2022 Cyanobacteria Monitoring Report for Orleans Pond Coalition, Orleans, Massachusetts

December 21, 2022

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1. SUMMARY

In 2022, the Association to Preserve Cape Cod (APCC) continued cyanobacteria monitoring in Orleans for the Orleans Pond Coalition, following similar monitoring in 2021. From June through November, APCC conducted biweekly sampling at six sampling locations (see Appendix 4 for sampling locations). Bakers Pond was monitored separately by the Brewster Ponds Coalition in 2022, but data from Bakers have been included in this report. APCC conducted 82 sampling events and collected a total of 82 samples and analyzed samples for cyanobacteria composition and phycocyanin, a cyanobacteria pigment that provides a measure of cyanobacteria biomass.

APCC utilizes a three-level risk characterization system known as "Risk Categories" to describe the results of cyanobacteria monitoring in terms of low, moderate, and high potential risks to human health and pets exposed to harmful cyanobacteria blooms (HCBs). The three Risk Categories are: "Acceptable" (low risk), "Potential for Concern" (moderate risk for humans and pets), and "Use Restriction Warranted" (high risk for humans and pets). In 2022, APCC incorporated complementary microcystin testing from the Barnstable County Department of Health and the Environment Water Quality Lab. Samples characterized by APCC as at risk for an exceedance of the Massachusetts Department of Public Health (MDPH) guidelines for microcystin in recreational waters of 8 parts per billion (ppb) were sent to the County Water Quality Lab for confirmatory testing. The lab then communicated confirmation of microcystin risks in terms of the state limit to APCC and the town health department.

During the 2022 monitoring season, cyanobacteria levels in Cedar Pond, Uncle Harvey's Pond, Crystal Lake, and Pilgrim Lake reached APCC's "Potential for Concern" Risk Category. There were no Orleans ponds that required a recreational advisory at any point in 2022. In addition, no toxin samples from any of the Orleans ponds required additional analysis from the County Water Quality Lab. APCC shared all monitoring results with Town of Orleans, the Orleans Pond Coalition and the public throughout the season via emailed updates, e-newsletters, frequent updates to our online map at https://apcc.org/our-work/science/community-science/cyanobacteria/, and written reports,

including this report. This document should be printed in color, as some sections are color-coded.

2. BACKGROUND

APCC's Cyanobacteria Monitoring Program partners with officials at the town, county, state, and federal levels as well as local pond associations and residents to conduct cyanobacteria monitoring in Cape Cod ponds. Each season, water samples are collected and processed weekly and shared with local officials and the general public through reports, emails, and an interactive map of monitoring results provided on our website (https://apcc.org/cyano). Our goals are to raise public awareness of the health and ecological risks posed by HCBs, to help inform proper responses to cyanobacteria blooms to protect public health, to monitor priority ponds across the Cape, and to motivate public action to address the causes of HCBs by improving water quality.

Cyanobacteria are an ancient group of photosynthetic microorganisms common in freshwater systems on Cape Cod, in the U.S., and worldwide. Under the right conditions, they can multiply rapidly and form harmful cyanobacteria blooms. According to the Centers for Disease Control and Prevention, certain common cyanobacteria genera can produce toxins known as cyanotoxins that can be harmful to humans (CDC). HCBs have increased worldwide, including in the U.S., due in part to nutrient enrichment and rising water temperatures due to climate change. As the occurrence of HCBs increases, the need for increased cyanobacteria monitoring and awareness has also increased. Additional resources on cyanobacteria are provided in Appendix 1.

Cape Cod ponds are commonly used for swimming, boating, paddle boarding, and fishing. Due to the increasing prevalence of HCBs and the resulting increased threat of public exposure to cyanobacteria and their toxins, MDPH provides guidelines for municipal officials to post and remove advisories at ponds based on established thresholds for cyanobacteria risks (MDPH). Frequent cyanobacteria monitoring of ponds provides the data for resource managers to track cyanobacteria trends in their ponds throughout the season, apply relevant public health criteria, and proactively post and remove recreational advisories. Cyanobacteria monitoring data also provide information on pond health and water quality and help to address data gaps caused by lack of conventional pond water quality monitoring data.

3. METHODS

Overview

APCC's Cyanobacteria Monitoring Program provides scientifically sound data on cyanobacteria community composition, biomass, and estimated toxin concentrations. Our program uses and follows the EPA's Quality Assurance Project Plan (QAPP) for cyanobacteria monitoring, developed by EPA for the Cyanobacteria Monitoring Collaborative or CMC (CMC QAPP). The CMC QAPP was developed by EPA Region 1 scientists, including Hillary Snook and others, with the goal of encouraging and facilitating widespread monitoring of cyanobacteria. The

QAPP is based on methods created by EPA scientists and other cyanobacteria specialists, including Dr. James Haney at the University of New Hampshire Center for Freshwater Biology and Nancy Leland of Lim-Tex, Inc. The method involves taking concentrated samples of "Bloom Forming Colonies" (BFCs) of cyanobacteria through a 3-meter student plankton net tow and unconcentrated samples of "Whole Lake Water" (WLW) through a 1-meter integrated tube. Samples are then examined for cyanobacteria composition using microscopy. Cyanobacteria composition is important to document because toxicity varies according to cyanobacteria genus. Samples are also analyzed for phycocyanin concentrations using fluorometry. Phycocyanin is an algal pigment produced by cyanobacteria, different and distinct from chlorophyll, which is produced by algae and plants. Phycocyanin concentrations provide a measure of cyanobacteria biovolume and abundance. The combination of information on composition (obtained through microscopy) and information on cyanobacteria pigment concentrations enables an estimation of risk posed by cyanobacteria at the time of monitoring.

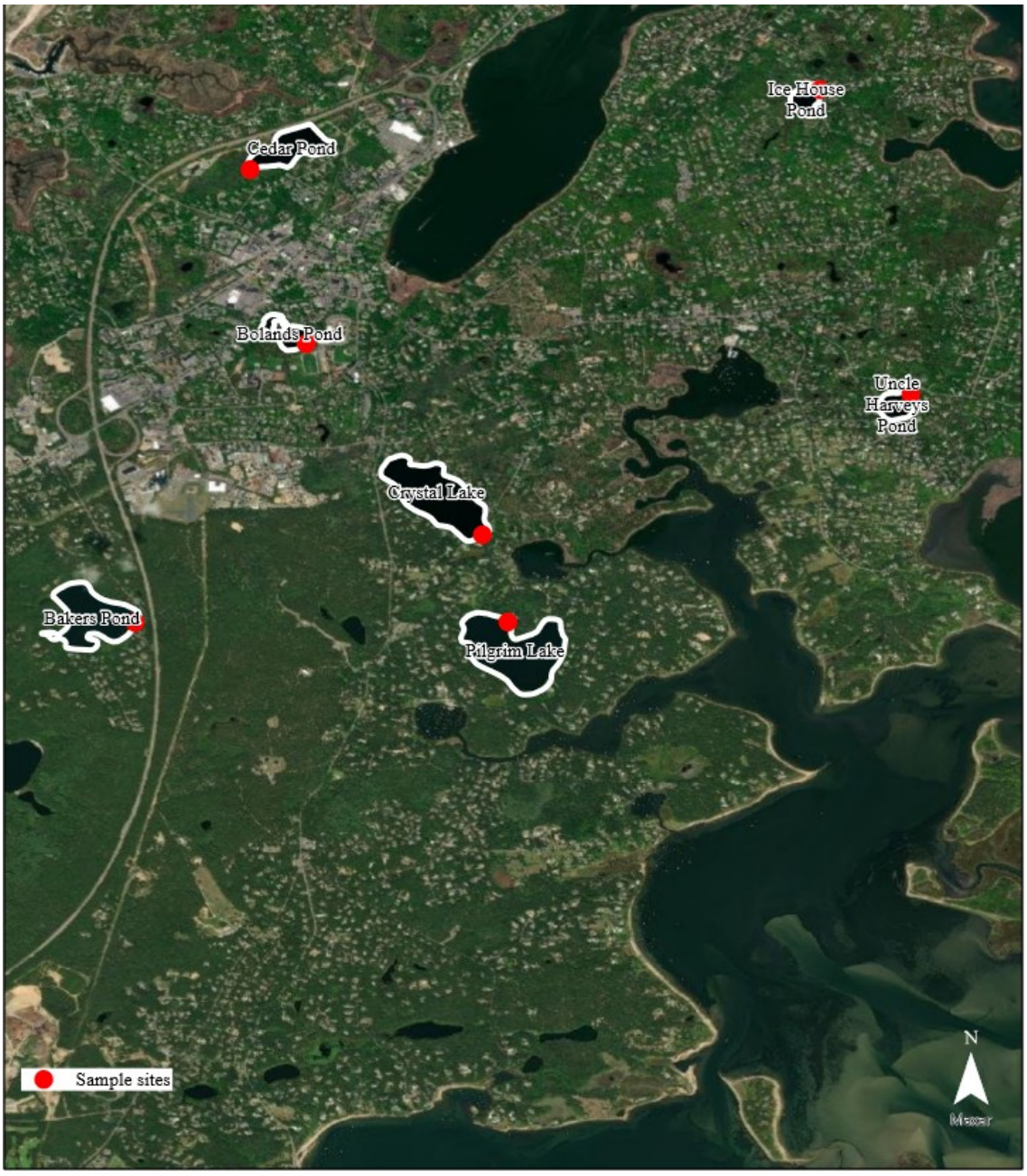
APCC also utilizes the CyanoCasting method developed by Nancy Leland (Leland, 2018), which builds on the methods described in the QAPP by including metrics that allow for the forecasting of potential imminent cyanobacteria blooms and estimates of cyanotoxin (i.e., microcystin) concentrations. The forecasting ability of this method provides valuable advance warnings of potential HCBs to inform proactive responses, such as increased sampling frequency or precautionary advisories of ponds to warn the public of the potential for cyanobacteria blooms. The ability to anticipate potential HCBs and estimate their microcystin concentrations based on frequent monitoring is a unique and valuable feature of APCC's program and stands in contrast to reactive responses involving measurement of cyanobacteria concentrations after a bloom has occurred (Leland et al. 2018, Leland et al 2019).

This year, as a complement to APCC's established monitoring program, the Barnstable County Department of Health and the Environment (BCDHE) Water Quality Lab expanded its cyanobacteria toxin testing capabilities to provide local officials with toxin measurements from ponds pre-screened by APCC as potentially containing cyanobacteria toxin levels of concern. The screening process was as follows: At each cyanobacteria sampling event, APCC collected separate water samples for toxin analysis if needed. APCC then analyzed cyanobacteria as described above and used the results to screen each pond. If samples had cyanobacteria results (i.e., risk categories) that indicated a possibility of an exceedance of state microcystin guidelines, APCC sent the separate water samples to the BCDHE Water Quality Lab to conduct confirmatory toxin testing of microcystin, one type of cyanobacteria toxin. Toxin test results were then used to determine whether an advisory was warranted. If so, APCC provided a recommendation to the local health official to post an advisory. Local health officials are responsible for deciding whether to post advisories or not. To assist with decision-making, APCC conducted follow-up monitoring that included information on when cyanobacteria levels decreased to the point where an advisory, if posted, could be lifted.

Sampling Locations

This season, at least 12 samples were collected at each location on a biweekly basis between June and November. Samples were collected in collaboration with the Orleans Pond Coalition at the locations shown in Figure 1. Bakers Pond was sampled by the Brewster Ponds Coalition.

Figure 1. Sampling Locations for the Orleans Pond Coalition in 2022.



Water Sampling

Water samples were collected by OPC citizen scientists with assistance from APCC staff and interns on a biweekly schedule, between June and November. At each sampling event, three samples were collected from shore, one using a 1-meter tube called the Whole Lake Water sample, a second using a 50-micron (um) mesh student plankton net called the Bloom Forming Colonies sample, and a third grab sample taken in a glass bottle with a PTFE-lined lid called the toxin sample. When cyanobacteria bloom material was found, a sample of the bloom material was taken for additional analysis. Between June 7, 2022, and November 11, 2022, APCC conducted 12 biweekly sampling events at each location for a total of 72 sampling events. Throughout the season extra off-week samples were taken if there was a concern that a cyanobacteria acceleration in growth could occur between the scheduled biweekly sampling events. There was a total of 10 additional samples taken from four ponds. The types of samples collected are described below.

Whole Lake Water (WLW) Sample

The sample taken from the 1-meter tube is called the Whole Lake Water (WLW) sample. This is an unconcentrated water sample containing cyanobacteria from the full extent of the 1-meter sampling depth from the surface to just above the bottom near shore. This sample is processed by APCC staff to obtain data on cyanobacteria size fractions in the water column. This process is further explained in the "Lab Analysis" section. This sample is not used to forecast future bloom accumulations, as it contains cyanobacteria currently in the water column near shore.

Bloom Forming Colonies (BFC) Sample

The second sample, which is using a student plankton net, is called the Bloom Forming Colonies (BFC) sample. This is a concentrated sample taken by towing the student plankton net across a 3-meter cast near the surface. This sample contains larger cyanobacteria colonies, which tend to form visible blooms and scums. Fundamentally, this sample is analogous to a natural cyanobacteria accumulation that may occur on a pond if the wind condensed cyanobacteria over a distance of 3 meters into a potentially harmful accumulation near shore. Nearshore accumulations of cyanobacteria are considered to pose a higher risk because this is where children and pets typically interact with the pond.

The concentrations of cyanobacteria in BFC samples can fluctuate dramatically and sudden or continuous increases of cyanobacteria concentrations in BFC samples can foreshadow cyanobacteria bloom formations in the near future. Understanding the toxin concentrations of this sample can also provide information on the likelihood of a future microcystin exceedance. This concept is discussed in more detail below.

Toxin Sample

The third sample is a simple grab sample using a 125 milliliter (mL) amber glass bottle with a PTFE-lined cap. This sample is called the toxin sample. When APCC's metrics using

cyanobacteria composition and concentration indicate a likelihood that microcystin concentrations may exceed 8 parts per billion (ppb), APCC delivered this sample to the Barnstable County Water Quality Lab for analysis of microcystin.

Cyanobacteria Scum Sample

The fourth sample, taken only when needed, is called the scum sample and may contain cyanobacteria bloom material. Although visual evidence alone of potential cyanobacteria bloom material can be compelling, microscope and fluorometry analysis of the material can confirm whether the material is indeed a cyanobacteria bloom rather than an accumulation of other algae, diatoms, etc. Microscope analysis of the bloom material also provides information on the genus of cyanobacteria making up the bloom, giving an understanding of the types of toxins that may be present.

Field Observations

Field observations were documented at each sampling event by completion of a field data sheet with information on weather, visual appearance of pond surface, water temperature, etc. Photographs were taken of the pond's shoreline at each sampling event, providing documentation of pond appearance and visible conditions and evidence of bloom accumulations.

Lab Analysis

Sample processing

On the same day as sample collection, APCC processed and analyzed samples following our protocol. Triplicate 5 milliliter (mL) samples were taken of each of the 3 to 4 sample types: the WLW sample, the < 50 micron (µm) sample, the BFC sample, and the scum sample when possible cyanobacteria bloom material was discovered. The < 50 µm sample was isolated by filtering the WLW sample through a 50 micron (µm) filter, which resulted in a sample containing only the relatively small colonies of cyanobacteria. Smaller cyanobacteria, known as pico-cyanobacteria, are also believed to produce cyanotoxins at concerning levels. APCC has been contributing to Nancy Leland's research on these communities and we hope to apply these findings to inform our program in future seasons. The WLW and scum samples were processed without further action. The BFC sample was further separated through the use of Zapprs (see EPA QAPP, CMC QAPP).

Microscopy

Using a microscope, APCC staff and interns counted colonies of cyanobacteria from a 1 mL sample from the BFC sample up to 100 colonies per mL. The information was used to estimate dominance of different cyanobacteria genera. If one genus was found to be the "dominant genus" (defined as 70% of the cyanobacteria community on the slide), then APCC targeted the toxins produced by that genus of cyanobacteria as the toxins of concern for that pond at that time. If a scum sample was taken, APCC also analyzed it under the microscope to inspect genus composition and to confirm whether the scum was indeed composed of cyanobacteria.

Fluorometry to measure phycocyanin pigments

Each triplicate 5 mL sample was frozen and thawed for the purpose of lysing cells to liberate cyanobacteria pigments. Samples were then analyzed for cyanobacteria pigments (phycocyanin) and non-cyanobacteria algal pigments (chlorophyll-a) using a calibrated fluorometer in parts per billion (ppb). APCC uses phycocyanin concentrations in micrograms per liter (ug/L) as an indicator of cyanobacteria biomass rather than cell counts. Understanding cyanobacteria concentrations using fluorometry allows APCC to track cyanobacteria community trends over time. All data was stored on APCC's online server.

Microcystin Testing by County Water Quality Lab

At each sampling event, APCC collected extra samples for analysis of microcystin if cyanobacteria risk levels were in the "Use Restriction Warranted" category. To ensure that samples for toxin testing were collected on the same date, time, and place as samples for cyanobacteria monitoring, APCC collected GRAB samples for toxin analysis at the same time and location as our samples for cyanobacteria analyses. Samples for toxin analyses were collected and preserved according to MDPH and EPA protocols (Local Public Health Institute of Massachusetts, Method 546). In the event that APCC's cyanobacteria data indicated the likelihood of a microcystin exceedance, the corresponding GRAB sample(s) were sent to the County Water Quality Lab for toxin analysis. The BCDHE Water Quality Lab then forwarded the toxin testing results and recommendations of a recreational advisory, when warranted, to local officials and APCC. Toxin testing results supplemented APCC's cyanobacteria monitoring data. The simultaneous collection of samples for cyanobacteria and cyanotoxins helped to ensure that cyanotoxin analyses (if warranted) correspond to cyanobacteria monitoring data in terms of time and place. This proactive sampling approach avoids a common pitfall of reactive sampling that can occur when cyanobacteria monitoring data are collected on one date and confirmatory samples are collected several days to a week later when conditions may have changed.

Interpretation of Results

APCC staff interpreted the results within a guidance framework that incorporates the most recent scientific information as well as existing state and federal guidance (EPA recreational waters, MDPH).

Massachusetts Department of Public Health (MDPH) Guidelines for Cyanobacteria

The MDPH cyanobacteria webpage describes guidelines for cyanobacteria in recreational freshwater bodies that are described in italics as follows ("Guidelines for Cyanobacteria at Recreational Freshwater Locations") (MDPH). Italics indicates text taken directly from state and federal guidance documents and websites.

[Issuing a Public Health Advisory]
"DPH recommends issuing a public health advisory for HABs at recreational freshwater locations when at least one of the following criteria is met:

1. ***A visible cyanobacteria scum or mat is evident.***
2. ***Total cell count of cyanobacteria exceeds 70,000 cells/mL.***
3. ***Concentration of the toxin microcystins exceeds 8 µg/L; or***
4. ***Concentration of the toxin cylindrospermopsin exceeds 15 µg/L***

Guideline values are based on US Environmental Protection Agency (US EPA) and World Health Organization (WHO 1999) (WHO 2003) recommendations. When issuing an advisory, signage should be posted at each access point at the waterbody warning against any contact with the water.

Rescinding a Public Health Advisory
Cyanobacteria cells can release cyanotoxins into the water when they die. Therefore, algal toxins may be present when a visible scum or mat is no longer evident. DPH recommends the rescinding of a public health advisory after two successive samples, collected a week apart, demonstrate cell counts or toxin levels below the quantitative guideline values." (MDPH)

Cyanobacteria Risk Categories

APCC interpreted cyanobacteria data using a system called "Cyanobacteria Risk Categories." This data interpretation system was created using guidance and feedback from cyanobacteria researchers, Cape Cod health agents, and state guidance. The criteria for the Risk Categories do not include cell counts or cylindrospermopsin (another cyanobacteria toxin), as neither APCC nor the BCDHE Water Quality Lab test for these metrics.

APCC tracked changes in cyanobacteria concentrations between each sampling event. The reason for tracking changes in cyanobacteria concentrations over time is that rapid growth rates, defined here as net daily cyanobacteria growth rates greater than or equal to 0.05, may indicate that a cyanobacteria bloom formation or microcystin exceedance is about to occur. Alternatively, the cyanobacteria concentrations may peak and then decrease before a cyanobacteria bloom or microcystin exceedance occurs. APCC recommended weekly testing of ponds where any APCC sample had a confirmed net daily cyanobacteria growth rate greater than or equal to 0.05. Before August 1, 2022, APCC would also place ponds in the "Potential for Concern" category for one week following a growth rate above 0.05. However, following new guidance from program partners, APCC began to not recommend a change in risk category based on cyanobacteria growth rate data alone starting August 1, 2022. Additionally, starting on August 1st, APCC would not calculate net daily cyanobacteria growth rates for phycocyanin values less than 5 ppb.

To assign a Cyanobacteria Risk Category to a pond for a given monitoring period, the most hazardous result among multiple criteria determined the risk category in which the pond was placed. A pond that met even a single criterion in the "Use Restriction Warranted" category was placed in that category. Likewise, a pond that met even a single criterion in the "Potential for Concern" category, but did not meet any criteria in the "Use Restriction Warranted" category, was placed in the "Potential for Concern" category. If a pond met no criteria in the "Use Restriction Warranted" or the "Potential for Concern" categories, that pond was placed in the

"Acceptable" category. All descriptions and criteria for these categories are summarized in Appendix 2 and discussed below.

APCC Cyanobacteria Risk Categories

Acceptable
Definition: No concerning cyanobacteria results at the time and place of sampling. To the best of APCC's knowledge and based on our monitoring results, regular recreational usage of the pond is safe with respect to cyanobacteria and toxins. Map color is blue. Formerly the Low Warning Tier.
Recommended Sampling Frequency: Biweekly. In samples containing low levels of cyanobacteria with high growth rates APCC will recommend weekly sampling.
Recommended Action: None.

Potential for Concern
Definition: Monitoring results or the presence of cyanobacteria scum at the time and place of sampling indicate a potential for increased risk for exposure to cyanobacteria toxins approaching but below state standards. Conditions do not yet warrant the posting of a recreational human health advisory according to guidelines from the Massachusetts Department of Public Health (MDPH). While these conditions pose low health risks to adults, risks are higher for children or pets based on lower body mass, particularly if contaminated water is incidentally ingested. Children may inadvertently consume pond water while swimming and pet exposure can result from drinking or ingesting pond water or from grooming after swimming. Map color is yellow. Map color yellow with crosshatching indicates a municipal pet advisory has been issued. Formerly the Moderate Warning Tier[1,2,4].
Recommended Sampling Frequency: Weekly.
Recommended Action:

1. APCC or the town will provide a GRAB sample for toxin analysis to the Barnstable County Water Quality Lab for samples suspected of possibly exceeding the MDPH guidelines for microcystin in recreational waters.
2. The posting of a "Pet Advisory" or similar advisory according to municipal policies and procedures until the pond returns to "Acceptable" status.
3. Sampling should be increased to weekly until all results are once again in the "Acceptable" category.

Use Restriction Warranted
Definition: Monitoring results at the time and place of sampling indicate the pond is unsafe for recreation by humans and pets based on one or more of the following criteria: 1) presence of microcystin at or above state standards (8 ppb microcystin) as described in MDPH guidance, 2) presence of significant cyanobacteria scum layers according to MDPH guidance, 3) a municipal health agent issues a closure for any other reason related to cyanobacteria. Recreational risk to adults is moderate following exposure. Recreational risks are especially high for children and pets following exposure through accidental ingestion of contaminated water. Children may inadvertently consume pond water while swimming and pet exposure can result from ingestion or directly drinking pond water or from grooming after swimming. Due to lower body masses, children and pets are more susceptible to cyanobacteria risks than adults. Map color is red. Map

color red with crosshatching indicates a municipal advisory has been issued. Formerly the High Warning Tier[3].
Recommended Sampling Frequency: Weekly.
Recommended Action:

1. APCC or the town will provide a GRAB sample for toxin analysis to the Barnstable County Water Quality Lab for samples suspected of possibly exceeding the MDPH guidelines for microcystin in recreational waters.
2. The town should post a recreational advisory or similar advisory according to municipal policies and procedures and otherwise notify the public to avoid contact and exposure until the pond meets criteria to be reopened or the advisory is lifted by the local health agent.
3. Sampling should be conducted weekly until there are two consecutive weeks when results include no significant cyanobacteria scum and toxin testing of samples contain a microcystin concentration below 8 ppb.

Recommendations for posting Use Restrictions and Advisories

Use restrictions and advisories are issued at the discretion of the municipal health agents. As of this date, there is no common set of guidelines in use by health agents across the Cape that provides consistency in posting criteria. As a result, members of the public are advised to contact the health agent in their town (see the contact list provided on APCC's website) to determine the official status of the pond in which they are interested. While ponds exceeding MDPH standards as discussed above were marked in red on APCC's map, this coloration does not always mean that a use restriction was issued by the town. APCC updates our list of restricted ponds as we are informed by the respective towns, but APCC does not speak for the towns unless otherwise and explicitly noted on our posting map.

APCC's recommendations for removing a recreational use advisory mirrors the reopening guidance from MDPH. For a microcystin toxin exceedance or cyanobacteria scum, APCC will recommend lifting a recreational use advisory or closure after two consecutive tests a week apart show microcystin concentrations less than 8 parts per billion (ppb) and little to no presence of cyanobacteria bloom material, depending on the basis for the original restriction. Health agents are solely responsible for the issuance and removal of recreational use advisories or closures related to water clarity, such as clarity less than 4 feet.

Reporting

Biweekly reports

APCC provided biweekly reports to report results to local municipal officials and pond associations. Depending on results, reports included recommendations concerning appropriate advisory posting or removal for the public to minimize or avoid risks due to cyanobacteria exposure. During periods of possible harmful cyanobacteria bloom formation requiring weekly sampling, additional reports and updates were sent to officials and pond associations as well. Pond associations play a key role in raising public awareness of cyanobacteria risks and alerting pond residents of cyanobacteria monitoring results throughout the season.

Interactive map

An interactive map is hosted on APCC's website where recent monitoring results were posted throughout the season. Updates were submitted on an automated basis at 7 p.m. on the same day as reports of results were emailed to town officials. In some cases, automated map updates were postponed a day if a town official requested additional time to review results before they would be posted. The interactive map is located at: https://apcc.org/cyano.

Email alerts

APCC provided an email registry signup on our website for an e-blast system designed to update interested residents about recent harmful cyanobacteria bloom discoveries. Residents could sign up for these Cyanobacteria Alerts throughout the season. The link for the Cyanobacteria Alert e-blast signup is located here https://apcc.org/our-work/science/community-science/cyanobacteria/cyanobacteria-alert/.

4. RESULTS

Cyanobacteria monitoring results, Risk Categories, and risk communication are described in this section. For each pond, a table is provided to describe results and risk category designations for each sampling event. A complete table of results is provided in Attachment 1 containing all data collected for the Orleans Pond Coalition in 2022. This table is formatted to be printed on an 11”x17” sheet. The full Risk Category criteria are included in Appendix 2. Data interpretation and risk communication to town officials and the public for each sampling event are described in this section as well.

Results for the sampling locations are described below. OPC in collaboration with APCC sampled from seven locations (see Appendix 4 for a list of sampling locations).

Bakers Pond: Boat Ramp

During the 2022 monitoring season, Bakers Pond experienced changes in cyanobacteria levels that at different times placed it in APCC's "Acceptable," and "Potential for Concern" Risk Categories (Table 1 below).

Following early "Acceptable" sampling events at Bakers Pond, the site reached the "Potential for Concern" category starting on 7/13/22 due to an elevated daily net cyanobacteria growth rate that exceeded 0.05. At this point, APCC increased sampling to weekly until the growth rate returned below 0.05. Bakers Pond also experienced elevated daily net cyanobacteria growth rates from 7/27/22 to 10/12/22, so APCC increased to weekly sampling. However, due to a change in communication protocol beginning on August 1st, 2022, Bakers Pond remained "Acceptable" on those dates.

On 10/12/22, Bakers Pond returned to "Potential for Concern" category due to the presence of a small cyanobacteria scum. This accumulation did not warrant a recreational advisory and the scum dissipated by the following week. Bakers Pond was "Acceptable" for the remainder of the sampling season.

Bakers Pond was monitored by the Brewster Ponds Coalition in 2022. Data collected from this partnership was shared with OPC and the Town of Orleans throughout the season.

Table 1. Summary of cyanobacteria monitoring results for Bakers Pond, Orleans, MA.

Sampling Date	APCC Current Risk Category	Dominant Genus	Bloom Forming Colonies Phycocyanin (ug/L)	Current Risk Category Notes
6/1/2022	Acceptable	*Dolichospermum* spp.	128	-
6/15/2022	Acceptable	N/A	2	-
6/29/2022	Acceptable	N/A	10	-
7/13/2022	Potential for Concern	*Dolichospermum* spp.	37	The BFC net daily cyanobacteria growth rate exceeded 0.05. Growth rate: 0.10 (BFC)
7/20/2022	Potential for Concern	*Microcystis* spp.	59	The BFC net daily cyanobacteria growth rate exceeded 0.05. Growth rate: 0.07 (BFC)
7/27/2022	Potential for Concern	*Dolichospermum* spp.	100	The <50 and BFC net daily cyanobacteria growth rates exceeded 0.05. Growth rates: 0.09 (<50) and 0.08 (BFC)
8/2/2022	Acceptable	*Dolichospermum* spp.	6	-
8/10/2022	Acceptable	*Dolichospermum* spp.	39	-
8/18/2022	Acceptable	*Microcystis spp.*	15	-
8/22/2022	Acceptable	*Dolichospermum* spp.	71	-
8/31/2022	Acceptable	*Dolichospermum* spp.	24	-
9/7/2022	Acceptable	*Dolichospermum* spp.	17	-
9/21/2022	Acceptable	*Dolichospermum* spp.	33	-
9/28/2022	Acceptable	*Dolichospermum* spp.	24	-
10/5/2022	Acceptable	Mixed	57	-
10/12/2022	Potential for Concern	*Dolichospermum* spp.	153	Small cyanobacteria scum present.
10/19/2022	Acceptable	N/A	90	-
11/2/2022	Acceptable	*Microcystis* spp.	2	-

Boland Pond: Path behind Nauset Regional Middle School

During the 2022 monitoring season, Boland Pond contained no concerning cyanobacteria results at the time and place of each sampling event, keeping the pond in APCC's "Acceptable" category for the entire season. (Table 2 below).

Table 2. Summary of cyanobacteria monitoring results for Boland Pond, Orleans, MA.

Sampling Date	APCC Current Risk Category	Dominant Genus	Bloom Forming Colonies Phycocyanin (ug/L)	Current Risk Category Notes
6/7/2022	Acceptable	*Dolichospermum* spp.	17	-
6/21/2022	Acceptable	*Dolichospermum* spp.	2	-
7/5/2022	Acceptable	N/A	8	-
7/19/2022	Acceptable	N/A	5	-
8/2/2022	Acceptable	N/A	20	-
8/16/2022	Acceptable	*Dolichospermum* spp.	57	-
8/30/2022	Acceptable	*Anabaena* spp.	22	-
9/13/2022	Acceptable	*Dolichospermum* spp.	94	-
9/27/2022	Acceptable	*Dolichospermum* spp.	18	-
10/11/2022	Acceptable	N/A	9	-
10/26/2022	Acceptable	N/A	9	-
11/8/2022	Acceptable	N/A	16	-

Cedar Pond: Intersection of Cedar Pond Road and Locust Road

During the 2022 monitoring season, Cedar Pond experienced changes in cyanobacteria levels that at different times placed it in APCC's "Acceptable" and "Potential for Concern" Risk Categories (Table 3 below).

Following early season "Acceptable" sampling events, Cedar Pond reached the "Potential for Concern" category starting on 7/5/22 due to net daily cyanobacteria growth rates that exceeded 0.05. At these points, APCC increased sampling to weekly until the growth rate returned below 0.05. Cedar Pond also experienced an elevated net daily cyanobacteria growth rate on 8/2/22, prompting weekly testing. In addition, on 9/13/22, 9/21/22, and 11/8/22 Cedar Pond experienced elevated net daily cyanobacteria growth rates, and OPC residents visually monitored the pond frequently during these times, checking for cyanobacteria accumulations, rather than conducting weekly sampling. However, due to a change in communication protocol beginning on August 1st, 2022, Cedar Pond remained "Acceptable" on these dates. Fortunately, these elevated growth rates did not result in cyanobacteria bloom formations nor toxin exceedances. The pond remained in the "Acceptable" category for the rest of the monitoring season.

Table 3. Summary of cyanobacteria monitoring results for Cedar Pond, Orleans, MA.

Sampling Date	APCC Current Risk Category	Dominant Genus	Bloom Forming Colonies Phycocyanin (ug/L)	Current Risk Category Notes
6/7/2022	Acceptable	N/A	8	-
6/21/2022	Acceptable	N/A	8	-
7/5/2022	Potential for Concern	N/A	9	The <50 net daily cyanobacteria growth rates exceeded 0.05. Growth rate: 0.07 (<50)
7/13/2022	Acceptable	N/A	3	-
7/19/2022	Acceptable	N/A	9	-
8/2/2022	Acceptable	N/A	20	-
8/11/2022	Acceptable	N/A	24	-
8/16/2022	Acceptable	N/A	9	-
8/30/2022	Acceptable	N/A	15	-
9/13/2022	Acceptable	*Oscillatoria* spp.	58	-
9/21/2022	Acceptable	Mixed	24	-
9/27/2022	Acceptable	*Microcystis* spp.	9	-
10/11/2022	Acceptable	N/A	9	-
10/25/2022	Acceptable	N/A	7	-
11/8/2022	Acceptable	NA	11	-

Crystal Lake: Town landing

During the 2022 monitoring season, Crystal Lake experienced changes in cyanobacteria levels that at different times placed it in APCC's "Acceptable" and "Potential for Concern Risk Categories (Table 4 below).

Following early "Acceptable" sampling events, Crystal Lake reached the "Potential for Concern" category starting on 7/5/22 due to net daily cyanobacteria growth rates that exceeded 0.05. At these points, APCC increased sampling to weekly until the growth rate returned below 0.05. Crystal Lake also experienced an elevated net daily cyanobacteria growth rate on 8/30/22 and OPC residents visually monitored the pond frequently during this time, checking for cyanobacteria accumulations, rather than conducting weekly sampling. However, due to a change in communication protocol beginning on August 1st, 2022, Crystal Lake remained "Acceptable" on this date. Fortunately, this elevated growth rate did not result in cyanobacteria bloom formations nor toxin exceedances. The pond remained in the "Acceptable" category for the rest of the monitoring season.

Table 4. Summary of cyanobacteria monitoring results for Crystal Lake, Orleans, MA.

Sampling Date	APCC Current Risk Category	Dominant Genus	Bloom Forming Colonies Phycocyanin (ug/L)	Current Risk Category Notes
6/7/2022	Acceptable	N/A	1	-
6/21/2022	Acceptable	*Woronichinia* spp.	5	-
7/5/2022	Potential for Concern	*Dolichospermum* spp.	80	The WLW and BFC net daily cyanobacteria growth rates exceeded 0.05. Growth rates: 0.07 (WLW) and 0.20 (BFC).
7/13/2022	Potential for Concern	*Dolichospermum* spp.	406	The BFC net daily cyanobacteria growth rate exceeded 0.05. Growth rate: 0.20 (BFC)
7/20/2022	Acceptable	*Dolichospermum* spp.	3	-
8/2/2022	Acceptable	Mixed	15	-
8/16/2022	Acceptable	N/A	6	-
8/30/2022	Acceptable	Mixed	21	-
9/13/2022	Acceptable	*Gloeotrichia* spp.	7	-
9/27/2022	Acceptable	*Woronichinia* spp.	7	-
10/11/2022	Acceptable	*Woronichinia* spp.	2	-
10/25/2022	Acceptable	Mixed	7	-
11/8/2022	Acceptable	*Dolichospermum* spp.	318	-

Ice House Pond: Path on Brick Hill Road

During the 2022 monitoring season, Ice House Pond contained no concerning cyanobacteria results at the time and place of each sampling event, keeping the pond in APCC's "Acceptable" category for the entire season. (Table 5 below).

Ice House Pond did experience elevated net daily cyanobacteria growth rates on 8/30/22, 10/25/22 and 11/8/22. OPC residents visually monitored the pond frequently during these times, checking for cyanobacteria accumulations, rather than conducting weekly sampling. However, due to a change in communication protocol beginning on August 1st, 2022, Ice House Pond remained "Acceptable" on these dates. Fortunately, these elevated growth rates did not result in cyanobacteria bloom formations nor toxin exceedances. The pond remained in the "Acceptable" category for the rest of the monitoring season.

Table 5. Summary of cyanobacteria monitoring results for Ice House Pond, Orleans, MA.

Sampling Date	APCC Current Risk Category	Dominant Genus	Bloom Forming Colonies Phycocyanin (ug/L)	Current Risk Category Notes
6/7/2022	Acceptable	N/A	6	-
6/21/2022	Acceptable	N/A	3	-
7/5/2022	Acceptable	N/A	3	-
7/20/2022	Acceptable	N/A	4	-
8/2/2022	Acceptable	*Aphanizomenon* spp.	5	-
8/16/2022	Acceptable	N/A	7	-
8/30/2022	Acceptable	N/A	9	-
9/13/2022	Acceptable	Mixed	3	-
9/27/2022	Acceptable	*Microcystis* spp.	14	-
10/11/2022	Acceptable	N/A	2	-
10/25/2022	Acceptable	*Microcystis* spp.	22	-
11/8/2022	Acceptable	*Microcystis* spp.	13	-

Pilgrim Lake: Pilgrim Lake Recreation and Conservation Area

During the 2022 monitoring season, Pilgrim Lake experienced changes in cyanobacteria levels that at different times placed it in APCC's "Acceptable" and "Potential for Concern" Risk Categories (Table 6 below).

Following early "Acceptable" sampling events at Pilgrim Lake, the site reached the "Potential for Concern" category on 7/5/22 and on 7/19/22 due to an elevated net daily cyanobacteria growth rate that exceeded 0.05. At these points, APCC increased sampling to weekly until the growth rate returned below 0.05. On 7/28/22, Pilgrim Lake experienced a minor cyanobacteria scum, keeping the pond in the "Potential for Concern" category. This accumulation did not warrant a recreational advisory and the scum dissipated by the following week. Pilgrim Lake also experienced elevated net daily cyanobacteria growth rates on 8/30/22 and 9/13/22. OPC residents visually monitored the pond frequently during these times, checking for cyanobacteria accumulations, rather than conducting weekly sampling. However, due to a change in communication protocol beginning on August 1st, 2022, Pilgrim Lake remained "Acceptable" on these dates. Fortunately, these elevated growth rates did not result in cyanobacteria bloom formations nor toxin exceedances. The pond remained in the "Acceptable" category for the rest of the monitoring season.

Table 6. Summary of cyanobacteria monitoring results for Pilgrim Lake, Orleans, MA.

Sampling Date	APCC Current Risk Category	Dominant Genus	Bloom Forming Colonies Phycocyanin (ug/L)	Current Risk Category Notes
6/7/2022	Acceptable	*Dolichospermum* spp.	209	-
6/21/2022	Acceptable	*Woronichinia* spp.	7	-
7/5/2022	Potential for Concern	N/A	19	The BFC net daily cyanobacteria growth rate exceeded 0.05. Growth rate: 0.07 (BFC)
7/13/2022	Acceptable	*Woronichinia* spp.	15	-
7/19/2022	Potential for Concern	*Dolichospermum* spp.	66	The BFC net daily cyanobacteria growth rate exceeded 0.05. Growth rate: 0.25 (BFC)
7/28/2022	Potential for Concern	*Dolichospermum* spp.	23	Small cyanobacteria scum present.
8/2/2022	Acceptable	*Dolichospermum* spp.	14	-
8/16/2022	Acceptable	Mixed	5	-
8/30/2022	Acceptable	Mixed	15	-
9/13/2022	Acceptable	N/A	205	-
9/27/2022	Acceptable	Mixed	134	-
10/11/2022	Acceptable	Mixed	31	-
10/25/2022	Acceptable	*Woronichinia* spp.	34	-
11/8/2022	Acceptable	*Woronichinia* spp.	21	-

Uncle Harvey's Pond: Town Landing

During the 2022 monitoring season, Uncle Harvey's Pond experienced changes in cyanobacteria levels that at different times placed it in APCC's "Acceptable" and "Potential for Concern" Risk Categories (Table 7 below).

Following early "Acceptable" sampling events at Uncle Harvey's Pond, the site reached the "Potential for Concern" category on 6/12/22 due to an elevated net daily cyanobacteria growth rate that exceeded 0.05, where it stayed for a few weeks. At this point, APCC increased sampling to weekly until the growth rate returned below 0.05. On 7/28/22, a minor cyanobacteria scum was observed at Uncle Harvey's Pond, keeping it in the "Potential for Concern" category. This accumulation did not warrant a recreational advisory and the scum dissipated by the following week. Uncle Harvey's Pond also experienced elevated net daily cyanobacteria growth rates on 8/16/22, 9/13/22, 9/21/22, 10/25/22, and 11/8/22. OPC residents visually monitored the pond frequently during these times, checking for cyanobacteria accumulations, rather than conducting weekly sampling. However, due to a change in communication protocol beginning on August 1st, 2022, Uncle Harvey's Pond remained "Acceptable" on these dates. Fortunately, these elevated growth rates did not result in cyanobacteria bloom formations nor toxin exceedances. The pond remained in the "Acceptable" category for the rest of the monitoring season.

Table 7. Summary of cyanobacteria monitoring results for Uncle Harvey's Pond, Orleans, MA.

Sampling Date	APCC Current Risk Category	Dominant Genus	Bloom Forming Colonies Phycocyanin (ug/L)	Current Risk Category Notes
6/7/2022	Acceptable	*Woronichinia* spp.	18	-
6/21/2022	Potential for Concern	*Dolichospermum* spp.	275	The <50, WLW, and BFC net daily cyanobacteria growth rates exceeded 0.05. Growth rates: 0.06 (<50), 0.15 (WLW), and 0.20 (BFC)
6/28/2022	Potential for Concern	*Dolichospermum* spp.	12,027	The <50, WLW, and BFC net daily cyanobacteria growth rates exceeded 0.05. Growth rates: 0.09 (<50), 0.25 (WLW), and 0.54 (BFC)
7/5/2022	Potential for Concern	*Woronichinia* spp.	26	The <50 net daily cyanobacteria growth rate exceeded 0.05. Growth rate: 0.06 (<50)
7/13/2022	Potential for Concern	*Woronichinia* spp.	53	The BFC net daily cyanobacteria growth rate exceeded 0.05. Growth rate: 0.09 (BFC)
7/19/2022	Potential for Concern	*Woronichinia* spp.	82	The <50, WLW, and BFC net daily cyanobacteria growth rates exceeded 0.05. Growth rates: 0.25 (<50), 0.31 (WLW), and 0.07 (BFC)
7/28/2022	Potential for Concern	*Woronichinia* spp.	124	A cyanobacteria scum present. The BFC net daily cyanobacteria growth rate equaled 0.05. Growth rate: 0.05 (BFC)
8/2/2022	Acceptable	*Woronichinia* spp.	16	-
8/16/2022	Acceptable	*Woronichinia* spp.	83	-
8/30/2022	Acceptable	*Woronichinia* spp.	42	-
9/13/2022	Acceptable	N/A	253	-
9/21/2022	Acceptable	*Gleocapsa* spp.	30	-
9/27/2022	Acceptable	*Woronichinia* spp.	32	-
10/11/2022	Acceptable	*Woronichinia* spp.	30	-
10/25/2022	Acceptable	*Woronichinia* spp.	108	-
11/8/2022	Acceptable	*Woronichinia* spp.	60	-

5. CONCLUSIONS

In 2022, four ponds and two lakes were monitored in the Town of Orleans; Boland Pond, Cedar Pond, Ice House Pond, Uncle Harvey's Pond, Crystal Lake and Pilgrim Lake. Cedar Pond, Uncle Harvey's Pond, Crystal Lake and Pilgrim Lake reached APCC's "Potential for Concern" Risk Category in 2022 due to moderate levels of cyanobacteria. As was the case last year, none of these Orleans ponds required any recreational advisory postings in 2022 due to cyanobacteria concerns. See Appendix 3 for a comparison of results over the past few years.

In the previous season of cyanobacteria monitoring in Orleans, APCC's monitoring data and the presence of cyanobacteria scums were used to estimate cyanobacteria risk. In 2022, the County Water Quality Lab's capability to conduct microcystin analyses provided the town health department and APCC with direct measurements of toxin, increasing understanding of current toxin risks. For this season, no toxin samples were sent to the County Water Quality Lab due to concerns of a possible exceedance.

APCC's 2022 cyanobacteria monitoring program collected and analyzed 12 biweekly samples and documented field conditions on each of the scheduled 72 sampling dates throughout the season as well as an additional 10 based on higher growth rates or higher warning categories. All results were promptly shared with the Orleans Pond Coalition and the Town of Orleans via biweekly reports and then entered into the APCC Interactive Map following the completion of sample analysis (https://apcc.org/cyano).

6. RECOMMENDATIONS

Based on the results from the 2022 monitoring season and previous monitoring work, APCC provides the following recommendations:

Recommendation 1: Continue the sampling season to include early and late season monitoring**.** Many ponds in APCC's cyanobacteria monitoring program experience their highest cyanobacteria concentrations in the spring and the fall. Early and late season monitoring can shed light on potential bloom conditions outside of the typical June to Labor Day monitoring season. Although residents may interact with these ponds less during these times, there are still dangers posed to pets who may consume or swim in these waters while on walks during colder months.

Recommendation 2: Continue yearly cyanobacteria monitoring. Monitoring over multiple years for full seasons would provide greater understanding of the cyanobacteria community in Boland Pond, Cedar Pond, Ice House Pond, Uncle Harvey's Pond, Crystal Lake, and Pilgrim Lake. More seasons of data will allow us to draw better predictions year after year. Continued monitoring will also allow for the ability to track degradation in the ponds as increased occurrence of harmful cyanobacteria blooms point to larger issues of pond impairment. Monitoring efforts will shed light on the ponds most in need of protection and restoration.

Recommendation 3: Reduce nutrient loading to freshwater ponds. Residents surrounding vulnerable pond ecosystems should reduce potential nutrient pollution flowing from their properties towards the pond. Excess fertilizer use, septic systems around ponds, inadequate

stormwater management, and inadequate vegetated buffers are examples of behaviors that exacerbate nutrient loading of ponds.

In addition to managing nutrients, changing climate conditions, including the currently warming atmosphere 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). Residents and officials should understand that there may be many factors leading to cyanobacteria issues on Cape Cod. Continued work around cyanobacteria and water quality will lead to increased awareness, a safer public, and hopefully improved health of our freshwater ponds.

For a comprehensive list of actions that residents, municipalities, and state agencies can take to promote pond health, visit APCC's State of the Waters: Cape Cod website (State of the Waters), specifically, the Action Plan for ponds. For additional information on restoration of impaired ponds, the new Freshwater Initiative program for Cape Cod ponds will provide towns, communities, and organizations with information and resources for pond protection, management, and restoration. This program is led by the Cape Cod Commission with support from APCC. For more information, visit the Cape Cod Commission's Freshwater Initiative website at: https://capecodcommission.org/our-work/cape-cod-freshwater-initiative/.

7.ACKNOWLEDGEMENTS

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Appendix 1. Resources on Cyanobacteria

Harmful cyanobacteria blooms in freshwater bodies 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[1]).
- 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), 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)

Appendix 2. APCC's Cyanobacteria Risk Categories.

APCC 2022 Cyanobacteria Risk Categories Revised 7/26/2022				
Criteria		**APCC Acceptable**	**APCC Potential for Concern**	**APCC Use Restriction Warranted**
Microcystin	Potential microcystin calculated by APCC based on measurement of phycocyanin in Bloom Forming Colony samples.	Potential microcystin calculated at low levels that do not warrant additional toxin testing[2,4].	Potential microcystin is elevated to a point where an exceedance is deemed possible and confirmatory toxin testing warranted[2,4].	
	Measured microcystin by Barnstable County Water Quality Lab.	Less than 4 ppb microcystin measured in GRAB sample.	Between 4 and 8 ppb microcystin measured in GRAB sample.	Greater than 8 ppb microcystin measured in GRAB sample[3].
Cyanobacteria Blooms and Scums	Cyanobacteria bloom material reported and confirmed by APCC.	None present at the time and place of sample collection.	A cyanobacteria scum or bloom is present but is deemed to be insignificant by the Massachusetts Department of Public Health and the town's health agent.	A cyanobacteria scum or bloom is present and is deemed to be significant by the Massachusetts Department of Public Health or the town's health agent[3].
Notes	To interpret cyanobacteria data using this table, the most hazardous result determines the category the pond is placed in from right to left. A pond that meets even a single criterion in the "Use Restriction Warranted" column will be placed in that category. Likewise, a pond that meets even a single criterion in the "APCC Potential for Concern" category but does not meet any criteria in the "APCC Use Restriction Warranted" category, will be placed in the "APCC Potential for Concern" category. If a pond meets no criteria in the "APCC Use Restriction Warranted" or the "APCC Potential for Concern" category, that pond is placed in the "APCC Acceptable" category. [2] Developed with recommendations from Nancy Leland of Lim-Tex Inc. and affiliated with the University of New Hampshire Center for Freshwater Biology. [3] Criteria attributed to MDPH. [4] Predictive cyanobacteria metrics that project and estimate risks, rather than reactive cyanobacteria metrics that measure risk after a bloom has occurred.			

Appendix 3. Boland, Cedar, Crystal, Ice House, and Uncle Harvey's Ponds, and Pilgrim Lake 2021-2022 Cyanobacteria Risk Comparison.

As of 2022 APCC has completed two seasons of cyanobacteria monitoring for the Town of Orleans. The tables below details APCC's communication of cyanobacteria risk for Boland, Cedar, Crystal, Ice House, and Uncle Harvey's Ponds, and Pilgrim Lake in each season. Red indicates a "Use Restriction Warranted" or "High Warning Tier" designation, yellow indicates a "Potential for Concern" or "Moderate Warning Tier" designation, and blue indicates an "Acceptable" or "Low Warning Tier" designation. See the 2021 APCC report for the Town of Orleans for more information on findings and risk communication in these sampling seasons.

Boland Pond 2022 Cyanobacteria Risk Comparison												
	June		July		August		September		October		November	
Year	1st-15th	16th-30th	1st-15th	16th-31st	1st-15th	16th-31st	1st-15th	16th-30th	1st-15th	16th-31st	1st-15th	16th-30th
2022												

Cedar Pond -2022 Cyanobacteria Risk Comparison												
	June		July		August		September		October		November	
Year	1st-15th	16th-30th	1st-15th	16th-31st	1st-15th	16th-31st	1st-15th	16th-30th	1st-15th	16th-31st	1st-15th	16th-30th
2022												

Crystal Lake 2021-2022 Cyanobacteria Risk Comparison												
	June		July		August		September		October		November	
Year	1st-15th	16th-30th	1st-15th	16th-31st	1st-15th	16th-31st	1st-15th	16th-30th	1st-15th	16th-31st	1st-15th	16th-30th
2021												
2022												

Ice House Pond 2021-2022 Cyanobacteria Risk Comparison												
	June		July		August		September		October		November	
Year	1st-15th	16th-30th	1st-15th	16th-31st	1st-15th	16th-31st	1st-15th	16th-30th	1st-15th	16th-31st	1st-15th	16th-30th
2021												
2022												

Pilgrim Lake 2021-2022 Cyanobacteria Risk Comparison												
	June		July		August		September		October		November	
Year	1st-15th	16th-30th	1st-15th	16th-31st	1st-15th	16th-31st	1st-15th	16th-30th	1st-15th	16th-31st	1st-15th	16th-30th
2021												
2022												

Uncle Harvey's Pond 2021-2022 Cyanobacteria Risk Comparison												
	June		July		August		September		October		November	
Year	1st-15th	16th-30th	1st-15th	16th-31st	1st-15th	16th-31st	1st-15th	16th-30th	1st-15th	16th-31st	1st-15th	16th-30th
2021												
2022												

Appendix 4: Sample Site Locations

- Bakers Pond - Dirt boat ramp and parking area off Bakers Pond Road.
- Boland Pond - Path behind Nauset Middle School
- Cedar Pond - Intersection of Cedar Pond Road and Locust Road.
- Crystal Lake - Town landing off Monument Road.
- Ice House Pond- Path on Brick Hill Rd near the intersection with Champlain Road.
- Pilgrim Lake - Pilgrim Lake Recreation and Conservation Area.
- Uncle Harvey's Pond- Town landing off Pochet Road.