Cyanobacteria Monitoring on Lake Champlain and Vermont Inland Lakes
2022 Season

Annual Report for the Lake Champlain Basin Program

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Executive Summary

An annual cyanobacteria monitoring program has been in place on Lake Champlain since 2002. Since 2012, oversight of the program has been the responsibility of the State of Vermont. The program represents a strong partnership between the Vermont Department of Environmental Conservation (VT DEC), the Vermont Department of Health (VDH), and the Lake Champlain Committee (LCC). Funding is provided by the Lake Champlain Basin Program, the State of Vermont, the Center for Disease Control (CDC), and private donors. Data are collected by State staff and an extensive network of trained community science volunteers. This report provides a summary of cyanobacteria monitoring efforts for Lake Champlain and for Vermont inland lakes, regardless of funding source, all of which is housed in the CyanoTracker database hosted by the VDH.

Cyanobacteria monitoring on Lake Champlain in 2022 continued to integrate qualitative observations and photographic documentation into guidance for lake users at a similar rate to previous years, and quantitative microscopic analyses of cyanobacteria as well as measurement of cyanotoxin concentrations were used to validate the visual protocol, and to inform public health decisions in response to the presence of cyanobacteria.

Objectives:

- routinely monitor cyanobacteria at locations on Lake Champlain and Vermont inland lakes through the established partnership between Vermont state staff, the Lake Champlain Committee, community science volunteers, and state/municipal staff in New York,
- provide consistent quantitative and semi-quantitative data to inform public health decisions and assess long-term trends in Lake Champlain and selected inland lakes,
- test for the presence of cyanotoxins when visual reports or microscope analyses suggest high likelihood of blooms,
- conduct 12 weeks of cyanobacteria toxin testing for drinking water facilities drawing from Lake Champlain in Vermont,
- facilitate communication about lake conditions through weekly updates to stakeholders via email and to the public through the Vermont Department of Health webpage,
- provide outreach and assistance to beach managers, lakeshore property owners and the public so they can learn to recognize and respond appropriately to the presence of cyanobacteria blooms.

Community science volunteers, staff, and the general public submitted 2534 site-specific reports during 2022, with 1869 from Lake Champlain, and 665 from other lakes in Vermont. Alert level conditions were reported 232 times on Lake Champlain during the monitoring period in 2022 (18% of reports). Microcystin was detected at three locations in Lake Carmi and four locations in Lake Champlain in 2022, with one sample at Carmi higher than the recreational guideline of 6 µg/L.

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1. Introduction and Project Synopsis

Lake Champlain is one of the largest lakes in the United States and an important water resource for the states of Vermont and New York, and the province of Quebec. It is primarily a recreational lake, but also serves as an important drinking water source for all three jurisdictions. Cyanobacteria blooms have been documented in the lake since the 1970s, with some areas experiencing extensive annual blooms. In 1999, several dog deaths were attributed to cyanobacteria toxins, raising health and safety concerns regarding drinking water supplies and recreational activities such as swimming, boating, and fishing.

An annual cyanobacteria monitoring program has been in place on Lake Champlain since 2002 and continues to expand to inland lakes in Vermont. Monitoring is implemented through a partnership approach. Data are collected by State staff and an extensive network of trained community science volunteers maintained by the State and the Lake Champlain Committee (LCC). Qualitative observations, photographic documentation, and quantitative analysis of phytoplankton populations are synthesized into guidance for lake users. Analysis of water - when warranted - for the presence of microcystin and anatoxin provides additional data to inform public health decisions.

Objectives:

- routinely monitor cyanobacteria at locations on Lake Champlain and Vermont inland lakes through the established partnership between Vermont state staff, the Lake Champlain Committee, community science volunteers, and state/municipal staff in New York,
- provide consistent quantitative and semi-quantitative data to inform public health decisions and assess long-term trends in Lake Champlain and selected inland lakes,
- test for the presence of cyanotoxins when visual reports or microscope analyses suggest high likelihood of blooms,
- conduct 12 weeks of cyanobacteria toxin testing for drinking water facilities drawing from Lake Champlain in Vermont,
- facilitate communication about lake conditions through weekly updates to stakeholders via email and to the public through the Vermont Department of Health webpage,
- provide outreach and assistance to beach managers, lakeshore property owners and the public so they can learn to recognize and respond appropriately to the presence of cyanobacteria blooms.

Geographic Coverage and Funding

Responsibility for cyanobacteria response in the Champlain Basin is held by multiple jurisdictions. State or provincial departments of health and environmental protection typically lead response efforts while authority to close beaches and waterfront areas often resides with beach managers and municipalities. The goal of this project is to provide data to assist in cyanobacteria response around the Basin. For consistency, Vermont utilizes the same protocols and infrastructure developed for Lake Champlain across the entire state.

Lake Champlain Basin Program (LCBP) funding supports the project coordinator, housed in the Vermont Department of Environmental Conservation's (VT DEC) Watershed Management Division, through the Lake Champlain Long-term Water Quality and Biological Monitoring Project (CLTM). LCBP funding also supports volunteer coordination, training, and support around Lake Champlain and several smaller Vermont lakes through a separate grant to the Lake Champlain Committee (LCC).

The Vermont Department of Health (VDH) and the VT DEC's Drinking Water and Groundwater Protection Division (DWGWPD) are strong partners in this monitoring program. Their funding is provided by the VDH and VT DEC, respectively, and occasionally includes grants from other sources.

VDH provides the technical support underlying the CyanoTracker website, shoreline monitoring at selected locations, toxin testing for locations on Lake Champlain and Vermont inland lakes, and bloom response in Vermont. Technical and public water system support for cyanotoxin response is provided by the DWGWPD and VDH.

The New York Departments of Environmental Conservation and Health support this monitoring effort by sharing information regarding cyanobacteria blooms on Lake Champlain when received by their offices. They are responsible for bloom response on the New York shores of Lake Champlain. New York maintains their own cyanobacteria reporting protocols for inland lakes including Lake George – see the New York Harmful Algal Blooms notification – and that information is not part of this monitoring project.

Several monitoring locations are located on Missisquoi Bay in Quebec and volunteers there submit reports through the CyanoTracker interface. Provincial and municipal officials there are responsible for bloom response. Quebec maintains a website of cyanobacteria reports received from around the province.

This report provides a summary of cyanobacteria monitoring efforts for Lake Champlain and for Vermont inland lakes, all of which is housed in the CyanoTracker database hosted by the VDH (with the exception of drinking water cyanotoxin analyses, which are found here) .

2. Methods

The 2022 cyanobacteria monitoring program was coordinated by the VT DEC and implemented in conjunction with the VDH and LCC. Visual data from Lake Champlain and other Vermont lakes monitored by LCC volunteers were collected following the project protocols utilizing materials developed and maintained by the LCC. VT DEC volunteers reporting from lakes outside the Champlain Basin followed the same project protocols. Water samples and visual reports were collected by VT DEC staff at selected open water stations historically monitored by the LTM on Lake Champlain. Shoreline samples for toxin analysis and microscopic analysis were collected as part of the Quality Assurance Protocol at select Vermont locations on Lake Champlain by community science volunteers and VT DEC staff. Cyanobacteria samples were also taken by VT DEC staff at Lake Carmi, Ticklenaked Pond, and Lake Memphremagog using the Open Water Protocol. Cyanobacteria counts were conducted by Vermont DEC staff as part of the Quality Assurance Protocol and Open Water Protocols. Several additional samples, primarily from managed recreational areas, were also analyzed as part of this project. Reports from the monitoring partners and volunteers were uploaded to the Cyanobacteria Tracking map (CyanoTracker) maintained by the VDH.

2.1 Monitoring Locations

During the 2022 season, routine reports were received from 198 monitored locations around Lake Champlain (139 sites) and from several Vermont inland lakes (59 sites). Table 1 provides a summary of stations by region, evaluation protocol, and type of site. More detailed documentation of the sampling locations is provided in Appendix A.

Table 1. Number of routinely monitored stations and sampling method in lakes monitored during 2022. Visual stations were evaluated on a weekly or biweekly basis. Data compiled from the season summary spreadsheet available through the VDH CyanoTracker. Further information about each station is found in Appendix A.

Waterbody	Region	Number of Visual Sites	**Number of Quality Assurance sites**	**Number of Open Water sites**
Adams Reservoir		2		
Berlin Pond		2		
Caspian Lake		1		
Coles Pond		1		
Echo Lake		1		
Emerald Lake		1		
Fern Lake		1		
Gillett Pond		1		
Indian Brook Reservoir		1		
Joes Pond		3		
Lake Bomoseen		1		
Lake Carmi		10		
Lake Carmi		2	3	3
Lake Champlain	Inland Sea	30	1	1
Lake Champlain	Main Lake Central	42	2	4
Lake Champlain	Main Lake North	14		2
Lake Champlain	Main Lake South	25	1	2
Lake Champlain	Malletts Bay	7		1
Lake Champlain	Missisquoi Bay	5	1	2
Lake Champlain	South Lake	6		2
Lake Champlain	St. Albans Bay	9	1	1
Lake Dunmore		1		
Lake Dunmore		2		
Lake Fairlee		3		
Lake Hortonia		1		
Lake Iroquois		2		

Lake Memphremagog		9		1
Lake Runnemede (Evarts Pond)		1		
Lake St. Catherine		2		
Martins Pond		1		
Miles Pond		1		
Mill Pond		1		
Molly's Falls Pond		1		
Nichols Pond		1		
Nichols Pond		1		
Shadow Lake		1		
Spring Lake		1		
Sunset Lake		1		
Ticklenaked Pond		1		
Winona Lake		1		

*Quality assurance sites were visited regularly and assessed visually and toxin and microscopy samples were collected and analyzed. VT DEC staff made visual reports and collected net phytoplankton samples at open water protocol sites during visits to long-term monitoring sites on Lake Champlain, and to sites on Lake Carmi and Lake Memphremagog.

2.2 Monitoring Protocols

2.2.1 The Visual Monitoring Protocol

Volunteer Recruitment and Training

Volunteers were asked to commit to monitoring at least one location for the duration of the monitoring period (late-June through early November). No volunteer was turned away. On Lake Champlain, this can lead to a cluster of observation points in more populated areas or areas with high interest. Volunteers attended a mandatory training session online to learn to recognize cyanobacteria, become familiar with the assessment protocol, and learn how to submit their weekly reports. Partners interacted with volunteers in the weeks following the training to ensure consistency among volunteers and their assessment skills.

The LCC trained nearly 300 volunteer monitors and interested community members in 26 formal training sessions during the 2022 season. LCC also held informal training sessions with volunteers unable to attend the pre-scheduled trainings. Due to the pandemic and monitor preference, the vast majority of the trainings were held virtually. Vermont State Park staff who participated in the monitoring project either attended an LCC virtual training or received monitoring guidance from VT DEC/VDH staff or State Parks staff (Appendix A).

LCC, VT DEC and VDH also recruited and trained volunteers to monitor at select inland Vermont lakes following the project protocols. Training was conducted by webinar. Some monitors attended an LCC virtual training and all monitors were provided with LCC's weekly emails. In addition, a number of Vermont State Park staff reported blooms on inland lakes as well as Lake Champlain, with internal trainings assisted by VDH and VT DEC and supported by LCC. In total, reports were received from 35 inland VT lakes. Both LCC and VT DEC staff also interacted regularly with community science volunteer monitors and Vermont State Park staff.

Weekly Observation Process - Volunteers

Monitoring by volunteers began the week of June 20. Volunteers committed to monitoring through September and were asked to continue longer if they could.

Protocols for the observation process, supporting documentation and the submittal process are found in Appendix B. Volunteers were asked to provide a single observation each week, preferably between 10 am and 3 pm, on the same day of the week Sunday through Saturday. Supplemental reports could also be provided and volunteers were encouraged to report any blooms they witnessed, regardless of the reporting day, and to report daily for the duration of blooms whenever possible. Volunteers evaluated cyanobacteria conditions at their location using the prompts, photographs, and descriptions provided by the LCC and VT DEC, and assigned it one of the six categories (Appendix D):

- Category 1 – very few or no cyanobacteria observed, recreational enjoyment not impaired by cyanobacteria.
    - 1a – no cyanobacteria present, clear water
    - 1b – no cyanobacteria present, brown and turbid conditions
    - 1c – no cyanobacteria present, other plant material
    - 1d – little cyanobacteria present, generally safe conditions
- Category 2 – cyanobacteria present at less than bloom levels.
- Category 3 – cyanobacteria bloom in progress.

The description 'bloom' is not a well-defined scientific term. For the purposes of the visual monitoring protocol, blooms refer to very dense cyanobacteria accumulations resulting in highly colored water and/or visible surface scums. Dense accumulations of eukaryotic algae are also referred to as blooms but under this protocol are assigned Category 1c, to the extent that they can be distinguished from cyanobacteria using visual protocols.

Each volunteer was asked to provide three photographs whenever Category 1d, 2, or 3 conditions were observed. All reports were uploaded to the VDH tracking map via a secured interface or submitted to the LCC or VT DEC via their online forms. These online forms were also used when the VDH website interface occasionally was not functional. Partners reviewed all bloom reports and photos. They also conferred with volunteers as needed to verify the presence of cyanobacteria and appropriate status or when no reports were received. Tracker software automatically notifies partners of Category 2 and 3 reports so these can be reviewed and posted quickly.

Source of Reports

In addition to the trained community science volunteers and field staff in VT DEC, VDH, LCC, and VT State Parks, cyanobacteria reports were received from numerous other sources. The NY DEC and the NY Department of Health notified Vermont when blooms were reported on their shores. The general public provided reports by email and telephone. All reports were evaluated and confirmed utilizing photos, descriptive information, and available corroborating information before posting to the CyanoTracker map.

2.2.2 Phytoplankton and Cyanotoxin Protocols

Shoreline Quality Assurance Sampling

In 2022, routine shoreline sampling was conducted at five sites on Lake Champlain. Kingsland Bay State Park was added as a routine shoreland site, due in part to the relatively high incidence of cyanobacteria blooms in the southern Main Lake during the 2021 monitoring season.

Table 2: Sites where routine shoreline quality assurance samples were collected

Site Number	Site Name (Location)	Waterbody (Region of Lake Champlain)	Sampler Affiliation	Number of Routine Shoreline Samples Collected
22	North Beach (Burlington, VT)	Lake Champlain (Main Lake Central)	LCC Volunteer	12
27	Red Rocks Beach (South Burlington, VT)	Lake Champlain (Main Lake Central)	LCC Volunteer	12
30	Shipyard, Highgate Springs (Highgate, VT)	Lake Champlain (Missisquoi Bay)	LCC Volunteer	10
31	St. Albans Bay Park (St. Albans Town, VT)	Lake Champlain (St. Albans Bay)	LCC Volunteer	11
180	Kingsland Bay State Park (Ferrisburgh, VT	Lake Champlain (Main Lake South)	VT DEC Staff	11

These unfiltered samples were analyzed for microcystin and anatoxin at the Vermont Public Health Laboratory. Samples were also taken for identification and quantification of cyanobacteria taxa to validate visual assessments. When occasional cyanobacteria samples were collected, a single whole water sample was collected by placing a 0.5-L bottle carefully at the surface and tipping to fill, avoiding dilution of the surface scum as much as possible. The sample was mixed thoroughly and decanted into sample bottles for subsequent cyanobacteria enumeration or toxin analysis. All samples were kept on ice in coolers or refrigerated until they reached the lab. These samples were used to evaluate the effectiveness of the visual assessment protocol and evaluate recreational risk.

The Open Water Protocol

VT DEC staff conducted cyanobacteria assessments during their biweekly monitoring for the Lake Champlain Long-term Water Quality and Biological Monitoring Project (CLTM) utilizing the visual assessment protocol to evaluate cyanobacteria conditions, and took 3m plankton tows to compare to these visual observations. Cyanobacteria blooms observed during transit were also assessed using the visual assessment protocol. When category 3 conditions were observed, whole water surface grabs were collected for the analysis of cyanotoxins and sometimes for cyanobacteria density. At locations where blooms were uncommon, whole water surface grabs for toxin and cyanobacteria were also collected during category 2 conditions.

VT DEC staff also visited open water stations on Lake Carmi, Ticklenaked Pond, and Lake Memphremagog in Vermont. Visual assessments were made at most of these stations between June and October, and taxonomic information on phytoplankton communities was collected using the open water protocol.

Toxin Monitoring at Vermont Drinking Water Facilities

Weekly raw and finished water samples at public drinking water systems drawing from Lake Champlain were collected by facility staff and transported to the VDH Public Health Laboratory for analysis of microcystin by ELISA. All sample containers and labels were provided to the facilities. Sample drop-off and pick-up opportunities were also provided.

Sampling began the week of July 12, 2022 and went through the week of September 27, 2022, though several systems do not operate after Labor Day. Results were shared with operators by the VDH lab by mail, by DWGWPD by email, and posted on the DWGWPD website.

2.2.3 Field and Lab Methods

Plankton sample collection

For the open water protocol, plankton are collected as integrated 63 µm mesh plankton net for determination of cyanobacteria density. Net concentrates were obtained by lowering the plankton net (opening 13cm in diameter) to 3m and drawing it steadily back to the surface. Note that cyanobacteria cells and colonies are often smaller than 63 µm and plankton nets displace some of the cells in the water column as samples are being collected, so net concentrations are likely an underestimate of true concentrations.

When alert level conditions are observed, a single whole water sample is normally collected by placing a bucket carefully at the surface and tipping to fill, avoiding dilution of the surface scum as much as possible. Net samples may provide a better picture of average cell concentrations than whole-water grab samples which target the densest accumulations of cyanobacteria, but whole-water grab samples better capture the upper limit of cell concentrations and toxicity to which people may be exposed; as such, cell concentrations from the two methods are not directly comparable. The samples are mixed thoroughly and decanted into sample bottles for subsequent cyanobacteria enumeration or toxin analysis. All samples are kept on ice in coolers until they reach the lab.

Plankton Enumeration

Plankton samples were analyzed using an inverted compound microscope at 200x in a Sedgewick Rafter (SR) cell. One mL aliquots were settled for 10 minutes before analysis. Estimates of cell density were obtained for all observed cyanobacteria using the size categories noted in Table 3 following rapid counting protocols described in (Rogalus and Watzin 2008, *Harmful Algae* **7**: 504-515, doi:10.1016/j.hal.2007.11.002). Observed individuals or colonies were assigned to a unit category, or several categories, as needed. The number of units in each category is then multiplied by the cell factor to obtain an estimate of cell density/mL in the sample. During the analysis, all cyanobacteria were identified to the lowest possible taxonomic level, but are summarized here at the genus level. Other algal groups (e.g. green algae, diatoms) were not counted. Identical counting protocols were used for whole water and plankton concentrates (except that more fields were generally counted in whole water samples), but cell densities from concentrated samples were later corrected based on the sampled volume of the plankton net. Plankton samples were counted by VT DEC staff or trained interns and data were uploaded to the VDH data interface. Alert level samples were analyzed and posted as soon as possible after samples were received at the laboratory.

Table 3. Size categories and cell factors used to estimate field densities of colonial cyanobacteria.

Taxon	Unit Catgory	Estimated cells/unit	Cell factor
Dolichospermum	Fragment Small Medium Large	< 20 20 – 100 100 – 1000 >1000	10 60 500 1000
Microcystis *Coelosphaerium* *Woronichinia* *Aphanocapsa*	Small Medium Large	< 100 100–1000 >1000	50 500 1000
Gloeotrichia	Fragment Small Medium Large	Single trichome Quarter of a colony Half of colony Entire colony	20 2500 5000 10,000
Aphanizomenon *Cuspidothrix*	Fragment Small Medium Large	Single trichome Small flake Medium flake Large flake	Measured 200 500 1000
Limnothrix, Planktothrix, *Oscillatoria,* *Lyngba, Scytonema* *Pseudanabaena,* *Phormidium*	Fragment	Single trichome	Measured

Toxin Analyses

Microcystin analyses were conducted by the Vermont Agricultural and Environmental Laboratory in Randolph, VT. Whole water samples for microcystin were analyzed as received unless biomass was high enough to interfere with analytical procedures. In that event, samples were diluted prior to analysis of microcystin by ELISA. Anatoxin samples were analyzed at the VDH laboratory.

2.2.4 Communication and Outreach

Members of the partner institutions (LCC, VT DEC, and VDH) comprised an internal communication group that shared all bloom reports upon receipt and coordinated response activities as needed. Partners received automated notification of category 2 and 3 reports posted to the tracking database, facilitating communication, and enabling volunteer reports to be reviewed and approved quickly. The group also shared literature and other pertinent information. The LCBP, NY DEC, NY DOH, and Vermont State Parks staff were also kept apprised of cyanobacteria conditions through the automated notification system.

Email updates summarizing reports and toxin data were provided to a group of stakeholders by VT DEC staff throughout the bloom season. These were primarily state and town health officials, state and town waterfront managers, Champlain water suppliers, and researchers. Updates were released typically on Monday mornings, but stakeholders also received email notification of extensive blooms as they occurred. The Lake Champlain Committee also provided weekly emails to volunteer monitors and partner agencies as well as interested community members, other agencies, and the media. LCC's emails were typically sent on Friday or Saturday. LCC's emails to monitors included links and resources to assist them in filing accurate reports along with photographs of conditions and monitoring tips. Emails to community members reported weekly results, background on cyanobacteria, photographs to aid in identification, and resources to help people recognize, avoid, and report cyanobacteria.

Notification of the Public

The Cyanobacteria Tracker, housed on the VDH website (http://healthvermont.gov/tracking/cyanobacteria-tracker), displayed the most up to date information on the presence of cyanobacteria blooms on Lake Champlain and in Vermont. On the website, a table listed all reports that had been received and approved during the 2022 season, and a map displayed the status of the most recent report for a given site. Reports received in the past two weeks were displayed on the map.

Map status was based on the visual assessment. At locations where water had also been sampled and analyzed, the visual assessment was used to generate the map status unless subsequent toxin analysis results indicated that this should change. No changes were necessary in 2022.

Results of the assessments translated to one of three map status categories:

VDH Map Status	Visual
Generally Safe (green)	Category 1
Low Alert (yellow)	Category 2
High Alert (red)	Category 3

A list of locations where blooms had been reported for the previous week was also compiled and displayed on the VDH webpage each week (https://www.healthvermont.gov/health-environment/recreational- water/lake-conditions).

Response to Monitoring Reports

Three jurisdictions were covered by the monitoring program efforts (New York, Vermont, and Quebec). While the monitoring program provided a lake-wide system of assessing and reporting cyanobacteria conditions shared via email and the VDH webpage, response to specific events was coordinated and implemented by the appropriate jurisdiction following their respective response protocols.

Outreach

Partners maintained individual websites highlighting monitoring activities, the interactive CyanoTracker map and annual data. Partners also held trainings, made presentations upon request, and responded to inquiries from the public, lake users and the media. Additionally, LCC posted a link to their weekly report on Facebook, emailed a weekly report to monitors tailored to their needs, and another to interested community members and the media.

3. Results

3.1 Overall effort

In 2022, 2534 site-specific visual reports were received between late May and the end of November. These were provided by project partners, volunteers, and others (Table 4). Most were from Lake Champlain (Fig. 1); however, routine reports were also provided from 30 inland lakes in Vermont by VT

DEC staff and volunteers coordinated by LCC or VT DEC (Fig 2), with supplemental reports from an additional five lakes. Fifty-six samples were assessed by microscopy for the Shoreline Quality Assurance Protocol, and an additional 64 samples were collected and counted following the Open Water Protocol.

Table 4. Summary of the 2022 cyanobacteria monitoring station reports by organizational affiliation. Supplemental reports are from locations other than regularly monitored sites or between regular reporting times. Data compiled from the season summary spreadsheet available through the VDH Tracking Map. Reports provided by the public and others outside of the monitoring program were interpreted using the visual assessment process and confirmed with photos. Further information about routine locations can be found in Appendix A.

Waterbody	Affiliation	Report Frequency	Number of Observations
Adams Reservoir	VT State Parks	Routine - Weekly	4
Berlin Pond	LCC Volunteer	Routine - Biweekly	2
Caspian Lake	VT DEC Volunteer	Routine - Weekly	4
Champlain - Inland Sea	General Public	Supplemental	5
Champlain - Inland Sea	LCC Staff	Supplemental	2
Champlain - Inland Sea	LCC Volunteer	Routine - Weekly	280
Champlain - Inland Sea	LCC Volunteer	Supplemental	33
Champlain - Inland Sea	VT DEC	Routine - Biweekly	7
Champlain - Inland Sea	VT State Parks	Routine - Weekly	61
Champlain - Inland Sea	VT State Parks	Supplemental	20
Champlain - Main Lake Central	General Public	Routine - Weekly	1
Champlain - Main Lake Central	General Public	Supplemental	9
Champlain - Main Lake Central	LCC Staff	Routine - Weekly	65
Champlain - Main Lake Central	LCC Staff	Supplemental	11
Champlain - Main Lake Central	LCC Volunteer	Routine - Weekly	433
Champlain - Main Lake Central	LCC Volunteer	Supplemental	83
Champlain - Main Lake Central	VDH	Supplemental	1
Champlain - Main Lake Central	VT DEC	Routine - Biweekly	18
Champlain - Main Lake North	General Public	Supplemental	3
Champlain - Main Lake North	LCC Volunteer	Routine - Weekly	147
Champlain - Main Lake North	LCC Volunteer	Supplemental	12
Champlain - Main Lake North	VDH	Routine - Weekly	1
Champlain - Main Lake North	VT DEC	Routine - Biweekly	10
Champlain - Main Lake South	General Public	Supplemental	1
Champlain - Main Lake South	LCC Staff	Supplemental	1

Champlain - Main Lake South	LCC Volunteer	null	2
Champlain - Main Lake South	LCC Volunteer	Routine - Weekly	260
Champlain - Main Lake South	LCC Volunteer	Supplemental	21
Champlain - Main Lake South	VDH	Supplemental	1
Champlain - Main Lake South	VT DEC	Routine - Biweekly	9
Champlain - Main Lake South	VT State Parks	Routine - Weekly	36
Champlain - Main Lake South	VT State Parks	Supplemental	5
Champlain - Malletts Bay	LCC Staff	Supplemental	1
Champlain - Malletts Bay	LCC Volunteer	Routine - Weekly	40
Champlain - Malletts Bay	VT DEC	Routine - Biweekly	4
Champlain - Malletts Bay	VT State Parks	Routine - Weekly	30
Champlain - Malletts Bay	VT State Parks	Supplemental	11
Champlain - Missisquoi Bay	LCC Volunteer	Routine - Weekly	38
Champlain - Missisquoi Bay	LCC Volunteer	Supplemental	10
Champlain - Missisquoi Bay	VT DEC	Routine - Biweekly	12
Champlain - South Lake	LCC Volunteer	Routine - Weekly	24
Champlain - South Lake	VT DEC	Routine - Biweekly	8
Champlain - St Albans Bay	LCC Volunteer	Routine - Weekly	73
Champlain - St Albans Bay	LCC Volunteer	Supplemental	59
Champlain - St Albans Bay	VT DEC	Routine - Biweekly	6
Champlain - St Albans Bay	VT State Parks	null	2
Champlain - St Albans Bay	VT State Parks	Routine - Weekly	11
Champlain - St Albans Bay	VT State Parks	Supplemental	2
Coles Pond	VT DEC	Routine - Biweekly	1
Coles Pond	VT DEC Volunteer	Routine - Weekly	3
Echo Lake	General Public	Routine - Weekly	1
Echo Lake	LCC Volunteer	Routine - Weekly	16
Emerald Lake	VT State Parks	Routine - Weekly	11
Fern Lake	LCC Volunteer	Routine - Biweekly	1
Gillett Pond	VT DEC Volunteer	Routine - Weekly	5
Indian Brook Reservoir	LCC Volunteer	Routine - Weekly	11
Joes Pond	LCC Volunteer	Routine - Weekly	2
Joes Pond	LCC Volunteer	Supplemental	3

Joes Pond	VT DEC Volunteer	Routine - Weekly	36
Joes Pond	VT DEC Volunteer	Supplemental	1
Knapp Pond 2	General Public	Supplemental	1
Lake Bomoseen	VT State Parks	Routine - Weekly	6
Lake Carmi	General Public	Supplemental	5
Lake Carmi	LCC Volunteer	Routine - Biweekly	2
Lake Carmi	LCC Volunteer	Routine - Weekly	28
Lake Carmi	LCC Volunteer	Supplemental	22
Lake Carmi	VDH	Supplemental	4
Lake Carmi	VT DEC	Routine - Biweekly	27
Lake Carmi	VT State Parks	Routine - Weekly	46
Lake Carmi	VT State Parks	Supplemental	20
Lake Dunmore	VT DEC Volunteer	Routine - Biweekly	3
Lake Dunmore	VT State Parks	Routine - Weekly	10
Lake Fairlee	LCC Volunteer	Routine - Weekly	30
Lake Fairlee	LCC Volunteer	Supplemental	2
Lake Hortonia	LCC Volunteer	Routine - Weekly	10
Lake Iroquois	LCC Volunteer	Routine - Weekly	32
Lake Iroquois	LCC Volunteer	Supplemental	2
Lake Memphremagog	General Public	Routine - Weekly	3
Lake Memphremagog	General Public	Supplemental	1
Lake Memphremagog	LCC Volunteer	Routine - Weekly	6
Lake Memphremagog	LCC Volunteer	Supplemental	2
Lake Memphremagog	MWA Volunteer	Routine - Weekly	28
Lake Memphremagog	MWA Volunteer	Supplemental	70
Lake Memphremagog	VT DEC	Routine - Biweekly	12
Lake Memphremagog	VT DEC Volunteer	Routine - Weekly	29
Lake Morey	DEC Volunteer	Supplemental	1
Lake Morey	General Public	Supplemental	51
Lake Morey	LCC Staff	Supplemental	2
Lake Raponda	General Public	Supplemental	1
Lake Runnemede (Evarts Pond)	VT DEC Volunteer	Routine - Weekly	5
Lake St. Catherine	VT DEC Volunteer	Supplemental	2
Lake St. Catherine	VT DEC Volunteer	Routine - Weekly	11
Martins Pond	LCC Volunteer	Routine - Weekly	6
Miles Pond	LCC Volunteer	Routine - Weekly	13
Miles Pond	LCC Volunteer	Supplemental	1
Mill Pond	VT DEC Volunteer	Routine - Weekly	4
Mill Pond	VT DEC Volunteer	Supplemental	2

Molly's Falls Pond	VT State Parks	Routine - Weekly	10
Nichols Pond	VT DEC Volunteer	Routine - Weekly	8
Shadow Lake	VT DEC Volunteer	Routine - Weekly	5
Shelburne Pond	LCC Volunteer	Supplemental	2
Spring Lake	VT DEC Volunteer	Routine - Weekly	11
Spring Lake	VT DEC Volunteer	Supplemental	2
Sunset Lake	VT DEC Volunteer	Routine - Weekly	6
Ticklenaked Pond	VT DEC	Routine - Biweekly	3
Ticklenaked Pond	VT DEC Volunteer	Routine - Weekly	6
Ticklenaked Pond	VT DEC Volunteer	Supplemental	1
Tinmouth Pond	General Public	Supplemental	1
Upper Ottauquechee River	General Public	Supplemental	1
Winona Lake	LCC Volunteer	Routine - Weekly	8

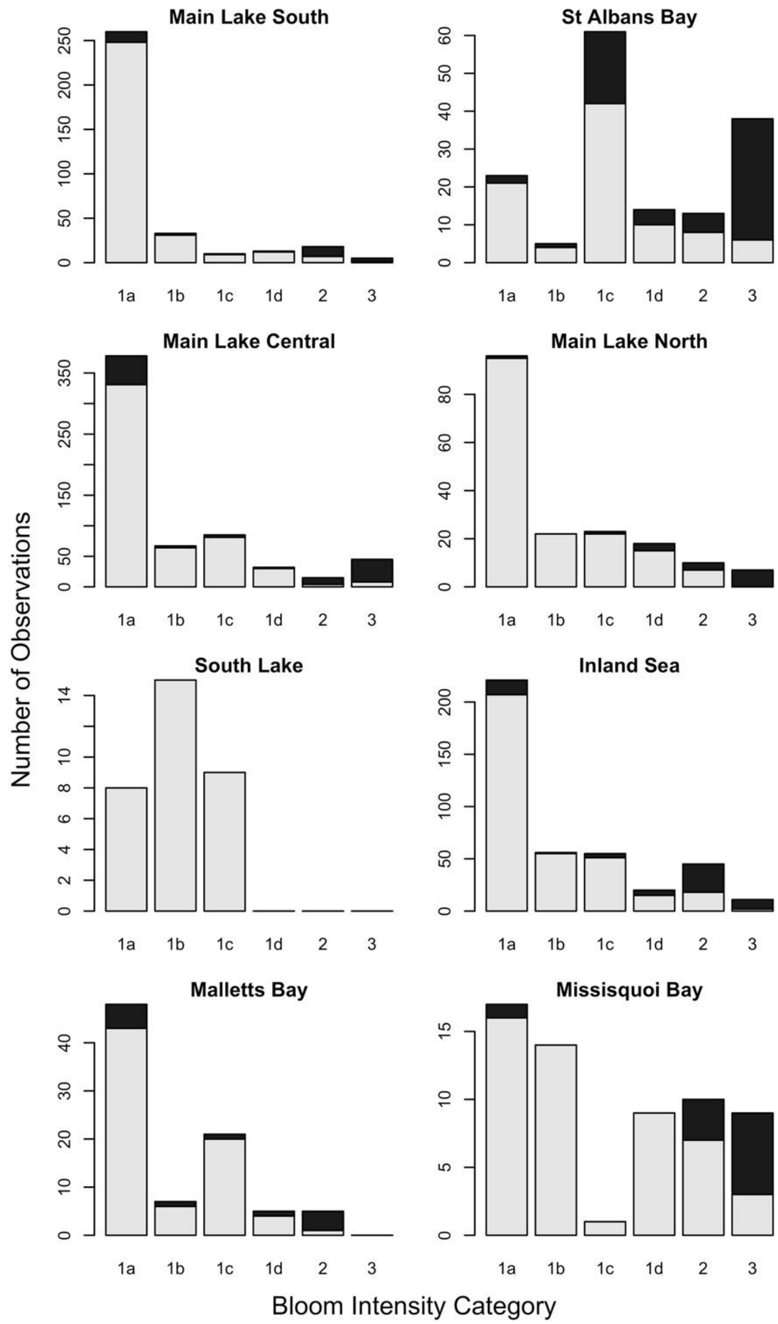

Figure 1. Summary of assessment reports received in 2022 in Lake Champlain. Data compiled from the season summary spreadsheet available through the VDH Tracking Map. Dark shading indicates supplemental reports. NOTE the difference in y-axis scale between basins. Category 1a = clear water, 1b = brown and turbid, 1c = other plant material, 1d = small amount of cyanobacteria. Category 2 = low alert. Category 3 = high alert.

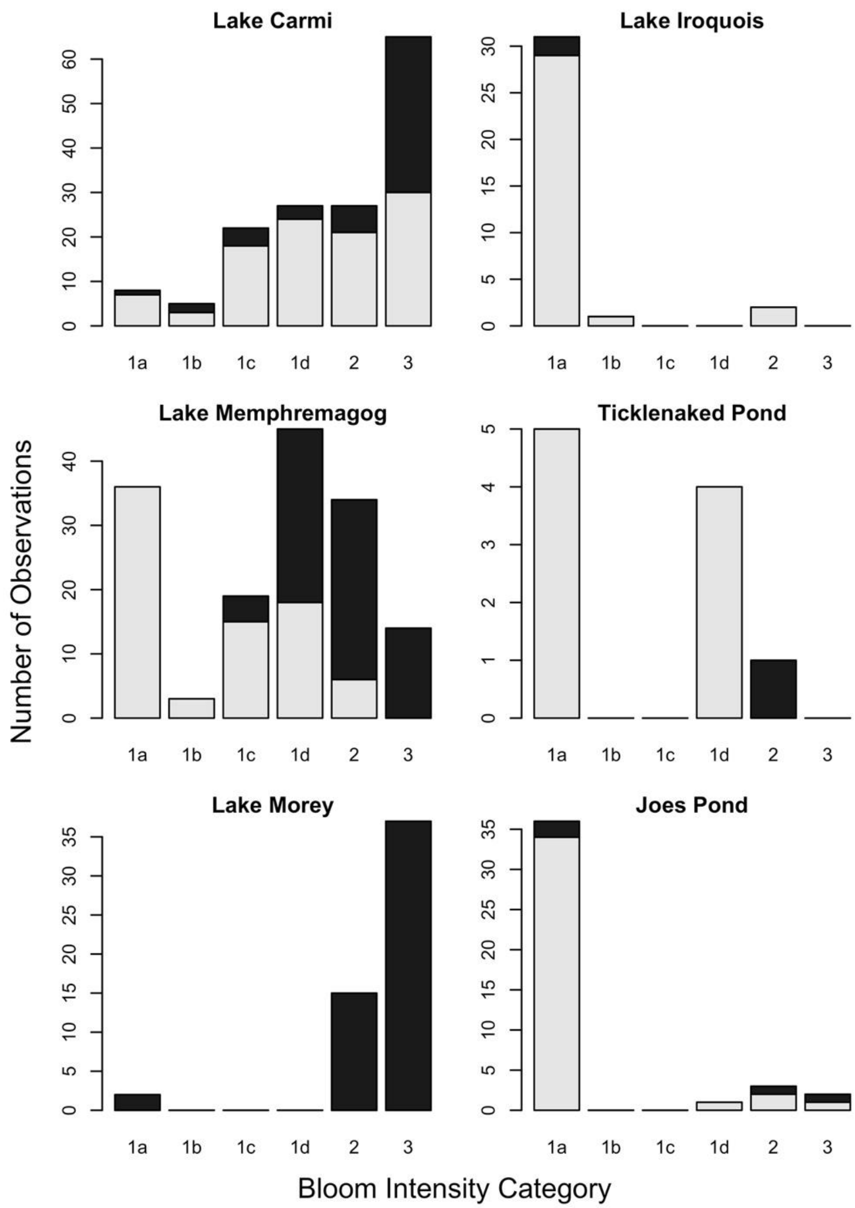

Figure 2. Summary of assessment reports received in 2022 from selected Vermont inland lakes. Data compiled from the season summary spreadsheet available through the VDH Tracking Map. Dark shading indicates supplemental reports. NOTE the difference in scale between lakes. Category 1a = clear water, 1b = brown and turbid, 1c = other plant material, 1d = small amount of cyanobacteria. Category 2 = low alert. Category 3 = high alert.

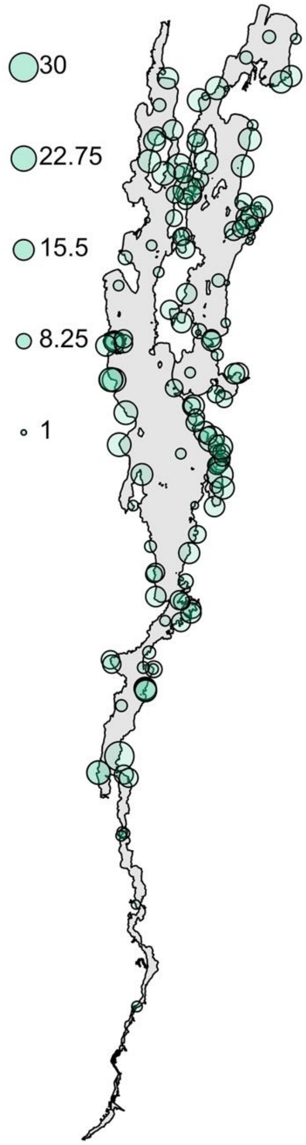

Figure 3.: Number of reports at monitoring sites on Lake Champlain. Size of circles is proportional to number of observations, see legend at left)

The cyanobacteria monitoring program had good coverage of most of Lake Champlain in 2022 (Fig. 3), with particularly high numbers of monitoring sites in the Burlington, VT area and in St. Alban's Bay. There were fewer monitoring locations on the New York shore of the lake, with a notable lack of reports in Plattsburgh and north of Plattsburgh along the lake's western shore, despite a number of bloom reports from nearby areas on the Vermont shores. There were also very few observations along the Canadian shore of Missisquoi Bay.

Toxin and Phytoplankton sampling effort

A total of 72 samples were analyzed for the presence of microcystin and 69 for anatoxin in 2022 (Table 5) from both routine sites and post-bloom sampling by beach managers. This number includes 62 samples from Lake Champlain and 11 from Lake Carmi. Microcystin was detected at 11 locations over the summer of 2022. The highest observed concentration of microcystin was measured on 10/6 in the southern open water area of Lake Carmi (9.4 µg/L), above the recreational threshold of 6 µg/L. The highest microcystin measured in Lake Champlain was 0.36 µg/L at Highgate Springs (Missisquoi Bay). Anatoxin was not above detection limits in any samples in 2022.

Potentially toxic cyanobacteria were observed in all but 21 samples examined microscopically (as is typical for samples from Lake Champlain). Cyanobacteria populations occasionally reached high cell concentrations, particularly in shoreland samples where high densities of cells can accumulate.

Table 5: Number of samples collected for toxin analyses and cell counts under different protocols. Phytoplankton samples include duplicates and several samples which did not have corresponding visual observations

	Phytoplankton		**Microcystin**	**Anatoxin**
	Plankton Net	**Whole Water**	**Whole Water**	**Whole Water**
Open Water Protocol	64			
Quality Assurance Protocol		52	66	63
Visual/Supplemental		4	6	6
Total	**64**	**56**	**72**	**69**

3.2 Summary of Cyanobacteria Conditions in 2022

Summaries of the assessment results from regularly monitored sites in 2022 is presented in Figure 4, showing the progression of the bloom season. The highest monitoring category reached in each region of Lake Champlain and Vermont inland lakes is noted in Table 6. The full list of records is available upon request or can be downloaded from the VDH website (http://www.healthvermont.gov/tracking/cyanobacteria-tracker).

Most reports (83%) received from Lake Champlain and Vermont inland lakes indicated that few or no cyanobacteria were present (category 1 of the visual protocol). In all, 439 reports of alert conditions (categories 2 and 3) were received during the summer of 2022, 17% of the total reports received.

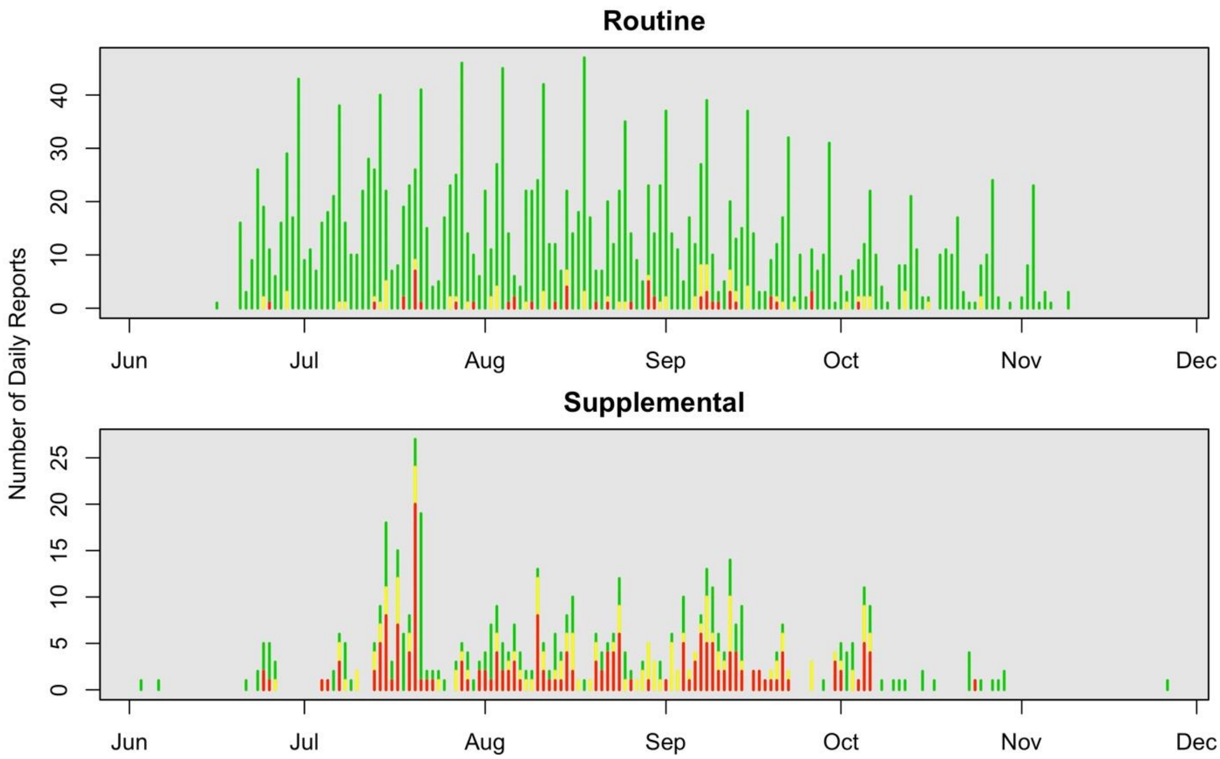

Figure 4. Number of visual assessment reports received on each day of the monitoring period in 2022 in Lake Champlain and Vermont inland lakes. Top panel shows routine reports, bottom panel shows supplemental reports. Green = "Generally Safe", yellow = "Low Alert", red = "High Alert"

Table 6. Highest status reached in each waterbody in 2022. Data compiled from the season summary spreadsheet available through the VDH Tracking Map. All assessments used the visual protocol.

Waterbody	number of observations	Maximum Web Status	Max Cell count (cells/mL)	Maximum Microcystin (µg/L)	Max Anatoxin (µg/L)
Adams Reservoir	4	Generally Safe			
Berlin Pond	2	Generally Safe			
Caspian Lake	4	Generally Safe			
Champlain - Inland Sea	408	High Alert	106		

Champlain - Main Lake Central	621	High Alert	6276	0.25	0
Champlain - Main Lake North	173	High Alert	218		
Champlain - Main Lake South	336	High Alert	3278	0.18	0
Champlain - Malletts Bay	86	Low Alert	136		
Champlain - Missisquoi Bay	60	High Alert	39122	0.36	0
Champlain - South Lake	32	Generally Safe			
Champlain - St Albans Bay	153	High Alert	525850	0.27	0
Coles Pond	4	Generally Safe			
Echo Lake	17	Generally Safe			
Emerald Lake	11	Generally Safe			
Fern Lake	1	Generally Safe			
Gillett Pond	5	Generally Safe			
Indian Brook Reservoir	11	Generally Safe			
Joes Pond	42	High Alert			
Knapp Pond 2	1	High Alert			
Lake Bomoseen	6	Generally Safe			
Lake Carmi	154	High Alert	345748	9.4	0
Lake Dunmore	13	Generally Safe			
Lake Fairlee	32	Generally Safe			
Lake Hortonia	10	Generally Safe			
Lake Iroquois	34	Low Alert			
Lake Memphremagog	151	High Alert	719		
Lake Morey	54	High Alert			
Lake Raponda	1	High Alert			
Lake Runnemede (Evarts Pond)	5	Generally Safe			
Lake St. Catherine	13	Low Alert			
Martins Pond	6	Generally Safe			
Miles Pond	14	Low Alert			
Mill Pond	6	High Alert			
Molly's Falls Pond	10	Generally Safe			
Nichols Pond	8	Generally Safe			
Shadow Lake	5	Generally Safe			
Shelburne Pond	2	High Alert			
Spring Lake	13	Generally Safe			
Sunset Lake	6	Generally Safe			
Ticklenaked Pond	10	Low Alert	1228		
Tinmouth Pond	1	Low Alert			
Upper Ottauquechee River	1	High Alert			
Winona Lake	8	Generally Safe			

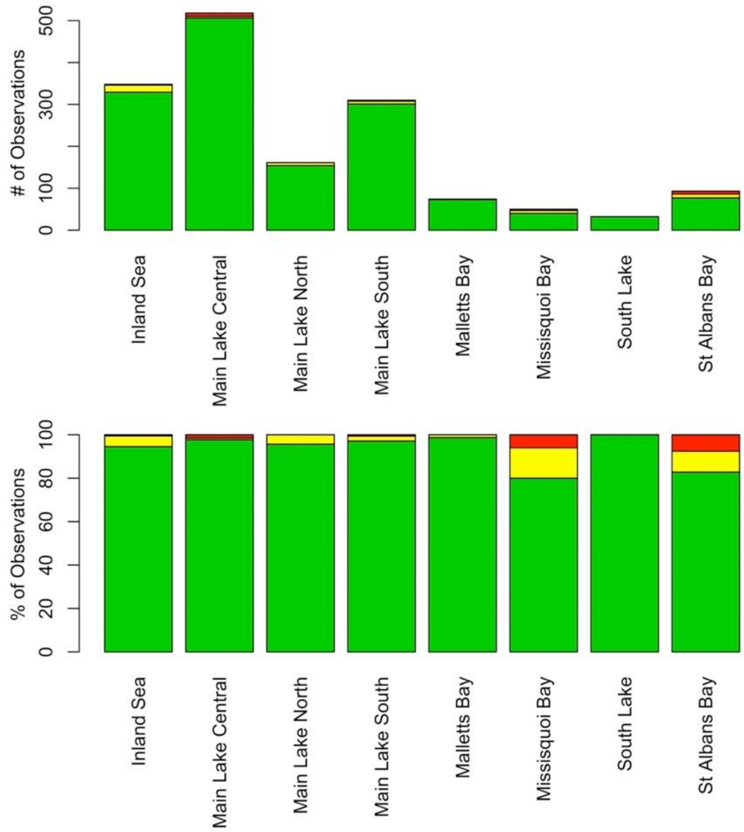

Figure 5: 2022 Web Report alert levels from routine reports for the basins of Lake Champlain. Green indicates "generally safe" conditions, yellow indicates "low alert", and red indicates "high alert". Top panel shows number of observations in each basin, bottom panels show the percentage of each report category in each basin. Supplemental reports are excluded.

3.2.1 Cyanobacteria conditions on Lake Champlain

In 2022, there considerably fewer reports of blooms in the Main Lake South region relative to 2021, when the region had unusually high incidence of blooms in both the Routine reports (Figs 6, 7) and in the Supplemental Reports (Fig. 8). Other areas of the lake appeared to have similar incidence of blooms as in recent years. Sites of particular concern in Lake Champlain, including St. Albans and Missisquoi Bays, had blooms reported at similar levels as previous years (Figs. 6,7,8). The number of both routine and supplemental reports from Missisquoi Bay increased somewhat over the past two years, but remains substantially lower than in 2013-2017, and increased reporting from the Canadian portion of the bay is desirable.

Microcystin and anatoxin concentrations in Lake Champlain were usually below detection limits in 2022 (Table 7), and all were below recreational alert thresholds. There were no major surprising findings in the microscopy data, with the same common cyanobacteria taxa continuing to dominate in affected samples as in previous years, with the exception of several notable blooms of benthic cyanobacteria.

A number of the cyanobacteria observations noted the presence of benthic cyanobacteria colonies, identified as Calothrix spp, in areas where they had not been previously observed. There is not a clear protocol established for assigning benthic blooms to alert categories, so best professional judgement was used. Future efforts should attempt to develop methods for the quantification and categorization of benthic blooms.

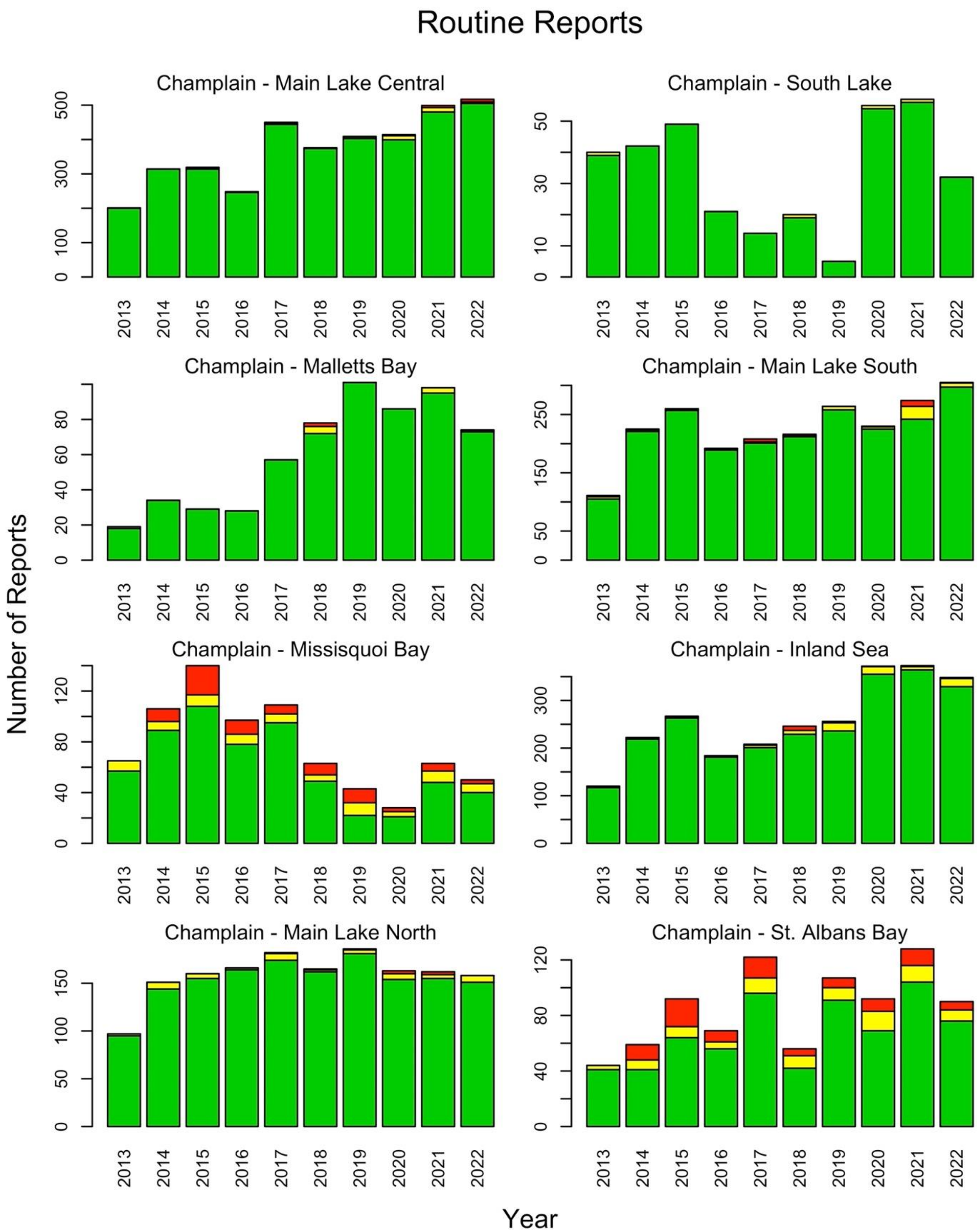

Figure 5: Web Report alert levels from routine reports for the basins of Lake Champlain during the years 2013 – 2022 showing the number of reports received in each year. Green indicates "generally safe" conditions, yellow indicates "low alert", and red indicates "high alert".

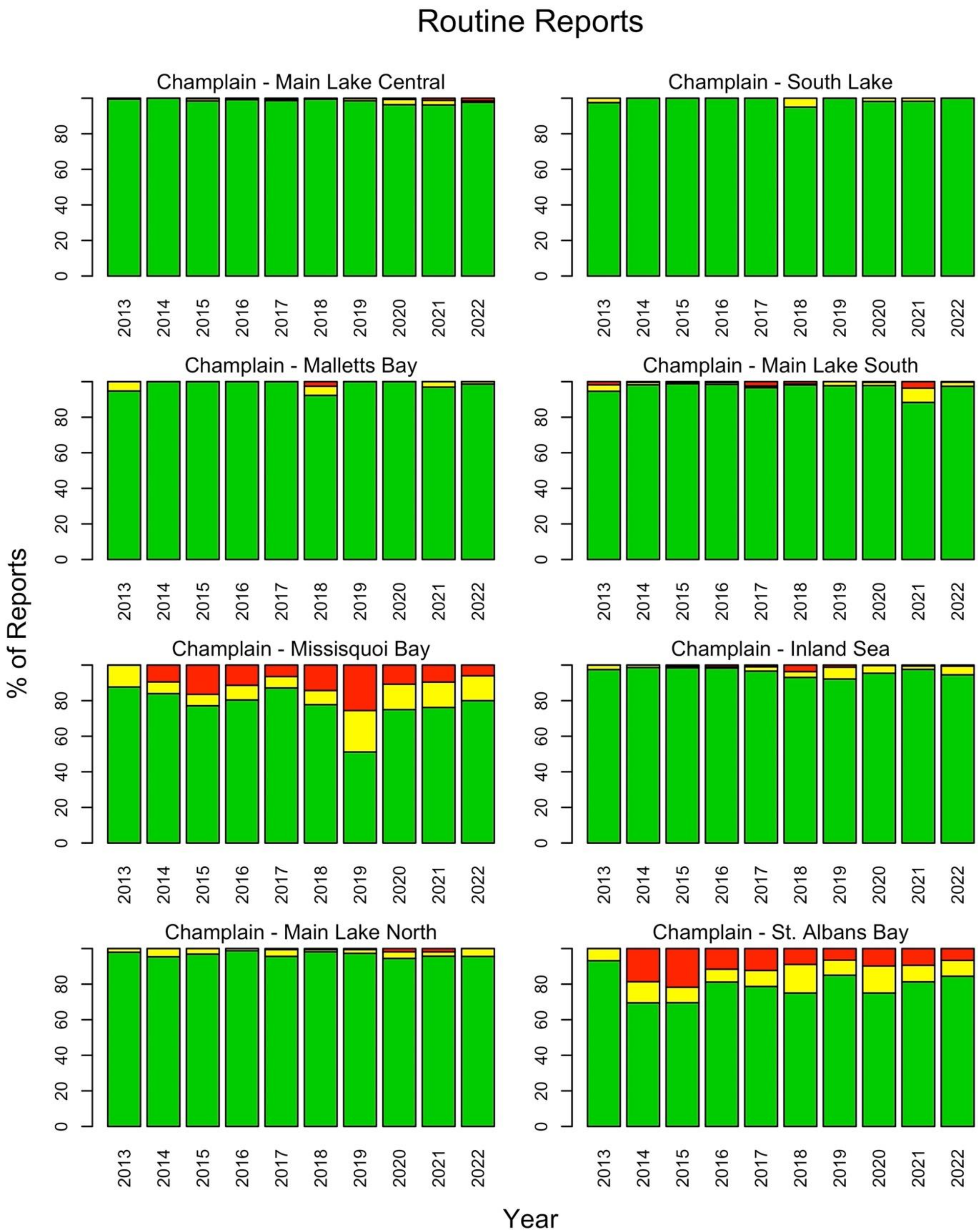

Figure 6: Web Report alert levels from routine reports for the basins of Lake Champlain during the years 2013 – 2022 showing the percentage of reports in each alert category. Green indicates “generally safe” conditions, yellow indicates “low alert”, and red indicates “high alert”.

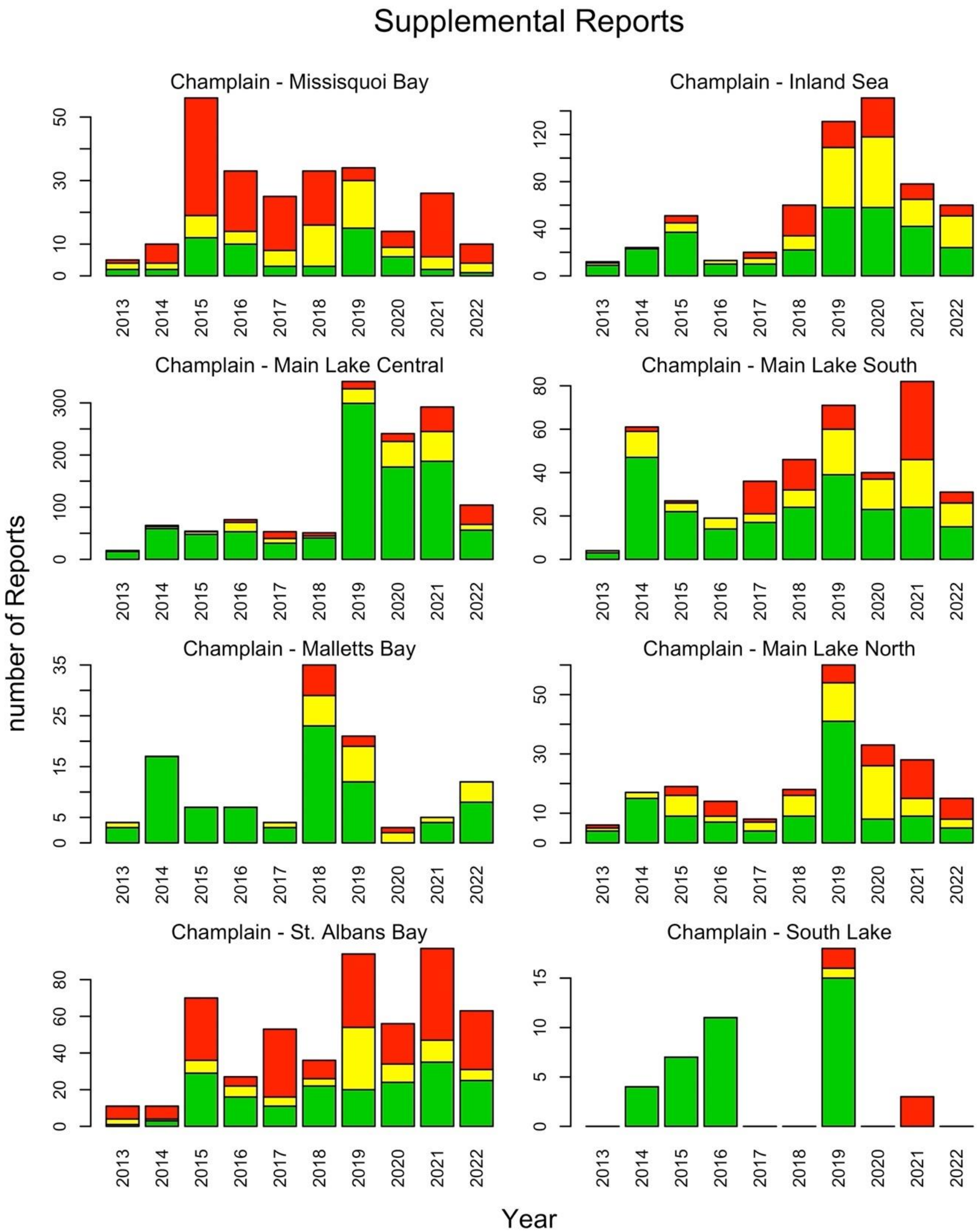

Figure 8: Web Report alert levels in Supplemental Reports for the basins of Lake Champlain during the years 2013 – 2022 showing the percentage of reports in each alert category. Green indicates "generally safe" conditions, yellow indicates "low alert", and red indicates "high alert". Supplemental reports reflect public interest and participation in bloom monitoring activities, as well as actual bloom conditions on the lake.

Table 7. Microcystin concentrations in major lake segments, 2014 – 2022. Data are from routine monitoring locations and bloom events. ND = not detected. Shaded boxes = not applicable. Detailed data for 2003 - 2013 can be found in Appendix D.

Lake Region		**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Inland Sea	median	<0.16	<0.16			<0.16	<0.16			
	range	<0.16–0.28	<0.16–0.02			All <0.16	<0.16–0.36			
	#samples	56	26	0	0	5	4	0	0	0
	#stations	4	4	0	0	5	4	0	0	0
Main Lake Central	median	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16
	range	<0.16–0.19	All <0.16	All <0.16	<0.16–1.25	All <0.16	All <0.16	<0.16–0.17	All <0.16	<0.16–0.25
	#samples	31	27	26	31	36	36	28	37	25
	#stations	2	2	2	4	4	6	4	6	3
Main Lake North	median			<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	
	range			All <0.16	All <0.16	All <0.16	All <0.16	All <0.16	<0.16–2.11	
	#samples	0	0	12	10	11	11	2	3	0
	#stations	0	0	1	1	1	2	1	3	0
Main Lake South	median	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16
	range	<0.16–0.51	All <0.16	All <0.16	<0.16–4.25	All <0.16	All <0.16	All <0.16	All <0.16	<0.16–0.18
	#samples	33	28	12	16	21	13	3	4	11
	#stations	3	2	1	3	4	1	1	2	2
St. Albans Bay	median	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16
	range	<0.16–0.2	<0.16–0.77	All <0.16	<0.16–0.35	<0.16–0.38	All <0.16	<0.16–0.22	All <0.16	<0.16–0.27
	#samples	4	12	15	21	13	16	12	11	12
	#stations	2	2	3	3	1	3	2	1	2
Malletts Bay	median					<0.16	<0.16			
	range					All <0.16				
	#samples	0	0	0	0	6	1	0	0	0
	#stations	0	0	0	0	3	1	0	0	0
South Lake	median									
	range									
	#samples	0	0	0	0	0	0	0	0	0
	#stations	0	0	0	0	0	0	0	0	0
Missisquoi Bay	median	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16
	range	<0.16–2.29	<0.16–0.43	All <0.16	<0.16–5.6	<0.16–0.38	<0.16–0.93	All <0.16	<0.16–0.2	<0.16–0.36
	#samples	40	38	19	18	16	14	13	17	13
	#stations	7	5	6	3	4	1	2	5	3

3.2.2 Cyanobacteria Conditions on Vermont inland lakes

Figure 8 shows the growth of the cyanobacteria monitoring program in inland lakes form 2013–2022, demonstrating continued increases in participation by volunteers in routine monitoring programs This growth reflects efforts on the part of project partners to increase participation, as well as increased interest on the part of the public. There were relatively few supplemental reports compared to the last several years, but it is difficult to attribute this to a change in bloom frequency rather than changes in the attention paid by volunteers or incorporation of more reports into the routine monitoring category. The changing frequency of reports suggests the need to develop methods to develop unbiased metrics to track incidence of cyanobacteria blooms on Vermont lakes over time. Routine monitoring reports are important for these efforts, although increased quantitative analyses would be useful for establishing baselines in different Vermont lakes, particularly where blooms have been observed.

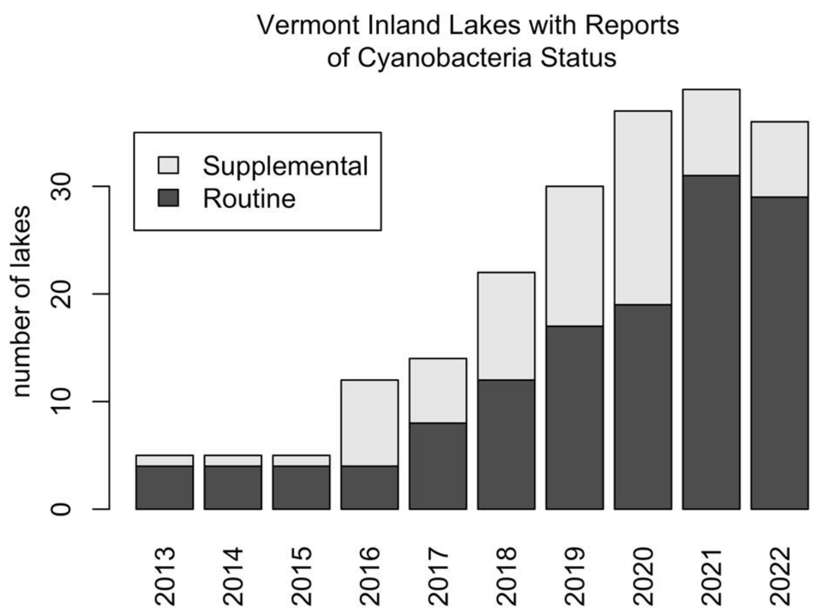

Figure 9: Number of lakes delivering reports of cyanobacteria status using the visual monitoring protocol. Dark bars indicate lakes with at least one routine reporting site, light gray bars indicate sites with only supplemental reports. NOTE: This does not mean that all lakes experienced cyanobacteria blooms, only that reports (including reports of "Generally Safe" conditions) were delivered.

Several inland lakes have consistently high numbers of reports over the 2013-2022 timeframe, providing the opportunity to look at trends. In 2022 Lake Carmi had relatively high incidence of bloom conditions, particularly on a percentage basis, relative to previous years. The difference from previous years was not huge, but is notable because this was the first field season in which the aeration system meant to reduce internal phosphorus loading was fully operational throughout the bloom season, but high incidence of blooms occurred nonetheless (Fig. 10). Lake Memphremagog had a lower number and percentage of alert-level conditions than 2021, when bloom conditions were quite prevalent, but had a higher percentage of low-alert blooms than 2013–2020; however, this could partly reflect the addition of new sampling sites with relatively high incidence of blooms.

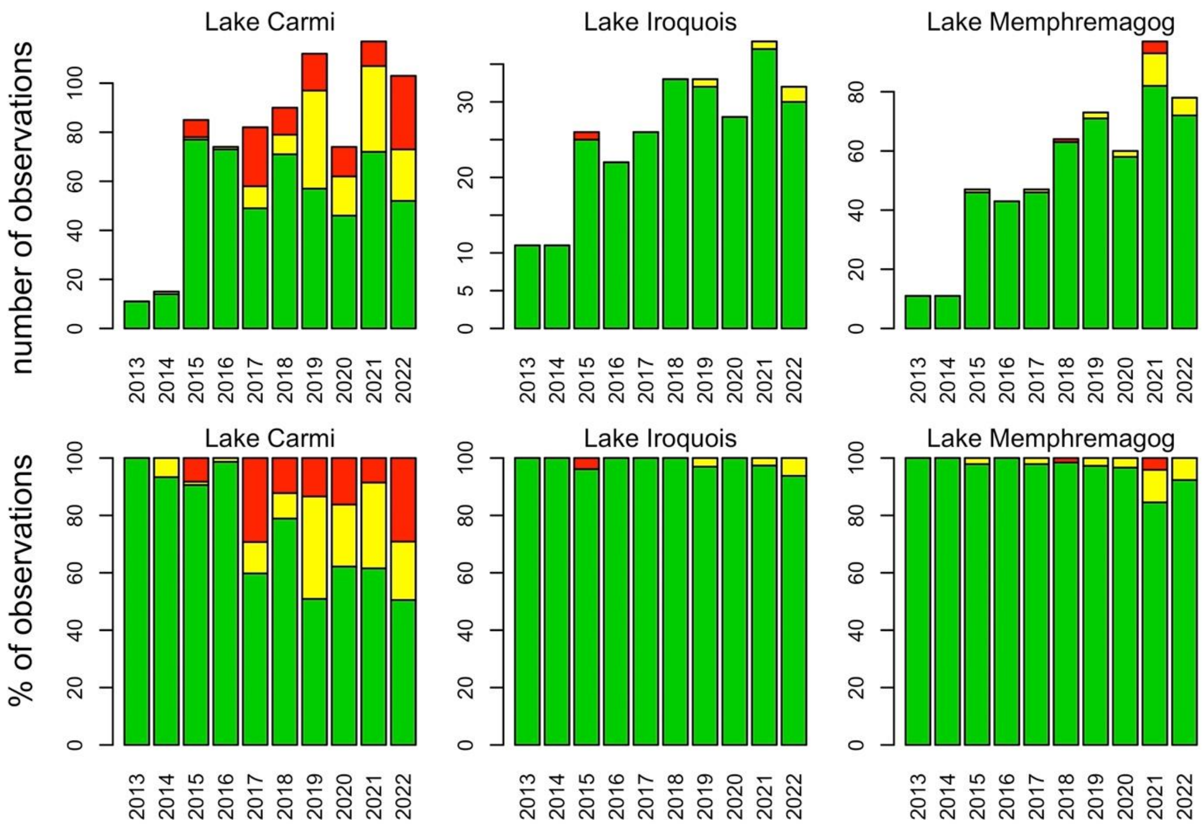

Figure 10: Web Report alert levels for selected inland lakes showing the total number (top) and percentage (bottom) of reports in each alert category. Green indicates "generally safe" conditions, yellow indicates "low alert", and red indicates "high alert". Supplemental reports are excluded.

Fourteen Inland waterbodies had reports of category 2 or 3 blooms in 2022 in Vermont, including:

Lake Carmi	Lake Iroquois
Tinmouth Pond	Lake Memphremagog
Ticklenaked Pond	Shelburne Pond
Lake Morey	Mill Pond
Joe's Pond	Knapp Pond 2
Lake Raponda	Lake St. Catherine
Miles Pond	Upper Ottauquechee River

Lake Carmi has been a focus of attention for some time due to the recurring cyanobacteria blooms there and the ongoing efforts on the part of VT DEC to restore the lake and minimize blooms. Table 8 summarizes microcystin concentrations observed at Lake Carmi since 2013.

Microcystin was detected in 7 of 11 samples on Lake Carmi this year, including the highest observed microcystin concentration among all samples tested by the monitoring program (9.4 µg/L). This was the highest reported microcystin concentration reported in the lake since testing began. For the first time at any site in the basin since regular testing began in 2013, median microcystin concentrations were over the detection limit of 0.16 µg/L.

Table 8. Microcystin concentrations in Lake Carmi, 2013 - 2021. The detection limit is 0.16 µg/L.

Lake		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Lake Carmi	median	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	0.26
	range	<0.16–0.21	<0.16–0.39	<0.16–0.40	<0.16	<0.16–4.4	<0.16–1.19	<0.16–1.1	<0.16–0.17	<0.16–5.31	<0.16–9.4
	#samples	10	19	17	25	35	32	36	13	17	11
	#stations	1	4	2	3	3	4	4	4	7	7

3.3 Effectiveness of the visual monitoring protocol

Quality assurance samples indicated that the visual monitoring protocol was a reasonable indicator of cyanobacteria concentrations. Median cell densities increased from “Generally Safe” through “Low Alert” and “High Alert” in both plankton net and whole water samples. However, there were a wide range of cell densities in samples with “Generally Safe” visual observations (Fig. 10), and there was broad overlap in observed cell densities in all categories using both protocols.

Median and maximum cell densities were both orders of magnitude higher in whole-water samples than in plankton net samples. This reflects the fact that during blooms, cells accumulate at the surface and along shorelines, resulting in very high local concentrations, whereas in net samples the range whole water column concentrations are more constrained.

The quality assurances samples continued to support the use of the visual protocol for assessing cyanotoxin concentrations, although it was imperfect. Microcystins were above detection in seven of the “Generally Safe” samples, and nine out of 21 alert-level samples. The highest concentration was observed in a “High Alert” sample. All microcystin samples were below recreational thresholds. Anatoxin was not detected. There were relatively few QA samples available from alert-level conditions, and in the coming years increasing efforts should be made to sample more bloom events, to get a better sense of the prevalence of toxicity.

Each year, there are unusual observations that challenge our monitors as they utilize the visual protocol. We continue to update training materials to include the unusual as well as common appearance of cyanobacteria and other aquatic phenomena.

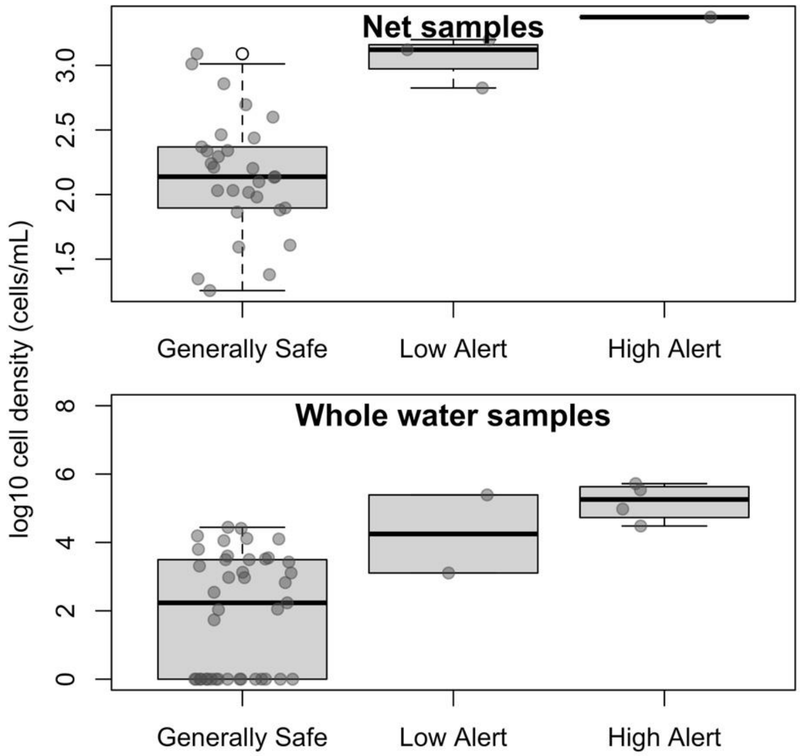

Fig. 11: Box and whiskers plots of cell densities (log_{10} n+1 transformed) for each alert category for whole water and plankton net samples. Dark lines represent median values for each category, top and bottom boundaries of the box represent 75th and 25th percentiles of the data, respectively, and whiskers represent range of the data, except if there are extreme outliers which are represented by open circles. Grey circles represent individual data points.

3.4 Drinking Water Supply Monitoring

In 2022, the VDH and DWGWPD offered free weekly microcystin testing for public drinking water facilities in Vermont for 12 weeks from July through late September. There were no detections of microcystins above detection limits at any of the drinking water sites in 2022. Results of the summer's testing are can be found online at https://dec.vermont.gov/water/drinking-water/water-quality-monitoring/blue-green-algae/cyanotoxin-monitoring.

3.5 Volunteer training

All LCC Volunteer trainings were conducted virtually rather than held at different locations around the Lake Champlain Basin, due to positive experiences with the convenience of online trainings on the part of both volunteers and staff during the Covid-19 pandemic. LCC trained nearly 300 potential monitors and interested community members at 26 formal Zoom sessions. LCC outreach, social media postings and media interviews and appearances alerted the public to the opportunity to become a volunteer monitor. LCC staff provided additional trainings throughout the season with virtual sessions held during May, June, and July, and informal sessions held throughout the season. VT DEC provided training for watershed associations and others on Vermont inland lakes located outside the Champlain Basin. LCC also trained a number of volunteers from inland VT lakes outside of the Champlain basin, and provided ongoing support as needed and weekly monitoring emails to monitors outside the Basin as well.

Training sessions provided information about cyanobacteria – causes, conditions that favor the development of blooms, appearance, associated health concerns, and management efforts aimed at reducing bloom frequency. Monitors were taught to distinguish cyanobacteria from other phenomena they might see in the lake such as green algae and pollen. Training sessions also introduced volunteers to the online LCC, VDH, and VT DEC cyanobacteria resources and report forms, and the VDH Tracker reporting process.

The volunteer monitor program has an impact beyond the recruitment of volunteers and collection of data. As awareness of the possible health effects associated with cyanobacteria spreads, the interest in learning more about these organisms increases. While not all trained volunteers go on to report, all became familiar with cyanobacteria, potential health risks associated with them, and the water quality conditions that increase the likelihood of blooms.

3.6 Outreach and Assistance

Project partners continue to provide outreach and assistance to individuals and municipalities, primarily through phone calls and email. In addition, the LCC sends out a weekly update on conditions to their volunteers and provides separate weekly emails to a list-serve of interested community members and agencies along with media reports throughout the season. Guidance and assistance to town health officers, beach managers, and residents was provided by partners during bloom events. All partners had webpages with resources and contacts for anyone seeking information about cyanobacteria. Partners also responded to media inquiries.

3.7 Communication with the Stakeholders and the Public

Results of the weekly assessments were communicated via email to a variety of stakeholders. The 193 recipients who received the VT DEC emails were largely associated with the states of Vermont and New York. Other recipients included federal officials and LCBP, provincial officials in Quebec, water facilities, local governmental organizations, or municipal staff, non-profits and universities, and unknown recipients. As noted earlier, LCC also provided weekly emails to all monitors and partner agencies as well as separate weekly emails to a list-serve and regular emails to the media once blooms began.

Information was shared with the public via the VDH cyanobacteria webpages - see table below. The VDH Cyanobacteria website received thousands of visits Between June and December 2022 (Table 7). Activity was greatest in July and August, peak months of recreational activity. The monitoring data was also accessible through the VDH's Environmental Public Health Tracking page http://healthvermont.gov/tracking/index.aspx.

VDH Cyanobacteria Webpages	URL
VDH Cyanobacteria Landing Page	healthvermont.gov/cyanobacteria

VDH Cyanobacteria Lake Conditions Page	healthvermont.gov/health-environment/recreational-water/lake-conditions
EPHT CyanoTracker Landing Page	healthvermont.gov/tracking/cyanobacteria-tracker
VDH Climate Change and Cyanobacteria Page	http://www.healthvermont.gov/health-environment/climate- health/cyanobacteria

Table 9. Usage of the VDH Cyanobacteria webpages in 2022

2021 Month	VDH Cyanobacteria Landing Page – Unique Page Views	VDH Cyanobacteria Tracker – Unique Page Views
June	533	2157
July	6,699	34,497
August	1,336	13,177
September	529	2,771
October	203	903
November	166	402
December	114	200
Total	9,580	54,107

3.8 Challenges

2022 had no major challenges with respect to the operations of the monitoring program, with operations returning to mostly normal conditions following the COVID-19 pandemic. There were minor technical issues with the cyanobacteria tracker website which caused some delays early in the season, but these were resolved as quickly as possible.

Each year, project partners train community science volunteers to recognize cyanobacteria using visual cues and knowledge gained over the life span of the monitoring effort. Our focus is on the typical appearance of cyanobacteria blooms and other aquatic phenomena. We remind our monitors that there are always exceptions and encourage them to share unusual observations with us. In turn, these are shared by the LCC with the wider team of volunteers and continue to enhance their ability to distinguish cyanobacteria from other aquatic phenomena. Definitive and quantitative evidence of both cyanobacteria composition and toxicity remains limited at most sites, particularly in inland lakes, due to the costs and labor associated with microscopic counts and laboratory analyses.

There were several incidence of benthic cyanobacteria colonies in Lake Champlain and Lake Morey. In Lake Champlain in Alburg, VT, there was a relatively large population of benthic colonial cyanobacteria of the genus Calothrix or Rivularia (taxonomy is inconsistent in these closely related taxa). In Lake Morey, VT, a large bloom of *Microseira wollei* rose to the surface in the fall, and persisted for more than a month. *Microseira wollei* is a primarily benthic taxa that can form thick mats. Under the right circumstances, these mats can rise to the surface and create serious surface blooms. The program does not have clear protocols in place to assess the risks from benthic cyanobacteria accumulations. Project partners are working to implement clear protocols, particularly given that benthic blooms have been increasingly reported around the country in recent years.

4. Summary and conclusions

The primary role of the cyanobacteria monitoring program is to provide data on cyanobacteria occurrence and abundance so that health protective decisions can be made for recreational water uses. The program serves an education and outreach role, helping volunteers and others recognize situations when recreational activities might not be prudent. Data also contribute to a historical perspective of bloom events and water quality in the Basin.

The data provided by the program assists drinking water facilities around Lake Champlain to evaluate the quality of their raw and finished water, and, in Vermont, provides operators with specific information about the presence/absence of selected cyanotoxins.

The cyanobacteria monitoring program continues to operate through a strong partnership between the State of Vermont, the Lake Champlain Committee, and the Lake Champlain Basin Program. As in years past, the majority of monitoring reports documented generally safe conditions on Lake Champlain and selected Vermont inland lakes.

Lake Morey in Fairlee, VT had an exceptional year, with a prolonged bloom of the cyanobacteria *Microseira wollei,* which grows predominantly as mats on lake bottoms but can rise to the surface under the right circumstances. The northern area of the Main Lake Basin on Lake Champlain also had a number of reports of benthic cyanobacteria of the genus Calothrix, which has not been previously observed. New protocols are being developed to assess the density, toxicity and threat associated with different levels of benthic cyanobacteria blooms.

Partners continue to use the visual assessment protocol to communicate cyanobacteria conditions across Lake Champlain, supported by toxin data and microscopy data collected routinely at key locations. The visual assessment protocol facilitates outreach on inland lakes, providing a common way to visually evaluate and communicate conditions to individuals who may be experiencing cyanobacteria for the first time. Participation in the monitoring program in inland lakes was high in 2022, with a number of lakes monitoring for the first time, although slightly lower than in 2021. Outreach continues to be an important component of the monitoring program.

Acknowledgements

Project funding was provided by the Lake Champlain Basin Program, the State of Vermont, CDC grants to the VDH, and private funding to the Lake Champlain Committee. This project is very much a collaborative effort and we'd like to thank all those who have contributed to its successful implementation – Pete Stangel and Connor Quinn (VT DEC Watershed Management); Angela Shambaugh (formerly of VT DEC); Ethan Hood, Alex Bernich, Mindy Morales (UVM), Jan Leja and Dan Jarvis (developers of the Tracker map); Lindsey Carlsen, Jared Carpenter, Emily DeAlto, Eileen Fitzgerald, Alexa Hachigian, and Rei Jia, (LCC); staff at VT State Parks; and especially the community science volunteer monitors who continue to be the backbone of this monitoring effort.

Appendix A. 2022 Routine Sampling Locations

Waterbody	Station	Site	Municipality	State	# of Reports	Latitude	Longitude
Adams Reservoir	Woodford State Park - Camper Beach	444	Bennington	VT	2	42.8877545	-73.039622
Adams Reservoir	Woodford State Park - Day Beach	443	Bennington	VT	2	42.8837491	-73.034472
Berlin Pond	Berlin Pond	301	Berlin	VT	1	44.1871755	-72.587741
Berlin Pond	Berlin Pond Boat Launch	533	Berlin	VT	1	44.208488	-72.582259
Caspian Lake	Caspian Lake Public Beach	561	Greensboro	VT	4	44.5763113	-72.298391
Coles Pond	Coles Pond Boat Launch	562	Walden	VT	4	44.5026355	-72.214381
Echo Lake	Echo Lake	315	Charleston	VT	17	44.8509888	-71.99058
Emerald Lake	Emerald Lake State Park - Day Beach	441	East Dorset	VT	11	43.277984	-73.010289
Fern Lake	Fern Lake, Leicester boat launch	552	Leicester	VT	1	43.8615334	-73.069982
Gillett Pond	Gillett Pond	323	Richmond	VT	5	44.3542611	-72.963181
Indian Brook Reservoir	Indian Brook Reservoir Boat Launch	491	Essex	VT	11	44.5356508	-73.077675
Joes Pond	Clubhouse Circle	465	West Danville	VT	12	44.4173021	-72.220856
Joes Pond	The Narrows, Joes Pond	463	West Danville	VT	12	44.4088965	-72.211428
Joes Pond	Town Beach, Joes Pond	464	West Danville	VT	14	44.4101745	-72.199063
Lake Bomoseen	Bomoseen State Park - Day Beach	438	Castleton	VT	6	43.6675846	-73.228538
Lake Carmi	Carmi DEC01- Central Open Water	409	Franklin	VT	9	44.9726316	-72.874504
Lake Carmi	Carmi DEC02- Southern Open Water	410	Franklin	VT	9	44.9592248	-72.886941
Lake Carmi	Carmi DEC03- Northeastern Open Water	411	Franklin	VT	9	44.9821424	-72.861453
Lake Carmi	Forsyth Drive	555	Franklin	VT	1	44.9873459	-72.873867
Lake Carmi	Lake Carmi	305	Franklin	VT	5	44.9764191	-72.884732
Lake Carmi	Lake Carmi State Park	201	Franklin	VT	15	44.960822	-72.876743
Lake Carmi	Lake Carmi State Park - Area B	415	Franklin	VT	16	44.9558091	-72.884054
Lake Carmi	Lake Carmi State Park South	165	Franklin	VT	15	44.9569311	-72.877291
Lake Carmi	Lake Carmi, Black Woods	164	Franklin	VT	9	44.9753164	-72.885489
Lake Carmi	Lake Carmi, North Beach	167	Franklin	VT	5	44.9902345	-72.871059
Lake Carmi	Patton Shore	518	Franklin	VT	9	44.9848603	-72.875028
Lake Carmi	Sandy Bay Beach		Franklin	VT	1		
Lake Champlain	Alburgh Dunes State Park	35	Alburgh	VT	22	44.8646464	-73.301971
Lake Champlain	Alburgh East Shore - Town Beach	430	Alburgh	VT	19	44.9550091	-73.264445
Lake Champlain	Alburgh Lakeshore Park	510	Alburgh	VT	19	44.9714874	-73.229676
Lake Champlain	Arnold Bay	3	Panton	VT	18	44.149436	-73.367362
Lake Champlain	Arnold Bay Panton Docks	537	Panton	VT	17	44.1480156	-73.366251
Lake Champlain	Arnold Bay South Side	539	Panton	VT	17	44.1463246	-73.366121
Lake Champlain	Ausable Point Campground Beach	376	Peru	NY	20	44.5719957	-73.426616
Lake Champlain	Ausable Point Road - Lake side	434	Peru	NY	20	44.5725942	-73.432542
Lake Champlain	Bayside Beach	377	Colchester	VT	10	44.545664	-73.215945

Lake Champlain	Beggs Park Beach, Essex NY	60	Essex	NY	12	44.3252948	-73.343918
Lake Champlain	Black Bridge	191	St. Albans Town	VT	2	44.8103091	-73.151893
Lake Champlain	Boat Launch on Hathaway Point Rd	379	St. Albans Town	VT	17	44.794173	-73.172245
Lake Champlain	Bullhead Bay Valcour Island	541	Valcour Island	NY	14	44.6220176	-73.426196
Lake Champlain	Bulwagga Bay/Port Henry	138	Port Henry	NY	20	44.0351687	-73.456526
Lake Champlain	Burlington, VT - Texaco Beach	72	Burlington	VT	7	44.4876328	-73.232139
Lake Champlain	Burton Island State Park	37	St. Albans Town	VT	13	44.7761356	-73.197568
Lake Champlain	Butterfly Bay Valcour Island	545	Valcour Island	NY	13	44.6261342	-73.425893
Lake Champlain	Button Bay Boat Launch	74	Ferrisburgh	VT	10	44.1762481	-73.351443
Lake Champlain	Button Bay State Park	180	Ferrisburgh	VT	4	44.1772943	-73.354593
Lake Champlain	Button Bay State Park - the point	421	Ferrisburgh	VT	4	44.1780264	-73.370683
Lake Champlain	Button Bay State Park - the Point	421	Ferrisburgh	VT	1	44.1780264	-73.370683
Lake Champlain	Camp Kiniya	142	Colchester	VT	5	44.6058352	-73.229334
Lake Champlain	Carry Bay - East Shore	420	North Hero	VT	9	44.8348378	-73.269401
Lake Champlain	Carrying Place South	474	North Hero	VT	12	44.8252621	-73.27657
Lake Champlain	Cedar Ledge	131	North Hero	VT	10	44.8459495	-73.26369
Lake Champlain	Charlotte Town Beach	76	Charlotte	VT	16	44.3345212	-73.281768
Lake Champlain	City Bay - Rt 2	78	North Hero	VT	9	44.8027594	-73.285677
Lake Champlain	Cohen Park St. Albans	174	St. Albans	VT	18	44.8648866	-73.180956
Lake Champlain	Colchester Point		Colchester	VT	2		
Lake Champlain	Colchester Point Boat Launch	412	Colchester	VT	17	44.5361752	-73.274426
Lake Champlain	Converse Bay	184	Charlotte	VT	8	44.2950503	-73.291197
Lake Champlain	Corlear Bay, Port Douglas Boat Launch	160	Chesterfield	NY	20	44.4835729	-73.416934
Lake Champlain	Cow Banks	532	South Hero	VT	8	44.6388604	-73.264008
Lake Champlain	Crater Club	534	Essex	NY	10	44.2878906	-73.347601
Lake Champlain	DAR State Park	39	Addison	VT	31	44.0544202	-73.416676
Lake Champlain	Dead Creek Inlet	413	Peru	NY	20	44.5722714	-73.433265
Lake Champlain	Delta Park	405	Colchester	VT	10	44.5360492	-73.278073
Lake Champlain	Essex Road	382	Willsboro	NY	5	44.3439141	-73.35729
Lake Champlain	Everest Rd.	185	Milton	VT	3	44.6496433	-73.21323
Lake Champlain	Fee Fee Point	461	North Hero	VT	15	44.8959211	-73.267103
Lake Champlain	Georgia Beach	193	Georgia	VT	2	44.768131	-73.163268
Lake Champlain	Gilligan's Bay	511	Crown Point	NY	4	43.952741	-73.411118
Lake Champlain	Grand Isle State Park	11	Grand Isle	VT	15	44.6903721	-73.288359
Lake Champlain	Graveyard Point	473	North Hero	VT	29	44.8316235	-73.286342
Lake Champlain	Hackett's Way	402	St. Albans Town	VT	16	44.7843513	-73.173844
Lake Champlain	Hathaway Point Road	403	St. Albans Town	VT	17	44.7963781	-73.163135
Lake Champlain	Holcomb Boat Launch	129	Isle la Motte	VT	20	44.8546931	-73.331621
Lake Champlain	Horicans Fish and Wildlife Access	127	Alburgh	VT	15	44.9141009	-73.31447

Lake Champlain	Keeler Bay Boat Launch	135	South Hero	VT	13	44.6679182	-73.319906
Lake Champlain	Keeler Bay East	134	South Hero	VT	15	44.6504109	-73.297947
Lake Champlain	Kill Kare State Park	56	St. Albans Town	VT	11	44.7786088	-73.183267
Lake Champlain	Kings Bay Fishing Access	432	North Hero	VT	20	44.8698121	-73.250475
Lake Champlain	Kingsland Bay State Park	15	Ferrisburgh	VT	13	44.2403105	-73.298734
Lake Champlain	Knight Point State Park	80	North Hero	VT	11	44.7687242	-73.294513
Lake Champlain	Knight Point State Park ‚Äì†the Point	419	North Hero	VT	10	44.76727	-73.299101
Lake Champlain	Lakeside Beach	514	Burlington	VT	11	44.4600705	-73.222118
Lake Champlain	Lapan Bay	385	St. Albans Town	VT	11	44.8155685	-73.178437
Lake Champlain	LaPlatte River mouth, Shelburne Bay	55	Shelburne	VT	15	44.3989733	-73.234545
Lake Champlain	Law Island - Northeast	540	Colchester	VT	11	44.5608953	-73.311627
Lake Champlain	Leddy Park	54	Burlington	VT	16	44.5008031	-73.25323
Lake Champlain	Lighthouse Point Road	472	Isle la Motte	VT	12	44.9054534	-73.34507
Lake Champlain	Long Point	18	Ferrisburgh	VT	12	44.2582132	-73.277635
Lake Champlain	Long Point Beach	460	Ferrisburg	VT	15	44.2529082	-73.279601
Lake Champlain	LTM 02	2	Benson	VT	4	43.7140089	-73.383001
Lake Champlain	LTM 04	4	Bridport	VT	4	43.951009	-73.407001
Lake Champlain	LTM 07	7	Panton	VT	5	44.1258652	-73.412835
Lake Champlain	LTM 09	9	Ferrisburg	VT	4	44.2421756	-73.329168
Lake Champlain	LTM 16	16	Shelburne	VT	5	44.425009	-73.232001
Lake Champlain	LTM 19	19	South Burlington	VT	4	44.471009	-73.299001
Lake Champlain	LTM 21	21	Burlington	VT	5	44.4748423	-73.231668
Lake Champlain	LTM 25	25	Colchester	VT	4	44.582009	-73.281168
Lake Champlain	LTM 33	33	Plattsburgh	VT	4	44.7011757	-73.418168
Lake Champlain	LTM 34	34	Milton	VT	6	44.7081757	-73.226835
Lake Champlain	LTM 36	36	Grand Isle	VT	4	44.7561757	-73.355001
Lake Champlain	LTM 40	40	St. Albans Town	VT	6	44.7853424	-73.162168
Lake Champlain	LTM 46	46	Alburgh	VT	6	44.948438	-73.339797
Lake Champlain	LTM 50	50	Swanton	VT	6	45.0133424	-73.173835
Lake Champlain	LTM 51	51	Saint-Armand	QC	6	45.0416758	-73.129668
Lake Champlain	Malletts Bay Boat Launch	120	Colchester	VT	11	44.5526695	-73.231279
Lake Champlain	Maquam Beach	139	Swanton	VT	4	44.9208171	-73.16136
Lake Champlain	Maquam Shore (Swanton, VT)	386	Swanton	VT	19	44.9026246	-73.166495
Lake Champlain	Melville Landing	176	St. Albans	VT	2	44.7618481	-73.167226
Lake Champlain	Monitor Bay Boat Launch	513	Crown Point	NY	4	43.947836	-73.413212
Lake Champlain	Mud Flats-Addison	456	Addison	VT	13	44.0313377	-73.408054
Lake Champlain	Niquette Bay State Park	67	Colchester	VT	15	44.5800469	-73.190336
Lake Champlain	Niquette Bay State Park - Cove Beach	416	Colchester	VT	15	44.5803952	-73.196106
Lake Champlain	North Bay Valcour Island	544	Valcour Island	NY	13	44.6235586	-73.428583

Lake Champlain	North Beach	22	Burlington	VT	24	44.4890515	-73.239705
Lake Champlain	North Harbor	147	Ferrisburgh	VT	6	44.1993697	-73.358874
Lake Champlain	North Shore Beach	391	Burlington	VT	10	44.520766	-73.269585
Lake Champlain	Oakledge Park Blanchard Beach	42	Burlington	VT	11	44.4574548	-73.225523
Lake Champlain	Oakledge Park rocky shoreline	44	Burlington	VT	11	44.4567031	-73.228048
Lake Champlain	Oakledge Park South Cove	43	Burlington	VT	12	44.4549479	-73.230078
Lake Champlain	Oliver Bay	45	Plattsburgh	NY	7	44.7391821	-73.405425
Lake Champlain	Pelots Point West	130	North Hero	VT	11	44.8261143	-73.310219
Lake Champlain	Perkins Pier	392	Burlington	VT	11	44.4727559	-73.220793
Lake Champlain	Peru Boat Launch	159	Peru, NY	NY	16	44.6186923	-73.442345
Lake Champlain	Phillipsburg, QC	58	Philipsburg, QC	QC	4	45.0388948	-73.078536
Lake Champlain	Point of the Tongue	494	Alburgh	VT	14	44.855138	-73.293217
Lake Champlain	Port Henry Boat Launch	153	Port Henry	NY	20	44.0516146	-73.453128
Lake Champlain	Port Kent Beach 2	394	Chesterfield	NY	20	44.5271334	-73.404524
Lake Champlain	Pt. Au Roche Boat Launch	109	Beekmantown	NY	1	44.790808	-73.363184
Lake Champlain	Ransoms Bay - Blue Rock	508	Alburgh	VT	2	44.9579761	-73.247855
Lake Champlain	Red Rocks Beach	27	South Burlington	VT	25	44.4419658	-73.22407
Lake Champlain	Rock Point - Eagle Bay	509	Burlington	VT	11	44.4955822	-73.246372
Lake Champlain	Rock River - Highgate	178	Highgate	VT	16	44.9883591	-73.087855
Lake Champlain	Rubenstein Lab,waterfront, Burlington VT	82	Burlington	VT	3	44.4762654	-73.222668
Lake Champlain	Saint Anne's Shrine	556	Isle La Motte	VT	17	44.8990727	-73.349162
Lake Champlain	Sand Bar State Park	57	Milton	VT	11	44.6280792	-73.243236
Lake Champlain	Sandbar Wildlife Mgmt. Area	503	Colchester	VT	14	44.6253018	-73.240147
Lake Champlain	Shelburne Beach	48	Shelburne	VT	11	44.361032	-73.266468
Lake Champlain	Shelburne Farms - Inn Beach	499	Shelburne	VT	2	44.4002748	-73.272362
Lake Champlain	Shipyard, Highgate Springs	30	Highgate	VT	18	44.9800294	-73.106936
Lake Champlain	Sloop Cove Valcour Island	543	Valcour Island	NY	12	44.622147	-73.409191
Lake Champlain	South Alburgh - Squires Bay	182	Alburgh	VT	11	44.9034187	-73.271717
Lake Champlain	South Beach Road	467	South Burlington	VT	18	44.4242792	-73.217548
Lake Champlain	South Hero Fish and Wildlife Boat Access	110	South Hero	VT	1	44.6368291	-73.265466
Lake Champlain	Spoon Bay Valcour Island	542	Valcour Island	NY	12	44.6286484	-73.408855
Lake Champlain	St. Albans Bay Park	31	St. Albans Town	VT	17	44.8086085	-73.144401
Lake Champlain	Starr Farm Beach	108	Burlington	VT	12	44.5138381	-73.271337
Lake Champlain	Stoney Point, Isle la Motte	128	Isle la Motte	VT	19	44.8714915	-73.359441
Lake Champlain	Swanton Boat Launch	536	Swanton	VT	1	44.970554	-73.211054
Lake Champlain	Teddy Bear Point Cove, Willsboro NY	63	Willsboro	NY	17	44.4424323	-73.37345
Lake Champlain	The Gut	49	Grand Isle	VT	13	44.7513821	-73.290264
Lake Champlain	Ticonderoga Boat Launch	188	Ticonderoga	NY	3	43.853615	-73.384939
Lake Champlain	Town Farm Bay	119	Charlotte	VT	10	44.2684993	-73.29437

Lake Champlain	Triangle Beach	466	Burlington	VT	9	44.4602304	-73.219406
Lake Champlain	US Coast Guard Boat Access Ramp	417	Burlington	VT	21	44.4800217	-73.223064
Lake Champlain	Van Everest Boat Launch Milton	175	Milton	VT	1	44.7049182	-73.210921
Lake Champlain	Vantines Boat Launch	115	Grand Isle	VT	4	44.7198187	-73.341612
Lake Champlain	West Shore Rd. North Hero 2	492	North Hero	VT	10	44.7937728	-73.31273
Lake Champlain	Westport Boat Launch	59	Westport	NY	12	44.1887633	-73.433336
Lake Champlain	Westport Public Beach	517	Westport	NY	12	44.1826054	-73.431287
Lake Champlain	Whallons Bay	122	Essex	NY	15	44.4225636	-73.745628
Lake Champlain	Whiskey Bay	426	Charlotte	VT	13	44.2703537	-73.301711
Lake Champlain	Whitney Creek	567	Addison	VT	13	44.02714	-73.39911
Lake Champlain	Willsboro Boat Launch	68	Willsboro	NY	4	44.3999111	-73.390693
Lake Champlain	Windmill Point South Beach	519	Alburgh	VT	16	44.9848349	-73.323477
Lake Dunmore	Branbury State Park - Day Beach	436	Brandon	VT	7	43.908293	-73.068747
Lake Dunmore	Lake Dunmore	314	Salisbury	VT	3	43.908479	-73.071665
Lake Dunmore	Mountainview Common Beach	553	Leicester	VT	3	43.880793	-73.073782
Lake Fairlee	Outlet, Lake Fairlee	481	Fairlee	VT	4	43.8836785	-72.243307
Lake Fairlee	Treasure Island Beach	520	Fairlee	VT	13	43.8979892	-72.216528
Lake Fairlee	VT F&W Access, Lake Fairlee	482	Fairlee	VT	13	43.8903725	-72.2269
Lake Hortonia	Lake Hortonia	333	Sudbury	VT	10	43.7527881	-73.210381
Lake Iroquois	Lake Iroquois	203	Williston	VT	13	44.3779997	-73.085157
Lake Iroquois	Lake Iroquois Southwest	169	Hinesburg	VT	19	44.3633141	-73.085933
Lake Memphremagog	Derby Bay	211	Derby	VT	6	44.9951922	-72.189088
Lake Memphremagog	Holbrook Bay	212	Newport Town	VT	6	44.9634322	-72.238167
Lake Memphremagog	Newport City Dock	342	Newport	VT	3	44.9368134	-72.212265
Lake Memphremagog	Newport Marina	478	Newport	VT	20	44.9378664	-72.217744
Lake Memphremagog	Prouty Beach	204	Newport	VT	10	44.9466801	-72.208826
Lake Memphremagog	Sunset Acres, Derby Bay	423	Derby	VT	8	44.9840555	-72.186309
Lake Memphremagog	VT DEC Station 3, Memphremagog	479	Newport	VT	6	44.9665629	-72.225541
Lake Memphremagog	VT DEC Station 4, Memphremagog	480	Newport	VT	12	44.9817568	-72.216781
Lake Memphremagog	Whipple Point F&W Access, Lake Memphremagog	484	Newport Town	VT	7	44.9540347	-72.233553
Lake Runnemede (Evarts Pond)	Lake Runnemede (Evarts Pond)	354	Windsor	VT	5	43.481834	-72.392536
Lake St. Catherine	Lake St. Catherine State Park - Camper Beach	440	Poultney	VT	6	43.4789179	-73.209323
Lake St. Catherine	Lake St. Catherine State Park - Day Beach	439	Poultney	VT	5	43.4825536	-73.210416
Martins Pond	Martins Pond Boat Lauch	551	Peacham	VT	6	44.3057495	-72.202285
Miles Pond	Miles Pond Public Beach	548	Concord	VT	13	44.4466816	-71.798343
Mill Pond	Kayak Access, Mill Pond VT	452	Windsor	VT	4	43.4780758	-72.39519
Molly's Falls Pond	Molly's Falls Pond Boat Launch	506	Marshfield	VT	10	44.3579876	-72.28705

Nichols Pond	Nichols Pond	347	Woodbury	VT	2	44.462204	-72.344288
Nichols Pond	Nichols Pond Dam Access	549	Woodbury	VT	6	44.4623095	-72.344134
Shadow Lake	Shadow Lake	358	Glover	VT	5	44.6754597	-72.224946
Spring Lake	Spring Lake Outing Club	546	Shrewsbury	VT	11	43.4922497	-72.92208
Sunset Lake	Sunset Lake Spillway	560	Benson	VT	6	43.7611246	-73.264661
Ticklenaked Pond	Ticklenaked Pond	368	Ryegate	VT	4	44.1878397	-72.098835
Ticklenaked Pond	Ticklenaked Pond - Boat Access	422	Ryegate	VT	5	44.189241	-72.098072
Winona Lake	Winona Lake (Bristol Pond Fishing Access)	455	Bristol	VT	8	44.181373	-73.099807

Appendix B. Shoreline Quality Assurance and Supplemental Toxin Data

Date	Report Cat.	Site	Site name	Waterbody	Web Status	Cyanobacteria genera present	Cyano. cell density (cells/mL)	Anatoxin (µg/L)	Microcystin (µg/L)
2022-09-05	1a	15	Kingsland Bay State Park	Lake Champlain	Generally Safe	none	0	<0.5	<0.16
2022-07-12	1a	15	Kingsland Bay State Park	Lake Champlain	Generally Safe	none	0	<0.5	<0.16
2022-08-01	1a	15	Kingsland Bay State Park	Lake Champlain	Generally Safe	none	0	<0.5	not tested
2022-07-18	1a	15	Kingsland Bay State Park	Lake Champlain	Generally Safe	Dolichospermum; Snowella	0	<0.5	<0.16
2022-08-29	1a	15	Kingsland Bay State Park	Lake Champlain	Generally Safe	Dolichospermum	3278	<0.5	<0.16
2022-09-19	1a	15	Kingsland Bay State Park	Lake Champlain	Generally Safe	none	0	<0.5	0.18
2022-08-22	1a	15	Kingsland Bay State Park	Lake Champlain	Generally Safe	Dolichospermum	0	<0.5	<0.16
2022-07-25	1a	15	Kingsland Bay State Park	Lake Champlain	Generally Safe	none	0	<0.5	<0.16
2022-09-12	2	15	Kingsland Bay State Park	Lake Champlain	Low Alert	Microcystis	1276	<0.5	<0.16
2022-08-08	1a	15	Kingsland Bay State Park	Lake Champlain	Generally Safe	none	0	<0.5	<0.16
2022-08-14	1a	15	Kingsland Bay State Park	Lake Champlain	Generally Safe	none	0	<0.5	<0.16
2022-09-12	1a	22	North Beach	Lake Champlain	Generally Safe	Dolichospermum; Aphanizomenon; Microcystis	6276	<0.5	0.24
2022-07-18	1a	22	North Beach	Lake Champlain	Generally Safe	Dolichospermum	0	<0.5	<0.16
2022-09-19	1a	22	North Beach	Lake Champlain	Generally Safe	Aphanizomenon	106	<0.5	0.25
2022-09-05	1a	22	North Beach	Lake Champlain	Generally Safe	Dolichospermum	0	<0.5	<0.16
2022-07-11	1a	22	North Beach	Lake Champlain	Generally Safe	none	0	<0.5	<0.16
2022-07-24	1b	22	North Beach	Lake Champlain	Generally Safe	Dolichospermum sp; Limnotrhix	0	<0.5	<0.16
2022-08-22	1a	22	North Beach	Lake Champlain	Generally Safe	Dolichospermum sp; Oscillatoria; Aphanizomenon; Cuspidothrix; Merismopedia	2041	<0.5	<0.16
2022-08-16	1a	22	North Beach	Lake Champlain	Generally Safe			<0.5	<0.16
2022-08-01		22	North Beach	Lake Champlain	Generally Safe			<0.5	<0.16
2022-08-08	1a	22	North Beach	Lake Champlain	Generally Safe	Aphanizomenon; Pseudanabaena	667	<0.5	<0.16
2022-08-29	1b	22	North Beach	Lake Champlain	Generally Safe	Aphanizomenon; Microcystis	1339	<0.5	<0.16
2022-09-26	1c	22	North Beach	Lake Champlain	Generally Safe			<0.5	<0.16
2022-08-23	1a	27	Red Rocks Beach	Lake Champlain	Generally Safe	Dolichospermum; Merismopedia	347	<0.5	<0.16
2022-09-13	1a	27	Red Rocks Beach	Lake Champlain	Generally Safe	Dolichospermum; Dolichospermum	944	<0.5	<0.16
2022-07-19	1b	27	Red Rocks Beach	Lake Champlain	Generally Safe	Dolichospermum; Merismopedia	3133	<0.5	<0.16
2022-07-26	1b	27	Red Rocks Beach	Lake Champlain	Generally Safe	Dolichospermum; Limnotrhix	0	<0.5	<0.16
2022-09-06	1a	27	Red Rocks Beach	Lake Champlain	Generally Safe	Aphanizomenon	53	<0.5	<0.16
2022-08-02	1a	27	Red Rocks Beach	Lake Champlain	Generally Safe			<0.5	<0.16
2022-07-12	1b	27	Red Rocks Beach	Lake Champlain	Generally Safe	Aphanizomenon; Merismopedia; Limnotrhix; Pseudanabaena	111	<0.5	<0.16
2022-09-20	1a	27	Red Rocks Beach	Lake Champlain	Generally Safe	Aphanocapsa (pico); Aphanizomenon	170	<0.5	0.22
2022-09-27	1b	27	Red Rocks Beach	Lake Champlain	Generally Safe	none	0	<0.5	0.21
2022-08-09	1a	27	Red Rocks Beach	Lake Champlain	Generally Safe	Pseudanabaena; Microcystis aeruginosa; Dolichospermum	4000	<0.5	<0.16

2022-08-29	1b	27	Red Rocks Beach	Lake Champlain	Generally Safe	Merismopedia	1276	<0.5	<0.16
2022-08-16	1a	27	Red Rocks Beach	Lake Champlain	Generally Safe	Woronichinia; Dolichospermum; Aphanizomenon; Coelospaerium	3537	<0.5	<0.16
2022-08-02	1a	30	Shipyard, Highgate Springs	Lake Champlain	Generally Safe			<0.5	<0.16
2022-09-13	1a	30	Shipyard, Highgate Springs	Lake Champlain	Generally Safe	Coelospaerium; Aphanizomenon; Merismopedia; Microcystis; Aphanocapsa (pico)	1990	<0.5	<0.16
2022-09-20	2	30	Shipyard, Highgate Springs	Lake Champlain	Low Alert	Microcystis aeruginosa; Pseudanabaena; Dolichospermum	3827	<0.5	0.36
2022-08-23	1b	30	Shipyard, Highgate Springs	Lake Champlain	Generally Safe	Microcystis aeruginosa; Aphanocapsa (pico); Merismopedia; Coelospaerium	11480	<0.5	<0.16
2022-09-27	1a	30	Shipyard, Highgate Springs	Lake Champlain	Generally Safe	none	0	<0.5	<0.16
2022-07-11	1a	30	Shipyard, Highgate Springs	Lake Champlain	Generally Safe	Microcystis(pico); Pseudanabaena; Limnotrhix; Aphanothece (pico)	0	<0.5	0.17
2022-08-08	1b	30	Shipyard, Highgate Springs	Lake Champlain	Generally Safe	Aphanizomenon; Microcystis (pico); Limnotrhix; Dolichospermum; Merismopedia	39122	<0.5	<0.16
2022-08-15	2	30	Shipyard, Highgate Springs	Lake Champlain	Low Alert	Merismopedia; Microcystis; Aphanocapsa (pico); Aphanizomenon; Pseudanabaena; Coelospaerium; Dolichospermum; Chroococcus	11671	<0.5	<0.16
2022-08-29	1d	30	Shipyard, Highgate Springs	Lake Champlain	Generally Safe	Aphanizomenon; Cuspidothrix; Dolichospermum	1599	<0.5	<0.16
2022-09-06	1d	30	Shipyard, Highgate Springs	Lake Champlain	Generally Safe	Dolichospermum	1020	<0.5	<0.16
2022-07-12	1c	31	St. Albans Bay Park	Lake Champlain	Generally Safe	Aphanizomenon; Microcystis; Limnotrhix; Merismopedia; Dolichospermum	2667	<0.5	<0.16
2022-09-13	3	31	St. Albans Bay Park	Lake Champlain	High Alert	Aphanizomenon; Dolichospermum; Cuspidothrix; Dolichospermum; Microcystis; Aphanocapsa (pico); Pseudanabaena; Microseira	94800	<0.5	<0.16
2022-07-19	1d	31	St. Albans Bay Park	Lake Champlain	Generally Safe	Microcystis; Aphanothece (pico); Dolichospermum; Snowella.	933	<0.5	<0.16
2022-09-20	1a	31	St. Albans Bay Park	Lake Champlain	Generally Safe	Dolichospermum; Microcystis; Coelospaerium; Cuspidothrix; Aphanizomenon	11276	<0.5	<0.16
2022-08-15	3	31	St. Albans Bay Park	Lake Champlain	High Alert	Dolichospermum; Pseudanabaena; Cuspidothrix; Microcystis; Aphanizomenon	525850	<0.5	<0.16
2022-07-26	1c	31	St. Albans Bay Park	Lake Champlain	Generally Safe	Aphanizomenon ; Aphanothece; Microcystis; Dolichospermum; Merismopedia; Snowella; Limnotrhix	27733	<0.5	<0.16
2022-08-09	3	31	St. Albans Bay Park	Lake Champlain	High Alert	Aphanizomenon; Dolichospermum; Microcystis; Radiocystis; Merismopedia	30244	<0.5	<0.16

2022-09-06	1c	31	St. Albans Bay Park	Lake Champlain	Generally Safe	Cuspidothrix; Dolichospermum; Aphanocapsa sp. (pico); Coelospaerium; Microcystis	13044	<0.5	<0.16
2022-08-30	1c	31	St. Albans Bay Park	Lake Champlain	Generally Safe	Dolichospermum; Aphanocapsa (pico); Aphanizomenon; Cuspidothrix; Microcystis	25769	<0.5	<0.16
2022-08-02	2	31	St. Albans Bay Park	Lake Champlain	Low Alert			<0.5	<0.16
2022-08-23	1c	31	St. Albans Bay Park	Lake Champlain	Generally Safe	Dolichospermum; Cuspidothrix; Pseudanabaena; Microcystis; Aphanocapsa (pico); Microcystis	12568	<0.5	<0.16
2022-09-21	2	40	LTM 40	Lake Champlain	Low Alert			<0.5	0.27
2022-07-21	1a	43	Oakledge Park South Cove	Lake Champlain	Generally Safe	Dolichospermum	0	<0.5	<0.16
2022-10-04	2	50	LTM 50	Lake Champlain	Low Alert			not tested	<0.16
2022-08-25	2	50	LTM 50	Lake Champlain	Low Alert	Microcystis; Dolichospermum; Aphanizomenon	1320	not collected	<0.16
2022-10-04	3	51	LTM 51	Lake Champlain	High Alert			not tested	0.28
2022-08-22	3	167	Lake Carmi, North Beach	Lake Carmi	High Alert			<0.5	9.4
2022-08-29	3	167	Lake Carmi, North Beach	Lake Carmi	High Alert	Dolichospermum; Microcystis; Pseudanabaena; Aphanocapsa sp. (pico); Woronichinia; Microseira; Dolichospermum; Aphanizomenon; Microcystis	345748	<0.5	2
2022-07-21	1a	184	Converse Bay	Lake Champlain	Generally Safe	Dolichospermum sp	3133	<0.5	<0.16
2022-08-22	1d	201	Lake Carmi State Park	Lake Carmi	Generally Safe	Dolichospermum; Cuspidothrix;Microcystis; Pseudanabaena; Aphanothece sp. (pico); Aphanocapsa sp. (pico); Plantothrix; Aphanizomenon; Microseira	15563	<0.5	0.26
2022-08-29	2	201	Lake Carmi State Park	Lake Carmi	Low Alert	Dolichospermum; Microcystis; Pseudanabaena; Microseira; Aphanocapsa (pico); Cuspidothrix; Aphanizomenon	245493	<0.5	0.62
2022-09-15	2	409	Carmi DEC01-Central Open Water	Lake Carmi	Low Alert			<0.5	<0.16
2022-08-29	3	409	Carmi DEC01-Central Open Water	Lake Carmi	High Alert			<0.5	0.2
2022-08-29	2)	410	Carmi DEC02-Southern Open Water	Lake Carmi	Low Alert			<0.5	<0.16
2022-09-15	2	410	Carmi DEC02-Southern Open Water	Lake Carmi	Low Alert			<0.5	<0.16
2022-09-15	2	411	Carmi DEC03-Northeastern Open Water	Lake Carmi	Low Alert			<0.5	<0.16
2022-08-29	3	411	Carmi DEC03-Northeastern Open Water	Lake Carmi	High Alert			<0.5	0.4
2022-07-20	3	411	Carmi DEC03-Northeastern Open Water	Lake Carmi	High Alert	Aphanizomenon; Dolichospermum; Limnotrhix; Microseira ; Gloeotrichia; Microcystis	2360	not collected	1.5

Appendix C. Open Water Protocol Data

Date	Site	Site Name	Waterbody	Report category	Web Status	Cyanobacteria taxa	Density (cells/mL)
2022-07-11	7	LTM 07	Lake Champlain	1a	Generally Safe	Aphanizomenon; Limnotrhix; Microcystis; Aphanothece; Pseudanabaena;	23
2022-07-22	7	LTM 07	Lake Champlain	1d	Generally Safe	Aphanizomenon; Dolichospermum;; Limnotrhix; Microcystis	135
2022-07-22	9	LTM 09	Lake Champlain	1d	Generally Safe	Aphanizomenon; Dolichospermum; Limnotrhix	173
2022-07-27	16	LTM 16	Lake Champlain	1d	Generally Safe	Aphanizomenon; Dolichospermum sp; Dolichospermum; Microcystis	107
2022-07-14	16	LTM 16	Lake Champlain	1a	Generally Safe	Aphanizomenon; Dolichospermum; Pseudanabaena; Limnotrhix	40
2022-07-14	19	LTM 19	Lake Champlain	1a	Generally Safe	Aphanizomenon; Dolichospermum; Pseudanabaena; Limnotrhix	196
2022-07-27	19	LTM 19	Lake Champlain	1d	Generally Safe	Aphanizomenon; Dolichospermum; Microcystis;	217
2022-07-14	21	LTM 21	Lake Champlain	1a	Generally Safe	Aphanizomenon; Dolichospermum;; Limnotrhix	14
2022-07-27	21	LTM 21	Lake Champlain	1d	Generally Safe	Aphanizomenon; Dolichospermum; Microcystis	217
2022-07-21	25	LTM 25	Lake Champlain	1a	Generally Safe	Aphanizomenon; Dolichospermum; Microcystis; Woronichinia	78
2022-08-08	25	LTM 25	Lake Champlain	1a	Generally Safe	Aphanizomenon; Dolichospermum; Microseira; Microcystis; Woronichinia;	136
2022-07-26	33	LTM 33	Lake Champlain	1a	Generally Safe	Aphanizomenon; Dolichospermum; Limnotrhix; Microcystis;	21
2022-07-13	33	LTM 33	Lake Champlain	1a	Generally Safe	Aphanizomenon; DolichospermumLimnotrhix; Merismopedia	125
2022-08-10	33	LTM 33	Lake Champlain	1a	Generally Safe	Aphanizomenon; Dolichospermum; Limnotrhix; Woronichinia; Microcystis; Merismopedia; Dolichospermum	17
2022-07-18	34	LTM 34	Lake Champlain	1a	Generally Safe	Aphanizomenon; Limnotrhix; Snowella; Dolichospermum	38
2022-08-15	34	LTM 34	Lake Champlain	1d	Generally Safe	Dolichospermum; Microcystis	72
2022-09-01	34	LTM 34	Lake Champlain	1a	Generally Safe	Aphanizomenon; Coelospaerium; Cuspidothrix; Dolichospermum; Microcystis	106
2022-08-10	36	LTM 36	Lake Champlain	1a	Generally Safe	Aphanizomenon; Aphanothece; Dolichospermum; Microcystis Microcystis	218
2022-07-26	36	LTM 36	Lake Champlain	1d	Generally Safe	Aphanizomenon; Dolichospermum; Microcystis; Spirulina	158
2022-07-19	40	LTM 40	Lake Champlain	1d	Generally Safe	Dolichospermum; Limnotrhix; Microcystis; Snowella; Aphanothece; Gloeotrichia	233
2022-08-15	40	LTM 40	Lake Champlain	2	Low Alert	Microcystis; Dolichospermum; Aphanizomenon; Aphanocapsa	667
2022-07-19	46	LTM 46	Lake Champlain	1d	Generally Safe	Dolichospermum; Microcystis; Aphanothece; Limnotrhix	75
2022-08-10	46	LTM 46	Lake Champlain	1d	Generally Safe	Aphanizomenon; Dolichospermum; Microcystis; Limnotrhix	103
2022-08-05	50	LTM 50	Lake Champlain	1d	Generally Safe	Microcystis; Merismopedia; Dolichospermum; Woronichinia	162
2022-08-25	50	LTM 50	Lake Champlain	2	Low Alert	Microcystis; Dolichospermum Aphanizomenon; Microcystis weisenbergii	1320
2022-07-19	50	LTM 50	Lake Champlain	1d	Generally Safe	Aphanizomenon; Merismopedia; Limnotrhix; Snowella; Aphanothece; Plantothrix; Pseudanabaena; Microcystis	95
2022-07-19	51	LTM 51	Lake Champlain	1d	Generally Safe	Aphanizomenon; Microcystis; Aphanothece; Snowella; Merismopedia; Pseudanabaena; Plantothrix	289
2022-08-05	51	LTM 51	Lake Champlain	1d	Generally Safe	Dolichospermum; Microcystis; Merismopedia; Pseudanabaena	397
2022-08-04	368	Ticklenaked Pond	Ticklenaked Pond	1d	Generally Safe	Aphanizomenon; Dolichospermum; Microcystis; Woronichinia; Aphanothece	1228
2022-10-13	368	Ticklenaked Pond	Ticklenaked Pond	1a	Generally Safe	Dolichospermum; Woronichinia; Microcystis; Aphanocapsa	273
2022-07-20	409	Carmi DEC01-Central Open Water	Lake Carmi	2	Low Alert	Aphanizomenon; Dolichospermum; Microcystis; Gloeotrichia; Plantothrix; Aphanothece; Pseudanabaena; Oscillatoria; Merismopedia; Limnotrhix	1579
2022-06-24	409	Carmi DEC01-Central Open Water	Lake Carmi	1d	Generally Safe	Microcystis; Woronichinia; Dolichospermum; Plantothrix; Pseudanabaena; Snowella; Gloeotrichia; Aphanothece	1025

2022-07-20	411	Carmi DEC03-Northeastern Open Water	Lake Carmi	3	High Alert	Aphanizomenon; Dolichospermum; Limnotrhix; Lyngbya; Gloeotrichia; Microcystis	2360
2022-08-09	480	VT DEC Station 4, Memphremagog	Lake Memphremagog	1a	Generally Safe	Aphanizomenon; Microcystis; Microseira; Woronichinia; Dolichospermum; Aphanothece; Coelospaerium; Limnotrhix	719
2022-07-28	480	VT DEC Station 4, Memphremagog	Lake Memphremagog	1d	Generally Safe	Aphanothece; Dolichospermum; Microseira; Microcystis; Woronichinia; Aphanothece; Coelospaerium; Merismopedia	495

Appendix D. Visual Assessment Protocols – Lake Champlain Committee

https://www.lakechamplaincommittee.org/get-involved/volunteers/cyanobacteriamonitors/algaebloomintensity/

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Category 3 cyanobacteria bloom in Clarenceville, Quebec. Photo by Nathalie Fortin.

Categorization of Water Conditions

General Instructions

Remember to avoid direct contact with Category 2 and 3 conditions.

All observations that are submitted and approved will be posted on the Vermont Department of Health Cyanobacteria Tracker.

Please make observations at the same location once per week. Routine observations should be made no earlier than 10:00 AM and preferably by 3:00 PM. Blooms most frequently appear during this timeframe because cyanobacteria have had a chance to rise from lower in the water column in response to light and heat. Reports of good conditions outside of this timeframe may be rejected.

Anyone providing reports should include the following information:

Water Temperature (°F)

Water Surface

1. Calm
2. Rolling
3. White Caps

Bloom Intensity

The rating scale runs from 1 (a, b, c, or d) to 3, with 1a being no cyanobacteria observed—clear water and 3 being a cyanobacteria bloom observed in progress.

- Category 1a
- Category 1b
- Category 1c
- Category 1d
- Category 2

- Category 3

Approximately how far along the shore the bloom extends (in feet).

Approximately how far out into the water the bloom extends (in feet).

Photographs

- For category 1d, 2, and 3 conditions, three digital photographs should be submitted via the online form:

1. Jar
2. Close
3. Broad

Category 1a: No cyanobacteria observed—clear water

There is high visibility through the water column. Objects lower in the water column—sand, rocks, or plants—are clearly visible. The overall appearance of the water is clear.

What you may observe:

Foam
Shed insect skins
Sporadic plants, like duckweed or American eelgrass

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3. Broad

Category 1a: No cyanobacteria observed—clear water

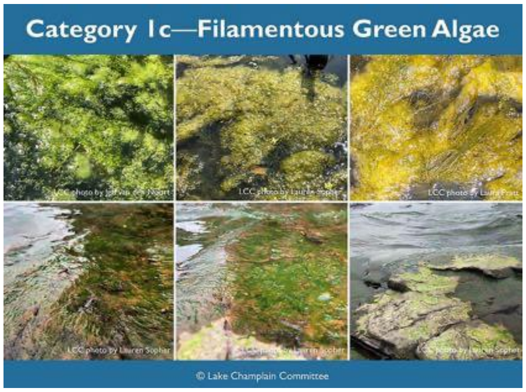
There is high visibility through the water column. Objects lower in the water column—sand, rocks, or plants—are clearly visible. The overall appearance of the water is clear.

What you may observe:

Foam
Shed insect skins
Sporadic plants, like duckweed or American eelgrass

Color: green or brown

Where: the water surface or bottom of lakes, ponds, rivers, and streams; attached to rocks above and below the water



Not sure if you're seeing potentially toxic cyanobacteria or non-toxic filamentous green algae? A stick test is a good way to differentiate cyanobacteria from plant matter. If you can pick it up with a stick or paddle, or see plant leaves, it's generally not cyanobacteria.

Keep in mind that the stick test is not 100% reliable because some types of cyanobacteria, like *Scytonema* sp., can be picked up with a stick.

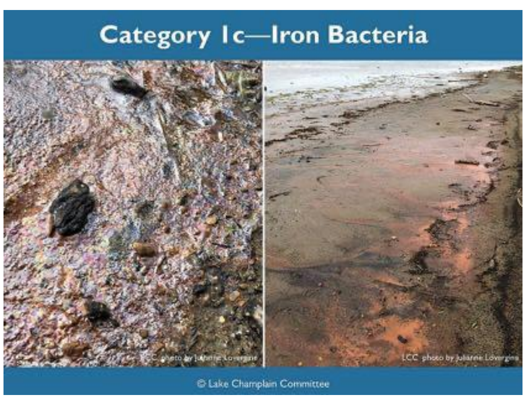
Iron Bacteria

What: organisms that obtain energy by oxidizing dissolved iron

Looks Like: red, orange, or brown slime and oily sheens

Color: red, orange, and brown

Where: locations that have iron in the soil and are frequently wet



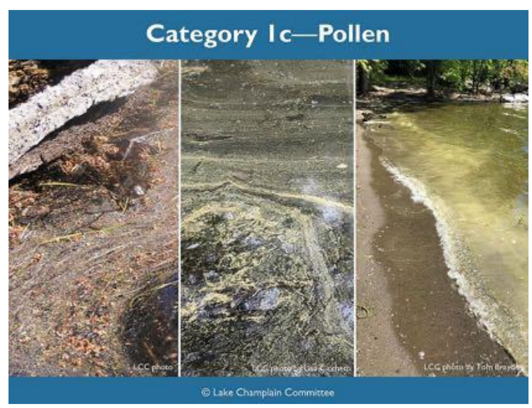
Pollen

What: a fine, powdery fertilizing element of flowering plants

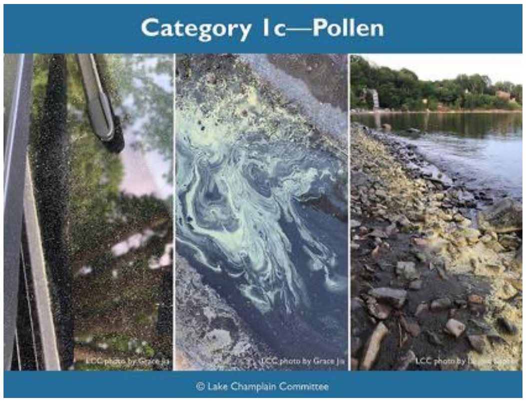
Looks Like: a thin film of sawdust on the water

Color: mustard yellow

Where: the surface of any body of water, especially at shorelines; accumulating on hard surfaces like vehicle windshields, sidewalks, and parking lots



Cyanobacteria are generally restricted to the water, whereas pollen can show up not only on the waterbody, but also in the vicinity. Reference the image below to see pollen on the windshield of a parked car (left), in a parking lot (middle), and along a shoreline (right).

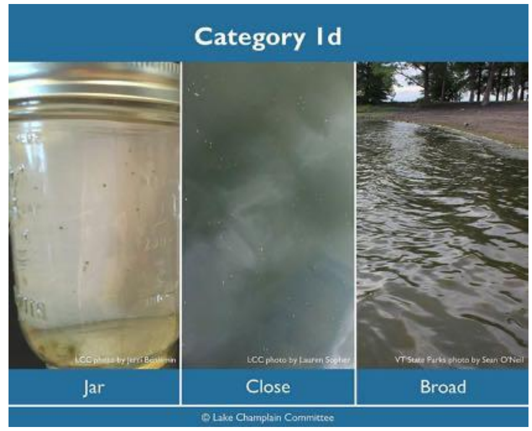


Category 1d: Little cyanobacteria observed—recreation not impaired—tiny specks present, but no streaks or patches—include photos

When cyanobacteria start to be visible in water, they often appear as tiny specks or fuzzy balls; cyanobacteria can occur in densities so low that they do not impair recreational enjoyment of the water.

What you may observe:

- Water can appear clear, but green **tiny specks** or fuzzy balls may be visible upon close inspection
- No surface or shoreline accumulations of cyanobacteria

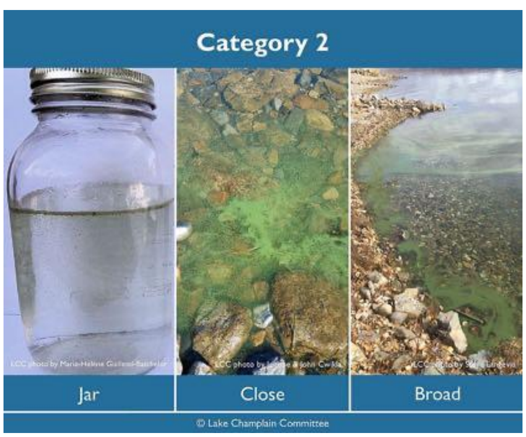


Category 2: Cyanobacteria present, but at less than bloom levels—include photos

Some cyanobacteria accumulation in the water column or on the surface, but not a continuous layer.

What you may observe:

- Open water **does not** appear green, blue, or blue-green
- **Streaks** of cyanobacteria on the water surface, but not a continuous layer
- **Small patches** of cyanobacteria on the water surface, but not a continuous layer
- A **narrow** band of cyanobacteria accumulation at the shoreline

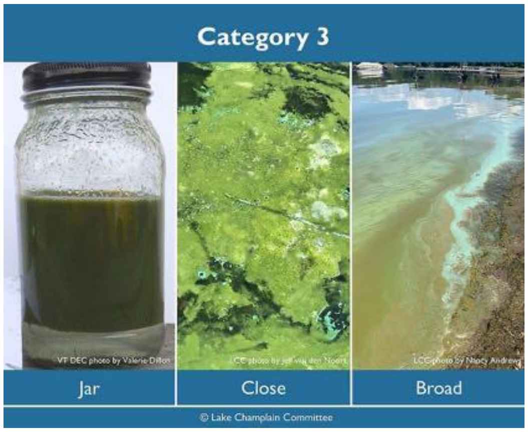


Category 3: Cyanobacteria bloom in progress—include photos

Extensive cyanobacteria accumulation in the water column or on the surface, forming a continuous layer.

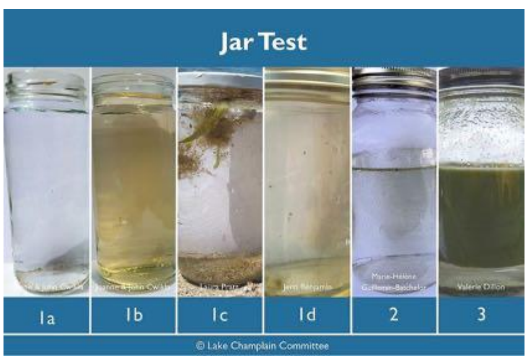
What you may observe:

- Open water **does** appear green, blue, or blue-green
- Continuous layer of **surface scum** on the water
- A **wide** band of cyanobacteria accumulation at the shoreline that extends at least 10-15 feet offshore



Jar Test of Each Category

The jar test line-up compares and contrasts the six bloom intensity categories: 1a, 1b, 1c, 1d, 2, and 3. View instructions for taking water samples here.



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Appendix E. Historical Microcystin Data for Lake Champlain

Note: Toxins before 2013 were sometimes measured on concentrated net samples, which can result in higher toxin concentrations than un-concentrated whole water samples (so direct comparisons of these data with more recent data should be avoided).

Lake Segment		2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Inland Sea	median	0.05	0.41	0.08	0.27	0.05	1.10	0.07	0.03	0.08		<0.16
	range	0.05 - 0.18	0.08-17.56	0.01-0.19	0.04-42.14	0.04-0.07	0.03-22.50	0.06-0.08	0.03-0.13	0.01-0.82		<0.16 - 0.43
	#samples	6	8	8	16	4	11	2	3	9	0	45
	#stations	1	3	3	7	3	4	2	2	4		4
Main Lake Central	median	0.05		7.42		2.82	0.25	0.03	0.10	0.02	0.13	<0.16
	range	0.01-0.12		6.04-8.80		0.02-5.61	0.03-0.47	0.03-23.36	0.02-0.14	0.01-0.03	0.13-0.64	<0.16 -0.17
	#samples	19	0	2	0	2	2	6	8	4	3	23
	#stations	4		1		2	2	3	5	4	1	2
Main Lake North	median											
	range						1.56	0.03		0.01		
	#samples	0	0	0	0	0	1	1	0	1	0	0
	#stations						1	1		1		
Main Lake South	median			0.04						0.01		<0.16
	range	0.07		ND - 0.07	3.47					0.01		<0.16 - 0.16
	#samples	1	0	2	1	0	0	0	0	2	0	22
	#stations	1		1	1					2		2
St. Albans Bay	median	0.05	0.05	0.30	0.06	0.05	0.04	0.02	0.05	0.04	0.03	0.032
	range	0.01-0.41	ND - 22.48	0.06-0.82	0.01-0.43	0.02-0.54	0.02-0.12	0.01-0.17	0.01-0.80	0.02-0.14	0.03-0.04	0.002-0.062
	#samples	32	29	18	36	20	10	4	10	12	5	2
	#stations	1	2	1	2	4	3	2	3	2	1	2
Malletts Bay	median				0.04							
	range				0.04-0.08					0.04		
	#samples	0	0	0	7	0	0	0	0	1	0	0
	#stations				2					1		
South Lake	median	0.96										
	range	0.53-1.38		0.01						0.02		
	#samples	2	0	1	0	0	0	0	0	1	0	0
	#stations	2		1						1		
Missisquoi Bay	median	0.09	0.84	0.66	0.52		2.56	0.54	0.03	0.65	0.99	<0.16
	range	ND - 23.91	0.01-6490.06	ND - 22.11	0.01-21.29		0.06-94.58	0.03-54.16	0.01-0.12	0.02-180.2	0.26-54.76	<0.16 - 1.3
	#samples	341	228	146	152	0	81	29	10	59	36	30
	#stations	14	11	10	12		10	8	7	8	3	6