser extent 1:10,000) aerial photos. In most cases, features on the aerial photographs are identified by means of photointerpretation keys and ground-truthing. Features are classified according to SJRWMD/SFWMD-modified Florida Land Use Cover Classification System codes. Interpretation of aerial photographs and subsequent stereoscopic analysis of digital images were used to delineate the features and transfer the polygons into GIS coverage. An accuracy assessment report has been provided for the surveys since 1999.

Monitoring Data: Field monitoring of seagrass has been conducted in the NIRL twice a year since 1994 by regional agency staff and collaborators. The monitoring program is coordinated by the SJRWMD. Seagrass and macroalgal cover are estimated by species in 1-m^2 quadrats placed every 10 m along each transect. Currently, there are 98 transects located throughout the NIRL; of these, 74 transects have been monitored since 1994. Transects are randomly distributed throughout the system, and each transect is located within 3 km of a water quality monitoring station.

Water quality monitoring has been conducted by a multiagency team since 1989. Major modifications of the water quality monitoring network occurred in 1996: all samples have been processed and analyzed by a single laboratory, and consistent methodology for the collection of field data and water samples has been established. These modifications improved quality control for the sake of data precision and accuracy.

Pertinent Reports and Scientific Publications

AVINEON INC. 2010. Final project report Saint Johns River Water Management District/South Florida Water Management District 2009 Indian River Lagoon seagrass mapping, May 2010. 49 p.

MORRIS, L. J., and R. W. VIRNSTEIN. 2004. The demise and recovery of seagrass in the Northern Indian River Lagoon, Florida. Estuaries 27: 915–922.

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SCHAUB, R., D. M. SCHEIDT, C. M. GARREAU, and C. R. HALL. 2009. Quantitative assessment of seagrass scarring in the southern Mosquito Lagoon and Northern Indian River of Brevard and Volusia counties, Florida. U.S. Fish and Wildlife Service, Merritt Island National Wildlife Refuge, Florida, Contract no. GS10F0237R, and St. Johns River Water Management District, Palatka, Florida. 39 p.

STEWARD, J. S., R. BROCKMEYER, R. VIRNSTEIN, P. GOSTEL, P. SIME, and **J. VANARMAN.** 2003. Indian River Lagoon surface water improvement and management (SWIM) plan, 2002 Update. St. Johns River Water Management District, Palatka, Florida, and South Florida Water Management District, West Palm Beach, Florida. 272 p.

STEWARD, J. S., R. W. VIRNSTEIN, L. J. MORRIS, and E. F. LOWE. 2005. Setting seagrass depth, coverage, and light targets for the Indian River Lagoon system, Florida. Estuaries 28: 923–935.

U.S. ARMY CORPS OF ENGINEERS and ST. JOHNS RIVER WATER MANAGEMENT DISTRICT. 2002. Central and Southern Florida Project, project management plan: Indian River Lagoon North feasibility study. June 18, 2002. USACE Southeast District, Jacksonville, Florida, and St. Johns River Water Management District, Palatka, Florida, 63 p. + appendices.

General References and Additional Information

St. Johns River Water Management District: http://www.sjrwmd.com/irlinsert/index.html, accessed March 2011.

Indian River National Estuary Program: http://www.epa.gov/region4/water/watersheds/documents/indian_river_lagoon.pdf, accessed March 2011.

Contacts

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Appendix A: Acronyms and abbreviations used in this report

Acronym or Abbreviation	Full Name
BMAP	Basin Management Action Plans
CAMA	Coastal and Marine Assessment
C-CAP	Coastwatch Change Analysis Project
CDOM	colored dissolved organic matter
CERP	Comprehensive Everglades Restoration Plan
CHNEP	Charlotte Harbor National Estuary Program
CMP	Coastal Management Program
DMC	digital mapping camera
EMAP	Environmental Monitoring and Assessment Program
ENP	Everglades National Park
ERP	Ecosystem Restoration Program
FDEP	Florida Department of Environmental Protection
FDOR	Florida Department of Regulation
FHAP	Fisheries Habitat Assessment Program
FIU	Florida International University
FKNMS	Florida Keys National Marine Sanctuary
FLUCCS	Florida Land Use Cover Classification Systems
FTMP	Fixed Transect Monitoring Project
FWC/FWRI	Fish and Wildlife Commission/Fish and Wildlife Research Institute
FWRI	Fish and Wildlife Research Institute
GCCC	Gulf Coast Community College
GINS	Gulf Islands National Seashore
GIS	geographic information system
IMAP	Inshore Monitoring and Assessment Program
IMU	inertial measurement unit
IRL	Indian River Lagoon
LWL	Lake Worth Lagoon

Acronym or Abbreviation	Full Name
Miami-Dade DERM	Miami-Dade County Department of Environmental Resource Management
MMS	Mineral and Mining Service
MRAID	Marine Resources Aerial Imagery Database
MRGIS	Marine Resources Geographic Information System
NASA	National Aeronautics and Space Administration
NCCOS	National Centers for Coastal Ocean Science
NEP	National Estuary Program
NERR	National Estuarine Research Reserve
NGO	nongovernmental organization
NIRL	Northern Indian River Lagoon
NOAA	National Oceanic and Atmospheric Administration
NRDA	Natural Resources Damage Assessment
NWFWMD	Northwest Florida Water Management District
NWRC	National Wetlands Research Center
OFW	Outstanding Florida Waters
PBC DERM	Palm Beach County Department of Environmental Resource Management
RECOVER	Restoration Coordination and Verification
RSOWQ	Remotely sensed optical water quality
SAB	St. Andrew Bay
SAV	submerged aquatic vegetation
SAV TWG	Submerged Aquatic Vegetation Technical Working Group
SBEP	Sarasota Bay Estuary Program
SCIS	Seagrass Conservation Information System
SDRS	spatially distributed random sampling
SFWMD	South Florida Water Management District
SIMM	Seagrass Integrated Mapping and Monitoring
SIRL	Southern Indian River Lagoon
SJRWMD	St. Johns River Water Management District
SRWMD	Suwannee River Water Management District

Acronym or Abbreviation	Full Name
SWFWMD	Southwest Florida Water Management District
SWIM	Surface Water Improvement and Management Program
TMDL	total maximum daily load
TSS	total suspended solids
UMAM	Uniform Mitigation Assessment Method
U.S. EPA	United States Environmental Protection Agency
USACOE	United States Army Corps of Engineers
USGS	United States Geological Survey
VOO	vessel of opportunity
WBBOWL	West Bay Bowl (in St. Andrew Bay)
WBARM	West Bay Arm (in St. Andrew Bay)