Cyanobacteria Monitoring on Lake Champlain Summer 2018

Annual Report for the Lake Champlain Basin Program

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Prepared by

Angela Shambaugh, Project Coordinator
Watershed Management Division
Vermont Department of Environmental Conservation
Montpelier, Vermont

in conjunction with

Bridget O'Brien
Environmental Health Division
Vermont Department of Health
Burlington, Vermont

Lori Fisher
Lake Champlain Committee
Burlington, Vermont

Heather Campbell
Drinking Water & Groundwater Protection Division
Vermont Department of Environmental Conservation
Montpelier, Vermont

Executive Summary

An annual 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 citizen volunteers.

Cyanobacteria monitoring on Lake Champlain in 2018 continued to integrate qualitative observations, photographic documentation, and quantitative analysis of cyanobacteria populations into guidance for lake users. Analysis of water for the presence of microcystin, cylindrospermopsin, and anatoxin, when warranted, provided additional data to inform public health decisions in response to the presence of cyanobacteria.

Objectives

- monitor cyanobacteria at locations on Lake Champlain and select Vermont inland lakes through the established partnership between state staff, the Lake Champlain Committee and citizen volunteers;
- provide consistent quantitative data at selected locations around Lake Champlain and select Vermont lakes;
- test for the presence of cyanotoxins when cyanobacteria density and composition triggers are reached at select monitoring locations;
- 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; and
- 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.

Citizen volunteers, staff, and the general public submitted 1855 site-specific reports during 2018 from Lake Champlain and inland lakes in Vermont. Citizen volunteers trained by the Lake Champlain Committee reported from 121 locations on Lake Champlain and several other Champlain Basin lakes in Vermont. Alert level conditions were reported 195 times on Lake Champlain during the monitoring period in 2018. Microcystin was detected at locations on Champlain and Lake Carmi in 2018. No locations exceeded the Vermont recreational guidance values for microcystin. Anatoxin was detected at one location in St. Albans Bay, also below Vermont's recreational guidance value.

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Introduction

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 citizen volunteers. 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 and citizen volunteers;
- provide consistent quantitative data at these locations to inform public health decisions and assess long-term trends;
- test for the presence of cyanotoxins when cyanobacteria density and composition triggers are reached at selected monitoring locations;
- facilitate communication about lake conditions through weekly updates to stakeholders via email and to the public through the Vermont Department of Health webpage;
- strengthen communication among the jurisdictions on Lake Champlain responsible for cyanobacteria response; and
- 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 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 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).

The Vermont Department of Health (VDH) and the VT DEC's Drinking Water and Groundwater Protection Division (DWGWPD) are strong partners in this monitoring program. Their funding is provided by the VDH and VT DEC, respectively, and occasionally includes grants from other sources. VDH provides the technical support underlying the CyanoTracker website, monitoring at selected locations, toxin testing for locations on Lake Champlain and Vermont inland lakes, and bloom response in Vermont. DWGWPD works with VDH to provide technical support for Vermont drinking water suppliers drawing from Lake Champlain.

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.

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.

Methods

The 2018 cyanobacteria monitoring program was coordinated by the VT DEC and implemented in conjunction with the VDH and LCC. Semi-qualitative visual data from Lake Champlain and other Vermont lakes monitored by LCC volunteers were collected following the protocol developed and maintained by the LCC. VT DEC volunteers reporting from lakes outside the Champlain Basin followed the same protocols. Quantitative samples were collected at selected open water stations historically monitored by the CLTM on Lake Champlain. Additional water samples for quantitative assessment were collected routinely at select shoreline locations on Lake Champlain and Lake Carmi by citizen volunteers and VDH staff. Additional samples, primarily from lakes reporting blooms for the first time or at managed recreational areas, were also analyzed as part of this project. Reports from the monitoring partners and volunteers were uploaded via a controlled web interface directly to the Cyanobacteria Tracking map (CyanoTracker) maintained by the VDH.

Sampling Locations

During the summer of 2018 reports were routinely received from 137 monitored locations around Lake Champlain and from several Vermont inland lakes. Table 1 provides a summary of stations by region, evaluation protocol, and type of site. Full documentation of the sampling locations is located in Appendix A.

Table 1. Location of routinely monitored stations and sampling method utilized in 2018. 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.

Lake	Region	Monitoring Method		
		Visual	Visual/quantitative	Open water protocol
Caspian Lake (Greensboro VT)		1		
Coles Pond (Walden VT)		1		
Lake Carmi (Franklin VT)		4	2	1
Champlain	Inland Sea	23		1
	Main Lake Central	27	2	4
	Main Lake North	11	1	2
	Main Lake South	16	1	2
	Malletts Bay	6		1
	Missisquoi Bay	3	1	3
	South Lake			2
	St. Albans Bay	5	1	1
Lake Iroquois (Hinesburg & Williston VT)		1		
Lake Memphremagog (Derby & Newport VT)		6		
Lake Morey (Fairlee VT)		1		
Lake Willoughby (Westmore VT)		1		
North Hartland Reservoir ((Hartland VT)		1		
Shelburne Pond (Shelburne VT)		1		
Stoughton Pond (Stoughton VT)		1		
Ticklenaked Pond (Ryegate VT)				1
Townshend Lake (Townshend VT)		1		
Total stations		**111**	**8**	**18**

Monitoring Protocols

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 (mid-June through early September). While the LCC did recruit to gain as wide a geographic distribution as possible, no volunteer was turned away. On Lake Champlain, this can lead to a cluster of observation points. All volunteers attended a mandatory training session to learn to recognize cyanobacteria, become familiar with the assessment protocol, and learn how to submit their weekly reports. LCC staff met with or interacted with each volunteer 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 citizens in 21 formal training sessions during 2018. Additional informal training sessions were provided at roughly a dozen public presentations and tabling events throughout the year. Over the course of the summer, LCC volunteer monitors reported from 121 different locations in 2018 (Figure 1 and Appendix A).

VT DEC also recruited and trained 16 volunteers to monitor on inland Vermont lakes following the LCC protocols. Training was conducted in person and by webinar. The webinar recording was posted on the VT DEC's cyanobacteria website as a resource for volunteers. VT DEC staff also interacted regularly with citizen volunteer monitors.

Weekly Observation Process - Volunteers

Monitoring by volunteers began the week of June 11. Volunteers committed to monitoring through early 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 three categories:

- Category 1 – very few or no cyanobacteria observed, recreational enjoyment not impaired by cyanobacteria.
- Category 2 – cyanobacteria present at less than bloom levels.
- Category 3 – cyanobacteria bloom in progress.

The description 'bloom' is not a well-defined scientific defined 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 algae are also known as blooms but under this protocol are captured in category 1.

Each volunteer was asked to provide three photographs whenever category 2 or category 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. LCC and state staff conferred with volunteers as needed to verify the presence of cyanobacteria and appropriate status. The LCC approved reports submitted directly by volunteers to the VDH web interface and uploaded any sent directly to LCC as quickly as possible. Their staff also followed up with volunteers when no reports were received. Category 2 and 3 reports were given priority, shared with partners at the VDH and VT DEC immediately, and posted immediately after any necessary verification.

In addition to the photos, four sites visited by volunteers were also assessed quantitatively:

North Beach - Burlington VT
Red Rocks Park – South Burlington VT
St. Albans Bay Park – St. Albans VT
The Shipyard - Highgate VT

Each week, these volunteers made a visual assessment and collected water samples from the shore. These unfiltered samples were analyzed for microcystin and anatoxin. Cyanobacteria and algae were identified and counted. 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 when evaluating recreational risk.

Weekly VDH Surveillance

The VDH conducted routine weekly monitoring at select sites on Lake Champlain and Lake Carmi:

Alburgh Dunes State Park – Alburgh VT
Tri-Town Rd – West Addison VT
Lake Carmi State Park – Franklin VT
Lake Carmi North Beach – Franklin VT

These locations were areas with high recreational usage, prone to blooms, or located in the vicinity of drinking water facilities. VDH staff made visual assessments and collected water samples for microcystin, anatoxin, and cyanobacteria density analyses. Samples were collected following the protocols used by the LCC volunteers. These samples were also used to evaluate the effectiveness of the visual assessment protocol.

The Open Water Protocol

Qualitative and quantitative data on taxonomic distribution, cell density and the presence of toxins were collected by the VT DEC following the Open Water Protocol. VT DEC staff conducted cyanobacteria assessments during their biweekly monitoring for the Champlain Long-term Water Quality and Biological Monitoring Project (CLTM). At each monitoring site, staff utilized the visual assessment protocol to evaluate cyanobacteria conditions and collected a 3m plankton tow. Cyanobacteria 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, anatoxin, and cylindrospermopsin) and cyanobacteria density. At locations where blooms were uncommon, whole water surface grabs for toxin and cyanobacteria were also collected during category 2 conditions. Routine monitoring began June 4th and continued through early October.

VT DEC also routinely visited open water stations on Lake Carmi and Ticklenaked Pond in Vermont beginning in late May. Visual assessments were made at these stations during each visit. Water samples were collected from one open water location during bloom events on both lakes.

Field Methods

Plankton were collected as integrated 63 µm mesh plankton net for determination of cyanobacteria density. Net concentrates were obtained by lowering the plankton net opening to 3m and drawing it steadily back to the surface. When alert level conditions were observed, a single whole water sample was

collected by placing a bucket 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 until they reached 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 – 15 minutes before analysis. Estimates of cell density were obtained for all observed cyanobacteria and selected other taxa using the size categories noted in Table 2. 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 while most other algae were identified simply at the division level, e.g. green algae or diatoms. Identical counting protocols were used for whole water and plankton concentrates. Plankton samples were counted by VT DEC staff 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 2. Size categories and cell factors used to estimate field densities of colonial algae.

Taxon	Unit Category	Estimated cells/unit	Cell factor
Anabaena *Aulocoseira* *Fragilaria*	Fragment Small Medium Large	< 20 20 – 100 100 – 1000 >1000	10 60 500 1000
Microcystis *Coelosphaerium* *Woronichinia*	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 *Lyngbya/Scytonema*	fragment	Single trichome	Measured

Reports from Other Sources

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. Additionally, reports were received from the general public by email, telephone and VDH's BloomAlert. These reports were evaluated and confirmed utilizing photos, descriptive information, and available corroborating information before posting to the CyanoTracker map.

Source	Number of Reports
BloomAlert	14
LCC Staff	26
LCC Volunteer	1388
MWA Volunteer	96
NY DEC	2
NYDOH	3
Other	16
Town Health Officer	1
USACE	34
VDH	73
VT DEC	164
VT DEC Volunteer	38

Toxin Analysis

Toxin analyses were conducted by the VDH 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.

Toxin Monitoring at Vermont Drinking Water Facilities

In 2018, the DWGWPD and the VDH received funding from the CDC's Public Health Emergency Preparedness Grant to support 12 weeks of 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 and cylindrospermopsin by ELISA. All sample containers and labels were provided to the facilities. Sample drop-off and pick-up opportunities were also provided.

Sampling began July 13, 2018. All 22 public facilities participated, though several systems do not operate after Labor Day. Results were shared with operators by the VDH lab and DWGWPD.

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, cell density, species composition and toxin data were provided to a group of stakeholders responsible for public health. These were primarily state and town health officials, state and town waterfront managers, Champlain water suppliers, and researchers. Updates were released typically on Friday mornings, but stakeholders also received email notification of extensive blooms as they occurred. The Lake Champlain Committee also provided weekly emails to LCC volunteer monitors and partner agencies as well as interested citizens, other agencies, and the media.

Notification of the Public

The Vermont Department of Health reported current cyanobacteria status on Lake Champlain on-line at http://healthvermont.gov/tracking/cyanobacteria-tracker. Status was presented as text and on an interactive web map that allowed viewers to find information by location around the lake. 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

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 2018.

The CyanoTracker software occasionally experienced problems beyond VDH's control in 2018. VDH staff worked to restore functionality as soon as practical. In those situations, monitors often used LCC's online reporting form to file reports or called LCC to verbally report information. These reports were added to the Tracker by LCC as soon as practical.

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 citizens and the media.

Results

Overall effort

We received 1855 site-specific reports in 2018. These were provided by project partners, volunteers, and others (Table 3). Most were from Lake Champlain, however regular reports were also provided from 11 inland lakes in Vermont by VDH staff, the US Army Corp (USACE) and volunteers coordinated by LCC or VT DEC. Reports based on the visual assessment protocol represented 85% of the total received. The remaining reports were obtained at the shoreline quality control stations or using the open water protocol.

Table 3. Summary of the 2018 cyanobacteria monitoring station reports. () indicates supplemental reports 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. Further information about locations can be found in Appendix A.

Waterbody	Region	Monitor	Assessment Method		
			Visual Assessment	Visual/ Quantitative	Open Water Protocol
Baker Pond (Brookfield VT)		VT DEC	(1)		
Caspian Lake (Greensboro VT)		VT DEC Volunteer	12		
Clyde Pond (Derby VT)		MWA Volunteer	(1)		
Coles Pond (Walden VT)		VT DEC Volunteer	12		
Fairfield Pond (Fairfield VT)		Other	(1)		
		VT DEC	(1)		
High Pond (Sudbury VT)		VT DEC	(1)		
Joes Pond (Danville VT)		Bloom Alert	(1)	(1)	
Lake Carmi (Franklin VT)		Bloom Alert	(1)		
		LCC Volunteer	36 (16)	(1)	
		Other	(1)		
		VDH	(1)	28	
		VT DEC	12		14
Champlain (VT, NY and QC)	Inland Sea	Bloom Alert	(3)		
		LCC Volunteer	237 (48)		
		Other	(4)		
		VDH	(2)	(2)	
		VT DEC		(1)	8
	Main Lake Central	BloomAlert	(1)		
		LCC Staff	10 (5)		
		LCC Volunteer	309 (42)	28 (2)	
		VDH		(3)	
		VT DEC			26 (1)
	Main Lake North	LCC Staff	(2)		
		LCC Volunteer	141 (16)		

Waterbody	Region	Monitor	Assessment Method		
			Visual Assessment	Visual/ Quantitative	Open Water Protocol
Champlain	Main Lake North	VDH		11	
		VT DEC			14
	Main Lake South	BloomAlert	(4)		
		LCC Volunteer	189 (29)	(1)	
		NY DEC	(1)		
		NYDOH	(3)		
		Other	(1)		
		VDH	(1)	14 (6)	
		VT DEC			12
	Malletts Bay	LCC Volunteer	69 (31)		
		NY DEC	(1)		
		Other	(1)		
		VT DEC	1 (2)		8
	Missisquoi Bay	BloomAlert	(1)		
		LCC Volunteer	26(28)	13 (1)	
		Other	(1)		
		VT DEC	(2)		24
	South Lake	LCC Volunteer	4		
		VT DEC			16
	St. Albans Bay	LCC Staff	(5)		
		LCC Volunteer	36 (26)	9	
		VDH	(1)	3(1)	
		VT DEC	(3)		8
Lake Iroquois (Hinesburg & WillistonVT)		LCC Volunteer	33 (8)		
Lake Memphremagog ((Derby & Newport VT)		LCC Staff	(1)		
		MWA Volunteer	64 (31)		
Lake Morey (Fairlee VT)		Other	(4)		
		VT DEC Volunteer	5 (1)		
Lake Salem (Derby VT)		Other	(1)		
		VT DEC	(1)		
Lake St. Catherine (Poultney VT)		BloomAlert	(2)		
Lake Willoughby (Westmore VT)		VT DEC Volunteer	5		
Nichols Pond (Woodbury VT)		Other	(1)		
North Hartland Reservoir (North Hartland VT)		USACE	11		
Rock River (VT & QC, Morses Line VT)		Other	(1)		
Saxtons River Recreation Area (Rockingham VT)		VT DEC	(2)		
		Other	(1)		
Shelburne Pond (Shelburne VT)		LCC Volunteer	12		

Waterbody	Region	Monitor	Assessment Method		
			Visual Assessment	Visual/ Quantitative	Open Water Protocol
Stoughton Pond (Stoughton VT)		USACE	11		
Ticklenaked Pond (Ryegate VT)		VT DEC	6		
		VT DEC Volunteer	(3)		
Townshend Lake (Townshend VT)		USACE	12		
Total Reports = 1855			**1590**	**126**	**139**

The number of samples analyzed in 2018 is summarized in Table 4. Two hundred seventy-four water samples were analyzed for phytoplankton density, 141 for microcystin, 121 for anatoxin, and 13 for cylindrospermopsin. Most toxin samples were collected for quality control purposes and were not triggered by assessment reports.

Table 4. Number of water and phytoplankton samples collected and analyzed in 2018. Data compiled from the season summary spreadsheet available through the VDH Tracking Map. Cylindrospermopsin was measured in response to bloom events.

Assessment Type	Phytoplankton		Microcystin	Anatoxin	Cylindrospermopsin
	Plankton Net	Whole water	Whole water	Whole water	Whole Water
Open Water Protocol	135	3	2	2	
Visual/Quantitative		136	139	119	13
Total	**135**	**139**	**141**	**121**	**13**

Assessment Results – Recreational Monitoring

Summaries of the assessment results from regularly monitored sites in 2018 is presented in Figure 2. The highest monitoring category reached in each region of Lake Champlain and Vermont inland lakes for is noted in Table 5. 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 (85%) received from routinely monitored sites on Lake Champlain and Vermont inland lakes indicated that few or no cyanobacteria were present (category 1 of the visual protocol). In all, 277 reports of alert conditions (categories 2 and 3) were received from regularly monitored sites, routine and supplemental, during the summer of 2018, 15% of the total reports received. The highest density of potentially toxic cyanobacteria was observed at the Shipyard in Highgate Springs VT (Champlain - Missisquoi Bay) on September 10, 2018 (6,636,000 cells/mL).

Figure 2. Summary of assessment reports received in 2018; 2a –Lake Champlain, 2b and 2c – Vermont inland lakes. Data compiled from the season summary spreadsheet available through the VDH Tracking Map.

Figure 2a -Lake Champlain regions

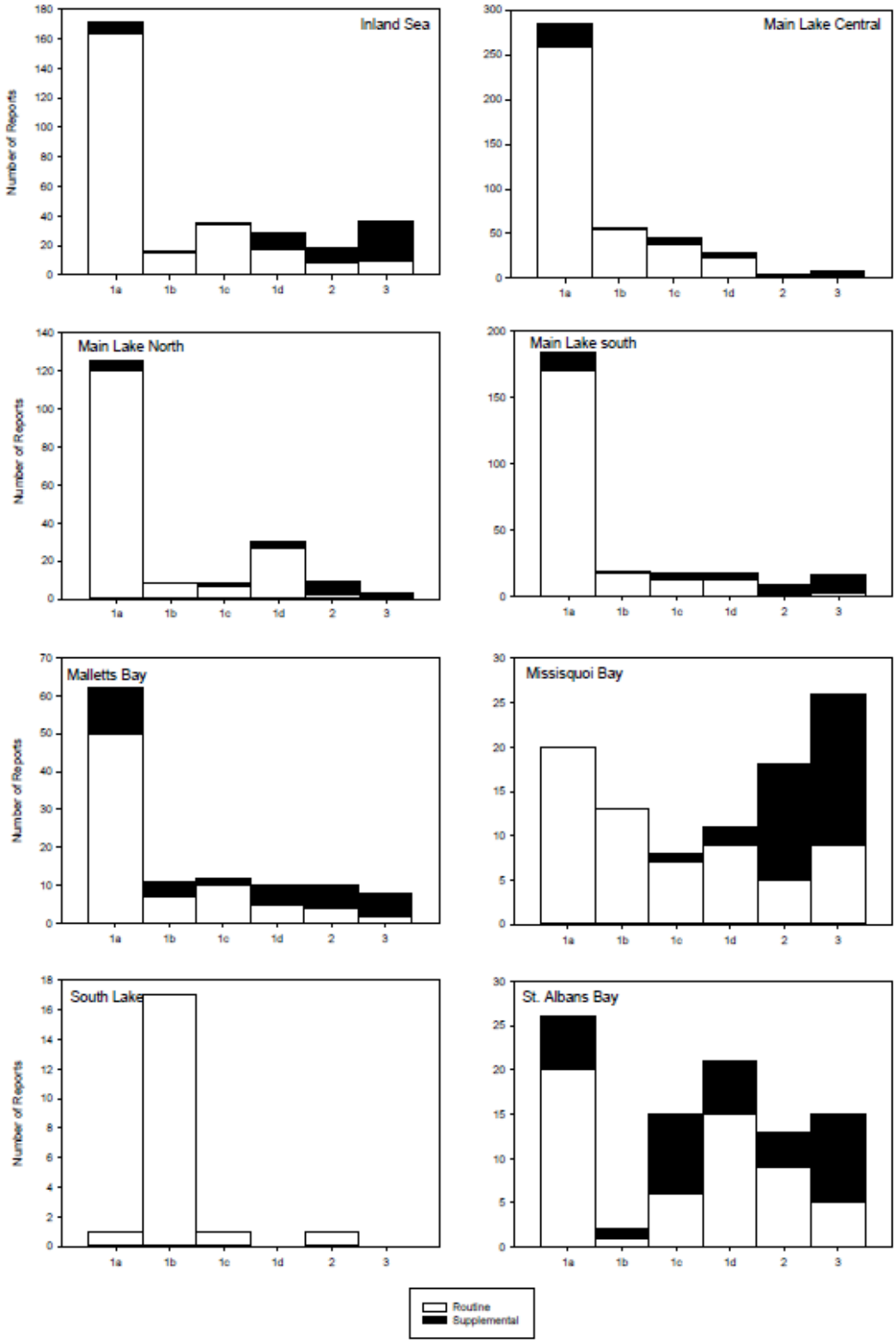


Figure 2b – Vermont inland lakes

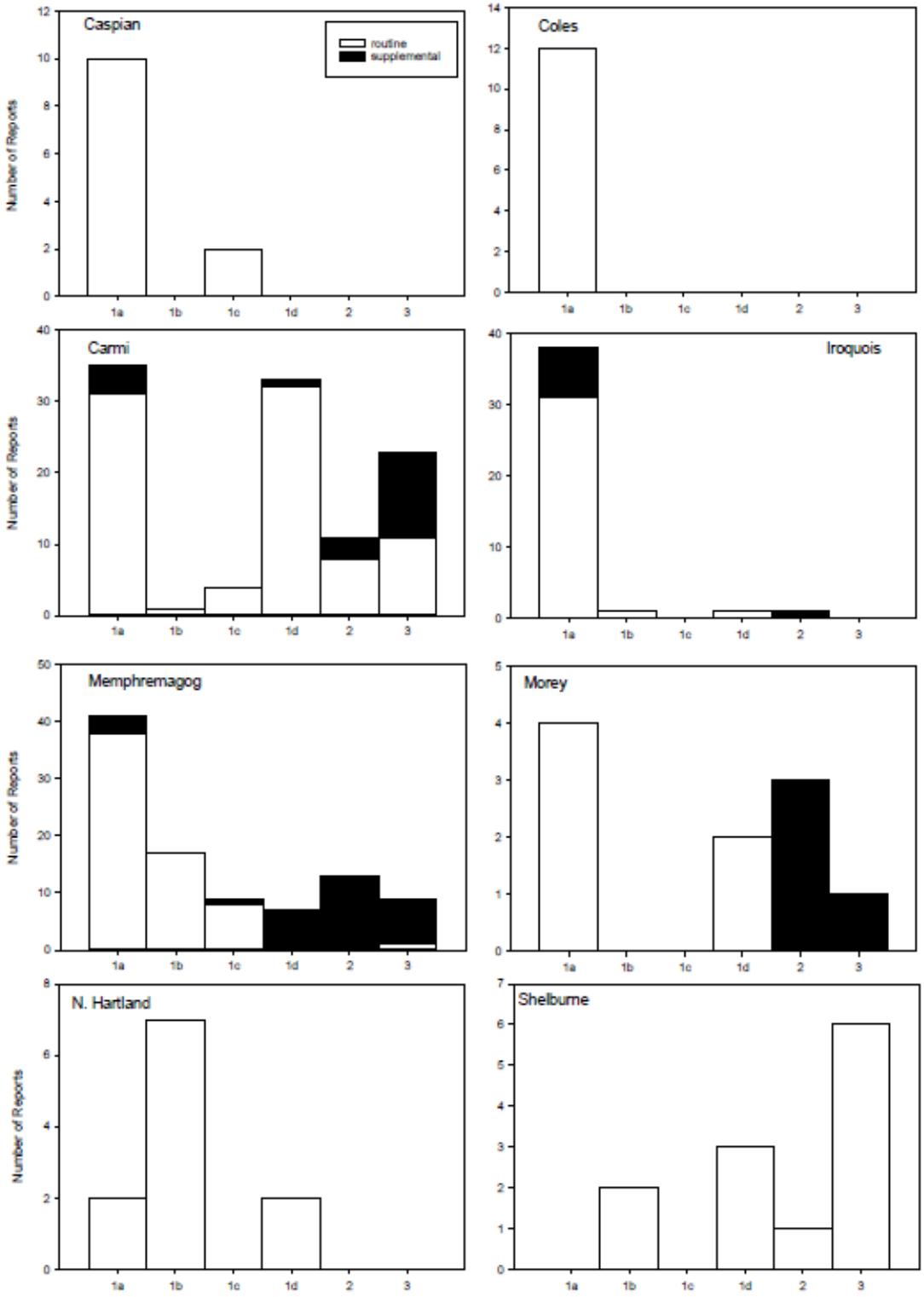
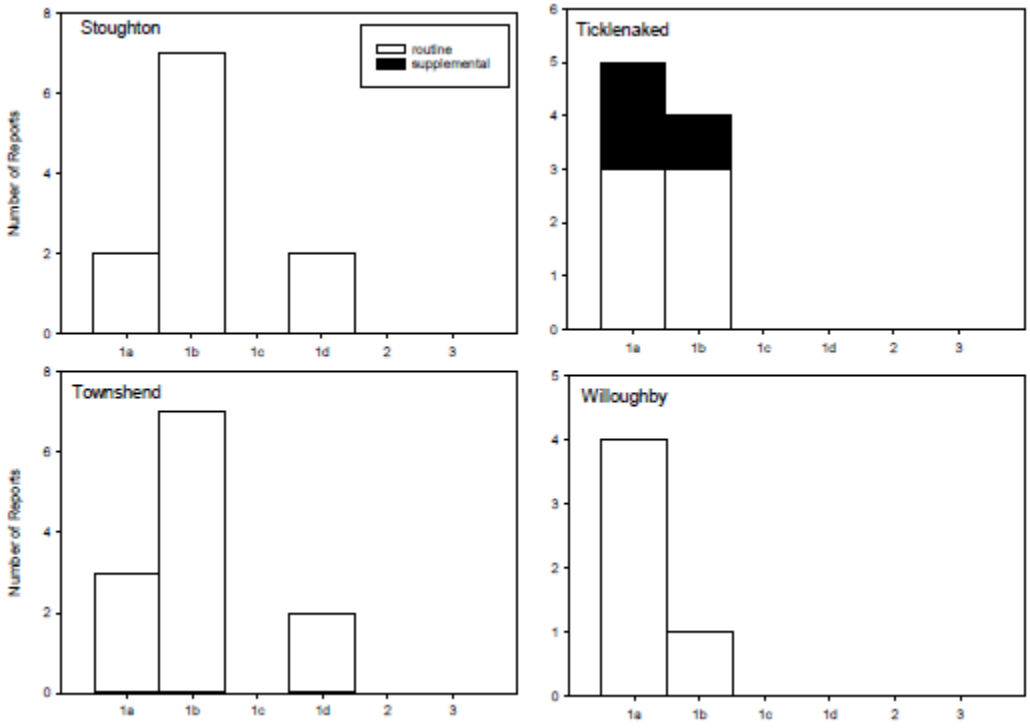


Figure 2c – Additional Vermont inland lakes



A total of 141 shoreline samples were analyzed for the presence of microcystin, 121 for anatoxin, and 13 for cylindrospermopsin in 2017 (Table 4) from both routine sites and one-time bloom events at other locations. The number of samples tested for each waterbody is provided in Table 5. Microcystin was detected at three locations over the summer of 2018 – Missisquoi and St. Albans Bays on Lake Champlain and Lake Carmi. The highest observed concentration of microcystin was measured on September 18 at North Beach on Lake Carmi (1.19 µg/L). Anatoxin was detected in a single sample from St. Albans Bay Park on August 14. There were no detections of cylindrospermopsin.

Table 5. Highest status reached in each waterbody in 2018. Data compiled from the season summary spreadsheet available through the VDH Tracking Map. Methods: V = visual, V/Q = visual/quantitative, O = open water protocol.

Lake	Region	Method	# Reports	Highest Status Observed	Highest Cell Density Observed, cells/mL	Highest Micro-cystin, µg/L (# Tested)	Highest Anatoxin µg/L (# Tested)	Highest Cylindro-spermopsin, µg/L (# tested)
Baker Pond (VT)		V	1	Low Alert	Not Tested	Not Tested	Not Tested	Not Tested
Caspian Lake (VT)		V	12	Generally Safe	Not Tested	Not Tested	Not Tested	Not Tested
Lake Carmi (VT)		V, V/Q	110	High Alert	1,156,600	**1.19** (32)	<0.5 (18)	Not Tested
Clyde Pond (VT)		V	1	Low Alert	Not Tested	Not Tested	Not Tested	Not Tested

Lake	Region	Method	# Reports	Highest Status Observed	Highest Cell Density Observed, cells/mL	Highest Micro-cystin, µg/L (# Tested)	Highest Anatoxin µg/L (# Tested)	Highest Cylindro-spermopsin, µg/L (# tested)
Coles Pond (VT)		V	12	Generally Safe	Not Tested	Not Tested	Not Tested	Not Tested
Champ-lain	Inland Sea	V, V/Q, O	132	High Alert	321,200	<0.16 (5)	<0.5 (2)	<0.5 (1)
	Main Lake Central	V, V/Q, O	427	High Alert	19,300	<0.16 (36)	<0.5 (30)	Not Tested
	Main Lake North	V, V/Q, O	183	High Alert	18,700	<0.16 (11)	<0.5 (11)	Not Tested
	Main Lake South	V, V/Q, O	262	High Alert	21,600	<0.16 (21)	<0.5 (21)	<0.5 (7)
	Malletts Bay	V,O	113	High Alert	597	<0.16 (6)	Not Tested	Not Tested
	Missisquoi Bay	V, V/Q, O	96	High Alert	6,636,000	**0.38** (16)	<0.5 (16)	Not Tested
	South Lake	V,O	20	Low Alert	1670	Not Tested	Not Tested	Not Tested
	St. Albans Bay	V, V/Q, O	92	High Alert	1,733,200	**0.27** (13)	**0.78** (13)	<0.5 (1)
Fairfield Pond (VT)		V	2	High Alert	Not Tested	Not Tested	Not Tested	Not Tested
High Pond (VT)		V	1	Low Alert	Not Tested	Not Tested	Not Tested	Not Tested
Lake Iroquois (VT)		V	41	Low Alert	Not Tested	Not Tested	Not Tested	Not Tested
Joes Pond (VT)		V	2	Low Alert	Not Tested	Not Tested	Not Tested	Not Tested
Lake Memphremagog (VT)		V	96	High Alert	Not Tested	Not Tested	Not Tested	Not Tested
Lake Morey (VT)		V	10	High Alert	Not Tested	Not Tested	Not Tested	Not Tested
Nichols Pond (VT)		V	1	Low Alert	90	Not Tested	Not Tested	Not Tested
North Hartland Reservoir (VT)		V	11	Generally Safe	Not Tested	Not Tested	Not Tested	Not Tested
Rock River (QC)		V	1	High Alert	Not Tested	Not Tested	Not Tested	Not Tested
Lake St. Catherine (VT)		V	2	High Alert	Not Tested	Not Tested	Not Tested	Not Tested
Lake Salem (VT)		V	2	High Alert	Not Tested	Not Tested	Not Tested	Not Tested
Saxtons River Rec Area (VT)		V	3	High Alert	Not Tested	<0.16 (1)	Not Tested	Not Tested
Shelburne Pond (VT)		V	12	High Alert	Not Tested	Not Tested	Not Tested	Not Tested
Stoughton Pond (VT)		V	11	Generally Safe	Not Tested	Not Tested	Not Tested	Not Tested
Ticklenaked Pond (VT)		V, O	9	Generally Safe	141	Not Tested	Not Tested	Not Tested
Townshend Lake (VT)		V	12	Generally Safe	Not Tested	Not Tested	Not Tested	Not Tested
Lake Willoughby (VT)		V	5	Generally Safe	Not Tested	Not Tested	Not Tested	Not Tested

Twenty-five cyanobacteria taxa were observed in Lake Champlain or inland lakes during the 2018 monitoring period (Table 6). The majority have been identified as potential toxin producers in the scientific literature.

Table 6. Cyanobacteria taxa observed in Lake Champlain cyanobacteria monitoring samples. Year of first report refers only to the cyanobacteria monitoring program. *Prior to 2012, cyanobacteria were noted to genus only.

Name	Toxin producer	Present in 2018	Year of first report
Anabaena circinalis	yes	yes	2003*
Anabaena planctonica	yes	yes	2003*
Anabaena spp	yes	yes	2003*
Anabaena flos-aquae	yes	no	2015
Aphanizomenon spp. (likely *A. gracile*)	yes	yes	2012
Aphanizomenon flos-aquae	yes	yes	2003*
Aphanocapsa spp.	no	yes	2004
Aphanothece spp.	yes	yes	2012
Arthrospira spp.	no	yes	2012
Chroococcus spp.	no	yes	2003
Coelosphaerium spp.	Yes	yes	2003
Cyanodictyon spp.	no	no	2016
Gloeotrichia spp.	yes	yes	2003
Gloeocapsa spp.	yes	no	2004
Komvophoron spp.	yes	no	2016
**Limnothrix* spp.	possible	yes	2012
Merismospedia spp.	no	yes	2003
Microcystis spp.	yes	yes	2003*
Microcystis wesenbergii	yes	yes	2012
Oscillatoria spp.	yes	yes	2005
Planktothrix spp.	yes	yes	2017
**Pseudanabaena* spp	yes	yes	2012
**Radiocystis* spp.	possible	yes	2012
Romeria spp.	no	yes	2014
**Scytonema crispum* (synonym *Lyngbya cinncinata*)	yes	yes	2012
Snowella spp	no	yes	2012
Trichodesmium spp	no	no	2015
Woronichinia spp (formerly *Gomphosphaeria* spp.)	yes	yes	2012
Filamentous cyanobacteria (Oscillatoriales)	possible	yes	2014
colonial taxon (likely *Cyanonephron* spp.)	no	yes	2014

Drinking Water Supply Monitoring

In 2018, the VDH offered, with support from the CDC Public Health Emergency Preparedness grant, free weekly microcystin testing for public drinking water facilities in Vermont from July 13 through September 28. The DWGWPD organized training sessions for facility operators, where LCC provided guidance on the visual assessment system, VDH provided an overview of Vermont's guidance for cyanotoxins in drinking water, and DWGWPD discussed treatment options for cyanobacteria and toxins in drinking water systems. Results of the summer's testing are can be found online at http://dec.vermont.gov/water/drinking-water/water-quality-monitoring/blue-green-algae/cyanotoxin-monitoring. There were no confirmed microcystin detections at these facilities in 2018.

Volunteer training

Volunteer trainings were conducted by LCC staff at locations around the Lake Champlain Basin. Twenty-one formal sessions trained nearly 300 potential monitors and interested citizens. Numerous media interviews and appearances alerted the public to the opportunity to become a volunteer monitor. LCC staff provided training for Vermont drinking water facility operators and for watershed organizations on Lakes Carmi, Iroquois and Memphremagog who wished to develop volunteer monitoring networks at those lakes.

In 2018, training for the Northwest Region Vermont State Parks staff switched from a direct training of all staff to a train-the-trainer model. In this new model, LCC trained the parks regional coordinator, who then trained on-the ground staff. The goal of this strategy was to build the capacity for cyanobacteria monitoring within the State Parks organization by getting more buy-in from monitoring staff and holding monitors accountable to someone inside their organization. This strategy helped increase the number of reports received from Vermont State Park locations, with 212 reports (146 routine) received from VT State Park locations in 2018 compared to 131 reports (115 routine) in 2017. Note that not all reports from State Park locations are necessarily from State Parks staff.

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 on-line LCC 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.

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 citizens 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.

Regional and National Activities

Project partners are active at the local, regional and national level. Partners continue to work closely with state and provincial staff in New York and Quebec to share monitoring information and bloom reports. VT DEC field staff continue to participate in EPA Region 1 efforts to develop a field screening method for cyanobacteria based on phycocyanin, a photosynthetic pigment found in cyanobacteria but few other algae.

The Program Manager continues to be a member of the Great Lakes HABS Collaboratory, an effort in the Great Lakes Region to leverage relationships among universities, states and federal partners to share cutting edge research and develop collaborative approaches to cyanobacteria monitoring. She also serves as a co-chair of the Inland HABS Program of the North American Lake Society (NALMS).

The combined qualitative and quantitative approach utilized by the Champlain cyanobacteria monitoring project continue to support national efforts to develop remote sensing platforms for use across the country. The CyAN Project (Cyanobacteria Assessment Network) is a collaborative effort of EPA, NASA, NOAA and the USGS to develop a satellite-based early warning indicator system. Project data from the Champlain project will continue to support ground-truthing and algorithm development activities in 2018. In addition, data from the monitoring program is being utilized by research projects at the University of Vermont and the Global Lake Ecological Observatory Network (GLEON). The CyAN app for Android devices will be available for public use in summer 2019.

As of January 2019, project partners (H. Campbell, L. Fisher, and B. O'Brien) are members of a national team organized by the Interstate Technology and Regulatory Council (ITRC) to develop guidance material on the prevention and control of cyanobacteria blooms. Program Manager (A. Shambaugh) serves as a co-leader for the team. The final materials are expected early in 2021.

Communication with the Stakeholders and the Public

Results of the weekly assessments were communicated via email to a variety of stakeholders. The 169 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 (7), provincial officials in Quebec (6), water facilities or municipal staff (28), non-profits and universities (18, including partners), and unknown recipients (4). 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. Between June and December 2018, the VDH Cyanobacteria website received over 3,000 visits while the interactive map received more than 7,000 views (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 portal at 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 7. Usage of the VDH Cyanobacteria webpages mid to late 2018

Month	VDH Cyanobacteria Landing Page - Unique Page Views*	VDH Cyanobacteria Tracker - Unique Page Views**
June	431	616
July	1168	2,625
August	1065	2,562
September	447	911
October	235	256
November	265	138
December	129	23
Total:	3740	7,131

* www.healthvermont.gov/cyanobacteria

** https://apps.health.vermont.gov/vttracking/cyanobacteria/2018/d/

Challenges

Each year, project partners trains citizen volunteers to recognize cyanobacteria using visual cues and knowledge gained over the 18 year 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.

Several of these exceptions are challenging for our monitors to evaluate. The benthic cyanobacterium *Scytonema* has become common on Champlain and Lake Carmi (VT), where it can form extensive surface accumulations that are more similar in appearance to filamentous green algae than to cyanobacteria. In 2018, we received several reports of presumed cyanobacteria surface scums that were instead formed by *Euglena*, a flagellated phototroph. This seems to have been a regional phenomenon, with New York identifying several blooms of this organism across the state as well. *Gloeotrichia*, a colonial cyanobacterium, typically present in low densities, bloomed at several Champlain locations in 2018 with an appearance more similar to pollen. Green-tinted water with no visible scum also can be a challenge for volunteers.

These occurrences were evaluated by the partners initially via photographs and direct contact with monitors. At several locations, a physical sample was required before a final determination could be made. Training materials will be updated with new photos and descriptions provided by volunteers, and we will continue to share with them unusual observations made over the course of the summer. Response to these unusual observations often requires significant effort from the partners, prioritized by extent of affected area and proximity to recreational areas or drinking water intakes.

Discussion

The primary role of the cyanobacteria monitoring program is to provide data on cyanobacteria occurrence and abundance to the VDH and other partners for the protection of public health. The data provided by the program assists drinking water facilities around Lake Champlain to evaluate the quality of their raw and finish water, and, in Vermont, provides operators with specific information about the presence/absence of selected cyanotoxins. The program serves an education and outreach role, helping volunteers and others recognize situations when recreational activities might not be prudent. Data also provide insight as to the effectiveness of the monitoring approach and contribute to a historical perspective of bloom events in the Basin.

Effectiveness of the visual monitoring protocol

Quantitative data collected during 2018 in conjunction with visual assessments at selected sites continue to support the visual assessment protocols as an effective tool to assess potential recreational risk. The majority of reports from quality control sites reported Category 1 (generally safe conditions), with correspondingly low concentrations of potentially toxic cyanobacteria (Appendix C). No microcystin or anatoxin was detected in any sample with a visual assessment in Category 1. Microcystin was detected in several samples in Categories 2 and 3 reports (alert level conditions). All were well below the Vermont recreational guidance level of 6 µg/L. Potentially toxic cyanobacteria were present in all samples with microcystin or anatoxin detections.

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.

Cyanobacteria conditions in 2018

Vermont inland lakes

Historical data from routinely monitored Lake Carmi, Shelburne Pond, Lake Iroquois and Lake Memphremagog are presented in Figure 4. Carmi and Shelburne typically experience several weeks of alert-level conditions each year, including 2018. Bloom conditions were frequently reported from Memphremagog in 2018. The higher number may be connected to an increasing number of volunteers reporting from the lake, however, blooms do occur there periodically.

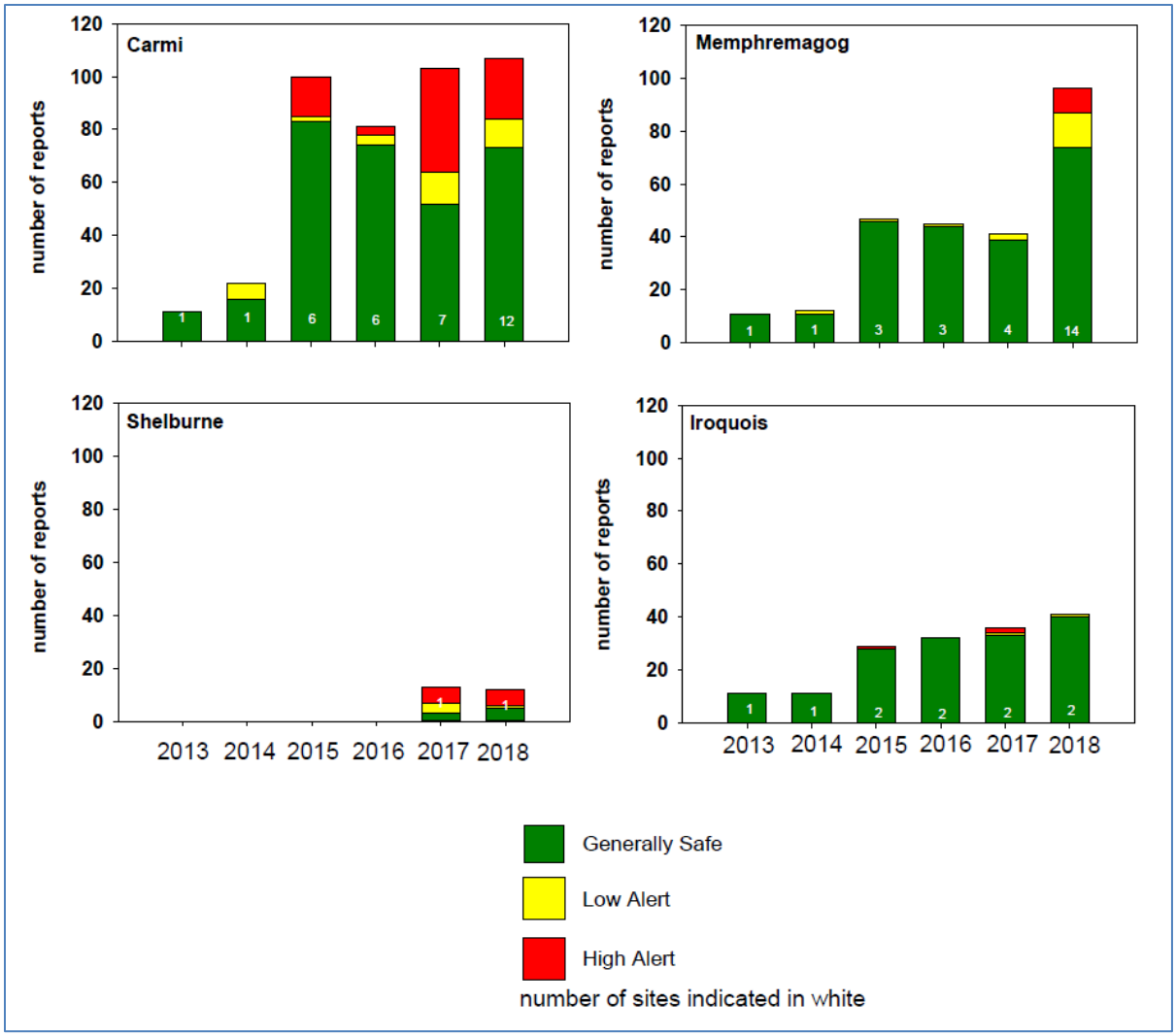


Figure 4. Webpage status reports on selected inland lakes since 2013. Supplemental reports are included.

Other waterbodies experiencing blooms in Vermont included

- Lakes
  - Morey
  - Salem
  - St. Catherine
- Ponds
  - Baker
  - Clyde
  - Fairfield
  - High
  - Joes
  - Nichols
  - Saxtons River Recreation Area Swimming pond

Table 8 summarizes microcystin concentrations observed at Lake Carmi since 2013, the only inland Vermont lake currently monitored routinely for cyanotoxins. Samples for cyanobacteria testing were

collected weekly at two locations on Lake Carmi by the VDH and additional samples were collected during blooms. Microcystin was detected twice on Lake Carmi this year. Both were below Vermont's recreational guideline of 6µg/L.

Table 8. Microcystin concentrations in Lake Carmi, 2013 - 2018. 0.16 is the reporting limit.

Lake		2013	2014	2015	2016	2017	2018
Lake Carmi	median	<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
	#samples	10	19	17	25	35	32
	#stations	1	4	2	3	3	4

Cyanobacteria Conditions on Lake Champlain:

Eighty-seven percent of the Champlain reports from 2018 indicated generally safe conditions (Figures 5 and 6). Alert-level conditions were reported 195 times, most of which were supplemental reports (67%, n=134). Alert level conditions were reported most frequently in the Inland Sea (n=55), Missisquoi Bay (n=44), St. Albans Bay (n=28) (Figure 7).

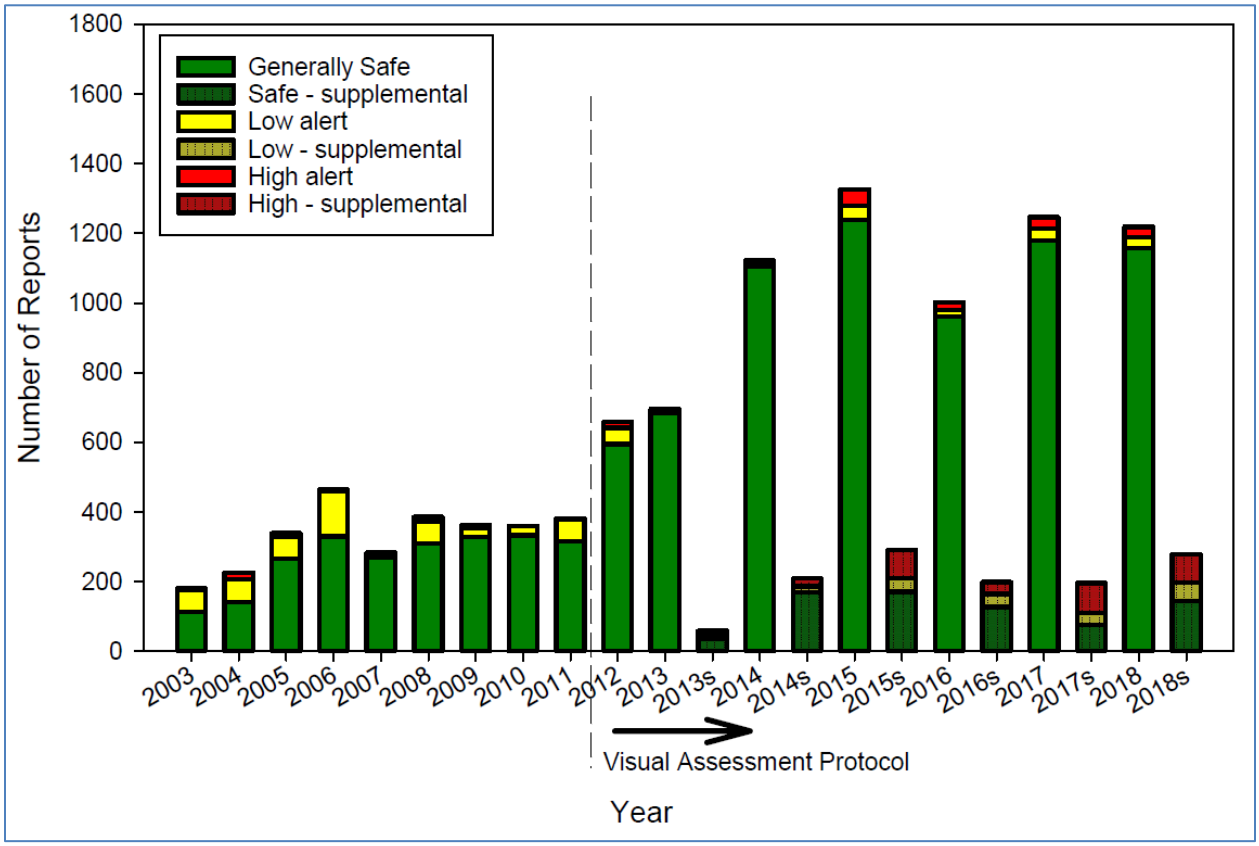


Figure 5. Number of yearly cyanobacteria status reports for Lake Champlain by category. Records prior to 2012 were determined using historical cell count and toxin data. Beginning in 2012, summaries include records obtained using the visual assessment protocol. The status generated by the visual assessment protocol is used at locations where both types of assessment were employed. Supplemental reports are included separately, indicated by an 's' following the year on the x axis.

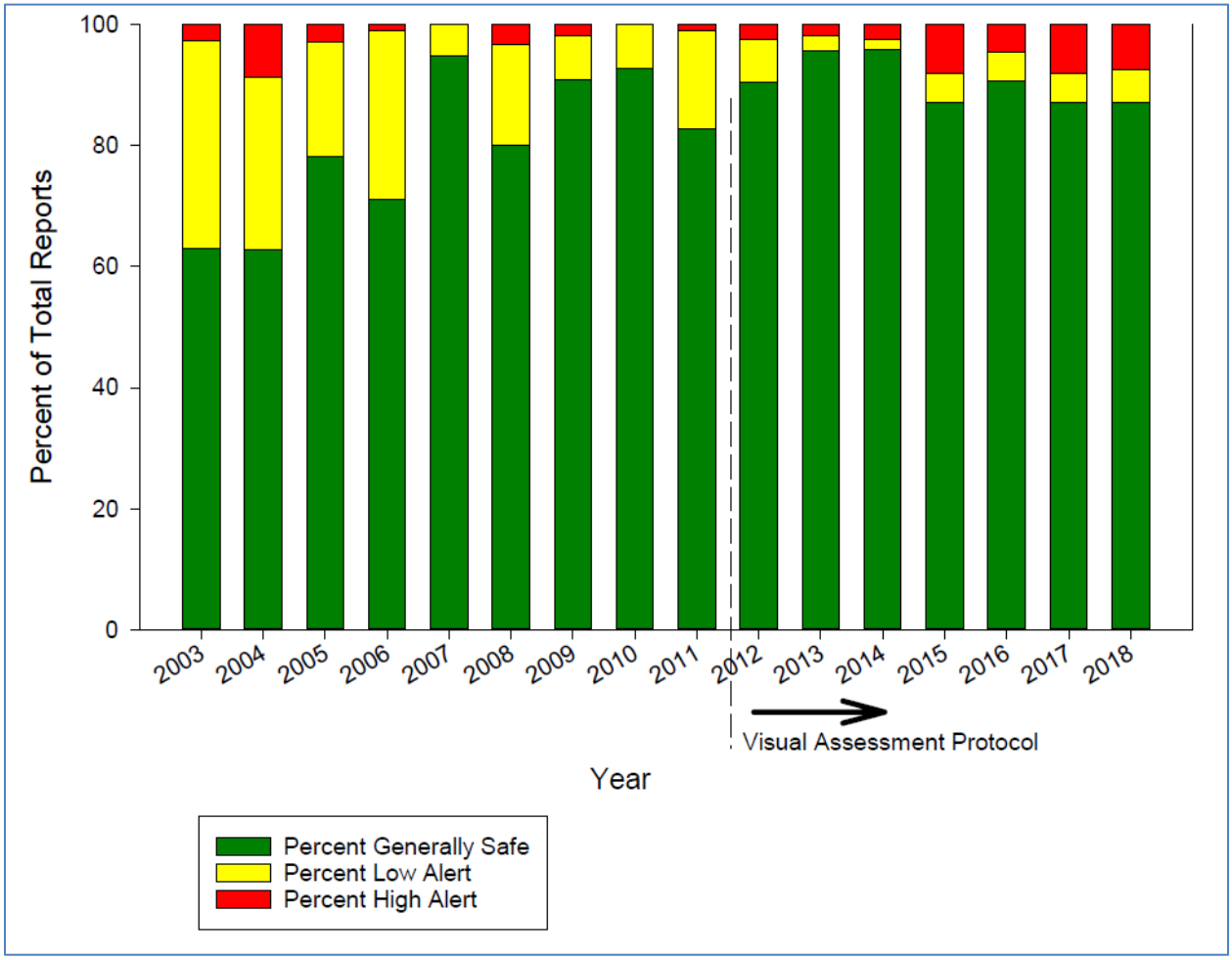


Figure 6. Cyanobacteria status reports Lake Champlain by category, percent of total reports received. Records prior to 2012 were determined using historical cell count and toxin data. Beginning in 2012, summaries include records obtained using the visual assessment protocol. The status generated by the visual assessment protocol is used at locations where both types of assessment were employed. Supplemental reports are included but not reported separately.

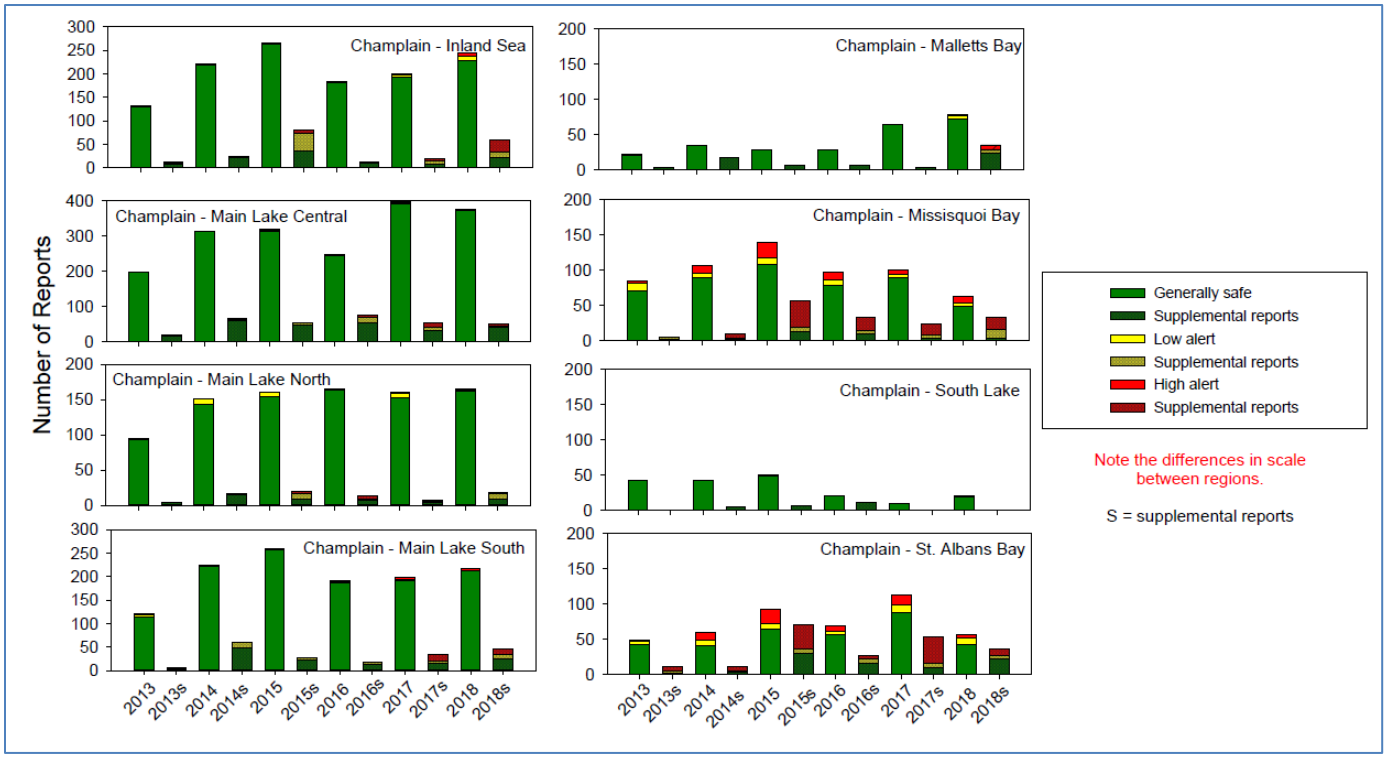


Figure 7. Number of yearly cyanobacteria reports for Lake Champlain by region, 2013 – 2018. The status generated by the visual assessment protocol is used at locations where both types of assessment were employed. Supplemental reports are included separately, indicated by an 'sr' preceeding the year on the x axis.

This year, Malletts Bay experienced a number of bloom events. Vermont State Park staff documented bloom conditions on the northern shores of inner Malletts Bay at Niquette State Park in late June and again in early August. Bloom reports came in from the northern shores of outer Malletts Bay as well. While monitoring activity has increased in Malletts Bay in recent years, resulting in an increased number of reports overall, blooms are not a common event on the bay.

Cyanotoxin sample efforts on Lake Champlain continue to target bloom situations whenever possible. Because microcystin concentrations are expected to be highest in these situations, this targeted sampling increases the opportunity to capture high microcystin events. Microcystin concentrations exceeding Vermont's recreational guideline of 6 µg/L are rarely documented and have occurred only in Missisquoi Bay (Table 9). In 2018, microcystin was detected at several sites on Lake Champlain. The Vermont recreational guidance value was not exceeded:

- Missisquoi Bay on September 7
    - LTM 50 – 0.18 µg/L
    - LTM 51 – 0.19 µg/L
- Missisquoi Bay on August 22
    - East Alburgh, north of Rt 78 – 0.38 µg/L
- St. Albans Bay on August 14
    - St. Albans Bay Park – 0.27 0.38 µg/L

Table 9. Microcystin concentrations in major lake segments, 2011 – 2018. Data are from routine monitoring locations and bloom events. Data do not distinguish between net plankton, which were tested through 2012, and whole water samples. ND = not detected. Shaded boxes = not applicable. Detailed data for 2003 - 2012 can be found in Appendix D.

Lake Region		Max 2003 - 2012	2013	2014	2015	2016	2017	2018
Inland Sea	median	1.10	<0.16	<0.16	<0.16			<0.16
	range	0.01 – 22.5	<0.16 - 0.43	<0.16 - 0.28	<0.16 – 0.02			All <0.16
	#samples		45	56	26	0	0	5
	#stations		4	4	4			5
Main Lake Central	median	7.42	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16
	range	0.01 -23.3	<0.16 -0.17	<0.16 -0.19	All <0.16	All <0.16	<0.16 – 1.25	All <0.16
	#samples		23	31	27	26	31	36
	#stations		2	2	2	2	4	4
Main Lake North	median					<0.16	<0.16	<0.16
	range	0.01 – 1.56				All <0.16	All <0.16	All <0.16
	#samples		0	0	0	12	10	11
	#stations					1	1	1
Main Lake South	median	0.04	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16
	range	<0.16 – 3.47	<0.16 - 0.16	<0.16-0.51	All <0.16	All <0.16	<0.16 – 4.25	All <0.16
	#samples		22	33	28	12	16	21
	#stations		2	3	2	1	3	4
St. Albans Bay	median	0.30	0.032	<0.16	<0.16	<0.16	<0.16	<0.16
	range	<0.16 – 22.48	0.002-0.062	<0.16 - 0.2	<0.16 – 0.77	All <0.16	<0.16 – 0.35	<0.16 – 0.38
	#samples		2	4	12	15	21	13
	#stations		2	2	2	3	3	1
Malletts Bay	median	0.04						<0.16
	range	0.04 – 0.08						All <0.16
	#samples		0	0	0	0	0	6
	#stations							3
South Lake	median	0.96						
	range	0.53 – 1.86						
	#samples		0	0	0	0	0	0
	#stations							
Missisquoi Bay	median	2.56	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16
	range	<0.16 - 6490	<0.16 - 1.3	<0.16 -2.29	<0.16 – 0.43	All <0.16	<0.16 – 5.6	<0.16 – 0.38
	#samples		30	40	38	19	18	16
	#stations		6	7	5	6	3	4

Summary

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. Missisquoi and St. Albans Bays on Lake Champlain, Lake Carmi and Shelburne Pond had the highest number of alert level reports during 2018, which is consistent with past years. Malletts Bay on Lake Champlain and Lake Memphremagog had higher numbers of alert level reports than has been typical in the past.

Partners continue to use the visual assessment protocol to communicate cyanobacteria conditions across Lake Champlain, supported by taxonomic and toxin data collected routinely at key locations. The visual assessment protocol also 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. Outreach continues to be an important component of the monitoring program as lakes and ponds around Vermont experience cyanobacteria blooms, some for the first time in local memory.

Generally safe conditions are well documented on routine monitoring days while alert level conditions are most likely to be captured in supplemental reports which represent extra effort on the part of our monitors. Because of their diligence and the increasing number of volunteers gathering data for this project, we have a good understanding of cyanobacteria conditions on Lake Champlain and several Vermont inland lakes. We have begun to explore how these data might be utilized to develop a cyanobacteria severity index to evaluate recent trends in bloom events on Lake Champlain.

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 – Jeremy Howland, Pete Stangel, and Natalie May (VT DEC Watershed Management); Leah Kelleher and Bennett Truman (VDH); Kirk Kimball and Marie Sawyer (VDH Laboratory); Jan Leja (VDH developer of the Tracker map); Daniel Denora and Alexa Hachigian (LCC); Emily White (VT State Parks); and especially the citizen volunteer monitors who continue to be the backbone of this monitoring effort.

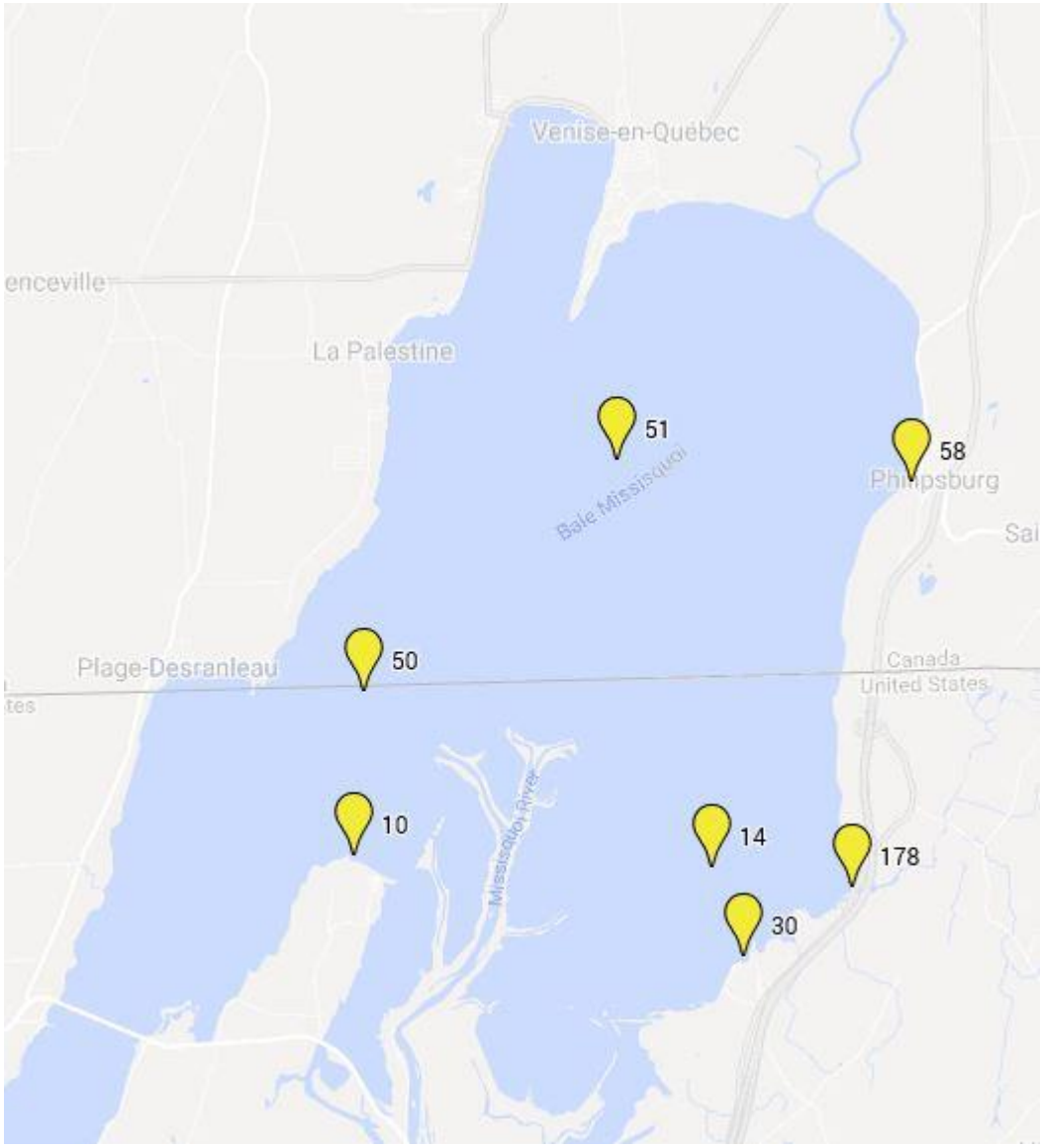
We would also like to recognize the important contributions that Pete Young, former GIS Manager at VDH, made to the Cyanobacteria Monitoring Program over the years. His work developing the online tracker map has improved information sharing between monitors and partners and made up to date information on cyanobacteria conditions readily available. His mapping work has engaged the public and made the program's data more usable.

Literature Cited

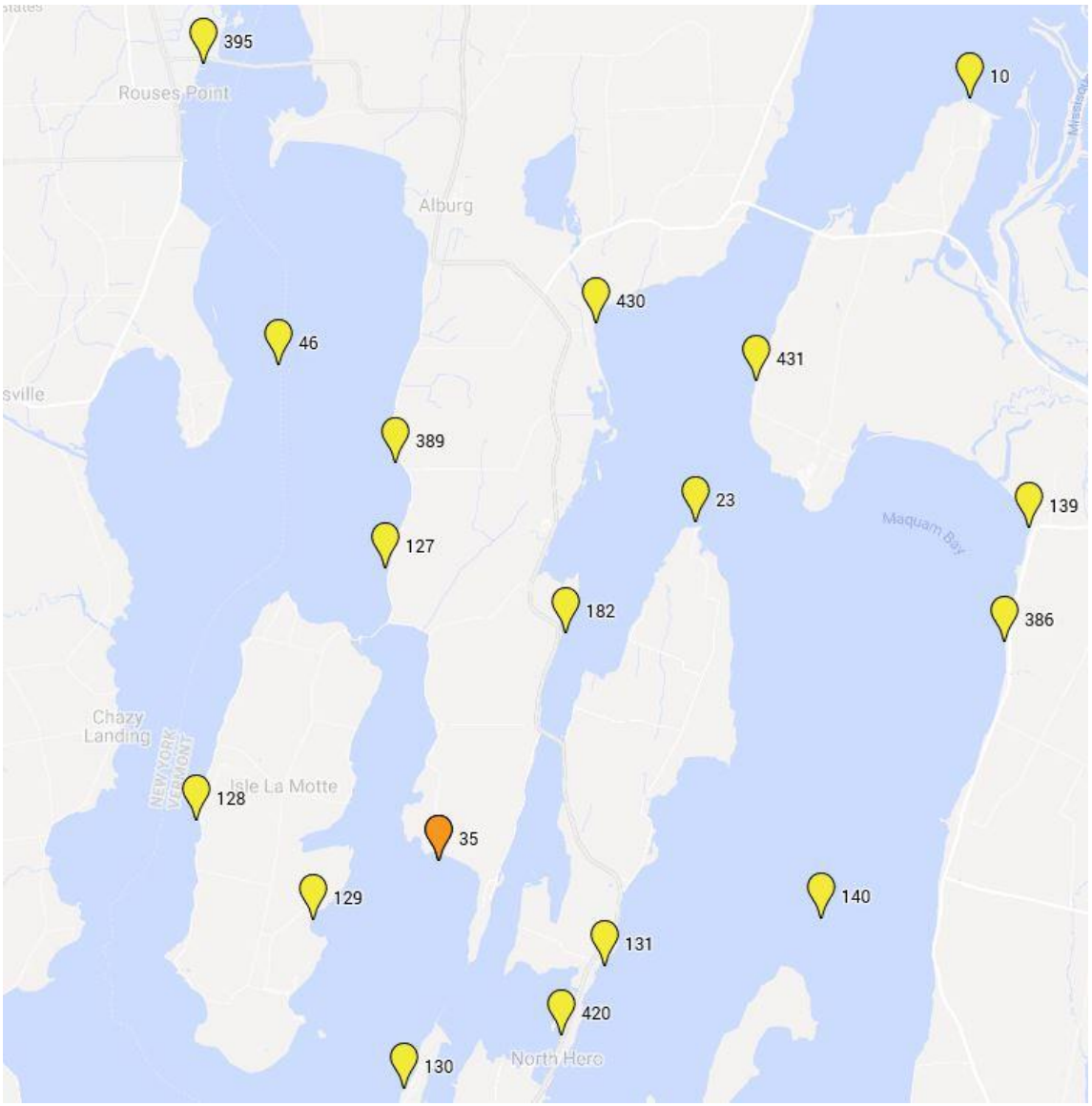
Rogalus, M. and M. Watzin. 2008. Evaluation of Sampling and Screening Techniques for Tiered Monitoring of Toxic Cyanobacteria in Lakes. Harmful Algae 7(4):504-514.

Appendix A – 2018 Sampling locations

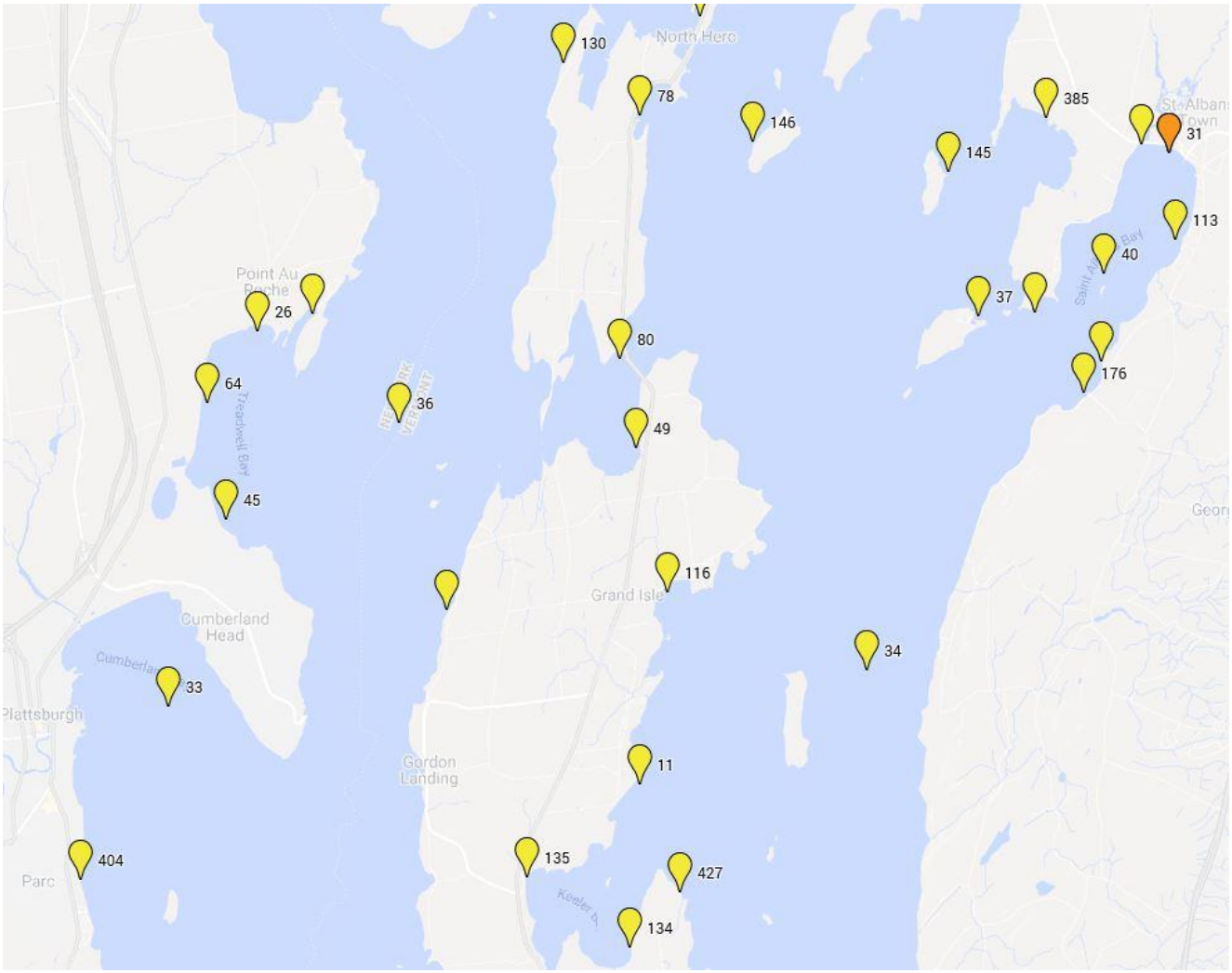
Maps of monitoring sites



Champlain - Missisquoi Bay

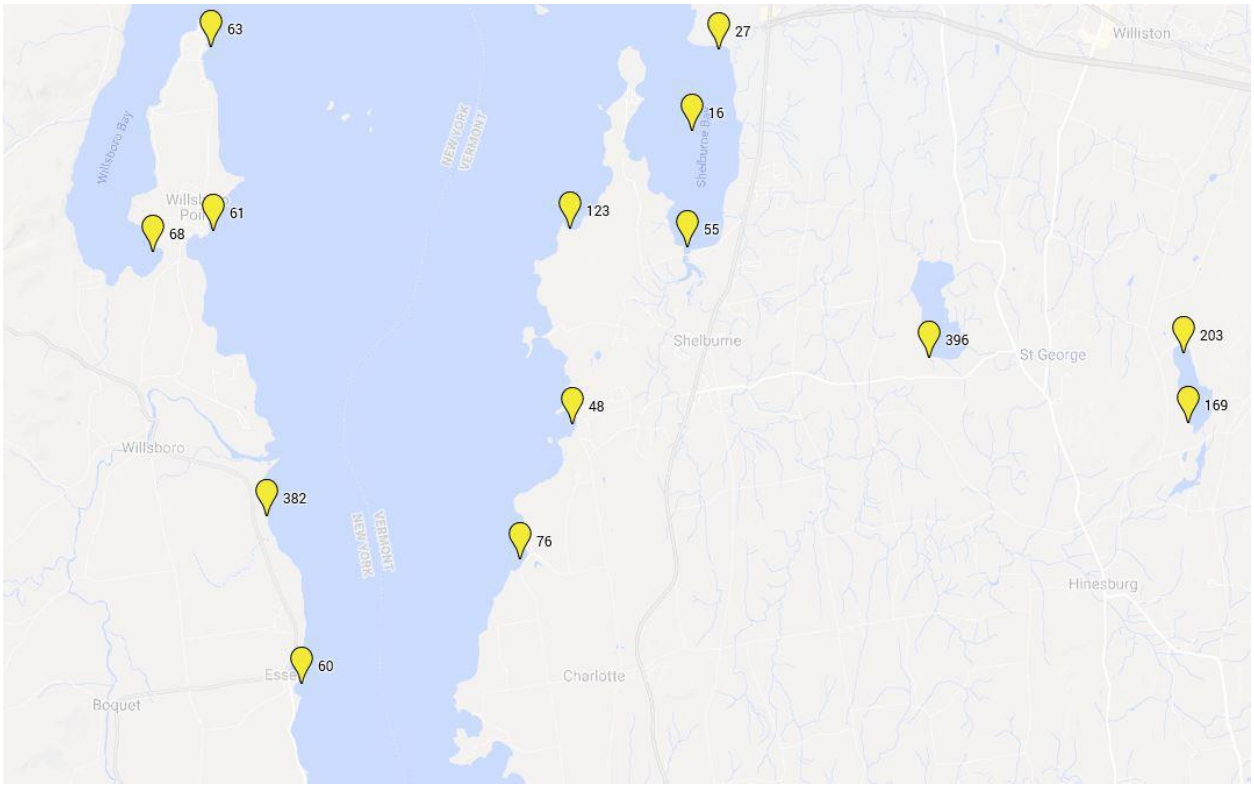


Champlain – Main Lake North and northern Inland Sea



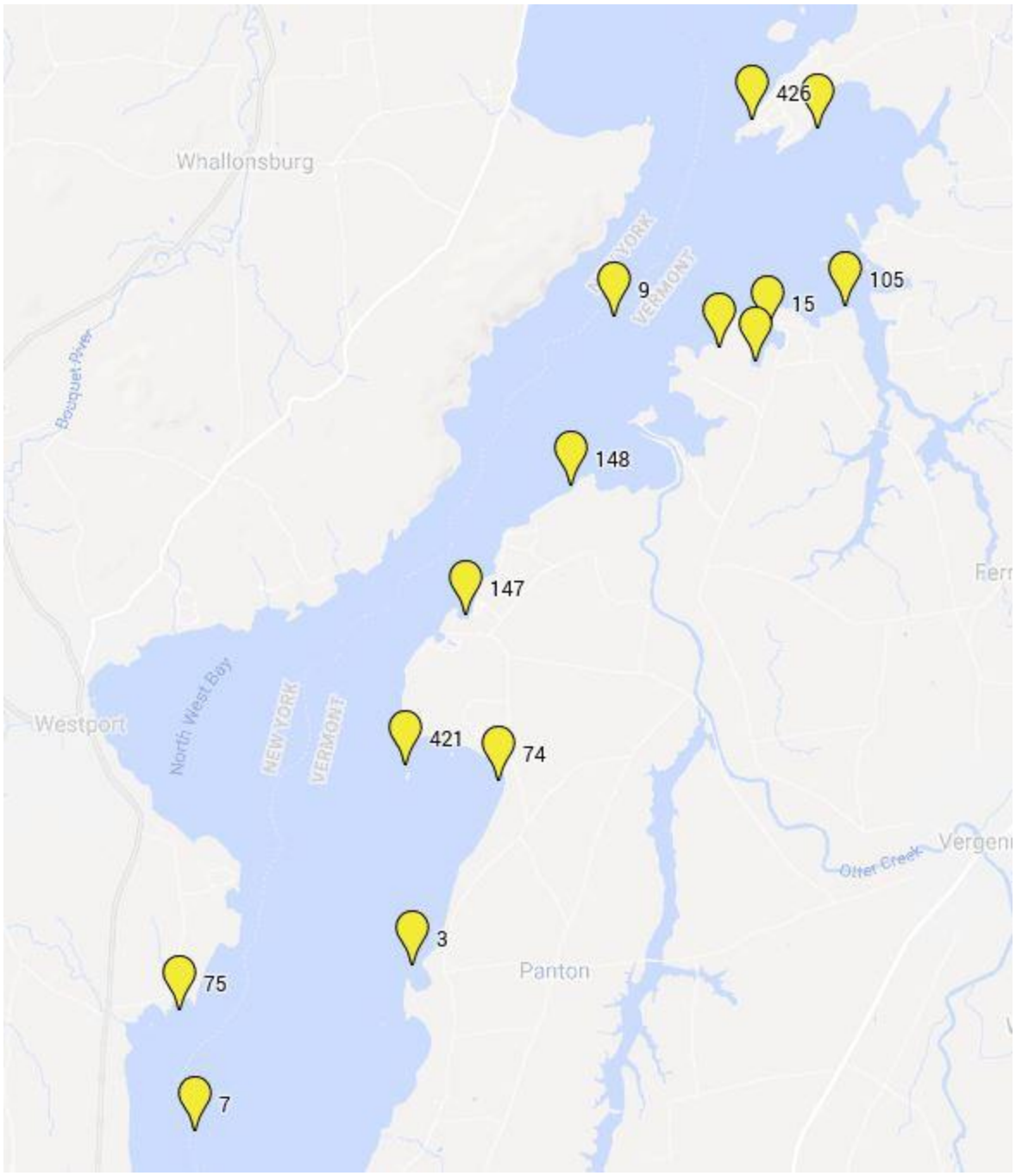
Champlain – Main Lake, southern Inland Sea, St. Albans Bay

Champlain – Main Lake, Malletts Bay

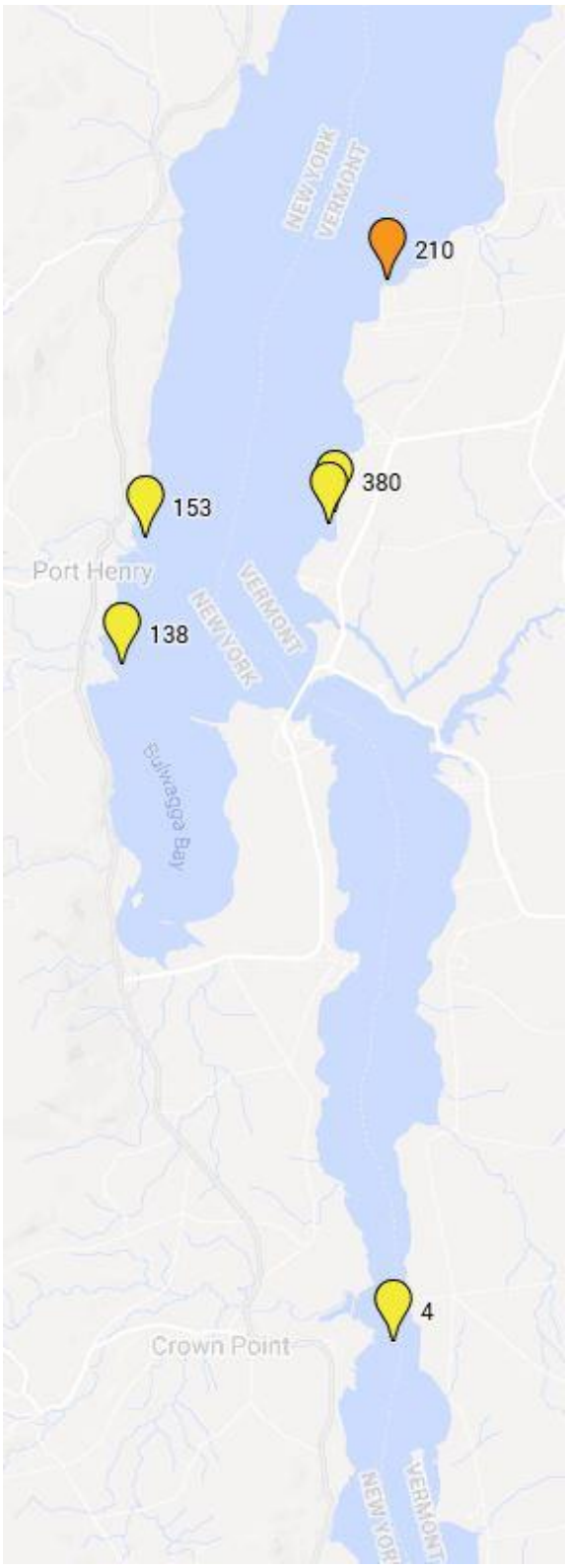


Champlain – Main Lake South

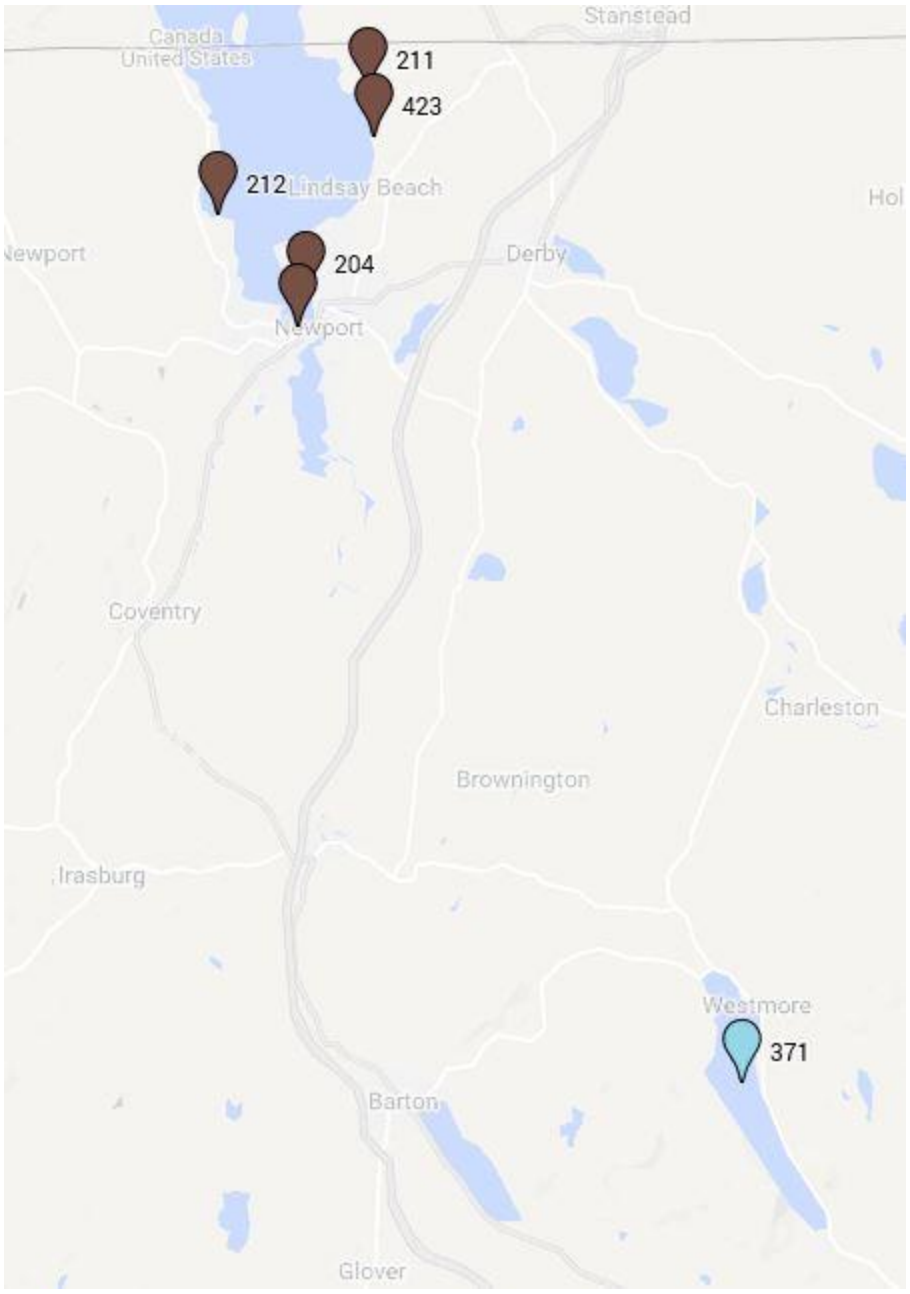
Shelburne Pond (#396), Lake Iroquois (#203, 169)



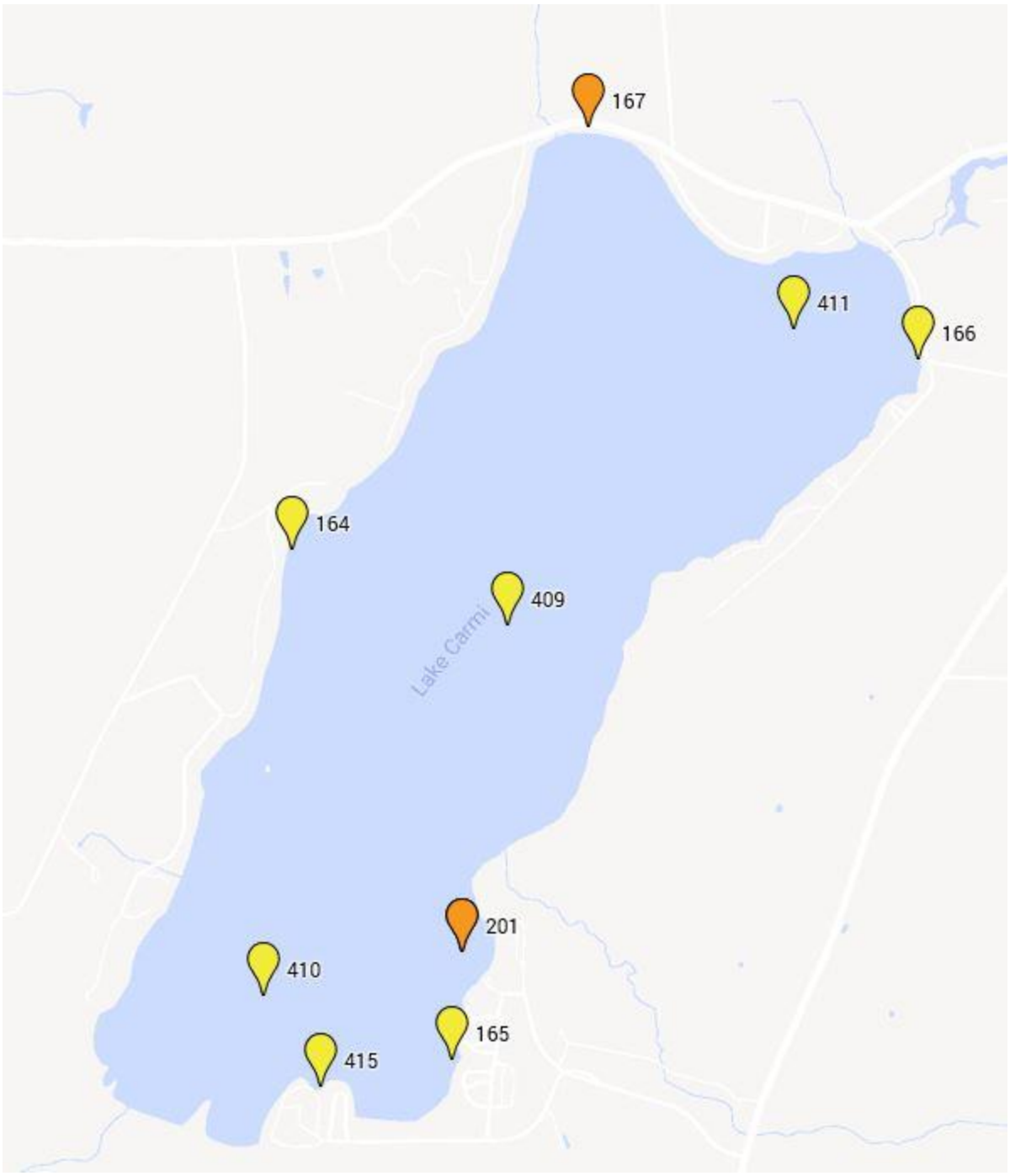
Champlain – Main Lake South continued



Champlain – Main Lake South and upper South Lake (left). South Lake (right)



Lake Memphremagog and Lake Willoughby (site 371)



Lake Carmi

Lake Seymour (site 306)

Coles Pond (site 311)

Ticklenaked Pond (site 368)

Lake Morey (site 345)

North Hartland Reservoir (site 406)

Stoughton Pond (site 407)

Townshend Lake (site 408)

Lake Champlain Region	Station	Municipality	State/ Province	Site	Latitude	Longitude
Inland Sea (from the RT 78 bridge in Swanton VT to the RT 2 causeway between Milton and South Hero VT; includes the Gut, Alburgh Passage and Carry Bay)	Alburgh East Shore - Town Beach	Alburgh	VT	430	44.95524	-73.2645
	Blockhouse Point Rd	North Hero	VT		44.85156	-73.2837
	Burton Island State Park	St. Albans Town	VT	37	44.77686	-73.1963
	Carry Bay East Shore	North Hero	VT	420	44.83521	-73.2725
	Cedar Ledge	North Hero	VT	131	44.84695	-73.2622
	City Bay - Rt 2	North Hero	VT	78	44.81589	-73.2891
	Dunham Bay	North Hero	VT	186	44.88562	-73.2734
	East Shore of Ransoms Bay	Swanton	VT	431	44.94555	-73.2262
	Grand Isle State Park	Grand Isle	VT	11	44.68602	-73.2891
	Idlewild Road	South Hero	VT	427	44.6651	-73.278
	Keeler Bay Boat Launch	South Hero	VT	135	44.66791	-73.3199
	Keeler Bay East	South Hero	VT	134	44.65414	-73.292
	Kings Bay	North Hero	VT	433	44.87087	-73.2508
	Kings Bay Fishing Access	North Hero	VT	432	44.86987	-73.2503
	Knight Island	North Hero	VT	146	44.81072	-73.2581
	Knight Point State Park	North Hero	VT	80	44.76867	-73.2945
	Knight Point State Park - The Point	North Hero	VT	419	44.76722	-73.2988
	Lapan Bay	St. Albans Town	VT	385	44.81537	-73.1778
	LTM 34	Milton	VT	34	44.70817	-73.2268
	Maquam Beach	Swanton	VT	139	44.92081	-73.1614
	Maquam Shore (Swanton, VT)	Swanton	VT	386	44.90156	-73.1671
	Marycrest Beach	Grand Isle	VT	116	44.72336	-73.2815
	North Hero State Park	North Hero	VT	23	44.92175	-73.2408
	North Hero State Park - Boat Launch	North Hero	VT		44.92114	-73.2431
	Oakridge Ln	North Hero	VT		44.90514	-73.2551
	Pelots Point West	North Hero	VT		44.8332	-73.3015
	Rt.2 South of N. Hero Bridge	North Hero	VT	104	44.87957	-73.273
	Sand Bar State Park	Milton	VT	57	44.62868	-73.24
	Savage Point	North Hero	VT		44.83344	-73.2917
	South Alburgh - Squires Bay	Alburgh	VT	182	44.90301	-73.2717
	South Hero Fish and Wildlife Boat Access	South Hero	VT	110	44.63641	-73.2652
	Strong House Lane	North Hero	VT		44.90786	-73.2325
	The Gut	Grand Isle	VT	49	44.75137	-73.2903
	Woods Island State Park	St. Albans Town	VT	145	44.80487	-73.2045
Main Lake Central	Allen Point	South Hero	VT	189	44.5992	-73.3114
	Ausable Point Road - Lake side	Peru	NY	140	44.92081	-73.1614
	Ausable Point State Park	Peru	NY	376	44.57174	-73.4263
	Buena Vista Park, Willsboro NY	Willsboro	NY	61	44.40395	-73.3735
	Burlington Inner Dock	Burlington	VT	381	44.482	-73.2246
	Burlington, VT - Texaco Beach	Burlington	VT	72	44.48764	-73.2321
	Clearwater Road	Shelburne	VT		44.41434	-73.2199

Main Lake Central (from the Grand Isle/Plattsburgh ferry crossing south to the Charlotte/Essex ferry)	Cliff Haven Camp	Plattsburgh	NY	404	44.66734	-73.4422
	Community Sailing Center	Burlington	VT	107	44.48206	-73.2255
	Corlear Bay-Port Douglas Boat Launch	Chesterfield	NY	160	44.48612	-73.4117
	Dead Creek Inlet	Peru	NY	413	44.57296	-73.4329
	Delta Park	Colchester	VT	405	44.5367	-73.2775
	Essex Road	Essex	NY	382	44.34376	-73.3577
	LaPlatte River mouth, Shelburne Bay	Shelburne	VT	55	44.40034	-73.2335
	Leddy Park	Burlington	VT	54	44.50083	-73.2534
	LTM 16	Shelburne	VT	16	44.425	-73.232
	LTM 19	South Burlington	VT	19	44.471	-73.299
	LTM 21	Burlington	VT	21	44.47483	-73.2317
	LTM 33	Plattsburgh	NY	33	44.70117	-73.4182
	North Beach	Burlington	VT	22	44.49106	-73.2404
	North Shore Beach	Burlington	VT	391	44.52076	-73.2696
	Oakledge Park Blanchard Beach	Burlington	VT	42	44.45744	-73.2255
	Oakledge Park rocky shoreline	Burlington	VT	44	44.45671	-73.228
	Oakledge Park South Cove	Burlington	VT	43	44.45475	-73.2301
	Peru Boat Launch	Peru	NY	159	44.61884	-73.4404
	Port Kent Beach	Chesterfield	NY	152	44.52865	-73.4035
	Providence Island	South Hero	VT		44.6245	-73.3605
	Red Rocks Beach	South Burlington	VT	27	44.442	-73.2241
	Rock Point Offshore	Burlington	VT		44.50149	-73.2529
	Shelburne Beach	Shelburne	VT	48	44.36306	-73.2676
	Shelburne Farms	Shelburne	VT	123	44.40445	-73.2683
	Starr Farm Beach	Burlington	VT	108	44.51376	-73.2714
	Sunset/Crescent Beach	South Hero	VT	132	44.60888	-73.3158
	Teddy Bear Point Cove, Willsboro NY	Willsboro	NY	63	44.44272	-73.3743
	US Coast Guard Boat Access Ramp	Burlington	VT	417	44.48003	-73.2229
	Whiskey Bay	Charlotte	VT	426	44.27033	-73.3017
	White's Beach in Crescent Bay	South Hero	VT	114	44.62114	-73.3234
	Willsboro Boat Launch	Willsboro	NY	68	44.39945	-73.3916
Main Lake North	4265 W Shore Road	Isle la Motte	VT		44.84258	-73.3601
	4266 W Shore Road	Isle la Motte	VT		44.8424	-73.3603
	Alburgh Dunes State Park	Alburgh	VT	35	44.86462	-73.302
	Holcomb Boat Launch	Isle la Motte	VT	129	44.85468	-73.3316
	Horicans Fish and Wildlife Access	Alburgh	VT	127	44.91408	-73.3145
	Lighthouse Point Road	Isle la Motte	VT		44.904	-73.3461
	LTM 36	Grand Isle	VT	36	44.75617	-73.355
	LTM 46	Alburgh	VT	46	44.94833	-73.34
	Mud Point	Alburgh	VT	389	44.93165	-73.3121
	Oliver Bay	Plattsburgh	NY	45	44.73745	-73.4023
	Pelots Point West	North Hero	VT	130	44.82611	-73.3101

Main Lake North (north of the Grand Isle/Plattsburgh ferry to the VT/QC border)	Pt. Au Roche Light	Beekmantown	NY		44.79828	-73.3606
	Pt. Au Roche State Park Beach	Beekmantown	NY	26	44.77414	-73.3938
	Pt. Au Roche State Park Deep Bay	Beekmantown	NY	84	44.77751	-73.3789
	Rouses Pt DEC Old Beach	Rouses Point	NY	395	44.99911	-73.3578
	Stoney Point, Isle la Motte	Isle la Motte	VT	128	44.87148	-73.3594
	Treadwell Bay, Beekmantown NY	Beekmantown	NY	64	44.76008	-73.4075
	Vantines Boat Launch	Grand Isle	VT	115	44.71981	-73.3419
Main Lake South (south from the Charlotte/Essex ferry to the Champlain bridge at Crown Point/Chimney Point)	Arnold Bay	Panton	VT	3	44.14974	-73.3695
	Arnold Bay Beach	Panton	VT		44.14959	-73.3674
	Beggs Park Beach, Essex NY	Essex	NY	60	44.30846	-73.3473
	Bulwagga Bay/Port Henry	Port Henry	NY	138	44.03688	-73.4548
	Burgey Farm Road	Addison	VT	380	44.05594	-73.4172
	Button Bay Boat Launch	Ferrisburgh	VT	74	44.17616	-73.3523
	Button Bay South	Ferrisburgh	VT	183	44.16863	-73.3556
	Button Bay State Park - The Point	Ferrisburgh	VT	421	44.17803	-73.3689
	Camp Dudley, Westport NY	Westport	NY	75	44.14322	-73.4157
	Charlotte Town Beach	Charlotte	VT	76	44.33473	-73.2829
	DAR State Park	Addison	VT	39	44.05453	-73.4183
	Ferrisburgh Stone Beach	Ferrisburgh	VT	137	44.2379	-73.3083
	Ferrisburgh Town Beach	Ferrisburgh	VT	117	44.23594	-73.301
	Fox Run Way	Westport	NY		44.12548	-73.4254
	Hawkins Bay	Ferrisburgh	VT	105	44.24376	-73.2834
	Hospital Creek by Champlain Bridge	Addison	VT		44.04136	-73.4152
	Kingsland Bay State Park	Ferrisburgh	VT	15	44.24031	-73.2987
	Long Point	Ferrisburgh	VT	18	44.25813	-73.2776
	LTM 07	Panton	VT	7	44.126	-73.4128
	LTM 09	Ferrisburgh	VT	9	44.24217	-73.3292
	North Harbor	Ferrisburgh	VT	147	44.19972	-73.3588
	Port Henry Beach	Moriah	NY	414	44.04993	-73.4539
	Port Henry Boat Launch	Port Henry	NY	153	44.05278	-73.4506
	Potash Bay	Addison	VT		44.09208	-73.394
	Succor Creek Inlet, Panton	Panton	VT		44.12513	-73.376
	Summer Point	Ferrisburgh	VT	148	44.21825	-73.338
	Town Farm Bay	Charlotte	VT	119	44.26916	-73.2887
	Tri-Town Road, West Addison	Addison	VT	210	44.08538	-73.4079
Malletts Bay (south of the Rt 2 causeway between Milton and South Hero VT, west to the Malletts Bay causeway	Bayside Beach	Colchester	VT	377	44.54566	-73.2159
	Camp Kiniya	Colchester	VT	142	44.60644	-73.2291
	Clay Point	Colchester	VT	133	44.59393	-73.2318
	Forest Trail (Malletts Bay)	Colchester	VT		44.58981	-73.2282
	LTM 25	Colchester	VT	25	44.582	-73.2812
	Malletts Bay Boat Launch	Colchester	VT	120	44.55416	-73.231
	Niquette Bay State Park	Colchester	VT	67	44.58129	-73.1889
	Niquette Bay State Park - The Cove	Colchester	VT	416	44.5803	-73.196

	Rosetti Park	Colchester	VT	111	44.55501	-73.2528
Missisquoi Bay (north of the Rt 78 bridge, including Quebec waters)	Country Club Road	Highgate	VT	172	44.9962	-73.093
	Donaldson Point	Swanton	VT	10	44.9932	-73.1753
	East Alburgh, North of Car Bridge	Alburgh	VT		44.97536	-73.2258
	Highgate Springs	Highgate	VT	14	44.99177	-73.1134
	Larry Greene Fish and Wildlife Access	Swanton	VT	29	44.96797	-73.2211
	Littoral Philipsburg	Philipsburg	QC		45.04193	-73.078
	LTM 50	Swanton	VT	50	45.01333	-73.1738
	LTM 51	Saint-Armand	QC	51	45.04167	-73.1297
	LTM 51	Saint-Armand	QC	51	45.04167	-73.1297
	Philipsburg, QC	Philipsburg	QC	58	45.03906	-73.0787
	Pike River	Saint-Armand	QC		45.07115	-73.0956
	Rock River - Highgate	Highgate	VT	178	44.9893	-73.0889
	Shipyard, Highgate Springs	Highgate	VT	30	44.98076	-73.1079
	Venise en-Quebec	Venise en Quebec	QC	399	45.0705	-73.1451
South Lake (south of the Champlain Bridge at Chimney/Crown Points to Benson VT)	LTM 02	Benson	VT	2	43.714	-73.383
	LTM 04	Bridport	VT	4	43.951	-73.407
	North Harbor	Ferrisburgh	VT	147	44.19972	-73.3588
St. Albans Bay (Black Bridge in the inner Bay to Kill Kare Point on the north; just west of Melville Landing on the Georgia VT shore)	Black Bridge	St. Albans Town	VT	191	44.8103	-73.1518
	Ferrand Rd. St. Albans	St. Albans Town	VT	113	44.79171	-73.1425
	Georgia Beach	Georgia	VT	193	44.7682	-73.1626
	Georgia Shore Road	Georgia	VT		44.76148	-73.1667
	Kill Kare State Park	St. Albans Town	VT	56	44.7777	-73.1808
	Lazy Lady Island - east shore	St. Albans Town	VT		44.78188	-73.162
	LTM 40	St. Albans Town	VT	40	44.78533	-73.1622
	Melville Landing	Georgia	VT	176	44.762	-73.1674
	St. Albans Bay Boat Launch	St. Albans Town	VT	32	44.79372	-73.1714
	St. Albans Bay Marina	St. Albans Town	VT		44.80647	-73.139
	St. Albans Bay Park	St. Albans Town	VT	31	44.80866	-73.1444

Vermont Inland Waterbody	Station	Municipality	Site	Latitude	Longitude
Baker Pond	Baker Pond	Brookfield		44.06763	-72.6362
Caspian Lake	Caspian Lake	Greensboro	306	44.58771	-72.3104
Clyde Pond	Clyde Pond dam	Derby		44.93461	-72.1758
Coles Pond	Coles Pond	Walden	311	44.5088	-72.2157
Fairfield Pond	Fairfield Pond	Fairfield	320	44.85422	-72.9897
High Pond	High Pond	Sudbury	331	43.75333	-73.1537
Joes Pond	Joes Pond	Cabot	337	44.41194	-72.2237
Lake Carmi	Carmi DEC01- Central Open Water	Franklin	409	44.9726	-72.8745
	Carmi DEC02- Southern Open Water	Franklin	410	44.9592	-72.8869
	Carmi DEC03- Northeastern Open Water	Franklin	411	44.98328	-72.8599
	Lake Carmi - northern shoreline	Franklin	305	44.97224	-72.8767
	Lake Carmi Boat Launch	Franklin		44.98996	-72.873
	Lake Carmi State Park	Franklin	201	44.96081	-72.8767
	Lake Carmi State Park - Area B	Franklin	415	44.95592	-72.8839
	Lake Carmi State Park - Area B	Franklin	415	44.95592	-72.8839
	Lake Carmi State Park - Boat Launch	Franklin	429	44.95969	-72.8759
	Lake Carmi State Park - Boat Launch	Franklin	429	44.95969	-72.8759
	Lake Carmi State Park South	Franklin	165	44.95692	-72.8773
	Lake Carmi, Black Woods	Franklin	164	44.9753	-72.8855
	Lake Carmi, Dewing Road	Franklin	166	44.98214	-72.8535
	Lake Carmi, North Beach	Franklin	167	44.99054	-72.8703
Lake Iroquois	Lake Iroquois	Williston	203	44.37807	-73.0867
	Lake Iroquois Southwest	Hinesburg	169	44.36327	-73.0856
Lake Memphremagog	Derby Bay	Derby	211	44.99435	-72.1886
	Farrant Point to Marina	Newport		44.9404	-72.2177
	Farrant St. Bluff Area	Newport		44.94378	-72.2239
	Holbrook Bay	Newport Town	212	44.96418	-72.2399
	Landing Street Boat Launch, Newport VT	Newport	424	44.94326	-72.2072
	mouth of Halls Creek, near Eagle Point	Derby		44.99814	-72.1991
	Newport City Dock	Derby	342	44.93686	-72.2122
	Newport City Dock	Newport	342	44.93686	-72.2122
	Newport City Dock	Newport City	342	44.93686	-72.2122
	Prouty Beach	Newport City	204	44.94501	-72.21
	Province Island	Derby		45.00389	-72.2309
	South Bay	Newport City	362	44.91708	-72.2099
	South Bay F&W Access, Newport VT	Newport City	425	44.92912	-72.2127
	South of Sunset Acres on the bike path	Derby		44.98347	-72.1862
	Sunset Acres, Derby Bay	Derby	423	44.98323	-72.1864
	Sunset Acres, Derby Bay	Derby	423	44.98323	-72.1864
	The Bluffs	Newport		44.95781	-72.2177

Vermont Inland Waterbody	Station	Municipality	Site	Latitude	Longitude
Lake Morey	Lake Morey	Fairlee	345	43.92139	-72.1532
	Lake Morey Rd Northeast	Fairlee	428	43.92899	-72.1395
	Lake Morey Rd Northeast	Fairlee	428	43.92899	-72.1395
Lake Salem	Lake Salem	Derby	356	44.93076	-72.1053
Lake St. Catherine	Lake St. Catherine - Inlet on Hall Bay	Poultney	363	43.46755	-73.2064
Lake Willoughby	Lake Willoughby	Westmore	371	44.75287	-72.0601
Nichols Pond	Nichols Pond	Woodbury	347	44.45748	-72.3443
North Hartland Reservoir	North Hartland Reservoir	Hartland	406	43.6046	-72.3622
Rock River	Rock River at VT & QC border near Morses Line, VT	Highgate		45.01467	-73.0144
Saxtons River Recreation Area	Saxtons River Recreation Area	Rockingham		43.14613	-72.5177
Shelburne Pond	Shelburne Pond Boat Launch	Shelburne	396	44.3772	-73.1621
Stoughton Pond	Stoughton Pond	Weathersfield	407	43.3434	-72.5093
Ticklenaked Pond	Ticklenaked Pond	Ryegate	368	44.18788	-72.0991
	Ticklenaked Pond - Boat Access	Ryegate	422	44.19188	-72.0972
Townshend Lake	Townshend Lake	Townshend	408	43.05706	-72.7067

Appendix B. Visual assessment protocols - Lake Champlain Committee

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

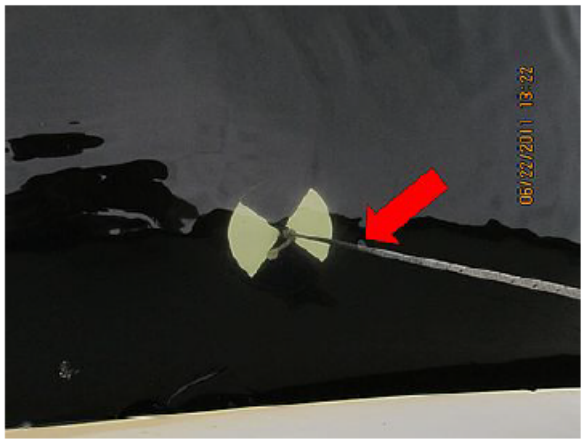
General Instructions

Observations should be made at the same location once per week. Observations must be made between 10:00 AM and 3:00 PM. At that time the algae have had a chance to rise from lower in the water column, but cells are not yet likely to have ruptured from the heat of mid-day. All observations submitted and approved will be posted on the Vermont Department of Health cyanobacteria tracker. Anyone providing reports should include information on the extent and type of algae and plant growth, the color of the water, and rate the algae intensity. The rating scale runs from one (a, b, c, or d) to three, with one being clear water with little to no cyanobacteria present and three being a cyanobacteria bloom in progress.

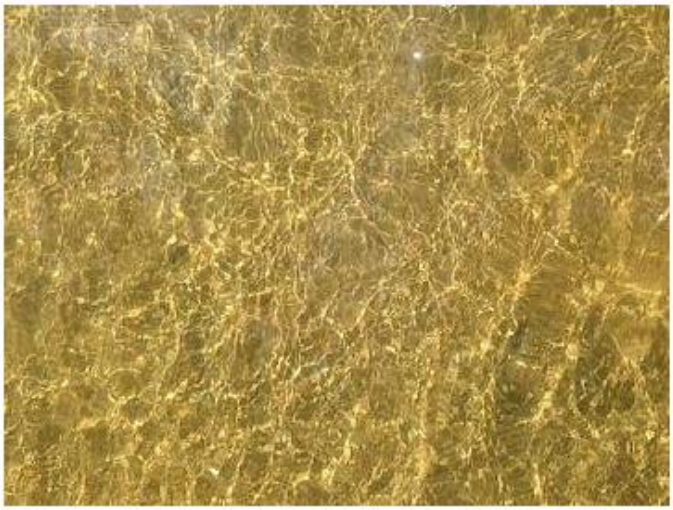
For category 2 and 3 conditions, three digital photographs should be submitted via the online form. Remember to avoid direct contact if the bloom is well developed.

Category 1a: No cyanobacteria present - clear water

Any organisms floating in water column are clear (e.g. insect 'skins') rather than green. Leafy or grass-like plants (including duckweed) may be present. Foam may be present.



Objects sitting lower in the water column are clearly visible (red arrow indicates water surface)



Overall appearance of water is clear

Category 1b - No cyanobacteria present - brown and turbid conditions

Brown turbid low visibility through water column

Brown and cloudy does not indicate presence of cyanobacteria

Category 1c - No cyanobacteria present - other plant material

Other material that doesn't count as cyanobacteria might include:

Long strands that tangle around paddles or boat hooks

Small bright mustard yellow (pollen) or grass green (duckweed) particles

Algae attached to rocks or the lake bottom.

Green dots are duckweed; stringy algae are not cyanobacteria

From a distance duckweed may look like green algae or cyanobacteria

Stringy algae attached to the bottom are not cyanobacteria

Duckweed up close

Category 1d - Little cyanobacteria present - Generally safe conditions

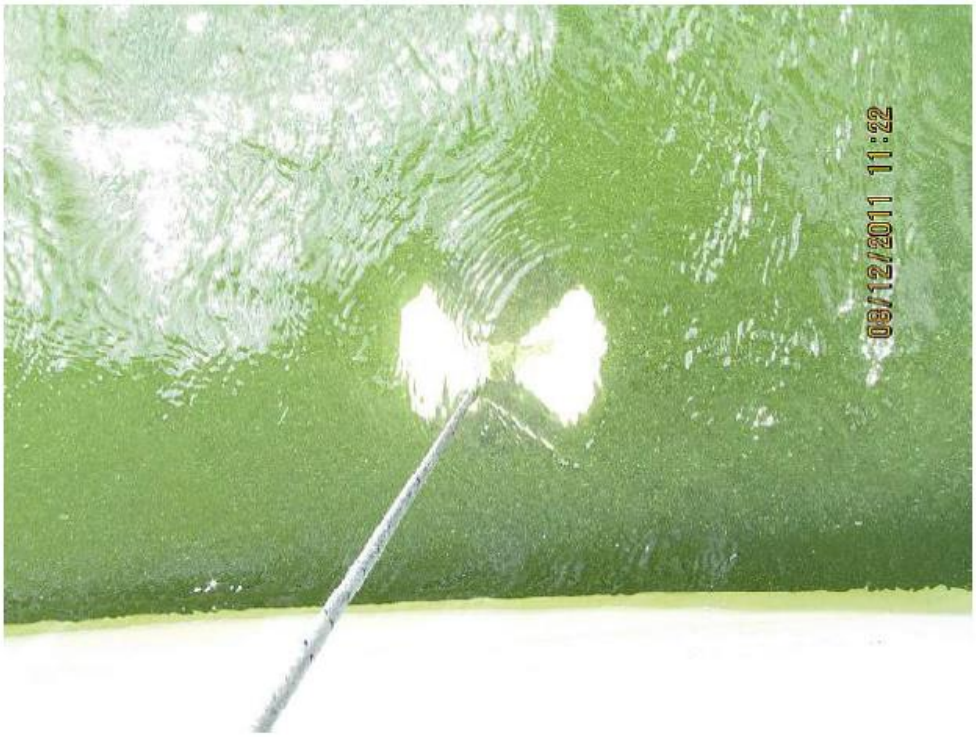
Green floating balls may be visible, but only on close inspection and in densities so low that they do not impair recreational enjoyment of the water. There are no surface or near shore accumulations of cyanobacteria.

Water appears perfectly clear

But close inspection shows some cyanobacteria present

Category 2: Cyanobacteria present, but at less than 'bloom' levels - Low alert conditions

Numerous green balls (pinhead size or larger) floating in water column, but not accumulated at water surface. Possible small (smaller than a softball) patches of algae accumulation. Open water color **not** green. Possible narrow band of cyanobacteria accumulation at shoreline.



Some cyanobacteria in water but not a uniform layer

3/26/2019 Cyanobacteria Bloom Intensity - LCC

Open water not green.

Band of cyanobacteria at shoreline

Category 3: Cyanobacteria bloom in progress - High alert conditions

Extensive surface scum on water – color may range from green to electric blue (not yellow/pollen). Usually accompanied by a thick accumulation at shoreline. Open water appears green.

Continuous layer of cyanobacteria at the surface - not stringy

Thick surface scum present

Instructions for Photographing Cyanobacteria Blooms & Taking Water Samples

Please take digital photographs of the water when category 2 or 3 bloom conditions are observed.

We need three photographs:

1. A close-up of the water surface,
2. A broad view of water in the vicinity, and
3. A close-up of a water sample in a clear container and placed against a solid contrasting background so objects in water are visible. A white background is preferable. Download LCC's Cyanobacteria Reporting Photo Card to use as a background and record information on for your jar test photos!

1.Use your camera's date stamp, or hold up a card in the photo with time, date, and location and category if possible.

2. Photograph both a close-up and a broad view.

3. Close-up of jar water sample after performing 30-minute jar test.

When collecting a water sample to photograph take care to avoid exposure to cyanobacteria. Wear gloves, don't wade or immerse yourself in the water and wash any exposed portions of your body immediately after collecting the sample. After sampling wash the gloves before reusing them. It is okay not to collect a physical sample for photography if you are uncomfortable doing so.

For best results, collect samples in water about knee deep. Invert the container before submerging it into the water and then tilt it once it is under water. This gives a more representative sample by collecting more than just the surface scum.

All photographs should include the time, date, and location. This information can be added by using the date stamp in your camera or by holding a piece of paper with the relevant information in the picture. Name the photograph file with the year-month-day-photographer's name-location-photo type-category.

Example photo file name: 2017-07-15_JaneDoe_DonaldsonPt_Closeup_category2

Appendix C – QA/QC Sample Data for 2018

Waterbody	Station	Report Date	Bloom Intensity	Density (cells/mL)	Microcystin (ug/L)	Anatoxin (ug/L)
Lake Carmi	Lake Carmi State Park	06/26/19	1d - Little BGA present	5510	<0.16	<0.5
		07/03/19	1d - Little BGA present	5810	<0.16	<0.5
		07/10/19	1d - Little BGA present	12200	<0.16	<0.5
		07/17/19	1d - Little BGA present	506	<0.16	<0.5
		07/24/19	1d - Little BGA present	12000	<0.16	<0.5
		07/31/19	1d - Little BGA present	5160	<0.16	<0.5
		08/07/19	1a - Little or no BGA present - clear water	2750	<0.16	<0.5
		08/14/19	1d - Little BGA present	16700	<0.16	<0.5
		08/21/19	1d - Little BGA present	7550	<0.16	<0.5
		08/28/19	1d - Little BGA present	197900	<0.16	<0.5
		09/06/19	1a - Little or no BGA present - clear water	25300	<0.16	<0.5
		09/11/19	3 - BGA bloom in progress	1156600	<0.16	<0.5
		09/18/19	3 - BGA bloom in progress	170000	0.54	<0.5
		09/25/19	1d - Little BGA present	16000	<0.16	<0.5
	Lake Carmi, North Beach	06/26/19	1d - Little BGA present	8250	<0.16	<0.5
		07/03/19	1d - Little BGA present	6120	<0.16	<0.5
		07/10/19	1d - Little BGA present	11500	<0.16	<0.5
		07/17/19	1d - Little BGA present	494	<0.16	<0.5
		07/24/19	1d - Little BGA present	487	<0.16	<0.5
		07/31/19	2 - BGA present - less than bloom levels	5860	<0.16	<0.5
		08/07/19	1d - Little BGA present	1450	<0.16	<0.5
		08/14/19	1c - Little or no BGA present - other material present	6590	<0.16	<0.5
		08/21/19	1d - Little BGA present	6830	<0.16	<0.5
		08/28/19	3 - BGA bloom in progress	249200	<0.16	<0.5
		09/06/19	1c - Little or no BGA present - other material present	32800	<0.16	<0.5
		09/11/19	3 - BGA bloom in progress	355500	<0.16	<0.5
		09/18/19	3 - BGA bloom in progress	214000	**1.19**	<0.5
		09/25/19	1c - Little or no BGA present - other material present	10900	<0.16	<0.5
Lake Champlain	Alburgh Dunes State Park	06/26/19	1a - Little or no BGA present - clear water	493	<0.16	<0.5
		07/03/19	1d - Little BGA present	0	<0.16	<0.5
		07/10/19	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		07/17/19	1d - Little BGA present	400	<0.16	<0.5
		07/24/19	1d - Little BGA present	0	<0.16	<0.5
		07/31/19	1d - Little BGA present	480	<0.16	<0.5

Waterbody	Station	Report Date	Bloom Intensity	Density (cells/mL)	Microcystin (ug/L)	Anatoxin (ug/L)
		08/07/19	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		08/14/19	1d - Little BGA present	8000	<0.16	<0.5
Lake Champlain	Alburgh Dunes State Park	08/21/19	1d - Little BGA present	293	<0.16	<0.5
		08/28/19	1d - Little BGA present	9920	<0.16	<0.5
		09/06/19	1a - Little or no BGA present - clear water	18700	<0.16	<0.5
	North Beach	06/26/19	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		07/02/19	1b - Little or no BGA present - brown or turbid water	0	<0.16	<0.5
		07/09/19	1c - Little or no BGA present - other material present	0	<0.16	<0.5
		07/16/19	1b - Little or no BGA present - brown or turbid water	0	<0.16	<0.5
		07/23/19	1a - Little or no BGA present - clear water	360	<0.16	<0.5
		08/01/19	1d - Little BGA present	0	<0.16	<0.5
		08/06/19	1c - Little or no BGA present - other material present	80	<0.16	<0.5
		08/13/19	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		08/20/19	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		08/27/19	1a - Little or no BGA present - clear water	2370	<0.16	<0.5
		09/04/19	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		09/10/19	1a - Little or no BGA present - clear water	3140	<0.16	<0.5
		09/18/19	1a - Little or no BGA present - clear water	1680	<0.16	<0.5
		09/24/19	1a - Little or no BGA present - clear water	1510	<0.16	<0.5
	Red Rocks Beach	06/25/19	1a - Little or no BGA present - clear water	880	<0.16	<0.5
		07/01/19	1b - Little or no BGA present - brown or turbid water	267	<0.16	<0.5
		07/09/19	1c - Little or no BGA present - other material present	0	<0.16	<0.5
		07/16/19	1c - Little or no BGA present - other material present	19300	<0.16	<0.5
		07/23/19	1b - Little or no BGA present - brown or turbid water	0	<0.16	<0.5
		07/30/19	1b - Little or no BGA present - brown or turbid water	267	<0.16	<0.5
		08/06/19	1b - Little or no BGA present - brown or turbid water	973	<0.16	<0.5
		08/13/19	1c - Little or no BGA present - other material present	800	<0.16	<0.5
		08/20/19	1b - Little or no BGA present - brown or turbid water	0	<0.16	<0.5
		08/27/19	1c - Little or no BGA present - other material present	13	<0.16	<0.5
		09/04/19	1c - Little or no BGA present - other material present	13	<0.16	<0.5
		09/10/19	1a - Little or no BGA present - clear water	533	<0.16	<0.5
		09/17/19	1c - Little or no BGA present - other material present	1510	<0.16	<0.5
		09/24/19	1a - Little or no BGA present - clear water	978	<0.16	<0.5
	Shipyard, Highgate Springs	06/25/19	1b - Little or no BGA present - brown or turbid water	0	<0.16	<0.5
		07/02/19	1a - Little or no BGA present - clear water	0	<0.16	<0.5

Waterbody	Station	Report Date	Bloom Intensity	Density (cells/mL)	Microcystin (ug/L)	Anatoxin (ug/L)
		07/09/19	1a - Little or no BGA present - clear water	1450	<0.16	<0.5
		07/16/19	1a - Little or no BGA present - clear water	0	<0.16	<0.5
Lake Champlain	Shipyard, Highgate Springs	07/23/19	1a - Little or no BGA present - clear water	400	<0.16	<0.5
		07/30/19	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		08/06/19	1a - Little or no BGA present - clear water	3910	<0.16	<0.5
		08/20/19	3 - BGA bloom in progress	159600	<0.16	<0.5
		08/27/19	1d - Little BGA present	33500	<0.16	<0.5
		09/05/19	1a - Little or no BGA present - clear water	4220	<0.16	<0.5
		09/10/19	1c - Little or no BGA present - other material present	6636000	<0.16	<0.5
		09/24/19	1b - Little or no BGA present - brown or turbid water	160900	<0.16	<0.5
	St. Albans Bay Park	06/26/19	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		07/03/19	1a - Little or no BGA present - clear water	3150	<0.16	<0.5
		07/10/19	1d - Little BGA present	20800	<0.16	<0.5
		07/16/19	2 - BGA present - less than bloom levels	3120	<0.16	<0.5
		07/23/19	1d - Little BGA present	18700	<0.16	<0.5
		07/31/19	1a - Little or no BGA present - clear water	502	<0.16	<0.5
		08/06/19	3 - BGA bloom in progress	57800	<0.16	<0.5
		08/14/19	3 - BGA bloom in progress	1733200	0.27	0.78
		08/21/19	3 - BGA bloom in progress	28900	<0.16	<0.5
		08/28/19	1d - Little BGA present	383200	<0.16	<0.5
		09/06/19	2 - BGA present - less than bloom levels	616000	<0.16	<0.5
		09/18/19	2 - BGA present - less than bloom levels	48900	<0.16	<0.5
		09/25/19	1d - Little BGA present	423000	<0.16	<0.5
	Tri-Town Road, West Addison	06/25/19	1c - Little or no BGA present - other material present	0	<0.16	<0.5
		07/02/19	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		07/09/19	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		07/16/19	1d - Little BGA present	1080	<0.16	<0.5
		07/23/19	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		07/30/19	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		08/06/19	1a - Little or no BGA present - clear water	1080	<0.16	<0.5
		08/13/19	1a - Little or no BGA present - clear water	1520	<0.16	<0.5
		08/20/19	1a - Little or no BGA present - clear water	0	<0.16	<0.5
		08/27/19	1a - Little or no BGA present - clear water	6350	<0.16	<0.5
		09/04/19	1b - Little or no BGA present - brown or turbid water	0	<0.16	<0.5
		09/10/19	1a - Little or no BGA present - clear water	67	<0.16	<0.5
		09/17/19	1a - Little or no BGA present - clear water	21600	<0.16	<0.5
		09/24/19	1c - Little or no BGA present - other material present	0	<0.16	<0.5

Appendix D – Historical Microcystin Data for Lake Champlain

Lake Segment		2003	2004	2005	2006	2007	2008	2009	2010	2011
Inland Sea	median	0.05	0.41	0.08	0.27	0.05	1.10	0.07	0.03	0.08
	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
	#samples	6	8	8	16	4	11	2	3	9
	#stations	1	3	3	7	3	4	2	2	4
Main Lake Central	median	0.05	NA	7.42	NA	2.82	0.25	0.03	0.10	0.02
	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
	#samples	19	0	2	0	2	2	6	8	4
	#stations	4	NA	1	NA	2	2	3	5	4
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
	#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
	range	0.07	NA	ND - 0.07	3.47	NA	NA	NA	NA	0.01
	#samples	1	0	2	1	0	0	0	0	2
	#stations	1	NA	1	1	NA	NA	NA	NA	2
St. Albans Bay	median	0.05	0.05	0.30	0.06	0.05	0.04	0.02	0.05	0.04
	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
	#samples	32	29	18	36	20	10	4	10	12
	#stations	1	2	1	2	4	3	2	3	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
	#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
	#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
	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
	#samples	341	228	146	152	0	81	29	10	59
	#stations	14	11	10	12	NA	10	8	7	8