Introduction

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Introduction

Florida seagrass beds are an extremely valuable natural resource, and Florida coastal waters contain the largest contiguous areas of seagrass beds in the United States. Approximately 2.48 million acres of seagrass have been mapped in estuarine and nearshore Florida waters (this report). Unmapped seagrass beds growing in deeper waters on the continental shelf west of Big Bend and southwestern Florida might cover as many as 6 million acres (Carlson and Madley, 2007). Seagrasses provide habitat for fish, shellfish, marine mammals, and sea turtles. Many economically important fish and shellfish species depend on seagrass beds during critical stages of their life histories, and this translates into Florida seagrass beds having a value of more than $20 billion each year (Costanza *et al.*, 1997). Seagrasses also play a role in the global carbon cycle, in nutrient cycles, in stabilizing sediment, in maintaining coastal biodiversity, and in providing food 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 (Orth *et al.*, 2006). Although concerted efforts to improve water quality have increased 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 seagrass recovery, regular mapping and monitoring of this valuable resource are required. We report here on the status and trends of Florida seagrasses through the use of mapping and monitoring data produced and contributed by a large group of partners and collaborators. This is the second edition of the report of the Seagrass Integrated Mapping and Monitoring Program (SIMM) which began in 2009.

Until the SIMM program began, there had been no coordinated statewide program that regularly assesses 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 (SJRWMD), the Southwest Florida Water Management District (SWFWMD), and the South Florida Water Management District (SFWMD), respectively. Other estuaries and seagrass beds have been mapped using opportunistic grants with no consistent frequency, often resulting in gaps of 8–12 years between mapping efforts. Previous to SIMM, the last statewide reporting effort used a collection of seagrass maps produced over a 10-year period (Carlson and Madley, 2007). Comparing data from such disparate mapping projects often requires that the data be reworked into a standard format for computing 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 collecting the imagery and producing the seagrass maps in geographic information system (GIS) software. These lags, added to the sometimes-long interval between mapping efforts for an area, result in a poor ability to detect seagrass losses quickly and prevent further losses. The occurrence and frequency of field monitoring of seagrass beds also varies widely across Florida coastal waters. Some estuaries have had continuous monitoring for more than 20 years (Tampa Bay, Indian River Lagoon, Florida Bay); monitoring programs at other locations began more recently and are ongoing; while other locations are monitored sporadically when financial support is available or not at all.

To provide more accurate estimates of changes in seagrass area and to provide greater spatial resolution and information on seagrass species composition, the SIMM program integrates seagrass mapping and monitoring across Florida and creates reports that are continuously updated in the Web. Monitoring programs can provide greater spatial resolution and information on seagrass and algal species composition much faster than mapping projects alone can do (Table I-1). 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 the SIMM report links existing monitoring programs via a reporting network. However, doing so presents several challenges, including gaps in spatial coverage, temporal gaps in monitoring data, and identifying key indicators, appropriate field methods, and statistical techniques for analyzing disparate data sets. These challenges also are opportunities to leverage funds to fill gaps, to standardize assessment methods, and to report information in a format that is similar across all programs. The goals of the SIMM program are 1) mapping all seagrasses in Florida waters at least every six years in those regions for which a routine mapping program does not exist; 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 seagrass-cover estimates and maps showing seagrass gains and losses.

Table I-1 Seagrass mapping and monitoring are complementary.

Characteristic	Mapping	Monitoring
Spatial coverage	Large; thousands of acres	Small: hundreds of m²
Spatial resolution	Coarse: 0.5 acre	Fine: 1 m²
Classification	Coarse: 2–3 categories	Fine: scalar
Species composition	None	Complete
Other biological assessments	None	As desired
Revisit interval	Long: 2–10 years	Short: 6–12 months
Data lag time	Long: 12–24 months	Short: 1–2 months
Cost	High	Low: depends on frequency

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, photo-interpretation, mapping and monitoring costs. SIMM program data have provided or could provide

- baseline data against which natural and human-caused disasters could be evaluated,
- background data for permitting efforts in general and the Uniform Mitigation Assessment Method (UMAM) of the Florida Department of Environmental Protection (FDEP) in particular;
- quantitative data to support Total Maximum Daily Load (TMDL) efforts and Basin Management Active Plans (BMAP) in estuaries, and
- quantitative metrics for developing and monitoring the effectiveness of numerical 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 the Tampa Bay region and other Florida estuaries; but by the mid-1980s, it was apparent that non-point-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 non-point-source pollution in Florida waters. Three water management districts—SJRWMD, SFWMD, and SWFWMD—began mapping seagrasses in their jurisdictional waters. The first seagrass maps for the Indian River Lagoon were produced in 1987 by SJRWMD and SFWMD. SWFWMD began seagrass mapping in Tampa Bay south

through northern Charlotte Harbor in 1988 and has continued mapping every two years. When the Tampa Bay National Estuary Program (now the Tampa Bay 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 map 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 to regularly assess 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 developed and validated two concepts that are key to any ecological assessment: 1) the success of ecological monitoring depends on developing 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 (U.S. Environmental Protection Agency, 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 that it prevents clumping of sample points by distributing them in an array of tessellated hexagons laid over the study area while 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 Florida Keys National Marine Sanctuary.

In light of the groundswell of interest in seagrass monitoring and developing practical sampling designs, Ken Haddad, then director of FWRI, held a workshop in June 2000 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, a now outdated database of seagrass mapping

and monitoring projects hosted on the original FWRI Website www.floridamarine.org. The workshop also led to the 2003 FWC publication *Florida Seagrass Manager's Toolkit*, by Gerald Morrison, Ronald Phillips, and Bill Sargent.

Also in 2000, Gil McRae, now director of FWRI, received a five-year grant from the U.S. Environmental Protection Agency (US 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 estimated of seagrass abundance. Over the course of the IMAP program (2000-2004), seagrass and macroalgae 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 data set against which changes resulting from the Comprehensive Everglades Restoration Program (CERP) might be measured. In 2005, Kevin Madley of FWRI supervised collections of a similar imagery set for Biscayne Bay. Finally, in 2007, Larry Handley, Diane Altsman, and Richard DeMay produced a report entitled "Seagrass Status and Trends in the Northern Gulf of Mexico: 1940–2002" (Handley *et al*., 2007). This report describes seagrass mapping data for 15 estuarine and lagoon 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, 8 reported seagrass losses over the preceding decade, 3 reported gains, and 2 had insufficient mapping data to allow reliable assessment. The need for a coordinated statewide seagrass mapping and monitoring program was obvious, and the Florida Coastal Management Program (FCMP) of the FDEP provided start-up funds for the development of the SIMM program. More recently, funding from the State Wildlife Grants program of the U.S. Fish and Wildlife Service and the Gulf Environmental Benefit Fund, administered by the National Fish and Wildlife Foundation, have supported the SIMM program. With these funds, we have continued to publish contributions of our collaborators in regional chapters, we have obtained imagery and mapping data for areas where seagrasses were showing evidence of change and where the most recent mapping data were more than six years old, and we have carried out field monitoring by FWRI staff or contractors for regions lacking routine in-water assessments of seagrass beds.

How this report is organized

This report updates information published

in each chapter of the first edition, 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, whereas regions receiving less scrutiny have less; and each chapter has a different flavor and emphasis, depending on the status of seagrasses and their stressors. We hope that readers and contributors will continue to provide us with additional and updated information so that our report accurately represents seagrass condition in Florida waters. 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) descriptions and links to data on fauna associated with local seagrass beds and the fisheries associated with seagrass ecosystems.

We have limited information for three subregions along Florida's coastline for which there is no monitoring and mapping program: the Ten Thousand Island region in southwestern Florida, Apalachicola and Ochlockonee bays in the Panhandle, and seagrass beds in Volusia County on the east coast.

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 (email 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.

Each chapter begins with a concise, general assessment and a color-coded "report card" graphic showing seagrass status, as well as a map of the distribution of seagrass beds in the estuary or subregion, created using the latest available mapping data. The "report card" status graphic, based on the authors' best professional judgment, provides a general assessment of the health of seagrass 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—measurable declines, moderate stressors, or declines in seagrass cover;
- Red—large negative changes in seagrass health and stressors, either acutely over a short period or chronically over several years.

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

Following the summary information is an outline of the geographic extent covered in the chapter. Some historical information about the estuary and a description of any modifications to the system may be included as well. A brief list of mapping, monitoring, management, and restoration recommendations follows. 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 causing these changes. In some chapters, acreages and change analysis are broken down either 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, Web sites, and additional information.

This report also has an Executive Summary where we review the factors affecting the growth of seagrasses and collate information for a statewide summary and assessment of seagrass status and trends.

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