2020 Cyanobacteria Monitoring Report
Long Pond Marstons Mills, Barnstable, Massachusetts

Prepared for Friends of Long Pond Marstons Mills (FLPMM)
By the Association to Preserve Cape Cod (APCC)

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Background

The Long Pond Marstons Mills Cyanobacteria Monitoring Program was established in 2020. The goals of the program are to improve understanding of cyanobacterial populations in Long Pond Marstons Mills, increase awareness of harmful cyanobacteria blooms throughout the community, and communicate results to help protect public health and safety. Working alongside sampling efforts from the Town of Barnstable's Health Department (The Town), APCC partnered with the Friends of Long Pond Marstons Mills (FLPMM) to monitor Long Pond for cyanobacteria from multiple sampling locations across the pond. The monitoring results documented a visible cyanobacteria bloom composed of the cyanobacteria genus *Microcystis* spp. for much of the sampling season. Results from the three sampling locations (Location 1 - 791 Santuit-Newtown Road, Marstons Mills; Location 2 - 296 Long Pond Road, Marstons Mills; and Location 3 - 251 Lake Shore Drive, Marstons Mills) are summarized in this report. All monitoring results were shared with FLPMM, the Town, and the public throughout the season.

Overview of APCC's Cyanobacteria Monitoring Program

Harmful cyanobacteria blooms are indicators of nutrient enrichment and warming temperatures due to climate change and are increasing in frequency and severity. Cyanotoxins pose health risks to humans and wildlife which ingest cyanotoxins present in water bodies. Harmful cyanobacteria blooms in freshwater bodies have become more common and are the subject of numerous reports published by scientists, state and federal agencies, and organizations, some of which are listed here:

- The World Health Organization recognized the public health consequences of cyanobacteria in water in 1999 (WHO 1999).
- The Centers for Disease Control (CDC) call cyanotoxins "among the most powerful natural poisons known" (CDC Fact Sheet on Harmful Algal Blooms). The CDC's Physician Card on Harmful Algal Blooms (HABs) states that swallowing water containing cyanobacteria can damage the central nervous system, liver or kidneys; skin contact can cause allergic dermatitis and conjunctivitis; and inhalation of aerosols

containing cyanobacteria or their toxins can cause wheezing, coughing, chest tightness, and shortness of breath.

- New England Interstate Water Pollution Control Commission (NEIWPCC) is an interstate commission that helps the states of the Northeast preserve and advance water quality. NEIWPCC's webpage states that "the frequency of HAB occurrence is on the rise and cyanobacteria toxicity has been associated with human health impacts including skin rashes, gastrointestinal and respiratory disease, and liver damage. Effects can be even more pronounced (potentially even fatal) in animals ranging from cattle to dogs. HABs have direct implications to the use of recreational waterbodies for contact recreation, the susceptibility of public water supplies to toxins, and the overall degradation of our aquatic resources."
- U.S. Environmental Protection Agency (EPA):
    - "Monitoring and Responding to Cyanobacteria and Cyanotoxins in Recreational Waters." EPA recreational waters
    - EPA Office of Ground Water and Drinking Water webpage. Managing Cyanotoxins in Public Drinking Water Systems. EPA drinking water
    - EPA webpage on nutrient pollution and HABs. EPA and nutrient pollution
- State agencies, including New York (NY), Vermont (VT), Rhode Island (RI), and New Hampshire (NH) have cyanobacteria monitoring programs and provide guidance concerning public health and environmental risks posed by cyanobacteria.
- Commonwealth of Massachusetts:
    - Cyanobacteria webpage: Massachusetts
    - Massachusetts Department of Public Health (MDPH) website on "Guidelines for cyanobacteria in freshwater recreational water bodies." MDPH

Over the course of the last decade, APCC has received input from many pond associations, organizations, and local and regional resource managers on Cape Cod regarding concerns about pond health, pond water quality and the need for data received in a timely manner to inform pond protection measures and ensure public safety. Harmful cyanobacteria blooms are indicators of nutrient enrichment and climate change. Blooms are increasing in frequency and severity and the cyanotoxins they produce pose concerning health risks to people, pets, and wildlife. In response to these concerns and limited pond water quality data, APCC developed its Cyanobacteria Monitoring Program in 2017 with guidance and input from state and federal agencies and scientists, including the EPA (EPA recreational waters), Massachusetts Department of Public Health (MDPH), and the town of Barnstable's Health Division (Town of Barnstable).

APCC's cyanobacteria monitoring program normally includes training for citizen scientists to collect water samples from shoreline stations. Volunteers then deliver samples to APCC for lab analysis and storage. These citizen scientists provide APCC with highly useful data and help to extend APCC's coverage of cyanobacteria monitoring across the region. In 2020, however, due to the COVID-19 pandemic and the need to limit exposure to volunteers and staff, APCC chose to have staff collect all samples and volunteers were not engaged.

APCC staff and interns interpret monitoring results within a guidance framework that incorporates the most recent scientific information as well as existing state and federal guidance (EPA recreational waters, MDPH). Results are provided to the pond associations and local

municipal officials along with recommendations concerning appropriate advisories for the public to minimize or avoid risks due to cyanobacteria exposure. Pond associations typically play a key role in raising awareness of the risks related to cyanobacteria exposure and alerting pond communities of APCC's findings throughout the season.

APCC's Cyanobacteria Monitoring Program provides a webpage with an interactive map where recent monitoring results are posted. Results are interpreted according to cyanobacteria risk levels related to existing local, state and federal guidance concerning people and pet exposure to cyanobacteria blooms (APCC Cyanobacteria). APCC's goals are to raise public awareness of the risks posed by cyanobacteria toxins related to cyanobacteria blooms (cyanotoxins), and to motivate public action to improve water quality.

In 2020 APCC monitored over 40 ponds across Cape Cod, including Long Pond. In 2019 APCC monitored 81 ponds and found that 40% exhibited "high" levels of cyanobacteria that warranted the posting of advisories for people and pets to avoid contact with pond water.

APCC collaborates with many local, regional, state and federal partners, including organizations, homeowners' associations, pond associations, water quality committees, municipal staff from Cape Cod and Martha's Vineyard towns, and state and federal agencies and organizations. Partners include the town of Barnstable, Cape Cod towns, Massachusetts Department of Public Health, Massachusetts Department of Environmental Protection, the U.S. EPA, Massachusetts Bays National Estuary Partnership, Massachusetts Division of Marine Fisheries, Barnstable County Department of Health and the Environment, with funding from Massachusetts Environmental Trust, Cape Cod Healthcare, private foundation grants, and dues and donations from APCC members.

Methods

APCC's Cyanobacteria Monitoring Program uses an EPA-approved monitoring protocol developed and published by the U.S. Environmental Protection Agency for the Cyanobacteria Monitoring Collaborative (CMC 2017) and published scientific articles (Leland and Haney, 2018; Leland, Haney, Conte, Malkus-Benjamin and Horsley, 2019). The protocol utilizes a combination of field observations, microscopy, and fluorometry to analyze cyanobacteria and cyanobacteria pigments in water samples from freshwater lakes and ponds. The data collected includes photographs and field observations, digital microscopy to identify composition (type of cyanobacteria present) and dominance, and concentrations of phycocyanin and chlorophyll pigments indicative of the amounts of cyanobacteria vs. general algae and phytoplankton, respectively. APCC tracks changes in cyanobacterial composition, dominance and abundance on a biweekly basis from June to October.

At this sampling frequency, APCC is often able to forecast when cyanobacteria blooms may be forming or when toxin concentrations may be approaching harmful levels. These signs instruct APCC to increase the frequency of testing and to inform town officials to be aware of potential threats and to plan for proactive management actions to protect public safety.

In Long Pond this season, samples were collected at the locations shown in Figure 1, between June and September.

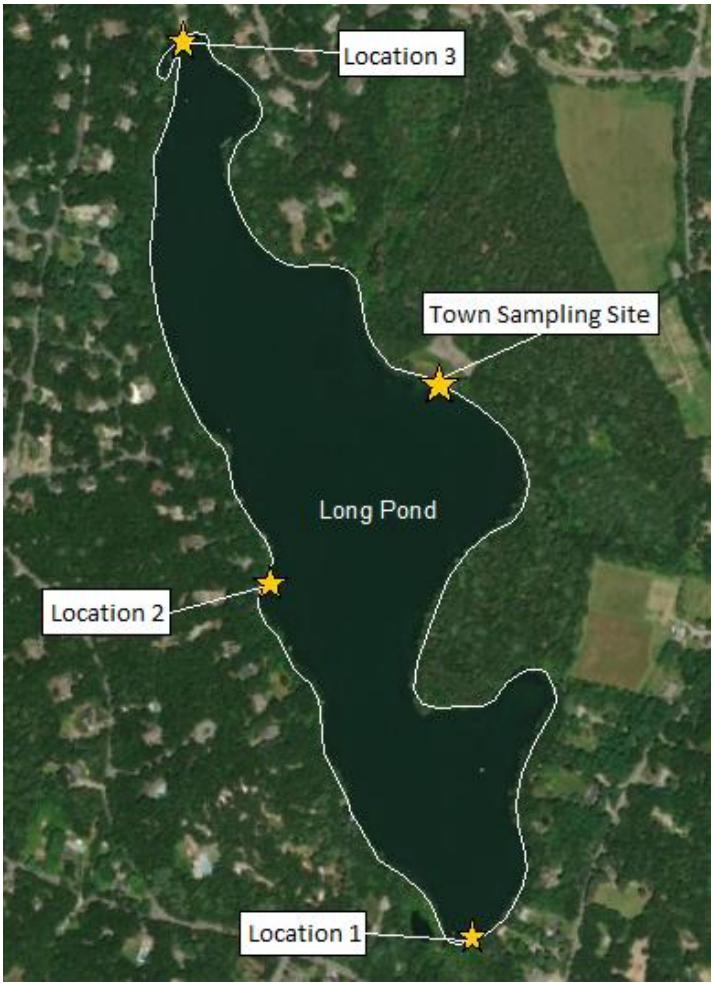

Figure 1. Cyanobacteria sampling stations in 2020.

To estimate cyanotoxin levels, measured phycocyanin concentrations in samples are compared to published relationships between concentrations of phycocyanin in whole lake water and bloom-forming colonies and cyanotoxin concentrations (Leland and Haney, 2018; Leland, Haney, Conte, Malkus-Benjamin and Horsley, 2019). Cyanotoxin analysis is conducted for specific instances by our scientific collaborators at the University of New Hampshire and Lim-Tek, Inc. When possible, APCC also conducts tests for one common cyanotoxin (microcystin) using Abraxis cyanotoxin test strip kits. These tests are rather costly and APCC is always seeking appropriate funding for cyanotoxin testing. Increased availability of cyanotoxin data to supplement our data can be a useful measure to determine more exact risk levels. In Long Pond, no Abraxis cyanotoxin tests were conducted by APCC in 2020. However, the Town conducted their own Abraxis cyanotoxin tests throughout the season to monitor the toxicity of the present visible cyanobacteria bloom.

In contrast to measuring cyanobacteria using cell counts, which is one of the methods listed by the Massachusetts Department of Public Health (MDPH), APCC's method is less costly, offers a faster turn-around time for results, and is often useful for predicting cyanobacteria bloom formation. APCC's method of using both microscopy to determine dominance as well as fluorometry of phycocyanin also reveals expected genus-specific toxicity which is not found through basic cell counts. Cyanobacteria pigment data and other collected data also support research efforts that will expand our understanding about the health of the ponds.

To interpret the results based on the dominant cyanobacteria genus in the sample and concentration of phycocyanin (PC) pigment, measured in micrograms per liter (ug/L) to estimate cyanotoxin levels, the threshold *s* in Table 1 are used. These phycocyanin values correspond to expected microcystin concentrations and each threshold denotes a regulatory standard for microcystin or the expectation of a cyanobacteria bloom formation. WLW stands for Whole Lake Water and denotes unconcentrated samples taken near shore with an integrated tube. The cyanobacteria concentrations in this sample reveal what was found in the water at moment of sample collection. BFC stands for Bloom-Forming Colonies and denotes samples taken with student plankton net towed over 3 meters near shore. The cyanobacteria concentrations in this sample reveal cyanobacteria growth and activity much more clearly than the WLW samples. BFC samples can describe exponential growth of cyanobacteria to predict blooms and can be used to forecast imminent threats due to cyanobacteria blooms. BFC concentrations are typically similar to a potential impending visible cyanobacteria scum accumulation. When these concentrations reach a certain threshold, we are often able to discern that a visible cyanobacteria bloom may have formed in another area of the pond not sampled or that a bloom likely recently formed or will form in the near future. BFC is APCC's preferred metric for cyanobacteria concentrations due to this forecasting ability, although WLW data is useful as well. As continued understanding of cyanobacteria risks emerge, APCC will update these tiers, as necessary.

Along with phycocyanin data, a visible cyanobacteria scum line or bloom formation may trigger a "high" warning tier designation. Exponential growth rates are also taken into account when assigning a warning tier. Finally, town advisory postings for cyanobacteria are taken into account along with APCC's data interpretations when assigning a tier designation. Once a pond reaches APCC's "high" warning tier, APCC will keep the pond in that tier until monitoring results fall below the criteria for the tier over two consecutive sampling events taken a week apart. This protocol is taken from the Massachusetts Department of Public Health (MDPH). When relating the findings to town officials, pond associations and the public, APCC uses the following descriptions:

Low indicates general safety for recreational activities according to our data. Assignment of results to this level indicates that monitoring data indicate no or low concentrations of cyanobacteria detected. To the best of our knowledge at the time and location of sample collection, regular recreational usage of the pond is safe with respect to cyanobacteria and toxins. On APCC's interactive map of results, the map color is blue.

Moderate indicates the cyanobacteria concentrations in the pond are particularly dangerous to children or pets if ingested and is very similar to the town of Barnstable's "Pet Advisory" level. Assignment of results to this level indicates that monitoring data indicate moderately high levels

of cyanobacteria concentrations detected. While these conditions pose low to minimal health risks to adults, they can be dangerous for children or pets if water is ingested accidentally or incidentally during recreational activities. Pet exposure can be from drinking water or grooming after swimming. Due to lower body masses, children and pets are more susceptible to impacts at lower concentrations than adults. This tier is consistent with the town of Barnstable's "Pet Advisory." If a town official declares a Pet Advisory for a pond at a given time, APCC will designate the pond in the "moderate" tier. On APCC's interactive map of results, the map color is yellow.

High indicates that APCC found that either toxin levels approached state standards for recreation or that a visible cyanobacteria scum was present; each poses a considerable risk for human and pet interactions with the pond. This tier is between the town of Barnstable's "Warning" and "Closure" tiers. Assignment of results to this level indicates that monitoring data indicate high levels of cyanobacteria concentrations were detected. Health risk to adults is high and is especially dangerous for children and pets when ingested. APCC found cyanobacteria concentrations near or exceeding state recreational standards with potential for exponential growth rates of cyanobacteria. Any accidental consumption of pond water is considered dangerous and interacting with the pond in general carries risk for adverse health effects. If a town official declares a Warning or Closure for a pond at a given time, APCC will designate the pond in the "high" tier. On APCC's interactive map of results, the map color is red.

Table 1. APCC Cyanobacteria Monitoring Results with Map Colors

Warning Tier	Dominant Genus	WLW	BFC
High	*Microcystis spp.* spp.	PC > 110 ug/L	PC > 390 ug/L
	Other	PC > 1,100 ug/L	PC > 3,900 ug/L
Moderate	*Microcystis spp.* spp.	16 ug/L < PC < 110 ug/L	110 ug/L < PC < 390 ug/L
	Other	160 ug/L < PC < 1,100 ug/L	1,110 ug/L< PC < 3,900 ug/L
Low	*Microcystis spp.* spp.	PC < 16ug/L	PC < 110ug/L
	Other	PC < 160ug/L	PC < 1,110 ug/L

Results

Location 1 (791 Santuit- Newton Rd)

A. Cyanobacteria Community Composition

Microscopic analysis revealed the composition and dominance of cyanobacteria found in Location 1 over the 11 sampling events as 97% *Microcystis* spp., 2% *Dolichospermum* spp. and 1% Woronichinia.

Table 2. Cyanobacteria Genera Dominance in Long Pond Location 1

Sampling Date	APCC Map Warning Tier	Percent dominance of each genus identified
6/18/2020	Low	99% *Microcystis* spp., 1% *Dolichospermum* spp.
6/24/2020	Low	100% *Microcystis* spp.
7/2/2020	High	100% *Microcystis* spp.
7/8/2020	High	100% *Microcystis* spp.
7/16/2020	High	100% *Microcystis* spp.
7/22/2020	High	100% *Microcystis* spp.
7/30/2020	High	100% *Microcystis* spp.
8/5/2020	High	99% *Microcystis* spp., 1% *Dolichospermum* spp.
8/13/2020	Moderate	100% *Microcystis* spp.
8/27/2020	Moderate	98% *Microcystis* spp., 1% *Dolichospermum* spp., 1% Woronichinia
9/10/2020	Low	72% *Microcystis* spp., 28% *Dolichospermum* spp.

B. Cyanobacteria Abundance based on Phycocyanin Pigment Concentrations

In Location 1, the lowest phycocyanin concentration recorded was 38.21 ug/L on June 18th and the highest phycocyanin concentration recorded was 429.68 ug/L on July 2nd.

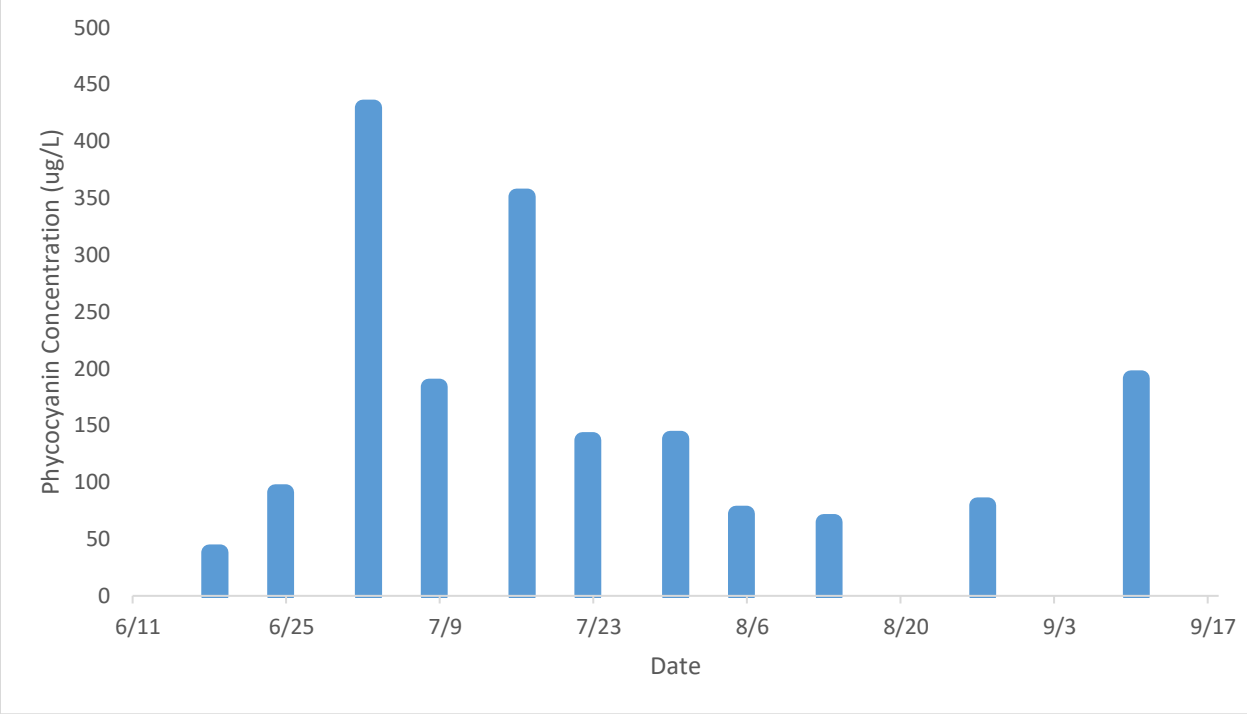

Figure 2. Phycocyanin Concentrations in Long Pond Location 1

C. Warnings, Advisories and APCC Cyanobacteria Map Levels

Long Pond Location 1 reached the "high" warning tier on July 2nd due to the appearance of a visible cyanobacteria bloom and phycocyanin readings that exceeded the criteria for the "high" tier given a *Microcystis* spp. dominant sample. The Town also found similar conditions and posted a Closure Advisory for the pond around this time. The "high" warning tier designation stayed in effect until August 13th when APCC demoted the pond to their "moderate" tier and The Town demoted the advisory designation to a Pet Advisory. On the final sampling date, the pond was lowered to the "low" warning tier due to increased dominance of *Dolichospermum* spp. despite an elevated phycocyanin reading. The Town similarly removed the Pet Advisory around this time.

D. Discussion

For much of the sampling period, Location 1 was placed in APCC's "high" warning tier due to the proliferation of a visible cyanobacteria bloom of the genus *Microcystis* spp. Throughout the month of July, Location 1 often experienced accumulations of thin green scum lines of visible cyanobacteria bloom material as well as elevated phycocyanin values. Visible cyanobacteria bloom accumulations at Location 1 were often less than were seen at other locations, but interestingly, phycocyanin values were generally similar between Location 1 and the other locations. Regardless, the risk for cyanobacteria exposure was high for Location 1 just as it was for the other locations for most of the season.

Location 2 (296 Long Pond Rd)

A. Cyanobacteria Community Composition

Microscopic analysis revealed the composition and dominance of cyanobacteria found in Location 1 over the 8 sampling events as 95% *Microcystis* spp. and 5% *Dolichospermum* spp.

Table 3. Cyanobacteria Dominance in Long Pond Location 2

Sampling Date	APCC Map Warning Tier	Percent dominance of each genus identified
6/18/2020	Blue	92% *Microcystis* spp., 8% *Dolichospermum* spp.
7/2/2020	High	100% *Microcystis* spp.
7/16/2020	High	100% *Microcystis* spp.
7/30/2020	High	96% *Microcystis* spp., 4% *Dolichospermum* spp.
8/5/2020	High	97% *Microcystis* spp., 3% *Dolichospermum* spp.
8/13/2020	Moderate	100% *Microcystis* spp.
8/27/2020	Moderate	100% *Microcystis* spp.
9/10/2020	Low	79% *Microcystis* spp., 21% *Dolichospermum* spp.

B. Cyanobacteria Abundance based on Phycocyanin Pigment Concentrations

In Location 2, the lowest phycocyanin concentration recorded was 49.19 ug/L on June 18th and the highest phycocyanin concentration recorded was 809.19 ug/L on July 2nd.

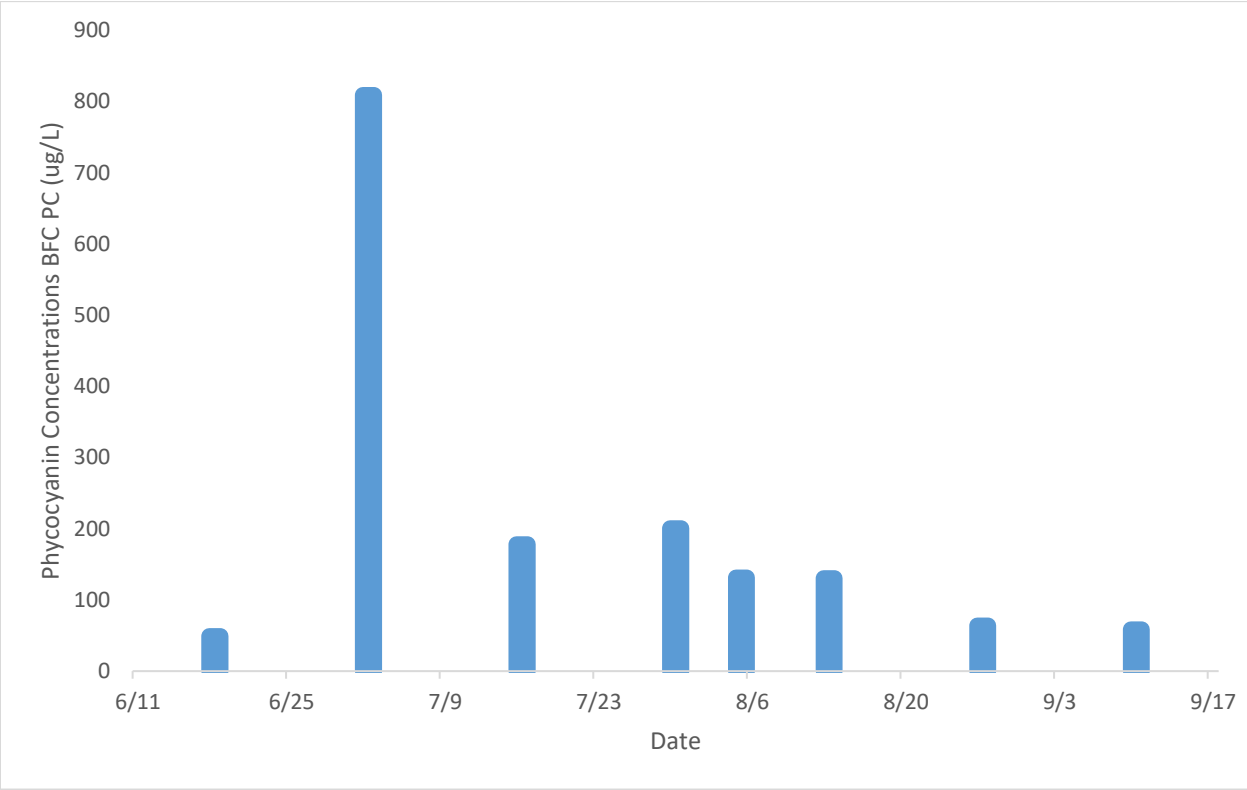

Figure 3. Phycocyanin Concentrations in Long Pond Location 2

C. Warnings, Advisories and APCC Cyanobacteria Map Levels

Long Pond Location 2 reached the "high" warning tier on July 2nd due to the appearance of a visible cyanobacteria bloom and phycocyanin readings that exceeded the criteria for the "high" tier given a *Microcystis* spp. dominant sample. The Town also found similar conditions and posted a Closure Advisory for the pond around this time. The "high" warning tier designation stayed in effect until August 13th when APCC lowered the level to the "moderate" tier and The Town lowered their advisory to a Pet Advisory. On the final sampling date, the pond was lowered to the "low" warning tier. The Town similarly removed the Pet Advisory around this time.

D. Discussion

As with Location 1, Location 2 was placed in the "high" warning tier due to the proliferation of a visible cyanobacteria bloom of the genus *Microcystis* spp. Throughout the month of July, Location 2 often experienced accumulations of cyanobacteria bloom material ranging from green scum lines along the shore to scattered dispersions of bloom material that ranged from shore to a few yards out. Location 2 experienced the highest phycocyanin reading among the three locations for the season on July 2nd but then readings were generally lower for the rest of the

season than the other two locations. Regardless, the risk for cyanobacteria exposure was high for Location 2 just as it was for the other locations for most of the season.

Location 3 (251 Lake Shore Drive)

A. Cyanobacteria Community Composition

Microscopic analysis revealed the composition and dominance of cyanobacteria found in Location 3 over the 8 sampling events as 94% *Microcystis* spp. and 6% *Dolichospermum* spp.

Table 4. Cyanobacteria Genera Dominance in Long Pond Location 3

Sampling Date	APCC Map Warning Tier	Percent dominance of each genus identified
6/18/2020	Blue	98% *Microcystis* spp., 2% *Dolichospermum* spp.
7/2/2020	High	100% *Microcystis* spp.
7/16/2020	High	100% *Microcystis* spp.
7/30/2020	High	96% *Microcystis* spp., 4% *Dolichospermum* spp.
8/5/2020	High	99% *Microcystis* spp., 1% *Dolichospermum* spp.
8/13/2020	Moderate	99% *Microcystis* spp., 1% *Dolichospermum* spp.
8/27/2020	Moderate	99% *Microcystis* spp., 1% *Dolichospermum* spp.
9/10/2020	Low	61% *Microcystis* spp., 39% *Dolichospermum* spp.

B. Cyanobacteria Abundance based on Phycocyanin Pigment Concentrations

In Location 3, the lowest phycocyanin concentration recorded was 35.14 ug/L on September 10th and the highest phycocyanin concentration recorded was 550.35 ug/L on July 2nd.

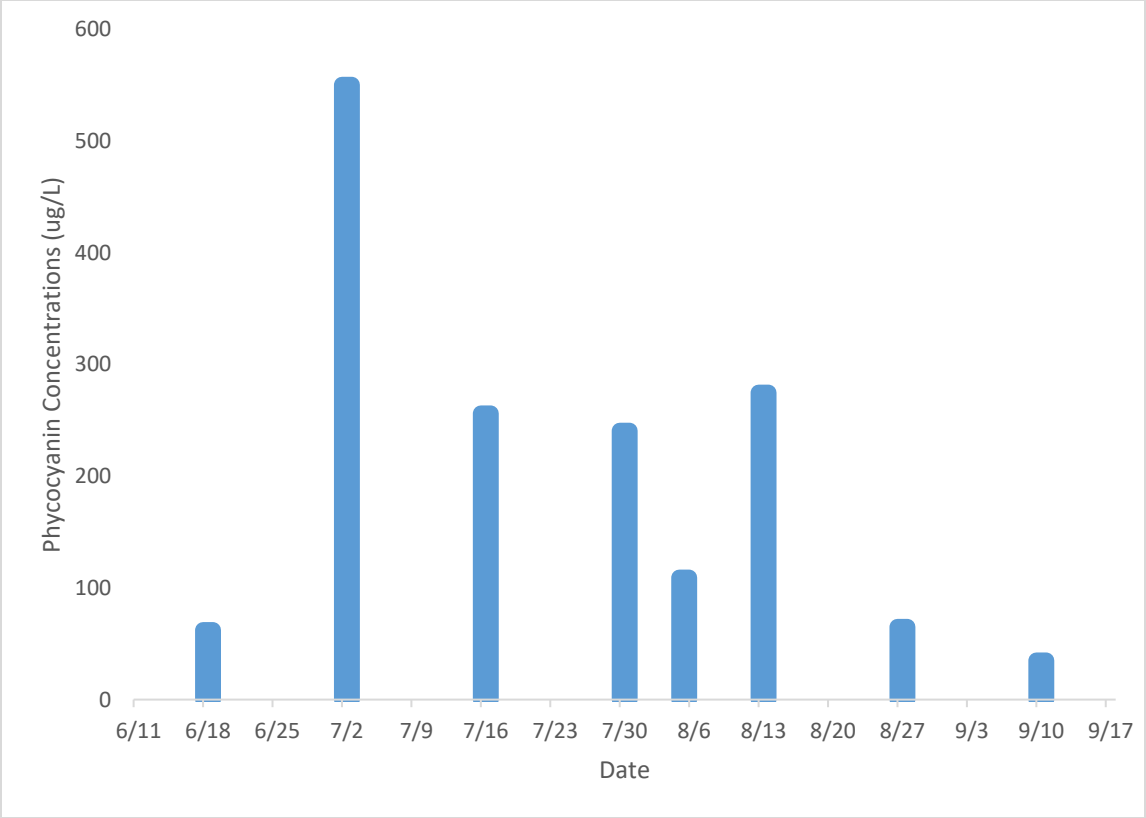

Figure 4. Phycocyanin Concentrations in Long Pond Location 3

C. Warnings, Advisories and APCC Cyanobacteria Map Levels

Long Pond Location 3 reached the "high" warning tier on July 2nd due to the appearance of a visible cyanobacteria bloom and phycocyanin readings that exceeded the criteria for the "high" tier given a *Microcystis* spp. dominant sample. The Town also found similarly concerning conditions and posted a Closure Advisory for the pond around this time. The "high" warning tier designation stayed in effect until August 13th when APCC lowered the level to the "moderate" tier and The Town lowered the advisory designation to a Pet Advisory. On the final sampling date, the pond was lowered to the "low" warning tier. The Town similarly removed the Pet Advisory around this time.

D. Discussion

As with the other two locations, Location 3 was placed in APCC's "high" warning tier due to the proliferation of a visible cyanobacteria bloom of the genus *Microcystis* spp. Throughout the month of July, Location 3 often experienced accumulations of cyanobacteria bloom material which were at times a mat of bloom material and at other times, scum lines or dispersed bloom material were observed. Location 3 experienced the most observed bloom material and on average higher phycocyanin readings than the other two locations. Location 3 is at the northern end of Long Pond and over the course of the season, southwesterly winds were found to be a common occurrence on sampling days which could possibly drive higher cyanobacteria bloom

accumulations in this end. Location 3 and the rest of the pond were placed in the "high" tier for most of the season regardless of these differences in bloom accumulation.

Conclusions

The 2020 monitoring season represented the first full season of cyanobacteria monitoring by APCC. All monitoring activities were successful, including collecting and analyzing samples and documenting results on every intended date throughout the season. The monitoring data provide a baseline for cyanobacteria trends in Long Pond over multiple sampling locations over the extent of a season. All results throughout the season were posted promptly to the APCC Interactive Map following the completion of sample analysis (APCC Cyanobacteria).

Long Pond experienced a significant cyanobacteria bloom dominated by cyanobacteria of the genus *Microcystis* spp. *Microcystis* spp. is a known producer of the hepatotoxin microcystin which can cause liver damage and also damage the kidneys and reproductive system (Microcystin). Microcystin is a cyanotoxin regulated by the Massachusetts Department of Public Health (MDPH). In general, Long Pond's cyanobacteria bloom was larger and persisted longer than many of the other ponds in APCCs Cyanobacteria Monitoring Program. This indicates a need for rehabilitation of the pond's health and continued monitoring in future seasons.

In addition, it is common for ponds to experience elevated cyanobacteria concentrations during periods of pond turnover in spring and fall (Paerl et al., 2001). In future seasons, it is recommended to extend the monitoring further into the fall and spring in order to monitor concentrations during these times. Although residents may interact with Long Pond less during these times, there are still potential dangers posed to pets who may consume or swim in these waters.

Recommendations

Monitoring over multiple years would provide greater understanding of the seasonal trends in cyanobacteria concentrations and cyanobacteria communities in Long Pond. More years of data will allow better predictions to be provided year over year. Continued monitoring will also allow us to track water quality degradation as related to occurrence of harmful cyanobacteria blooms that point to larger issues of pond impairment. Monitoring efforts will shed light on the ponds most in need of protection and possibly rehabilitation. Monitoring in the early and late season will also lead to an increased understand of the cyanobacteria trends and the effects of pond overturn in Long Pond.

APCC plans to conduct a pilot study of a different cyanotoxin, anatoxin-a, in 2021 in select ponds on Cape Cod. Anatoxin-a is a neurotoxin produced by *Dolichospermum* spp, a common cyanobacteria genus detected in 2020 in Long Pond. The occurrence of anatoxin-a in natural water bodies has not been adequately researched, and more data could help to characterize the risk potential from this neurotoxin. The results of the study could help inform APCC of further cyanotoxin risk in the ponds in our network, including Long Pond.

To promote improved pond health, residents surrounding vulnerable pond ecosystems should take action to reduce potential nutrient pollution flowing from their property. Excess fertilizer use, improper management of septic systems, poor stormwater management infrastructure, and a lack of adequate vegetation buffers are all examples of behavior that serve to exacerbate the nutrient loading of Long Pond. For a complete list of actions residents can take to promote pond health, please visit APCC's Recommended Actions for Ponds page, a part of the State of the Waters: Cape Cod project (State of the Waters).

To promote improved pond health, residents surrounding vulnerable pond ecosystems should take certain actions on their properties so that their properties are not contributing to the nutrient pollution. These actions include avoiding use of fertilizers, properly maintaining septic systems by pumping at least every three years, ensuring precipitation is infiltrated on the property with zero stormwater runoff from property, and establishing a vegetated buffer between the pond and the lawn. For a complete list of actions residents can take to promote pond health, please visit APCC's Recommended Actions for Ponds page, a part of the State of the Waters: Cape Cod project (State of the Waters).

In general, APCC does not support the use of aluminum sulfate (alum) treatments to alleviate phosphorus loading and cyanobacteria blooms. While these treatments often produce desired results in the short term, they only provide temporary relief from one factor (phosphorus) contributing to the increasing issue of excessive cyanobacteria growth, and they raise significant concern among environmentalists for a variety of reasons. Recent research has found that alum treatments can produce "unintended ecological consequences," including increasing dissolved aluminum and sulfate in lake water, altering important nitrogen cycling processes, and affecting benthic communities (Nogaro et al., 2013). Negative side-effects of dissolved forms of aluminum may harm certain invertebrates and are known to be toxic to fish (Gensemer and Playle, 1999). A third paper on this topic concluded that alum treatment should not be used to treat cyanobacteria HABs due to unintended effects, including microcystin toxin release and reduced activity of beneficial cyanobacteria-lysing and microcystin-degrading bacteria (Han et al., 2013).

Furthermore, there is growing evidence that management of nitrogen as well as phosphorus is important in controlling cyanobacteria blooms. Nitrogen loading has been found to promote blooms of certain non-nitrogen fixing genera of cyanobacteria including *Microcystis* spp. (Paerl et al. 2010), which was present in Long Pond this season. *Microcystis* spp. has been found to dominate waters with low phosphorus concentrations and nitrogen loading may "selectively promote the abundance of *Microcystis* spp." (Gobler et al. 2016).

In addition to nutrient loading, changing climate conditions, including warming and altered rainfall patterns, are believed to play a significant role in the increasing frequency and intensity of harmful cyanobacteria blooms (Paerl et al., 2019).

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