Summary Report for Franklin County Coastal Waters

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in

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General assessment

Seagrass beds in Franklin County coastal waters appear stable or slightly improving in status, based on temporal changes observed from mapping data (1992–2010) and field monitoring data (2009–2017). Mapping of imagery collected in the fall of 2010 showed that 14,611 acres of seagrass were present in the region, and 8,100 acres, or 55% of the total, were continuous beds (Table 1). Most of the seagrass beds were in the eastern region (Figure 1). In 1992, Franklin County waters contained 14,452 acres of seagrass. During the 18-year period between mapping efforts, Apalachicola Bay lost 2,004 acres of seagrass, or 64% of the area mapped there in 1992. The Alligator Harbor subregion also lost seagrass area: 535 acres or 71% of the area mapped in 1992. Seagrass area in St. Vincent Sound remains small, but the area doubled from 1992 to 2010 from 52 to 108 acres, of which all but 2 acres were patchy beds. In eastern coastal Franklin County subregions (Dog Island and Reef, Turkey Point and Carrabelle River), seagrass area increased by 1,901 acres from 1992 to 2010, or 27%.

Data from annual field monitoring assessments in 2009–2017 indicate that seagrass species composition and frequency of occurrence show small year-to-year variations (see Table 2). Manateegrass (*Syringodium filiforme*), turtlegrass (*Thalassia testudinum*), and shoalgrass (*Halodule wrightii*) are about equally abundant. Within the region, seagrass species vary spatially: shoalgrass is most common in St. George Sound and near Eastpoint; turtlegrass is most common at Carrabelle; and manateegrass is most common at Turkey Point, Dog Island Reef, and Lanark Reef. In 2017, shoalgrass and manatee were co-dominant at Dog Island. Stargrass (*Halophila engelmannii*) and widgeongrass (*Ruppia maritima*) occur sporadically. Increasing development in the watershed raises concerns about impacts on 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, Carrabelle, and Apalachicola rivers contributes considerable freshwater, color, and turbidity to coastal waters during stormy periods (see Figure 2). Excessive runoff from the 2009–2010 El Niño and

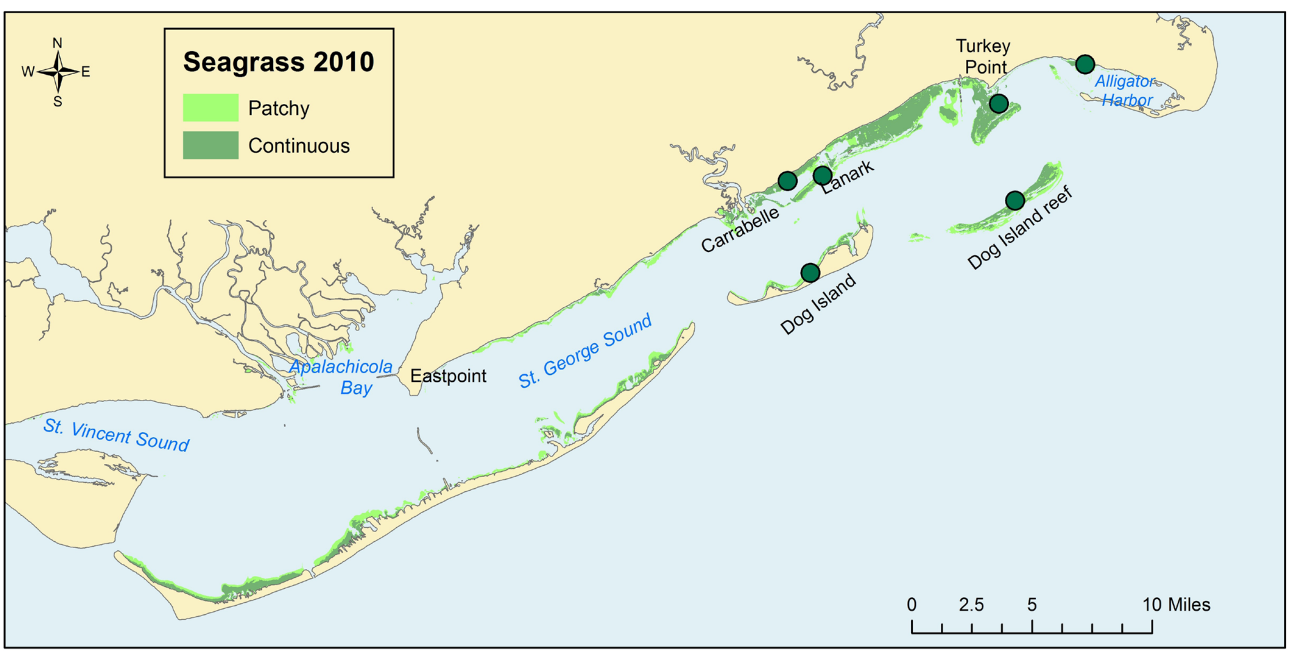

Figure 1. Seagrass cover in Franklin County coastal waters, 2010. Dots show locations at which productivity of turtlegrass was measured in 2016.

prolonged storminess from the summer of 2012 through early 2014 reduced water clarity during the summer monitoring periods, but optical water quality was much improved in 2016 and 2017.

The general status of seagrasses in the region is shown as good or green in status graphics 1 and 2. Attributes of seagrass beds, acreage, texture, and species composition, are stable (status graphic 2). Water clarity has improved somewhat since the last status evaluation in the second edition of this chapter. Chlorophyll-a concentrations, which estimate phytoplankton density, are moderate compared to other estuaries on the Florida Gulf coast. Propeller scarring is likely localized with limited impact on seagrass beds, but the lack of water clarity in recent imagery prevented a quantitative assessment of scarring.

Geographic extent

Franklin County coastal waters cover about 212 square miles (Northwest Florida Water Management District 2017) and include, from west to east, St. Vincent Sound, Apalachicola Bay, St. George Sound, Dog Island, Dog Island Reef, and Alligator Harbor (Figure 1). This region includes portions of the Apalachicola National Estuarine Research Reserve and the Alligator Harbor Aquatic Preserve. Most of the coastline is covered by tidal marshes. The area surveyed during annual summer field monitoring extends from Alligator Harbor in the east to St. George Sound in the west, ending at the causeway on the western side of St. George Island. Franklin County has a very small population (about 11,900 in 2016; U.S. Census Bureau), and most of the county is covered by forests or wetlands. The Apalachicola River drains into the western part of the region and significantly affects water quality and food webs (Livingston 2015). The watershed of the Apalachicola River covers about 20,000 square miles in Florida, Alabama, and Georgia, and headwaters begin in the southern Appalachian Mountains in northern Georgia. The long-term (1978–2016) average discharge of the Apalachicola River is about 22,600 cubic feet per second, as measured at Sumatra, Florida, making it the 21st largest river in the contiguous United States (Northwest Florida Water Management District 2017). Historically, water from the river supported large commercial oyster, blue crab, shrimp, and finfish fisheries, but recent droughts in the upper watershed coupled with increasing demands for water in Georgia and Alabama, have significantly reduced discharge from the river. The loss of freshwater inflow to coastal waters and other factors have dramatically reduced fishery harvests, particularly those of oysters, and caused widespread economic hardship in Franklin County. A second, much smaller, source of freshwater is the Carrabelle River, which upstream includes the New River. The watershed of the combined New and Carrabelle rivers covers 516 square miles in Liberty and Franklin counties and is primarily forested. While discharge from the Apalachicola River is usually turbid, freshwater at the mouth of the Carrabelle is darkly stained with tannins but relatively free of particles (Figure 2). Livingston (2015) provides extensive information on organisms and ecosystem changes in the region from the 1970s to the 2000s.

Mapping and monitoring recommendations

- Continue monitoring seagrass biennially. Florida Fish and Wildlife Conservation Commission (FWC) staff monitored seagrasses annually in the summer from 2006 through 2014, and in 2016. In 2017, staff from the Central Panhandle Aquatic Preserves began monitoring seagrasses in Alligator Harbor and at Turkey Point.
- Expand field monitoring to include potential seagrass habitat in Apalachicola Bay and St. Vincent Sound to the west and in Ochlockonee, Oyster, and Goose Creek bays to the east.

1. General Status of Seagrasses in Franklin County Coastal Waters

Status and stressors	Status	Trend	Assessment, causes
Seagrass acreage	Green	Stable	Status varies across the region
Seagrass density	Green	Slightly improving	Better water clarity, 2014–2017
Water clarity	Yellow	Improving	
Natural events	Yellow	Fewer impacts, 2014–2017	Inter-annual climatic variation
Propeller scarring	Yellow	Localized, shallow waters	Ongoing, low impact

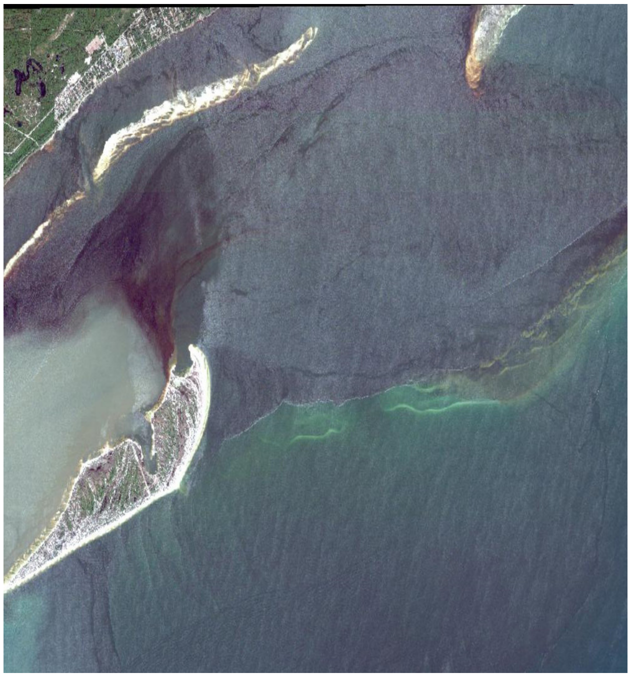

Figure 2. Aerial image of central St. George Sound acquired in 2010, showing turbid and tannin-stained waters and sunglint off the water surface.

- Acquire high-resolution aerial imagery of the region when water clarity allows, and map seagrass communities for inclusion in GIS products. Coastal waters are often turbid due to discharge from the Apalachicola River or dark in color due to water from the Carrabelle River or tidal creeks draining coastal marshes (Figure 2); despite these challenges, aerial imagery remains the most cost-effective approach to seagrass mapping, but ground-truthing is essential for validating aerial images. Imagery products from the U.S. Department of Agriculture National Agricultural Imagery Program (NAIP) will be evaluated as they are released for mapping suitability.

Management and restoration recommendations

- Assess the effects of watershed development on storm runoff quantity and quality. Ensure that coastal development minimizes the addition of raw stormwater and nutrients to coastal waters.
- Evaluate the effects of storm runoff from the Apalachicola and Ochlockonee rivers on light available to seagrasses in the region.
- Evaluate whether levels of nutrients and suspended sediments are increasing in land runoff and coastal waters, and determine the source of these inputs.
- Evaluate the extent of propeller scarring in high-boat-use areas. Use the boating and angling guides for waters in the region to improve boater education about and awareness of seagrass beds, and plan and conduct restoration if needed. Where possible, place educational signage at boat ramps and at locations where seagrass beds continue to be scarred.

The Northwest Florida Water Management District, through the Surface Water Improvement and Management (SWIM) program, provides a framework for resource management, protection, and restoration using a watershed approach. An updated SWIM plan for the Apalachicola River and Bay Watershed was released in

2. Seagrass Status and Potential Stressors in Franklin County coastal waters

Status indicator	Status	Trend	Assessment, causes
Seagrass acreage	Green	Stable	Status variable across the region
Seagrass meadow texture	Green	Improving	Better water clarity, 2014–2017
Seagrass species composition	Green	Stable but low	
Overall seagrass trends	Green	Improving	
Seagrass stressor	**Intensity**	**Impact**	**Explanation**
Water clarity	Yellow	Improving	Reduced storm runoff
Nutrients	Yellow	Likely increasing	Coastal property development; storm runoff
Phytoplankton	Yellow	Moderate	Storm runoff
Natural events	Yellow	2009–2010 El Niño; storminess in 2012 and 2013	Interannual climatic variation
Propeller scarring	Yellow	Localized	Focused boating activity

fall 2017 (Northwest Florida Water Management District 2017). The plan describes the watershed's physical characteristics and natural resources, provides an assessment of current conditions, and identifies priority challenges affecting watershed resources and functions. Priority projects described in the plan are:

- Stormwater planning and retrofit
- Septic tank abatement
- Advanced on-site treatment systems
- Agriculture and silviculture best management practices
- Basinwide sedimentation abatement
- Riparian buffer zones
- Aquatic, hydrologic, and wetland restoration
- Estuarine habitat restoration
- Strategic land conservation
- Watershed stewardship initiative
- Sub-basin restoration plans
- Wastewater treatment and management improvements
- Analytical program support
- Comprehensive monitoring program

Among cooperative local government projects are efforts to retrofit stormwater management systems to improve water treatment, to extend sewer service, and to eliminate septic systems. Initiatives upstream in the watershed include enhanced agricultural management practices and protection and restoration of springs.

Public and conservation lands comprise approximately 611,888 acres of the watershed that lie within Florida (i.e., approximately 33 percent). These lands include the Apalachicola River Water Management Area (WMA) (Northwest Florida Water Management District), Tate's Hell State Forest (Florida Forest Service), and the Apalachicola River Wildlife and Environmental Area (Florida Fish and Wildlife Conservation Commission). Two aquatic preserves, the Apalachicola Bay Aquatic Preserve and the Alligator Harbor Aquatic Preserve, are managed by the Florida Department of Environmental Protection. State parks include Torreya, Florida Caverns, Three Rivers, and St. George Island state parks. Federally managed areas include the Apalachicola National Estuarine Research Reserve, St. Vincent National Wildlife Refuge on St. Vincent Island, and the Apalachicola National Forest. Private conservation lands include The Nature Conservancy's Bluffs and Ravines Preserve, among others. The watershed also comprises parklands maintained by local governments.

Summary assessment

In the Florida Panhandle, the status of seagrasses and the potential for recovery of seagrass where beds have been lost are being assessed by the Roadblocks to Seagrass Recovery project (http://myfwc.com/research/habitat/seagrasses/projects/roadblocks/) of the Fish and Wildlife Research Institute of the Florida Fish and Wildlife Conservation Commission. This project is funded by the National Fish and Wildlife Federation's (NFWF) Gulf Environmental Benefit Fund (GEBF), and activities include mapping of seagrasses from the Alabama state line to the mouth of the Suwannee River, field assessments of seagrass cover and species composition, and quantitative estimation of factors affecting recovery and restoration of seagrasses. These factors include current and historical seagrass extent, optical water quality and light attenuation, sediment quality and toxicity, bathymetry, propeller scarring, and physical stressors such as wind energy. Data and results are part of a seagrass recovery potential (SRP) model that will be served on the Web.

Table 1. Seagrass acreage in Franklin County coastal waters in 1992 and 2010.

Subregion	1992	2010 Patchy	2010 Continuous	2010 All seagrass	Change, 1992–2010
St. Vincent Sound	52	106	2	108	56
Apalachicola Bay	3,146	974	167	1,142	−2,004
St. George Sound	3,562	2,363	1,940	4,303	740
Dog Island and Reef, Turkey Point, Carrabelle River	6,937	2,933	5,905	8,838	1,901
Alligator Harbor and shoal	755	135	85	220	−535
Total	14,452	6,511	8,099	14,611	159

In 2010, Franklin County coastal waters contained 14,611 acres of seagrass, with 8,838 acres found in eastern waters (Dog Island and Reef, Turkey Point, Carrabelle River), 4,303 acres in St. George Sound, 1,142 acres in Apalachicola Bay, 220 acres in Alligator Harbor and associated shoal, and 108 acres in St. Vincent Sound (Table 1). Mapping data from 1992 imagery indicated that seagrasses covered 14,452 acres in the region, indicating little or no change in total area over the 18-year period. In 2010, the eastern waters of Franklin County contained the largest extent of continuous seagrass beds (5,905 acres) and showed the greatest increase in seagrass area over the 18-year period. In sharp contrast, in 2010, Apalachicola Bay had only 167 acres of continuous beds (15% of the subregion's total acreage) and had lost 2,004 acres since 1992.

Monitoring data collected in late summer in 2009–2014 and 2016–2017 show that manateegrass, turtlegrass, and shoalgrass occur at about the same frequency throughout the region and that no temporal trends are evident (Tables 2 and 3A). Despite fairly stable frequency of occurrence and seagrass species composition, seagrass beds appear to be thinning (Figure 4), and this was especially evident in 2012 and 2013. Optical water-quality measurements show that water clarity declined in 2013 and 2014, probably the result of freshwater runoff from frequent storm events. Optical water quality improved in 2016 and 2017 (see Table 7), but seagrass densities have not fully recovered. Interannual variations in optical water quality associated with reduced storm frequency and regional precipitation (e.g., La Niña events) likely contribute to these observations. Water clarity in the Alligator Harbor subregion is poor, with elevated turbidities and chlorophyll-a concentrations (indicative of phytoplankton) and reduced light penetration through the water column.

Seagrass mapping assessment

See the summary assessment above. Based on comparison of the 1992 and 2010 mapping data, seagrass cover in the Franklin County region appears stable, but in each subregion, large changes in seagrass area occurred during the 18-year period. Maps from 2010 imagery showed that 55% of seagrass acreage in Franklin County coastal waters was in continuous beds and that most of the continuous beds were in the eastern portion of the region (Dog Island and Reef, Turkey Point, and Carrabelle River). In all other subregions, however, patchy seagrass beds dominated. Acquisition and mapping of recent imagery are needed but depend on funding and acquisition of images when coastal waters are clear.

Monitoring assessment

Monitoring data collected in late summer in 2009–2014, and 2016–2017 show that manateegrass, turtlegrass, and shoalgrass occur at about the same frequency throughout the region, and no temporal trends are evident (Table 2). Stargrass (*Halophila engelmannii*), widgeongrass (*Ruppia maritima*), and the green alga *Caulerpa prolifera* occur only sporadically. Of all sampled quadrats, 56–64% were bare, and this is partly the result of site selection. When sampling points were established in 2006, some deep sites were inadvertently selected because they appeared on the available imagery to have seagrass signatures. Despite having no seagrass present, those sites have been revisited each sampling season. The frequency of occurrence of seagrasses varies widely among subregions. In 2017, Alligator Harbor had the lowest occurrence of seagrass with 87% of quadrats bare (Figure 3; Table 3A), while Turkey Point, Dog Island, Dog Island Reef, and East Point had the lowest frequency of occur-

Table 2. Occurrence (% of quadrats having a species present) of seagrasses and the green alga *Caulerpa prolifera* in Franklin County coastal waters, 2009–2017. Monitoring was not conducted in 2015. Generally, 10 quadrats were evaluated at each site.

Year	# quadrats sampled	Shoal-grass	Manatee-grass	Turtle-grass	Star-grass	Widgeon-grass	Bare	*C. prolifera*
2009	939	16.6	21.5	14.8	0.21	0.21	60.9	2.7
2010	1006	11.4	23.3	14.0	0	0	60.5	2.4
2011	1230	21.1	18.0	16.8	0	0.81	56.7	1.5
2012	1205	17.6	22.2	14.5	0.41	0	57.8	0.8
2013	1260	13.7	20.5	14.8	0.08	0	63.8	0
2014	1240	18.7	19.9	13.7	0.32	0.08	61.0	0
2016	1220	18.8	23.0	16.6	0.82	0	54.8	0
2017	1241	20.2	23.6	16.3	0.24	0	54.9	0

Table 3A. Occurrence (% of quadrats having a species present) of seagrasses in subregions of Franklin County coastal waters, 2009–2017. No monitoring was conducted in 2015. Generally, 10 quadrats were evaluated per site.

Subregion	Year	# quadrats sampled	Shoal-grass	Manatee-grass	Turtle-grass	Star-grass	Widgeon-grass	Bare
Alligator Harbor	2009	128	10.2	4.7	7.0			82.8
	2010	160	3.1	12.5	1.3			83.8
	2011	160	6.9		11.3			87.5
	2012	160	6.3		11.3			85.0
	2013	160	11.3	0.63	6.9			85.0
	2014	160	7.5		15.6		0.63	84.4
	2016	130	14.6		13.8			80.8
	2017	160	9.4		8.1			87.5
Turkey Point	2009	166	11.4	44.0	32.5			43.4
	2010	219	3.2	40.6	21.9			47.5
	2011	170	4.1	43.5	40.0			44.1
	2012	210	8.6	44.3	31.9	0.48		43.3
	2013	210	5.7	47.6	31.0			43.3
	2014	210	8.6	33.8	24.8			51.9
	2016	210	11.0	43.8	37.6	1.4		43.8
	2017	201	8.5	45.3	29.4			41.3
Dog Island	2009	108	28.7	23.1	16.7		1.9	54.6
	2010	129	31.8	10.1	18.6			52.7
	2011	130	33.1	21.5	28.5			40.8
	2012	110	40.0	30.9	24.5			30.9
	2013	130	29.2	29.2	15.4			50.8
	2014	120	30.8	36.7	22.5			40.0
	2016	130	17.7	48.5	23.8			33.1
	2017	130	35.4	33.8	23.1			45.4
Dog Island Reef	2009	116	13.8	27.6	15.5			58.6
	2010	130	8.5	45.4	16.2			45.4
	2011	150	18.7	35.3	15.3			45.3
	2012	150	2.0	41.3	14.0	2.7		58.0
	2013	150	0.67	34.7	18.0			64.0
	2014	150	3.3	35.3	16.7	0.67		61.3
	2016	150	9.3	42.7	14.7			48.0
	2017	140	5.7	54.3	23.6	0.7		40.0

Table 3A (continued). Occurrence (% of quadrats having a species present) of seagrasses in subregions of Franklin County coastal waters, 2009–2017. No monitoring was conducted in 2015. Generally, 10 quadrats were evaluated per site.

Subregion	Year	# quadrats sampled	Shoal-grass	Manatee-grass	Turtle-grass	Star-grass	Widgeon-grass	Bare
Lanark Reef	2009	140	15.7	26.4	7.1	1.4		59.3
	2010	180	8.9	20.0	5.6			71.1
	2011	170	9.4	24.7	9.4			65.9
	2012	185	7.0	28.6	6.5			66.5
	2013	180	6.1	18.9	8.9	0.56		73.9
	2014	180	7.2	21.7	6.1	1.7		72.8
	2016	170	16.5	10.6	7.1	2.9		70.6
	2017	170	8.2	24.7	15.3	0.6		65.9
Carrabelle River	2009	136	18.4	21.3	22.1			62.5
	2010	170	20.6	10.0	21.2			68.2
	2011	170	17.1	9.4	26.5		5.9	55.9
	2012	170	15.3	11.8	17.6			62.4
	2013	170	11.8	17.6	27.1			58.2
	2014	160	21.9	20.0	18.1			53.1
	2016	180	12.2	17.2	22.2	1.1		53.3
	2017	170	18.8	7.1	23.5			57.1
St. George Sound	2009	128	23.4					82.8
	2010				No data			
	2011	200	44.0	4.0				55.5
	2012	150	52.0	2.0				48.0
	2013	190	25.3					74.7
	2014	190	43.2	4.2				55.8
	2016	150	41.3	6.7				52.7
	2017	200	42.5	8.5				53.5
East Point	2009				No data			
	2010							
	2011	70	52.9					47.1
	2012	70	28.6	4.3				67.1
	2013	70	34.3	4.3	2.9			58.6
	2014	70	42.9		1.4			57.1
	2016	70	54.3	4.3				44.3
	2017	70	48.6	15.7	1.4	1.4		38.6

Table 3B. Occurrence (% of quadrats having a species present) of seagrasses in Alligator Harbor and at Turkey Point in 2017. Assessments were completed by staff of the Central Panhandle Aquatic Preserves. Four quadrats were evaluated per site.

Subregion	# Sites	# Quadrats	Shoal-grass	Turtle-grass	Manatee-grass	Bare
Alligator Harbor	5	20	25.0	10.0		75.0
Turkey Point	7	28	17.9	64.3	78.6	14.3

rence of bare quadrats (39–45%). In 2017, turtlegrass was the most frequently found seagrass near Carrabelle River, and manateegrass was the most common seagrass at Turkey Point, Lanark Reef, and Dog Island Reef. Manateegrass and shoalgrass were equally abundant at Dog Island. Shoalgrass was co-dominant with turtlegrass in Alligator Harbor, though at low frequencies. Shoalgrass was the most common seagrass in St. George Sound and at East Point.

In 2017, the Central Panhandle Aquatic Preserves began field monitoring of seagrasses in Alligator Harbor and at Turkey Point. The FO data calculated from the assessment in summer 2017 (Table 3B) are greater in absolute value compared to FWRI data but are similar to assessments by FWRI in terms of species present and the frequency of bare quadrats.

While frequency of occurrence is a measure of the spatial distribution and frequency of observing each seagrass species, measurement of quadrat cover (similar to the Braun-Blanquet method) adds an assessment of plant density at each site. We calculated means of cover assessment, using only those quadrats in which a species was present, for the period 2009–2017 when assessments were carried out using the same techniques. The percent cover of seagrass, averaged across the region (Figure 4), was greatest for shoalgrass, manateegrass, and turtlegrass from 2009 through 2011, but all species decreased sharply in density in 2012 and reached a minimum in 2013. Density of seagrasses increased slowly from 2014 through 2017. Mean percent cover, calculated for each subregion of the Franklin County coastal waters, varied considerably by seagrass species, over time, and from one subregion to another (Figure 5). In Alligator Harbor, the three primary seagrass species, shoalgrass, manateegrass and turtlegrass, were present in 2009 and 2010 with mean percent cover ranging from 18 to 49%, but in 2011 shoalgrass mean cover increased to more than 60% and manateegrass disappeared. Turtlegrass and shoalgrass exhibited declining mean percent cover in 2012 and 2013, and manateegrass was absent (2012) or had very low cover (2013).

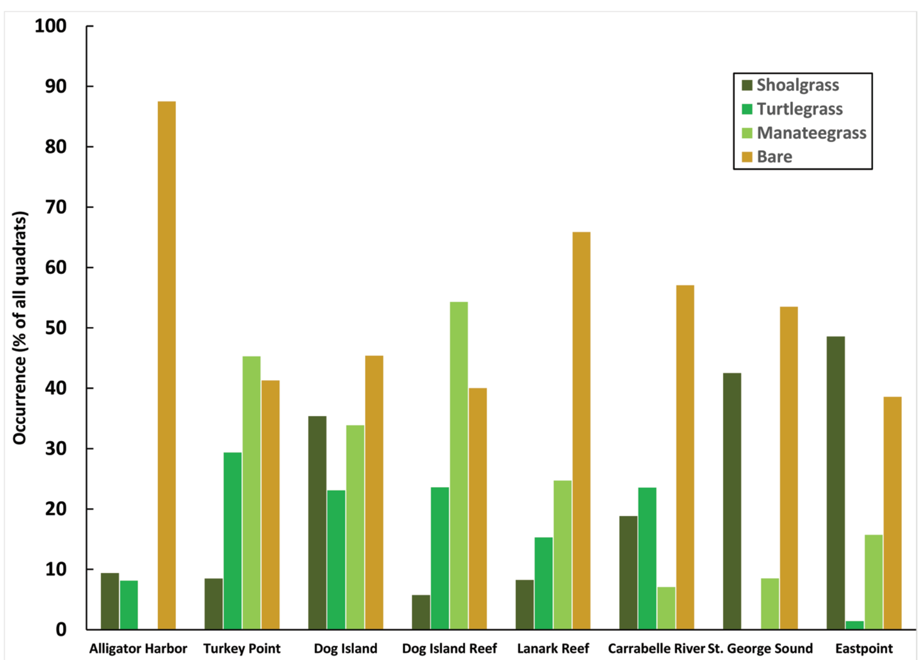

Figure 3. Frequency of occurrence of shoalgrass, turtlegrass, manateegrass, and bare quadrats in subregions of Franklin County coastal waters, 2017.

Since that time the mean cover of these two species has increased. Poor optical water quality in Alligator Harbor (Table 7) likely caused the loss of seagrass species and thinning of remaining beds in 2012 and 2013. Remarkably, Humm (1956) reported that in the 1950s seagrasses, primarily turtlegrass and manateegrass, completely carpeted the bottom of Alligator Harbor. At Turkey Point, mean percent cover varied by seagrass species and by year, but all species exhibited a drop in mean cover in 2012–2013. In addition, stargrass was observed only in 2012 and 2016. At Lanark Reef, the mean percent cover of the two most common species, turtlegrass and manateegrass, was similar, and those species showed a similar decrease in mean cover in 2012. Since 2012, seagrass densities have remained near or below 20%. Shoalgrass had the greatest mean percent cover in seagrass beds near Dog Island for 2009–2013, but mean cover of all species has remained low. In contrast to observations near Dog Island, turtlegrass and manateegrass at Dog Island Reef had greater mean percent cover than did shoalgrass. Mean percent cover of all seagrasses at Dog Island Reef dropped in 2012 and has remained near 20% through 2017. Compared with data from other subregions, mean percent cover of shoalgrass and turtlegrass was strikingly greater in seagrass beds near the mouth of the Carrabelle River during monitoring years 2009–2011. But like most other subregions in Franklin County coastal waters, mean percent cover declined sharply in 2012 and 2013. Densities have increased somewhat since 2012, but only shoalgrass cover has returned to values close to those measured in 2009–2011. Seagrass beds in St. George Sound (not sampled in 2010) and near Eastpoint (not sampled in 2009 and 2010) were dominated by shoalgrass, and mean cover was lowest in 2013 and has increased slightly since that time.

Productivity of turtlegrass

As part of the Roadblocks to Seagrass Recovery study to evaluate the suitability of potential seagrass habitat in Florida Panhandle estuaries, scientists measured the productivity of turtlegrass at six locations in Franklin County waters using the punch and harvest technique of Zieman and Zieman (1989). See the monitoring methods and data section below for more information. Measurements were made twice at each location, in June and October 2016. Biomass of live turtlegrass ranged from 73 to 536 with a mean of 229 g/m^2 at the productivity sites (Table 4). Alligator Harbor and Dog Island Reef had the lowest live biomass while Lanark Reef and Carrabelle, both located near the north shore of the bay, had the most live biomass. Dead biomass was 5–50% of live biomass. No consistent differences were observed between months sampled or between above-sediment and below-sediment fractions.

A variety of measures of productivity can be reported using the data collected from these experiments. We report counts of turtlegrass shoots, 1-sided leaf area index (LAI), shoot specific blade growth, and productivity on a leaf area basis. Shoot counts, reported per m^2, are a common metric for seagrass ecosystems, and counts can vary widely over short distances. Because turtlegrass is a

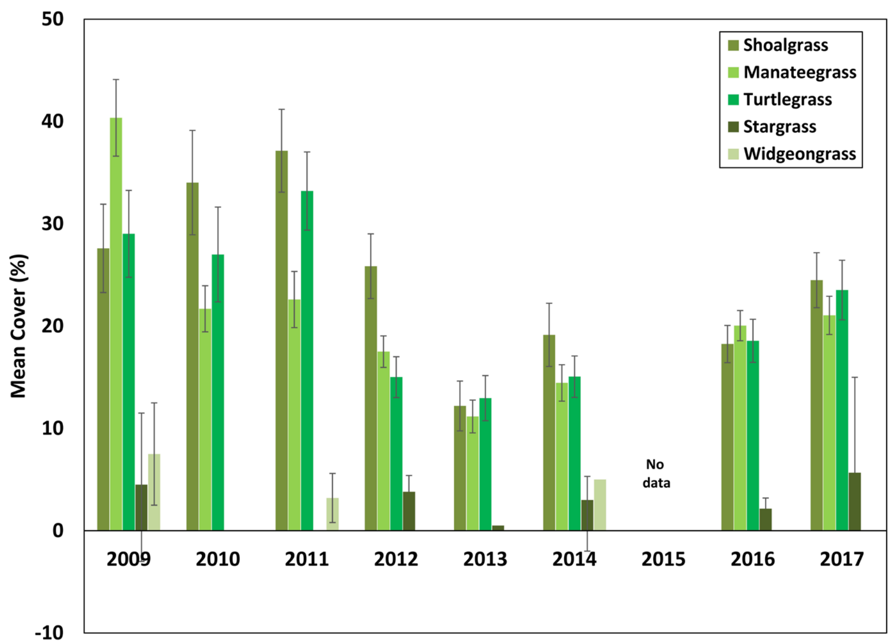

Figure 4 Mean cover (±2 standard error) of seagrasses in quadrats in subregions of Franklin County coastal waters, 2009–2017. Sampling was not done in 2015.

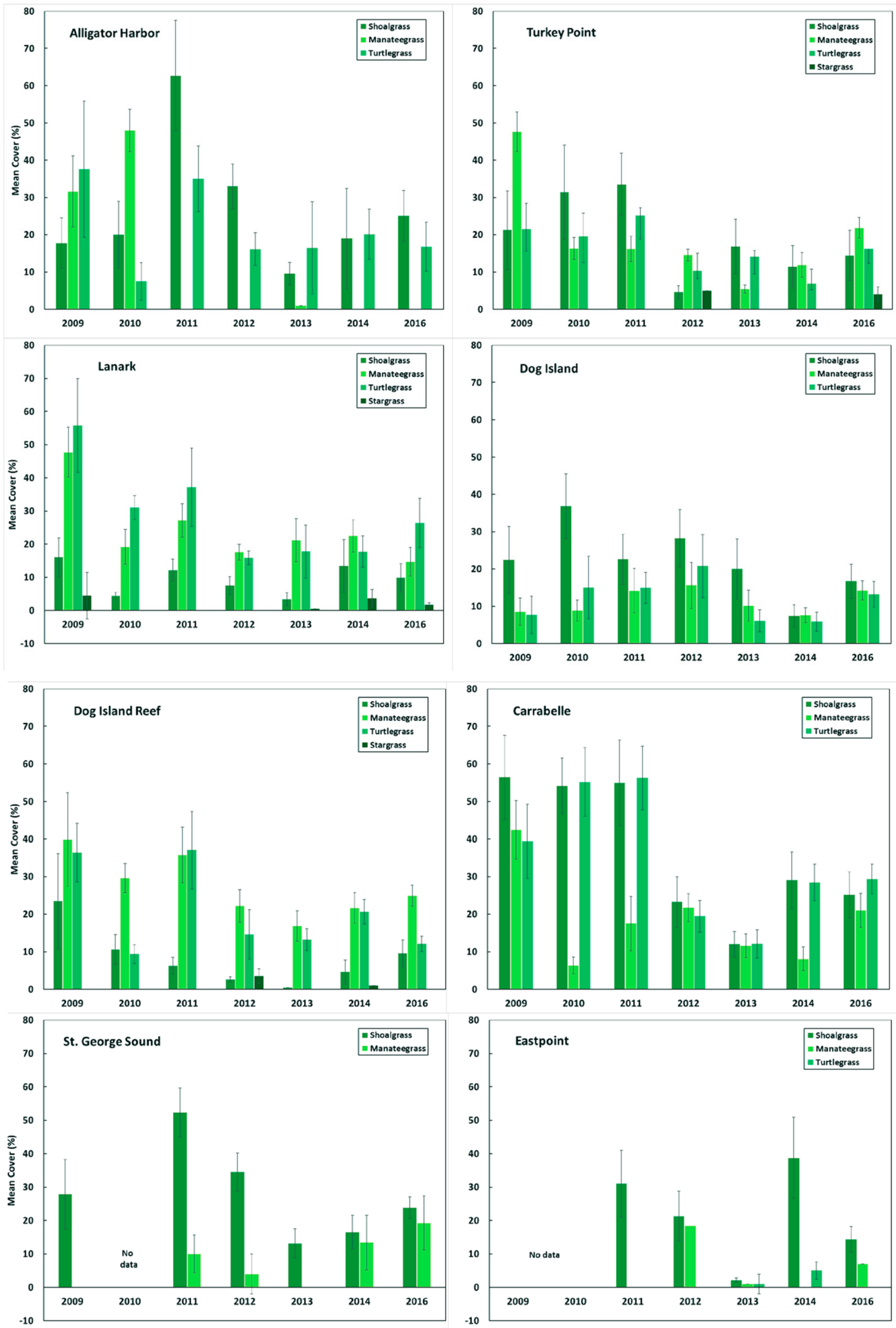

Figure 5. Mean cover (±2 standard error) of seagrass species in subregions of Franklin County coastal waters, 2009–2017. Cover was not assessed in 2015.

Table 4. Mean biomass of live and dead turtlegrass material at productivity sites in six subregions of Franklin County coastal waters in June and October 2016.

			Turtlegrass biomass (g/m^2)					
			Live			Dead		
Subregion	**Month**	**Fraction**	**Mean**	**Std. dev.**	**N**	**Mean**	**Std. dev.**	**N**
Alligator Harbor	June	Above	88.9	14.5	4	14.4	20.1	4
		Below	30.7	15.2	4	6.5		1
		Total	**120**			**20.9**		
	October	Above	62.8	18.5	4	12.5	4.8	4
		Below	15.2	13.8	3	12.3		1
		Total	**77.9**			**24.8**		
Turkey Point	June	Above	139	36.4	4	7.7	6.4	3
		Below	158	85.1	4			
		Total	**296**			**7.7**		
	October	Above	117	39.2	4	26.2	18.8	3
		Below	47.3	41.1	4	2.5		1
		Total	**165**			**28.7**		
Dog Island Reef	June	Above	111	70.0	4	12.8	8.0	4
		Below	20.5	32.8	4			
		Total	**131**			**12.8**		
	October	Above	57.2	35.5	4	18.8	16.3	4
		Below	15.7	11.6	4	3.3		1
		Total	**73.0**			**22.1**		
Lanark Reef	June	Above	89.8	53.8	4	7.4	6.0	3
		Below	96.9	98.1	4	7.5		1
		Total	**187**			**14.9**		
	October	Above	224	150	4	30.9	21.0	4
		Below	207	114	4	11.7	9.9	3
		Total	**431**			**42.6**		
Dog Island	June	Above	196	38.2	4	16.2	26.6	4
		Below	210	118	4	6.3	4.7	2
		Total	**405**			**22.5**		
	October	Above	68.8	51.2	4	43.4	38.2	4
		Below	19.6		1			
		Total	**88.4**			**43.4**		
Carrabelle	June	Above	300	20.9	3	10.1	8.7	3
		Below	236	59.7	3	22.9		1
		Total	**536**			**33.0**		
	October	Above	95.4	29.5	4	21.0	16.5	4
		Below	140	77.4	4	12.9		1
		Total	**235**			**33.9**		

long-lived species, the variation in shoot counts over short periods of time is likely to be less than variation from one place to another. In these experiments, scientists conducted measurements at the same site at two times, but the location of the quadrats by necessity were slightly different from one sampling period to another. Many quadrats had manateegrass and/or shoalgrass present as well as turtlegrass. Average counts of turtlegrass (229–253 shoots/m^2; Table 5, Figure 6) did not vary much between sampling periods; manateegrass and shoalgrass had greater counts/m^2 than turtlegrass, and variation between sampling periods was much greater. Shoot counts of turtlegrass were lowest at Dog Island Reef (Figure 6).

The 1-sided LAI is a unitless metric calculated by dividing the total blade area in cm^2 covering 1 m^2 of sediment surface by 10,000 (i.e., the number of cm^2 in 1 m^2). The 2-sided LAI (2 × 1-sided LAI) estimates total blade surface area compared to the sediment surface. Sites in Alligator Harbor had the lowest mean 1-sided LAI (0.60–0.63), and sites at Carrabelle had the highest mean 1-sided LAI (1.4–2.5; Table 6; Figure 6). Because variation among quadrats at each site was large, no trends could be distinguished between sampling periods.

Shoot-specific blade growth (SSBG) is a measure of the increase in blade area of each punched shoot during the experiment and is reported in cm^2/day. We report means of SSBG (Figure 6) because these data provide information on shoot performance at each site; multiplying SSBG by shoot counts estimates productivity in cm^2/m^2/day. Despite low shoot counts and 1-sided LAI values, turtlegrass shoots had the highest SSBG at Dog Island Reef (Figure 6). While optical water quality data are not available for summer 2016 (see Table 7), data from other years show that Dog Island Reef usually has the best water clarity of locations in the region; therefore, light availability might be a factor in blade growth. SSBG at sites in Alligator Harbor was low, and shoot counts and 1-sided LAI were similar to values measured at Dog Island Reef. In contrast to conditions at Dog Island Reef, Alligator Harbor typically has poor optical water quality (Table 7).

Productivity (cm^2/m^2/day) was low (Table 6) compared with other studies in the Big Bend and Florida Bay (see other SIMM chapters), and low values were partially due to low shoot counts of turtlegrass (Table 5). Productivity as a fraction of mean leaf area (productivity/leaf area) was also low compared to measurements in Big Bend and Tampa Bay (unpublished data), suggesting factors other than low shoot counts contributed to the values in Franklin County coastal waters.

Water quality and clarity

Since 2007, staff from FWRI and the FWC Division of Habitat and Species Conservation (HSC) have measured water quality and clarity as part of the annual seagrass monitoring program. In 2016, Sandra Brooke and her staff from the Florida State University Coastal and Marine Laboratory conducted field seagrass assessments. Staff measured the standard water-quality parameters of salinity, water temperature, water depth, Secchi depth, and pH, as well as the optical water quality (OWQ) parameters—light attenuation, chlorophyll-a concentration, turbidity, total suspended solids, and water color. Light attenuation, expressed as an extinction coefficient, k_{par} (m^{-1}), and the resultant light available to seagrasses on the bottom are a function of the levels of the other OWQ parameters, turbidity, total suspended solids (TSS), chlorophyll-a concentration (used as an estimate of phytoplankton density), and water color. The relative contribution of each component of light attenuation varies by location, season, and from one year to the next.

Table 7 shows mean values of OWQ parameters for each subregion and year of sampling. Light attenuation (k_{par}) was not measured in 2016 and 2017. Over 10 years

Table 5. Mean counts of live and dead shoots of shoalgrass, manateegrass, and turtlegrass in quadrats where turtlegrass productivity was measured in June and October 2016 at 6 locations in Franklin County coastal waters.

Month	Species	Live Shoots (#/m^2)			Dead Shoots (#/m^2)		
		Mean	Std. dev.	N	Mean	Std. dev.	N
June	Shoalgrass	446	422	7	25.0	.	1
October		632	736	7	0	0	5
June	Manateegrass	414	370	14	10.7	28.3	7
October		1260	513	20	14.1	24.1	16
June	Turtlegrass	229	112	20	55.0	101	10
October		253	164	24	35.5	41.9	19

of annual monitoring, Alligator Harbor had the poorest optical water quality with the highest turbidity, TSS, and chlorophyll-a levels in the region. Light attenuation in Alligator Harbor was very high in 2012 and 2013. Monitoring began in the Eastpoint subregion in 2010, and mean values of OWQ parameters were elevated and somewhat like values for Alligator Harbor. Turkey Point, Dog Island, Dog Island Reef, Lanark Reef, Carrabelle River, and St. George Sound had moderate levels of OWQ parameters compared with optimal, clear-water conditions for seagrass beds in the Gulf of Mexico. In every subregion except Eastpoint, color was elevated in 2012 or 2013 to levels 3–10 times those of 2010–2011. This is indicative of the contribution of stormwater runoff over several months from coastal watersheds to nearshore waters, which resulted from the greatly increased precipitation during this period.

Mapping methods, data, and imagery

High-resolution (1 m) 4-band aerial imagery was collected for the entire northern Gulf coast in October 2010, and photo-interpretation of Franklin County coastal waters was completed by PhotoScience Inc. (St. Petersburg). The Florida Land Use Cover and Forms Classification System (Florida Department of Transportation 1999) was used to classify bottom features. More recently, imagery was collected throughout the Florida Panhandle coastal region in 2015 by the National Agricultural Inventory Program (NAIP) of the U.S. Department of Agriculture This imagery provided excellent resolution of seagrass beds everywhere except in Franklin County coastal waters. When the imagery was collected, waters were very turbid and bottom signatures could not be interpreted. We continue to examine imagery collected by NAIP and the Florida Department of Transportation for water clarity and will arrange for photo-interpretation when good imagery is available.

The 1992 imagery of Franklin County is part of the northwest Florida seagrass mapping data set and was collected in December 1992 and early 1993. The data set 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. Imagery was natural color at 1:24,000 scale. Aerial photographs were interpreted and delineated by USGS and then transferred to a base map using a zoom transfer scope. Maps were digitized into ArcInfo software.

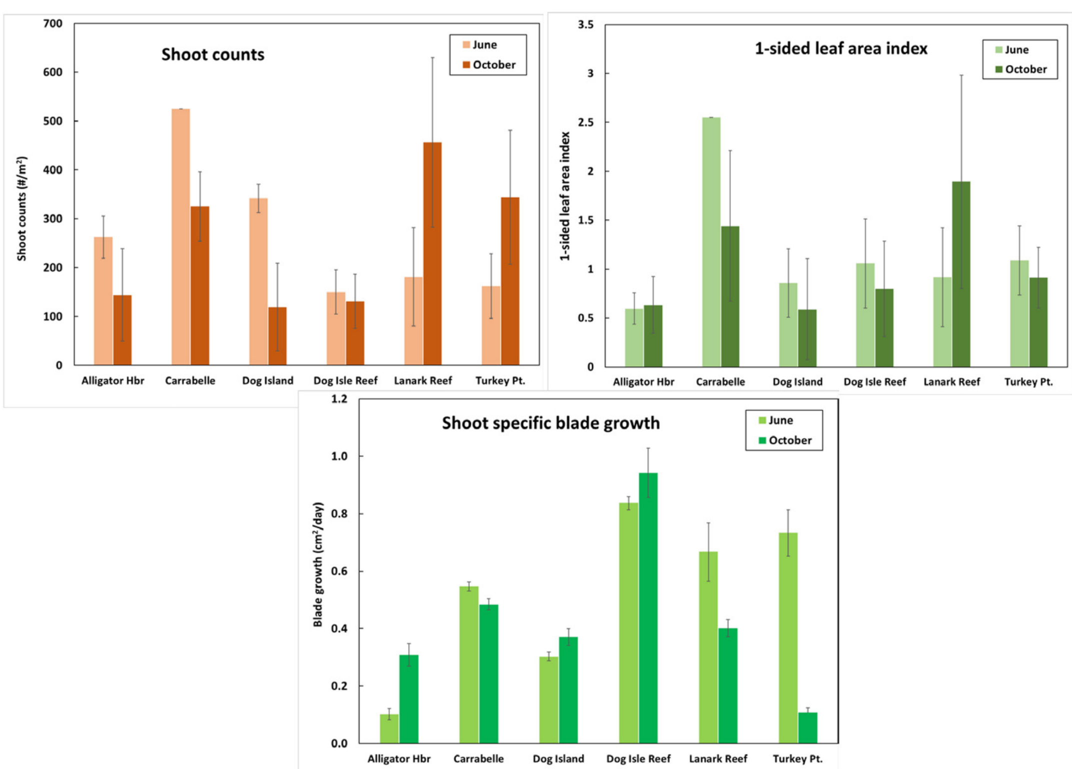

Figure 6. Mean (± 2 standard error) shoot counts (#/m^2), 1-sided leaf area index (LAI), and shoot-specific blade growth (cm^2/day) of turtlegrass in subregions of Franklin County coastal waters, June and October 2016.

To compare mapped seagrass areas among years, a polygon was defined for the bay and its subregions and used for each set of mapping data. Change in area was estimated in ArcMap.

Monitoring methods and data

Since 2006, a spatially distributed, random sampling design has been used to monitor seagrasses in each of eight subregions of Franklin County coastal waters during the summer months. No sampling occurred in 2015. At each sampling site, seagrass and macroalgal cover is estimated in 10 randomly located 0.25-m^2 quadrats using a modification of the Braun-Blanquet technique. In addition to seagrass field assessment, staff members measure the standard field water-quality parameters of salinity, water temperature, water depth, Secchi depth, and pH, as well as the OWQ parameters—light attenuation, chlorophyll-a concentration, turbidity, total suspended solids, and water color. For more information, contact Sandra Brooke (2016 data) or Katie Konchar, FWC HSC, or Paul Carlson at FWRI (all other years).

Productivity of turtlegrass

Productivity of turtlegrass was measured by scientists from the Florida State University Coastal and Marine Laboratory in June and October 2016 at six locations: Alligator Harbor, Carrabelle, Dog Island, Dog Island Reef, Lanark Reef, and Turkey Point (see Figure 1). At each location, 4 quadrats, 20 cm on a side (0.04 m^2), were anchored into a turtlegrass bed using 6-inch sod staples. Each shoot of turtlegrass in a quadrat was punched just above the end of the short shoot with a 20-gauge hypodermic needle, following the method of Zieman and Zieman (1989). After about 10 days, all the seagrass material, above and below the sediment surface in each quadrat, was carefully harvested, chilled, and transported to the laboratory for processing.

In the laboratory, punched turtlegrass shoots were separated from the rest of the seagrass material, and the length, width, and punch translocation distance were measured for each blade in each shoot, with up to 20 punched shoots assessed for each quadrat. The location of the punch hole in the oldest blade was used as the reference position against which to measure extension of the remaining younger blades. The remaining seagrass

Table 6. Estimates of leaf productivity of turtlegrass at six locations in Franklin County in June and October 2016. Productivity is the area of new leaf growth per square meter per day. Leaf area index (LAI) is unitless and is the total blade area as a fraction of a square meter.

			Productivity ($cm^2/m^2/day$)					
Subregion	**Site**	**Month**	**Mean**	**Std. dev.**	**N**	**LAI (1-sided)**	**Leaf area (cm^2/m^2)**	**Productivity/ leaf area (%/day)**
Alligator Harbor	AHR11	June	66.9	65.9	3	0.6	5,960	1.12%
		October	162	98.3	4	0.63	6,340	2.55%
Carrabelle	CRR18	June	181	.	1	2.55	25,500	0.71%
		October	169	46.7	4	1.44	14,400	1.17%
Dog Island	DIN08	June	184	137	3	0.86	8,570	2.15%
		October	112	126	4	0.59	5,880	1.90%
Dog Island Reef	DRR15	June	147	67.6	4	1.06	10,600	1.38%
		October	109	86.2	4	0.8	7,980	1.37%
Lanark Reef	LAR05	June	125	56.6	4	0.92	9,170	1.36%
		October	397	159	4	1.89	18,900	2.10%
Turkey Point	TPR27	June	153	105	4	1.09	10,900	1.40%
		October	376	222	4	0.91	9,120	4.12%
Region mean			181.8			1.1	11,100.00	1.78%

tissues were separated into blade, short shoot, root and rhizome fractions and into live or dead, above-sediment or below-sediment fractions. Tissues were gently rinsed with tap water and dried for 5–7 days at 50°C and then weighed. The total number of shoots, both live and dead, of each species of seagrass in each quadrat was also recorded, as was the presence of macroalgae.

Optical water quality measurements

Measurements of optical water quality parameters—chlorophyll-a, color, turbidity, total suspended solids (TSS), and light attenuation—have been part of the field assessments of seagrasses in the SIMM program since 2004. The amount of sunlight reaching the bottom is often the most important factor determining the survival of seagrass communities, and attenuation of light in the water column results from reflection, diffraction, and absorption by water itself, by the quantity, quality, and size of particles in the water, and from the amount of color that has been added to the water column by colored dissolved organic matter (CDOM). The quantity and character of particles in the water are estimated by the measurement of chlorophyll-a as an indicator of phytoplankton abundance, by measurement of TSS as a gravimetric estimate of the number of particles in the water, and by the measurement of turbidity which estimates light scattering by particles as well as the quantity of particles present. The color of the water column can be measured by light absorption of a filtered water sample at 440 nm (color) or, for CDOM, by light absorption over 300–600 nm.

Chlorophyll-a concentrations were determined by filtering triplicate 60-ml aliquots of surface water through 25-mm-diameter GFF glass fiber filters in the field. Each filter was stored in a microcentrifuge vial and immediately frozen in liquid nitrogen. In the laboratory, filters were transferred to an ultra-low-temperature freezer and held at −60°C until analysis. To measure the amount of chlorophyll-a, filters were soaked in 10 ml of methanol in the dark for 40 hours at 4°C. On the day of analysis, methanol extracts were centrifuged at 3,500 rpm for 20 minutes to remove filter fibers from the extract. Fluorescence of each extract was measured using a Turner Designs model 10-AU-005 fluorometer following the methods of Welshmeyer (1994). Calibration of the fluorometer used fresh spinach extracts and the trichromatic equations of the Environmental Protection Agency (EPA) method 446.0 (Arar 1997).

Water samples for the measurement of color, turbidity, and TSS were collected by triple rinsing and then nearly filling each sample bottle with water from the site. Samples were kept on ice or refrigerated until analysis. To measure color, water was filtered through a 0.22-µm membrane filter. Light absorbance at 440 nm of the filtered sample was determined using a 10-cm cell path in a Hitachi U-2900 spectrophotometer after Kirk (1976) and Gallegos et al. (1990). Absorbance of certified color standards was used to estimate color in platinum cobalt units (pcu). Turbidity was measured nephelometrically on a Hach 2100Q turbidimeter using calibrated standards following method 214 A of *Standard Methods for the Examination of Water and Wastewater* (1985), and units were nephelometric turbidity units (ntu). TSS was measured gravimetrically following method 2540 D of *Standard Methods* (1985) by filtering water samples through combusted, tared GFC glass fiber filters. Filters were then dried at 50°C for at least five days and then re-weighed using a 5-place Mettler balance.

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Table 7. Means of optical water quality parameters for subregions of Franklin County coastal waters from 2007–2014, 2016, and 2017. n.d. = no data.

Subregion	Turbidity (ntu)	Total suspended solids (mg/l)	Color (pcu)	Chlorophyll-a (µg/l)	Light attenuation k_{par} (m^{-1})	
					Spherical	Flat
Alligator Harbor						
2007	10.1	29.7	9.57	19.9	0.616	0.666
2008	7.96	16.2	4.68	10.6	n.d.	n.d.
2009	6.60	16.4	8.57	8.83	1.434	1.443
2010	7.68	25.3	13.1	13.3	0.510	0.587
2011	2.47	15.7	6.96	10.1	0.713	n.d.
2012	5.34	10.1	18.6	8.21	1.170	2.226
2013	12.9	23.1	27.9	23.2	1.877	1.771
2014	9.63	17.4	9.46	17.3	0.444	0.415
2017	13.2	23.2	12.4	25.1	n.d.	n.d.
Turkey Point						
2007	1.30	3.92	6.94	1.89	0.443	0.545
2008	1.65	5.18	4.27	2.17	n.d.	n.d.
2009	1.61	4.78	9.62	2.64	1.108	1.079
2010	2.63	6.27	9.15	5.87	0.670	0.650
2011	3.28	8.11	5.34	2.96	0.652	0.589
2012	2.28	4.65	24.2	6.00	0.745	0.781
2013	4.62	7.11	54.5	6.38	1.707	1.703
2014	1.97	4.10	7.19	3.63	0.759	0.563
2016	4.00	9.09	14.5	5.67	n.d.	n.d.
2017	2.36	4.56	12.8	7.53	n.d.	n.d.
Dog Island						
2007	3.72	8.75	4.68	3.41	0.547	0.536
2008	2.50	8.14	3.47	3.73	n.d.	n.d.
2009	2.17	5.59	13.1	5.72	0.448	0.523
2010	4.02	7.44	6.85	4.79	0.737	0.945
2011	1.82	3.73	5.93	5.05	0.746	0.745
2012	3.66	6.56	25.0	5.26	0.950	0.949
2013	2.56	5.27	14.8	3.64	n.d.	n.d.
2014	1.51	3.08	6.32	4.82	0.520	0.423
2017	2.07	3.32	43.2	3.78	n.d.	n.d.
Dog Island Reef						
2007	0.99	4.97	1.36	1.77	0.846	0.906
2008	1.07	2.17	2.15	2.09	n.d.	n.d.
2009	1.28	2.87	2.63	1.10	0.550	0.594
2010	0.47	2.00	5.23	1.86	0.356	0.400
2011	1.76	7.10	0.98	2.49	0.576	n.d.
2012	0.77	1.94	12.9	2.64	1.015	1.110
2013	1.73	3.96	11.7	2.26	0.670	0.755
2014	0.77	1.38	4.77	1.84	0.429	0.387
2017	1.18	2.90	16.9	2.88	n.d.	n.d.

Table 7 (continued). Means of optical water quality parameters for subregions of Franklin County coastal waters from 2007–2014, 2016, and 2017. n.d. = no data.

Subregion	Turbidity (ntu)	Total suspended solids (mg/l)	Color (pcu)	Chlorophyll-a (µg/l)	Light attenuation k_{par} (m^{-1})	
					Spherical	Flat
Lanark Reef						
2007	2.07	5.37	8.68	2.17	0.642	0.687
2008	2.20	4.86	5.46	2.99	n.d.	n.d.
2009	2.15	5.74	26.4	4.12	0.747	0.777
2010	3.78	7.71	7.49	3.99	0.696	0.606
2011	1.85	7.15	4.29	2.95	0.288	n.d.
2012	1.74	3.17	17.5	3.36	0.544	0.699
2013	2.43	4.35	41.8	6.45	1.474	1.381
2014	1.26	2.69	11.6	3.06	0.682	0.592
2017	2.14	3.97	30.6	6.50	n.d.	n.d.
Carrabelle River						
2007	7.37	15.8	7.27	7.13	0.373	0.370
2008	2.90	5.72	8.60	4.74	n.d.	n.d.
2009	2.92	4.77	10.4	3.32	0.767	0.795
2010	6.29	12.0	16.3	7.16	0.906	0.893
2011	2.62	6.94	6.38	4.22	0.544	0.540
2012	3.03	5.18	63.4	6.14	0.613	0.637
2013	3.42	6.27	29.8	4.49	n.d.	n.d.
2014	4.15	7.07	22.1	4.57	0.816	0.723
2017	3.02	5.11	14.8	5.18	n.d.	n.d.
St. George Sound						
2007	3.16	6.05	3.69	1.63	0.721	0.480
2008	3.23	7.17	5.40	5.79	n.d.	n.d.
2009	4.27	9.12	8.82	5.14	0.589	0.711
2010	4.01	7.16	89.0	11.0	0.766	0.907
2011	4.55	8.70	6.05	7.61	0.571	0.634
2012	7.37	11.7	29.8	7.86	0.555	0.570
2013	4.83	7.62	18.3	4.81	n.d.	n.d.
2014	3.89	6.02	4.13	3.14	0.593	0.605
2016	1.36	3.81	14.1	2.92	n.d.	n.d.
2017	2.58	4.00	11.9	6.80	n.d.	n.d.
Eastpoint						
2010	8.71	13.4	150	17.7	n.d.	n.d.
2011	6.43	12.3	5.84	8.04	1.054	1.025
2012	10.0	17.1	27.7	21.2	0.820	0.773
2013	2.45	3.96	22.1	4.08	n.d.	n.d.
2014	4.17	7.25	8.54	4.93	0.953	0.840
2017	4.63	6.46	29.7	6.98	n.d.	n.d.

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