Cyanobacteria Monitoring on Lake Champlain and Vermont Inland Lakes
2021 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.

In 2021 the program resumed mostly normal operations, after disruption in the previous year due to the COVID-19 pandemic. Cyanobacteria monitoring on Lake Champlain in 2021 continued to integrate qualitative observations and photographic documentation into guidance for lake users at a similar rate to previous years. Quantitative microscopic analyses of cyanobacteria as well as measurement of cyanotoxin concentrations were resumed at a similar rate to pre-pandemic years, 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 3074 site-specific reports during 2021, with 2265 from Lake Champlain, and 809 from other lakes in Vermont. Alert level conditions were reported 417 times on Lake Champlain during the monitoring period in 2021 (18% of reports). Microcystin was detected at 1 location in Lake Carmi and 3 locations in Lake Champlain in 2021, and at the drinking water intake in Alburgh East Village, but was never above recreational alert thresholds. 2021 was notable for relatively high numbers of blooms reported in the Southern Main Lake basin and in Lake Memphremagog.

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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, anatoxin and/or cylindrospermopsin 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 around Lake Champlain and several smaller Vermont lakes through a separate grant to the Lake Champlain Committee (LCC). In 2021, LCBP provided funding for cyanotoxin testing at Vermont drinking water facilities on Lake Champlain.

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. In 2021, sampling at shoreline quality assurance stations was supported by the Centers for Disease Control and Prevention through the Safe Water for Community Health grant to VDH.

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.

2. Methods

The 2021 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 Protocol. 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 2021 season, routine reports were received from 219 monitored locations around Lake Champlain (147 sites) and from several Vermont inland lakes (72 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 2021. 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	# Visual Sites	# Quality Assurance Sites	# Open Water Sites
Adams Reservoir		2		
Berlin Pond		2		
Caspian Lake		1		
Colchester Pond		1		
Cole's Pond		1		
Crystal Lake		1		
Emerald Lake		1		
Halfmoon Lake		1		
Indian Brook Reservoir		1		
Island Pond		1		
Joes Pond		3		
Lake Bomoseen		1		
Lake Carmi		12	3	3
Lake Champlain	Champlain - Inland Sea	31		1
	Champlain - Main Lake Central	38	2	4
	Champlain - Main Lake North	12		2
	Champlain - Main Lake South	23	1	2
	Champlain - Malletts Bay	9		1
	Champlain - Missisquoi Bay	10	1	2
	Champlain - South Lake	7		2
	Champlain - St. Albans Bay	12	1	1
Lake Dunmore		2		
Lake Elmore		1		
Lake Fairlee		2		
Lake Groton		2		

Lake Iroquois		3		
Lake Memphremagog		12		1
Lake Pinneo		1		
Lake Runnemede		1		
Lake Shaftsbury		1		
Lake St. Catherine		2		
Maidstone Lake		1		
Mill Pond		1		
Molly's Falls Pond		1		
Ricker Pond		1		
Spectacle Pond		1		
Ticklenaked Pond		2		1
Waterbury Reservoir		7		
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. Not all volunteers were able to use the internet-based reporting system and instead submitted their reports by telephone or email.

The LCC trained nearly 300 volunteer monitors and interested community members in 21 formal training sessions during the 2021 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. LCC conducted three in-person field training sessions. .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. The webinar recording was posted on the VT DEC's cyanobacteria website as a resource for volunteers. 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. In total, reports were received from 39 inland VT lakes. Both LCC and VT DEC staff also interacted regularly with community science volunteer monitors.

Weekly Observation Process - Volunteers

Monitoring by volunteers began the week of June 22. 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 10am and 3pm, 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 2021, shoreline sampling was handled differently compared to previous years to make better use of field staff and diversify the locations of samples being collected. While the four weekly LCC volunteer sampling sites remained consistent, several sites previously sampled by VDH were redistributed to VT DEC staff and State Parks staff. Sampling locations were areas with high recreational usage or prone to blooms (Table 2). Several samples were compromised due to incomplete labeling.

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	14
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	12
31	St. Albans Bay Park (St. Albans Town, VT)	Lake Champlain (St. Albans Bay)	LCC Volunteer	9
180	Button Bay State Park (Ferrisburgh, VT)	Lake Champlain (Main Lake South)	VT DEC Staff	2
167	Lake Carmi, North Beach (Franklin, VT)	Lake Carmi	VT DEC Staff	5
484	Whipple Point F&W Access (Newport, VT)	Lake Memphremagog	VT DEC Staff	3
201	Lake Carmi State Park	Lake Carmi	VT State Parks	5

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

After disruption in 2020 due to the pandemic, in 2021 regular sampling for the Open Water Protocol by Vermont DEC staff resumed. 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 toxins (microcystin and anatoxin) 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

In 2021, the DWGWPD and the VDH received funding from the Lake Champlain Basin Program to support 12 weeks of voluntary cyanotoxin monitoring at Vermont public drinking water systems drawing from Lake Champlain. Weekly raw and finished water samples 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, 2021 and went through the week of September 27, 2021, though several systems do not operate after Labor DayResults 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, but were documented if they were at very high concentrations. 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, typically within 24 - 48 hours for open water stations. 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	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 Analysis

Toxin analyses were conducted by the Vermont Public Health Laboratory in Colchester, 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.

Whole water samples for anatoxin analysis were concentrated using solid phase extraction cartridges unless large amounts of biomass were present. In that event, aliquots were diluted prior to extraction. Samples were run by LC/MS/MS.

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.

Weekly email updates summarizing reports and toxin data were provided to a group of stakeholders by VT DEC staff. 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 2021 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 2021.

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 2021, 3074 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 31 inland lakes in Vermont by VT DEC staff and volunteers coordinated by LCC or VT DEC (Fig 2), with supplemental reports from an additional 8 lakes. 68 samples were assessed by microscopy for the Shoreline Quality Assurance Protocol, and an additional 136 samples were collected and counted following the Open Water Protocol.

Table 4. Summary of the 2021 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	# Reports
Adams Reservoir	VT State Parks	Routine - Weekly	8
Baker Pond	LCC Volunteer	Supplemental	1
Berlin Pond	LCC Volunteer	Routine - Biweekly	9
Caspian Lake	VT DEC Volunteer	Routine - Weekly	15
Champlain - Inland Sea	General Public	Supplemental	8
	LCC Staff	Supplemental	4
	LCC Volunteer	Routine - Biweekly	2
	LCC Volunteer	Routine - Weekly	313
	LCC Volunteer	Supplemental	46
	VT DEC	Routine - Biweekly	6
	VT DEC	Routine - Weekly	1
	VT State Parks	Routine - Weekly	51
	VT State Parks	Supplemental	20
Champlain - Main Lake Central	General Public	Supplemental	18
	LCC Staff	Routine - Weekly	43

	LCC Staff	Supplemental	108
	LCC Volunteer	Routine - Weekly	431
	LCC Volunteer	Supplemental	165
	VT DEC	Routine - Biweekly	25
	VT DEC	Supplemental	1
Champlain - Main Lake North	General Public	Supplemental	5
	LCC Volunteer	Routine - Weekly	148
	LCC Volunteer	Supplemental	21
	VT DEC	Routine - Biweekly	14
	VT DEC	Supplemental	2
Champlain - Main Lake South	General Public	Routine - Weekly	4
	General Public	Supplemental	15
	LCC Staff	Routine - Weekly	1
	LCC Staff	Supplemental	3
	LCC Volunteer	Routine - Weekly	222
	LCC Volunteer	Supplemental	57
	VT DEC	Routine - Biweekly	15
	VT DEC	Supplemental	1
	VT State Parks	Routine - Weekly	32
	VT State Parks	Supplemental	6
Champlain - Malletts Bay	LCC Volunteer	Routine - Weekly	64
	VT DEC	Routine - Biweekly	6
	VT State Parks	Routine - Weekly	28
	VT State Parks	Supplemental	5
Champlain - Missisquoi Bay	General Public	Supplemental	5
	LCC Volunteer	Routine - Biweekly	4
	LCC Volunteer	Routine - Weekly	44
	LCC Volunteer	Supplemental	20
	VT DEC	Routine - Biweekly	15
	VT DEC	Supplemental	1
Champlain - South Lake	General Public	Supplemental	3
	LCC Volunteer	Routine - Weekly	43
	VT DEC	Routine - Biweekly	14
Champlain - St. Albans Bay	General Public	Supplemental	1
	LCC Volunteer	Routine - Weekly	111
	LCC Volunteer	Supplemental	93
	VT DEC	Routine - Biweekly	7
	VT State Parks	Routine - Weekly	10
	VT State Parks	Supplemental	3

Chittenden Reservoir	General Public	Supplemental	1
Clyde Pond	MWA Volunteer	Supplemental	6
Colchester Pond	LCC Volunteer	Routine - Weekly	6
	LCC Volunteer	Supplemental	1
Coles Pond	VT DEC Volunteer	Routine - Weekly	15
Crystal Lake	VT State Parks	Routine - Weekly	7
Emerald Lake	VT State Parks	Routine - Weekly	14
Halfmoon Lake	VT State Parks	Routine - Weekly	13
Indian Brook Reservoir	General Public	Supplemental	2
	LCC Volunteer	Routine - Weekly	10
Island Pond	VT State Parks	Routine - Weekly	7
Joes Pond	LCC Staff	Supplemental	1
	VT DEC Volunteer	Routine - Weekly	41
	VT DEC Volunteer	Supplemental	1
Kent Pond	General Public	Supplemental	1
Lake Bomoseen	VT State Parks	Routine - Weekly	6
	VT State Parks	Supplemental	2
Lake Carmi	General Public	Supplemental	9
	LCC Volunteer	Routine - Weekly	36
	LCC Volunteer	Supplemental	1
	VT DEC	Routine - Biweekly	36
	VT DEC	Supplemental	1
	VT State Parks	Routine - Weekly	45
	VT State Parks	Supplemental	33
Lake Dunmore	LCC Volunteer	Routine - Weekly	12
	VT State Parks	Routine - Weekly	2
Lake Elmore	VT State Parks	Routine - Weekly	13
Lake Fairlee	VT DEC Volunteer	Routine - Weekly	25
	VT DEC Volunteer	Supplemental	1
Lake Groton	VT State Parks	Routine - Weekly	5
Lake Iroquois	General Public	Supplemental	1
	LCC Volunteer	Routine - Weekly	38
	LCC Volunteer	Supplemental	8
Lake Memphremagog	General Public	Supplemental	13
	MWA Volunteer	Routine - Weekly	54
	MWA Volunteer	Supplemental	74
	VT DEC	Routine - Biweekly	18
	VT DEC	Supplemental	1
	VT DEC Volunteer	Routine - Weekly	25

	VT DEC Volunteer	Supplemental	10
Lake Morey	General Public	Supplemental	3
Lake Pinneo	VT DEC Volunteer	Routine - Weekly	1
Lake Runnemede (Evarts Pond)	VT DEC Volunteer	Routine - Weekly	6
Lake Shaftsbury	VT State Parks	Routine - Weekly	1
Lake St. Catherine	VT State Parks	Routine - Weekly	33
Maidstone Lake	VT State Parks	Routine - Biweekly	1
Mill Pond	VT DEC Volunteer	Routine - Weekly	7
Missisquoi NWR - Cranberry Pool	LCC Volunteer	Supplemental	1
Molly's Falls Pond	VT State Parks	Routine - Weekly	5
	VT State Parks	Supplemental	2
Muckross Pond	General Public	Supplemental	1
Ricker Pond	VT State Parks	Routine - Weekly	11
Shelburne Pond	General Public	Supplemental	2
	LCC Volunteer	Supplemental	1
Spectacle Pond	VT State Parks	Routine - Weekly	7
Ticklenaked Pond	VT DEC	Routine - Biweekly	2
	VT DEC	Supplemental	1
	VT DEC Volunteer	Routine - Weekly	9
Waterbury Reservoir	VT State Parks	Routine - Weekly	70
Winona Lake	LCC Volunteer	Routine - Weekly	17

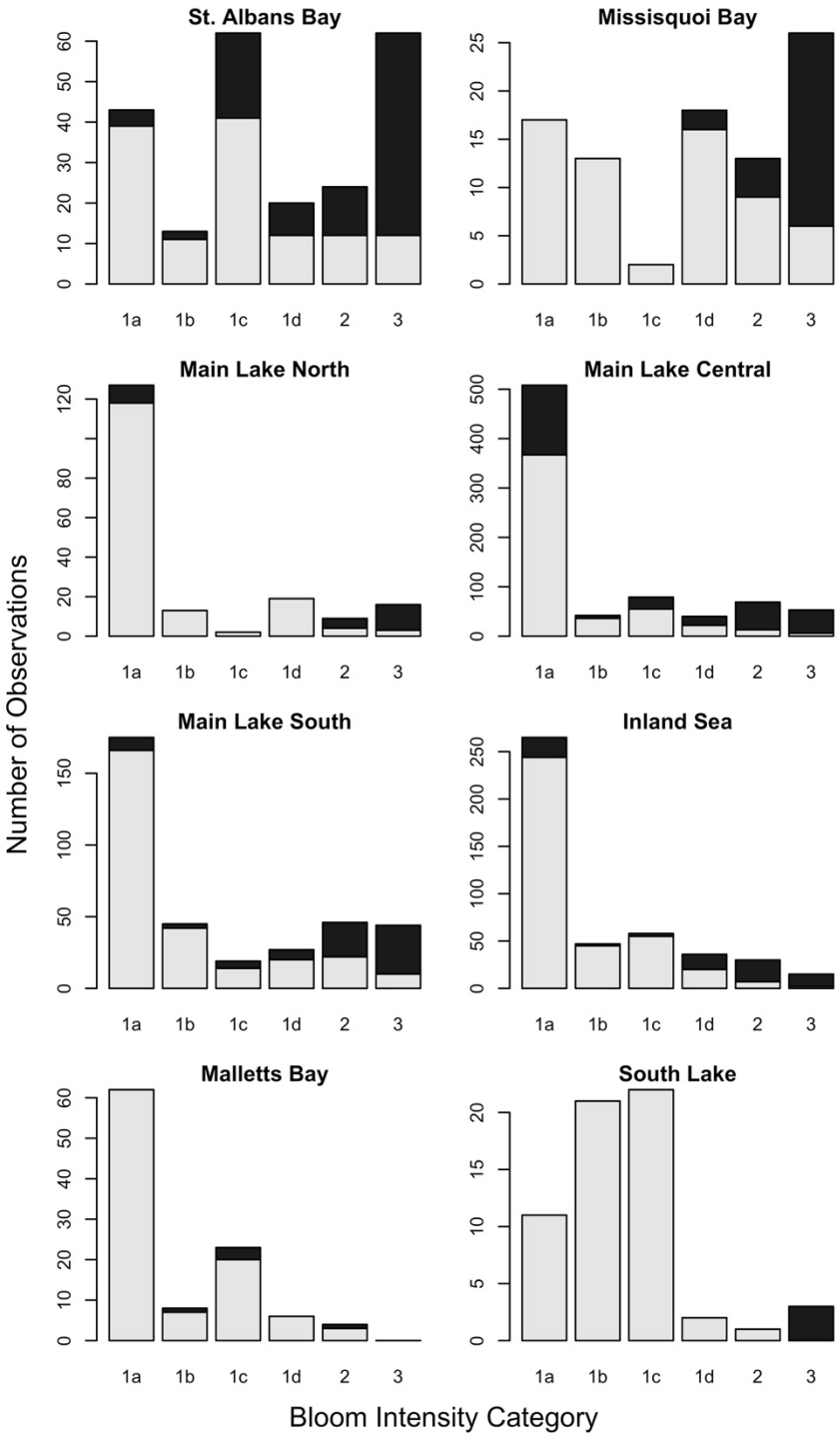

Figure 1. Summary of assessment reports received in 2021 in Lake Champlain. Data compiled from the season summary spreadsheet available through the VDH Tracking Map. Dark shading indicates supplemental reports. NOTE the difference in scale between basins. Category 1a = clear water, 1b = brown and turbid, 1c = other plant material, 1d = small amount of cyanobacteria. Category 2 = low alert. Category 3 = high alert.

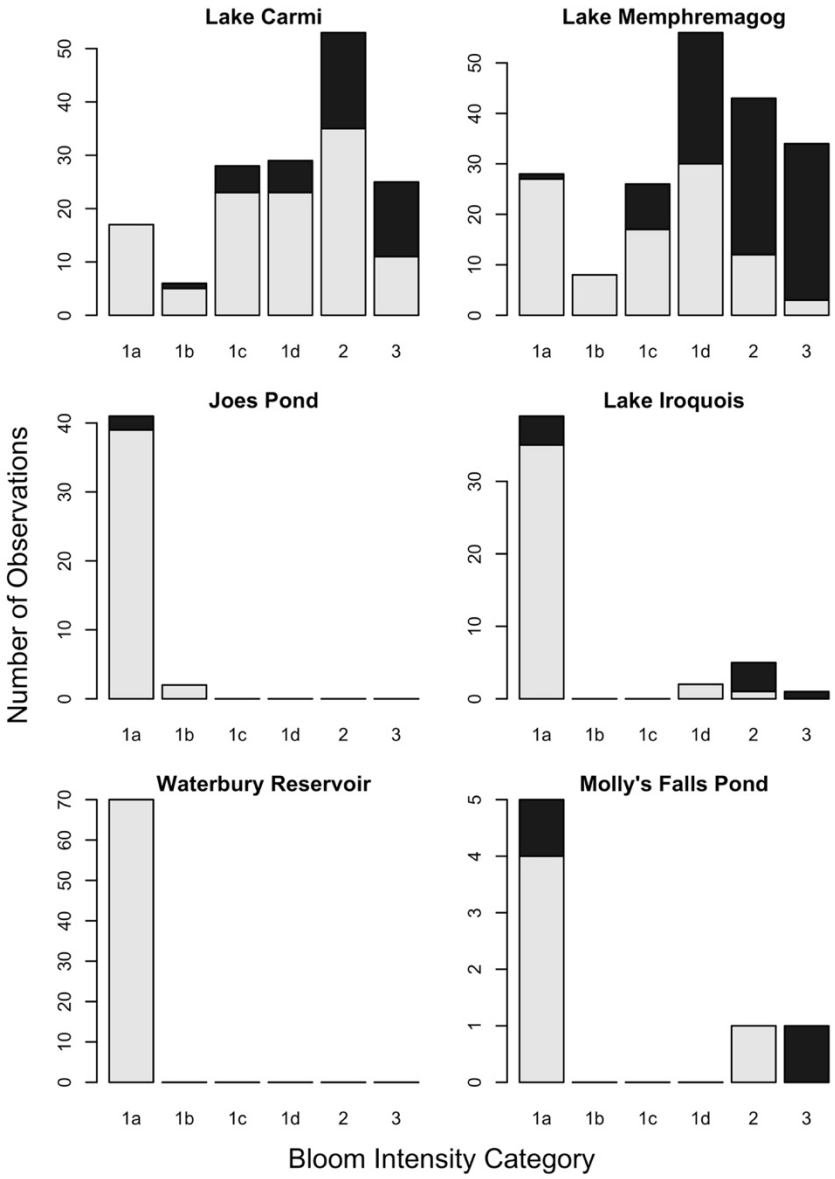

Figure 2. Summary of assessment reports received in 2021 from selected Vermont inland lakes. Data compiled from the season summary spreadsheet available through the VDH Tracking Map. Dark shading indicates supplemental reports. NOTE the difference in scale between lakes. Category 1a = clear water, 1b = brown and turbid, 1c = other plant material, 1d = small amount of cyanobacteria. Category 2 = low alert. Category 3 = high alert.

Toxin and Phytoplankton sampling effort

A total of 93 samples were analyzed for the presence of microcystin and 91 for anatoxin in 2021 (Table 5) from both routine sites and post-bloom sampling by beach managers. This number includes 67 samples from Lake Champlain, 13 from Lake Carmi, and 6 from Lake Memphremagog. Microcystin was detected at 4 locations over the summer of 2021. The highest observed concentration of microcystin was measured on 10/6 in the southern open water area of Lake Carmi (5.31 µg/L). The highest microcystin in Lake Champlain was 2.11 µg/L, measured in open water at long-term monitoring site 36

off of Grand Isle. Anatoxin was detected in 5 samples in 2021, with the highest concentration of 3.1µg/L observed on 9/14 in Missisquoi Bay at Highgate Springs.

Taxonomic analyses were resumed after being severely restricted during 2020 due to complications arising from the COVID 19 pandemic. Potentially toxic cyanobacteria were observed in Lake Champlain, Lake Carmi, Lake Memphremagog, and Ticklenaked pond (Table 6). Cyanobacteria populations sometimes 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	136			
Quality Assurance Protocol		68	92	90
Visual/Supplemental		5	3	3
Total	**136**	**73**	**95**	**93**

3.2 Summary of Cyanobacteria Conditions in 2021

Summaries of the assessment results from regularly monitored sites in 2021 is presented in Figure 3, 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 (81%) received from Lake Champlain and Vermont inland lakes indicated that few or no cyanobacteria were present (category 1 of the visual protocol). In all, 588 reports of alert conditions (categories 2 and 3) were received during the summer of 2021, 19% of the total reports received.

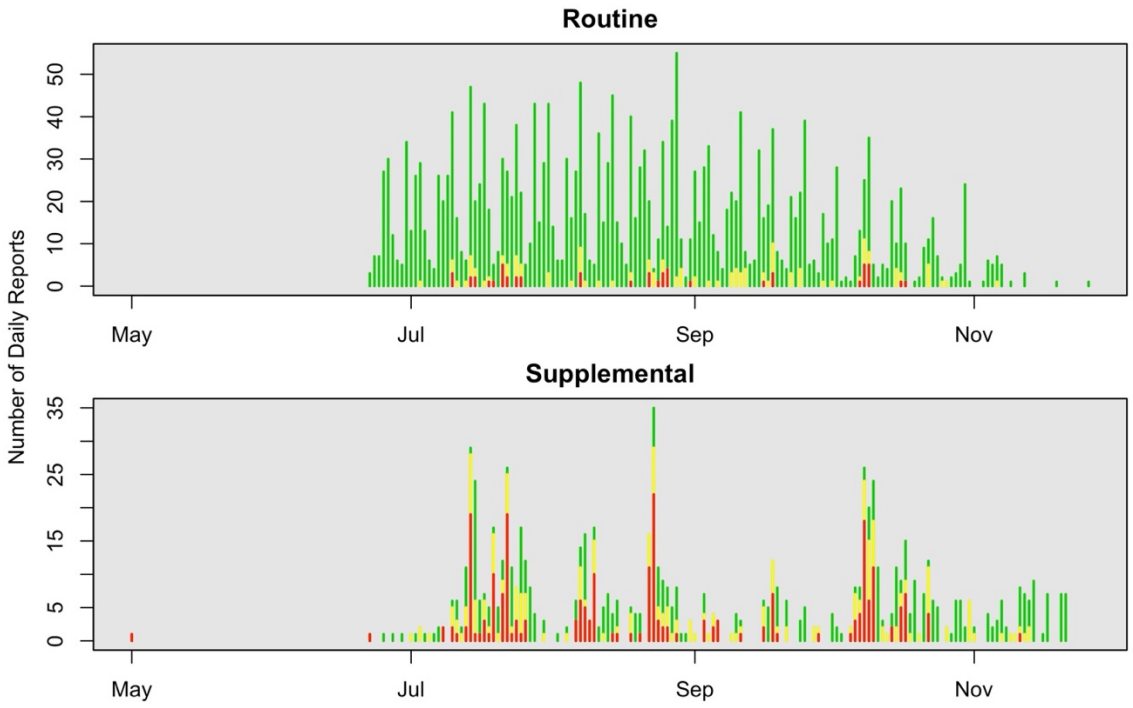

Figure 3. Number of visual assessment reports received on each day of the monitoring period in 2021 in Lake Champlain and Vermont inland lakes. Top panel shows routine reports, bottom panel shows supplemental reports. Green = "Generally Safe", yellow = "Low Alert", red = "High Alert"

Table 6. Highest status reached in each waterbody in 2021. Data compiled from the season summary spreadsheet available through the VDH Tracking Map. All assessments used the visual protocol. NA indicates no available data.

Waterbody	# of visual observations	maximum web status	msaximum cell count measured (cells/mL)	maximum microcystin measured (µg/L)
Adams Reservoir	8	Generally Safe	NA	NA
Baker Pond	1	Generally Safe	NA	NA
Berlin Pond	9	Generally Safe	NA	NA
Caspian Lake	15	Generally Safe	NA	NA
Chittenden Reservoir	1	Low Alert	NA	NA
Clyde Pond	6	Low Alert	NA	NA
Colchester Pond	7	Generally Safe	NA	NA
Coles Pond	15	Generally Safe	NA	NA
Crystal Lake	7	Generally Safe	NA	NA
Emerald Lake	14	Generally Safe	NA	NA
Halfmoon Lake	13	Generally Safe	NA	NA
Indian Brook Reservoir	12	Low Alert	NA	NA
Island Pond	7	Generally Safe	NA	NA
Joes Pond	43	Generally Safe	NA	NA
Kent Pond	1	Low Alert	NA	NA

Lake Bomoseen	8	Generally Safe	NA	NA
Lake Carmi	161	High Alert	33930	5.31
Champlain - Inland Sea	451	High Alert	30367	NA
Champlain - Main Lake Central	791	High Alert	12644557	0
Champlain - Main Lake North	190	High Alert	10552	2.11
Champlain - Main Lake South	356	High Alert	8635204	0
Champlain - Malletts Bay	103	Low Alert	1819	NA
Champlain - Missisquoi Bay	89	High Alert	5614796	0.2
Champlain - South Lake	60	High Alert	6830	NA
Champlain - St. Albans Bay	225	High Alert	1229592	0
Lake Dunmore	14	Generally Safe	NA	NA
Lake Elmore	13	Generally Safe	NA	NA
Lake Fairlee	26	Generally Safe	NA	NA
Lake Groton	5	Generally Safe	NA	NA
Lake Iroquois	47	High Alert	NA	NA
Lake Memphremagog	195	High Alert	4965	0
Lake Morey	3	High Alert	NA	NA
Lake Pinneo	1	Generally Safe	NA	NA
Lake Runnemede (Evarts Pond)	6	Generally Safe	NA	NA
Lake Shaftsbury	1	Generally Safe	NA	NA
Lake St. Catherine	33	Generally Safe	NA	NA
Maidstone Lake	1	Generally Safe	NA	NA
Mill Pond	7	Generally Safe	NA	NA
Missisquoi NWR - Cranberry Pool	1	High Alert	NA	NA
Molly's Falls Pond	7	High Alert	NA	NA
Muckross Pond	1	Low Alert	NA	NA
Ricker Pond	11	Generally Safe	NA	NA
Shelburne Pond	3	High Alert	NA	NA
Spectacle Pond	7	Generally Safe	NA	NA
Ticklenaked Pond	12	Generally Safe	5862	NA
Waterbury Reservoir	70	Generally Safe	NA	NA
Winona Lake	17	Generally Safe	NA	NA

3.2.1 Cyanobacteria Conditions on Lake Champlain in Context

Eighty-two percent of the Lake Champlain reports from 2021 indicated generally safe conditions (n=1848, Figures 4 and 5). Alert-level conditions were reported 406 times, many of which were supplemental reports. Alert level conditions were reported most frequently in the Main Lake South (n=90), St. Albans Bay (n=86), and Main Lake Central (n=116).

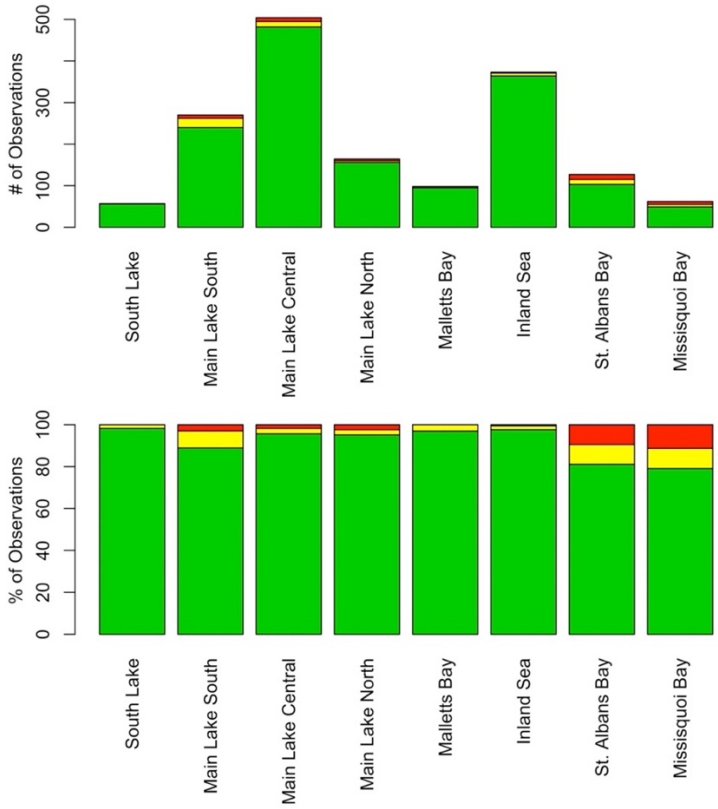

Figure 4: 2021 Web Report alert levels from routine reports for the basins of Lake Champlain. Green indicates "generally safe" conditions, yellow indicates "low alert", and red indicates "high alert". Top panel shows number of observations in each basin, bottom panels show the percentage of each report category in each basin. Supplemental reports are excluded.

In 2021, there were more frequent reports of bloom conditions, and a higher proportion of alert-level conditions, in the Main Lake South region than in previous years in both the Routine reports (Figs 5, 6) and in the Supplemental Reports (Fig. 7). Other areas of the lake appeared to have similar incidence of blooms as in previous years. It is not clear whether the increased numbers of reports in some areas such as St. Albans Bay reflect increased bloom severity or more public awareness and participation in the monitoring program. Sites of particular concern in Lake Champlain, including St. Albans and Missisquoi Bays, had blooms reported at similar levels as previous years (Figs. 5,6,7). The number of both routine and supplemental reports from Missisquoi Bay increased somewhat over the past two years, however increased reporting from the Canadian portion of the bay would be desirable.

Microcystin and anatoxin concentrations were usually below detection limits in 2021 (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.

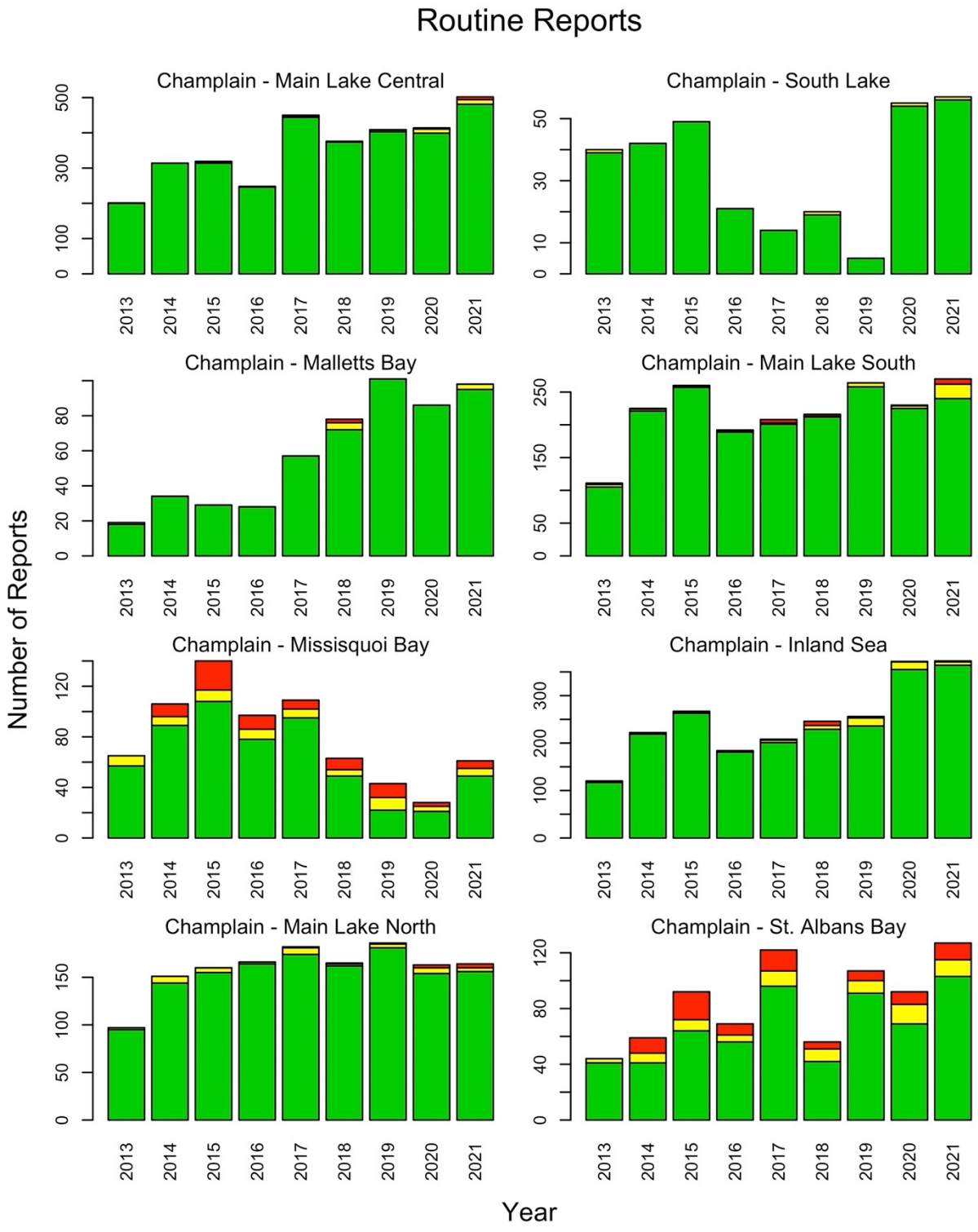

Figure 5: Web Report alert levels from routine reports for the basins of Lake Champlain during the years 2013 – 2021 showing the number of reports received in each year. Green indicates “generally safe” conditions, yellow indicates “low alert”, and red indicates “high alert”.

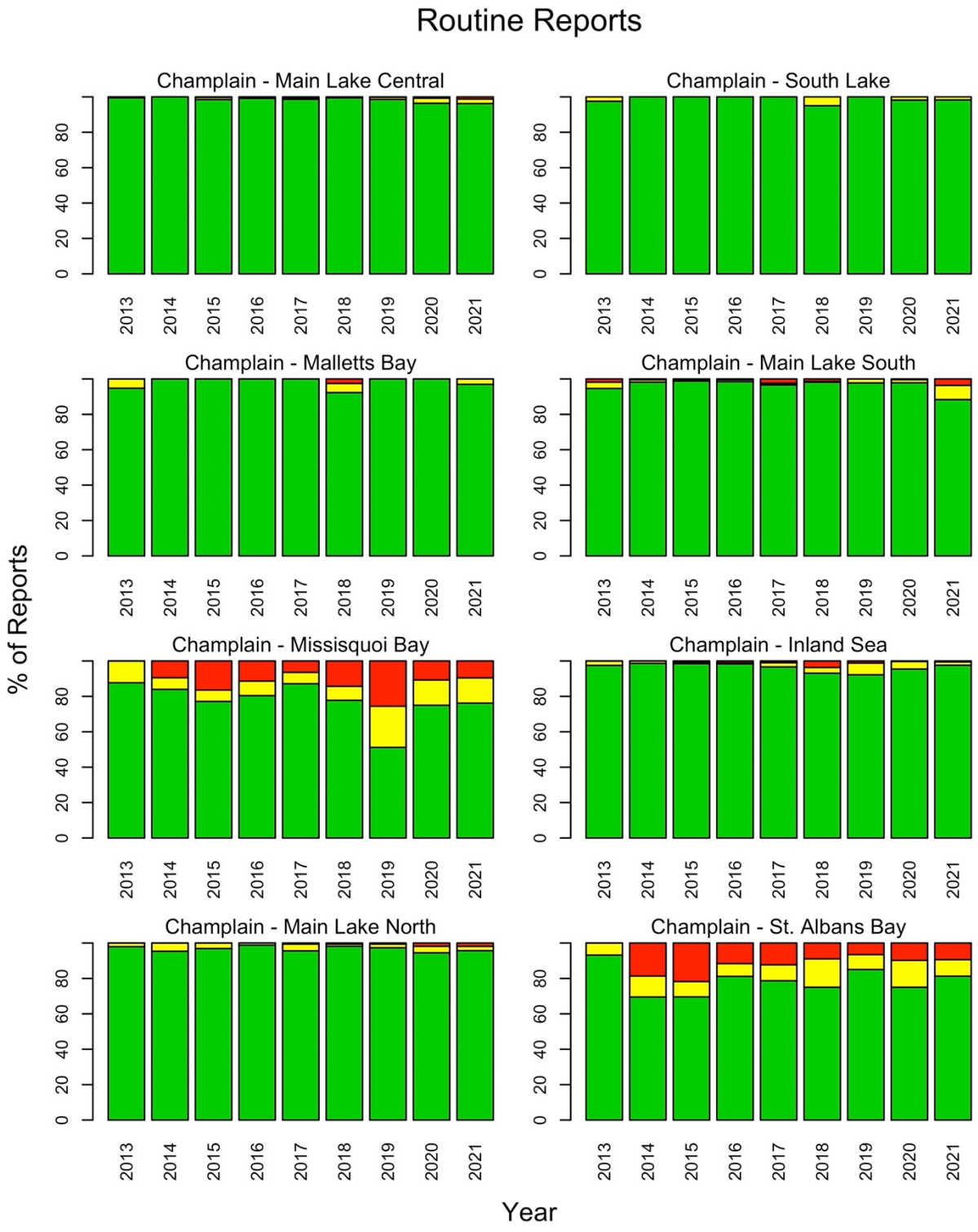

Figure 6: Web Report alert levels from routine reports for the basins of Lake Champlain during the years 2013 – 2021 showing the percentage of reports in each alert category. Green indicates “generally safe” conditions, yellow indicates “low alert”, and red indicates “high alert”.

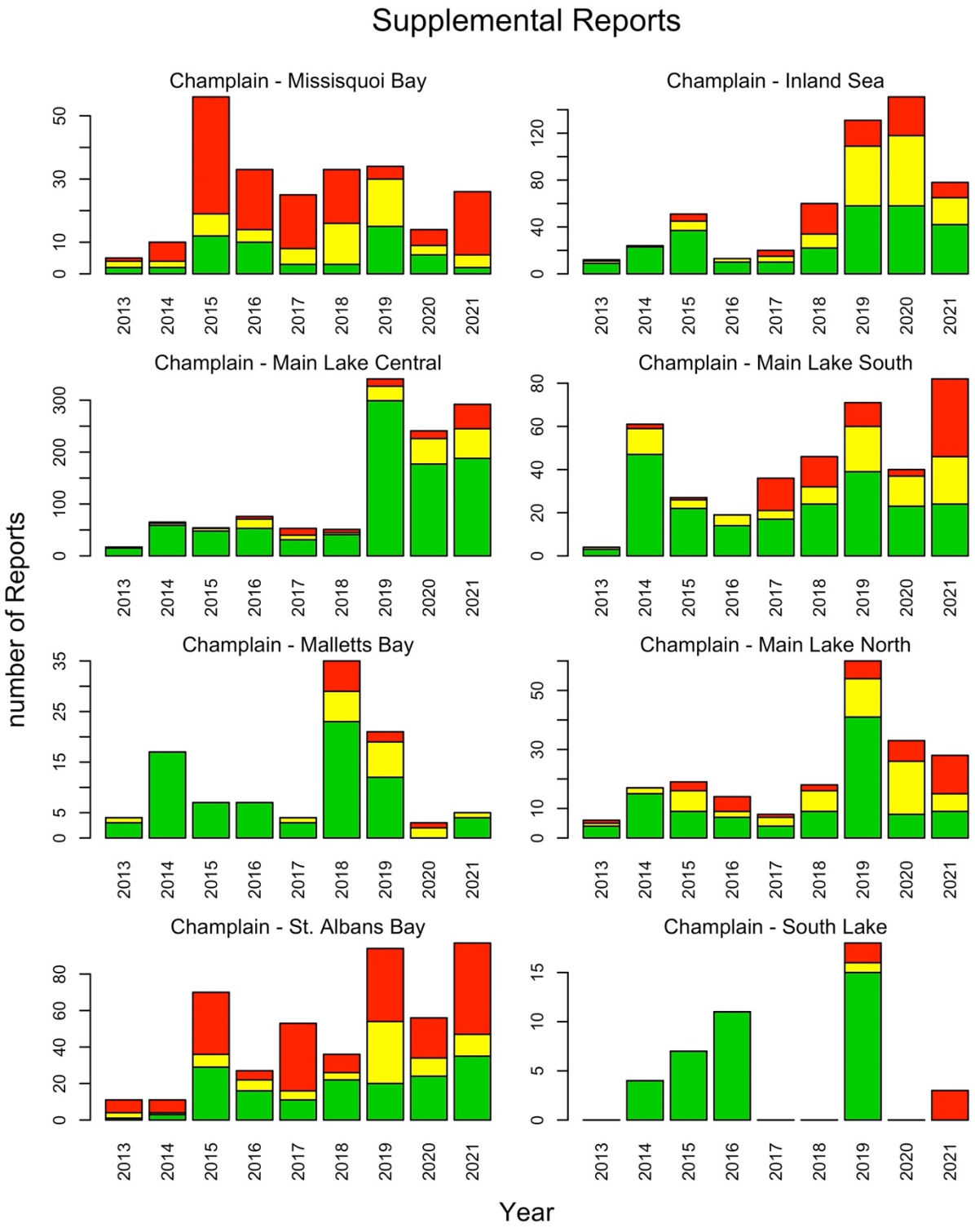

Figure 7: Web Report alert levels in Supplemental Reports for the basins of Lake Champlain during the years 2013 – 2021 showing the percentage of reports in each alert category. Green indicates "generally safe" conditions, yellow indicates "low alert", and red indicates "high alert". Supplemental reports 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 – 2021. 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
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
	#stations	4	4			5	4		
Main Lake Central	median	<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
	#samples	31	27	26	31	36	36	28	37
	#stations	2	2	2	4	4	6	4	6
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
	#stations			1	1	1	2	1	3
Main Lake South	median	<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
	#samples	33	28	12	16	21	13	3	4
	#stations	3	2	1	3	4	1	1	2
St. Albans Bay	median	<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
	#samples	4	12	15	21	13	16	12	11
	#stations	2	2	3	3	1	3	2	1
Malletts Bay	median					<0.16	<0.16		
	range					All <0.16	NA		
	#samples	0	0	0	0	6	1	0	0
	#stations					3	1	0	
South Lake	median								
	range								
	#samples	0	0	0	0	0	0	0	0
	#stations								
Missisquoi Bay	median	<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
	#samples	40	38	19	18	16	14	13	17
	#stations	7	5	6	3	4	1	2	5

3.2.2 Cyanobacteria Conditions on Vermont inland lakes

Figure 8 shows the growth of the cyanobacteria monitoring program in inland lakes form 2013–2021, 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. The number of supplemental reports declined relative to the last three 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.

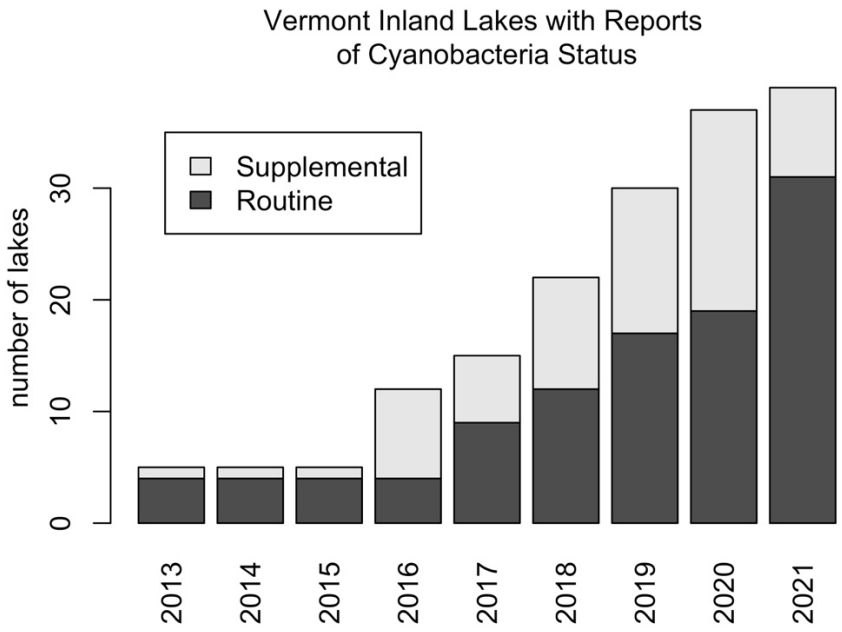

Figure 8: Number of lakes delivering reports of cyanobacteria status using the visual monitoring protocol. Dark bars indicate lakes with at least one routine reporting site, light gray bars indicate sites with only supplemental reports. NOTE: This does not mean that all lakes experienced cyanobacteria blooms, only that reports (including reports of "Generally Safe" conditions) were delivered.

Several inland lakes have consistently high numbers of reports over the 2013-2021 timeframe, providing the opportunity to look at trends. Conditions in 2021 in Lake Carmi and Lake Iroquois were not obviously different from conditions observed in recent years (Fig. 10). Lake Memphremagog had a higher number and percentage of alert-level conditions reported in 2021 than in previous years, however, suggesting that 2021 was a strong bloom year in that waterbody.

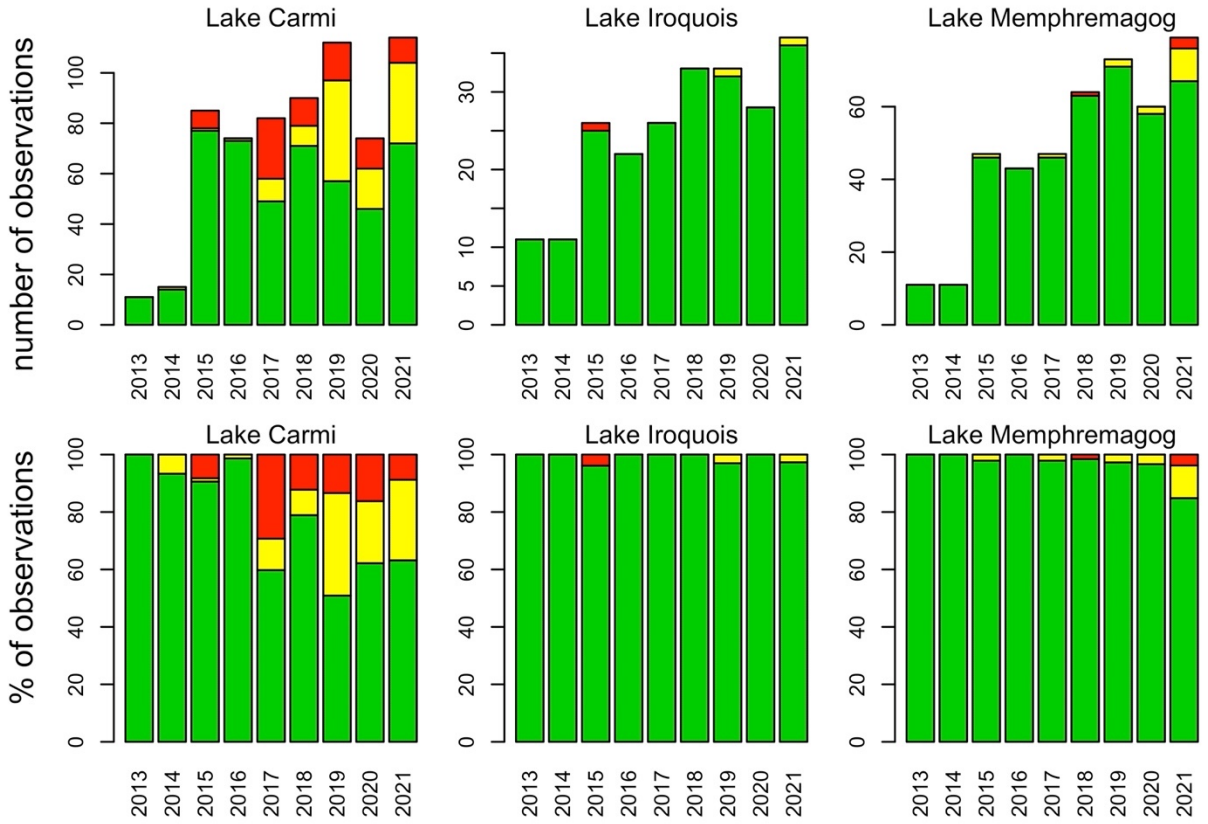

Figure 9: Web Report alert levels for selected inland lakes showing the total number (top) and percentage (bottom) of reports in each alert category. Green indicates "generally safe" conditions, yellow indicates "low alert", and red indicates "high alert". Supplemental reports are excluded.

Inland waterbodies with reports of category 2 or 3 blooms in 2021 in Vermont included:

Chittenden Reservoir
Clyde Pond
Cranberry Pond
Kndian Brook Reservoir
Kent Pond
Shelburne Pond
Lake Iroquois
Lake Memphremagog
Lake Morey
Molly's Falls Pond
Lake Carmi

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 three times on Lake Carmi this year, including the highest observed microcystin concentration, however all were well below Vermont's recreational guideline of 6 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
Lake Carmi	median	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16
	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
	#samples	10	19	17	25	35	32	36	13	17
	#stations	1	4	2	3	3	4	4	4	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, including the highest observed cell densities in the net samples (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 also supported the use of the visual protocol for assessing cyanotoxin concentrations, although there were a relatively few samples with toxin detected with which to conduct a robust analysis. Microcystins were not above detection in any of the “Generally Safe” samples, and the highest observed microcystin concentration was in a “High Alert” sample. All microcystin samples were below recreational thresholds. Anatoxin was detected in 5 samples, three of which had “Generally Safe” reports, however, all were well below recreational guidance thresholds.

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.

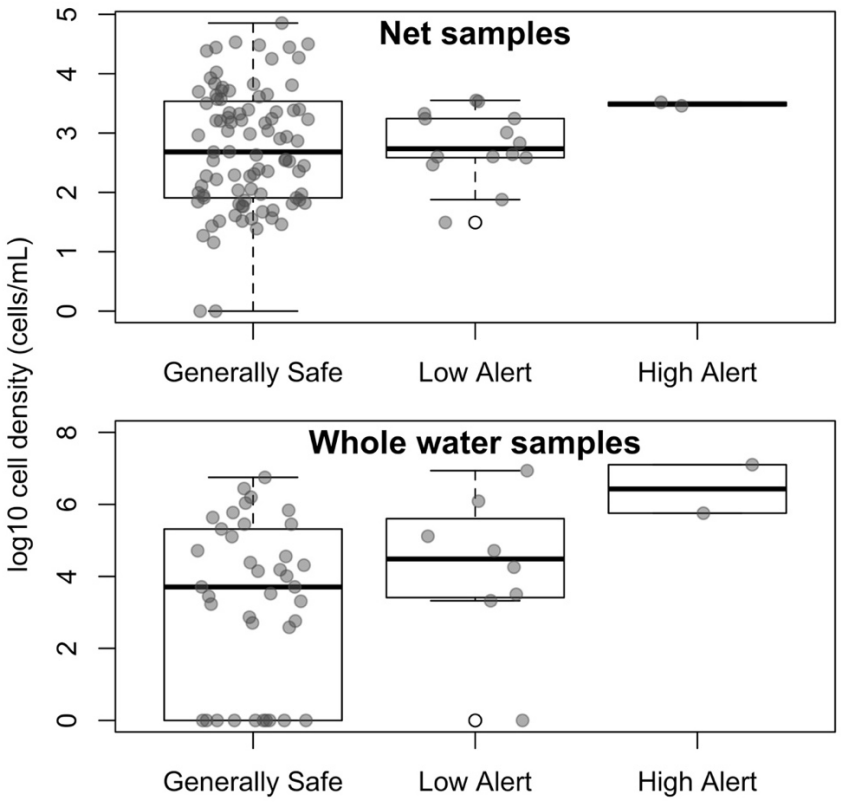

Fig. 10: Box and whiskers plots of cell densities (log_{10} n+1 transformed) for each alert category for whole water and plankton net samples. Dark lines represent median values for each category, top and bottom boundaries of the box represent 75th and 25th percentiles of the data, respectively, and 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 2021, the VDH and DWGWPD offered, with support from the Lake Champlain Basin Program, free weekly microcystin testing for public drinking water facilities in Vermont for 12 weeks from June through late September. Microcystin was not detected at a majority of sites, but were detected in raw water at the Alburgh Village water intake consistently (13 times) from September 28 through October 18, with a maximum observed concentration of 0.33 µg/L. Toxins were not detected in treated drinking water from this site. Microcystin was also detected once at Thompson's Point in Charlotte VT (0.74 µg/L), although this was not confirmed with a follow-up sample 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

Due to the COVID-19 pandemic all LCC Volunteer trainings were conducted virtually rather than held at different locations around the Lake Champlain Basin, and this was continued in 2021 due to ongoing concerns with COVID-19, as well as a positive experience with the convenience of online trainings on the part of both volunteers and staff. LCC trained nearly 300 potential monitors and interested community members at 21 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, July, August and September. In 2021, reports were provided from 18 Vermont and 1 New York state parks by staff, LCC volunteers, and VDH staff. VT DEC provided training for watershed associations and others on Vermont inland lakes located outside the Champlain Basin LCC 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 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 171 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 2021 (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 2021

2021 Month	VDH Cyanobacteria Landing Page – Unique Page Views	VDH Cyanobacteria Tracker – Unique Page Views
June	529	2037
July	3,063	18,034
August	1,467	12,573
September	376	2,225
October	431	1,691
November	272	449
December	228	260
Total	6,366	37,269

Note that in past years, State IP addresses were removed from the page view numbers reported. As most state employees were working remotely in 2021, these views could not be removed from the above data and are therefore included.

3.8 Challenges

2021 had no major challenges with respect to the monitoring program, with operations returning to mostly normal conditions following the COVID-19 pandemic. Some innovations adopted during the pandemic, such as the use of online volunteer trainings, are likely to continue into the future, while important in-person work including microscopic analyses were resumed and will hopefully expand in the future.

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.

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. The southern area of the Main Lake Basin on Lake Champlain, as well as Lake Memphremagog, had relatively high numbers of blooms as compared to previous years, although a significant difference from previous years was not validated statistically. Microcystin and anatoxin detections were infrequent and observed concentrations were all below the Vermont recreational guidance levels in 2021.

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. The increase in routine monitoring in inland lakes was a positive outcome in 2021, continuing a trend from previous years. Outreach continues to be an important component of the monitoring program.

Because of their diligence and the increasing number of volunteers gathering data for this project through both routine and supplemental reports, we have a good understanding of cyanobacteria conditions on Lake Champlain and several Vermont inland lakes. With the increasing volume of historical data available, VDH and VT DEC are beginning to develop ways to use historical data to investigate temporal and spatial patterns in bloom frequency (see Appendix E), and ultimately to improve our understanding of the factors controlling blooms.

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 Kelsey Colbert (VT DEC Watershed Management); Angela Shambaugh (formerly of VT DEC); Dr. Ana Morales-Williams and Lindsay VanFossen (UVM), Obehi (Ob) Ilenikhena (CDC/VDH), Marie Sawyer and Suzy Stanton (VDH Laboratory); Jan Leja and Dan Jarvis (developers of the Tracker map); Lindsey Carlsen, Jared Carpenter, Emily DeAlto, Alexa Hachigian, and Grace 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. 2021 Routine Sampling Locations

WATERBODY	SITE NAME	SITE NUM.	MUNICIPALITY	STATE/ PROVINCE	# OF REPORTS	LATITUDE	LONGITUDE
ADAMS RESERVOIR	Woodford State Park - Camper Beach	444	Bennington	Vermont	4	42.8847444	-73.039091
ADAMS RESERVOIR	Woodford State Park - Day Beach	443	Bennington	Vermont	4	42.888755	-73.038241
BERLIN POND	Berlin Pond	301	Berlin	Vermont	4	44.1871665	-72.58774
BERLIN POND	Berlin Pond Boat Launch	533	Berlin	Vermont	5	44.2083966	-72.582286
CASPIAN LAKE	Caspian Lake	306	Greensboro	Vermont	15	44.5765297	-72.298357
COLCHESTER POND	Colchester Pond Paddlecraft Access	458	Colchester	Vermont	6	44.5506132	-73.12372
COLES POND	Coles Pond	311	Walden	Vermont	15	44.5028019	-72.213784
CRYSTAL LAKE	Crystal Lake State Park	505	Barton	Vermont	7	44.7335347	-72.15388
EMERALD LAKE	Emerald Lake State Park - Day Beach	441	East Dorset	Vermont	14	43.2782859	-73.008584
HALFMOON LAKE	Half Moon State Park - Camper Beach	437	Hubbardton	Vermont	13	43.6945493	-73.219099
INDIAN BROOK RESERVOIR	Indian Brook Reservoir Boat Launch	491	Essex	Vermont	9	44.5570535	-73.084374
INDIAN BROOK RESERVOIR	Indian Brook Reservoir, Upper Lot Picnic Access	null	Essex Junction	Vermont	1	44.4965835	-73.067374
ISLAND POND	Brighton Island Pond Day Use Beach	522	Island Pond	Vermont	7	44.792758	-71.862504
JOES POND	Clubhouse Circle	465	West Danville	Vermont	12	44.4172924	-72.220848
JOES POND	The Narrows, Joes Pond	463	West Danville	Vermont	13	44.4089506	-72.21145
JOES POND	Town Beach, Joes Pond	464	West Danville	Vermont	16	44.4101375	-72.198302
LAKE BOMOSEEN	Bomoseen State Park - Day Beach	438	Castleton	Vermont	6	43.655682	-73.225179
LAKE CARMI	Carmi DEC01- Central Open Water	409	Franklin	Vermont	10	44.9725869	-72.874507
LAKE CARMI	Carmi DEC02- Southern Open Water	410	Franklin	Vermont	10	44.9591827	-72.886989
LAKE CARMI	Carmi DEC03- Northeastern Open Water	411	Franklin	Vermont	10	44.9832431	-72.859898
LAKE CARMI	Lake Carmi State Park	201	Franklin	Vermont	15	44.960818	-72.876351
LAKE CARMI	Lake Carmi State Park - Area B	415	Franklin	Vermont	15	44.9557976	-72.884059
LAKE CARMI	Lake Carmi State Park - Boat Launch	429	Franklin	Vermont	1	44.9596768	-72.875867
LAKE CARMI	Lake Carmi State Park South	165	Franklin	Vermont	15	44.9569015	-72.877205
LAKE CARMI	Lake Carmi, Black Woods	164	Franklin	Vermont	13	44.9752955	-72.885496
LAKE CARMI	Lake Carmi, North Beach	167	Franklin	Vermont	5	44.990535	-72.87031
LAKE CARMI	Lake Carmi, Westcott Shore	168	Franklin	Vermont	10	44.957115	-72.893955
LAKE CARMI	Patton Shore	518	Franklin	Vermont	13	44.9847288	-72.874966
LAKE CHAMPLAIN	Alburgh Dunes State Park	35	Alburgh	Vermont	8	44.8650912	-73.300146

LAKE CHAMPLAIN	Alburgh East Shore - Town Beach	430	Alburgh	Vermont	16	44.955	-73.264444
LAKE CHAMPLAIN	Alburgh Lakeshore Park	510	Alburgh	Vermont	16	44.9714782	-73.229674
LAKE CHAMPLAIN	Arnold Bay	3	Panton	Vermont	19	44.1500575	-73.367363
LAKE CHAMPLAIN	Arnold Bay South Shoreline		Panton	Vermont	5	44.4965835	-73.067374
LAKE CHAMPLAIN	Arnold Bay, Panton	206	Panton	Vermont	2	44.1489039	-73.367936
LAKE CHAMPLAIN	Ausable Point Campground Beach	376	Peru, NY	New York	21	44.5720396	-73.426591
LAKE CHAMPLAIN	Ausable Point Road - Lake side	434	Peru, NY	New York	19	44.5726986	-73.432635
LAKE CHAMPLAIN	Bayside Beach	377	Colchester	Vermont	16	44.5461283	-73.217039
LAKE CHAMPLAIN	Beadles Cove	53	Shoreham	Vermont	2	43.8494844	-73.370577
LAKE CHAMPLAIN	Beggs Park Beach, Essex NY	60	Essex, NY	New York	16	44.3084482	-73.348047
LAKE CHAMPLAIN	Black Bridge	191	St. Albans Town	Vermont	6	44.8102831	-73.151998
LAKE CHAMPLAIN	Boat Launch on Hathaway Point Rd	379	St. Albans Town	Vermont	19	44.7941764	-73.172188
LAKE CHAMPLAIN	Bulwagga Bay/Port Henry	138	Port Henry, NY	New York	12	44.0341541	-73.456943
LAKE CHAMPLAIN	Burgey Farm Road	380	Addison	Vermont	4	44.0578323	-73.416632
LAKE CHAMPLAIN	Burlington, VT - Texaco Beach	72	Burlington	Vermont	17	44.4876001	-73.232051
LAKE CHAMPLAIN	Burton Island State Park	37	St. Albans Town	Vermont	11	44.7766368	-73.196428
LAKE CHAMPLAIN	Button Bay Boat Launch	74	Ferrisburgh	Vermont	11	44.1760798	-73.351104
LAKE CHAMPLAIN	Button Bay South	183	Ferrisburgh	Vermont	1	44.180928	-73.361644
LAKE CHAMPLAIN	Button Bay State Park	180	Ferrisburgh	Vermont	15	44.180859	-73.361616
LAKE CHAMPLAIN	Camp Kiniya	142	Colchester	Vermont	2	44.60632	-73.228978
LAKE CHAMPLAIN	Carry Bay - East Shore	420	North Hero	Vermont	6	44.8350548	-73.27288
LAKE CHAMPLAIN	Carrying Place South	474	North Hero	Vermont	20	44.8252666	-73.276604
LAKE CHAMPLAIN	Cedar Ledge	131	North Hero	Vermont	15	44.8464462	-73.262611
LAKE CHAMPLAIN	Charlotte Town Beach	76	Charlotte	Vermont	14	44.3341946	-73.281441
LAKE CHAMPLAIN	Chilconi Cove	498	St. Albans City	Vermont	2	44.7840915	-73.185011
LAKE CHAMPLAIN	Chimney Point	143	Addison	Vermont	4	44.0352402	-73.420605
LAKE CHAMPLAIN	City Bay - Rt 2	78	North Hero	Vermont	15	44.8159141	-73.289139
LAKE CHAMPLAIN	Clearwater Road	500	Shelburne	Vermont	5	44.4142071	-73.219809
LAKE CHAMPLAIN	Cohen Park St. Albans	174	St. Albans	Vermont	17	44.8649084	-73.180877
LAKE CHAMPLAIN	Colchester Point Boat Launch	412	Colchester	Vermont	18	44.5361063	-73.274561
LAKE CHAMPLAIN	Community Sailing Center	107	Burlington	Vermont	6	44.4820337	-73.22553
LAKE CHAMPLAIN	Corlear Bay, near Hatch Point	null	Willsboro, NY	New York	1	44.4965835	-73.067374
LAKE CHAMPLAIN	Corlear Bay, Port Douglas Boat Launch	160	Chesterfield, NY	New York	20	44.4839117	-73.416775
LAKE CHAMPLAIN	Cow Banks	532	South Hero	Vermont	9	44.6388047	-73.264004
LAKE CHAMPLAIN	Crater Club	534	Essex, NY	New York	5	44.284414	-73.3469
LAKE CHAMPLAIN	DAR State Park	39	Addison	Vermont	24	41.2237336	-72.318804

LAKE CHAMPLAIN	Dead Creek Inlet	413	Peru, NY	New York	19	44.5731608	-73.433946
LAKE CHAMPLAIN	Delta Park	405	Colchester	Vermont	10	44.5367025	-73.27749
LAKE CHAMPLAIN	East Shore North	501	Grand Isle	Vermont	1	44.7600742	-73.272165
LAKE CHAMPLAIN	Essex Road	382	Willsboro, NY	New York	12	44.3440091	-73.357203
LAKE CHAMPLAIN	Fee Fee Point	461	North Hero	Vermont	15	44.8924097	-73.241166
LAKE CHAMPLAIN	Ferrand Rd. St. Albans	113	St. Albans Town	Vermont	9	44.7915439	-73.141875
LAKE CHAMPLAIN	Georgia Beach	193	Georgia	Vermont	4	44.7683512	-73.162642
LAKE CHAMPLAIN	Gilligan's Bay	511	Crown Point, NY	New York	10	43.9527136	-73.411002
LAKE CHAMPLAIN	Grand Isle State Park	11	Grand Isle	Vermont	13	44.6864114	-73.2893
LAKE CHAMPLAIN	Graveyard Point	473	North Hero	Vermont	26	44.8330799	-73.285114
LAKE CHAMPLAIN	Hackett's Way	402	St. Albans Town	Vermont	18	44.7843055	-73.173874
LAKE CHAMPLAIN	Hathaway Point Road	403	St. Albans Town	Vermont	19	44.7962682	-73.162907
LAKE CHAMPLAIN	Holcomb Boat Launch	129	Isle la Motte	Vermont	20	44.854684	-73.33162
LAKE CHAMPLAIN	Horicans Fish and Wildlife Access	127	Alburgh	Vermont	15	44.915468	-73.313929
LAKE CHAMPLAIN	Idlewild Road	427	South Hero	Vermont	12	44.6641601	-73.277409
LAKE CHAMPLAIN	Keeler Bay Boat Launch	135	South Hero	Vermont	16	44.6679158	-73.319901
LAKE CHAMPLAIN	Keeler Bay East	134	South Hero	Vermont	12	44.6508081	-73.297536
LAKE CHAMPLAIN	Kill Kare State Park	56	St. Albans Town	Vermont	10	44.778467	-73.183179
LAKE CHAMPLAIN	Kings Bay Fishing Access	432	North Hero	Vermont	20	44.869803	-73.250474
LAKE CHAMPLAIN	Kingsland Bay State Park	15	Ferrisburgh	Vermont	14	44.2403048	-73.297379
LAKE CHAMPLAIN	Knight Point State Park	80	North Hero	Vermont	10	44.768814	-73.294389
LAKE CHAMPLAIN	Knight Point State Park , at the Point	419	North Hero	Vermont	16	44.7670944	-73.298935
LAKE CHAMPLAIN	Lakeside Beach	514	Burlington	Vermont	14	44.4601288	-73.222175
LAKE CHAMPLAIN	Lapan Bay	385	St. Albans Town	Vermont	12	44.8156513	-73.178368
LAKE CHAMPLAIN	LaPlatte River mouth, Shelburne Bay	55	Shelburne	Vermont	6	44.3986606	-73.23449
LAKE CHAMPLAIN	Leddy Park	54	Burlington	Vermont	19	44.5009717	-73.253532
LAKE CHAMPLAIN	Lighthouse Point Road	472	Isle la Motte	Vermont	6	44.9056613	-73.345399
LAKE CHAMPLAIN	Littoral Philipsburg	468	St. Armand, QC	New York	1	45.040279	-73.077984
LAKE CHAMPLAIN	Long Point	18	Ferrisburgh	Vermont	18	44.2582965	-73.277462
LAKE CHAMPLAIN	Long Point Beach	460	Ferrisburg	Vermont	11	44.2528667	-73.279568
LAKE CHAMPLAIN	LTM 02	2	Benson	Vermont	6	43.7139627	-73.383087
LAKE CHAMPLAIN	LTM 04	4	Bridport	Vermont	6	43.951006	-73.406957
LAKE CHAMPLAIN	LTM 07	7	Panton	Vermont	6	44.1259469	-73.412998
LAKE CHAMPLAIN	LTM 09	9	Ferrisburg	Vermont	6	44.2420843	-73.32905
LAKE CHAMPLAIN	LTM 16	16	Shelburne	Vermont	6	44.4249262	-73.231968
LAKE CHAMPLAIN	LTM 19	19	South Burlington	Vermont	6	44.4709138	-73.299083
LAKE CHAMPLAIN	LTM 21	21	Burlington	Vermont	6	44.4748455	-73.231707
LAKE CHAMPLAIN	LTM 25	25	Colchester	Vermont	6	44.5820949	-73.281082

LAKE CHAMPLAIN	LTM 33	33	Plattsburgh, NY	New York	7	44.7011391	-73.418337
LAKE CHAMPLAIN	LTM 34	34	Milton	Vermont	7	44.7076934	-73.226731
LAKE CHAMPLAIN	LTM 36	36	Grand Isle	Vermont	7	44.7558652	-73.355421
LAKE CHAMPLAIN	LTM 40	40	St. Albans Town	Vermont	7	44.7852305	-73.162225
LAKE CHAMPLAIN	LTM 46	46	Alburgh	Vermont	7	44.9483415	-73.340186
LAKE CHAMPLAIN	LTM 50	50	Swanton	Vermont	8	45.0131658	-73.173808
LAKE CHAMPLAIN	LTM 51	51	Saint-Armand, QC	Quebec	4	45.0432853	-73.126245
LAKE CHAMPLAIN	LTM 53	476	Quebec	Quebec	3	45.0416375	-73.141267
LAKE CHAMPLAIN	Malletts Bay Boat Launch	120	Colchester	Vermont	15	44.5529241	-73.231589
LAKE CHAMPLAIN	Maquam Beach	139	Swanton	Vermont	6	44.9208214	-73.16137
LAKE CHAMPLAIN	Maquam Shore (Swanton, VT)	386	Swanton	Vermont	17	44.9014539	-73.166816
LAKE CHAMPLAIN	Melville Landing	176	St. Albans	Vermont	6	44.76212	-73.167395
LAKE CHAMPLAIN	Monitor Bay Boat Launch	513	Crown Point, NY	Vermont	10	43.9478261	-73.413149
LAKE CHAMPLAIN	Mud Flats-Addison	456	Addison	Vermont	13	44.0315301	-73.408292
LAKE CHAMPLAIN	Niquette Bay State Park	67	Colchester	Vermont	15	44.581121	-73.189882
LAKE CHAMPLAIN	Niquette Bay State Park - Cove Beach	416	Colchester	Vermont	13	44.580375	-73.196118
LAKE CHAMPLAIN	North Beach	22	Burlington	Vermont	23	44.4910613	-73.240348
LAKE CHAMPLAIN	North Harbor	147	Ferrisburgh	Vermont	12	44.1993246	-73.358575
LAKE CHAMPLAIN	North Hero State Park	23	North Hero	Vermont	2	44.9193862	-73.241282
LAKE CHAMPLAIN	North Hero State Park - Boat Launch	475	North Hero	Vermont	11	44.9206666	-73.242132
LAKE CHAMPLAIN	North Shore Beach	391	Burlington	Vermont	10	44.520757	-73.269584
LAKE CHAMPLAIN	Oakledge Park Blanchard Beach	42	Burlington	Vermont	20	44.4575786	-73.225333
LAKE CHAMPLAIN	Oakledge Park rocky shoreline	44	Burlington	Vermont	20	44.4567508	-73.228046
LAKE CHAMPLAIN	Oakledge Park South Cove	43	Burlington	Vermont	25	44.4549726	-73.230074
LAKE CHAMPLAIN	Oliver Bay	45	Plattsburgh, NY	New York	10	44.7391158	-73.405322
LAKE CHAMPLAIN	Pelagic Philipsburg	469	St. Armand, QC	Quebec	1	45.038969	-73.107304
LAKE CHAMPLAIN	Pelots Point West	130	North Hero	Vermont	14	44.826288	-73.309988
LAKE CHAMPLAIN	Perkins Pier	392	Burlington	Vermont	8	44.4727313	-73.22076
LAKE CHAMPLAIN	Peru Boat Launch	159	Peru, NY	New York	17	44.6180785	-73.441216
LAKE CHAMPLAIN	Phillipsburg, QC	58	Philipsburg, QC	Quebec	5	45.0387796	-73.077523
LAKE CHAMPLAIN	Pike River Mouth	470	St. Armand, QC	Quebec	1	45.0729715	-73.093915
LAKE CHAMPLAIN	Point of the Tongue	494	Alburgh	Vermont	17	44.8551155	-73.293229
LAKE CHAMPLAIN	Port Henry Boat Launch	153	Port Henry, NY	New York	12	44.0525409	-73.452908
LAKE CHAMPLAIN	Port Kent Beach	152	Chesterfield, NY	New York	2	44.5275469	-73.405083
LAKE CHAMPLAIN	Port Kent Beach 2	394	Chesterfield, NY	New York	18	44.5270836	-73.404562
LAKE CHAMPLAIN	Ransoms Bay - Blue Rock	508	Alburgh	Vermont	15	44.9603439	-73.251735
LAKE CHAMPLAIN	Red Rocks Beach	27	South Burlington	Vermont	16	44.441946	-73.224071

LAKE CHAMPLAIN	Rock Point - Eagle Bay	509	Burlington	Vermont	8	44.4954798	-73.246385
LAKE CHAMPLAIN	Rock River - Highgate	178	Highgate	Vermont	19	44.9883757	-73.087812
LAKE CHAMPLAIN	Rosetti Park	111	Colchester	Vermont	8	44.5545384	-73.253728
LAKE CHAMPLAIN	Rouses Pt	28	Alburgh	Vermont	8	44.9946927	-73.359026
LAKE CHAMPLAIN	Sand Bar State Park	57	Milton	Vermont	9	44.6289486	-73.239913
LAKE CHAMPLAIN	Sandbar Wildlife Mgmt. Area	503	Colchester	Vermont	16	44.6252825	-73.240189
LAKE CHAMPLAIN	Shelburne Beach	48	Shelburne	Vermont	12	44.3594439	-73.265035
LAKE CHAMPLAIN	Shelburne Farms - Inn Beach	499	Shelburne	Vermont	2	44.4010516	-73.27143
LAKE CHAMPLAIN	Shipyard, Highgate Springs	30	Highgate	Vermont	20	44.9801136	-73.10614
LAKE CHAMPLAIN	South Alburgh - Squires Bay	182	Alburgh	Vermont	14	44.9033659	-73.27193
LAKE CHAMPLAIN	South Beach Road	467	South Burlington	Vermont	16	44.4240492	-73.217865
LAKE CHAMPLAIN	St Albans Bay Dock		St Albans	Vermont	1	44.4965835	-73.067374
LAKE CHAMPLAIN	St. Albans Bay Park	31	St. Albans Town	Vermont	10	44.8085919	-73.144195
LAKE CHAMPLAIN	Starr Farm Beach	108	Burlington	Vermont	15	44.51389	-73.27124
LAKE CHAMPLAIN	Stoney Point, Isle la Motte	128	Isle la Motte	Vermont	19	44.8714824	-73.35944
LAKE CHAMPLAIN	Strong House Lane	435	North Hero	Vermont	11	44.9074701	-73.231599
LAKE CHAMPLAIN	Sunset/Crescent Beach	132	South Hero	Vermont	9	44.611183	-73.318781
LAKE CHAMPLAIN	Teddy Bear Point Cove, Willsboro NY	63	Willsboro, NY	New York	17	44.4425495	-73.373635
LAKE CHAMPLAIN	Thayer Beach	398	Colchester	Vermont	7	44.5530728	-73.255568
LAKE CHAMPLAIN	The Gut	49	Grand Isle	Vermont	15	44.7511305	-73.290162
LAKE CHAMPLAIN	Ticonderoga Boat Launch	188	Ticonderoga, NY	New York	10	43.8534169	-73.385033
LAKE CHAMPLAIN	Town Farm Bay	119	Charlotte	Vermont	9	44.2690766	-73.288717
LAKE CHAMPLAIN	Triangle Beach	466	Burlington	Vermont	19	44.4647923	-73.219561
LAKE CHAMPLAIN	US Coast Guard Boat Access Ramp	417	Burlington	Vermont	12	44.480175	-73.223068
LAKE CHAMPLAIN	Van Everest Boat Launch Milton	175	Milton	Vermont	6	44.7047767	-73.211756
LAKE CHAMPLAIN	Venise en-Quebec	399	Venise en-Quebec	Quebec	1	45.0705	-73.1451
LAKE CHAMPLAIN	West Shore Rd. North Hero 2	492	North Hero	Vermont	11	44.7938627	-73.313056
LAKE CHAMPLAIN	Westport Boat Launch	59	Westport, NY	New York	18	44.1882996	-73.43281
LAKE CHAMPLAIN	Westport Public Beach	517	Westport, NY	New York	16	44.1833489	-73.431254
LAKE CHAMPLAIN	Whallons Bay	122	Essex, NY	New York	17	44.2734704	-73.347562
LAKE CHAMPLAIN	Whiskey Bay	426	Charlotte	Vermont	14	44.2703291	-73.30155
LAKE CHAMPLAIN	White Bay		Panton	Vermont	1	44.4965835	-73.067374
LAKE CHAMPLAIN	Willsboro Boat Launch	68	Willsboro, NY	New York	6	44.4000779	-73.390863
LAKE CHAMPLAIN	Windmill Point South Beach	519	Alburgh	Vermont	19	44.9841015	-73.321397
LAKE DUNMORE	Lake Dunmore	314	Salisbury	Vermont	2	43.9080985	-73.068487
LAKE DUNMORE	Pine Lane, Salisbury VT	485	Salisbury	Vermont	12	43.9224403	-73.079207

LAKE ELMORE	Lake Elmore State Park	202	Elmore	Vermont	13	44.5403328	-72.527371
LAKE FAIRLEE	Outlet, Lake Fairlee	481	Fairlee	Vermont	12	43.88397	-72.243318
LAKE FAIRLEE	VT F&W Access, Lake Fairlee	482	Fairlee	Vermont	13	43.890697	-72.226544
LAKE GROTON	Boulder Beach State Park	504	Groton	Vermont	1	44.2781729	-72.262883
LAKE GROTON	Stillwater Campers Beach	526	Groton	Vermont	4	44.281291	-72.271339
LAKE IROQUOIS	Lake Iroquois	203	Williston	Vermont	17	44.3787675	-73.085828
LAKE IROQUOIS	Lake Iroquois	335	Williston	Vermont	1	44.3791201	-73.087444
LAKE IROQUOIS	Lake Iroquois Southwest	169	Hinesburg	Vermont	20	44.3631045	-73.085706
LAKE MEMPHREMAGOG	Derby Bay	211	Derby	Vermont	12	44.9949202	-72.189606
LAKE MEMPHREMAGOG	Farrant's Point	null	Newport	Vermont	1	44.4965835	-73.067374
LAKE MEMPHREMAGOG	Lake Park area	null	Derby	Vermont	1	44.4965835	-73.067374
LAKE MEMPHREMAGOG	Landing Street Boat Launch, Newport VT	424	Newport	Vermont	1	44.9432437	-72.207172
LAKE MEMPHREMAGOG	Newport City Dock	342	Derby	Vermont	17	44.936888	-72.212332
LAKE MEMPHREMAGOG	Newport Marina	478	Newport	Vermont	24	44.9376553	-72.217758
LAKE MEMPHREMAGOG	Prouty Bay	null	Newport	Vermont	2	44.4965835	-73.067374
LAKE MEMPHREMAGOG	Prouty Beach	204	Newport	Vermont	12	44.9468456	-72.208754
LAKE MEMPHREMAGOG	South Bay	362	Newport City	Vermont	1	44.9170538	-72.209962
LAKE MEMPHREMAGOG	South Bay F&W Access, Newport VT	425	Newport	Vermont	3	44.9292843	-72.212437
LAKE MEMPHREMAGOG	Strawberry Acres, Newport VT	448	Newport	Vermont	1	44.9552325	-72.234065
LAKE MEMPHREMAGOG	Sunset Acres, Derby Bay	423	Derby	Vermont	2	44.9851262	-72.186326
LAKE MEMPHREMAGOG	VT DEC Station 3, Memphremagog	479	Newport	Vermont	8	44.9663943	-72.225445
LAKE MEMPHREMAGOG	VT DEC Station 4, Memphremagog	480	Newport	Vermont	8	44.9816986	-72.216197
LAKE MEMPHREMAGOG	Whipple Point F&W Access, Lake Memphremagog	484	Newport Town	Vermont	4	44.953909	-72.233264
LAKE PINNEO	Beach, Lake Pinneo	486	Hartford	Vermont	1	43.649604	-72.431961
LAKE RUNNEMEDE (EVARTS POND)	Lake Runnemede (Evarts Pond)	354	Windsor	Vermont	6	43.4845863	-72.3916
LAKE SHAFTSBURY	Shaftsbury State Park - Day Beach	442	Shaftsbury	Vermont	1	43.0221912	-73.183475
LAKE ST. CATHERINE	Lake St. Catherine State Park - Camper Beach	440	Poultney	Vermont	16	43.4786896	-73.209178
LAKE ST. CATHERINE	Lake St. Catherine State Park - Day Beach	439	Poultney	Vermont	17	43.482241	-73.210152
MAIDSTONE LAKE	Maidstone Lake	341	Maidstone	Vermont	1	44.5378857	-71.489757
MILL POND	Kayak Access, Mill Pond VT	452	Windsor	Vermont	7	43.4763572	-72.396395
MOLLY'S FALLS POND	Molly's Falls Pond Boat Launch	506	Marshfield	Vermont	5	44.3560273	-72.286367
RICKER POND	Ricker Pond Campers Beach	525	Groton	Vermont	11	44.2459302	-72.24747

SPECTACLE POND	Brighton Spectacle Pond Campers Beach	521	Island Pond	Vermont	7	44.7947322	-71.851025
TICKLENAKED POND	Ticklenaked Pond	368	Ryegate	Vermont	2	44.1892639	-72.098886
TICKLENAKED POND	Ticklenaked Pond Fish and Wildlife Access	515	Ryegate	Vermont	9	44.1895255	-72.09808
WATERBURY RESERVOIR	Blush Hill Boat Launch	530	Waterbury	Vermont	10	44.3822521	-72.741327
WATERBURY RESERVOIR	Elephant Rock Day Use Area	529	Waterbury	Vermont	10	44.3863812	-72.743844
WATERBURY RESERVOIR	Little River A-side Campers Beach	527	Waterbury	Vermont	10	44.3910704	-72.759603
WATERBURY RESERVOIR	Little River B-side Campers Beach	528	Waterbury	Vermont	10	44.3909468	-72.762465
WATERBURY RESERVOIR	Sand Beach, Day Use	531	Waterbury	Vermont	10	44.4091333	-72.752829
WATERBURY RESERVOIR	Waterbury Center State Park	507	Waterbury Center	Vermont	10	44.3825839	-72.727816
WATERBURY RESERVOIR	Waterbury Reservoir Boat Launch	490	Waterbury	Vermont	10	44.3834578	-72.774099
WINONA LAKE	Winona Lake (Bristol Pond Fishing Access)	455	Bristol	Vermont	17	44.1830455	-73.099954

Appendix B. Shoreline Quality Assurance and Supplemental Toxin Data

Date	Report Category	Site #	Site	Waterbody	Web Status	CyanoTaxa	Cell Density (ml-1)	Anatoxin	Microcystin
2021-08-10	1b	31	St. Albans Bay Park	Lake Champlain	Generally Safe	Aphanizomenon; Dolichospermum; Gloeotrichia	1089048	0.6	<0.16
2021-08-23	1d	31	St. Albans Bay Park	Lake Champlain	Generally Safe	Aphanizomenon; Dolichospermum; Microcystis	24289	0.9	<0.16
2021-09-21	1a	30	Shipyard, Highgate Springs	Lake Champlain	Generally Safe	Aphanizomenon; Dolichospermum; Phormidium	35875	2.3	<0.16
2021-09-14	2	30	Shipyard, Highgate Springs	Lake Champlain	Low Alert	Aphanizomenon; Dolichospermum; Microcystis; Phormidium	130536	3.1	<0.16
2021-10-07	3		Alburgh West Shore - Offshore	Lake Champlain	High Alert			< 0.5	0.83
2021-07-01	2		Missisquoi Bay Bridge East	Lake Champlain	Low Alert			<0.5	<0.16
2021-07-08	2	480	VT DEC Station 4, Memphremagog	Lake Memphremagog	Low Alert			<0.5	<0.16
2021-07-08	1d	484	Whipple Point F&W Access, Lake Memphremagog	Lake Memphremagog	Generally Safe	none	0	<0.5	<0.16
2021-07-12	3	22	North Beach	Lake Champlain	High Alert	Dolichospermum ; Planktolygnbya	569133	<0.5	<0.16
2021-07-12	1c	30	Shipyard, Highgate Springs	Lake Champlain	Generally Safe	Aphanothece ; Merismopedia ; Pseudabae ; Planktolygnbya	2757143	<0.5	<0.16
2021-07-12	1a	31	St. Albans Bay Park	Lake Champlain	Generally Safe			<0.5	<0.16
2021-07-12	2	417	US Coast Guard Boat Access Ramp	Lake Champlain	Low Alert			<0.5	<0.16
2021-07-13	2	180	Button Bay State Park	Lake Champlain	Low Alert	none	0	<0.5	<0.16
2021-07-13	2	184	Converse Bay	Lake Champlain	Low Alert	Dolichospermum ; Pseudabae ; Planktolygnbya	8635204	<0.5	<0.16
2021-07-13	1a	22	North Beach	Lake Champlain	Generally Safe			<0.5	<0.16
2021-07-13	1a	27	Red Rocks Beach	Lake Champlain	Generally Safe	Dolichospermum	207483	<0.5	<0.16
2021-07-13	1a	42	Oakledge Park Blanchard Beach	Lake Champlain	Generally Safe			<0.5	<0.16
2021-07-13	1a	43	Oakledge Park South Cove	Lake Champlain	Generally Safe			<0.5	<0.16
2021-07-13	1a	54	Leddy Park	Lake Champlain	Generally Safe			<0.5	<0.16
2021-07-13	1a	72	Burlington, VT - Texaco Beach	Lake Champlain	Generally Safe			<0.5	<0.16
2021-07-15	2	411	Carmi DEC03-Northeastern Open Water	Lake Carmi	Low Alert			<0.5	<0.16
2021-07-16	3	72	Burlington, VT - Texaco Beach	Lake Champlain	High Alert			<0.5	<0.16
2021-07-19	1a	22	North Beach	Lake Champlain	Generally Safe	Dolichospermum	1701	<0.5	<0.16
2021-07-19	1a	31	St. Albans Bay Park	Lake Champlain	Generally Safe			<0.5	<0.16
2021-07-20	2	27	Red Rocks Beach	Lake Champlain	Low Alert			<0.5	<0.16
2021-07-20	1b	30	Shipyard, Highgate Springs	Lake Champlain	Generally Safe	Aphanothece ; Merismopedia ; Pseudoabae	1586735	<0.5	<0.16
2021-07-20	1a	484	Whipple Point F&W Access, Lake Memphremagog	Lake Memphremagog	Generally Safe	none	0	<0.5	<0.16
2021-07-21	1a	22	North Beach	Lake Champlain	Generally Safe			<0.5	<0.16
2021-07-21	1b	42	Oakledge Park Blanchard Beach	Lake Champlain	Generally Safe			<0.5	<0.16
2021-07-21	1a	72	Burlington, VT - Texaco Beach	Lake Champlain	Generally Safe			<0.5	<0.16

2021-07-23	2	115	Vantines Boat Launch	Lake Champlain	Low Alert			<0.5	<0.16
2021-07-23	1a	22	North Beach	Lake Champlain	Generally Safe			<0.5	<0.16
2021-07-23	1a	54	Leddy Park	Lake Champlain	Generally Safe			<0.5	<0.16
2021-07-23	1a	72	Burlington, VT - Texaco Beach	Lake Champlain	Generally Safe			<0.5	<0.16
2021-07-26	1c	201	Lake Carmi State Park	Lake Carmi	Generally Safe			<0.5	<0.16
2021-07-26	1c	415	Lake Carmi State Park - Area B	Lake Carmi	Generally Safe			<0.5	<0.16
2021-07-26	1b	22	North Beach	Lake Champlain	Generally Safe			<0.5	<0.16
2021-07-26	1c	31	St. Albans Bay Park	Lake Champlain	Generally Safe			<0.5	<0.16
2021-07-27	1a	27	Red Rocks Beach	Lake Champlain	Generally Safe	Dolichospermum	5102	<0.5	<0.16
2021-07-27	1a	30	Shipyard, Highgate Springs	Lake Champlain	Generally Safe	Aphanothece ; Aphanocapsa ; Chroococcus ; Pseudabae ; Gloeocapsa	592347	<0.5	<0.16
2021-07-29	2	429	Lake Carmi State Park - Boat Launch	Lake Carmi	Low Alert			<0.5	<0.16
2021-08-02	1a	22	North Beach	Lake Champlain	Generally Safe	none	0	<0.5	<0.16
2021-08-03	1b	27	Red Rocks Beach	Lake Champlain	Generally Safe	Dolichospermum	510	<0.5	<0.16
2021-08-03	1a	30	Shipyard, Highgate Springs	Lake Champlain	Generally Safe	Dolichospermum ; Aphanothece ; Aphanocapsa ; Aphanizomenon ; Merismopedia	686224	<0.5	<0.16
2021-08-03	2	40	LTM 40	Lake Champlain	Low Alert	Dolichospermum ; Microcystis ; Aphanothece ; Aphanocapsa ; Merismopedia	1229592	<0.5	<0.16
2021-08-05	1d	484	Whipple Point F&W Access, Lake Memphremagog	Lake Memphremagog	Generally Safe			<0.5	<0.16
2021-08-06	1a	72	Burlington, VT - Texaco Beach	Lake Champlain	Generally Safe			<0.5	<0.16
2021-08-06	1d	165	Lake Carmi State Park South	Lake Carmi	Generally Safe			<0.5	<0.16
2021-08-09	1c	22	North Beach	Lake Champlain	Generally Safe	Dolichospermum	15306	<0.5	<0.16
2021-08-09	1b	27	Red Rocks Beach	Lake Champlain	Generally Safe	Dolichospermum	5102	<0.5	<0.16
2021-08-10	1d	30	Shipyard, Highgate Springs	Lake Champlain	Generally Safe	Dolichospermum ; Gloeotrichia ; Aphanothece ; Aphanizomenon ; Pseudabae	5614796	<0.5	<0.16
2021-08-12	2	411	Carmi DEC03-Northeastern Open Water	Lake Carmi	Low Alert			<0.5	<0.16
2021-08-16	1a	22	North Beach	Lake Champlain	Generally Safe	Dolichospermum ; Aphanizomenon	127551	<0.5	<0.16
2021-08-17	1b	27	Red Rocks Beach	Lake Champlain	Generally Safe	Dolichospermum ; Aphanizomenon	280612	<0.5	<0.16
2021-08-17	1a	30	Shipyard, Highgate Springs	Lake Champlain	Generally Safe	Dolichospermum ; Aphanothece ; Aphanocapsa ; Aphanizomenon ; Planktolyngbya	431633	<0.5	<0.16
2021-08-17	1c	31	St. Albans Bay Park	Lake Champlain	Generally Safe	Dolichospermum ; Microcystis ; Aphanothece ; Aphanocapsa ; Aphanizomenon ; Gloeocapsa	280612	<0.5	<0.16
2021-08-23	1c	22	North Beach	Lake Champlain	Generally Safe	Aphanizomenon; Aphanocapsa; Microcystis	3327	<0.5	<0.16
2021-08-23	2	50	LTM 50	Lake Champlain	Low Alert			<0.5	<0.16

2021-08-24	1a	27	Red Rocks Beach	Lake Champlain	Generally Safe	Aphanizomenon; Coelosphaerium; Dolichospermum	2802	<0.5	<0.16
2021-08-24	1d	30	Shipyard, Highgate Springs	Lake Champlain	Generally Safe	none	0	<0.5	<0.16
2021-08-27	2	167	Lake Carmi, North Beach	Lake Carmi	Low Alert			<0.5	<0.16
2021-08-27	2	410	Carmi DEC02-Southern Open Water	Lake Carmi	Low Alert			<0.5	<0.16
2021-08-30	2	31	St. Albans Bay Park	Lake Champlain	Low Alert	Aphanizomenon; Microcystis; Phormidium	18014	<0.5	<0.16
2021-08-31	1a	22	North Beach	Lake Champlain	Generally Safe		736	<0.5	<0.16
2021-08-31	1b	27	Red Rocks Beach	Lake Champlain	Generally Safe	Gloeotrichia	20471	<0.5	<0.16
2021-08-31	1d	30	Shipyard, Highgate Springs	Lake Champlain	Generally Safe	Aphanizomenon; Dolichospermum	14012	<0.5	<0.16
2021-09-07	1a	22	North Beach	Lake Champlain	Generally Safe	none	0	<0.5	<0.16
2021-09-07	1a	27	Red Rocks Beach	Lake Champlain	Generally Safe	none	0	<0.5	<0.16
2021-09-07	1d	30	Shipyard, Highgate Springs	Lake Champlain	Generally Safe	Aphanizomenon; Dolichospermum; Phormidium	51945	<0.5	<0.16
2021-09-07	2	31	St. Albans Bay Park	Lake Champlain	Low Alert	Aphanizomenon; Dolichospermum; Microcystis	51753	<0.5	<0.16
2021-09-08	2	429	Lake Carmi State Park - Boat Launch	Lake Carmi	Low Alert			<0.5	<0.16
2021-09-14	1a	22	North Beach	Lake Champlain	Generally Safe	none	0	<0.5	<0.16
2021-09-14	1a	27	Red Rocks Beach	Lake Champlain	Generally Safe	none	0	<0.5	<0.16
2021-09-14	1d	31	St. Albans Bay Park	Lake Champlain	Generally Safe			<0.5	<0.16
2021-09-21	1a	22	North Beach	Lake Champlain	Generally Safe	none	0	<0.5	<0.16
2021-09-21	1b	27	Red Rocks Beach	Lake Champlain	Generally Safe	Aphanizomenon	576	<0.5	<0.16
2021-09-28	1a	27	Red Rocks Beach	Lake Champlain	Generally Safe	none	0	<0.5	<0.16
2021-09-28	1b	30	Shipyard, Highgate Springs	Lake Champlain	Generally Safe	Dolichospermum	384	<0.5	<0.16
2021-10-20	2	167	Lake Carmi, North Beach	Lake Carmi	Low Alert				<0.16
2021-10-20	2	411	Carmi DEC03-Northeastern Open Water	Lake Carmi	Low Alert				<0.16
2021-07-12	3	417	US Coast Guard Boat Access Ramp	Lake Champlain	High Alert	Dolichospermum ; Microcystis ; Woronichinia ; Pseudabae	12644558		
2021-07-13	2		Boat Docks by ECHO center, North of the Melosira	Lake Champlain	Low Alert		2108		
2021-07-13	2		LCCSC Dock & Ramp	Lake Champlain	Low Alert		3174		
2021-07-27	1d	180	Button Bay State Park	Lake Champlain	Generally Safe		2041	<0.5	<0.16
2021-08-11	1d	180	Button Bay State Park	Lake Champlain	Generally Safe		10204	<0.5	<0.16
2021-09-08	2	167	Lake Carmi, North Beach	Lake Carmi	Low Alert			<0.5	<0.16
2021-09-22	2	167	Lake Carmi, North Beach	Lake Carmi	Low Alert			<0.5	<0.16
2021-10-06	2	167	Lake Carmi, North Beach	Lake Carmi	Low Alert			<0.5	<0.16
2021-08-23	2		LTM 53	Lake Champlain	Low Alert			0.8	0.2
2021-10-07	2		LTM 53	Lake Champlain	Low Alert			<0.5	<0.16

Appendix C. Open Water Protocol Data

Report Date	Waterbody	site #	siteName	Bloom category	Web Status	CyanoTaxa	Cyanobacteria cells mL^{-1}
2021-06-23	Lake Champlain	16	LTM 16	1a	Generally Safe	Dolichospermum ; Aphanothece ; Aphanizomenon ; Planktolyngbya	73
2021-06-23	Lake Champlain	19	LTM 19	1a	Generally Safe	Dolichospermum ; Microcystis ; Woronichinia ; Aphanizomenon	345
2021-06-24	Lake Memphremagog	480	VT DEC Station 4, Memphremagog	1d	Generally Safe	Dolichospermum ; Microcystis ; Woronichinia ; Aphanothece	1086
2021-06-25	Lake Champlain	40	LTM 40		Generally Safe	Dolichospermum ; Microcystis ; Gloeotrichia	4474
2021-06-28	Lake Champlain	46	LTM 46	1a	Generally Safe	Dolichospermum ; Gloeothrichia	2186
2021-06-28	Lake Champlain	50	LTM 50	1d	Generally Safe	Microcystis ; Gloeotrichia ; Aphanothece ; Aphanocapsa ; Chroococcus ; Merismopedia	71394
2021-06-29	Lake Champlain	33	LTM 33	1a	Generally Safe	Dolichospermum ; Aphanothece ; Aphanizomenon	36
2021-06-29	Lake Champlain	36	LTM 36	1a	Generally Safe	Dolichospermum ; Microcystis ; Aphanothece ; Aphanizomenon	427
2021-06-30	Lake Carmi	409	Carmi DEC01- Central Open Water		Generally Safe	Dolichospermum ; Microcystis ; Woronichinia ; Aphanothece ; Aphanizomenon ; Lyngbya ; Gloeothrichia	17845
2021-06-30	Lake Carmi	410	Carmi DEC02- Southern Open Water		Generally Safe	Dolichospermum ; Microcystis ; Gloeotrichia ; Woronichinia ; Aphanothece ; Aphanizomenon ; Lyngbya	27825
2021-06-30	Lake Carmi	411	Carmi DEC03- Northeastern Open Water		Generally Safe	Dolichospermum ; Microcystis ; Gloeotrichia ; Woronichinia ; Aphanothece ; Aphanocapsa ; Aphanizomenon ; Lyngbya ; Trichodesmium	33930
2021-07-06	Lake Champlain	25	LTM 25	1a	Generally Safe	Dolichospermum ; Woronichinia ; Aphanizomenon ; Chroococcus	735
2021-07-07	Lake Champlain	2	LTM 02	1b	Generally Safe	Dolichospermum ; Aphanizomenon	108
2021-07-07	Lake Champlain	4	LTM 04	1b	Generally Safe	Dolichospermum ; Microcystis ; Woronichinia ; Aphanothece ; Aphanizomenon ; Chroococcus ; Planktolygnbya	195
2021-07-08	Lake Memphremagog	479	VT DEC Station 3, Memphremagog	2	Low Alert	Dolichospermum ; Woronichinia ; Aphanothece ; Aphanizomenon	675
2021-07-12	Lake Champlain	16	LTM 16	1d	Generally Safe	Dolichospermum ; Aphanocapsa ; Aphanizomenon	1604
2021-07-12	Lake Champlain	19	LTM 19	1d	Generally Safe	Dolichospermum ; Microcystis	1625
2021-07-13	Lake Champlain	7	LTM 07	1d	Generally Safe	Dolichospermum ; Aphanizomenon	477
2021-07-13	Lake Champlain	9	LTM 09	1d	Generally Safe	Dolichospermum ; Aphanizomenon	1516
2021-07-14	Ticklenaked Pond	368	Ticklenaked Pond	1d	Generally Safe	Dolichospermum ; Microcystis ; Woronichinia ; Aphanothece ; Aphanocapsa ; Aphanizomenon	5862
2021-07-16	Lake Champlain	46	LTM 46	1d	Generally Safe	Dolichospermum ; Microcystis ; Gloeotrichia ; Aphanizomenon	8451
2021-07-16	Lake Champlain	50	LTM 50	1d	Generally Safe	Dolichospermum ; Microcystis ; Gloeotrichia ; Aphanothece ; Aphanocapsa	27624
2021-07-16	Lake Champlain	51	LTM 51	1d	Generally Safe	Dolichospermum ; Gloeotrichia ; Aphanothece ; Aphanocapsa ; Aphanizomenon	24229
2021-07-20	Lake Memphremagog	480	VT DEC Station 4, Memphremagog	1a	Generally Safe	none	0
2021-07-21	Lake Champlain	34	LTM 34	1d	Generally Safe	Dolichospermum ; Gloeotrichia ; Aphanothece ; Aphanocapsa ; Aphanizomenon ; Planktolyngbya	30368
2021-07-21	Lake Champlain	40	LTM 40	1d	Generally Safe	Dolichospermum ; Gloeotrichia ; Aphanothece ; Aphanocapsa ; Aphanizomenon ; Planktolyngbya	31635
2021-07-22	Lake Champlain	33	LTM 33	1d	Generally Safe	Dolichospermum ; Gloeotrichia ; Aphanothece ; Chroococcus	6420
2021-07-22	Lake Champlain	36	LTM 36	1d	Generally Safe	Dolichospermum ; Gloeotrichia ; Aphanocapsa ; Aphanizomenon ; Chroococcus	10553

2021-07-23	Lake Champlain	25	LTM 25	1d	Generally Safe	Dolichospermum ; Woronichinia ; Aphanothece ; Aphanocapsa ; Aphanizomenon ; Lyngbya ; Chroococcus	918
2021-07-26	Lake Champlain	2	LTM 02	1b	Generally Safe	Dolichospermum ; Aphanocapsa ; Aphanizomenon	966
2021-07-26	Lake Champlain	4	LTM 04	1b	Generally Safe	Dolichospermum ; Microcystis ; Aphanocapsa ; Aphanizomenon	6830
2021-07-27	Lake Champlain	7	LTM 07	1d	Generally Safe	Dolichospermum ; Microcystis ; Aphanothece ; Aphanocapsa ; Aphanizomenon ; Chroococcus	3711
2021-07-27	Lake Champlain	9	LTM 09	1d	Generally Safe	Dolichospermum ; Aphanocapsa ; Aphanizomenon ; Chroococcus ; Cylindrospermopsis ; Trichodesium	2108
2021-08-02	Lake Champlain	46	LTM 46	1a	Generally Safe	Dolichospermum ; Gloeotrichia ; Aphanizomenon ; Chroococcus	5166
2021-08-02	Lake Champlain	50	LTM 50	1d	Generally Safe	Dolichospermum ; Microcystis ; Gloeotrichia ; Aphanothece ; Aphanizomenon ; Chroococcus ; Merismopedia	18659
2021-08-03	Lake Champlain	34	LTM 34	1a	Generally Safe	Dolichospermum ; Gloeotrichia ; Aphanothece	6655
2021-08-04	Lake Champlain	25	LTM 25	1a	Generally Safe	Dolichospermum ; Microcystis ; Woronichinia ; Aphanocapsa ; Chroococcus	1820
2021-08-05	Lake Memphremagog	479	VT DEC Station 3, Memphremagog	1d	Generally Safe	Dolichospermum ; Microcystis ; Woronichinia ; Aphanothece ; Aphanocapsa ; Aphanizomenon ; Lyngbya ; Chroococcus ; Pseudanabaena	3734
2021-08-05	Lake Memphremagog	480	VT DEC Station 4, Memphremagog	1d	Generally Safe	Dolichospermum ; Microcystis ; Woronichinia ; Aphanothece ; Aphanocapsa ; Aphanizomenon ; Chroococcus ; Pseudanabaena	4966
2021-08-06	Lake Champlain	33	LTM 33	1d	Generally Safe	Dolichospermum ; Gloeotrichia ; Chroococcus	5155
2021-08-10	Lake Champlain	2	LTM 02	1b	Generally Safe	Dolicchospermum ; Microcystis ; Aphanizomenon	333
2021-08-10	Lake Champlain	4	LTM 04	1b	Generally Safe	Dolichospermum ; Microcystis ; Aphanocapsa ; Aphanizomenon	1651
2021-08-11	Lake Champlain	7	LTM 07	1d	Generally Safe	Dolichospermum ; Microcystis ; Aphanothece ; Aphanocapsa ; Aphanizomenon ; Chroococcus	2262
2021-08-11	Lake Champlain	9	LTM 09	1d	Generally Safe	Dolichospermum ; Microcystis ; Aphanothece ; Aphanocapsa ; Aphanizomenon ; Chroococcus	3174
2021-08-16	Lake Champlain	16	LTM 16	1d	Generally Safe	Dolichospermum ; Microcystis ; Aphanocapsa ; Aphanizomenon ; Chroococcus ; Gloeocapsa	4087
2021-08-16	Lake Champlain	19	LTM 19	1d	Generally Safe	Dolichospermum ; Microcystis ; Aphanothece ; Aphanocapsa ; Aphanizomenon ; Chroococcus ; Gloeocapsa	2410
2021-08-16	Lake Champlain	21	LTM 21	1d	Generally Safe	Dolichospermum ; Microcystis ; Woronichinia ; Aphanothece ; Aphanocapsa ; Aphanizomenon ; Chroococcus ; Gloeocapsa	2497
2021-08-17	Lake Champlain	34	LTM 34	1a	Generally Safe	Dolichospermum ; Woronichinia ; Aphanocapsa ; Aphanizomenon ; Chroococcus ; Gloeocapsa	1701
2021-08-17	Lake Champlain	40	LTM 40	1d	Generally Safe	Dolichospermum ; Microcystis ; Aphanothece ; Aphanocapsa ; Aphanizomenon ; Chroococcus ; Pseudanabaena ; Gloeocapsa	4344
2021-08-23	Lake Champlain	51	LTM 51	2	Low Alert	Aphanizomenon; Dolichospermum; Microcystis	1018
2021-08-25	Lake Champlain	25	LTM 25	1a	Generally Safe	Aphanizomenon; Lyngba	26
2021-08-26	Lake Champlain	33	LTM 33	1d	Generally Safe	Dolichospermum; Aphanizomenon; Lyngba	97
2021-08-26	Lake Champlain	36	LTM 36	1d	Generally Safe	Aphanizomenon; Dolichospermum; Microcystis	113
2021-08-27	Lake Carmi	409	Carmi DEC01-Central Open Water	2	Low Alert	Lyngba	30
2021-08-27	Lake Carmi	411	Carmi DEC03-Northeastern Open Water	2	Low Alert	Aphanizomenon; Dolichospermum; Lyngba; Microcystis; Oscillatoria; Woronichinia	2116
2021-08-30	Lake Champlain	2	LTM 02	1b	Generally Safe	Lyngba	58
2021-08-30	Lake Champlain	4	LTM 04	1b	Generally Safe	Microcystis; Aphanizomenon; Dolichospermum	802

2021-09-01	Lake Champlain	7	LTM 07	1d	Generally Safe	Microcystis; Aphanocapsa; Dolichospermum; Aphanizomenon; Planktothrix; Lyngba	2474
2021-09-01	Lake Champlain	9	LTM 09	1d	Generally Safe	Aphanizomenon; Lyngba; Microcystis	226
2021-09-02	Lake Memphremagog	480	VT DEC Station 4, Memphremagog	1d	Generally Safe	Coelosphaerium; Dolichospermum; Microcystis; Woronichinia	204
2021-09-03	Lake Champlain	16	LTM 16	1a	Generally Safe	Aphanizomenon; Dolichospermum; Lyngba	165
2021-09-03	Lake Champlain	19	LTM 19	1a	Generally Safe	Aphanizomenon; Aphanocapsa; Dolichospermum; Microcystis	188
2021-09-03	Lake Champlain	21	LTM 21	1a	Generally Safe	Aphanizomenon; Aphanocapsa; Lyngba	92
2021-09-08	Lake Carmi	411	Carmi DEC03-Northeastern Open Water	2	Low Alert	Aphanizomenon; Dolichospermum; Lyngba; Microcystis; Planktothrix; Woronichinia	1744
2021-09-09	Lake Champlain	34	LTM 34	1a	Generally Safe	Dolichospermum; Lyngba	46
2021-09-10	Lake Champlain	40	LTM 40	2	Low Alert	Aphanizomenon; Aphanocapsa; Dolichospermum; Microcystis; Merismopedia	400
2021-09-10	Lake Champlain	50	LTM 50	2	Low Alert		292
2021-09-10	Lake Champlain	51	LTM 51	2	Low Alert	Aphanizomenon; Dolichospermum; Microcystis	383
2021-09-13	Lake Champlain	36	LTM 36	1d	Generally Safe	Aphanizomenon; Dolichospermum; Microcystis	69
2021-09-13	Lake Champlain	46	LTM 46	1d	Generally Safe	Microcystis	246
2021-09-14	Lake Champlain	25	LTM 25	1d	Generally Safe	Aphanocapsa; Dolichospermum; Woronichinia	32
2021-09-14	Lake Champlain	33	LTM 33	1d	Generally Safe	Aphanizomenon	13
2021-09-15	Lake Memphremagog	480	VT DEC Station 4, Memphremagog	1d	Generally Safe	Aphanizomenon; Aphanocapsa; Dolichospermum; Lyngba; Microcystis; Woronichinia; Aphanothece	483
2021-09-16	Lake Champlain	2	LTM 02	1b	Generally Safe	Aphanizomenon; Microcystis	92
2021-09-16	Lake Champlain	4	LTM 04	1b	Generally Safe	Aphanizomenon; Aphanocapsa; Dolichospermum	57
2021-09-17	Lake Champlain	7	LTM 07	1d	Generally Safe	Aphanizomenon; Dolichospermum	40
2021-09-17	Lake Champlain	9	LTM 09	1d	Generally Safe	Aphanizomenon; Dolichospermum	35
2021-09-20	Lake Champlain	34	LTM 34	1a	Generally Safe	Aphanizomenon; Dolichospermum; Microcystis	49
2021-09-20	Lake Champlain	40	LTM 40	2	Low Alert	Aphanizomenon; Aphanocapsa; Dolichospermum; Microcystis	399
2021-09-21	Lake Champlain	46	LTM 46	1d	Generally Safe	Dolichospermum; Microcystis	65
2021-09-21	Lake Champlain	50	LTM 50	1d	Generally Safe	Aphanizomenon; Dolichospermum	1470
2021-09-22	Lake Carmi	409	Carmi DEC01-Central Open Water	2	Low Alert	Aphanizomenon; Dolichospermum; Lyngba; Microcystis; Woronichinia	3549
2021-09-22	Lake Carmi	410	Carmi DEC02-Southern Open Water	1d	Generally Safe	Aphanizomenon; Dolichospermum; Lyngba; Microcystis; Woronichinia	1743
2021-09-22	Lake Carmi	411	Carmi DEC03-Northeastern Open Water	2	Low Alert	Aphanizomenon; Dolichospermum; Microcystis; Woronichinia	3397
2021-09-23	Lake Champlain	16	LTM 16	1a	Generally Safe	Aphanizomenon; Microcystis	28
2021-09-23	Lake Champlain	19	LTM 19	1d	Generally Safe	Aphanizomenon; Coelosphaerium; Microcystis	63
2021-09-23	Lake Champlain	21	LTM 21	1a	Generally Safe	Aphanizomenon; Dolichospermum; Microcystis	186
2021-09-29	Lake Champlain	33	LTM 33	1d	Generally Safe	none	0
2021-09-30	Lake Memphremagog	480	VT DEC Station 4, Memphremagog	1d	Generally Safe	Aphanizomenon; Dolichospermum; Lyngba; Microcystis; Woronichinia	864
2021-10-05	Lake Champlain	2	LTM 02	1b	Generally Safe	Aphanizomenon	63
2021-10-05	Lake Champlain	4	LTM 04	1b	Generally Safe	Aphanizomenon; Dolichospermum	18
2021-10-06	Lake Carmi	409	Carmi DEC01-Central Open Water	3	High Alert	Aphanizomenon; Aphanocapsa; Dolichospermum; Microcystis; Woronichinia	3293

2021-10-06	Lake Carmi	410	Carmi DEC02-Southern Open Water	3	High Alert	Aphanizomenon; Aphanocapsa; Dolichospermum; Microcystis; Woronichinia	2874
2021-10-07	Lake Champlain	46	LTM 46	1d	Generally Safe	Microcystis	127
2021-10-07	Lake Champlain	50	LTM 50	1d	Generally Safe	Aphanizomenon; Dolichospermum	347
2021-10-07	Lake Champlain	51	LTM 51	2	Low Alert	Aphanizomenon; Dolichospermum; Microcystis	1753
2021-10-08	Lake Champlain	16	LTM 16	1d	Generally Safe	Aphanizomenon; Dolichospermum; Microcystis	72
2021-10-08	Lake Champlain	19	LTM 19	1d	Generally Safe	Aphanizomenon; Dolichospermum; Microcystis	226
2021-10-08	Lake Champlain	21	LTM 21	1d	Generally Safe	Aphanizomenon; Dolichospermum; Microcystis	280
2021-10-12	Lake Champlain	7	LTM 07	1d	Generally Safe	Aphanizomenon; Dolichospermum	32
2021-10-12	Lake Champlain	9	LTM 09	1d	Generally Safe	Aphanizomenon; Dolichospermum; Microcystis	80
2021-10-13	Lake Champlain	34	LTM 34	1d	Generally Safe	Aphanizomenon; Dolichospermum; Microcystis	23
2021-10-13	Lake Champlain	40	LTM 40	2	Low Alert	Aphanizomenon; Dolichospermum; Microcystis	437
2021-10-14	Lake Champlain	33	LTM 33	1d	Generally Safe	Aphanizomenon; Dolichospermum; Microcystis	88
2021-10-14	Lake Champlain	36	LTM 36	2	Low Alert	Aphanizomenon; Dolichospermum; Microcystis	75
2021-10-19	Lake Champlain	25	LTM 25	1a	Generally Safe	Aphanizomenon; Aphanocapsa; Dolichospermum; Microcystis; Woronichinia	80
2021-10-20	Lake Carmi	409	Carmi DEC01-Central Open Water	1d	Generally Safe	Aphanizomenon; Dolichospermum; Lyngba; Microcystis; Woronichinia	1095
2021-11-03	Lake Carmi	409	Carmi DEC01-Central Open Water	1d	Generally Safe	Dolichospermum; Microcystis; Woronichinia	356

Appendix C. Visual Assessment Protocols – Lake Champlain Committee

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

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- Job Openings

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.

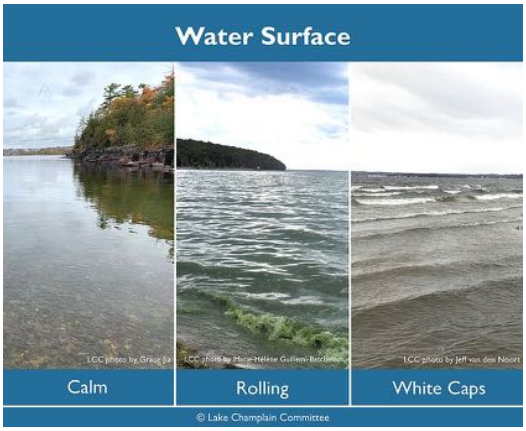
Please make observations at the same location once per week. Routine observations should be made no earlier than 10:00 AM and preferably by 3:00 PM. Blooms most frequently appear during this timeframe because cyanobacteria have had a chance to rise from lower in the water column in response to light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

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

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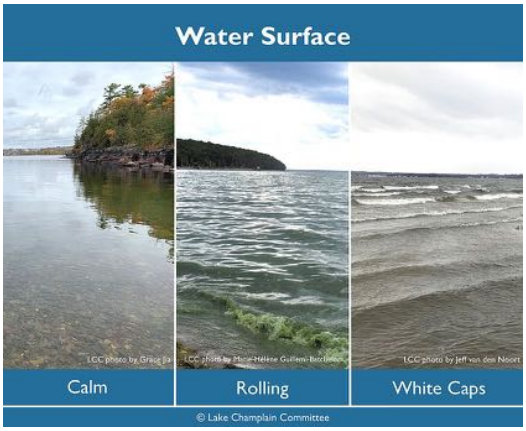

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What you may observe:

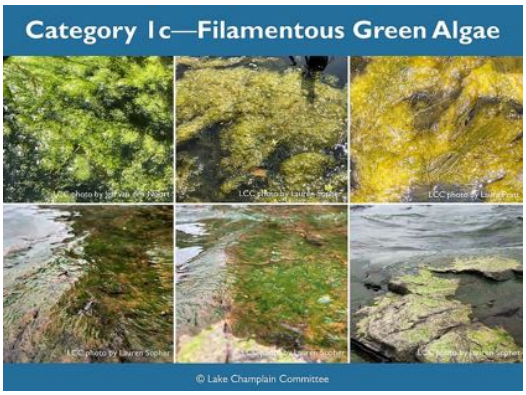
Foam

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

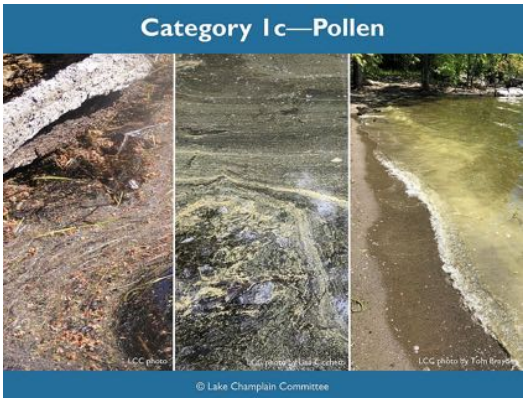
Pollen

What: a fine, powdery fertilizing element of flowering plants

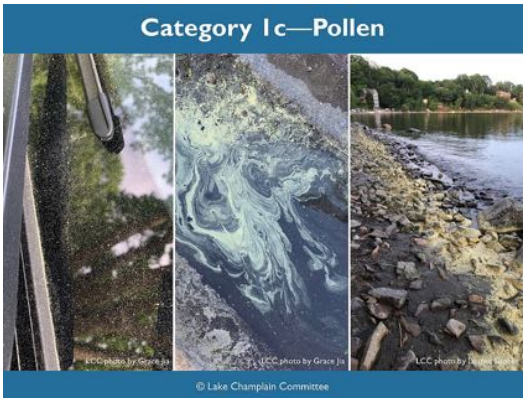
Looks Like: a thin film of sawdust on the water

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).

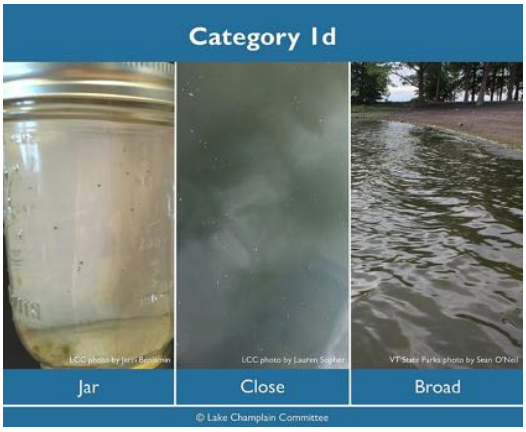


Category 1d: Little cyanobacteria observed—recreation not impaired—tiny specks present, but no streaks or patches—include photos

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

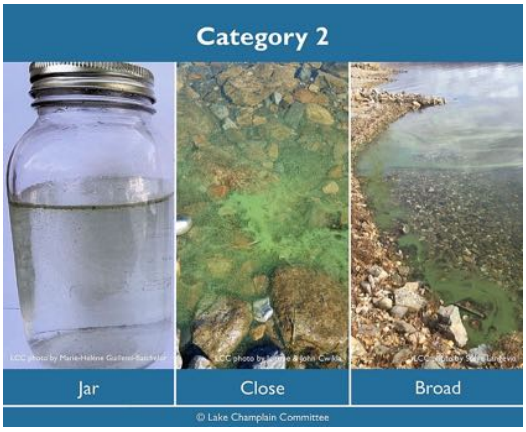


Category 2: Cyanobacteria present, but at less than bloom levels—include photos

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

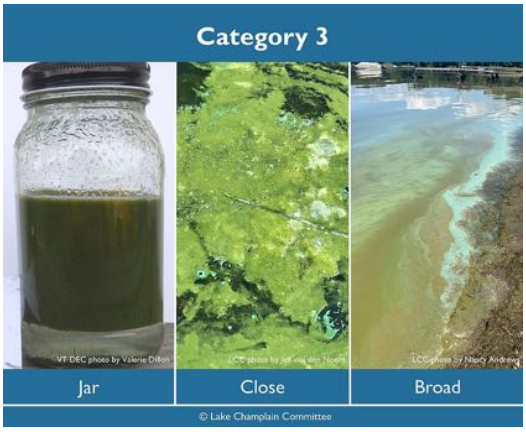


Category 3: Cyanobacteria bloom in progress—include photos

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

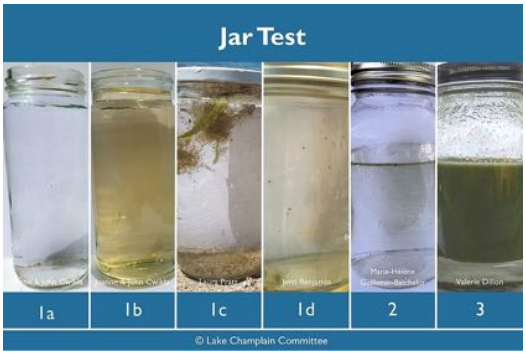
What you may observe:

- 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 D. Historical Microcystin Data for Lake Champlain

Note: Toxins before 2013 were 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).

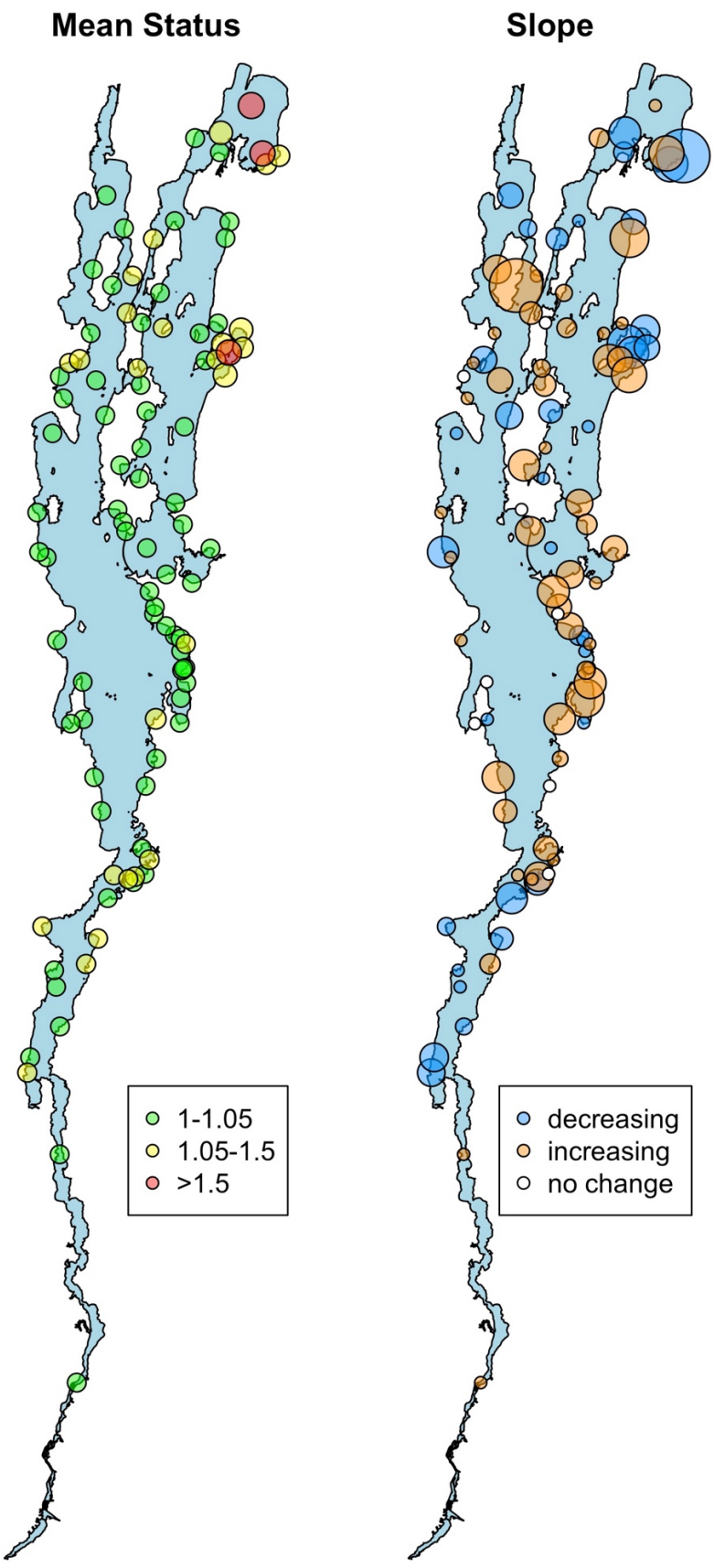
Lake Segment		2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Inland Sea	median	0.05	0.41	0.08	0.27	0.05	1.10	0.07	0.03	0.08		<0.16
	range	0.05 - 0.18	0.08-17.56	0.01-0.19	0.04-42.14	0.04-0.07	0.03-22.50	0.06-0.08	0.03-0.13	0.01-0.82		<0.16 - 0.43
	#samples	6	8	8	16	4	11	2	3	9	0	45
	#stations	1	3	3	7	3	4	2	2	4		4
Main Lake Central	median	0.05	NA	7.42	NA	2.82	0.25	0.03	0.10	0.02	0.13	<0.16
	range	0.01-0.12	NA	6.04-8.80	NA	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	NA	1	NA	2	2	3	5	4	1	2
Main Lake North	median	NA	NA	NA	NA	NA	NA	NA	NA	NA		
	range	NA	NA	NA	NA	NA	1.56	0.03	NA	0.01		
	#samples	0	0	0	0	0	1	1	0	1	0	0
	#stations	NA	NA	NA	NA	NA	1	1	NA	1		
Main Lake South	median	NA	NA	0.04	NA	NA	NA	NA	NA	0.01		<0.16
	range	0.07	NA	ND - 0.07	3.47	NA	NA	NA	NA	0.01		<0.16 - 0.16
	#samples	1	0	2	1	0	0	0	0	2	0	22
	#stations	1	NA	1	1	NA	NA	NA	NA	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	NA	NA	NA	0.04	NA	NA	NA	NA	NA		
	range	NA	NA	NA	0.04-0.08	NA	NA	NA	NA	0.04		
	#samples	0	0	0	7	0	0	0	0	1	0	0
	#stations	NA	NA	NA	2	NA	NA	NA	NA	1		
South Lake	median	0.96	NA	NA	NA	NA	NA	NA	NA	NA		
	range	0.53-1.38	NA	0.01	NA	NA	NA	NA	NA	0.02		
	#samples	2	0	1	0	0	0	0	0	1	0	0
	#stations	2	NA	1	NA	NA	NA	NA	NA	1		
Missisquoi Bay	median	0.09	0.84	0.66	0.52	NA	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	NA	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	NA	10	8	7	8	3	6

Appendix E: Examining Trends in Visual Report Data from Lake Champlain

As part of ongoing efforts to use visual monitoring data from the cyanobacteria monitoring program to improve our understanding of spatial and temporal patterns of cyanobacteria blooms (continuing work on the development of a cyanobacteria index from previous years), routine reports from Lake Champlain were analyzed and visualized. For this analysis, web status was converted to a numeric value (Generally Safe = 1, Low Alert = 2, High Alert = 3), and was averaged for each routine monitoring site in Lake Champlain, for each year. Only site-years with at least 5 observations at a given site were considered. Additionally, only sites with at least 4 years of valid site-years between 2013 and 2021 were selected, to ensure that there was a reasonable number of years of data from which to calculate trends. The combination of these criteria mean that a minimum of 20 visual observations were made at each of the selected sites. For each of the selected sites, mean values of web status were calculated, as well as the slope of numeric web status over time.

The resulting maps show a familiar pattern of areas where blooms tend to be the most severe (left panel, Mean Status). Note that the color code is not directly comparable to the mean status from earlier parts of the report (i.e., a yellow point does not indicate a mean status of 2). Rather, a yellow point indicates that at 1 least in 20 reports is “low alert” or about 1 in 10 is “high alert”, with the remaining observations “generally safe”. Similarly, a red point indicates that roughly 1 in 2 reports is “low alert”, or 1 in 4 reports is “high alert”. Larger points indicate sites with higher mean values.

The panel on the right (Slope) shows the trend over time in mean annual web status, with the size of the circles proportional to the steepness of the slope. Note that very few of these trends are statistically significant individually; this is largely due to the granularity of the data and the relatively short time series available. That being said, large numbers of trends in the same direction in the same geographic area, may provide stronger evidence that a change in bloom frequency is occurring even if the individual trends are not statistically significant. The figure below is not conclusive, but suggests that blooms may be declining slightly in some areas with historically severe blooms (Missisquoi Bay and inner St. Albans Bay), but other areas (particularly around Burlington and Mallett’s Bay) have almost exclusively positive trends over time, indicating that blooms in these areas may be becoming more severe.


Mean Status
1-1.05
1.05-1.5
>1.5
Slope
decreasing
increasing
no change