Summary Report for Tampa Bay

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in
Seagrass Integrated Mapping and Monitoring Program
Mapping and Monitoring Report No. 3

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Technical Report 17, Version 3 • 2018
DOI10.13140/RG.2.2.12366.05445

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General assessment

Seagrasses covered 41,655 acres of the Tampa Bay region in 2016 (Table 1; PhotoScience Inc. and Kaufman 2017). Most (90%; 37,666 acres) of the seagrass acreage occurred in the Old Tampa Bay and Middle and Lower Tampa Bay subregions and in Boca Ciega Bay. Seagrass covered approximately 40,400 acres in the Tampa Bay region in 1950, and nearly half had been lost by 1982, due to excessive nitrogen inputs and algal blooms. Dedicated efforts to reduce nitrogen inputs and to clean up bay waters since the early 1980s have resulted in the return of 20,002 acres of seagrass. Old Tampa Bay, Middle Tampa Bay, Lower Tampa Bay, Terra Ceia Bay, and the Manatee River had more seagrass acreage in 2016 than in 1950, but Hillsborough Bay and Boca Ciega Bay still had less seagrass acreage than in 1950. Hillsborough Bay, a highly industrial area including the Port of Tampa, had lost practically all seagrass by 1982 (Johansson and Lewis 1992). By 2016, 87% of the 1950 acreage had returned (2,007 acres). From 2014 through 2016, seagrass beds in Old Tampa Bay, Terra Ceia Bay, and the Manatee River expanded in acreage by 8.5%, 6.6%, and 10%, respectively. While Hillsborough Bay showed small increases between 2014 and 2016, seagrasses increased sharply (36%; 525 acres) between 2012 and 2014. Other segments of the Tampa Bay region have shown small gains in seagrass acreage; the one exception is Middle Tampa Bay, where acreage declined by 42 acres from 2014 to 2016. Continued efforts to protect and restore seagrass acreage are challenged by several adverse impacts, including nonpoint-source inputs of nitrogen from the highly urban watershed surrounding the bay; occasional weather-related forced releases of poorly treated point-source wastewater; annual outbreaks of dinoflagellate blooms; and propeller scarring.

Seagrass species composition has been fairly stable over the past five years (Table 2), but the composition of beds varies across the region. Shoalgrass (*Halodule wrightii*) is the most common species in the Tampa Bay region, and it is dominant in northern subregions (Old Tampa Bay, Hillsborough Bay). Turtlegrass (*Thalassia testudinum*) is dominant in Lower Tampa Bay and common in Old Tampa Bay and Middle Tampa Bay. Manateegrass (*Syringodium filiforme*) is found in all subregions except Hillsborough Bay, and manateegrass and turtlegrass often occur in the same beds in Middle Tampa Bay. The presence of widgeongrass (*Ruppia maritima*) and stargrass (*Halophila engelmannii*) is sporadic and at low levels. The frequency of occurrence (FO) of all seagrass species combined has increased steadily throughout Tampa Bay since 2006 (Table 2, Figure 2; Johansson 2017), reaching 80% or better in all subregions except Hillsborough Bay.

Geographic extent

The Tampa Bay 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 (also discussed in the Western Pinellas County chapter). Boca Ciega Bay is located between the Pinellas peninsula and the barrier islands along the Gulf of Mexico. Tampa Bay

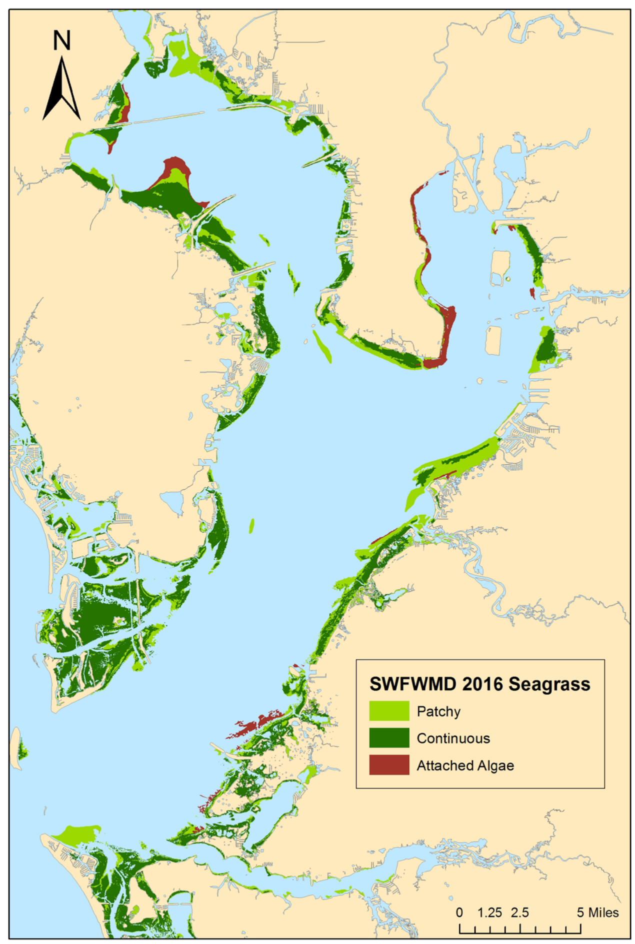

Figure 1. Seagrass cover in the Tampa Bay region, 2016. Data from SWFWMD.

General status of seagrasses in the Tampa Bay region			
Status and stressors	**Status**	**Trend**	**Assessment, causes**
Seagrass acreage	Green	Increasing	Steady gains; urban runoff a concern
Water clarity	Yellow	Improving	Urban runoff has poor quality in Boca Ciega Bay
Natural events	Yellow	Sporadic; minimal impacts	El Niño, tropical cyclones
Propeller scarring	Orange	Extensive	Heavy boat traffic

(Figure 1) is a subtropical estuary and is relatively large (about 1,000 km^2), well-mixed, and shallow (average depth = 4 m). The surrounding watershed is small (6,700 km^2) compared with the surface area of the bay, and about 85% of inflowing freshwater is delivered by four tributaries (Swarzenski et al. 2007). Groundwater maintains the base flow of tributaries and delivers water directly to the estuary by submarine groundwater discharge (Kroeger et al. 2007). Surficial sediments are a combination of quartz sands and biogenic carbonate (Brooks and Doyle 1998), and sediment loads in freshwater inflow are low (210,000 metric tons yr^{-1}; Swarzenski et al. 2007). The watershed is mostly urban (>3 million people in 2016; U.S. Census Bureau), but land uses also include agriculture, phosphate mining, shipping, and other commercial functions. Concomitant with accelerated development in the mid–20th century, water quality in the bay deteriorated significantly, resulting in dense algal blooms and macroalgal overgrowth, which in turn impacted seagrass meadows, fisheries, and recreational use. Poor water quality resulted from excessive nitrogen in sewage, industrial waste, and atmospheric sources. Since the late 1970's, significant reductions in nitrogen inputs have gradually restored Bay water quality and seagrass acreage (Johansson and Lewis 1992; Greening and Janicki 2006; Greening et al. 2011). Heavy runoff resulting from the 1998 El Niño elevated phytoplankton levels and reduced light availability to seagrasses, and the region temporarily lost 2,075 acres of seagrass (Table 1). More recently, spills of minimally treated sewage containing elevated nutrients in the summers of 2015 and 2016 and runoff effects of Hurricane Irma in September 2017 may affect water quality and clarity.

Mapping and monitoring recommendations

- Continue biennial imagery acquisition and mapping. Imagery was acquired in December 2017 and January 2018, and photo-interpretation and mapping efforts will be completed by late 2018.
- Continue in situ seagrass monitoring carried out annually through the voluntary efforts of many organizations (see Johansson 2016).
- Continue to integrate data from various seagrass monitoring programs to obtain the best estimates of seagrass status and trends in the Tampa Bay region.

Management and restoration recommendations

- Continue reducing nitrogen inputs from the watershed to the estuary to return phytoplankton productivity to healthy levels and to improve water clarity.
- Increase research focus on areas where seagrass recovery has lagged and determine why expansion there is not like that in other areas of the bay.
- Monitor the impact of propeller scarring and develop proactive boater education and regulation strategies for reducing impacts. Implement projects for restoring scarred seagrass beds as funding becomes available.
- Routinely update and advocate for the use of boating and angling guides for waters in the region to improve boater education and awareness of seagrass beds and to reduce propeller scarring.

Summary assessment

Seagrasses covered 41,655 acres in the Tampa Bay region in 2016, and beds have increased in area since 2014, except in Middle Tampa Bay where small losses were measured. Total seagrass acreage in 2016 was greater than levels estimated for 1950, before rapid urbanization had begun. Only two subregions, Hillsborough Bay and Boca Ciega Bay, had seagrass acreage in 2016 that was less than acreage estimates from 1950. Seagrass species composition and meadow texture appear to be stable, and the frequency of occurrence of seagrass species has increased steadily throughout the bay since 1998. Three seagrass species occur commonly in the bay region: turtlegrass, manateegrass, and shoalgrass. Stargrass and widgeongrass are observed occasionally during monitoring. Shoalgrass is usually the dominant seagrass species in northern and east-central segments of the bay region, and manateegrass and turtlegrass are most common in Middle and Lower Tampa Bay. Stressors to seagrass include phytoplankton levels, turbidity, and propeller scarring. Continuing efforts to restore seagrass acreage are challenged by nonpoint-source inputs of nitrogen from the region's highly urban watershed. Heavy runoff resulting from the 1998 El Niño elevated phytoplankton levels and reduced light availability to seagrasses, and the region temporarily lost 2,075 acres of seagrass (Table 1). More recently, spills of minimally treated sewage containing elevated nutrients in the summers of 2015 and 2016 and runoff effects of Hurricane Irma in September 2017 may affect water quality and clarity.

Seagrass mapping

Methods, data, and imagery: The Southwest Florida Water Management District (SWFWMD) has obtained aerial imagery of submerged aquatic vegetation in the Tampa Bay region approximately every two years since 1988. More recently (2004–2016), acquisition of aerial photographs and interpretation transitioned from scanned true color film media to digitally-acquired aerial imagery with 1-ft. resolution. Tampa Bay seagrass coverage estimates developed by the SWFWMD since 1988 rely on acquisition of late fall/early winter aerial images for digitization of seagrass photographic signatures. Two broad thematic mapping categories are used: patchy and continuous seagrass coverage. Mapped patchy seagrass polygons represent interpreted areas where 25% to 75% of the bay bottom is considered unvegetated, while continuous seagrass polygons contain <25% of unvegetated bay bottom. Until 2012, a minimum mapping unit of 0.202 ha (0.5 acres) was used to detect features and develop the polygons in a GIS environment. The detection unit was reduced to 0.101 ha (0.25 acres) in 2014. Retrospective groundtruthing of photo-interpreted polygons is conducted approximately six months after acquisition at 250–500 locations of question or interest. Concurrent with acquisition of imagery, in situ observations of seagrass coverage are made at 150 randomly selected sample sites in Tampa Bay, and these data are used to qualify the final seagrass coverage map product. Maps must achieve >90% thematic accuracy for final product acceptance. Spatial coverages of mapped seagrass to date are publicly available from the SWFWMD (http://data-swfwmd.opendata.arcgis.com/).

Results: Mapping data from 2016 show that most subregions of Tampa Bay had exceeded estimates of seagrass

Seagrass status and potential stressors in the Tampa Bay region			
Status indicator	**Status**	**Trend**	**Assessment, causes**
Seagrass cover	Green	Steady gains	All areas except Middle Tampa Bay
Seagrass meadow texture	Green	Improving	Increasing frequency of occurrence
Seagrass species composition	Green	Stable	Small changes
Overall seagrass trends	Green	Improving	Improving water quality
Seagrass stressor	**Intensity**	**Impact**	**Explanation**
Water clarity	Yellow	Improving	Affected by runoff and storms
Nutrients	Yellow	Relative low	
Phytoplankton	Orange	Moderate levels	Responsive to nutrients in storm runoff
Natural events	Yellow	Minimal impact	El Niño, tropical cyclones
Propeller scarring	Orange	Extensive	Heavy boat traffic

area in 1950, thereby meeting targets of restoration of seagrass acreage. Only in Hillsborough Bay and Boca Ciega Bay was seagrass acreage less than estimates from 1950. Between 2014 and 2016, total seagrass cover for the Tampa Bay region increased by 1,360 acres, from 40,295 acres to 41,655 acres, or 3.9% (Table 1). The greatest percentage increase occurred in Hillsborough Bay and the Manatee River; most other segments showed small increases. Very small losses were measured in Middle Tampa Bay, where 42 acres were lost, or 0.4% less than acreage estimated in 2014. In 2016, the region exceeded by 3,655 acres the target restoration goal of 38,000 acres.

Seagrass monitoring

Methods: Seagrasses have been monitored in the Tampa Bay region each fall since 1986 by regional agencies and collaborators. Beginning in 1997, monitoring has been accomplished by volunteer agencies (see Johansson 2016 for list) participating in the Tampa Bay Interagency Seagrass Monitoring Program (TBISP) and coordinated by the Tampa Bay Estuary Program (TBEP). Seagrass cover is estimated by species along about 60 transects using the Braun-Blanquet method in quadrats located every 10, 25 or 50 m, depending on the bay segment being surveyed. Participants assess an average of 1,550 1-m × 1-m quadrats each fall. Transects generally run perpendicular to shore, beginning at the shoreline and ending at the estimated depth beyond which seagrass is not likely to occur. Transects are distributed throughout each bay subregion. At each quadrat, water depth, sediment type, visual assessments of epiphyte load on seagrass blades, general appearance of seagrasses, and the occurrence of drift and attached macroalgae are also recorded. At less frequent intervals along each transect, seagrass shoot density and canopy height are measured.

Reports and data: Recent reports by Johansson (2016, 2017) summarize the Tampa Bay monitoring data from 1997 through 2015. These reports provide a detailed look at the FO of seagrass species in all subregions of Tampa Bay. The transect program database is maintained by the TBEP (contact Gary Raulerson).

Results: The percentage frequency of occurrence (FO) for all seagrass species increased in all subregions of Tampa Bay from 1997 through 2015 (Table 2). Overall, the mean FO across the region has increased from about 60% to nearly 80%, and all subregions, except Lower Tampa Bay (LTB), have had statistically significant increases in seagrass occurrence from 1997–2015 (Johansson 2016). The greatest increases occurred in Old Tampa Bay (OTB) and Hillsborough Bay (HB); HB had a large and recent

Table 1. Seagrass acreage in the Tampa Bay region, 1950–2016. Data from PhotoScience Inc. and Kaufman (2017). Shaded numbers indicate acreage exceeding 1950 estimates. The TBEP restoration goal is 38,000 acres for the region. Mapping data also exist for 1996, 1999, and 2004 but are not shown.

									Change 2014–2016		Change 1950–2016
Bay segment	1950	1982	2006	2008	2010	2012	2014	2016	Acres	%	Acres
Hillsborough Bay	2,300	0	415	810	836	1,448	1,973	2,007	34	1.7%	−293
Old Tampa Bay	10,700	5,943	5,434	5,829	6,687	6,999	10,273	11,147	874	8.5%	447
Middle Tampa Bay	9,600	4,042	5,089	6,659	8,208	9,025	9,694	9,652	-42	-0.4%	52
Lower Tampa Bay	6,100	5,016	6,578	6,322	6,862	6,959	7,638	7,797	159	2.1%	1,697
Boca Ciega Bay	10,800	5,770	8,961	8,457	8,554	8,544	8,880	9,070	190	2.1%	−1,730
Terra Ceia Bay	700	751	1,007	932	998	1,011	1,180	1,258	78	6.6%	558
Manatee River	200	131	814	638	752	654.8	656.3	723.3	67	10.2%	523
Total	**40,400**	**21,653**	**28,299**	**29,647**	**32,897**	**34,642**	**40,295**	**41,655**	**1,360**	**3.9%**	**1,255**

increase. The seagrass presence in Middle Tampa Bay (MTB) and Boca Ciega Bay (BCB) also increased from 1997–2015, albeit more slowly than in the upper subregions. In contrast, FO in LTB has been relatively stable.

The percentage FO for each seagrass species and for the common attached green alga *Caulerpa prolifera* in each subregion of Tampa Bay for 2006–2015 is shown in Figure 2 and Table 3. Overall, shoalgrass is the most common species in the region. The FO of shoalgrass along the transects has increased at a statistically significant rate from near 30% in 2000 to nearly 50% in 2013. The trend closely parallels the trend of FO for all species combined. Proportionally, shoalgrass generally ranged between 50% and 60% of the seagrass species and has had the most prominent expansion in absolute FO of all species for 1997–2015.

Turtlegrass, the dominant Lower Tampa Bay species, and manateegrass are also common. The FO of turtlegrass has been stable near 20%. Although the FO of manateegrass was low in 1997 (near 3%), the presence of manateegrass has increased nearly six times at a statistically significant rate, and its FO in 2015 was slightly less than that of turtlegrass. Consequently, manateegrass has had the most

Table 2. Trends of percent frequency of occurrence for all seagrass species in the Tampa Bay region and subregions, 1997–2015. TB = Tampa Bay region; OTB = Old Tampa Bay; HB = Hillsborough Bay; MTB = Middle Tampa Bay; LTB = Lower Tampa Bay; BCB = Boca Ciega Bay. Red blocks = seagrass reported in <25% of meter square placements; orange blocks = 25–50%; yellow blocks = 51–75%; green blocks = >75%; gray blocks = no data collected; and blue blocks = small number of observations. Significant upward trends, derived from Mann-Kendall statistics ($p \leq 0.05$), are printed in boldface type. The presence of *Caulerpa prolifera,* a common green alga, is not included in the FO calculations. Table modified from Johansson (2016).

		Bay segment				
Year	Tampa Bay	OTB	HB	MTB	LTB	BCB
1997			14			
1998	63		15		82	85
1999	60		12	57	77	72
2000	57		15	53	70	74
2001	59	49	21	60	63	74
2002	59	45	23	59	55	81
2003	57	47	21	51	58	77
2004	57	47	20	50	60	89
2005	60	57	17	52	65	93
2006	61	53	19	59	70	85
2007	65	63	23	65	66	94
2008	64	60	25	67	67	95
2009	67	77	33	77	66	76
2010	76	93		70	71	86
2011	71	77	44	72	64	83
2012	75	81	68	76	74	92
2013	80	91	67	79	74	88
2014	78	88	59	74	80	100
2015	80	92	63	80	81	81
Kendall Tau Statistic	0.71	0.75	0.74	0.68	-0.50	0.39

Legend
<25%
25–50%
51–75%
>75%
No data
Small no. of observations

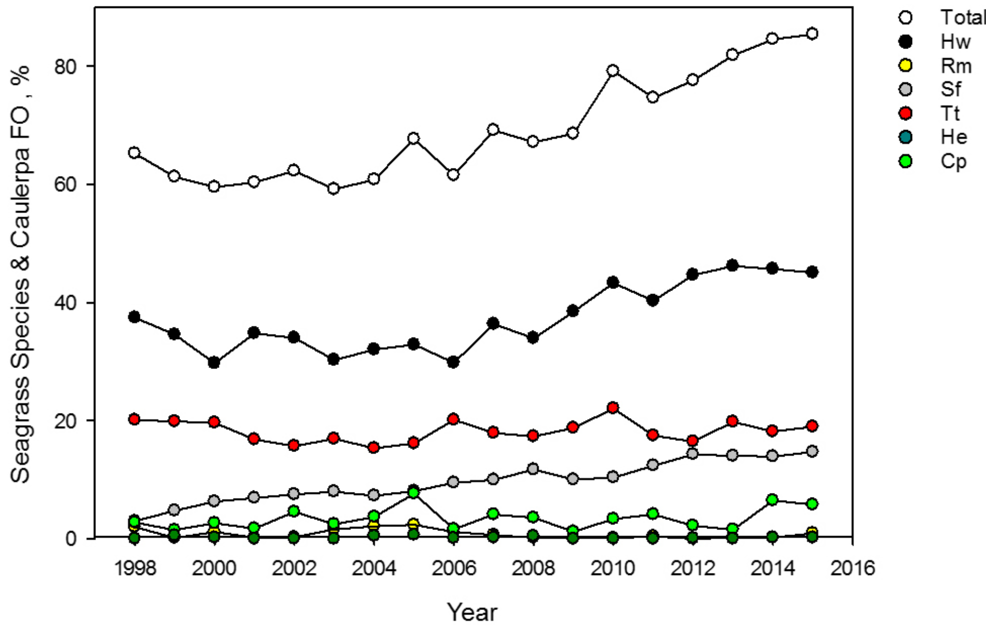

Figure 2. Trends in the percentage frequency of occurrence (FO) of all seagrass species, and for each species individually, 1998–2015. Shoalgrass = Hw; manateegrass = Sf; turtlegrass = Tt; widgeongrass = Rm; stargrass = He; *Caulerpa prolifera* = Cp. Note that *C. prolifera* is not included in the total seagrass FO. Figure from Johansson (2016).

prominent percentage increase in FO of all seagrass species. Stargrass and widgeongrass occur infrequently in the region. *Caulerpa prolifera* also occurs at low and variable levels, most often in Hillsborough Bay and Old Tampa Bay. The percentage of quadrats with no vegetation has decreased steadily since 2006 throughout Tampa Bay (Table 3). Bare quadrats have decreased only slightly in Middle Tampa Bay.

Management and restoration recommendations

The Tampa Bay Estuary Program recently updated its Comprehensive Conservation and Management Plan for Tampa Bay (CCMP 2017). The CCMP serves as the regional framework for the further protection, management, and restoration of the natural resources of the Tampa Bay estuary. Thirty-nine actions have been identified for sustained progress in bay restoration efforts through 2027. The CCMP addresses historical challenges for the bay—such as reducing nutrient pollution and restoring key habitats—as well as new or emerging concerns such as potential impacts related to climate change.

- The TBEP recommends continuing efforts to improve and sustain bay water quality and light transmission so that seagrass can thrive and expand by:
- Increasing efforts to reduce nutrient inputs to Tampa Bay, particularly from point and nonpoint sources emanating from urban and suburban areas of the watershed.
- Monitoring the impact of propeller scarring and developing a proactive strategy for reducing impacts.
- Routinely updating and advocating for the use of boating and angling guides for waters in the region to improve boater education and awareness of seagrass beds and to reduce propeller scarring.
- Enhancing monitoring and research to ascertain any effects of climate change and ocean acidification on coastal marine resources in the region.
- Expanding research on the role seagrass may have on sequestering carbon dioxide and buffering impacts of ocean acidification.

Pertinent reports and scientific publications

Avery WM, Hennenfent KB, Johansson JOR, Pacowta JJ. 2010. Tampa Bay interagency seagrass monitoring program training and field manual. Submitted to the Tampa Bay Estuary Program by the Bay Study Group, City of Tampa.

Table 3. Percentage frequency of occurrence of seagrass species and *Caulerpa prolifera* (a green alga) in subregions of Tampa Bay, 2006–2015.

Year	# of quadrats	Bare	Frequency of occurrence (%)					
			Shoal-grass	Manatee-grass	Turtle-grass	Widgeon-grass	Star-grass	*Caulerpa prolifera*
Hillsborough Bay								
2006	374	65.0	29.4			2.41		3.74
2007	384	53.6	32.6			1.82		14.1
2008	404	51.5	39.6			0.50		10.1
2009	401	44.4	49.1					8.48
2010	181	33.1	73.5					
2011	325	46.5	50.8			0.31		2.15
2012	277	26.7	67.5					
2013	239	28.0	69.5			2.51		
2014	292	21.9	67.8			0.34		19.52
2015	232	18.5	74.6				0.86	9.48
Old Tampa Bay								
2006	744	29.2	50.9	16.1	19.0	2.82	0.40	5.65
2007	555	36.2	49.4	16.8	15.3	3.78	1.80	8.83
2008	617	23.5	46.4	18.6	18.3	0.65		10.7
2009	485	21.4	54.6	19.0	19.2	0.62	0.21	2.06
2010	328	16.8	74.7	14.0	21.3	0.31		
2011	421	21.4	54.9	17.3	16.4	1.66		
2012	438	18.5	55.3	24.2	13.0	.		
2013	443	10.6	61.9	23.9	14.9	0.68		0.23
2014	441	10.9	57.8	24.5	15.9	1.81		3.63
2015	479	4.59	62.4	23.8	14.6	12.3		5.22
Middle Tampa Bay								
2006	702	30.2	42.2	21.4	16.4	2.56		
2007	682	29.0	40.9	22.1	17.9	0.44		0.29
2008	670	30.3	41.0	17.9	18.7	0.15		0.60
2009	541	23.3	48.8	17.9	18.5	0.37	0.74	
2010	237	31.2	51.5	21.5	8.02			
2011	336	28.3	42.3	33.0	19.6			
2012	381	25.7	42.0	30.2	15.0		0.53	
2013	413	21.8	47.0	28.8	16.0	0.24		5.09
2014	354	28.2	49.4	23.2	16.9			7.35
2015	401	24.9	43.9	30.9	19.0	0.75		2.99
Lower Tampa Bay								
2006	320	33.4	30.3	10.9	47.5		0.63	
2007	343	40.8	26.2	9.91	42.6		0.58	
2008	330	41.8	27.3	11.8	41.2		1.21	
2009	303	40.3	28.1	9.90	46.9			
2010	332	35.8	29.2	11.1	50.6			
2011	156	42.3	25.0	13.5	39.7			
2012	172	36.6	22.1	8.72	47.7			
2013	123	31.7	38.2	20.3	48.8			1.63
2014	145	18.6	27.6	17.9	60.0		0.69	
2015	123	26.0	39.0	22.8	53.7			

Brooks GR, Doyle LJ. 1998. Recent sedimentary development of Tampa Bay, Florida: a microtidal estuary incised into Tertiary platform carbonates. Estuaries 21:391–406.

Florida Department of Transportation. 1999. Florida land use, cover and forms classification system, a handbook, Division of Surveying and Mapping, Geographic Mapping Section, Tallahassee.

Greening HS, Cross LM, Sherwood ET. 2011. A multiscale approach to seagrass recovery in Tampa Bay, Florida. Ecological Restoration 29:82–93.

Greening HS, Janicki A. 2006. Toward reversal of eutrophic conditions in a subtropical estuary: water quality and seagrass response to nitrogen loading reductions in Tampa Bay, Florida, USA. Environmental Management 38:163–178.

Greening H, Janicki A, Sherwood ET, Pribble R, Johansson JOR. 2014. Ecosystem responses to long-term nutrient management in an urban estuary: Tampa Bay, Florida, USA. Estuarine, Coastal and Shelf Science 151:A1–A16. DOI: 10.1016/j.ecss.2014.10.003. Accessed January 2018.

Hu C, Chen Z, Clayton TD, Swarzenski P, Brock JC, Muller-Karger FE. 2004. Assessment of estuarine water-quality indicators using MODIS medium-resolution bands: initial results from Tampa Bay, FL. Remote Sensing of the Environment 93:423–441.

Janicki Environmental Inc. 2011. Development of numeric nutrient criteria for Boca Ciega Bay, Terra Ceia Bay, and Manatee River, Florida. Prepared for the Tampa Bay Estuary Program, St. Petersburg, Florida.

Janicki Environmental Inc. 2011. Proposed numeric nutrient criteria for Tampa Bay, 2011. Prepared for the Tampa Bay Estuary Program, St. Petersburg, Florida.

Johansson JOR. 2016. Seagrass transect monitoring in Tampa Bay: a summary of findings from 1997 through 2015. Technical Report #08-16 Tampa Bay Estuary Program. St. Petersburg, Florida.

Johansson, JOR 2017. State of Tampa Bay seagrasses as learned from the bay-wide interagency transect monitoring program. Janicki Environmental Inc. St. Petersburg, Florida.

Johansson JOR, Lewis RR III. 1992. Recent improvements in water quality and biological indicators in Hillsborough Bay, a highly impacted subdivision of Tampa Bay, Florida, USA. Pp. 1199–1215 in Vollenweider, RA, Marchetti R, Viviani R (eds.). Marine Coastal Eutrophication. Proceedings of an international conference, Bologna, Italy, 21-24 March 1990. Elsevier, Amsterdam, The Netherlands.

Kroeger KD, Swarzenski PW, Reich C, Greenwood WJ. 2007. Submarine groundwater discharge to Tampa Bay: nutrient fluxes and biogeochemistry of the coastal aquifer. Marine Chemistry 104:85–97.

Lawson KM, Tuckett QM, Ritch JL, Nico LG, Fuller PL, Matheson RE, Gestring K, Hill JE. 2017. Distribution and status of five non-native fish species in the Tampa Bay drainage (USA), a hot spot for fish introductions. Bioinvasions Records 6:393–406.

Morrison G, Greening H. 2011. Seagrass. Pp. 63–103 in Yates KK, Greening H, Morrison G (eds.). Integrating science and resource management in Tampa Bay, Florida. Circular 1348, U.S. Geological Survey, Reston, Virginia. http://pubs.usgs.gov/circ/1348/. Accessed January 2018.

PhotoScience Inc., Kaufman KA. 2015. SWFWMD seagrass 2014: seagrass distribution from Tarpon Springs to Boca Grande. Final report for the Southwest Florida Water Management District, St. Petersburg.

SWFWMD (Southwest Florida Water Management District). 2015. District reports largest amount of seagrass in Tampa Bay in more than 60 years. News release, May 13, 2015. SWFWMD, Brooksville. http://www.swfwmd.state.fl.us/news/article/2064/. Accessed January 2018.

Sherwood ET, Greening HS, Johansson JOR, Kaufman K, Raulerson GE. 2017. Tampa Bay (Florida, USA): documenting seagrass recovery since the 1980's and reviewing the benefits. Southeastern Geographer 57:294–319.

Swarzenski PW, Baskaran M, Yates K, Henderson C. 2007. Tampa Bay as a model estuary for examining the impact of human activities on biogeochemical processes: an introduction. Marine Chemistry 104:1–3.

Tampa Bay Estuary Program. 2007. Gulf Coast National Estuary Program Coastal Condition, Tampa Bay Estuary Program. Pp. 223–312 (Chapter 5) in U.S. Environmental Protection Agency National Estuary Program Coastal Condition Report. EPA, Washington, D.C. https://s3.amazonaws.com/wateratlasimages/Gulf-Coast-NEP-Coastal-Condition-Report-Chap5.pdf. Accessed January 2018.

Tampa Bay Estuary Program. 2010. Data summary from the Tampa Bay Interagency Seagrass Monitoring Program through year 2008. Technical Report #01-10. Prepared by the City of Tampa Bay Study Group (Walt Avery and Roger Johansson), Tampa, Florida.

Tomasko DA, Corbett CA, Greening HS, Raulerson GE. 2005. Spatial and temporal variation in seagrass coverage in southwest Florida: assessing the relative effects of anthropogenic nutrient load reductions and rainfall in four contiguous estuaries. Marine Pollution Bulletin 50:797–805.

General references and additional information

Tampa Bay Estuary Program Tech Website. Tampa Bay Estuary Program, St. Petersburg, Florida. http://www.tbeptech.org/. Accessed January 2018.

Tampa Bay Estuary Program Comprehensive Conservation and Management Plan. Tampa Bay Estuary Program, St. Petersburg, Florida. https://indd.adobe.com/view/cf7b3c48-d2b2-4713-921c-c2a0d4466632. Accessed January 2018.

Tampa Bay Estuary Program Transect Geo-Data Base. Tampa Bay Estuary Program, St. Petersburg, Florida. https://www.tbeptech.org/DATA/GIS/Seagrass/TB_SEAGRASS_TRANSECT_DATASET_thru_2015.zip. Accessed January 2018.

Boating and angling guide to Tampa Bay. 2013. Florida Fish and Wildlife Conservation Commission, St. Petersburg. http://ocean.floridamarine.org/boating_guides/tampa_bay/index.html. Accessed January 2018.

The state of Florida's seagrass. Florida Sportsman, June 2017: http://www.floridasportsman.com/2017/06/07/florida-seagrass-update/. Accessed January 2018.

Tampa Bay, Florida, meets seagrass recovery goal. Southeast Regional Office website, NOAA Fisheries, National Oceanic and Atmospheric Administration, St. Petersburg, Florida. http://sero.nmfs.noaa.gov/habitat_conservation/hcd_headlines/02_tampa_seagrass_goal.html. Accessed January 2018.

Seagrass monitoring and restoration. Tampa Bay Watch website. Tampa Bay Watch, Tierra Verde, Florida. http://www.tampabaywatch.org/seagrass.html. Accessed January 2018.

Seagrass restoration in Tampa Bay. Sound Waves e-newsletter, November 2002. U.S. Geological Survey. https://soundwaves.usgs.gov/2002/11/. Accessed January 2018.

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Document citation

Johansson JOR, Kaufman K, Brown A, Sherwood E, Raulerson G. 2018. Summary report for the Tampa Bay region. In Yarbro L, Carlson PR Jr (eds.). Seagrass Integrated Mapping and Monitoring Report No. 3. Technical Report 17, Version 3. Fish and Wildlife Research Institute, Florida Fish and Wildlife Conservation Commission, St. Petersburg.

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