Guana Water Quality

Two-Year Summary Report

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# Background

The objective of this study effort was to quantify spatial/temporal variability of selected water quality parameters within the Guana system. Water quality observations in this system have been very limited historically and this study aimed to develop a baseline survey of water quality conditions over a variety of seasonal conditions and a spatial gradient. Besides the spatial gradient objective, sites were selected at Mickler’s weir and either side of Guana dam to study hydrologic connections.

Monthly water sample collections began in the Guana system in July 2017 with five sites: Micklers, Lake Middle, Lake South, River North and Guana River. This totaled to three stations in the Guana Lake and two in the Guana River. Starting in July 2018, at the conclusion of the one-year pilot study, an additional five sampling stations were added after input and additional funding from FDEP’s Division of Environmental Assessment and Restoration (DEAR) and Florida Fish and Wildlife Conservation Commission (FWC). The original five stations, plus these new five stations, were then sampled for another full year (Figure 1).

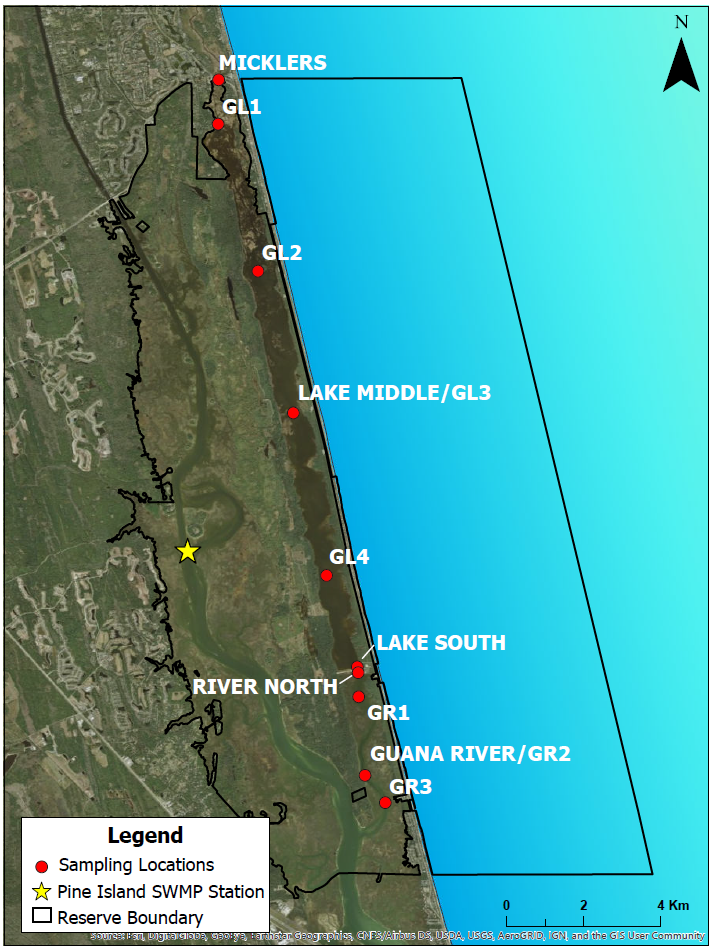


Figure 1: Map of Water Quality Sampling Stations in Guana Lake and River between 2017-2019

The Guana Tolomato Matanzas National Estuarine Research Reserve (GTMNERR) is part of a national program and is one of 29 reserves around the country. The cornerstone of the Reserve System is its System-Wide Monitoring Program (SWMP). This national monitoring program was developed to track long-term change and short-term variability to gain a better understanding of how our estuaries function, change over time, and to predict how coastal systems respond to natural and human-induced change. SWMP was implemented at the GTMNERR in 2002 and consists of three core components: water quality, weather, and vegetation. The Reserve’s water quality and nutrient station located in the Tolomato River (30.05085, -81.367467) was used as a reference station for this study. This station has had monthly water samples collected for analysis since 2002 and has often served as a baseline for the Guana River.

## Characterization

Northeast Florida has a humid subtropical climate characteristic of the Gulf and Atlantic coastal plain of the southeastern United States. Seasonal variation in temperature within the Reserve follows that of rainfall with a summer period of high temperatures between June and September and a cooler period extending from December through March. The average air temperature recorded at the FDEP-Stevens Tolomato River Platform <http://fldep-stevens.com/station.php?site=8720494> during the timeframe of the sampling was 21.5 (C).

The average annual rainfall is approximately 52 inches (132 cm) per year, with the wet season extending from June through September. During the study period, Hurricane Irma (September 2017) brought abnormally high amounts of precipitation to the area and the effects of this storm were observed for many months following the event (Figure 1).

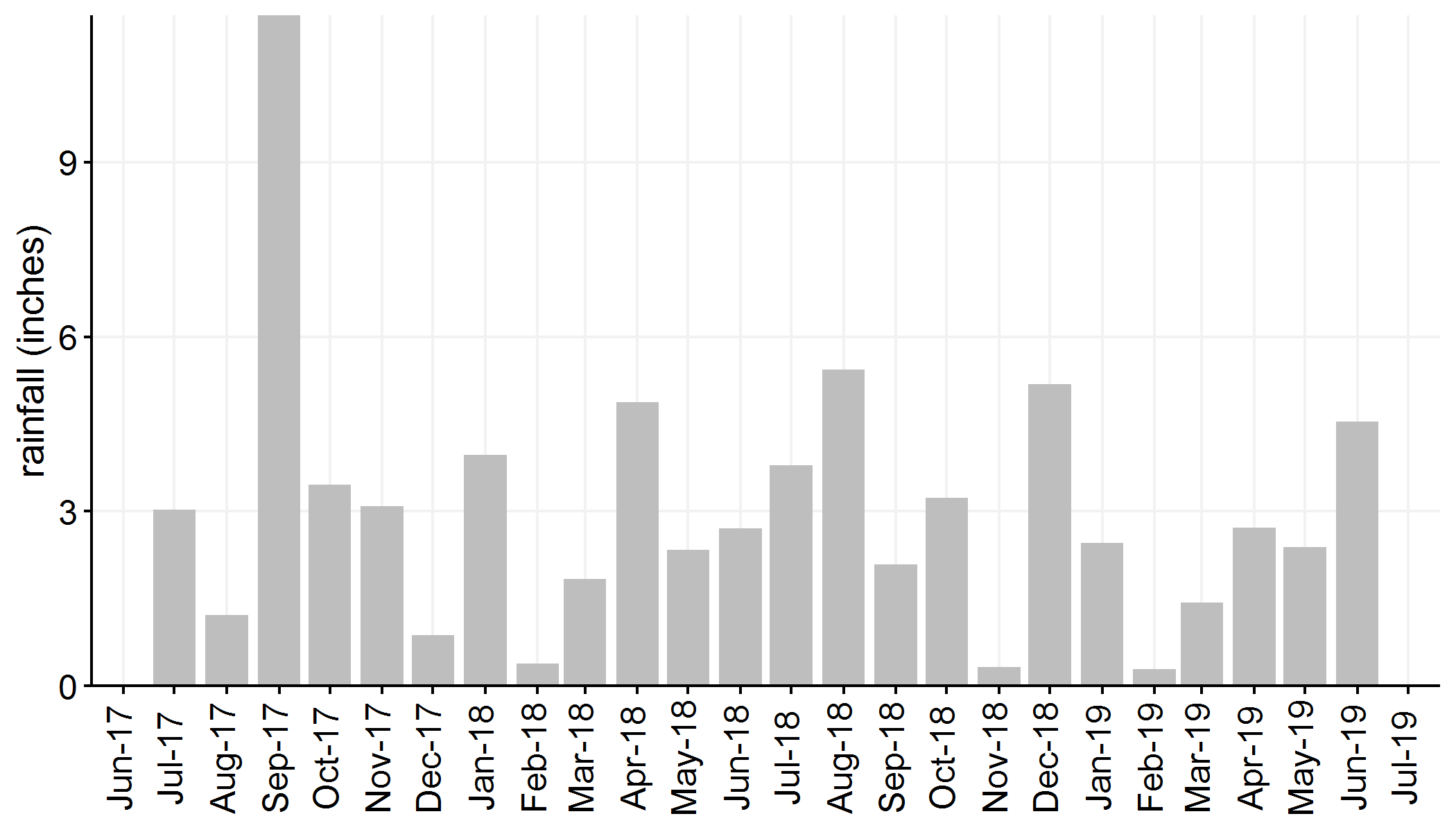


Figure 1: Monthly total rainfall during the study period (July 2017 - June 2019) observed at the Florida Department of Environmental Protection’s Tolomato River Station #872-0494 <http://fldep-stevens.com/station.php?site=8720494>.

### Guana

The headwaters of the Guana River originate in the Diego Plains drainage area in Ponte Vedra Beach. This drainage basin encompasses approximately 7,800 acres (3,157 hectares). The Guana River runs parallel to the Tolomato on the seaward side, with the two lagoons joining 7 miles (11.3 km) north of the St. Augustine Inlet. The natural hydrology of the Guana Tolomato Matanzas system has been somewhat altered by water control structures, including dikes, inland wells, drainage ditches and a dam across a portion of the Guana River. Guana Lake receives water from the north at Mickler’s weir and water periodically exhanges with Guana River through the Guana dam depending on water level management and tidal conditions. As such, there often is a distinct latitudinal gradient in salinity within the lake, as evident in data collected at the time of water sample collections (Figure 2).

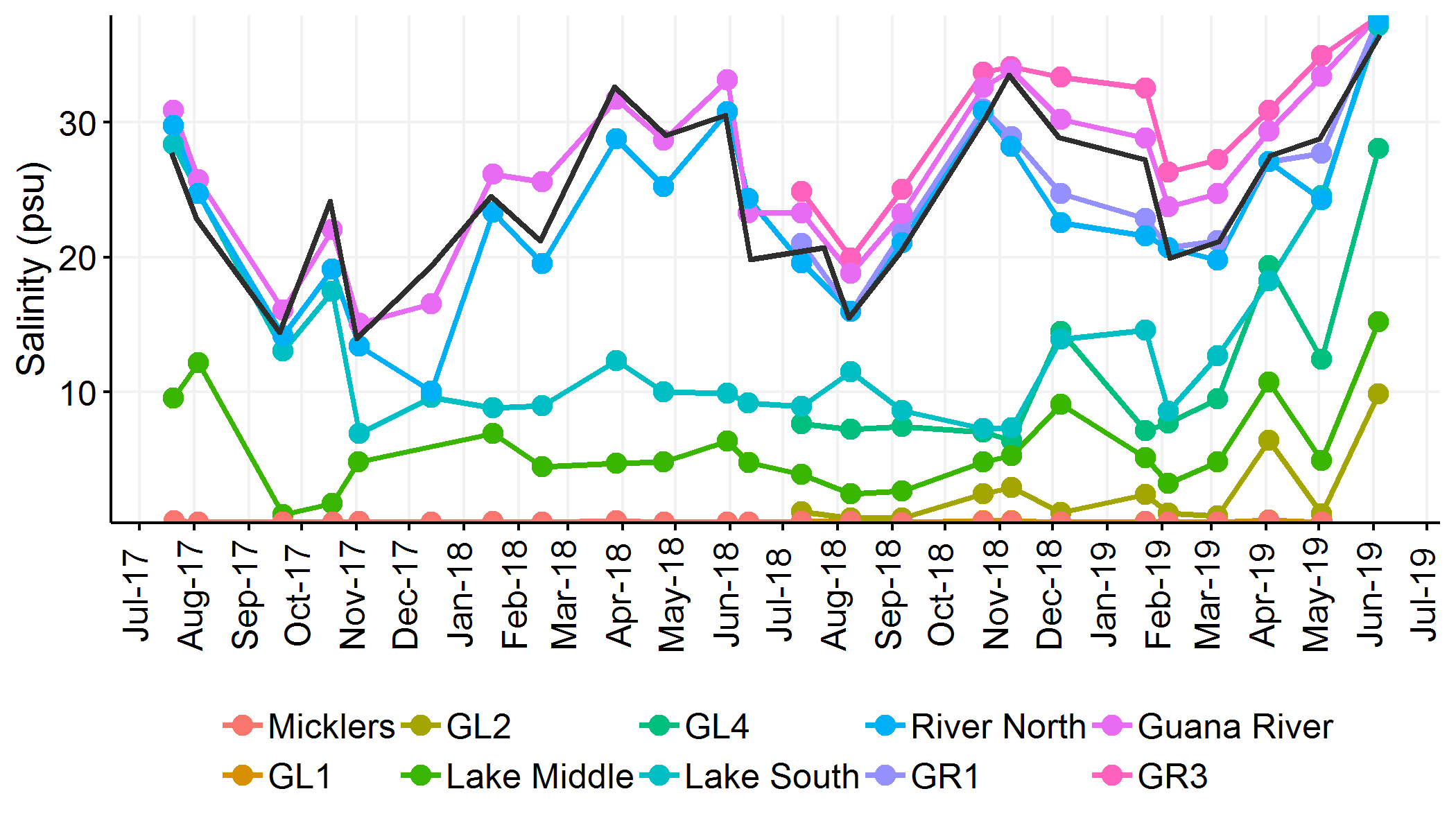
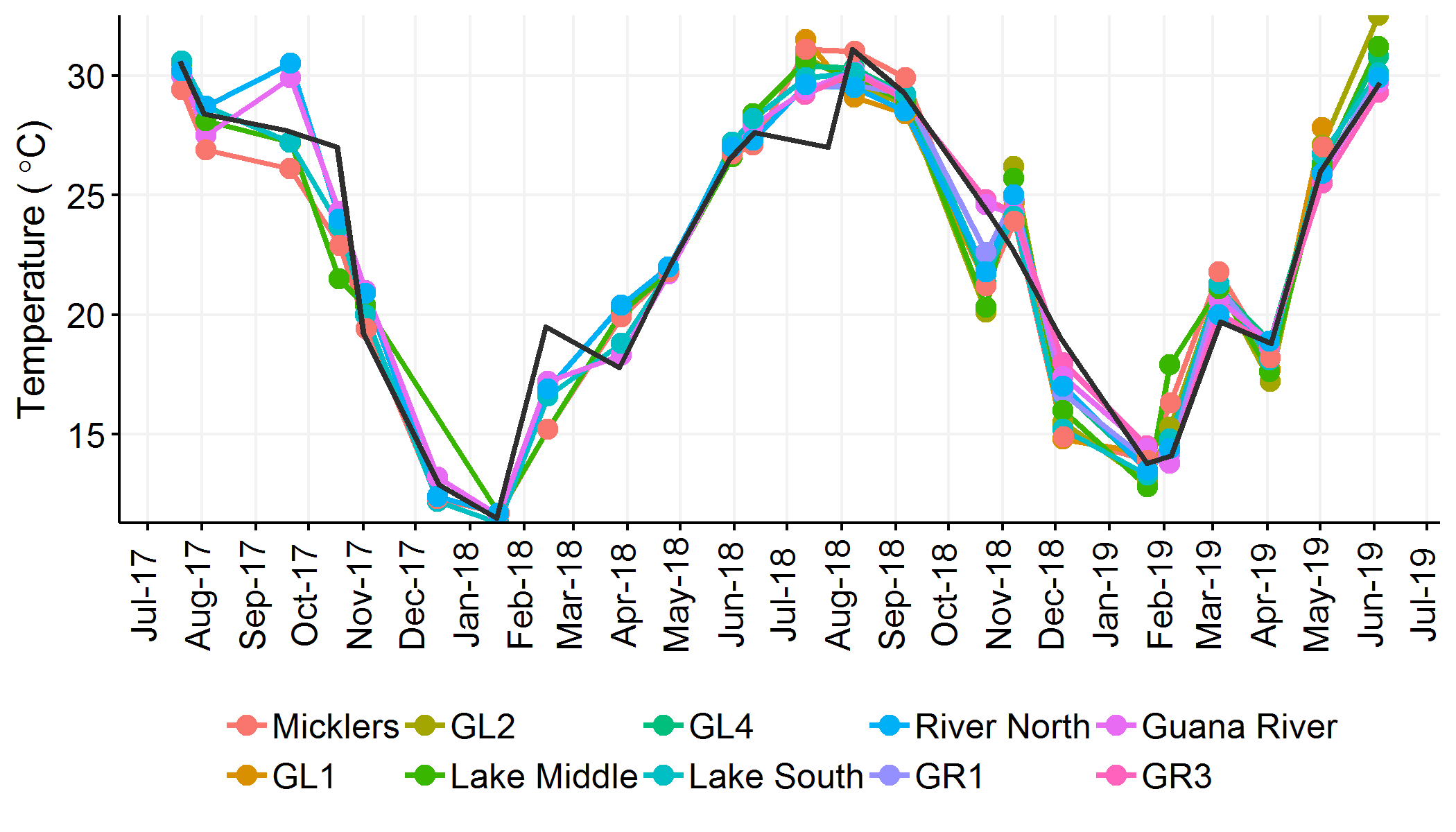


Figure 2: Salinity (psu) measured at each sampling station on the day of water sample collections. Black line represents data collected at the GTMNERR Pine Island System-Wide Monitoring Program station

Water temperatures in both the lake and the river follow similar seasonal patterns and do not diverge too much between waterbodies (Figure 3).



### Pine Island Reference Station

The Tolomato River Basin is about 18 miles (29 km) in length with a drainage area of approximately 53,802 acres (21,773 hectares); it converges with the Matanzas River and Salt Run from the south before flowing into the Atlantic Ocean at the St. Augustine Inlet. The Pine Island (PI) station is at Channel Marker 25 (30.05085, -81.367467) in the Tolomato River. This site is located within the Guana River Marsh Aquatic Preserve in the northern section of the GTMNERR. Channel Marker 25 is adjacent to Pine Island near the mouth of Deep Creek, which provides freshwater drainage from silviculture-dominated uplands in the northwestern portion of the Tolomato River basin. The average depth at this site is approximately 3.3 m with a tidal range of about 1.6 m; the bottom type is muddy sand. Salinity ranged from 7.2 to 34.5 psu during 2018.

## Guana Dam

The FWC maintains water and salinity levels of Guana Lake through the use of swing gates in Guana Dam. The gates allow for controlled discharge and recharge of the lake while still maintaining two-way flow. The lake drawdown usually begins mid-February and last through April. During this period, lake water is discharged through the dam at a rate of approximately six inches per month until desired water levels are reached. Lake recharge usually takes place between July and October with the intent of maintaining marine strength salinity at the south end of the lake and a salinity of 8-12 ppt at Six Mile Landing, which is near the GL2 Site.

In 2018 the dam was closed for construction, and water exchange between the lake and river ceased. The first closure occurred at the end of March and lasted for roughly three months. During this time, the lake side underwent little change in salinity levels. Mid-July the dam was reopened for a month and an initial lake discharge followed by a brief recharge was performed. This reopening lead to the convergence of salinity levels between the river sites and Lake South (Figure). Salinity levels on the river side dropped by an average of 20.30% across all river sites. This sudden change in salinity can be attributed to discharge of mesohaline waters into the system as well as an increase in rainfall during the summer months. The lake side also saw a change in salinity; however, Lake South, which lies just north of the dam, was the only noticeably impacted site. Lake South salinity levels increased from 8.93 ppt to 11.49 ppt, a 29% increase.

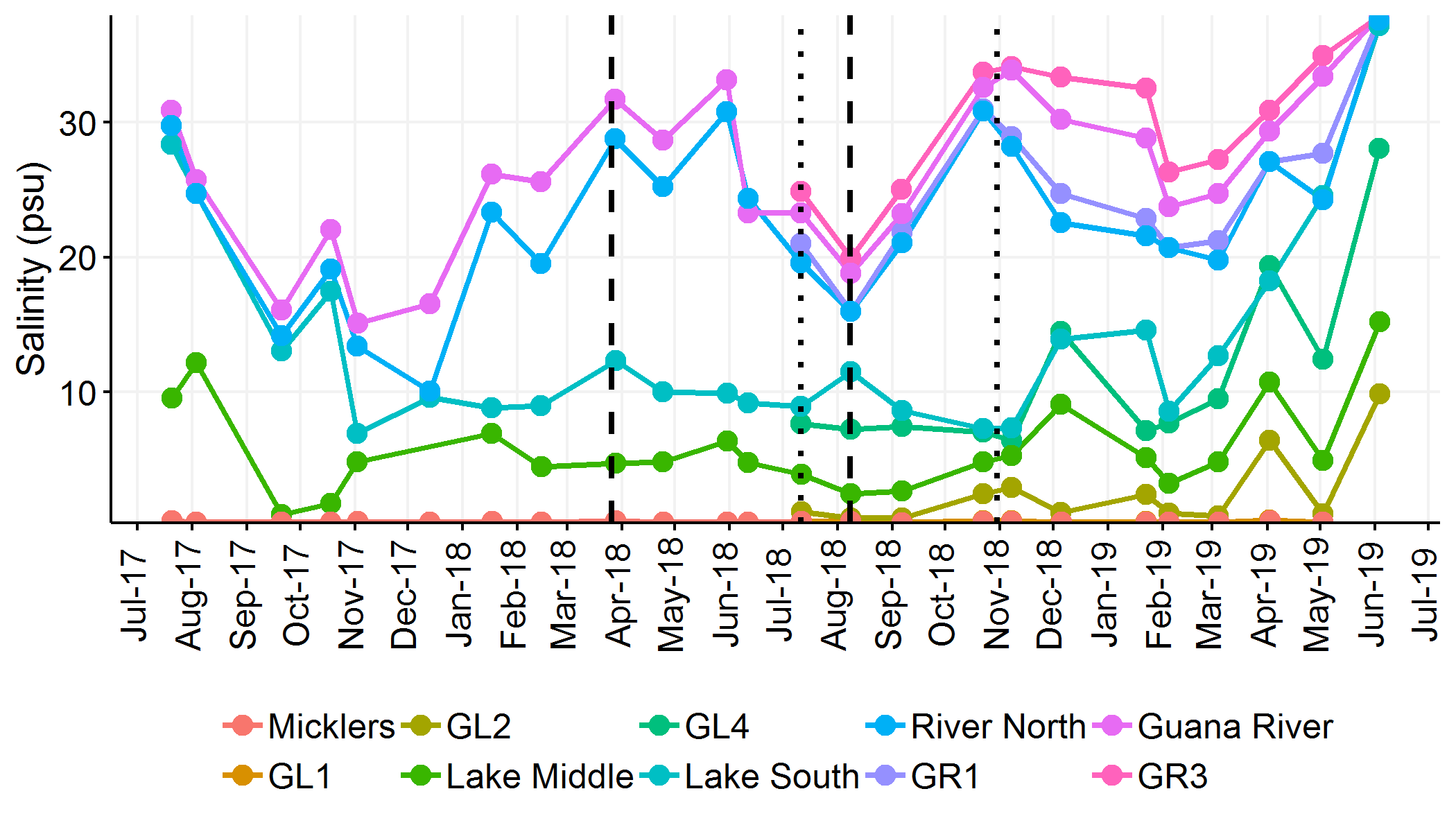


Figure #: Salinity (psu) measured at each sampling station on the day of water sample collections. Vertical lines indicate status of the Guana Dam during construction in 2018. Dashed lines are when the dam was closed off for construction and the dotted lines are when it was opened again for water exchange.

Again the dam was closed in August and remained closed until October. After the second closure, salinity levels between the river sites and Lake South diverged. The river side salinities increased to or above previous levels, while the Lake South site decreased to its prior salinity level. With reopening of the dam at the end of October, the converging effect between the two sides was not as drastic for the river sites. River levels did decrease across all sites, but the major difference was seen on the lake side. Whereas with the first reopening only Lake South seemed to be affected, the second reopening resulted in significant increases at Lake South, GL4, and Lake Middle (91%, 107%, 89% increase, respectively). The difference between the two reopenings was a result of the how the dam structure was setup for water exchange. Instead of a discharge, the second reopening was immediately followed with a lake recharge which allowed for more exchange of polyhaline waters from Guana River.

## Assessment

Florida’s Department of Environmental Protection (DEP) determines legal water quality standards for each state waterbody. **In the Guana system, there are multiple waterbody types:** the Lake is a Class III Estuary and the River is a Class II Estuary. As such, they have different water quality standards per statute 62.302.530. The following threshold levels are included in the figures used in this report.

Table x: Annual Geometric Mean threshold values for nutrient criteria for Class II (River) and Class III (Lake) Estuary waters.

|  |  |  |
| --- | --- | --- |
| Parameter | Lake | River |
| Chlorophyll a (μg/L) | 11 | 6.600 |
| Total Phosphorus (mg/L) | NA | 0.105 |
| Total Nitrogen (mg/L) | NA | 0.650 |
| Enterococcus (MPN) | 35 | 35.000 |
| Fecal coliform (MPN) | NA | 43.000 |
| Dissolved Oxygen (% sat) | 38 | 38.000 |

# Methods

All samples were obtained during the same ebb tide of each sampling day and within one day of the GTMNERR monthly collections for nutrient analyses at the System-Wide Monitoring Program stations. No distinction was made between neap and spring tide conditions. All water samples were sent to ALS Environmental Labs in Jacksonville, FL for nutrient and bacterial analyses with the exception of September and December 2018 and February and May 2019, which were sent to the Florida Department of Environmental Protection (FDEP) Central Laboratory in Tallahassee, FL. In September 2018 and February 2019, additional samples were taken and sent to Source Molecular Labs in Miami, FL for fecal source tracking. *For more specific information regarding methodology, please see the provided metadata report*.

All of the data included in the calculations and figures have been provisionally reviewed by GTMNERR staff. Included in the dataset are laboratory remarks, which use the FDEP lab codes, and flags, which are determined using the National Estuarine Research Reserve (NERR) System’s Centralized Data Management Office (CDMO). The Data Management Manual can be downloaded from <http://cdmo.baruch.sc.edu/request-manuals/>. For any further questions, please reach out to the project’s principal investigator, Dr. Nikki Dix ([Nikki.Dix@floridadep.gov](mailto:Nikki.Dix@floridadep.gov)).

# Physical and Chemical Indicators of Water Quality

### Dissolved oxygen (% saturation), turbidity, and sucralose.

When plankton (algae) bloom, oxygen in the water gets depleted as the dead algae sink in the water column and are decomposed by bacteria. Hypoxic (oxygen poor) conditions often physically stress many of the animals in our estuaries, but anoxic (completely depleted of oxygen) conditions can kill them.

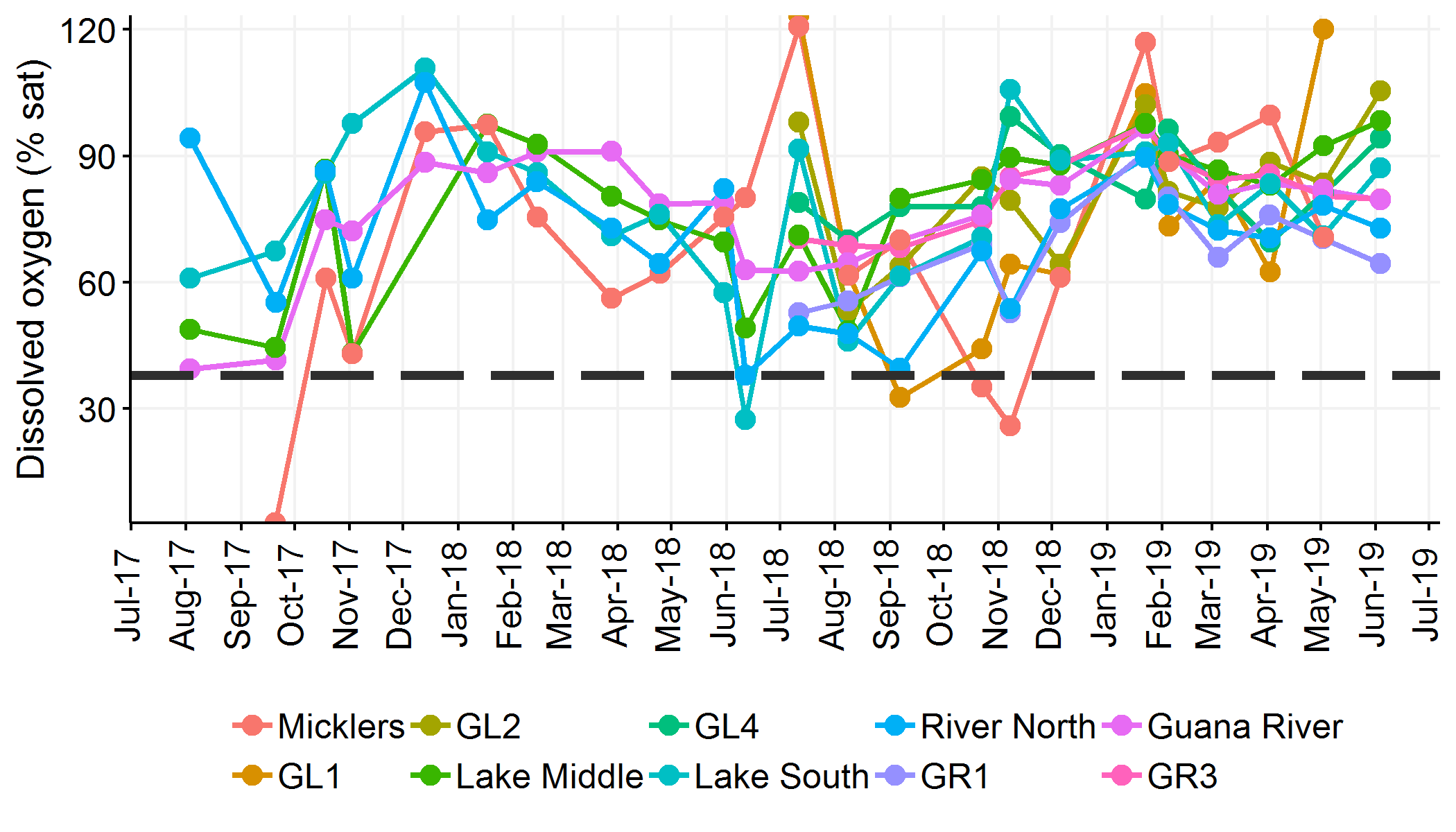


Figure 4: Dissolved oxygen (% saturation) measured at each sampling station on the day of water sample collections. Horizontal line represents the Florida state threshold criteria of 38% saturation for both Class II and III estuarine waters.

### Turbidity

[Insert Text Here to describe how important or why we measure turbidity]

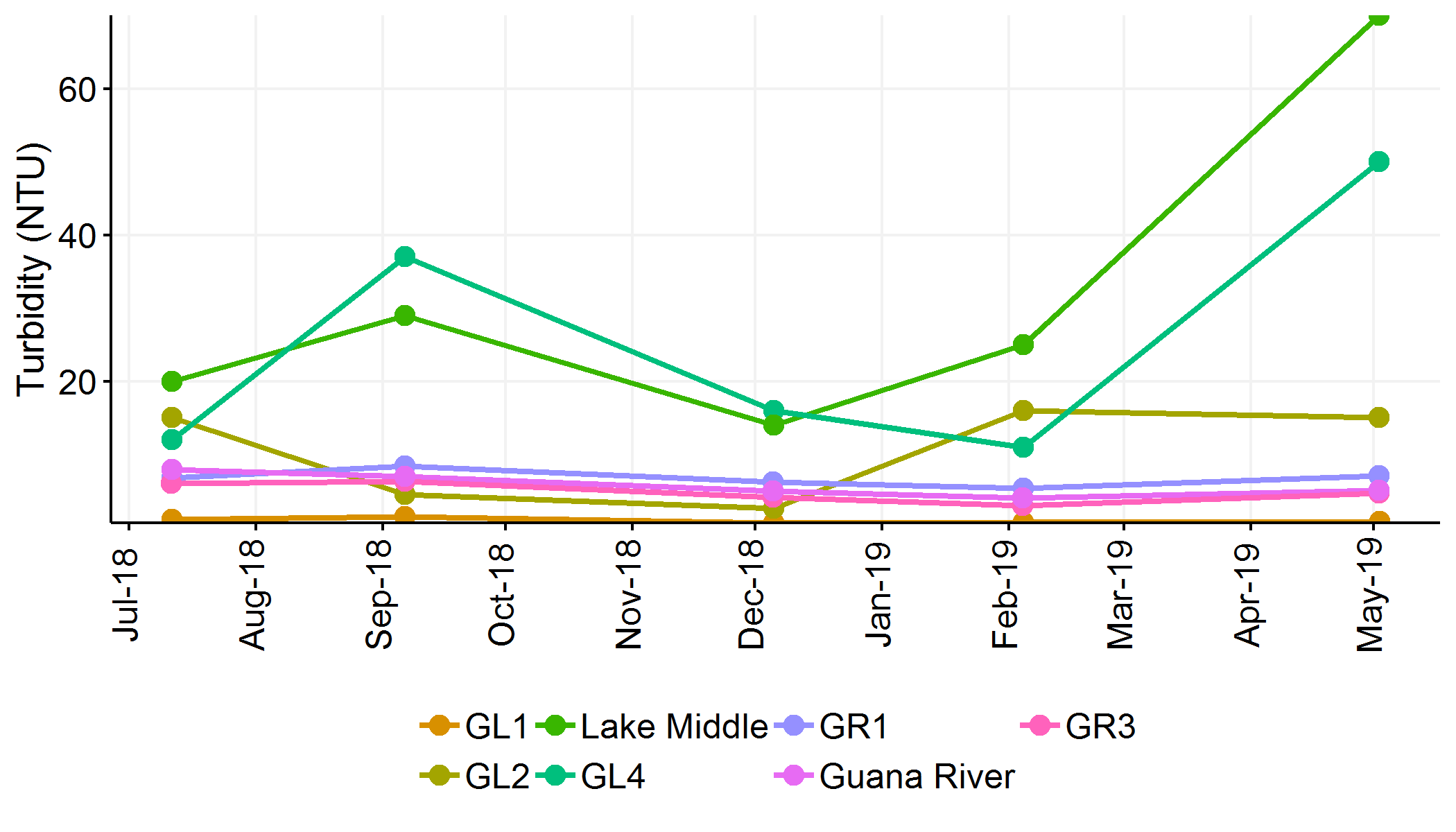


Figure x: Turbidity (NTU) and Total Suspended Solids (TSS).

### Sucralose

[Insert Text Here to describe how important or why we test for sucralose]

Table x: Sucralose results

|  |  |  |
| --- | --- | --- |
| Site | September 2018 | February 2019 |
| GL1 | 1.60 | 2.10 |
| GL2 | 1.40 | 1.50 |
| Lake Middle | 0.87 | 1.20 |
| GL4 | 0.51 | 0.69 |
| GR1 | 0.26 | 0.38 |
| Guana River | 0.22 | 0.30 |
| GR3 | 0.22 | 0.19 |

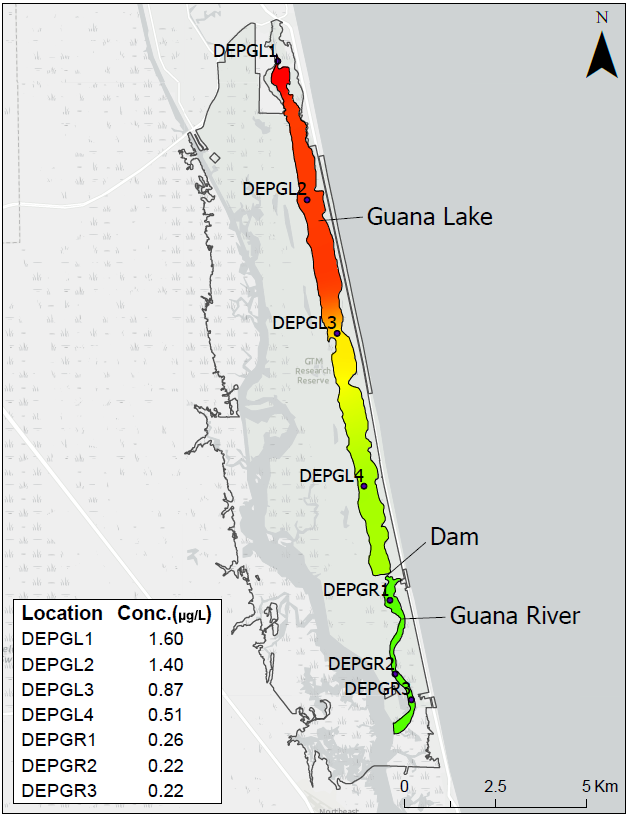


Figure x: Map of interpolated sucralose in Guana system in September 2018.

## Nutrients:

In 2000, it was estimated that 60 percent of coastal waters in the United States were moderately to severely affected by nutrient pollution (Howarth et al. 2000). Phosphorus and nitrogen are the most important nutrients for plants to grow. In small amounts they are beneficial to many ecosystems. Thus, they are used in many agricultural and gardening practices for that same purpose. During the rainy season, many of these nutrients are then washed into our inland waterways and estuaries, where they are taken up by aquatic plants for reproduction and growth. This may lead to **eutrophication**, which is the feeding of a waterbody, or the enrichment of water by excess nutrients resulting in an increase in algal biomass.

### Nitrogen

**Sources:** Nonpoint source, organic waste, detergents, fertilizer, manure, industrial effluent, internal loading (bottom sediment)

**Major contributor:** Soil erosion during flooding.

Under normal conditions, phosphorus is usually a limiting nutrient. Phosphorus attaches to soil particles and easily enters the system through run off or flooding. This means we should expect to see TP increase during/after the recharging of the lake? Is that what is happening?

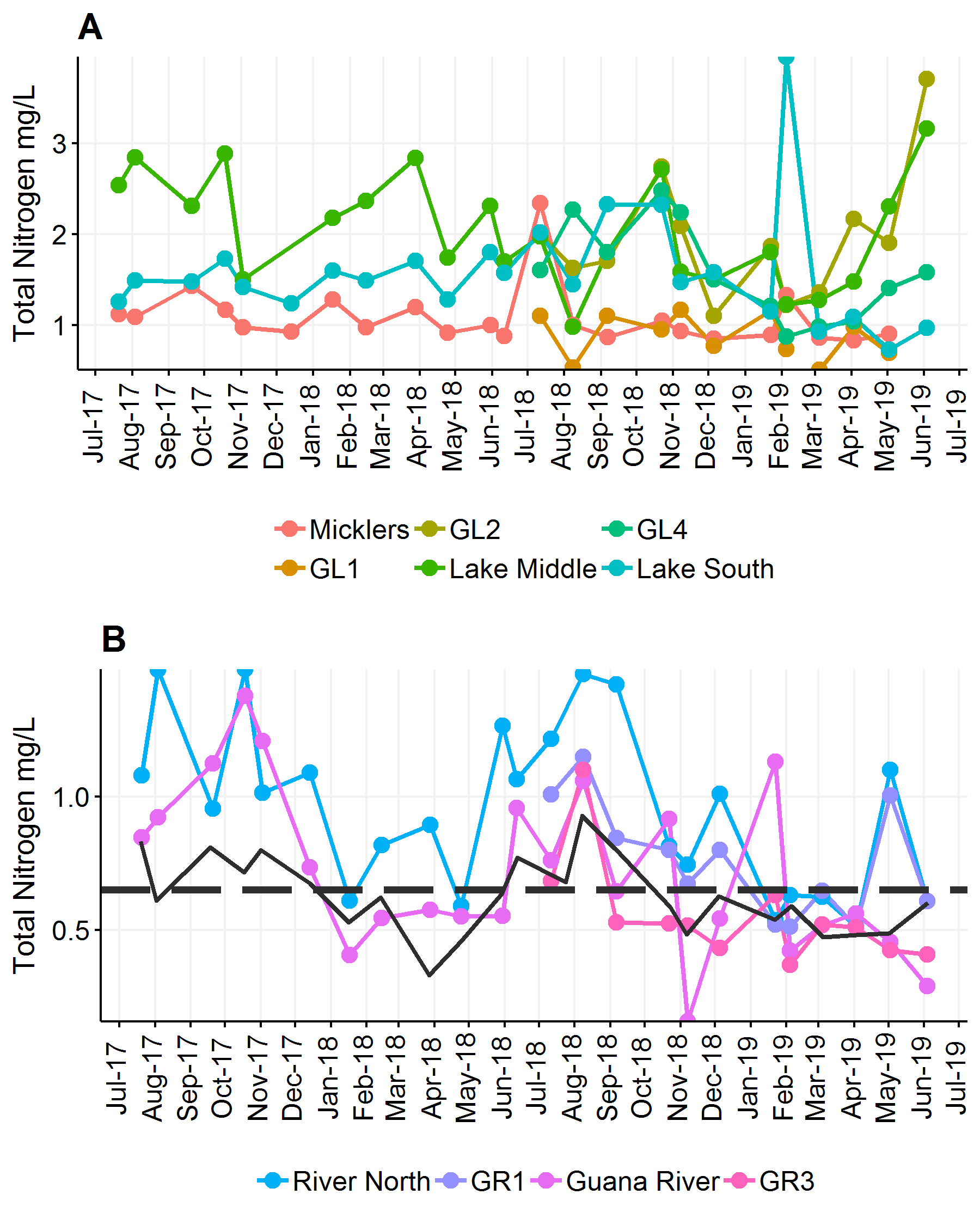


Figure x: Total Nitrogen (mg/L) collected at each sampling station on the day of water sample collections in the lake (A) and river (B). Horizontal line represents the Florida state threshold criteria for Class II estuarine waters (0.65 mg/L).

### Phosphorus

**Sources:** Fertilizers (chemical and animal), sewage, atmosphere, animal waste

**Major contributor:** Rainwater runoff

Like phosphorous, nitrogen is essential to aquatic ecosystems. In abundance it causes ecological imbalance, resulting in rapid growth of algal blooms, which reduce water quality.

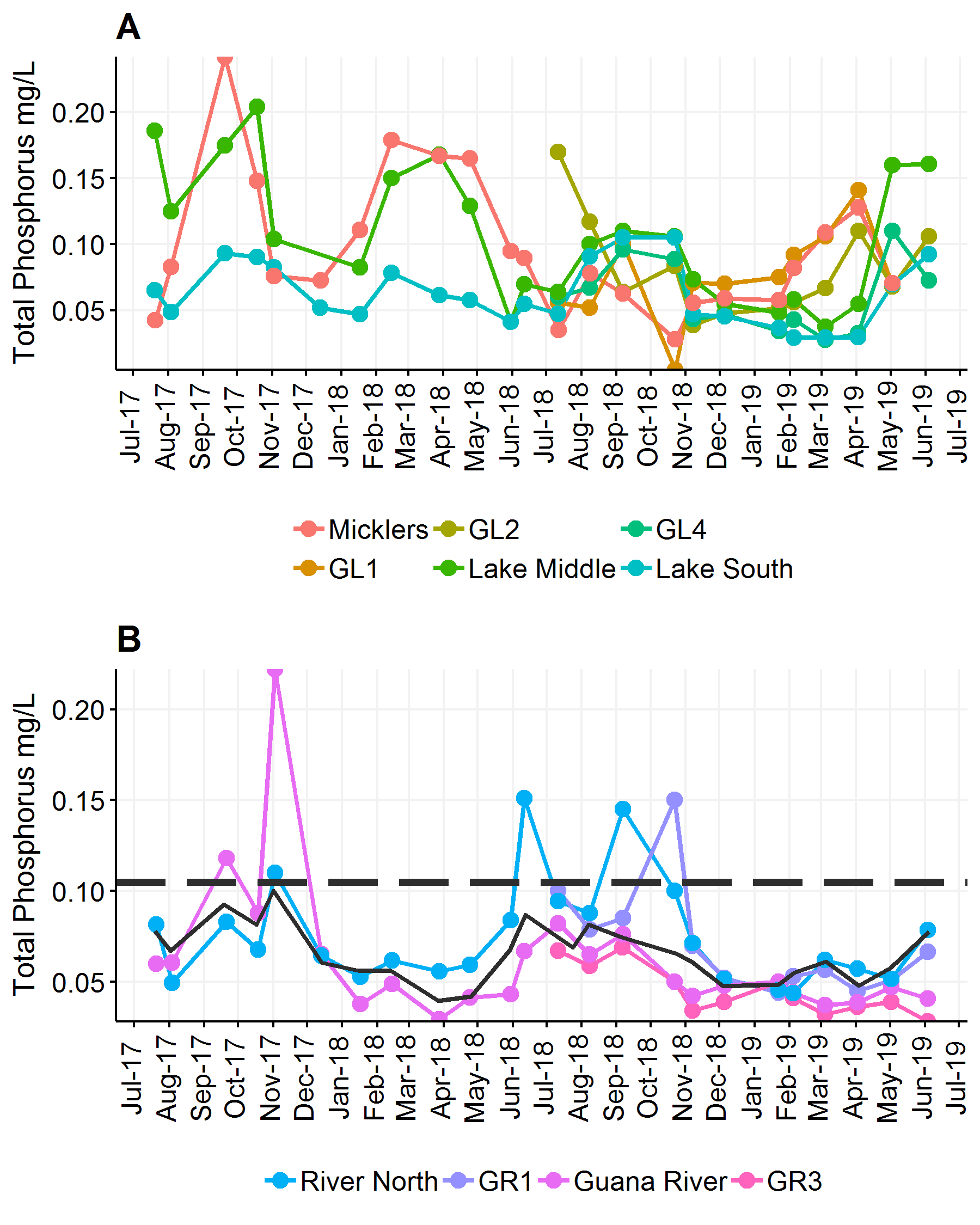


Figure x: Total Phosphorus (mg/L) collected at each sampling station on the day of water sample collections in the lake (A) and river (B). Horizontal line represents the Florida state threshold criteria for Class II estuarine waters (0.105 mg/L).

# Biological Indicators

## Plant Pigments

Plankton are the base of aquatic food webs. They, like terrestrial plants, are photosynthetic (containing pigments like chlorophyll *a*) and can harness the energy from the sun to create their own food. They are then the main source of food for many aquatic animals. The chlorophyll *a* data presented in the figures and used in calculations of the annual geometric mean has had the pheophytin correction.

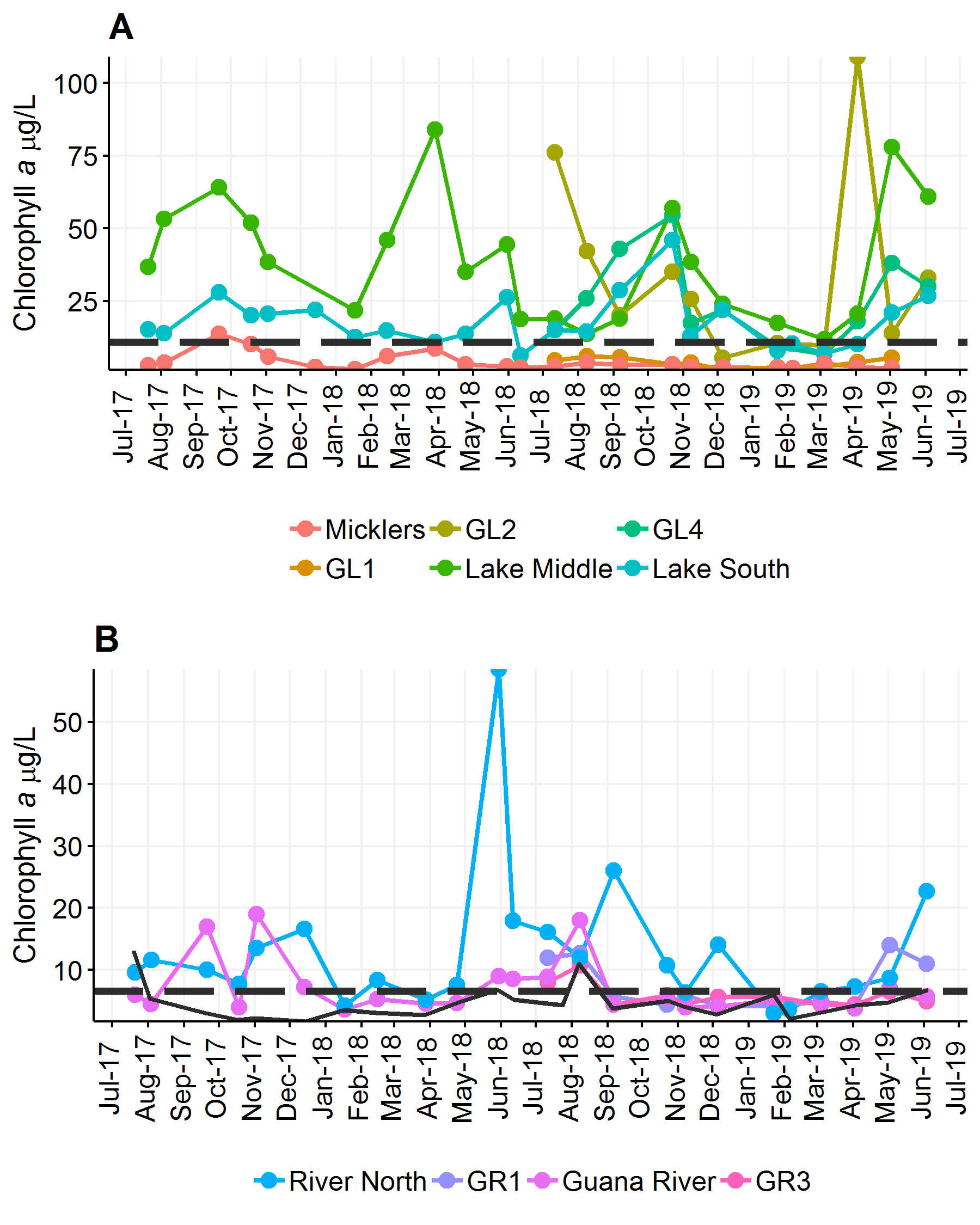


Figure x: Chlorophyll a (ug/L) concentrations (with pheophytin correction) collected at each sampling station on the day of water sample collections in the lake (A) and river (B). Horizontal lines represent the Florida state threshold criteria for Class II (6.6 ug/L) and Class III (11 ug/L) estuarine waters.

## Bacteria

Fecal indicator bacteria (FIB) are bacteria such as *Escherichia coli* (E. coli) and *Enterococcus*, which live in the gut of warm-blooded animals and are introduced into the environment through fecal matter. Most FIB are harmless to humans, but the presence of FIB indicates that pathogens also found in fecal matter, which are harmful to humans, may also be present. In the Guana system, thresholds are only present for fecal coliform bacteria in the River.

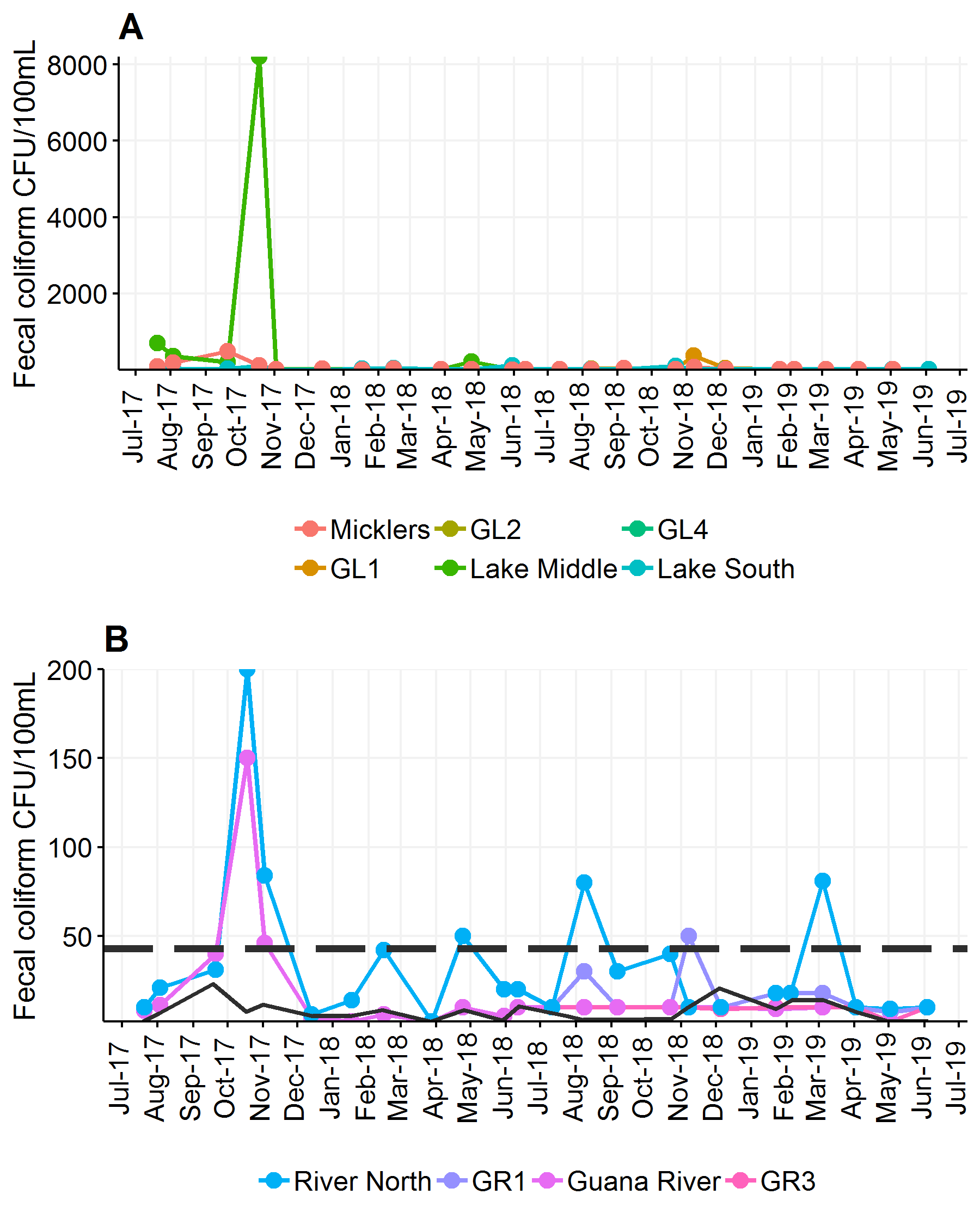


Figure x: Fecal coliform (MPN/100mL) concentrations collected at each sampling station on the day of water sample collections in the lake (A) and river (B). Horizontal lines represent the Florida state threshold criteria for Class II estuarine waters (43 MPN/100mL).

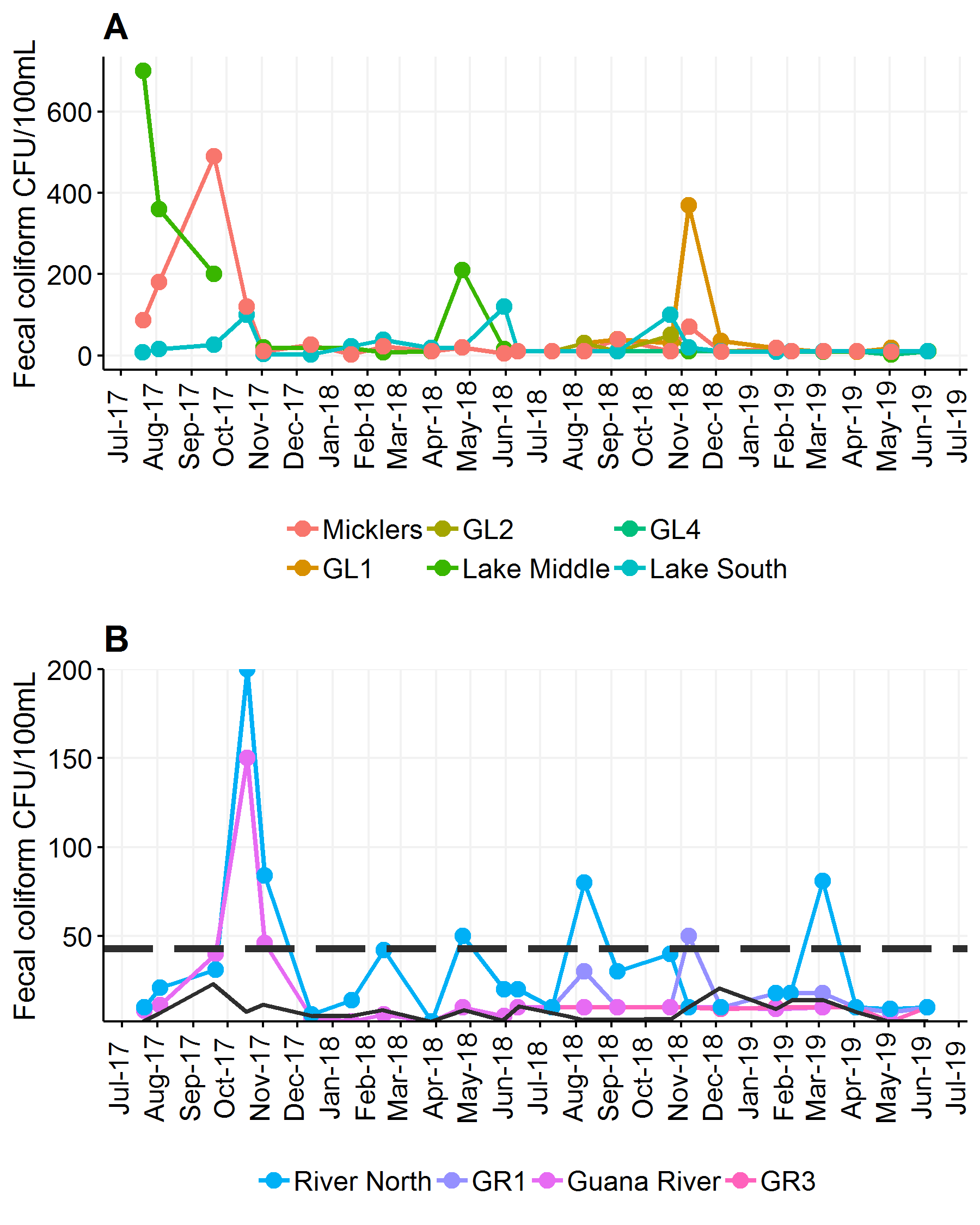


Figure x: Fecal coliform (MPN/100mL) concentrations collected at each sampling station on the day of water sample collections in the lake (A) and river (B) with adjusted axis in the lake. Horizontal lines represent the Florida state threshold criteria for Class II estuarine waters (43 MPN/100mL).

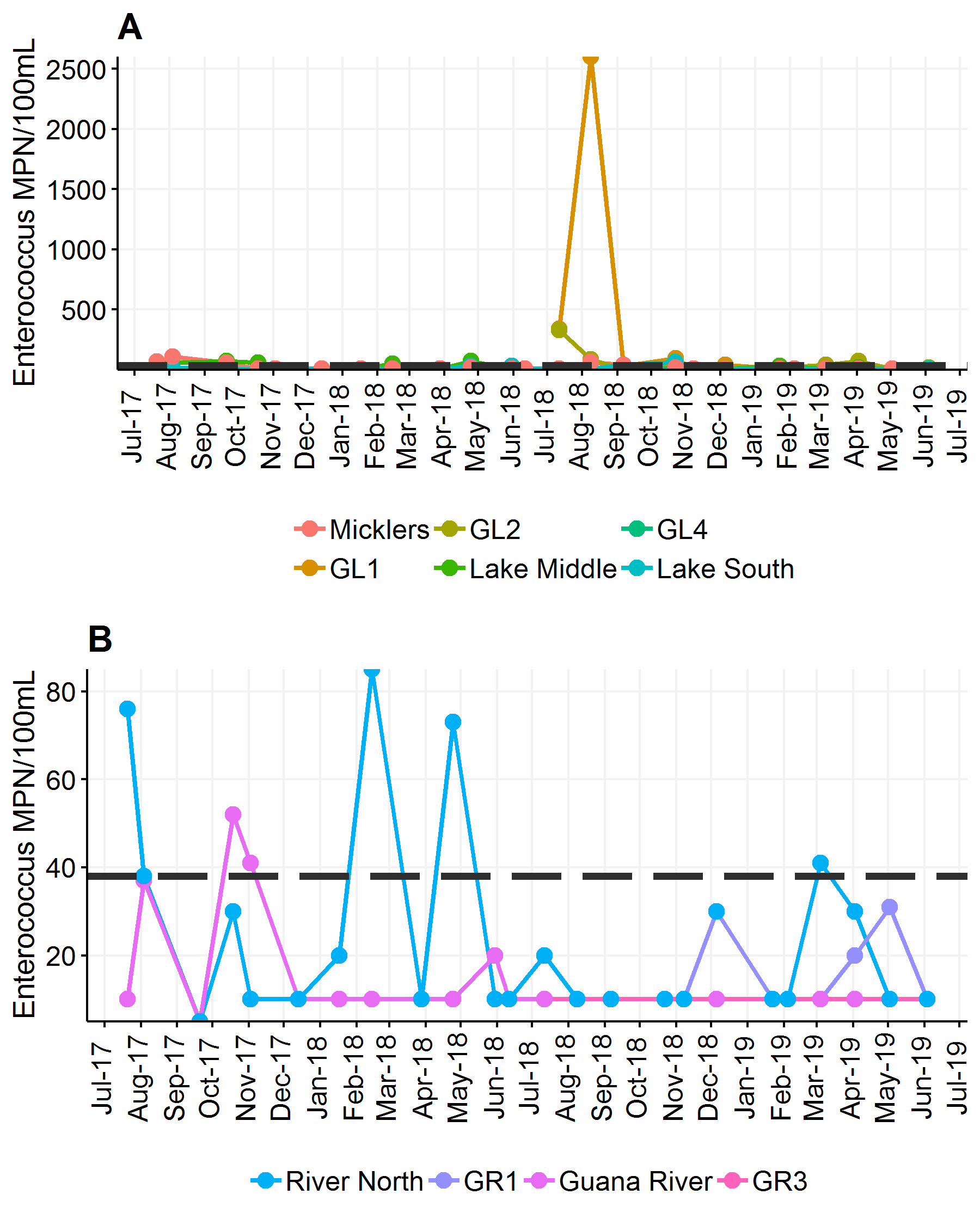


Figure x: Enterococcus bacteria (MPN/100mL) concentrations collected at each sampling station on the day of water sample collections in the lake (A) and river (B). Horizontal lines represent the Florida state threshold criteria for Class II and III estuarine waters (38 MPN/100mL) .

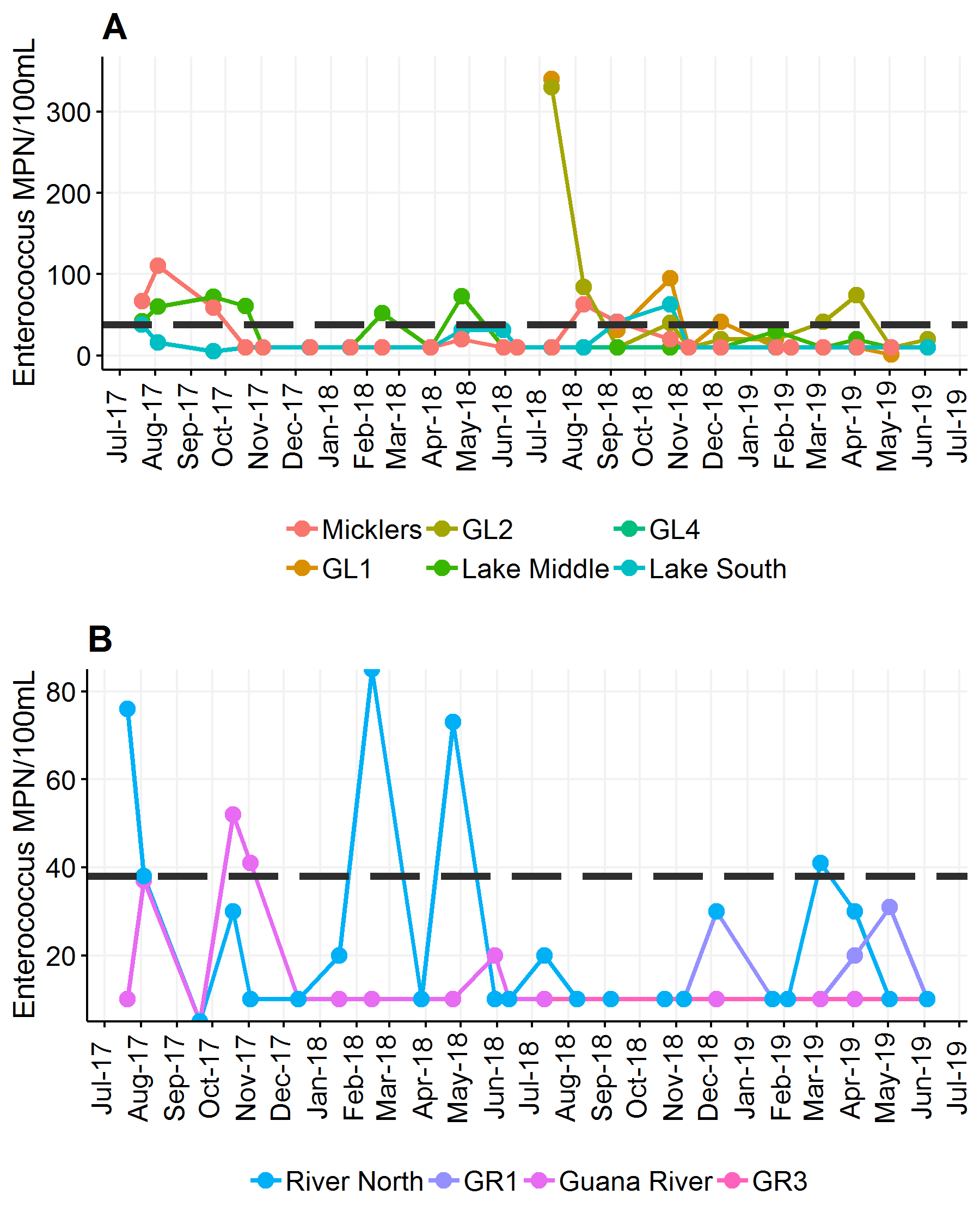


Figure x: Enterococcus bacteria (MPN/100mL) concentrations collected at each sampling station on the day of water sample collections in the lake (A) and river (B) with adjusted axis in the lake. Horizontal lines represent the Florida state threshold criteria for Class II and III estuarine waters (38 MPN/100mL) .

Bacterial levels at the stations generally did not exceed the water quality standards for their associated waterbody. However, high levels were observed in months following large rainfall events, such as Hurricane Irma in the October 2017 sampling event.

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Table x: Annual Geometric Means for water quality parameters collected in Guana Lake used in assessment by Florida Department of Environmental Protection. ‘Year 1’ (July 2017-June 2018), only includes data collected at the Lake Middle site. ‘Year 2’ (July 2018 - June 2019), all open water lake sites are presented.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter Abbrev. | Year1AGM | Year1sd | Year2AGM | Year2sd |
| CHLa\_C | 41.42 | 1.55 | 15.43 | 2.87 |
| DO\_p | 65.81 | 1.37 | 79.16 | 1.28 |
| ENTERO | 26.32 | 2.56 | 18.25 | 3.61 |
| FECCOL | 74.19 | 9.57 | 12.25 | 2.25 |
| TN | 2.24 | 1.25 | 1.50 | 1.64 |
| TP | 0.12 | 1.63 | 0.07 | 1.79 |

Table x: Annual Geometric Means for water quality parameters collected in Guana River used in assessment by Florida Department of Environmental Protection. ‘Year 1’ (July 2017-June 2018), only includes data collected at the Lake Middle site. ‘Year 2’ (July 2018 - June 2019), all open water lake sites are presented.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter Abbrev. | Year1AGM | Year1sd | Year2AGM | Year2sd |
| CHLa\_C | 6.68 | 1.72 | 6.03 | 1.52 |
| DO\_p | 70.64 | 1.34 | 75.21 | 1.17 |
| ENTERO | 14.39 | 2.07 | 10.93 | 1.34 |
| FECCOL | 10.13 | 3.65 | 10.03 | 1.74 |
| TN | 0.76 | 1.45 | 0.55 | 1.86 |
| TP | 0.06 | 1.73 | 0.05 | 1.42 |

Table x: Annual Geometric Means for water quality parameters collected at the GTMNERR System-Wide Monitoring Program Pine Island Station.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter Abbrev. | Year1AGM | Year1sd | Year2AGM | Year2sd |
| chla\_n | 3.75 | 1.79 | 4.43 | 1.53 |
| feccol\_cfu | 6.06 | 2.10 | 5.82 | 2.22 |
| tn | 0.63 | 1.31 | 0.59 | 1.24 |
| tp | 0.07 | 1.34 | 0.06 | 1.21 |

# Discussion

## Ecology

This is where correlation plots and discussions/ties in with other datasets will be included.

### Plankton

* PMN monthly data
* SWMP station timeseries (LM & GR)

### Oysters

* general patterns with GTM oyster data?
* monthly spat data

### Fish

* Guana bi-weekly/monthly seining

*what about anything with the education staff??*

# Appendix A:

Table x: Parameters available in data set.

|  |  |
| --- | --- |
| Parameter | Abbrev |
| Total Alkalinity | Alkalinity |
| Wind Direction | WIND\_D |
| Chlorophyll a, Uncorrected (Trichromatic) | CHLa\_UnC |
| Total Nitrogen | TN |
| Total Suspended Solids | TSS |
| Fluoride | Fluoride |
| Organic Carbon | W-TOC |
| Air temperature | ATEMP |
| Wind Speed | WIND\_S |
| Water temperature | WTEM |
| Ammonia as Nitrogen, Dissolved | NH4\_N |
| Chlorophyll a, Corrected (Monochromatic) | CHLa\_C |
| Chlorophyll b (Trichromatic) | CHLb\_Tri\_N |
| Chlorophyll c (Trichromatic) | CHLc\_Tri\_N |
| Nitrate+Nitrite | NO23F |
| Turbidity | Turbidity |
| Secchi Disk | SECCHI |
| Water Depth | WDEPTH |
| Specific Conductance | SpCond |
| pH | pH |
| Dissolved oxygen | DO |
| Dissolved oxygen, percent saturation | DO\_p |
| Salinity | SALT |
| Coliform, Fecal | FECCOL |
| Enterococcus | ENTERO |
| Kjeldahl Nitrogen, Dissolved | DTKN |
| Total Phosphorus | TP |
| Kjeldahl Nitrogen | TKN |
| OD664b/OD665a | OD664b/OD665a |
| Pheophytin a | PHEA |
| human-specific HF183 Bacteroides genetic marker | HF183 |
| Fluridone | Fluridone |
| Linuron | Linuron |
| Methylchlorophenoxypropionic acid | MCPP |
| Naproxen | Naproxen |
| 2,4-Dichlorophenoxyacetic acid | 2, 4-D |
| Triclopyr | Triclopyr |
| TDS | W-TDS |
| Chloride | W-CL-IC |
| Sulfate | W-SO4-IC |
| Sucralose | Sucra |
| Acetaminophen | Aceta |
| Bentazon | Bentazon |
| Carbamazepine | Carbamazepine |
| Diuron | Diuron |
| Fenuron | Fenuron |
| Hydrocodone | Hydrocodone |
| Ibuprofen | Ibuprofen |
| Imazapyr | Imazapyr |
| Imidacloprid | Imidacloprid |
| Primidone | Primidone |
| Pyraclostrobin | Pyraclostrobin |
| Color (true) | W-COLOR |
| coastal bird specific Catellicoccus marimammalium Gull2 genetic marker | GULL2 |
| bird specific Helicobacter GFD genetic marker | GFD |
| Bromide | W-BR-IC |
| Ruminant specific Bacteroidetes BacR genetic marker | BacR |
| canine-specific DG3 Bacteroides genetic marker | DG3 |

# Appendix B:

Below are annual geometric means for each station by year for all parameters.