STATE OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL PROTECTION

QUARTERLY REPORT #5
JULY – SEPTEMBER 2021
DEP AGREEMENT NO. INV006

Monitoring, predicting, and controlling harmful algal blooms by buoy ultrasonic technology in a range of lakes in southwest Florida

Submitted by

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Our activity in the fifth quarter of this project was focused on continuing Task 4: Monitoring and Verification.

Field trips performed in this quarter related to Task 4

- July 13, 2021: Took July monthly water samples
  Participants: Lauren Griffiths, Li Zhang
- August 10, 2021: Took August monthly water samples
  Participants: Lauren Griffiths, Li Zhang, Andrew Wilson
- September 8-9, 2021: Assisted LG Sonic with maintenance work on LG Sonic buoys
  Participants: Andrew Wilson, Li Zhang, Matthew Ruppert, Hannah Hartzler
- September 21, 2021: Took September monthly water samples
  Participants: Andrew Wilson, Matthew Ruppert

Task 4: Monitoring and Verification

Task Description: The Grantee will conduct monitoring in accordance with the Department-approved QAPP for this project (see Task #2). The QAPP must specify the sampling procedures, locations, instruments, frequency, and parameters to be sampled. The Grantee will coordinate research with the project team at the FGCU Everglades Wetland Research Park, LG Sonic, The Ohio State University, and University of South Florida.

Deliverables: 1) Summary of completed monitoring activities (dates completed, sampling conducted and any not conducted and why), 2) monitoring results along with an interpretation of those results (as expected or not as expected) submitted electronically, along with, 3) the draft or final (when submitting the final request) laboratory report and sampling logs (must also have field and weather data) to the Department's Grant Manager. Upon request, the Grantee will provide a hardcopy to the Department's Grant Manager. These deliverables must be submitted 30 days prior to each payment request and may be submitted no more frequently than monthly.

Performance Standard: The Department Grant Manager will review the monitoring results for completion and compliance with QAPP requirements. Upon review and written acceptance by the Department Grant Manager of all deliverables under this task, the Grantee may proceed with payment request submittal.

Payment Request Schedule: Grantee may submit a payment request for cost reimbursement no more frequently than once per month. These deliverables must be submitted by the 30th of each subsequent month and 30 days prior to each payment request and may be submitted no more frequently than monthly. The Deliverable(s) must have been submitted and accepted in writing by the Department's Grant Manager prior to payment request submittal.

Progress in this Quarter: During this quarter, we manually sampled 9 buoys in 7 experimental lakes by row boat monthly (3 times in this quarter). Samples were delivered on the day of sampling to certified Lee County Environmental Laboratory and analyzed within the required hold time for chlorophyll and turbidity. All other parameters were analyzed *in situ* with a YSI data sonde.

Photos of maintenance work in experimental lakes TB3, TB7 and TB8 on September 8, 2021

Monthly sampling data

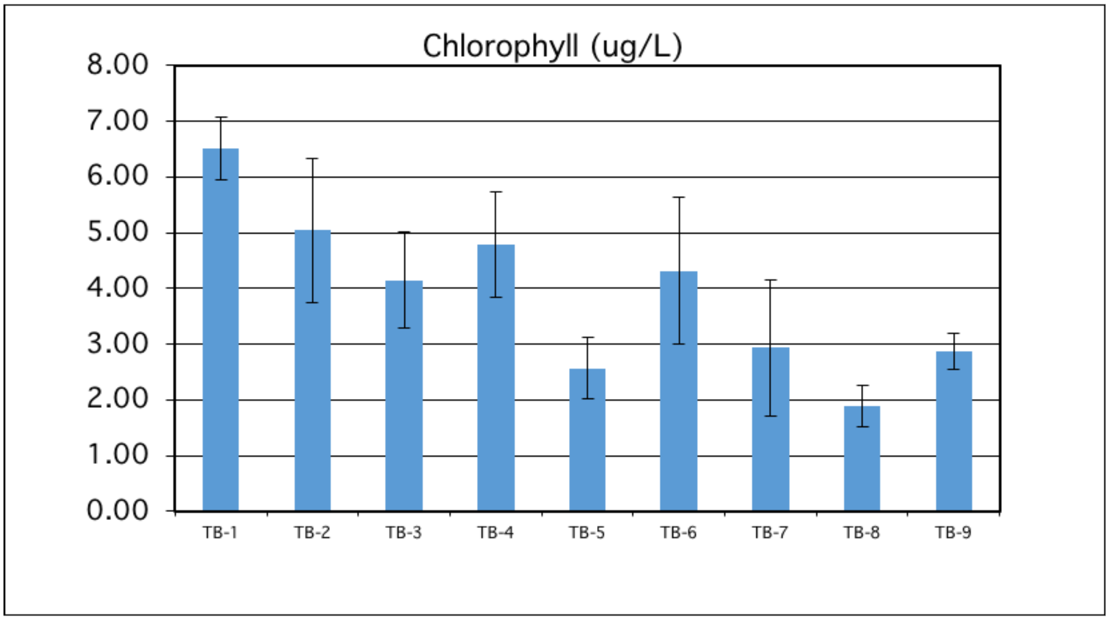

Figure 1. Average ± standard error chlorophyll at each buoy location based on monthly water samples taken January–August 2021.

Water bodies can be classified by trophic status as oligotrophic, mesotrophic, eutrophic or hypertrophic, which is a response to nutrient add-ins to the water (Bougarne & Abbou, 2019). The classification of a trophic state of an aquatic system is often evaluated by measuring several criteria, including chlorophyll concentration that indicates the extent of algal biomass and excessive eutrophication. Figure 1 illustrates chlorophyll concentrations observed at each of the study sites (Smith, 2003). Among the sites, TB-1 site had the highest average chlorophyll concentrations, while TB-8 was the lowest. Sites TB-5, TB-7, and TB-9 showed concentrations that fall between 2-3 ug/L, with TB-7 and TB-9 being very close to 3 ug/L and TB-5 ~2.5 µg/L. Sites TB-2, TB-3, TB-4, and TB-6 all have chlorophyll concentrations between 4-5 ug/L. Sites TB-2 and TB-4 both have concentrations closer/ or at 5 ug/L while sites TB-3 and TB-6 have chlorophyll concentrations between 3-3.5 µg/L. Using a system developed by the OECD, which is used internationally, these sites trophic status can be determined based on the chlorophyll concentrations (Bougarne & Abbou, 2019): Oligotrophic <2.5; mesotrophic 2.5 - 8; and eutrophic lakes 8-25 µg/L. According to these guidelines, all lakes from this study are considered 'mesotrophic', except TB-8. TB-5 is very close to being oligotrophic but is slightly above the threshold. TB-1 is the closest lake to eutrophication but has chlorophyll values that are less than 8 µg/L. Other scales have slight variations to the one above and can be used to evaluate these concentrations, but no scales found in other literature show these lakes' status as eutrophic. However, this scale is based on annual averages and these data only include 8 months, so some variation is expected.

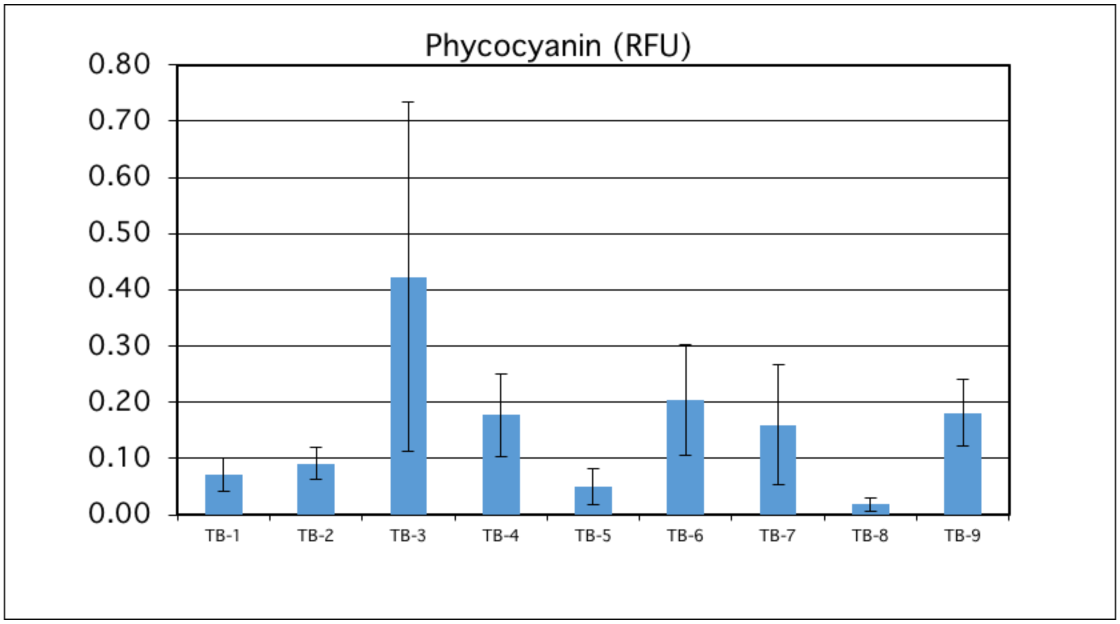

Figure 2. Average ± standard error phycocyanin at each buoy location based on monthly water samples taken January–August 2021.

Compared to chlorophyll, phycocyanin (PC) is a bluish green pigment found extensively in cyanobacteria used as an indicator for harmful algal blooms (HAB) in freshwater lakes (Marion et al., 2012; Mchau et al., 2019). TB-1, TB-2, TB-5, and TB-8 all have PC values lower than 0.10 RFU with TB-8 having the lowest value. TB-4, TB-6, TB-7, and TB-9 all have RFU values between 0.10-0.20 RFU. TB-6 has the highest value out of the 4 locations listed above with a value at 0.20 RFU. TB-3 has the highest RFU value out of the nine sites. TB-3 value is slightly over 0.40 RFU. Using RFU values found in McQuaid et al.'s study (2011) these values can be compared to values found in other water bodies. Any value below 1.7 RFU is considered below the WHO alert level 1 standard. Based on this, all locations in this study had PC concentrations lower than the WHO alert level 1 during the monitoring period from January to August 2021.

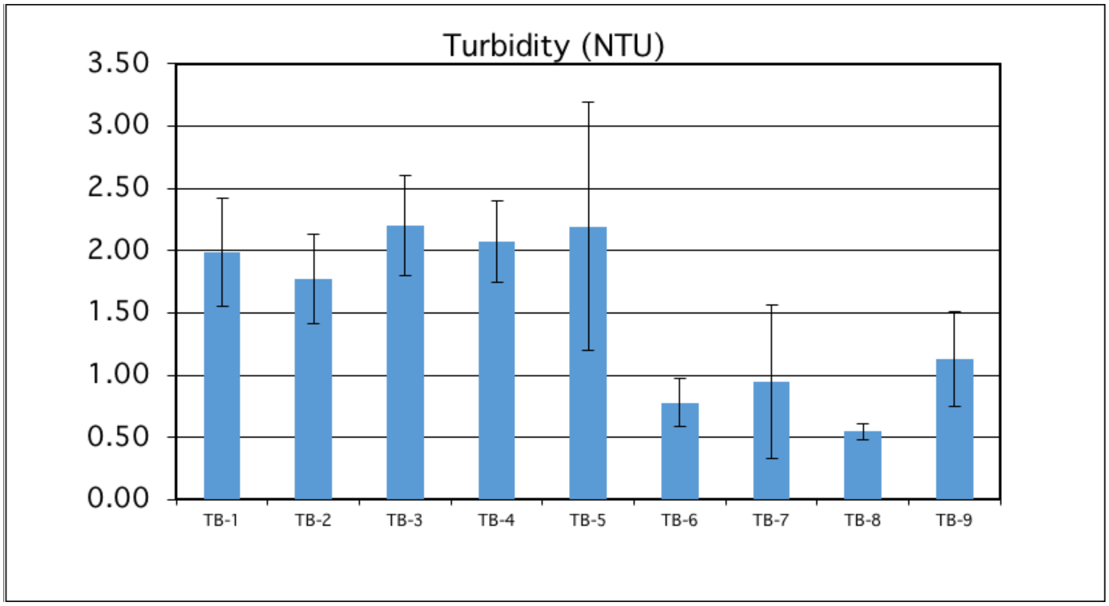

Figure 3. Average ± standard error turbidity at each buoy location based on monthly water samples taken January–August 2021.

Turbidity is a crucial water quality parameter to examine when assessing water quality because it is one of the factors effecting the health of primary producers in a body of water. A bloom itself can increase the turbidity of a water source. Figure 3 shows that TB-1 and TB-2 have NTU values between 1.50-2.00. TB-3, TB-4, and TB-5 have NTU values between 2.00-2.50, with TB-3 and TB-5 having the highest NTU values out of the nine sites. TB-6, TB-7, and TB-8 all have values between 0.50-1.00 NTU. TB-9 is the only site with an NTU value between 1.00-1.50. When comparing these values to others in the literature, these values are relatively low and should not cause any negative impacts on organisms within the body such as fish foraging success and primary production. A value below 5 NTU is allowed for recreational purposes.

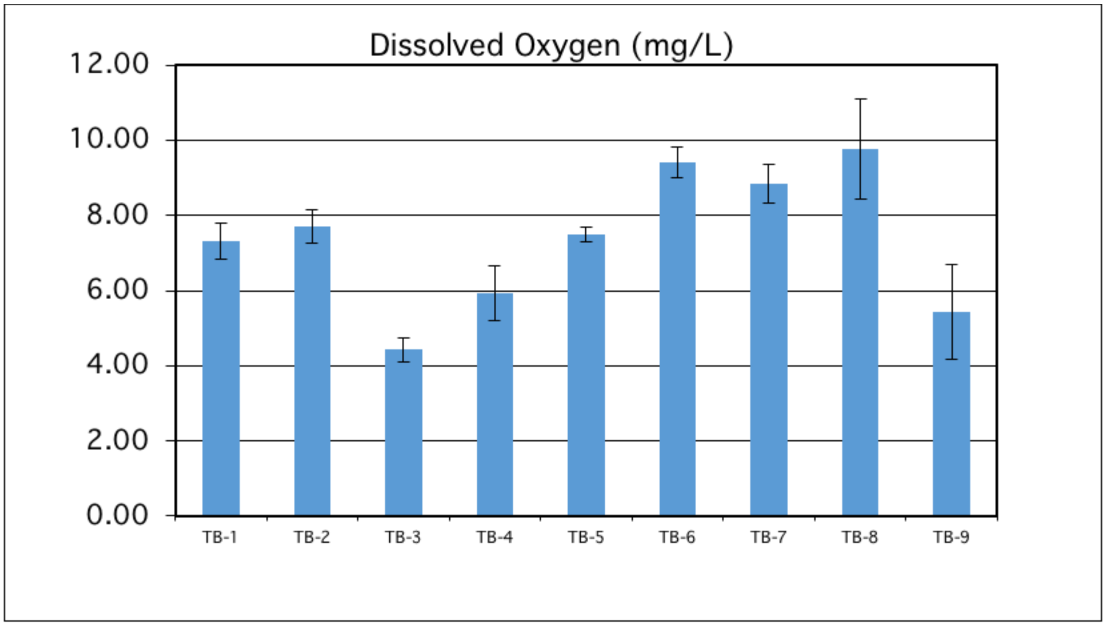

Figure 4. Average ± standard error dissolved oxygen at each buoy location based on monthly water samples taken January–August 2021.

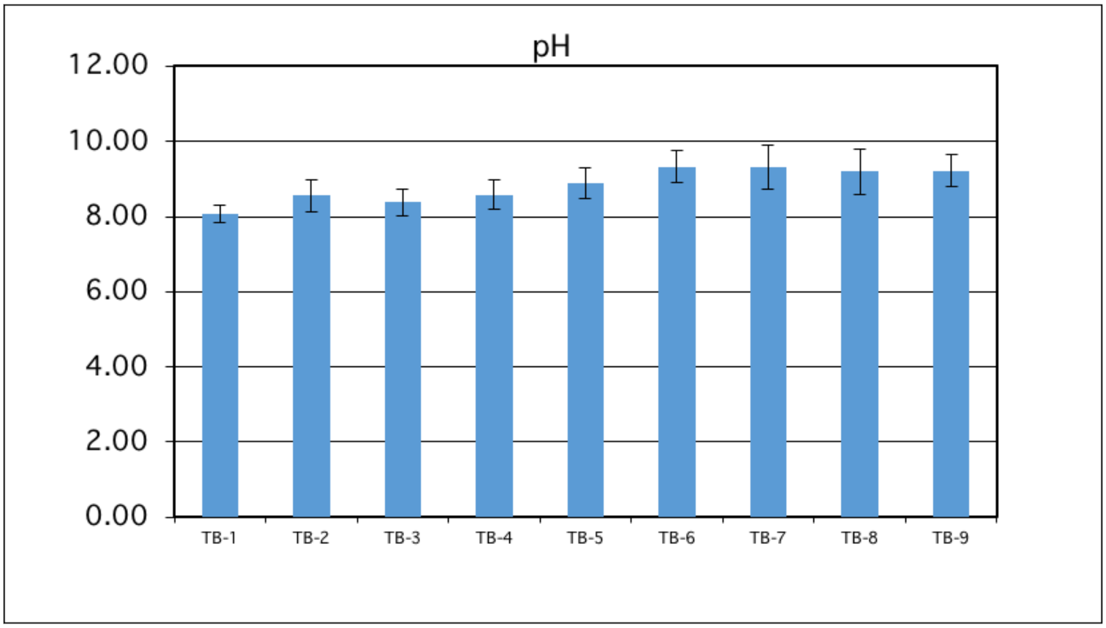

Figure 5. Average ± standard error pH at each buoy location based on monthly water samples taken January–August 2021.

pH values affect the solubility and availability of chemical constituents, such as nutrients. Thus pH is used as a parameter for water quality testing, especially when the testing is being used to gauge algal bloom probabilities (USGS). Figure 5 shows that the pH values for all nine sites fall between 8.00 and 10.00. Alkaliphiles thrive in high pH environments. The optimal growth pH is at or above a pH of 9. This information indicates that TB-5, TB-6, TB-7, TB-8, and TB-9 have optimal pH values for alkaliphiles, which includes many photosynthetic organisms, including cyanobacteria (López-Archilla et al., 2004). In addition, algae and cyanobacteria (photosynthetic organisms) utilize carbon dioxide from the water column as part of their photosynthesis; thus it can result in increased pH.

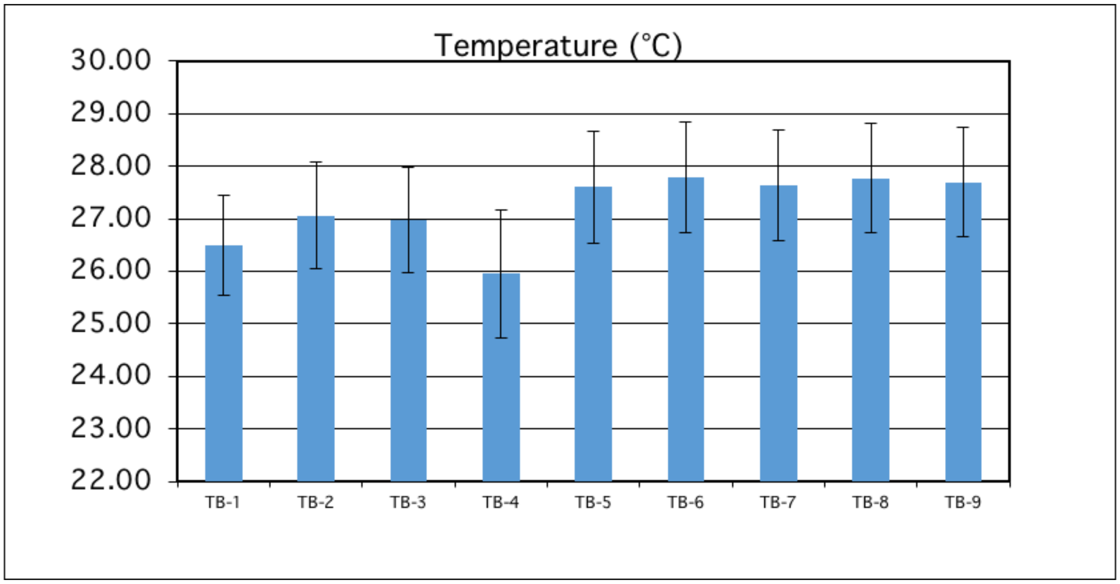

Figure 6. Average ± standard error temperature at each buoy location based on monthly water samples taken January–August 2021.

Daily averages from MPC-buoys

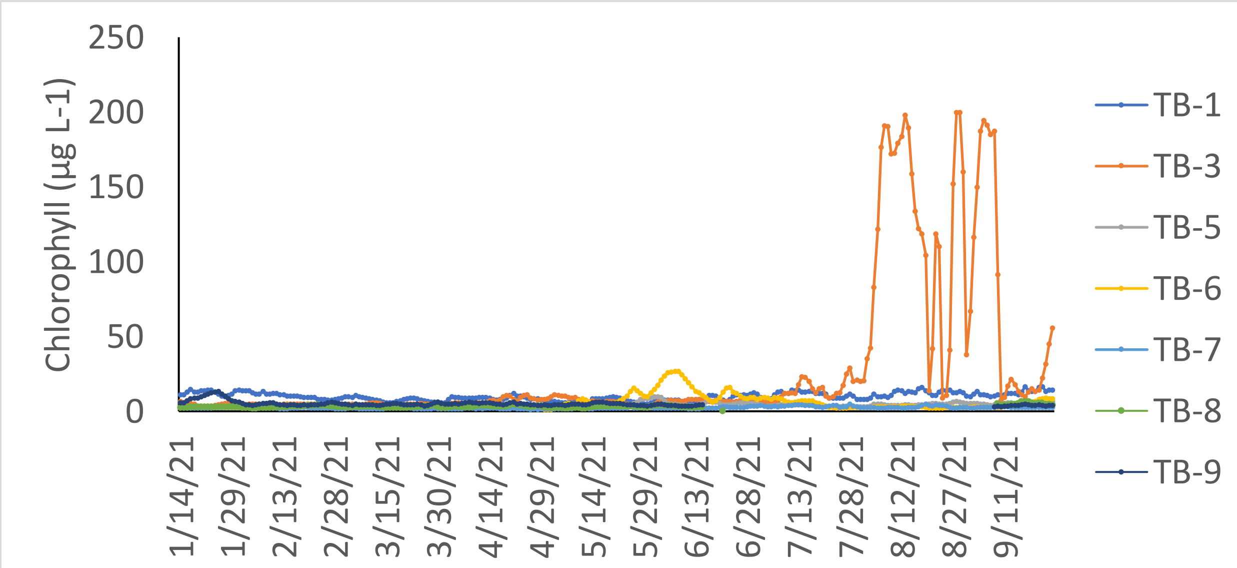

Figure 7. Daily average chlorophyll at each buoy based on readings by the MPC-buoy collected every 30 minutes.

Most of the buoy 30-min readings at the buoys remained low until late summer TB-3 had a spike that almost reached 15 µg/L between mid-April and mid-May and then peaked much higher to 200 µg/L in July –August 2021 (Figure 7). This was the highest concentrations of chlorophyll in the study lakes. TB-5 had a spike at the end of May that was slightly above 10 µg/L, but it quickly dropped back down. TB-7 and TB-8 seemed to have very little change throughout the months and did not have any extreme spikes. Between the end of May and middle of June TB-6 showed a chlorophyll concentration increase of ~20 µg/L.

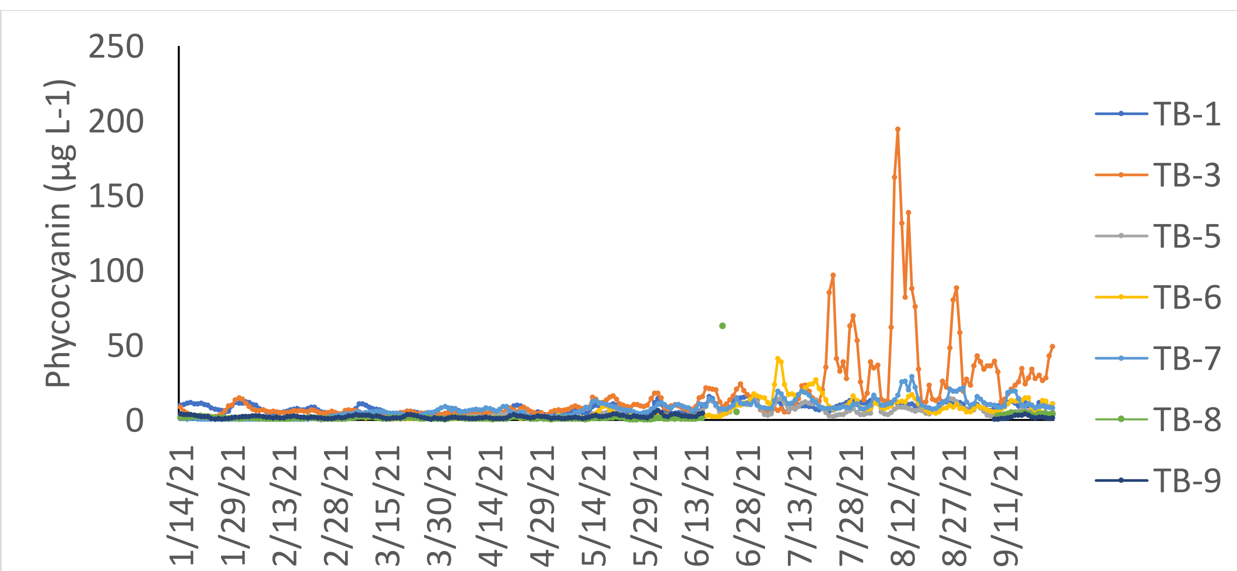

Figure 8. Daily average phycocyanin (PC) at each buoy based on readings by the MPC-buoy collected every 30 minutes.

Figure 8 shows that phycocyanin (PC) levels increased for almost all sites in May, and the months following containing the highest levels of PC. TB-1 and TB-3 showed the highest PC levels during the months of January and February compared to other sites. By mid-June it appears that all sites were experiencing an increase in PC levels with dramatic increases especially in July and August for TB-3 (Figure 8). Since PC is an indicator for cyanobacteria blooms, it can be stated that blooms are most likely to occur at the beginning of May and last until at least mid-June. After June, it seems that these blooms continued to possibly even higher levels of PC.

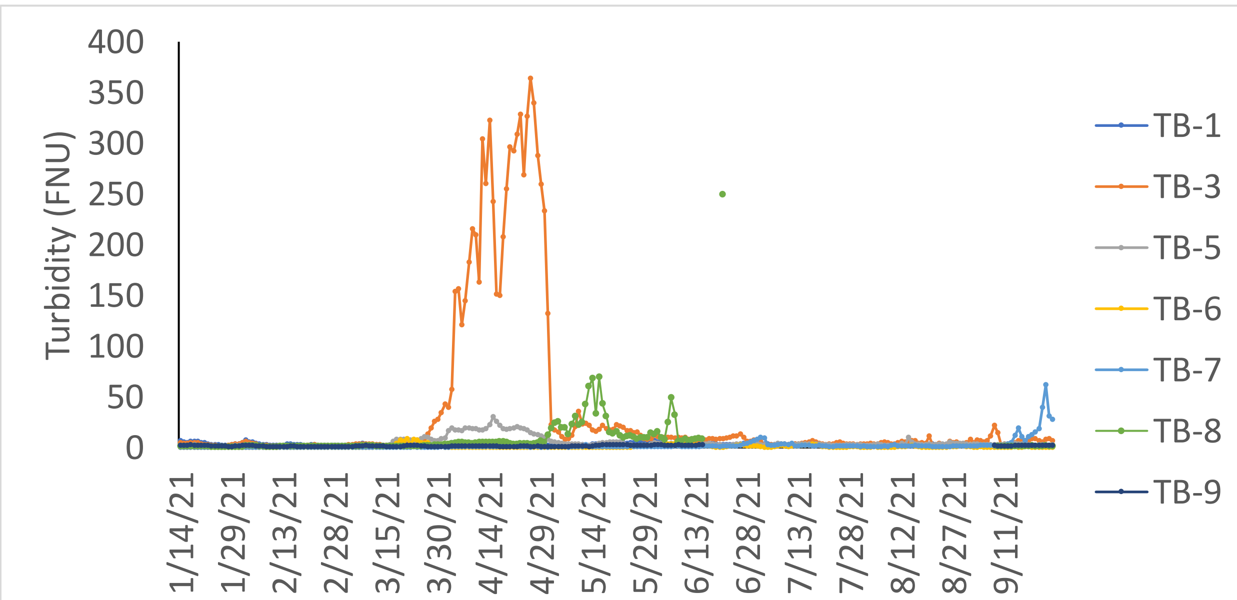

Figure 9. Daily average turbidity at each buoy based on readings by the MPC-buoy collected every 30 minutes.

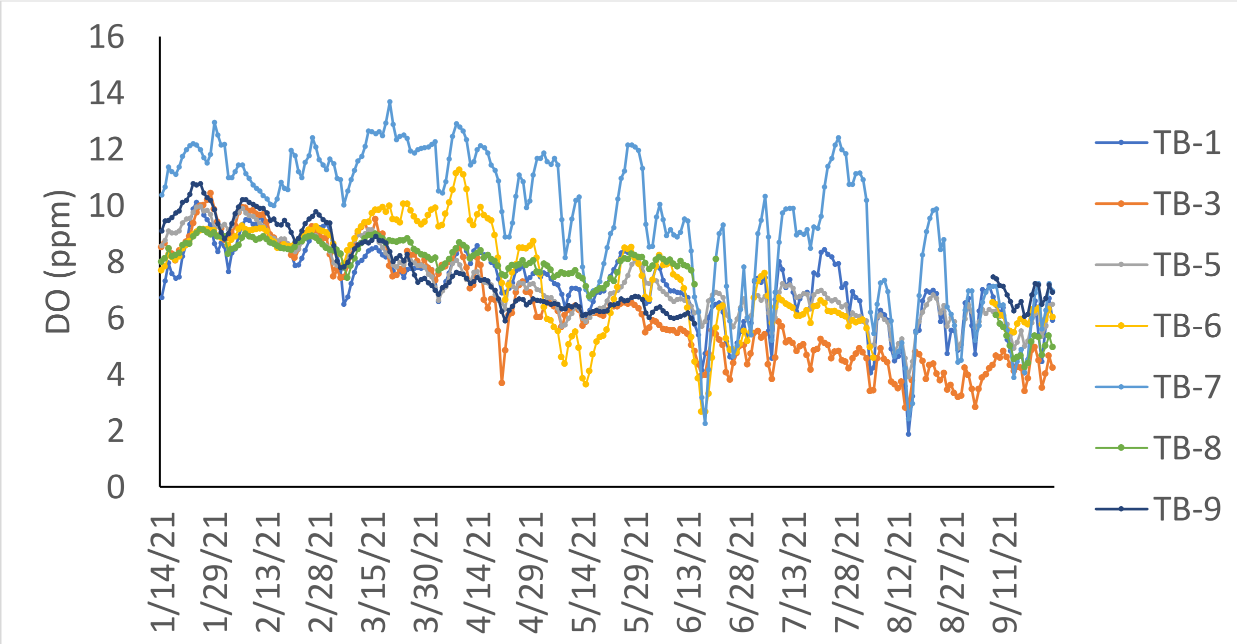

Figure 10. Daily average dissolved oxygen at each buoy based on readings by the MPC-buoy collected every 30 minutes.

The pattern of dissolved oxygen in the nine buoys shown over the nine months (Figure 10; January to September 2021) shows overall averages in the lakes decreasing from about 10 ppm to 5 ppm, caused primarily by increasing water temperatures and thus lower DO saturation levels. TB-1 shows much higher levels of DO and pH and higher oscillations of both (Figures 10 and 11), potentially due to more significant algal blooms caused by fertilizer inputs from the nearby golf course.

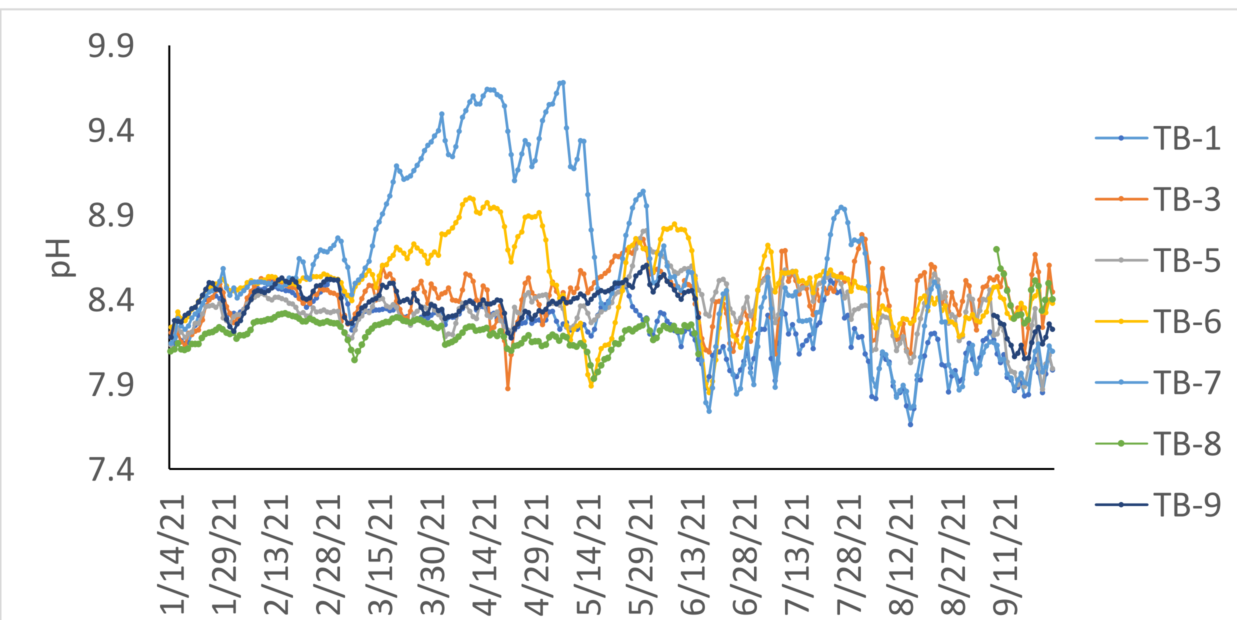

Figure 11. Daily average pH at each buoy based on readings by the MPC-buoy collected every 30 minutes.

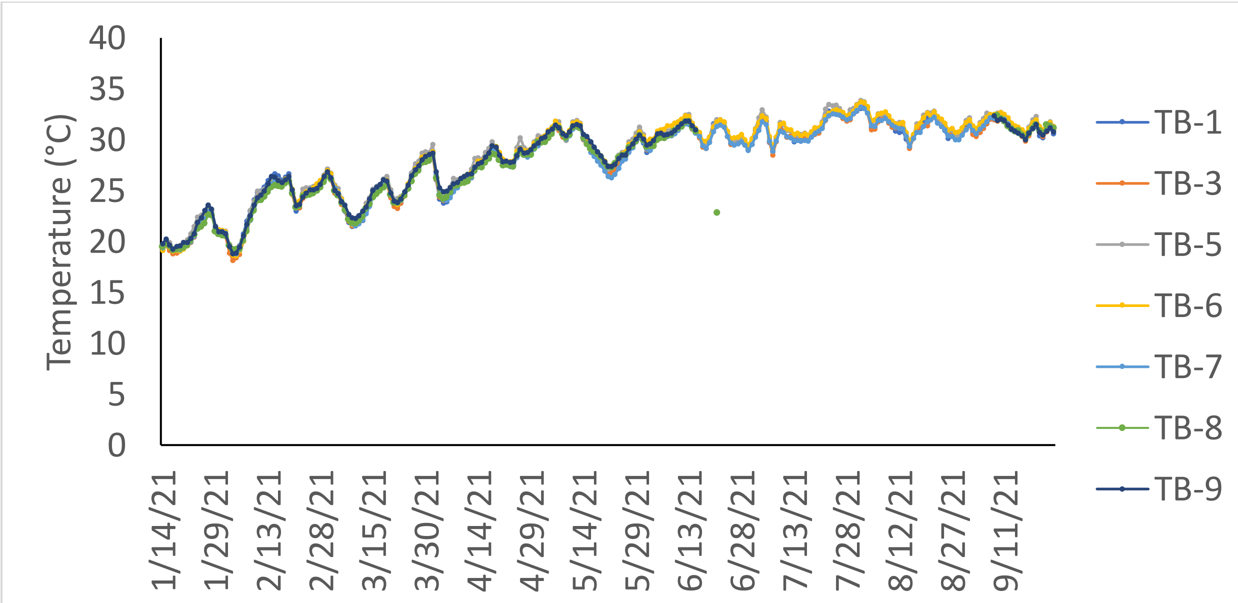

Figure 12. Daily average temperature at each buoy based on readings by the MPC-buoy collected every 30 minutes.

Monthly averages from MPC-buoys

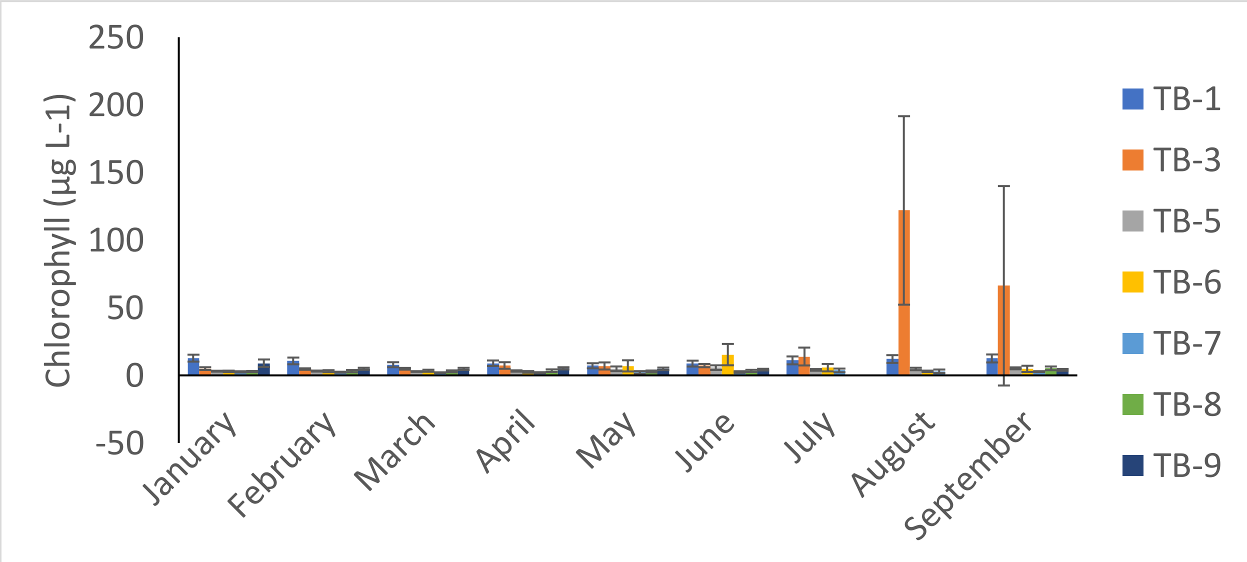

Figure 13. Monthly average ± standard deviation chlorophyll at each buoy based on readings by the MPC-buoy collected every 30 minutes.

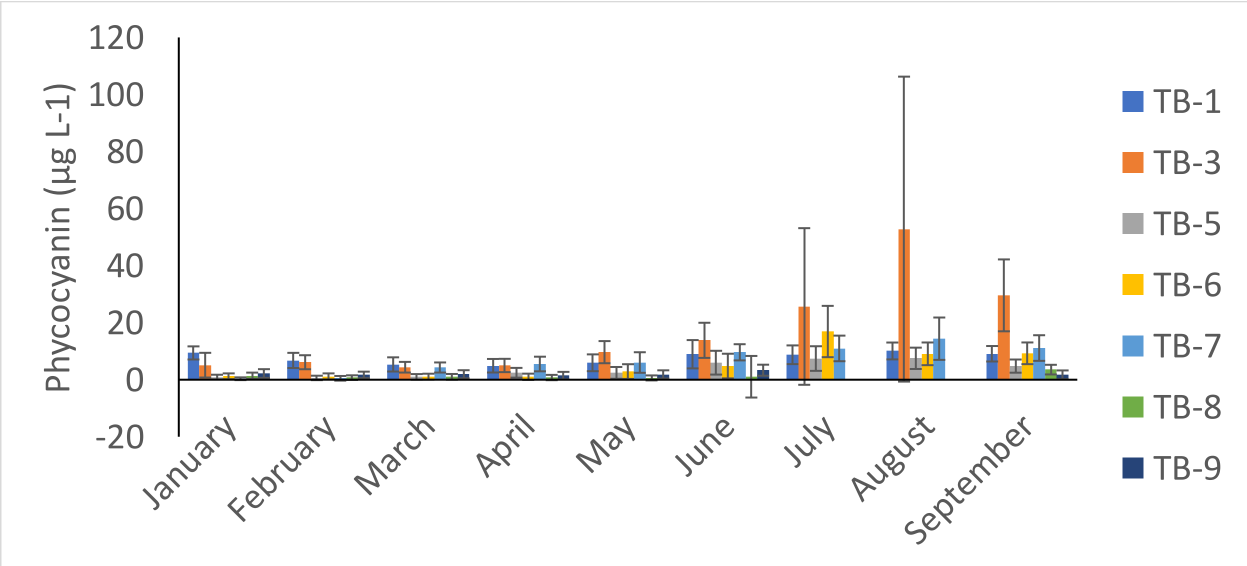

Figure 14. Monthly average ± standard deviation phycocyanin at each buoy based on readings by the MPC-buoy collected every 30 minutes.

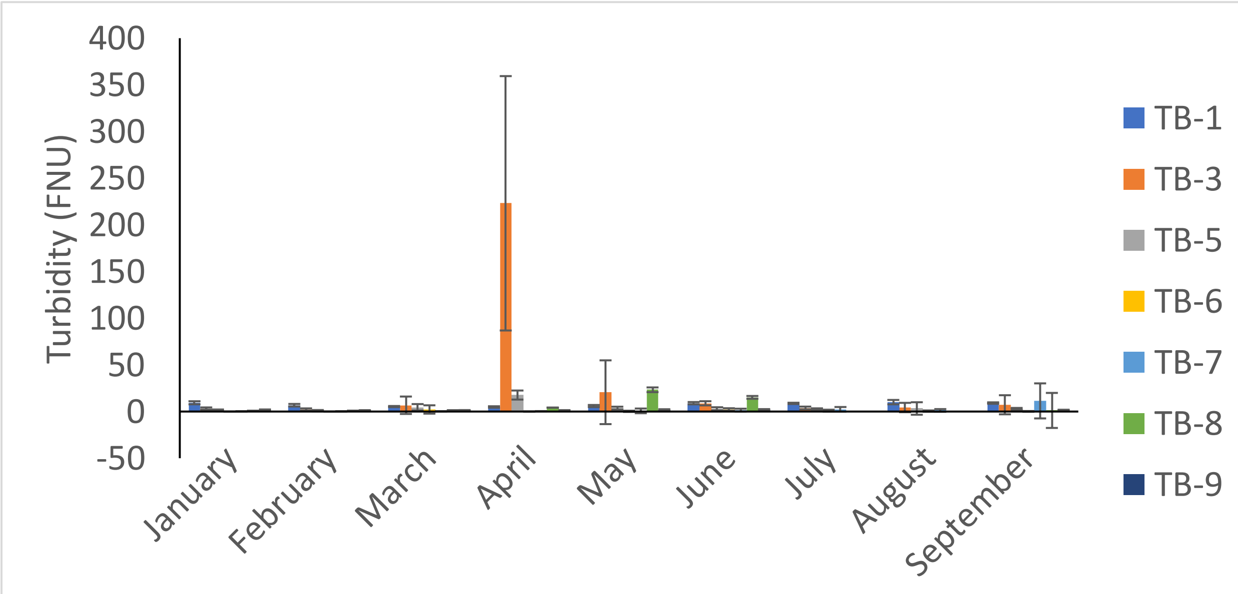

Figure 15. Monthly average ± standard deviation turbidity at each buoy based on readings by the MPC-buoy collected every 30 minutes.

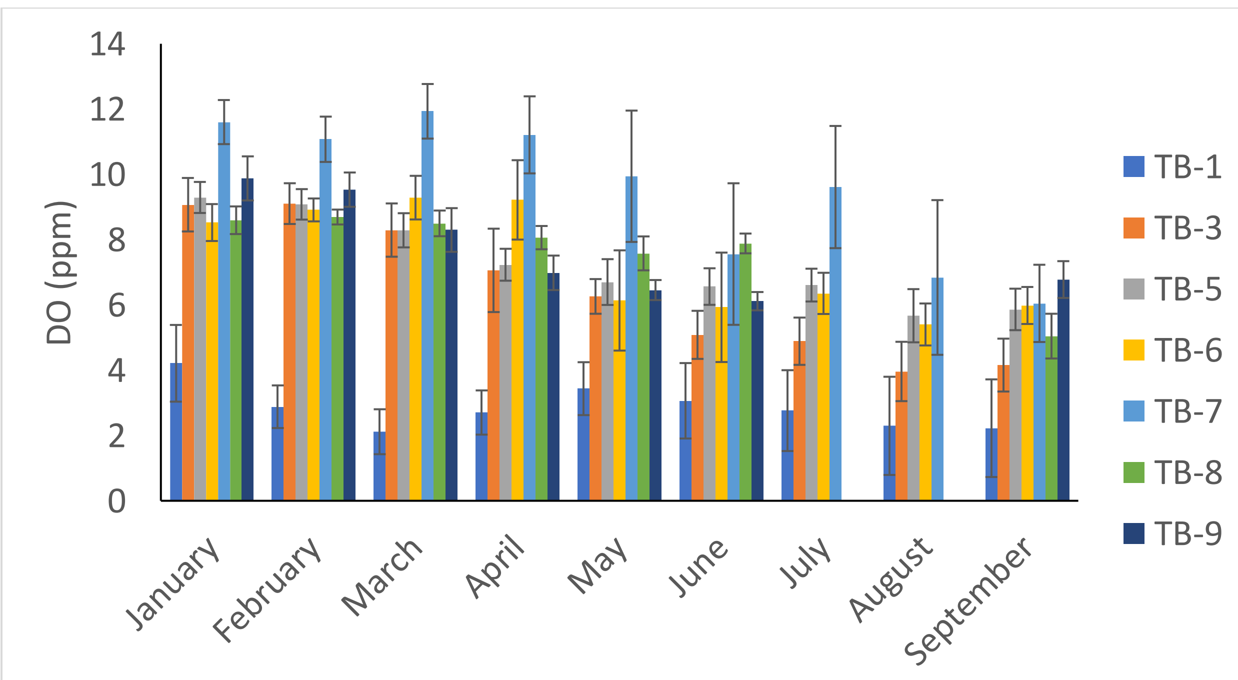

Figure 16. Monthly average ± standard deviation dissolved oxygen at each buoy based on readings by the MPC-buoy collected every 30 minutes.

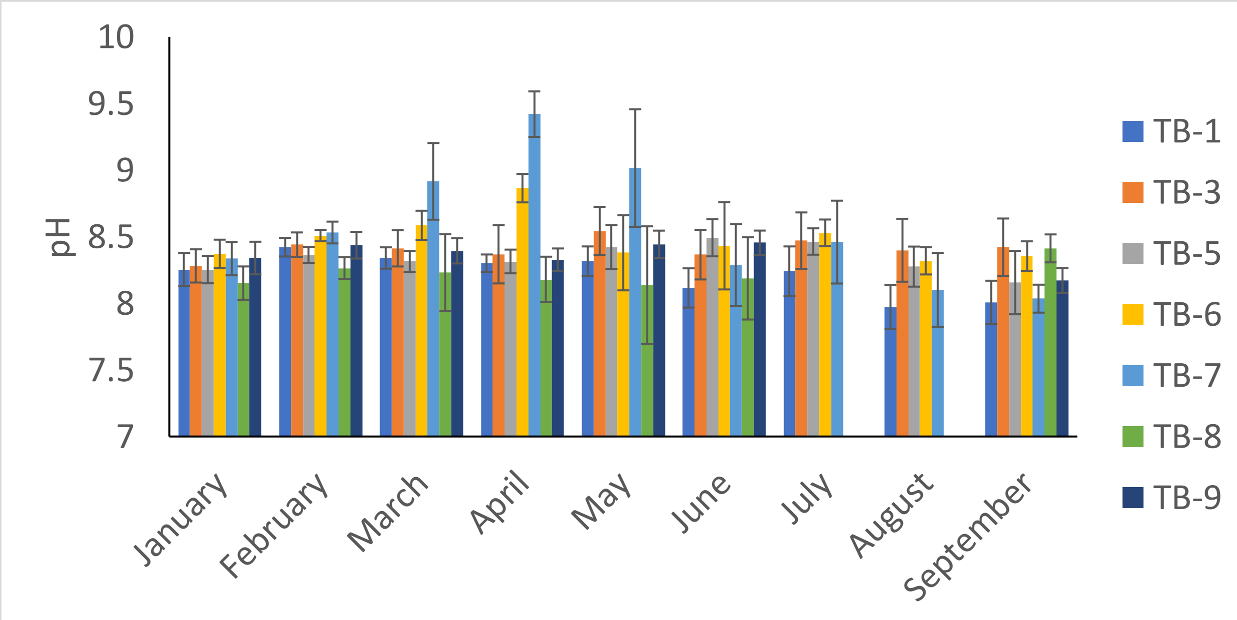

Figure 17. Monthly average ± standard deviation pH at each buoy based on readings by the MPC-buoy collected every 30 minutes.

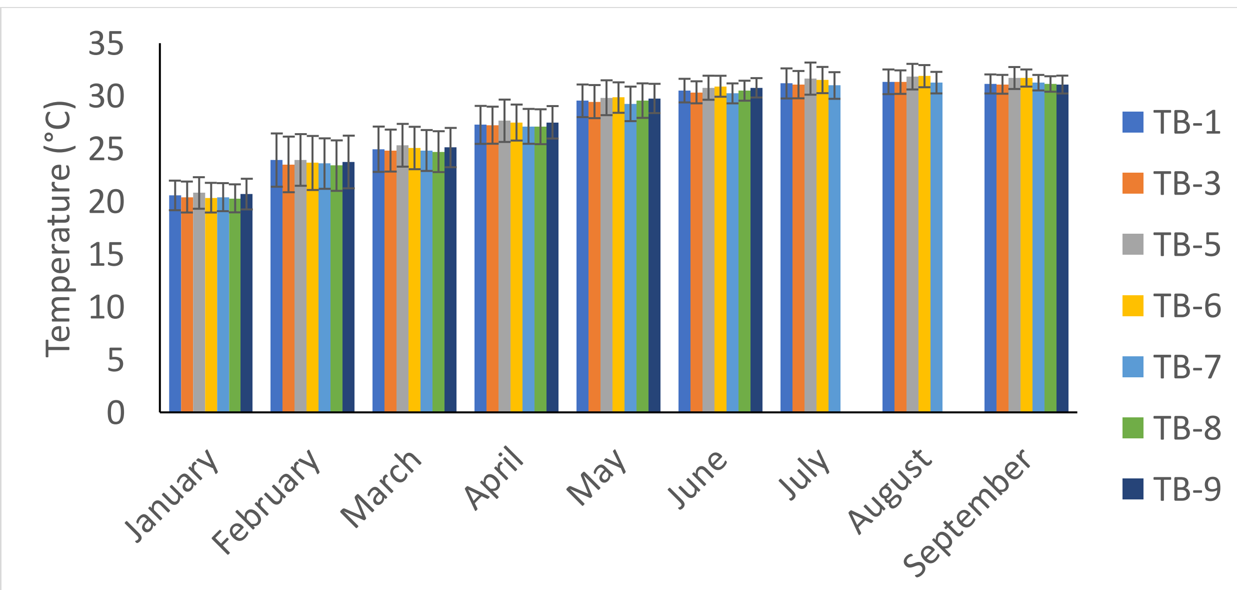

Figure 18. Monthly average ± standard deviation temperature at each buoy based on readings by the MPC-buoy collected every 30 minutes.

Preliminary Findings during this Quarter

The collected data, in addition to communications with LG Sonic, suggest that these buoys may not function efficiently in lakes dominated by filamentous algae, such as those often found in Florida. In other deployments in different locations, these buoys have been shown effective where unicellular algal blooms are more common. Ultrasonic treatment is better equipped to treat microalgae compared to the "more plant-like" filamentous algae which has more complex structure and accumulates around the shoreline away from the buoys.

Increasing temperatures during this quarter led directly to lower average dissolved oxygen and increased opportunities for harmful algal blooms that create short-term water quality pulses. It appears that most of these mid to late summer blooms are occurring in the lakes that are on the perimeter of the golf courses which probably receive the highest applications of fertilizer. So far, it has been difficult to find significant differences between these lakes and control lakes.

Anticipated Work Schedule for the Upcoming Quarter of October through December 2021

Task 4 is on schedule and we will continue to monitor and sample for one more quarter through December 2021. Some of this progress will be described the next quarterly report (October – December 2021).

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