vegetation was too dense for the birds to access and forage within. This suggests that fire alone is insufficient as a treatment tool to manage highly eutrophic areas for birds. Although wading birds have been observed feeding in emergent cattail after a natural fire in WCA-3A North (WCA-3AN), these were in areas where the regrowth of the vegetation appeared to be less dense than it was in the F treatments, possibly because of lower soil nutrient levels and differences in hydrology in WCA-3AN compared to WCA-2A.

Relevance to Water Management

The need to actively manage highly resilient disturbed habitats is becoming well established in the restoration ecology literature. However, the combination of vegetation treatment strategies to accomplish different goals are still being refined. This study was designed to assess which management strategies of fire and herbicide may be the most effective. Preliminary aerial vegetation surveys indicated that for highly heterogeneous responses, timing is important for these computer-aided classifications to be successful— both time after treatment as well as time of year. Additional vegetation surveys as the plots mature will be conducted to further refine computer-aided analysis of aerial surveys, which ultimately should be more cost effective than on the ground sampling. However, we did establish that in nutrient enriched areas, fire alone is not a viable long-term solution for either cattail control or improved wading bird use. By contrast, while herbicide alone does not initially provide a good foraging habitat, after the standing dead falls beneath the water surface, they may support more foraging. Continued surveys in future years will allow us to examine the longer-term effects of these vegetation treatments on wading bird foraging, especially the relative effects of the FH versus the HF treatments. The data will be used to help managers determine the optimal treatments for maximizing wading bird responses but minimizing herbicide use.

THE FLORIDA BAY PROJECT:
WATER QUALITY CONDITIONS AND STATUS

Stephen P. Kelly

Introduction

Water quality in Florida Bay (eastern, central, and western regions) has been monitored since 1991 (WY1992) to ensure that District operations and projects protect and restore the coastal ecosystem to the extent possible. CERP performance measures focus on Chla concentration, an indicator of algal biomass, as well as the nutrient inputs that initiate and sustain blooms. Operational changes to the South Dade Conveyance System, including implementation of the C-111 South Dade Project, Modified Water Deliveries to ENP (especially Tamiami Trail modifications), the C-111 Spreader Canal Western Project Phase I, which became operational in July 2012, and the newly implemented Florida Bay Improvement Project in the upper Taylor Slough area, will further change freshwater flow patterns and may alter downstream water quality.

There are many factors that influence the nutrient and Chla concentrations and variation in the bay including inflows, storm and wind events, circulation patterns, nutrient recycling, and even construction events. It is not possible to attribute any one of these factors as the most important driver of current conditions, but rather it is likely a synergistic effect of some or all of them (Chapter 12 [Abbot et al. 2007] and Appendix 12-3 [Rudnick et al. 2007] of the 2007 SFER – Volume I). Additionally, starting in July 2015, a large die-off of SAV, primarily turtle grass (*Thallasia testudinum*), occurred in the central region of the bay encompassing approximately 40,000 acres. The consensus among multiple local agencies and institutions including SFWMD, ENP, FWC, NOAA, Florida International University, and Florida Atlantic University is that the die-off was caused by a localized drought in South Florida that began in 2014 and continued in 2015. This resulted in reduced freshwater flows to the bay and, along with extreme

temperatures, salinities, and DO levels, likely triggered the die-off. DO levels in the bottom waters of the die-off areas were hypoxic to anoxic. These extremely low levels were likely caused by low oxygen solubility due to high temperature and salinity levels and high nighttime respiration rates. Bottom waters and sediment pore waters also contained high concentrations of sulfide, up to 12 milli-molar, which is toxic to seagrass, with observations of a dense yellow fog in the bottom waters. It was also hypothesized in 2015 that large quantities of dead seagrass leaves as well as the decaying root systems would release nutrients into the water column when temperatures begin to rise in August 2016 (WY2017), which could trigger an algal bloom. Presented here is a brief update of ecologically important parameters and how they have changed in WY2017. For a complete description of water quality assessments in Florida Bay, refer to Chapter 6 of the *2015 South Florida Environmental Report (SFER) – Volume I* (Sklar and Dreschel 2015).

Methods

Water samples and physical parameters (temperature, salinity, conductivity, pH, and DO) are collected every other month at some sites and monthly starting in April 2016 at a subset of sites. Samples are collected at 0.5 m below the surface and processed according to the SFWMD *Field Sampling Quality Manual* (SFWMD 2015) following Florida Department of Environmental Protection (FDEP) protocols. Physical parameters are collected with a calibrated multi-parameter water quality sonde following SFWMD protocols. Samples are processed on site, stored on ice, and shipped overnight to the SFWMD Chemistry Laboratory in West Palm Beach for analysis according to the SFWMD *Chemistry Laboratory Quality Manual* (SFWMD 2017) and following FDEP protocols. All sample results are quality assured before being uploaded to the Districts' corporate environmental database, DBHYDRO.

Results

Annual averages of most parameters analyzed: Chla, TP, TN, DIN, TOC, and turbidity—continue to be stable during the last eight water years, indicated by little to no interannual concentration changes, and were statistically similar between WY2016 and WY2017 with some notable exceptions (**Table 6-6**). Chla was 3 times higher, TP was 1.5 times higher, and turbidity was 1.7 times higher in the central region in WY2017 compared to WY2016. This is the area that experienced the SAV die-off, and these elevated levels could be attributable to the release of nutrients from decaying SAV fueling an increase in Chla concentrations. TOC in this region was elevated during the middle of the water year (August–December) but ended the water year much lower (**Table 6-6** and **Figures 6-32** through **6-34**). This resulted in the TOC not being statistically different between WY2016 and WY2017. In addition, Chla was 2.5 times higher and TP was 1.5 times higher in the western region in WY2017 compared to WY2016. This area is adjacent to the SAV die-off area and may have been influenced by circulation patterns in the die-off areas.

Results in WY2017 were compared to the period of record (POR) and the 25th and 75th percent quartiles. The POR for all analytes, with the exception of TN, is from WY1992 to WY2016. The POR for TN was reduced to WY2009 to WY2016 due to a possible error in the longer-term data set. An intercalibration is ongoing and will be reported when complete. In the figures that follow, the monthly spatial averages of each parameter in the three regions of the bay are compared to the temporal median of the monthly spatial means and the interquartile range for the entire POR (WY1992–WY2016), except for TN as mentioned above. The median and interquartile range was used as a comparison to the last three water years to reduce the occurrence of outliers that may skew the results. In addition, the legal standards for each basin as set forth in Section 65-302.532, Florida Administrative Code (F.A.C.), is also included (**Table 6-6**).

Table 6-6. Annual averages and standard deviations of WY2016 and WY2017 as well as Section 65-302.532, F.A.C., basin standards. Numbers that are statistically different (t-test, p < 0.05) are in bold red.

Parameter [a]	F.A.C. [b,c]	WY2016	WY2017
Eastern Region			
Total Nitrogen (mg/L)	0.65	**0.87 ± 0.14**	**0.74 ± 0.12**
Dissolved Inorganic Nitrogen (mg/L)		0.15 ± 0.12	0.12 ± 0.06
Total Phosphorus (ug/L)	7	3.17 ± 1.01	3.49 ± 1.08
Chlorophyll *a* (µg/L)	0.4	0.34 ± 0.13	0.38 ± 0.18
Total Organic Carbon (mg/L)		7.30 ± 1.98	7.32 ± 1.84
Turbidity (NTU)		5.11 ± 5.98	4.37 ± 3.41
Central Region			
Total Nitrogen (mg/L)	0.99	1.49 ± 0.48	1.39 ± 0.45
Dissolved Inorganic Nitrogen (mg/L)		**0.24 ± 0.30**	**0.06 ± 0.06**
Total Phosphorus (ug/L)	19	12.63 ± 5.58	18.29 ± 14.17
Chlorophyll *a* (µg/L)	2.2	**1.88 ± 1.31**	**5.63 ± 7.60**
Total Organic Carbon (mg/L)		10.77 ± 3.57	11.85 ± 3.32
Turbidity (NTU)		**2.02 ± 1.15**	**3.47 ± 2.80**
Western Region			
Total Nitrogen (mg/L)	0.37	0.49 ± 0.31	0.56 ± 0.41
Dissolved Inorganic Nitrogen (mg/L)		0.02 ± 0.01	0.03 ± 0.03
Total Phosphorus (ug/L)	15	**10.83 ± 4.84**	**16.70 ± 10.91**
Chlorophyll *a* (µg/L)	1.4	1.52 ± 1.54	3.77 ± 6.02
Total Organic Carbon (mg/L)		4.12 ± 1.37	5.01 ± 2.89
Turbidity (NTU)		3.28 ± 3.18	4.73 ± 5.05

a. Key to units: µg/L – micrograms per liter, mg/L - milligrams per liter, and NTU – nephelometric turbidity units.
b. Section 65-302.532, F.A.C.
c. Concentrations are based on the annual geometric mean and are basin specific.

The WY2017 results were mixed. In the east, TP was lower than the 25th percent quartile, continuing this long-term trend. The elevated TN seen in WY2016 has returned to the long-term median concentration. Chla is at the long-term median, and TOC ended the water year under the 25th percent quartile (**Table 6-7**) and **Figures 6-32** through **6-34**) and Turbidity was also lower than the 25th percent quartile with two exceptions in October 2016 and January 2017 (data not shown).

Table 6-7. Deviation of WY2017 from the POR (WY1992–WY2016) averages unless otherwise noted. Numbers in bold red italics are statistically different (t-test, p < 0.05).

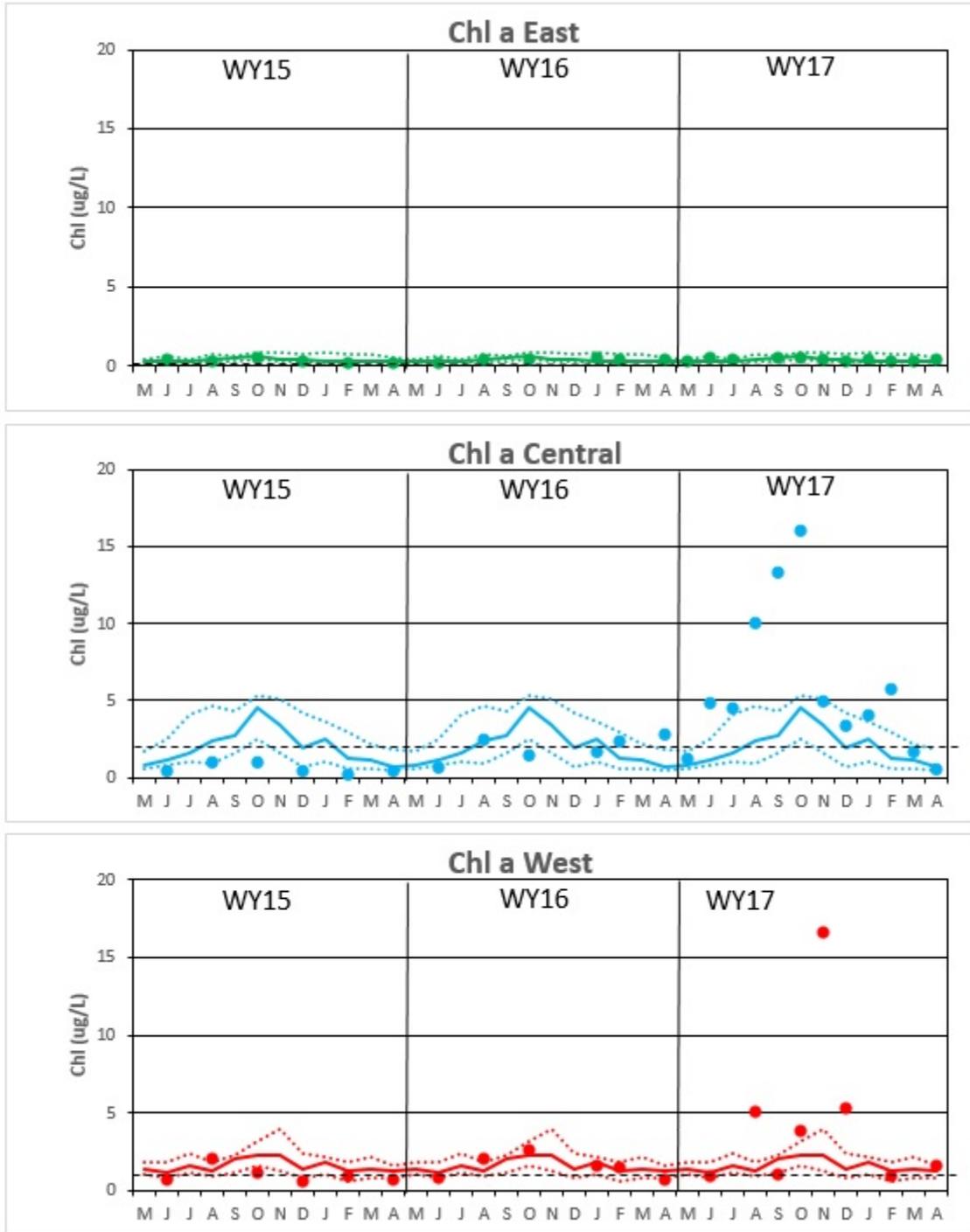| Region	TN [a]	DIN	TP	Chla	TOC	Salinity	Turbidity
Eastern	100 %	100 %	*52 %*	79 %	88 %	103 %	*53 %*
Central	*121 %*	70 %	105 %	*233 %*	92 %	106 %	*49 %*
Western	*140 %*	*155 %*	106 %	*207 %*	98 %	102 %	64 %

a. TN POR WY2009–WY2016.

Figure 6-32. Mean Chla concentrations in micrograms per liter (µg/L) in the three regions of the bay studied during WY2015–WY2017 (solid symbols) compared to the monthly median and the interquartile range for the entire POR, WY1992–WY2014 (solid and dotted lines). The legal basin standards as set forth in Section 65-302.532, F.A.C., are also shown (black dashed line).
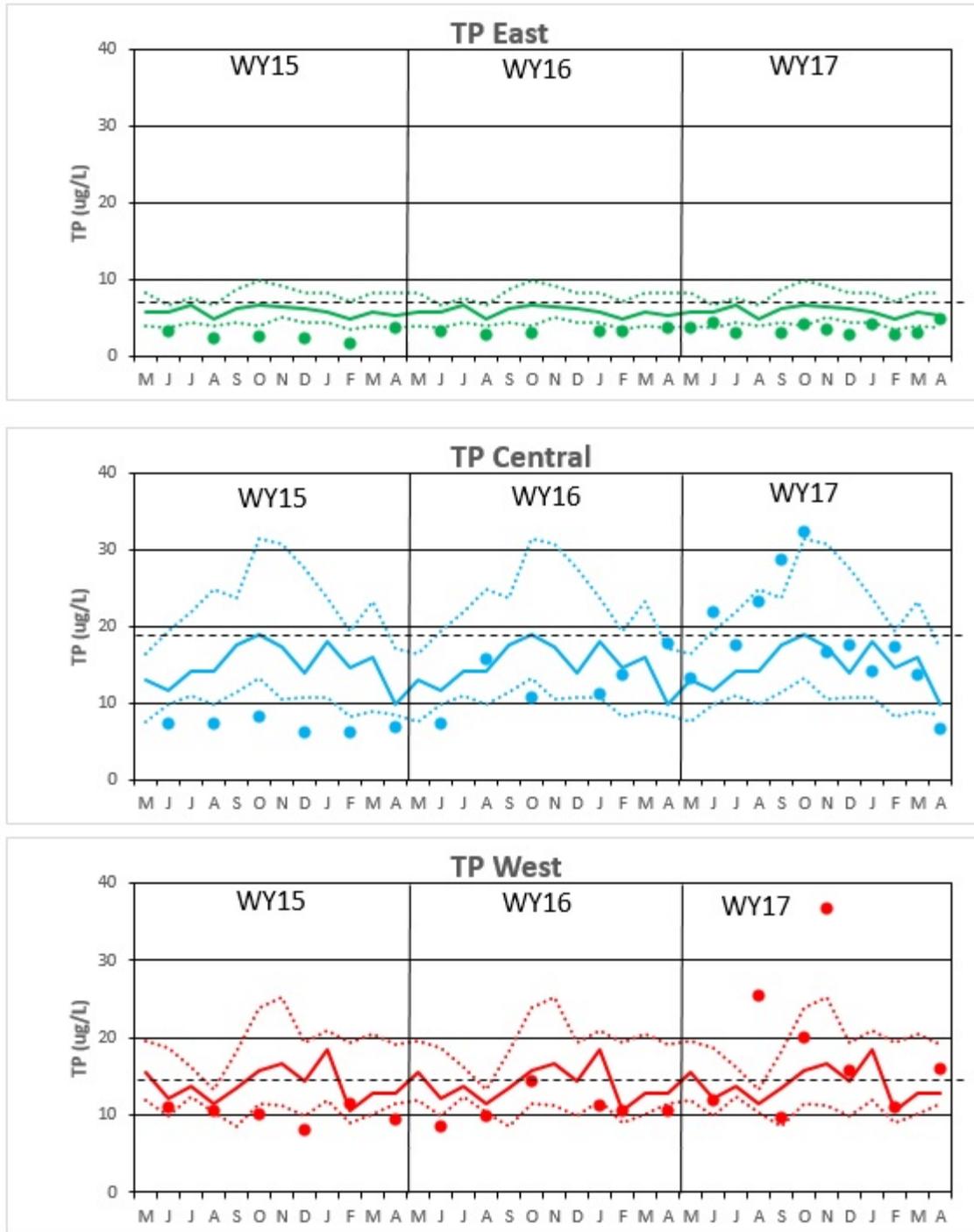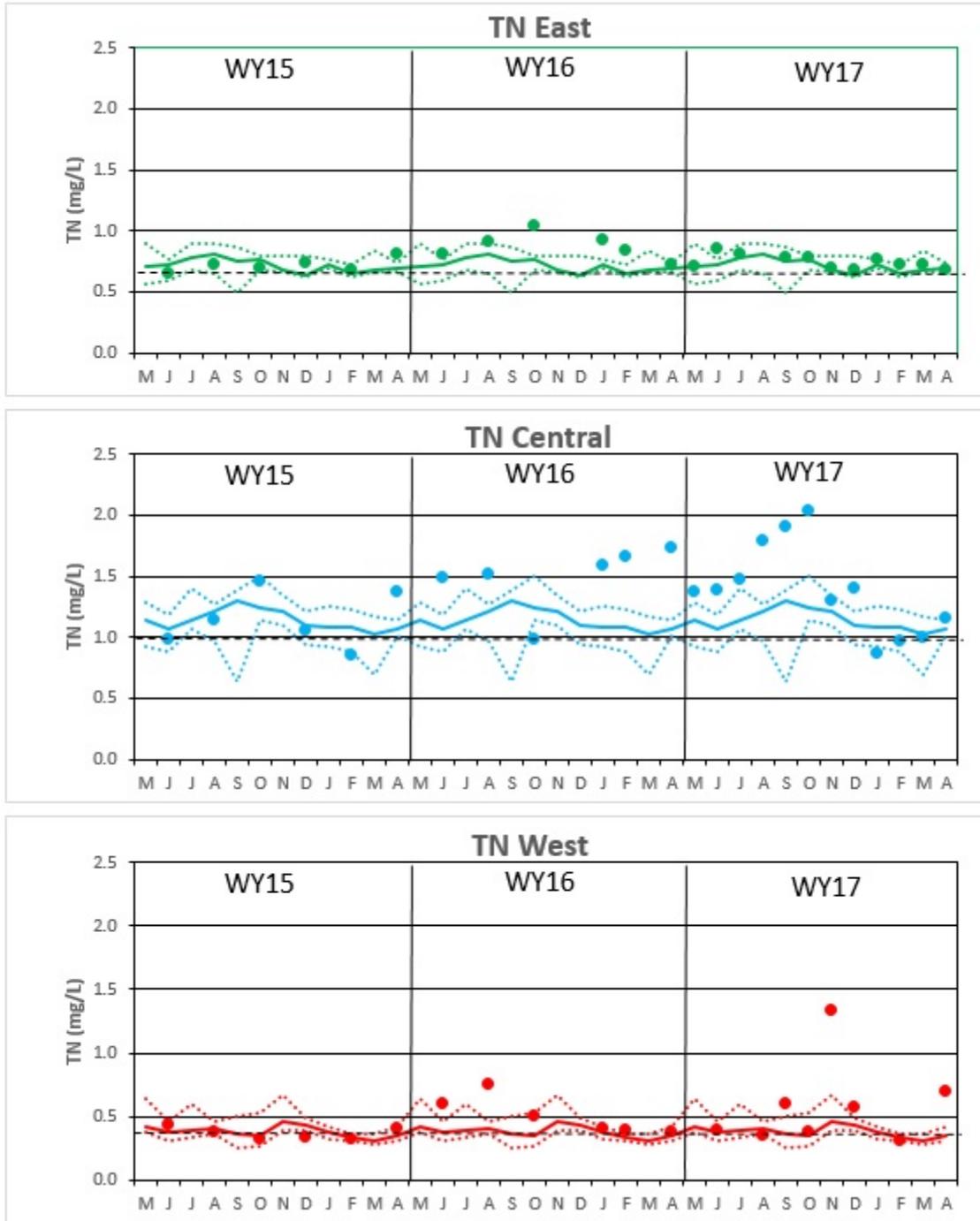
Figure 6-33. Mean TP concentrations in micrograms per liter (μg/L) in the three regions of the bay studied during WY2015–WY2017 (solid symbols) compared to the monthly median and the interquartile range for the entire POR, WY1992–WY2014 (solid and dotted lines). The legal basin standards as set forth in Section 65-302.532, F.A.C., are also shown (black dashed line).

Figure 6-34. Mean TN concentrations in milligrams per liter (mg/L) in the three regions of the bay studied during WY2015–WY2017 (solid symbols) compared to the monthly median and the interquartile range for the revised POR, WY2009–WY2014 (solid and dotted lines). The legal basin standards as set forth in Section 65-302.532, F.A.C., are also shown (black dashed line).

In the central region, both TP and TN started the water year greater than the 75th percent quartile but ended at close to the median concentration. Chla also started the water year well above the 75th percent quartile, but ended the water year still slightly elevated but close to the median concentration. TOC and turbidity were variable during the water year, TOC in the central region was elevated (at the 75th percent quartile) during the middle of the water year (August – December) but ended the water year less than the 25th percent quartile (**Table 6-7** and **Figures 6-32** through **6-34**). Again, this is the area that experienced the SAV die-off, and these elevated levels could be attributable to the release of nutrients from decaying SAV fueling an increase in Chla concentrations.

To the west, Chla was above the 75th percent quartile in August, October, November, and December 2016. There were also peaks in TP much greater than the 75th percent quartile in August and November 2016. TN also had peaks greater than the 75th percent quartile in September, November, December and 2016, and April 2017. DIN was also elevated throughout much of the water year with most greater than the 75 percent quartile. TOC and turbidity were variable during the water year and had peaks greater than the 75 percent quartile in August and October 2016 (turbidity) and November 2016 (TOC) (**Table 6-7** and **Figures 6-32** through **6-34**).

In summary, both the central and western regions of the bay had some elevated nutrient and Chla levels during WY2017. Both areas are influenced by circulation patterns in the area of the SAV die-off and the cause for the elevated levels in both regions could be attributable to the release of nutrients from decaying SAV fueling an increase in Chla concentrations. Chla levels in the central and western regions were greater than the F.A.C. standards during WY2017, TP was also above the standard in the western region, and above the standard for TN in all regions (**Table 6-6**).

Relevance to Water Management

Water management in the area is focused on operational changes to the South Dade Conveyance System. These changes are designed to increase freshwater flows to the bay and to lessen the frequency, duration, and extent of elevated salinity levels. The implementation of the C-111 South Dade Project, Modified Water Deliveries to ENP, the C-111 Spreader Canal Western Features Project Phase I, and the newly implemented Florida Bay Improvement Project in the upper Taylor Slough area are expected to improve freshwater flow patterns in the southern Everglades and Florida Bay. As mentioned earlier, there are many factors that influence the nutrient and Chla concentrations and variation in the bay including inflows caused by precipitation and water management changes upstream of the bay, storm and wind events, circulation patterns, nutrient recycling, and even construction events. We have reported on increases in some nutrient and Chla concentrations in the central and western bay regions during WY2017 that appear be the result of the SAV die-off. Both areas are influenced by circulation patterns in the area of the die-off and the cause for the elevated levels in both regions could be attributable to the release of nutrients from decaying SAV fueling an increase in Chla concentrations. Chla levels in the central and western regions were greater than the F.A.C. standards during WY2017. TP was also above the standard in the western region, and above the standard for TN in all regions**.** As mentioned earlier, this could be attributable to increased precipitation leading to increased freshwater runoff, the release of nutrients from decaying SAV, changes in water management operations, or a combination of all three.

SYNOPTIC ECOLOGICAL MAPPING IN FLORIDA BAY

Christopher J. Madden, Theresa Strazisar, and Joe Stachelek[6]

Introduction

The Everglades Systems Assessment Section monitors systemwide conditions in Florida Bay to detect environmental trends, and to document the effects of water management and restoration activities on bay ecology. Surface water quality mapping of salinity, chlorophyll, other photosynthetic pigments, colored dissolved organic matter (CDOM), oxygen, pH and turbidity has been implemented in Florida Bay for 20 years. Through quarterly and bimonthly high-resolution sampling and spatial data interpolations, the Dataflow program has produced a long-term data set encompassing 1996 to present (May 2017). We present findings from baywide surveys in April, June, August, and October 2016, and January, May, and August 2017. This program benefits such projects as the C-111 Spreader Canal Western Features Project Phase I, Florida Bay MFL, and the Upper Taylor Slough Project.

Methods

The Dataflow mapping system is a portable, self-contained flow-through instrument containing sensors for high speed real-time measurements of water quality. From the moving boat, a continuous stream of water is pumped from the water body though a fixed ram and passed to a series water quality probes. Data values are continuously logged every 5 seconds and merged with a global positioning system (GPS)-based georeference to enable 2-dimensional spatial representations of water quality patterns. Continuous map surfaces for each parameter are created using inverse path distance weighting interpolation from the collected data points (Madden and Day 1992, Stachelek and Madden 2015).

Results

A unique aspect of Florida Bay is its complex geography of shoals and banks, which create distinct basins within the bay that can be hydrologically isolated from each other. This, in addition to periods of low freshwater inflow, limits circulation and allows evaporation to raise salinity to hypersaline levels. Salinity targets and benchmarks have been established in CERP and MFL rules to protect bay biology and Dataflow mapping is a key tool to determining how freshwater inputs and salinity distributions result in impacts on the living resources of the bay.

Salinity

Florida Bay surface water salinities were notably lower in WY2017 than in WY2016, a year in which a historic drought occurred in the southern Everglades and stressful conditions developed through the dry season. Below average precipitation (10th percentile) and elevated salinities (> 70 in parts of central and western Florida Bay) triggered massive seagrass die-off in the central bay in summer 2015. This was followed by a dry season with unseasonably high precipitation in December 2015 due to an El Niño event (75th percentile, see SFER 2017, Chapter 6; Sklar and Dreschel 2017). Heavy rains reduced salinities throughout the bay, especially in the central and far western basins (see the *Florida Bay Benthic Vegetation* section earlier in this chapter), which likely curtailed the die-off, at least temporarily. Baywide, salinities decreased by as much as 17 from December 2015 to April 2016, when salinities were < 35 across the entire bay (**Figure 6-35**).

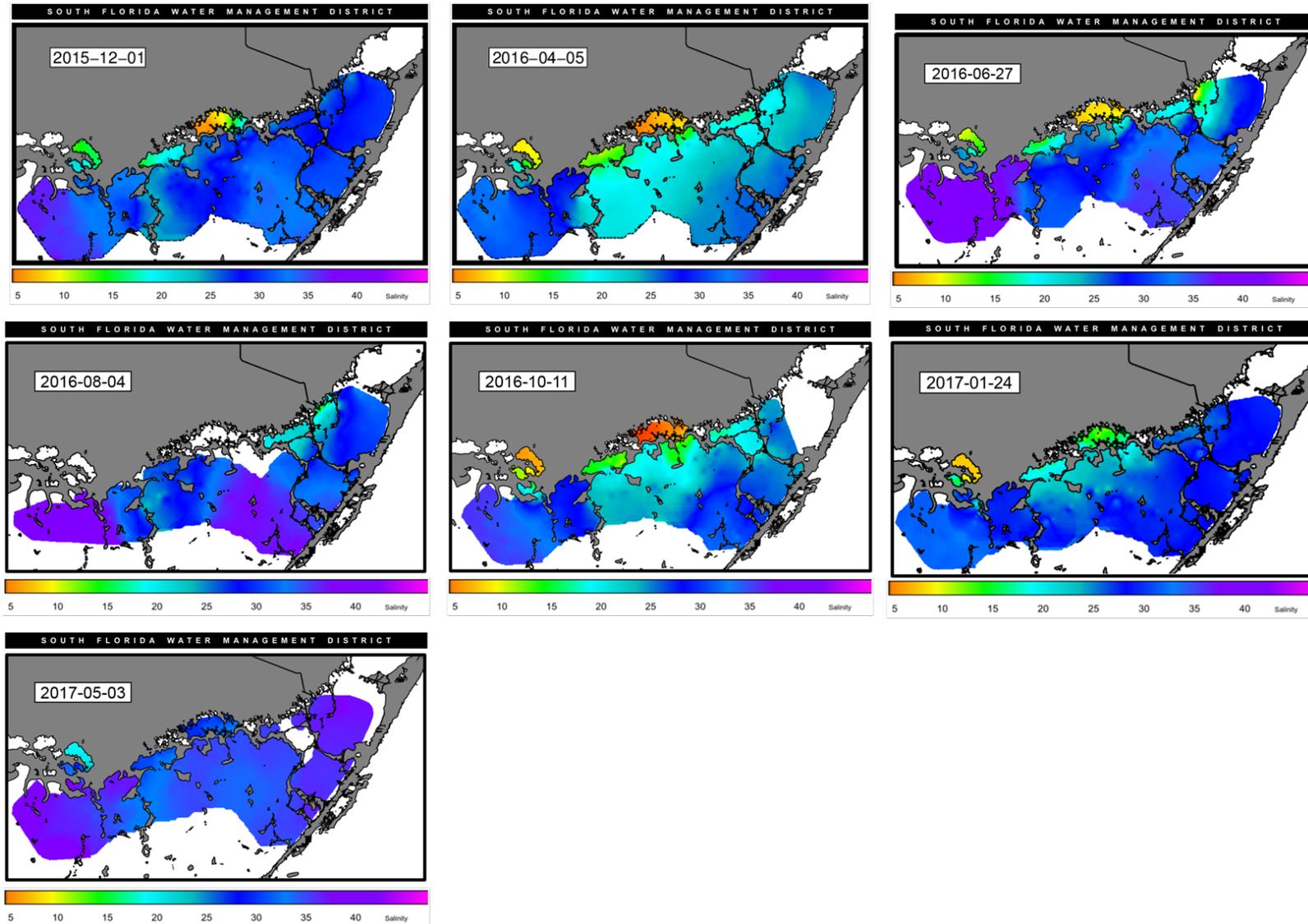[6] Michigan State University, East Lansing, Michigan.

Figure 6-35. Surface salinities mapped from WY2016–WY2018.

After the El Niño rains diminished, salinities began to increase in the western bay through the dry season to 17 to 40 (**Figure 6-35**), a pattern typical during this time of year. However, high temperatures (> 75th percentile) and low rainfall (< 75th percentile) between May and July 2016 caused lower than average freshwater inputs into the bay (see the *Florida Bay Watershed Hydrology and Salinity* section earlier in this chapter) again resulting in hypersaline conditions > 35 throughout large areas of the bay in August, especially in the western region (**Figure 6-35**). Salinities decreased in October responding to increased freshwater inputs following high August rainfall. The influence of freshwater discharge is evidenced by the presence of a horizontal salinity gradient, lowest closest to the coastal Everglades and increasing seaward. Along this gradient, salinities were 5 to 7 in the western lakes and Joe Bay and 10 to 15 in central Florida Bay closest to Taylor River and increased with distance from the freshwater inputs up to 38 in the western bay.

From January through May 2017 salinities increased through the dry season from 10 to 30 in January to 20 to 40 in May. Prior to initiation of the rainy season (early June 2017) salinities were markedly higher than historical averages (70th percentile; see the *Florida Bay Watershed Hydrology and Salinity* section earlier in this chapter).

Chlorophyll and Other Pigments

During WY2016–WY2017, a broad range in Chla concentrations were observed in Florida Bay surface waters. In the western lakes, Chla was consistently elevated (up to 24 µg L^{-1}) compared to the broader regions of the bay where concentrations typically remain below 10 µg L^{-1} (**Figure 6-36**). Based on the historical pattern of seagrass die-off in Florida Bay, dead seagrass leaves and decaying roots are likely to have released large amounts of labile nutrients into the water column, potentially triggering algal blooms (see the *The Florida Bay Project: Water Quality Conditions and Status* section earlier in this chapter). Surface water quality in WY2017 is consistent with this pattern of elevated Chla in areas of die-off, following a lag of several months.

In the year following the seagrass die-off, the concentration of Chla was notably elevated in central and western Florida Bay (15 µg L^{-1}) where large masses of seagrass wrack were observed in WY2016. In October 2016, Chla concentrations reached over an order of magnitude higher in the western than the eastern bay with maxima at 33 and 3 µg L^{-1}, respectively (**Figure 6-36**). This pattern was accompanied by high phycocyanin pigment levels, indicating blue-green algae, with ~3 times greater relative fluorescence units (RFU) in the western-central bay (~145 RFU) compared to < 50 RFU in eastern Florida Bay (**Figure 6-37**). The elevated Chla concentrations experienced in October 2016 have since subsided in recent months as in past blooms due to nutrient limitation (Glibert et al. 2009, Shangguan et al. 2017a, b; May 2017; **Figure 6-36**).
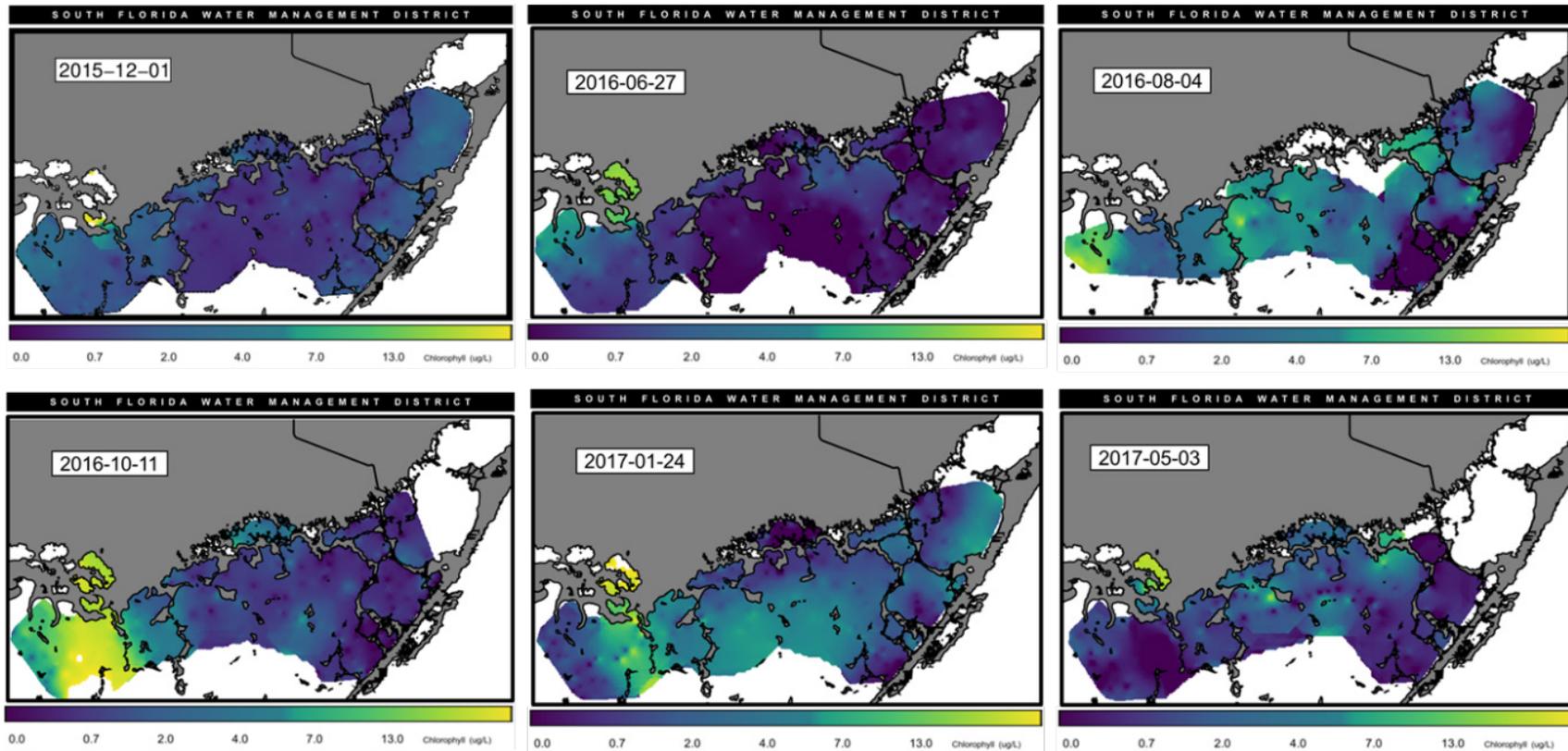
Figure 6-36. Surface concentrations of chlorophyll a (µg L^{-1}) mapped from WY2016–WY2018.
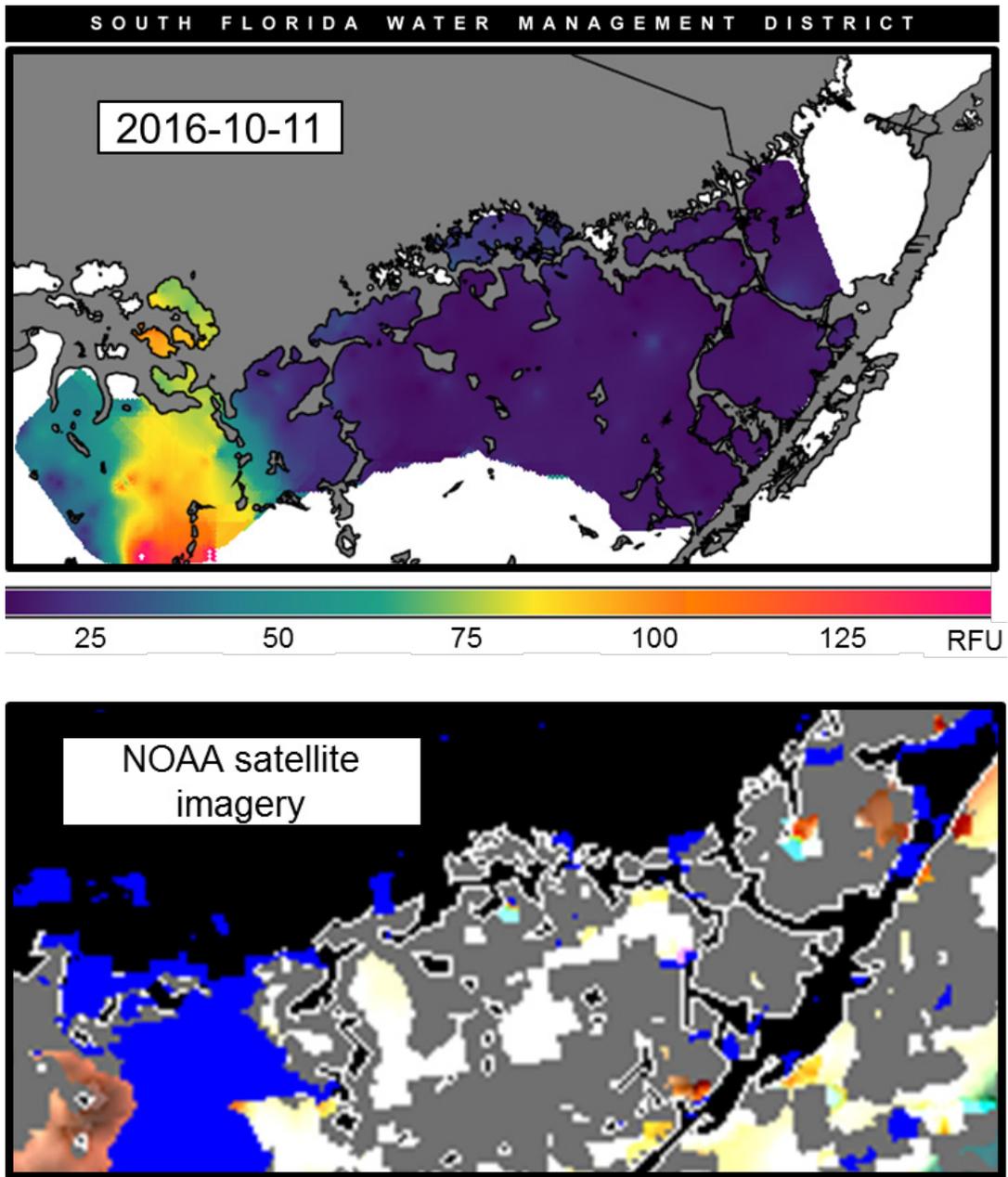
Figure 6-37. Surface concentrations of the pigment phycocyanin is RFU mapped in October 2016 (top). Below, a satellite image provided by NOAA in which the blue band indicates elevated phycocyanin levels.

Ecological Monitoring of Water Management Operations: Aerojet Canal and C-111 Canal

In Joe Bay, centrally located on the north coast of Florida Bay (**Figure 6-38**), salinity in the mid-wet season in August ranged from 15 to 20, starkly contrasting with other coastal bays which were marine to hypersaline. The abnormally high salinity in the coastal bays and in Florida Bay itself (> 40) is attributed to below average precipitation during the wet season. The more normal salinity levels in Joe Bay are likely due to operation of the S-199 and S-200 structures, which discharge water into the Aerojet Canal directly upstream of Joe Bay as part of the CERP C-111 Spreader Canal Western Features Project Phase I.

In May 2017, salinities in eastern Florida Bay were ~35 to 40 prior to a precipitation event June 2 through 4 that created a sharp transition into the wet season (**Figure 6-38**) and the need for emergency water releases from the C-111 canal through S-197 to provide upstream flood protection. Data flow monitoring was initiated to determine how the releases affected salinity and water quality in the discharge area. On August 1, 2017, after several weeks of releases, the northeastern bay region showed a salinity gradient from 5 at the canal mouth to nearly 35 from Manatee Bay into Barnes Sound. Although the salinity directly at the mouth of the canal was unusually low relative to natural conditions, the majority of the affected waters reflected salinity from 13 to 20, which is not outside historical norms for the wet season for this region. This demonstrates the influence of precipitation at both the local scale and freshwater releases from an influx of water upstream through the S-197 canal.
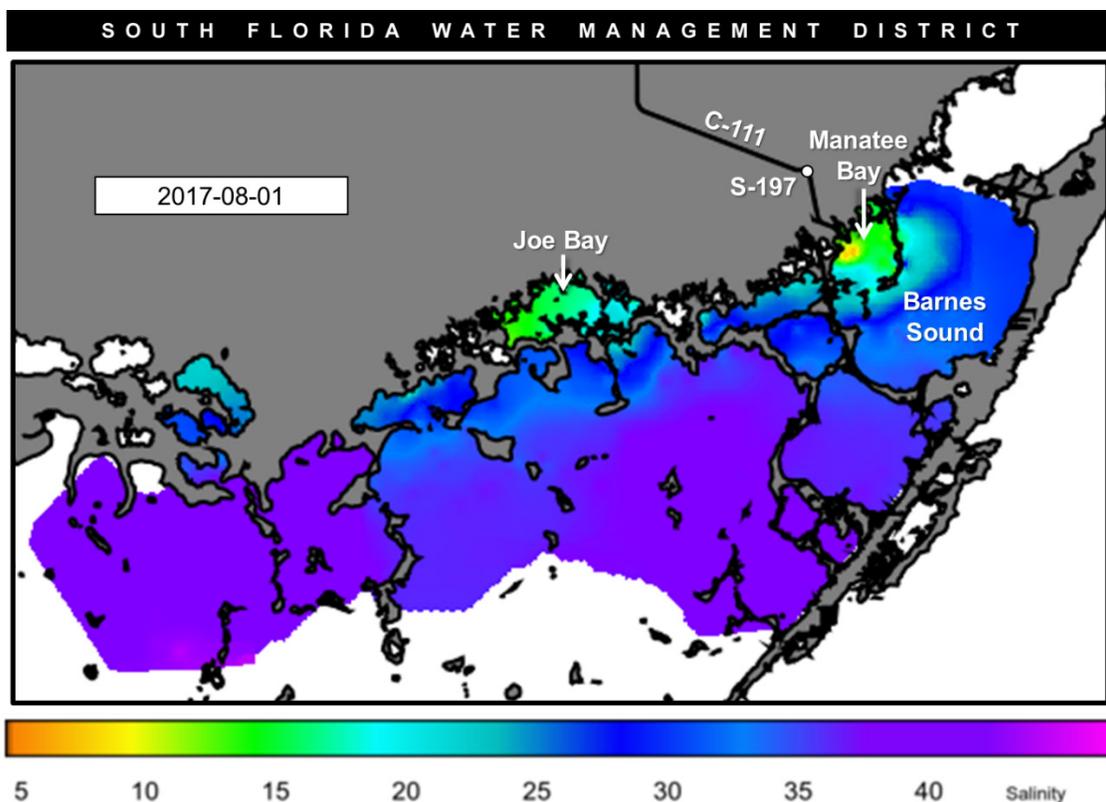

Figure 6-38. Surface salinities mapped in July 2017 (WY2018). The C-111 canal (black line) and S-197 structure (white dot) are indicated north of Florida Bay. Manatee Bay and Barnes Sound are located in northeastern bay and Joe Bay is located at the center of the northern Florida Bay coast.

Relevance to Water Management

Monitoring salinity, chlorophyll, and other parameters at high spatial resolution is critical in this physically complex seascape for early warning of emerging hypersalinity conditions that can lead to seagrass die-off and for monitoring chlorophyll, algal blooms, and potentially harmful blooms. Ongoing restoration efforts are expected to increase their water deliveries. In addition, Taylor River is used as the sentinel monitoring site in the Florida Bay MFL rule. The robust relationship between Taylor River discharge and nearshore salinity suggests that it is an appropriate sentinel monitoring site for tracking trends and conditions of northeastern Florida Bay.

ECOLOGICAL MONITORING OF THE SOUTHERN EVERGLADES FOR THE C-111 PROJECT: NUTRIENTS IN INFLOWS TO FLORIDA BAY

Christopher J. Madden and Tiffany Troxler[2]

Introduction

The Taylor Slough watershed and the C-111 basin subwatershed can deliver significant contributions of freshwater to the estuarine portions of central and eastern Florida Bay, respectively (Hunt and Nuttle 2007). These watersheds may undergo hydrological and ecological change resulting from restoration activities that increase freshwater flow to the area, particularly the C-111 Spreader Canal Western Features Project Phase I, which came online in July 2012, and the Florida Bay Project, which is being constructed in 2017. The District is monitoring how changes in the quantity, timing, distribution, and quality of water delivery affect the ecology of the southern Everglades wetlands and Florida Bay. This integrated monitoring/science project addresses ecosystem dynamics at estuarine sites extending from Garfield Bight in the west to Highway Creek and the Triangle Lands in the east, encompassing all major creek inflow sites. Nutrients, salinity, and water flow are monitored at these major discharge points.

Methods

Nutrients are measured at principle creek discharge points to Florida Bay from Taylor Slough to ensure that influence from upstream sources is not altering nutrient deliveries in ways that could degrade water quality in the estuary. TN and TP are sampled at Alligator Creek, and McCormick Creek in the western slough; Argyll Henry and Taylor Mouth in the central slough; and Joe Bay and Trout Creek in the eastern slough and C-111 panhandle. Samples are collected by autosampler every 18 hours and composited into 3-day samples.

Results

During the period of CY2015-early CY2017, TN increased in the western and eastern creeks by 20 to 50% versus the long-term average (**Figure 6-39**). The western two sites had much higher TN than others, averaging 180 micromoles (μM) long term in Alligator Creek and 100 in McCormick Creek. The central and eastern stations all had long-term averages of about 50. In the central slough stations of Argyle Henry and Taylor Mouth, there was no change in TN during CY2015–CY2017 versus the long-term average of 53 μM, while the eastern sites increased by 20 to 30%. Given the variability at these sites, the short-term increases at the eastern sites, within one standard error of the mean, may not be statistically significant.
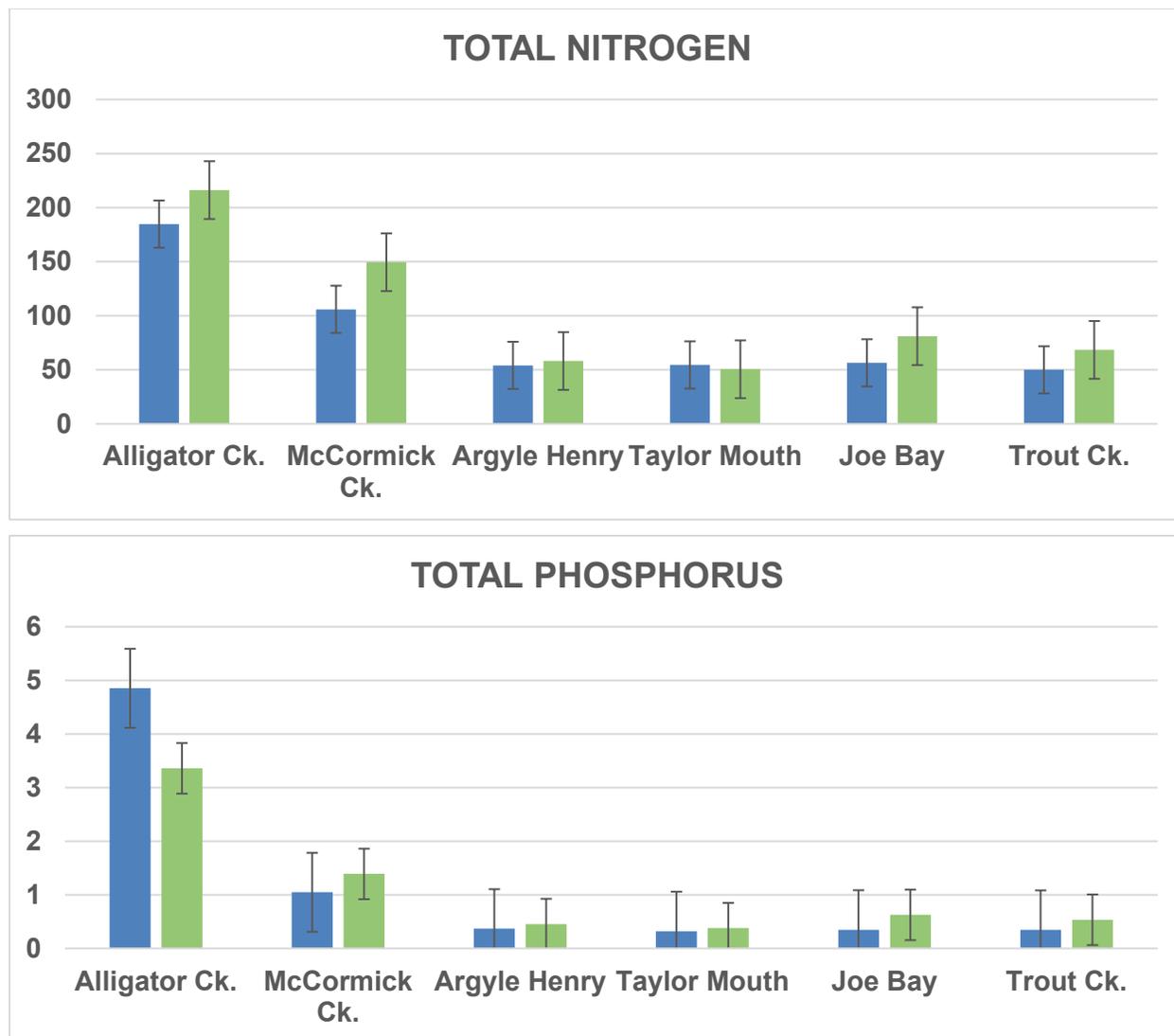
Figure 6-39. Long-term averages (blue) for TN (top) and TP (bottom) nutrient concentrations in six creeks representing major discharges to Florida Bay in uM. The period of record extends from mid-1990s or mid-2000s to present. Recent averages during CY2015–CY2017 (green) for TN (top) and TP (bottom) concentrations are compared to the long-term mean. (Note: Ck – creek)

For TP, the western sites were also historically higher in concentration than the central and eastern sites (**Figure 6-39**). The long-term average in Alligator Creek was about 5 µM and in McCormick Creek, about 1 µM while the central and eastern sites all showed long-term averages of about 0.3 µM TP. In CY2015–CY2017, Alligator Creek reflected a <u>decrease</u> in TP concentration of about 40%, while all other creeks showed slight but non-significant increases, remaining statistically the same as the long-term average.

Focusing on the higher resolution daily measurements that indicate short-term changes in nutrient concentrations, Alligator Creek showed a significant increase in TN (**Figure 6-40**) above the long-term average of 180 beginning in late CY2015 and remained above average through CY2016. After a brief period of about 2 months of below average concentration, TN again became elevated in CY2017 for Alligator Creek. TN in McCormick Creek reflected nearly the same pattern but at significantly lower concentrations, averaging about 110 µM. From CY2015–CY2017 the central slough stations of Argyle Henry and Taylor Mouth showed fluctuations about the mean TN of near 55 µM (much lower than western stations) and did

not trend away from the mean during the study period. Eastern stations Joe Bay and Trout Creek showed increases above the long-term mean of 50 µM by significant amounts—up to three times—during CY2015 and CY2016, dropping in late 2016 and rising again in 2017. The seasonal pattern was quite similar to the western stations, albeit at lower concentrations.
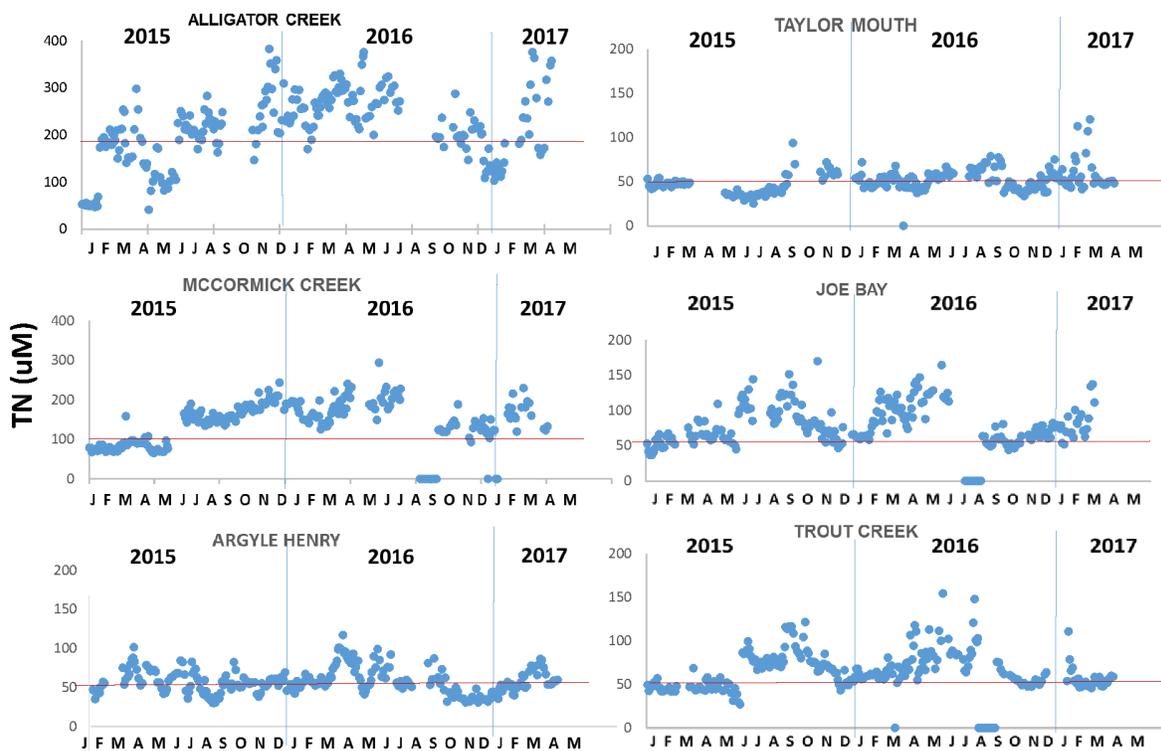

Figure 6-40. Tri-daily TN concentrations from CY2015 to CY2017 in six creeks representing major discharges to Florida Bay. The red line represents the long-term mean.

For TP (**Figure 6-41**), the western creeks again showed the highest historic concentrations, with Alligator Creek's long-term mean at 5 µM, an order of magnitude greater than central and eastern sites. McCormick Creek also showed elevated TP long term, with an average just above 1 µM. Although daily concentrations in Alligator Creek showed a strong decrease below average TP during the period CY2015–CY2017 to almost half that, McCormick Creek increased over the mean during the period, particularly in CY2016 and again in CY2017.

Argyle Henry and Taylor Mouth in CY2015–CY2017 were mostly below the long-term average of TP, but with significant short-term spikes in concentration especially in the late dry season months of March–May in most years. Joe Bay and Trout Creek also trended above the mean in CY2015–CY2016 and, although both sites regressed to the mean in late CY2016 and early CY2017, Joe Bay showed an increase in April–May 2017.
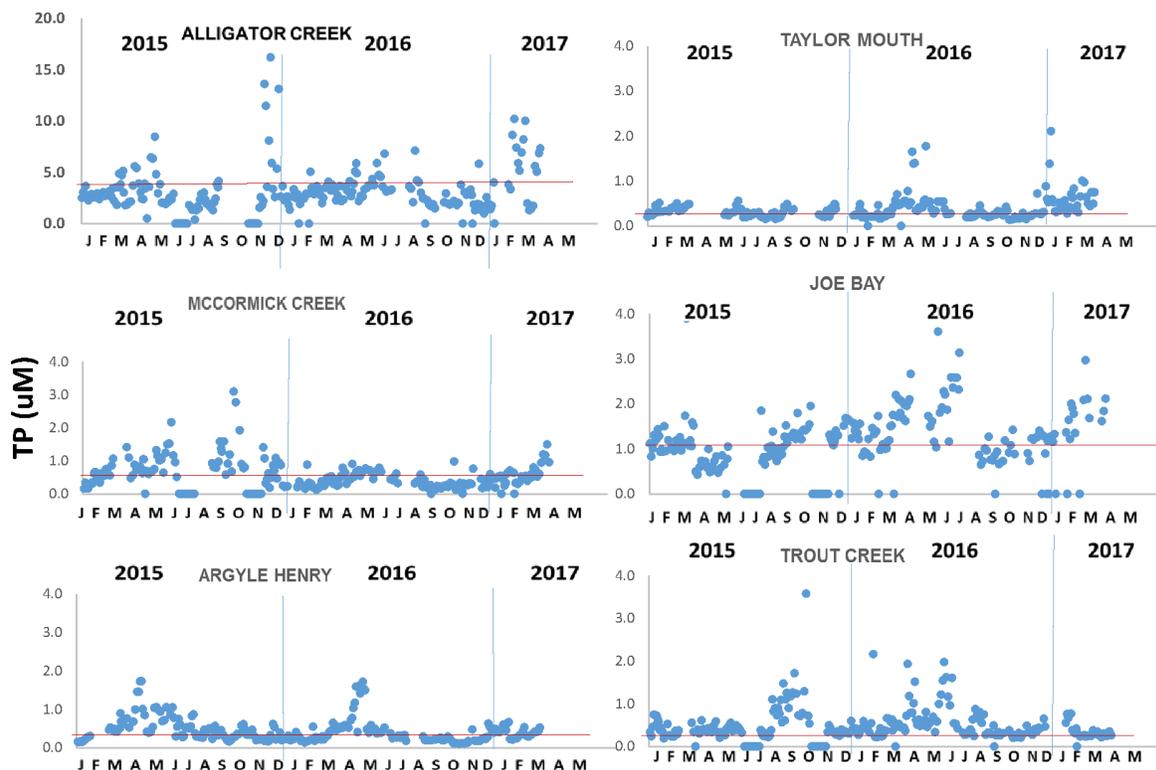
Figure 6-41. Tri-daily TP concentrations from CY2015 to CY2017 in six creeks representing major discharges to Florida Bay. The red line represents the long-term mean.

The pattern of long period seasonal and annual oscillations of increasing nutrient concentrations on the eastern and western flanks of the slough, while remaining steady in the central primary flow-way, may suggest that concentrations are affected by factors other than, or in addition to, upstream freshwater deliveries, such as local processes, marine influence, climate, and precipitation cycles. Significant, anomalous disturbances occurred during the CY2015–2017 period, including severe drought, massive seagrass die-off, and extremely low precipitation and negative freshwater flow, allowing marine water to encroach far upstream in the transition zone creeks. This may partially explain the elevations in nutrients, especially TP, during the driest part of the year. Changes in ionic regime due to hypersalination and the influx of water from the marine end-member may be responsible for mobilization of adsorbed nutrients on particulates. The release of organically bound nutrients due to the die-off and decomposition of SAV is also implicated. Data from additional years of monitoring after return to a more normal hydrologic regime may clarify the sources and reasons for the generally higher nutrient concentrations in recent years.

Relevance to Water Management

It is important to monitor and document ecosystem changes relative to changing water flow patterns resulting from restoration. Alterations in hydrology must be monitored for both negative impacts and positive benefits on the ecosystem through nutrient and salinity regimes, and the vegetation and faunal communities. Long-term monitoring of major discharge points allows managers to discriminate between natural variability and trends that might negatively impact the estuary through changes in nutrient stoichiometry, signs of algal blooms, or eutrophication.

THE PEAT COLLAPSE INVESTIGATION: EFFECTS OF PROJECTED SEA LEVEL RISE ON EVERGLADES COASTAL ECOSYSTEMS

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Introduction

In the coastal Everglades, inland of salt-tolerant mangrove wetlands, are brackish and freshwater coastal peat marshes. In several areas of ENP, these wetlands are and will continue to be exposed to increased duration and inundation of seawater due to sea level rise. This exposure will impact processes that control soil carbon (C) balance such as soil redox potential, soil respiration, and the intensity of osmotic stress to vegetation. The term "peat collapse" has been used to describe a shift in soil C balance, leading to a net loss of organic C and soil elevation, culminating in a conversion of vegetated freshwater marshes to open water. This process has been documented to varying degrees across the United States (Cahoon et al. 2003, Nyman et al. 2006, Voss et al. 2013) and has been attributed to changes in microbial processes, increased sulfate reduction, sulfide accumulation, and inadequate root production contributing to the instability of inland marshes. A critical concern for the management of freshwater and coastal habitats in ENP is the potential for inland marshes, exposed to increasing sea level rise, to collapse (CISREP 2014). If these plant communities cannot adapt to the salinity changes associated with increasing sea levels, significant coastal wetland loss may occur, dramatically altering and increasing the vulnerability of the South Florida coastline. The objective of this experimental study is to investigate the effects of saltwater intrusion on coastal wetlands biogeochemistry and C storage by examining how coupled saltwater intrusion and drought alter costal wetland C procesess.

C cycling in soils is fundamentally linked to the metabolism of microbial communities. Stressors like saltwater intrusion will affect coastal wetlands of the Florida Everglades by altering microbial activities and biogeochemical processes. Through this study, we are starting to understand how soil microbial extracellular enzyme activities (EEAs) differentially respond to ambient and elevated water salinity (10 or 20) and inundation (soil surface exposed by 5 cm or completely submerged) can affect soil C balance and nutrient acquisition in oligohaline sawgrass peat soils. Soil microbial EEAs drive organic matter decomposition, and minor changes in microbial enzyme production can result in large changes in soil C loss. During initial increase (< 10 days) and longer-term exposure (> 90 days) to elevated salinity and inundation, we measured carbon (C) and nutrient-based EEAs and microbial respiration rates. By measuring microbial EEAs and root breakdown rates in freshwater and brackish water peat soils it can be determined if prolonged exposure to saltwater can result in increased C loss through changes in microbial EEAs potential that result in increased root breakdown rates and if brackish peat soils have a lower magnitude response to saltwater intrusion compared to freshwater peat soils because of prior exposure.

Methods

This ongoing study continues with the overall goal to develop the critical building blocks for linking the results from controlled salinity threshold marsh experiments to vegetation changes and shift in soil carbon balance that lead to peat collapse in the coastal Everglades. We established two 80- × 20-m plots in freshwater sawgrass and brackish sawgrass-mangrove transition communities. Field manipulations simulating saltwater intrusion are accomplished by "dosing" plots monthly with a sea salt mix. A total of twelve 1.3-m diameter clear, perforated, and closable plastic chambers were set up within each 80- × 20-m

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