Cyanobacteria Monitoring on Lake Champlain Summer 2016

Final Report for the Lake Champlain Basin Program

April 2017

Prepared by

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

in conjunction with

Sarah Vose
Bridget O'Brien
Radiological & Toxicological 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 CDC, and private donors. Data are collected by state staff and an extensive network of trained citizen volunteers.

Cyanobacteria monitoring on Lake Champlain in 2016 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 and anatoxin, when warranted, provided additional data to inform public health decisions in response to the presence of cyanobacteria. Enhancements of the web-based tracking map maintained by the VDH streamlined volunteer reporting and facilitated public outreach for 2016.

Objectives

- monitor cyanobacteria at locations on Lake Champlain through the established partnership of state staff, the Lake Champlain Committee staff, and citizen volunteers;
- provide consistent quantitative data at selected locations around Lake Champlain;
- recruit additional volunteers to monitor conditions on selected Vermont lakes with periodic cyanobacteria blooms;
- 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 VDH webpages;
- 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.

More than 1398 site-specific reports were submitted during 2016 from more than 150 locations on Lake Champlain and inland lakes in Vermont. Citizen volunteers trained by the Lake Champlain Committee reported from 106 locations on Lake Champlain and 12 on other Vermont lakes. Blooms, defined as category 3 of the visual protocol were reported 76 times during the monitoring period in 2016. No microcystin or anatoxin was detected in 2016.

Table of Contents

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 monitoring program has been in place on Lake Champlain since 2002, developed initially by the University of Vermont (UVM). 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 and private donors. Data are collected by state staff and an extensive network of trained citizen volunteers.

Cyanobacteria monitoring on Lake Champlain in 2016 continued to integrate qualitative observations, photographic documentation and quantitative analysis of algae populations into guidance for lake users. Analysis of water for the presence of microcystin and anatoxin, when warranted, provided additional data to inform public health decisions in response to the presence of cyanobacteria. Enhancements of the web-based tracking map maintained by the VDH greatly facilitated the receipt and review of reports from volunteers and state staff.

Objectives

- monitor cyanobacteria at locations on Lake Champlain and selected 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;
- recruit additional volunteers to monitor conditions on selected Vermont lakes with periodic cyanobacteria blooms;
- test for the presence of cyanotoxins when algal 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 VDH 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.

Methods

The 2016 cyanobacteria monitoring program was coordinated by the VT DEC, Watershed Management Division (WsMD) and implemented in conjunction with the VDH and LCC. Quantitative samples were collected following a modification of the UVM tiered alert protocol at selected open water stations historically monitored by the program. Additional water samples for quantitative assessment were collected at selected shoreline locations. Qualitative data were gathered following the protocol developed in 2012 by the LCC. Reports from the monitoring partners were uploaded via a controlled web interface directly to the Cyanobacteria Tracking map maintained by the VDH.

Sampling Locations

Routine reports were received from a total of 110 locations during the summer of 2016 (Figure 1). Occasional reports were received from an additional 36 stations. 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.

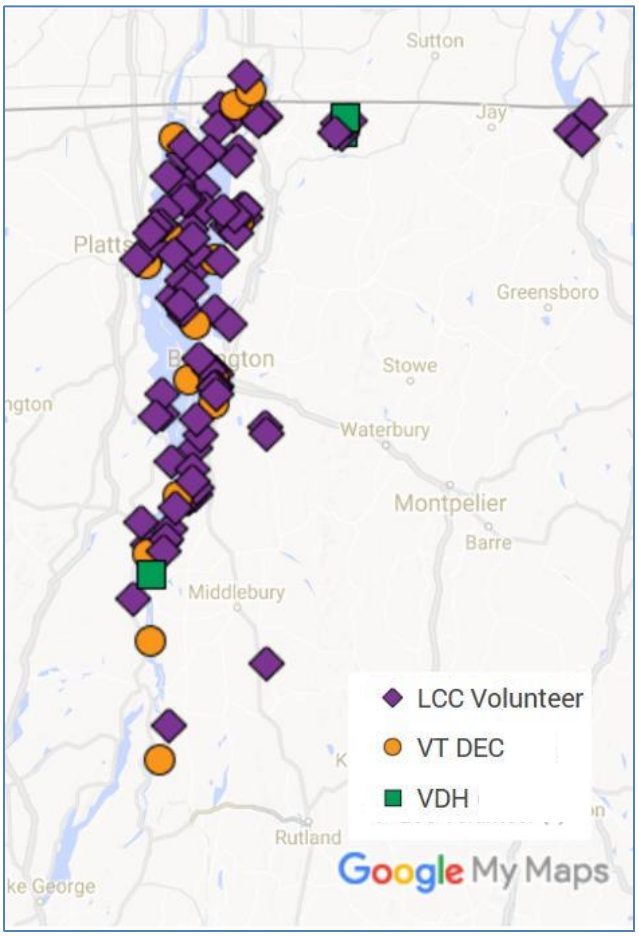


Figure 1. Overview of cyanobacteria monitoring stations on Lake Champlain and selected Vermont inland lakes in 2016

Table 1. Stations routinely monitored on Lake Champlain and selected Vermont lakes during 2016. Data compiled from the season summary spreadsheet available through the VDH Tracking Map.

Lake	Region	Assessment Type	Mid-lake (# of Sites)	Shoreline (# of Sites)
Champlain	Inland Sea	Visual		18
		Tiered Alert	1	
	Main Lake Central	Visual/Tiered Alert		2
		Visual		18
		Tiered Alert	4	
	Main Lake North	Visual/Tiered Alert		1
		Visual		12
		Tiered Alert	2	
	Main Lake South	Visual/Tiered Alert		2
		Visual		16
		Tiered Alert	1	
	Malletts Bay	Visual/Tiered Alert		
		Visual		2
		Tiered Alert	1	
	Missisquoi Bay	Visual/Tiered Alert		1
		Visual		5
		Tiered Alert	2	
	South Lake	Visual/Tiered Alert		
		Visual		1
		Tiered Alert	2	
	St. Albans Bay	Visual/Tiered Alert		1
		Visual		5
		Tiered Alert	1	
Dunmore		Visual		1
Iroquois		Visual		2
Memphremagog		Visual		3
Carmi		Visual/Tiered Alert		2
		Visual		4

Monitoring Protocols

The Tiered Alert Protocol

Quantitative data on taxonomic distribution, cell density and the presence of toxins were collected by the VT DEC following a modification of the Tiered Alert protocol (Table 2). Monitoring began the week of June 1st and continued through mid-October. The VT DEC utilized this protocol at selected open water stations around Lake Champlain (Figure 1 and Appendix A). Samples were collected at biweekly intervals, following the cell density triggers outlined in the protocol or the presence of visible accumulations of cyanobacteria, in conjunction with the monitoring conducted for the Lake Champlain Long-term Water Quality and Biological Monitoring Program. Whole water samples collected weekly at selected shoreline locations by experienced monitors were also evaluated for the presence of cyanobacteria using the tiered alert cell count protocol.

Table 2. Outline of the Tiered Alert sampling protocol. *The presence of a visible scum automatically qualifies as Alert Level 2, regardless of previous conditions.

Framework Level	Frequency	Activity	Response
Qualitative*	2/month	3m vertical plankton tow (63µm mesh), screened within 72 hrs.	If potentially toxic taxa observed, proceed to *Quantitative Level* for next sampling visit
Quantitative*	2/month	3m vertical plankton tow (63µm mesh), enumeration within 24 hrs.	If potentially toxic taxa densities >2000 cells/mL, proceed to *Vigilance Level* for next sampling visit
Vigilance*	2/month	3m vertical plankton tow (63µm mesh), Full enumeration within 24 hrs. If conditions suggest onset of a bloom, whole water samples will be collected for toxin analysis.	If potentially toxic taxa densities >4000 cells/mL, proceed to *Alert Level1* for next sampling visit. Return to Quantitative Level if densities <2000 cells/mL.
Alert Level 1*	2/month	Collect whole water samples for phytoplankton and toxin analysis. Full enumeration and microcystin analysis with 24 hrs.	If microcystin >6µg/L (VT recreational standard) proceed to *Alert Level 2.* Return to Vigilance Level if densities <4000 cells/mL.
Alert Level 2	2/month	As for Alert Level 1	If microcystin >6µg/L, the VT recreational standard, remain at *Alert Level 2.* Return to Alert Level 1 if microcystin concentrations <6µg/L. VT, NY and QE public health officials follow their respective response plans.

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 scums and blooms 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 cell. One mL aliquots were settled for 10 – 15 minutes before analysis. During qualitative analysis, SR cells were scanned rapidly for the presence of potentially toxic cyanobacteria, generating presence/absence data only. For quantitative analysis, estimates of cell density were obtained for all observed cyanobacteria and selected other taxa using the size categories noted in Table 3. 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. However, plankton counts were used to determine the cyanobacteria status only at the open water stations monitored by the VT DEC. Plankton samples were counted by VT DEC staff and data were uploaded to the VDH data interface, typically within 24 hours for tiered alert stations. Bloom and 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 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

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 to early September). While the LCC did recruit to gain as wide a geographic distribution as possible, no volunteer was turned away. In a few areas of the lake, this did 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.

Weekly Observation Process

The LCC trained 275 volunteer monitors and interested citizens in 19 training sessions during 2016. Over the course of the summer, volunteer monitors reported from 118 different locations in 2016 (Figure 1 and Appendix A). 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, Sunday through Wednesday. Supplemental reports could also be provided.

Volunteers evaluated cyanobacteria conditions at their location using the prompts, photographs, and descriptions provided by the LCC, and assigned it one of the three categories:

- Category 1 – few or no cyanobacteria observed, recreational enjoyment not impaired by cyanobacteria. (Category 1 contained multiple subcategories.)
- 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 algal accumulations resulting in highly colored water and/or visible surface scums.

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 via their online form. LCC staff reviewed all reports and photos, conferring with volunteers, VDH, and the VT DEC 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. 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, and 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, anatoxin and cyanobacteria density.

Toxin Analysis

Toxin analyses were conducted by the VDH laboratory in Burlington 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.

Communication and Outreach

Members of the partner institutions LCC, VT DEC and VDH comprised an internal communication group which shared all bloom reports upon receipt and provided updates on response activities as needed. Partners also received automated notification of alert level 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 Lake Champlain Basin Program (LCBP), NY DEC, and the Quebec Ministrie de Développement durable, Environnement, et Lutte Contre les Changements Climatiques (MDDELCC) were also kept apprised of cyanobacteria conditions. The MDDELCC provided their observations and analytical results from northern Missisquoi Bay over the summer, which were shared through the tracking map with the public.

Weekly email updates summarizing reports, cyanobacteria 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 Thursday afternoons but stakeholders also received email notification of extensive blooms as they occurred.

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	Tiered Alert Protocol	Visual
Generally Safe (green)	Qualitative, Quantitative, Vigilance	Category 1
Low Alert (yellow)	Alert Level 1	Category 2
High Alert (red)	Alert Level 2	Category 3

Map status was based on the primary report type for each station, visual or tiered alert. At the VDH sites and the quantitative sites monitored by LCC volunteers, water samples for toxin and phytoplankton analysis were collected concurrently with the visual assessment. At these locations, 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 2016.

Effective July 1 2016, Act 86 required the VDH to begin public notification within 1 hour of determining that there was a public health risk associated with the presence of cyanobacteria on any Vermont surface waters. VDH used the Cyanobacteria Tracker to initiate public outreach and also made direct contact with affected municipalities as soon as possible after confirming cyanobacteria reports at the Low and High Alert levels. Authority to close beaches or other public venues on surface waters lies with the town health officer (THO) and VDH worked with THOs to implement public outreach strategies such as signs and closures at affected locations.

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, and shared that information 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 Tracker map and annual data. Partners also held trainings, made presentations upon request, and responded to inquiries from the public, lake users and the media.

Results

Overall effort
Nearly 1400 site-specific reports were made by project partners, volunteers, and other during 2016 (Table 4). Most of these were from Lake Champlain but regular reports were also provided by VDH staff and LCC coordinated volunteer efforts on lakes Carmi, Dunmore, Iroquois and Memphremagog in Vermont. In addition, supplemental reports (n = 251) were received from locations not monitored regularly, made outside of the regular monitoring period by LCC volunteers, or provided by the public. Reports based on the visual assessment protocol represented 92% of the total received. Reports from stations using both the tiered alert and visual assessment protocols represented 7%. The remaining reports were obtained using the tiered alert protocol.

The number of samples analyzed in 2016 is summarized in Table 5. Two hundred eighteen water samples were analyzed for phytoplankton density, 585 for microcystin, and 113 for anatoxin. Most toxin samples were collected for quality control purposes or as part of the drinking water monitoring effort and were not triggered by assessment reports. Eight supplemental samples for phytoplankton analysis and 19 for toxin analysis were by provided by project partners after observing blooms.

Assessment Results – Recreational Monitoring
A summary of the assessment results from regularly monitored stations in 2016 is presented in Table 6. The highest monitoring category reached in each region of Lake Champlain and Vermont inland lakes for which we have information is noted in Table 7. There were no reports of cyanobacteria mats in 2016. The full list of records is available upon request or can be downloaded from the VDH website (https://apps.health.vermont.gov/vttracking/BlueGreenAlgae/2016Summary/). No reports of human or animal illness due to cyanobacteria were received in 2016.

Most routine reports (96%) indicated that few or no cyanobacteria were present (category 1 of the visual protocol and qualitative/quantitative/vigilance levels of the tiered alert protocol). Blooms, identified as category 3 of the visual protocol, were reported 22 times at regularly monitored stations. Fifty-four supplemental reports indicated bloom conditions, some representing multiple reports for blooms which persisted over several days. In all, 76 reports of bloom conditions were received during the summer of 2016, 5% of the total reports received. The highest density of potentially toxic cyanobacteria was observed offshore of the Alburgh VT shoreline of Missisquoi Bay on September 29, 2016 (788,200 cells/mL).

Table 4. Summary of the 2016 cyanobacteria monitoring station reports distributed through the email update and on-line status map. () 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.

Waterbody	Region	Monitor	Tiered alert	Visual	Visual/ Quantitative
Champlain	Inland Sea	VT DEC	6		
		LCC		178(12)	
		VDH		(1)	
	Main Lake Central	VT DEC	31		
		LCC		191(75)	26
		VDH		(1)	
	Man Lake North	VT DEC	13(1)		
		LCC		142(11)	
		VDH		(2)	11
	Main Lake South	VT DEC	14	(3)	
		LCC		164(15)	
		VDH			12
	Malletts Bay	VT DEC	9		
		LCC		19(7)	
		VDH			
	Missisquoi Bay	VT DEC	21	(4)	
		LCC		63(27)	13
		VDH		(2)	
	South Lake	VT DEC	14		
		LCC		7(11)	
		VDH			
	St. Albans Bay	VT DEC	7		
		LCC		51(27)	10
		VDH			(1)
Chittenden		VDH		(6)	(2)
Dewey		VDH		(1)	
Emerald		Other*		(1)	
Carmi		LCC		50(5)	
		VDH		24	
		VT DEC		(2)	
Dunmore		LCC		5	
Iroquois		LCC		22(10)	
Memphremagog		LCC		43(2)	
Morey		VDH		(3)	
		Other*		(3)	
Pinneo		Other*		(2)	
Maidstone		Other*		(3)	
North Hartland		Other*		(3)	
Stoughton		Other*		(9)	

Table 5. Number of water and phytoplankton samples collected and analyzed in 2016. Data compiled from the season summary spreadsheet available through the VDH Tracking Map and the DWGWDP Drinking Water Monitoring Program summary.

Assessment Type	**Phytoplankton**		**Microcystin**	**Anatoxin**
	Plankton Net	**Whole Water**	**Whole Water**	**Whole Water**
Tiered Alert	117	4	8	8
Visual/Quantitative		89	97	97
Supplemental	1	7	11	8
Drinking Water Monitoring			469	
Total	**118**	**100**	**585**	**113**

Table 6. Summary of assessment reports received in 2016. () indicate supplemental reports. Data compiled from the season summary spreadsheet available through the VDH Tracking Map.

Waterbody	**Region**	**1a - Little or no BGA present - clear water**	**1b - Little or no BGA present - brown or turbid water**	**1c - Little or no BGA present - other material present**	**1d - Little BGA present - recreation not impaired**	**2 - BGA present - less than bloom levels (include photos)**	**3 - BGA bloom in progress (include photos)**	**Tiered Alert – Quanti-tative**	**Total**
Champlain	Inland Sea	113 (5)	23 (3)	33 (1)	6 (1)	1 (3)	2	6	184 (13)
	Main Lake Central	165 (41)	20 (6)	23 (5)	7 (1)	2 (15)	(8)	31	248 (76)
	Main Lake North	117 (6)	8	16	10 (1)	2 (2)	(5)	13	166 (14)
	Main Lake South	98 (8)	33 (3)	30 (2)	12 (1)	2 (4)	1	14	190 (18)
	Malletts Bay	12 (2)	7 (5)					9	28 (7)
	Missisquoi Bay	38 (4)	14 (1)	11 (3)	4 (2)	8 (4)	11 (19)	11	97 (33)
	South Lake	7 (8)	(1)	(2)				14	21 (11)
	St. Albans Bay	31 (8)	6 (2)	9 (2)	7 (3)	5 (6)	8 (6)	3	69 (27)
Carmi		53 (1)	8	3	9	1 (3)	(3)		74 (7)
Chittenden Reservoir		(1)			(4)	(1)	(2)		(8)
Dewey						(1)			(1)
Dunmore		5							5
Emerald						(1)			(1)
Iroquois		21 (8)	(1)	1 (1)					22 (10)
Maidstone					(1)	(2)			(3)
Memphremagog		28	10	5	(1)	(1)			43 (2)
Morey						(6)			(6)
North Hartland							(3)		(3)
Pinneo							(2)		(2)
Stoughton						(3)	(6)		(9)
	Grand Total	**688 (92)**	**129 (22)**	**131 (16)**	**55 (15)**	**21 (52)**	**22 (54)**	**101**	**1147 (251)**

Table 7. Highest status reached in each waterbody in 2016. Data compiled from the season summary spreadsheet available through the VDH Tracking Map. Methods: V = visual, Q = Quantitative, Q/V = QA/QC station utilizing both quantitative and visual protocols. *Tracker status based on USAC reports.

Lake	Region	Method	# Reports	Highest Status Observed	Highest Cell Density Observed	Highest Microcystin (# Tested)	Highest Anatoxin (# Tested)
Champlain	Inland Sea	V, Q	197	High Alert	685	Not Tested	Not Tested
	Main Lake Central	V, Q, Q/V	324	High Alert	7960	<0.16 (26)	<0.5 (26)
	Main Lake North	V, Q, Q/V	180	High Alert	4990	<0.16 (12)	<0.5 (12)
	Main Lake South	V, Q, Q/V	208	High Alert	22100	<0.16 (12)	<0.5 (12)
	Malletts Bay	V, Q	35	Generally Safe	458	Not Tested	Not Tested
	Missisquoi Bay	V, Q, Q/V	130	High Alert	788200	<0.16 (19)	<0.5 (19)
	South Lake	V, Q	32	Generally Safe	125	Not Tested	Not Tested
	St. Albans Bay	V, Q, Q/V	96	High Alert	100600	<0.16 (15)	<0.5 (15)
Chittenden Reservoir		Q/V	8	High Alert	38100	<0.16 (5)	<0.5 (4)
Dewey		V*	1	Low Alert	55500	Not Tested	Not Tested
Emerald		V	1	Low Alert	Not Tested	Not Tested	Not Tested
Carmi		Q/V	81	High Alert	570400	<0.16 (25)	<0.5 (25)
Dunmore		V	5	Generally Safe	Not Tested	Not Tested	Not Tested
Iroquois		V	32	Generally Safe	Not Tested	Not Tested	Not Tested
Memphre-magog		V	45	Low Alert	Not Tested	Not Tested	Not Tested
Morey		V	6	Low Alert	Not Tested	<0.16 (1)	Not Tested
Pinneo		V*	2	High Alert	Not Tested	Not Tested	Not Tested
Maidstone		V	3	Low Alert	Not Tested	<0.16 (1)	Not Tested
North Hartland		V*	3	High Alert	Not Tested	Not Tested	Not Tested
Stoughton		V*	9	High Alert	Not Tested	Not Tested	Not Tested

A total of 116 recreational samples were analyzed for the presence of microcystin and 113 for anatoxin in 2016 (Table 5). The number of samples tested for each waterbody is provided in Table 7. No microcystin or anatoxin was detected. Cylindrospermopsin was not tested in 2016.

Twenty-three cyanobacteria taxa were observed in Lake Champlain or inland lakes during the 2016 monitoring period (Table 8). The majority have been identified as potential toxin producers in the scientific literature. Two new but rare taxa – *Komvophoron* spp. and *Cyanodictyon* spp. – were observed.

Photographs are located in Appendix E. There were not enough individuals of these taxa in the sample to send out for confirmation.

Table 8. 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 2016	Year of First Report
Anabaena circinalis	yes	yes	2003*
Anabaena planctonica	yes	yes	2003*
Anabaena spp	yes	yes	2003*
Anabaena flos-aquae	yes	yes	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	no	2012
Chroococcus spp.	no	yes	2003
Coelosphaerium spp.	Yes	no	2003
Cyanodictyon spp.	no	yes	2016
Gloeotrichia spp.	yes	yes	2003
Gloeocapsa spp.	yes	no	2004
Komvophoron spp.	yes	yes	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
**Pseudanabaena* spp	yes	yes	2012
**Radiocystis* spp.	possible	no	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
colonial taxon (likely *Cyanonephron* spp.)	no	yes	2014

Drinking Water Supply Monitoring

In 2016, the VDH offered again free weekly microcystin testing for public drinking water facilities in Vermont from July 12 through September 26. The DWGWPD organized training sessions for facility operators, where LCC provided guidance on the visual assessment system and VDH provided an overview of Vermont's guidance for cyanotoxins in drinking water. Results of the summer's testing are presented in Table 9 and can be found online at http://dec.vermont.gov/water/drinking-water/water-quality-monitoring/blue-green-algae/cyanotoxin-monitoring.

Microcystin was detected at one facility in *raw* water (0.16 µg/L). Immediate follow-up testing was conducted within 24 hours, following the voluntary drinking water guidance for cyanobacteria. Microcystin in the follow up tests, both raw and finished, was below detection and there was no impact to drinking water services at the affected facility.

Table 9. Results of the Drinking Water Monitoring Project in 2016. Testing was limited to the 22 public facilities in Vermont.

Facility	**Microcystin - Raw Water**		**Microcystin – Finish Water**	
	Number of Samples	**Result**	**Number of Samples**	**Result**
Alburgh F.D. #1	9	Below detection	9	Below detection
Alburgh Village	9	Below detection	9	Below detection
Apple Island Resort	11	Below detection	11	Below detection
Basin Harbor Club - Ferrisburg	12	Below detection	12	Below detection
Bow and Arrow – North Hero	11	Below detection	11	Below detection
Burlington Public Works	12	Below detection	12	Below detection
Burton Island State Park (Closed for the season Sept 7)	9	Below detection	9	Below detection
Camp Skyland – South Hero (Closed for the season Aug 31)	8	Below detection	8	Below detection
Champlain Water District	12	Below detection	12	Below detection
Grand Isle Consolidated	12	Below detection	12	Below detection
Grand Isle F.D. #4	13	0.16 µg/L (9/28/16) Confirmation sample 9/30/16 was below detection	13	Below detection
North Hero	11	Below detection	12	Below detection
Paradise Bay – South Hero	11	Below detection	12	Below detection
Ruthcliffe – Isle La Motte (Closed for the season Sept 1)	8	Below detection	8	Below detection
Sandbar State Park – Milton (Closed for the season Sept 7)	7	Below detection	7	Below detection
South Hero F.D. #4	11	Below detection	11	Below detection
St. Albans	12	Below detection	12	Below detection
Swanton	12	Below detection	12	Below detection
Thompsons Pt. - Charlotte	12	Below detection	12	Below detection
Tritown Water District	12	Below detection	12	Below detection
Vergennes/Panton	12	Below detection	12	Below detection
West Wind – Charlotte11	11	Below detection	11	Below detection

Reproducibility of Assessment Results

Environmental variability

Phytoplankton composition and density is highly variable in natural environments such as Lake Champlain. Cyanobacteria exhibit considerable variation in population density within very short distances and time intervals. The effectiveness of the tiered alert protocol in light of this variability was documented by Rogalus and Watzin (2008). In 2016, consistency between duplicates was good (Table 10). Of the 13 duplicate counts made over the summer, there was one instance where the second count indicated a change of status from generally safe to alert level.

Table 10. Comparability of phytoplankton quality control samples in 2016.

Test	N	Status Identical	Change from generally safe to alert (N)
Field duplicates	8	7	1
Laboratory duplicates	5	5	0

Volunteer training

Volunteer trainings were conducted by LCC staff at locations around the Lake Champlain Basin. Nineteen formal sessions trained 275 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.

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 others around the Basin. Guidance and assistance to town health officers, beach managers, and residents was provided during bloom events. All partners maintained 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. Several partners continue to participate in the NEIWPCC regional cyanobacteria workgroup. VT DEC field staff also 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 has joined the Great Lakes HABS Collaboratory, an effort to leverage relationships among universities, states and federal partners to share cutting edge research and develop collaborative approaches to cyanobacteria monitoring.

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. Historic and current data from the Champlain project will support ground-truthing and algorithm development activities in 2017.

Communication with the Stakeholders and the Public

Results of the weekly assessments were communicated via email to a variety of stakeholders. The 140 recipients were largely associated with the states of Vermont and New York (n = 90, including partners). Other recipients included federal officials (6), provincial officials in Quebec (4), water facilities or municipal staff (15), non-profits and universities (16, including partners), and unknown recipients (9).

Information was shared with the public via the VDH cyanobacteria webpages - http://healthvermont.gov/enviro/bg_algae/bgalgae.aspx. Between June 16 and November 2016, the website received over 23,000 visits while the interactive map received more than 12,000 views (Table 11). Activity was greatest in July and August, corresponding to 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.

Table 11. Usage of the VDH Cyanobacteria webpages mid to late 2016. *Site maintenance and development prior to June 15 artificially increased views. **Mobile devices were not tracked appropriately by the software and are not presented here.

Month*	**Cyanobacteria Website Unique Views**	**Cyanobacteria Tracker Map – computer views only****
June 16 - 30	2,200	647
July	9,392	4977
August	6,224	3285
September	3,187	2169
October	1,690	554
November	1,051	421
December	837	377
Total:	**24,581**	**12,430**

Discussion

The primary role of the 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 evaluate the quality of their raw 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 in conjunction with visual assessments at selected sites continue to support the visual assessment protocols as an effective tool to assess potential recreational risk. In 2016, LCC volunteers at Red Rocks and North Beaches in the Burlington area, the Shipyard at Highgate Springs, and St. Albans Bay Park collected water samples when they made their assessments. VDH staff did the same for two stations on Lake Champlain (Alburgh Dunes State Park, Tri-town Road in West Addison) and Lake Carmi (North Beach and the beach in Lake Carmi State Park).

These data continue to show that the visual assessment protocol is a successful tool for the evaluation of recreational risk from cyanobacteria. The majority of reports noted Category 1 (generally safe conditions), with correspondingly low concentrations of potentially toxic cyanobacteria (Appendix C). No microcystin or anatoxin was detected in any quality control sample. Four samples had enough potentially toxic cyanobacteria observed during microscopic analysis that they would have been more appropriately characterized as Category 1d (small amounts of cyanobacteria present) but this would not have changed the status as reported on the Tracker map.

Cyanobacteria conditions on four Vermont inland lakes

The VDH made routine observations following the visual assessment protocol and collected water samples for toxin and phytoplankton analysis from two locations on Lake Carmi. Lake associations at Iroquois, Carmi and Memphremagog conducted routine monitoring sites on their respective lakes utilizing the visual assessment system but did not collect water samples. One LCC volunteer routinely reported from Lake Dunmore using the visual assessment protocol. Volunteer participation greatly increased the number of reports received from inland lakes in Vermont again this year.

The majority of reports from these lakes indicated generally safe conditions. Lake Carmi did experience bloom conditions during a week in August and again in October, two and four alert level reports, respectively. Lake Memphremagog had one alert level report in September. Lakes Iroquois and Dunmore experienced no blooms in 2016.

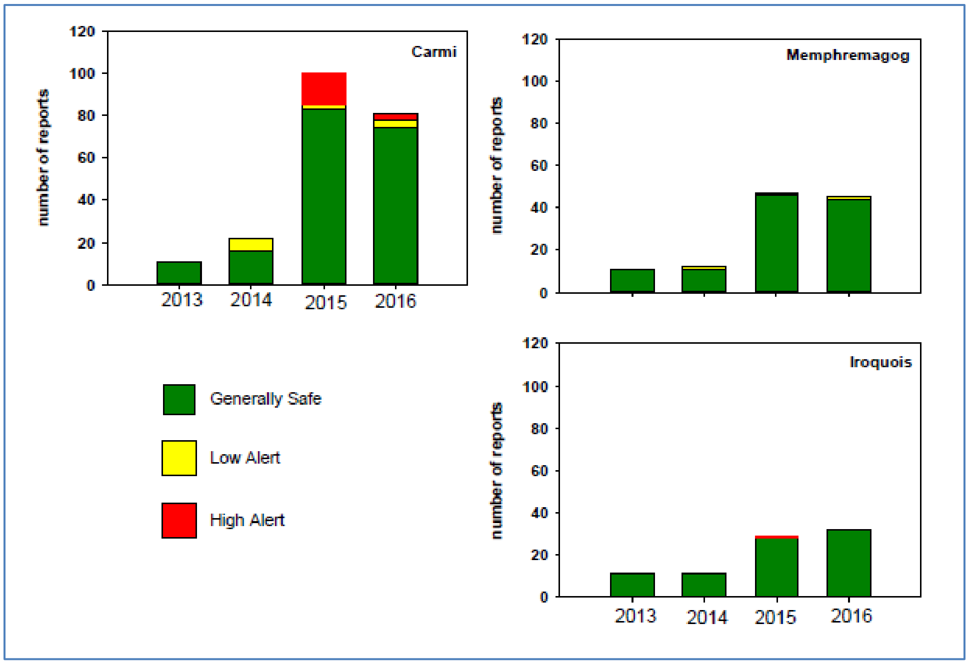


Figure 2. Webpage status reports on selected inland lakes since 2013. Supplemental reports are included. Only one year of routine monitoring data is available for Lake Dunmore, therefore it was not included.

Table 12 summarizes microcystin concentrations observed at selected Vermont inland lakes since monitoring began in 2012. There were no detections of microcystin on these lakes in 2016.

Table 12. Microcystin concentrations in selected Vermont lakes, 2013 - 2016. Stations were monitored weekly. Supplemental bloom samples are also included. <0.16 is the reporting limit

Lake		2013	2014	2015	2016
Lake Carmi	median	<0.16	<0.16	<0.16	<0.16
	range	<0.16 - 0.21	<0.16 - 0.39	<0.16 – 0.40	<0.16
	#samples	10	19	17	25
	#stations	1	4	2	3
Lake Elmore	median	<0.16	<0.16	<0.16	
	range	<0.16	<0.16 - 0.18	<0.16 – 0.19	
	#samples	11	11	11	
	#stations	1	1	1	
Lake Iroquois	median	<0.16	<0.16	<0.16	
	range	<0.16	<0.16	<0.16	
	#samples	11	11	11	
	#stations	1	1	2	
Lake Memphremagog	median	<0.16	<0.16	<0.16	
	range	<0.16	<0.16	<0.16 – 0.17	
	#samples	11	11	11	
	#stations	1	1	1	

Lake		2013	2014	2015	2016
Chittenden Reservoir	median				<0.16
	range				
	#samples				4
	#stations				1
Lake Morey, Maidstone Lake	median				<0.16
	range				<0.16
	#samples				1
	#stations				1

Cyanobacteria Conditions on Lake Champlain:

Alert-level conditions were reported 114 times (72 as supplemental reports) in 2016 (Figure 3 and Table 6), approximately 9% of the reports submitted (Figure 4). Ninety-one percent of the reports from 2016 indicated generally safe conditions. Alert level conditions were reported most frequently in Missisquoi Bay and St. Albans Bay in 2016 (Figure 5).

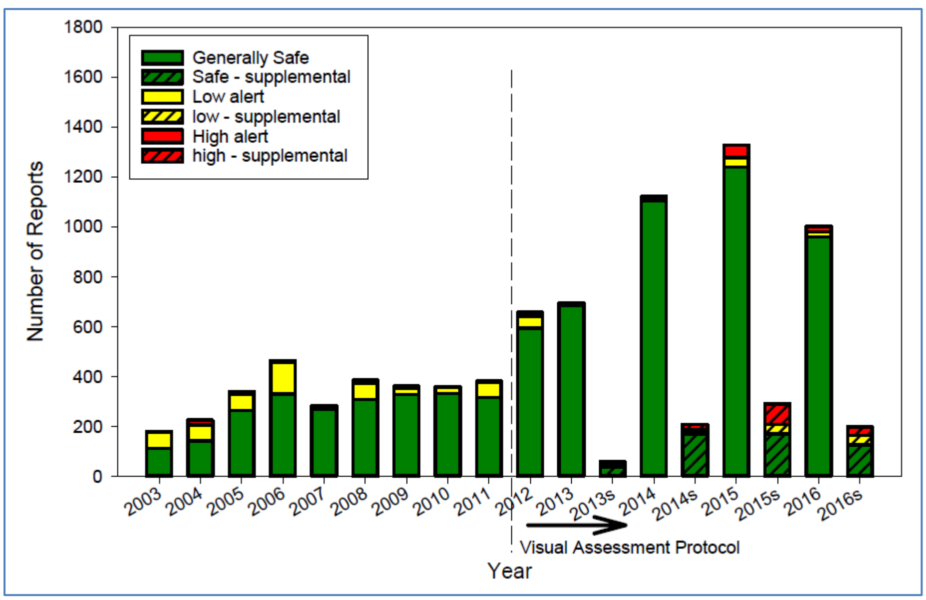


Figure 3. Number of yearly cyanobacteria status reports for Lake Champlain by category. Records prior to 2012 were determined using historical cell count and toxin data. Beginning in 2012, summaries include records obtained using the visual assessment protocol. The status generated by the visual assessment 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.

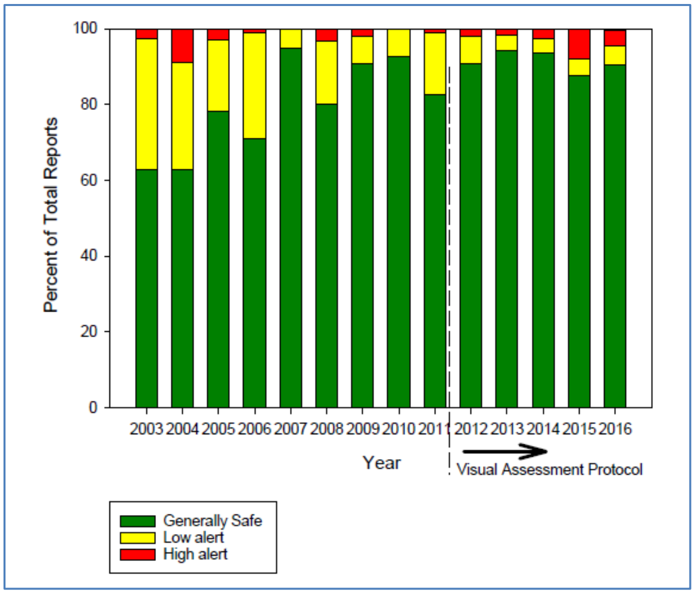


Figure 4. Cyanobacteria status reports Lake Champlain by category, percent of total reports received. Records prior to 2012 were determined using historical cell count and toxin data. Beginning in 2012, summaries include records obtained using the visual assessment protocol. The status generated by the visual assessment protocol is used at locations where both types of assessment were employed. Supplemental reports are included but not reported separately.

Figure 5. Number of yearly cyanobacteria reports for Lake Champlain by region, 2013 – 2016. 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.

Cyanotoxin sample efforts 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. Despite targeted sampling efforts, over the last five summers, microcystin concentrations exceeding Vermont's recreational guideline of 6µg/L are rarely documented and have occurred only in Missisquoi Bay (Table 16). In 2016, no microcystin was detected in samples from Lake Champlain.

Public Outreach and Act 86

Act 86 went into effect on July 1, 2016. This law requires the VDH

- to coordinate efforts to monitor cyanobacteria in the waters of the State with the VT DEC;
- maintain a public website providing information on cyanobacteria in areas used for boating, recreation and swimming; and
- begin public outreach within one hour of determining that the presence of cyanobacteria is a public health hazard.

For 2017, the partners will

- Explain Act 86 reporting requirements during volunteer trainings, and stress the importance of rapid report filing and appropriate supporting photos;
- Continue to train town health officers about cyanobacteria and response options before their town experiences a bloom;
- Address, to the best of our ability, delays that may occur when reports are filed outside of normal business hours; and
- Continue to remind lake users that conditions change rapidly and the visual assessment protocol offers an easy portable way to identify when it may not be prudent to be in the water.

Table 16. Microcystin concentrations in major lake segments, 2011 – 2016. Data are from routine monitoring locations and bloom events. Data do not distinguish between net plankton and whole water samples. ND = not detected. Shaded boxes = not applicable. Full historical data can be found in Appendix D.

Lake Segment		Max 2003 - 2010	2011	2012	2013	2014	2015	2016
Inland Sea	median	1.10	0.08		<0.16	<0.16	<0.16	
	range	0.01 – 22.5	0.01-0.82		<0.16 - 0.43	<0.16 - 0.28	<0.16 – 0.02	
	#samples		9	0	45	56	26	0
	#stations		4		4	4	4	
Main Lake Central	median	7.42	0.02	0.13	<0.16	<0.16	<0.16	<0.16
	range	0.01 -23.3	0.01-0.03	0.13-0.64	<0.16 -0.17	<0.16 -0.19	All <0.16	All <0.16
	#samples		4	3	23	31	27	26
	#stations		4	1	2	2	2	2
Main Lake North	median							<0.16
	range	0.01 – 1.56	0.01					All <0.16
	#samples		1	0	0	0	0	12
	#stations		1					1
Main Lake South	median	0.04	0.01		<0.16	<0.16	<0.16	<0.16
	range	<0.16 – 3.47	0.01		<0.16 - 0.16	<0.16-0.51	All <0.16	All <0.16
	#samples		2	0	22	33	28	12
	#stations		2		2	3	2	1
St. Albans Bay	median	0.30	0.04	0.03	0.032	<0.16	<0.16	<0.16
	range	<0.16 – 22.48	0.02-0.14	0.03-0.04	0.002-0.062	<0.16 - 0.2	<0.16 – 0.77	All <0.16
	#samples		12	5	2	4	12	15
	#stations		2	1	2	2	2	3
Malletts Bay	median	0.04						
	range	0.04 – 0.08	0.04					
	#samples		1	0	0	0	0	0
	#stations		1					
South Lake	median	0.96						
	range	0.53 – 1.86	0.02					
	#samples		1	0	0	0	0	0
	#stations		1					
Missisquoi Bay	median	2.56	0.65	0.99	<0.16	<0.16	<0.16	<0.16
	range	<0.16 - 6490	0.02-180.2	0.26-54.76	<0.16 - 1.3	<0.16 -2.29	<0.16 – 0.43	All <0.16
	#samples		59	36	30	40	38	19
	#stations		8	3	6	7	5	6

Conclusions

As in years past, the majority of monitoring reports noted generally safe conditions on Lake Champlain and Vermont inland lakes for which we have data. Persistent and extensive blooms did occur on St. Albans Bay, Missisquoi Bay and Lake Carmi in late summer and early fall. The main lake also experienced numerous blooms in July.

The monitoring project continues to grow. LCC Volunteers continue to be the backbone of the monitoring program, providing areal coverage and report frequencies which are difficult to obtain with a traditional monitoring program. While several federal agencies are cooperating to develop satellite monitoring for the Northeast, volunteers will continue to be essential to this monitoring program because of their ability to report more frequently and without interruption by cloud cover. In 2017, we plan to expand to additional Vermont lakes by collaborating with existing VT DEC volunteer monitoring efforts.

Acknowledgements

Project funding was provided by the Lake Champlain Basin Program, the State of Vermont, CDC grants to the VDH, and private grants 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 (VT DEC Watershed Management); Emily Adler and Bennett Truman (VDH); Kirk Kimball and Marie Sawyer (VDH Laboratory); Pete Young and Jan Leja (VDH developers of the Tracker map); Alexa Hachigian and Mike Winslow (LCC), and especially the LCC citizen volunteer monitors who continue to be the backbone of this monitoring effort.

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 – 2016 Sampling locations

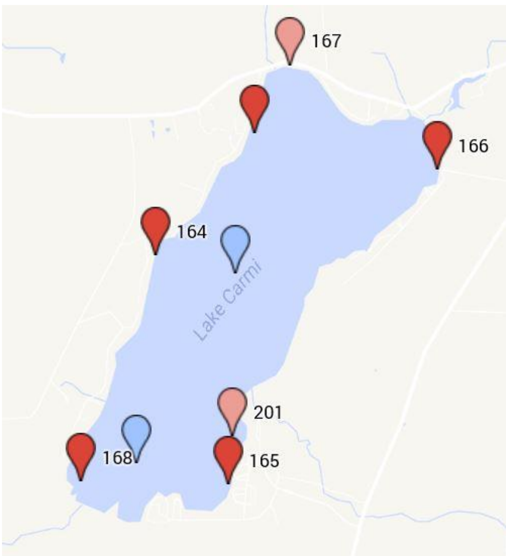
Waterbody	Region	Station	Site Number	Latitude	Longitude
Chittenden Reservoir		Chittenden Reservoir Boat Launch		43.72730	-72.91970
		Chittenden Reservoir - Lakewide		43.73120	-72.90970
Dewey Pond		Dewey Pond		43.64580	-72.40410
Emerald Lake		Emerald Lake State Park		43.27510	-73.00580
Lake Carmi		Lake Carmi, Black Woods	164	44.97530	-72.88546
		Lake Carmi State Park South	165	44.95692	-72.87729
		Lake Carmi, Dewing Road	166	44.98214	-72.85354
		Lake Carmi, North Beach	167	44.99054	-72.87031
		Lake Carmi, Westcott Shore	168	44.95712	-72.89396
		Lake Carmi State Park	201	44.96081	-72.87674
		Open waters, southern Lake Carmi		44.95860	-72.88770
		Open water, central Lake Carmi		44.97380	-72.87640
		Patten Shore Road		44.98510	-72.87430
Lake Champlain	Champlain - Inland Sea	Grand Isle State Park	11	44.68602	-73.28912
		North Hero State Park	23	44.92175	-73.24078
		Pelots Bay	24	44.82537	-73.29915
		LTM 34	34	44.70817	-73.22683
		Burton Island	37	44.77686	-73.19632
		The Gut	49	44.75137	-73.29026
		Sand Bar State Park	57	44.62876	-73.23994
		City Bay - Rt 2	78	44.81589	-73.28908
		Knight Point State Park	80	44.76867	-73.29446
		South Hero Fish and Wildlife Boat Access	110	44.63641	-73.26523
		Marycrest Beach	116	44.72336	-73.28155
		Cedar Ledge	131	44.84695	-73.26219
		Keeler Bay East	134	44.65414	-73.29196
		Keeler Bay Boat Launch	135	44.66791	-73.31991
		Maquam Beach	139	44.92081	-73.16136
		Woods Island	145	44.80487	-73.20453
		Knight Island	146	44.81072	-73.25808
		Van Everest Boat Launch Milton	175	44.70587	-73.21043
		South Alburgh - Squires Bay	182	44.90300	-73.27185
		Maquam Shore Road, Swanton	209	44.90310	-73.16770
		Alburgh VT - shoreline		44.92180	-73.25750
Lake Champlain	Champlain - Main Lake Central	Wilcox Dock, Plattsburgh	12	44.70887	-73.44538
		LTM 16	16	44.42500	-73.23200
		LTM 19	19	44.47100	-73.29900

Waterbody	Region	Station	Site Number	Latitude	Longitude
Lake Champlain	Champlain – Main Lake Central	LTM 21	21	44.47483	-73.23167
		North Beach	22	44.49106	-73.24037
		Red Rocks Beach	27	44.44200	-73.22413
		LTM 33	33	44.70117	-73.41817
		Oakledge Park Blanchard Beach	42	44.45744	-73.22551
		Oakledge Park South Cove	43	44.45496	-73.23004
		Oakledge Park rocky shoreline	44	44.45671	-73.22803
		Plattsburgh City Beach	47	44.71949	-73.43075
		Shelburne Beach	48	44.36306	-73.26761
		Leddy Park	54	44.50083	-73.25341
		Buena Vista Park, Willsboro NY	61	44.40395	-73.37346
		Teddy Bear Point Cove, Willsboro NY	63	44.44272	-73.37428
		Willsboro Boat Launch	68	44.39945	-73.39155
		Burlington, VT - Texaco Beach	72	44.48764	-73.23213
		Charlotte Town Beach	76	44.33473	-73.28290
		Community Sailing Center	107	44.48206	-73.22552
		Starr Farm Beach	108	44.51376	-73.27140
		White's Beach in Crescent Bay	114	44.62114	-73.32344
		Shelburne Farms	123	44.39440	-73.27750
		Sunset/Crescent Beach	132	44.60888	-73.31585
		Plattsburgh Boat Launch	150	44.69916	-73.44167
		Boat Launch, Corlear Bay, Port Douglas NY	160	44.48612	-73.41174
		Allen Point	189	44.59928	-73.31143
		Beech Bay	190	44.63250	-73.34290
		Farrell Bay		44.39300	-73.40440
		Cedar Lane, Willsboro		44.39509	-73.39594
		Boquet River		44.34810	-73.35850
		Sledrunner Point		44.42000	-73.24910
	Champlain - Main Lake North	Carry Bay	5	44.83359	-73.28991
		Pt. Au Roche State Park Beach	26	44.77414	-73.39380
		Alburgh Dunes State Park	35	44.86462	-73.30196
		LTM 36	36	44.75617	-73.35500
		Oliver Bay	45	44.73745	-73.40234
		LTM 46	46	44.94833	-73.34000
		Treadwell Bay, Beekmantown NY	64	44.76008	-73.40752
		Pt. Au Roche S.P. Deep Bay	84	44.77751	-73.37886
		Pt. Au Roche Boat Launch	109	44.80440	-73.36297
		Vantines Boat Launch	115	44.71981	-73.34189
		Horicans Fish and Wildlife Access	127	44.91408	-73.31449
		Stoney Point, Isle la Motte	128	44.87148	-73.35944
		Holcomb Boat Launch	129	44.85468	-73.33162

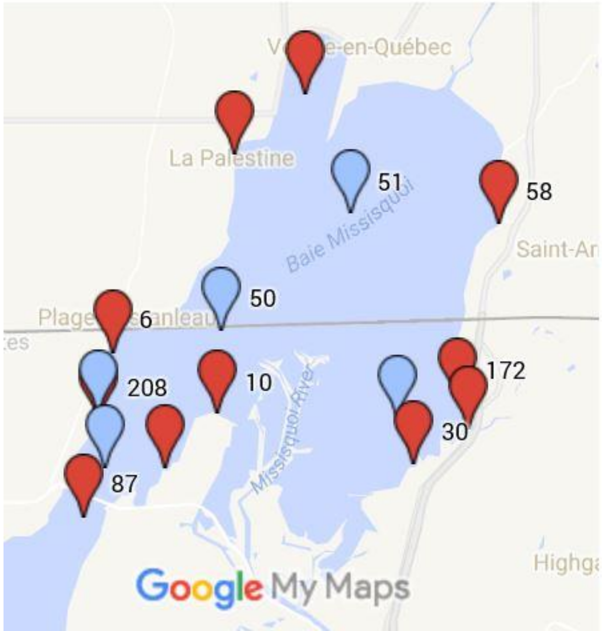
Waterbody	Region	Station	Site Number	Latitude	Longitude
Lake Champlain	Champlain - Main Lake North	Pelots Point West	130	44.82608	-73.31012
		Comfort Bay	192	44.72630	-73.38730
		Mud Point		44.93350	-73.31330
		North Hero - Alburgh Bridge		44.88560	-73.27330
	Champlain - Main Lake South	Arnold Bay	3	44.14974	-73.36947
		LTM 07	7	44.12600	-73.41283
		LTM 09	9	44.24217	-73.32917
		Kingsland Bay State Park	15	44.24030	-73.29873
		Long Point	18	44.25813	-73.27764
		DAR State Park	39	44.05453	-73.41825
		Westport Boat Launch	59	44.18873	-73.43284
		Beggs Park Beach, Essex NY	60	44.30846	-73.34732
		Button Bay Boat Launch	74	44.17616	-73.35225
		Camp Dudley, Westport NY	75	44.14322	-73.41567
		Hawkins Bay	105	44.24376	-73.28336
		Ferrisburgh Town Beach	117	44.23594	-73.30098
		Town Farm Bay	119	44.26916	-73.28875
		Ferrisburgh Stone Beach	137	44.23790	-73.30828
		Bulwagga Bay/Port Henry	138	44.03688	-73.45475
		Summer Point	148	44.21825	-73.33801
		Panton Shore North	151	44.15354	-73.36426
		Port Henry Public Beach	153	44.05278	-73.45059
		Button Bay State Park	180	44.18093	-73.36176
		Converse Bay	184	44.29396	-73.28979
		Tri-Town Road, West Addison	210	44.08538	-73.40791
		Spaulding Bay		44.13050	-73.37026
	Champlain - Malletts Bay	LTM 25	25	44.58200	-73.28117
		Niquette Bay State Park	67	44.58129	-73.18889
		Rosetti Park	111	44.55501	-73.25280
		Malletts Bay Boat Launch	120	44.55416	-73.23100
		Camp Kiniya	142	44.60644	-73.22908
		Bayside Beach		44.54690	-73.21550
	Champlain - Missisquoi Bay	Chapman Bay	6	45.00785	-73.21122
		Donaldson Point	10	44.99320	-73.17530
		Highgate Springs	14	44.99177	-73.11338
		Shipyard, Highgate Springs	30	44.98076	-73.10788
		LTM 50	50	45.01333	-73.17383
		LTM 51	51	45.04167	-73.12967
		Philipsburg, QC	58	45.03906	-73.07869
		Alburgh, offshore	86	44.99302	-73.21592
		Larry Greene Fish and Wildlife Access	87	44.96797	-73.22112
		Country Club Road, Highgate VT	172	44.99611	-73.09301
		Rock River - Highgate	178	44.98938	-73.08930
		Alburgh Springs	208	44.99135	-73.21596

Waterbody	Region	Station	Site Number	Latitude	Longitude
Lake Champlain	Champlain - Missisquoi Bay	All locations on western Missisquoi Bay		44.97970	-73.21400
		Campbell's Bay, Swanton VT		44.97990	-73.19300
		Clarenceville, QC		45.05580	-73.16940
		Venise-en-Quebec		45.07050	-73.14510
	Champlain - South Lake	LTM 02	2	43.71400	-73.38300
		LTM 04	4	43.95100	-73.40700
		Allen Bay	52	43.78301	-73.35396
		Chimney Point	143	44.03481	-73.42260
		McCuen Slang Waterfowl Area	179	44.02431	-73.40159
		Ticonderoga Boat Launch	188	43.85481	-73.38492
	Champlain - St. Albans Bay	St. Albans Bay Park	31	44.80866	-73.14436
		St. Albans Boat Launch	32	44.79372	-73.17143
		LTM 40	40	44.78533	-73.16217
		Kill Kare State Park	56	44.77770	-73.18080
		Ferrand Rd. St. Albans	113	44.79171	-73.14254
		Melville Landing	176	44.76174	-73.16764
		Black Bridge	191	44.81030	-73.15180
		Georgia Beach	193	44.76742	-73.16264
Lake Dunmore		Lake Dunmore Boat Launch		43.90780	-73.08530
Lake Iroquois		Lake Iroquois Southwest	169	44.36327	-73.08564
		Lake Iroquois	203	44.37807	-73.08674
Lake Memphremagog		Prouty Beach, Newport VT	204	44.94501	-72.20998
		Derby Bay	211	44.99438	-72.18835
		Holbrook Bay	212	44.96392	-72.23968
		Eagle Point, Lake Memphremagog		45.00100	-72.20440
Lake Morey		Lake Morey Beach		43.92120	-72.15770
		Lake Morey		43.92270	-72.15370
		East side, Lake Morey		43.92620	-72.14500
		East side, Lake Morey		43.92620	-72.14500
Lake Pinneo		Lake Pinneo		43.65250	-72.43210
Maidstone Lake		Westside Lake Rd		44.64620	-71.65620
		Private 8 West, Maidstone Lake		44.64660	-71.65570
North Hartland Lake		North Hartland Lake		43.60460	-72.36220
Stoughton Pond		Stoughton Pond - West Shoreline		43.34350	-72.51080
		Stoughton Pond - SW End		43.34310	-72.51070
		Stoughton Pond - East End		43.34680	-72.51070
		Stoughton Pond		43.34340	-72.50930

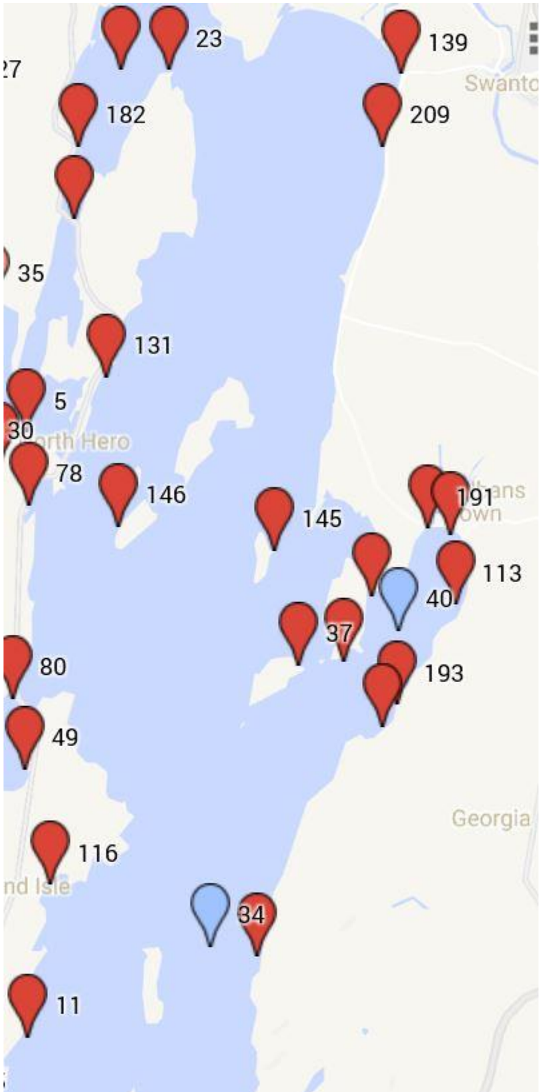
Maps of monitoring stations – 2017



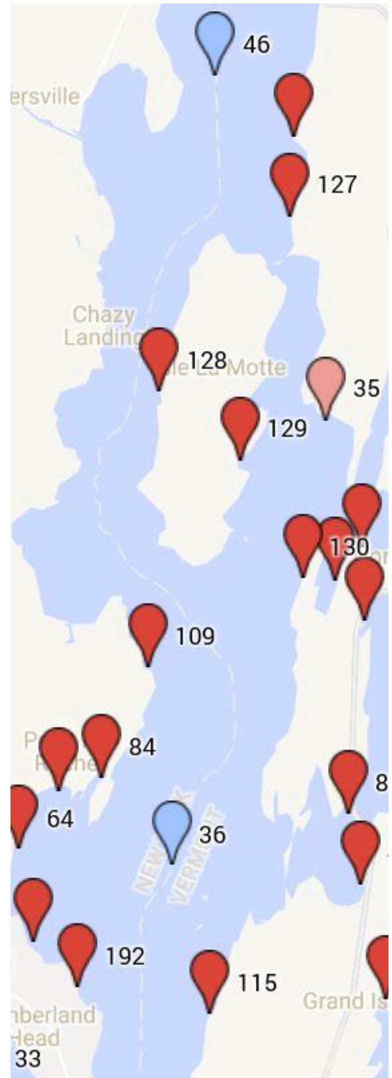
Lake Carmi



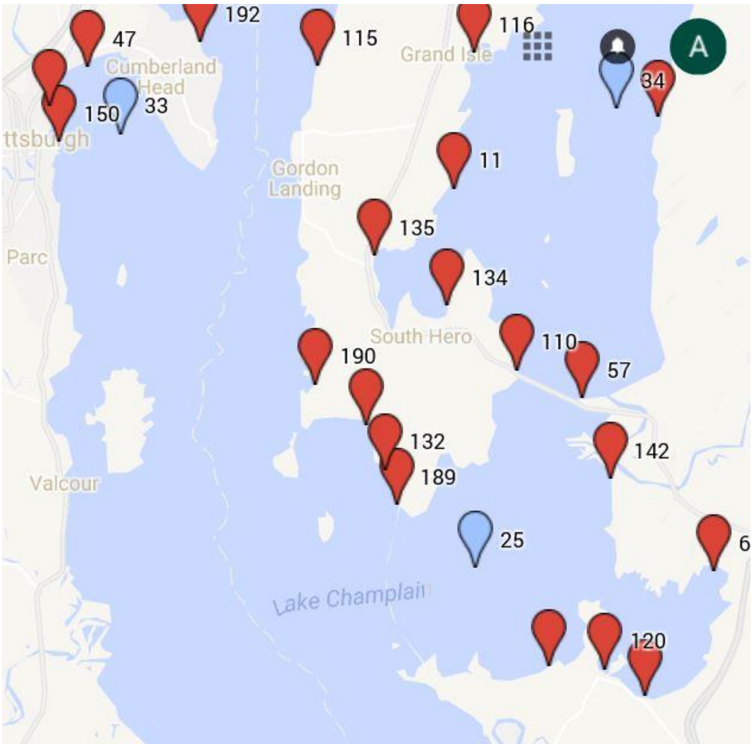
Champlain – Missisquoi Bay



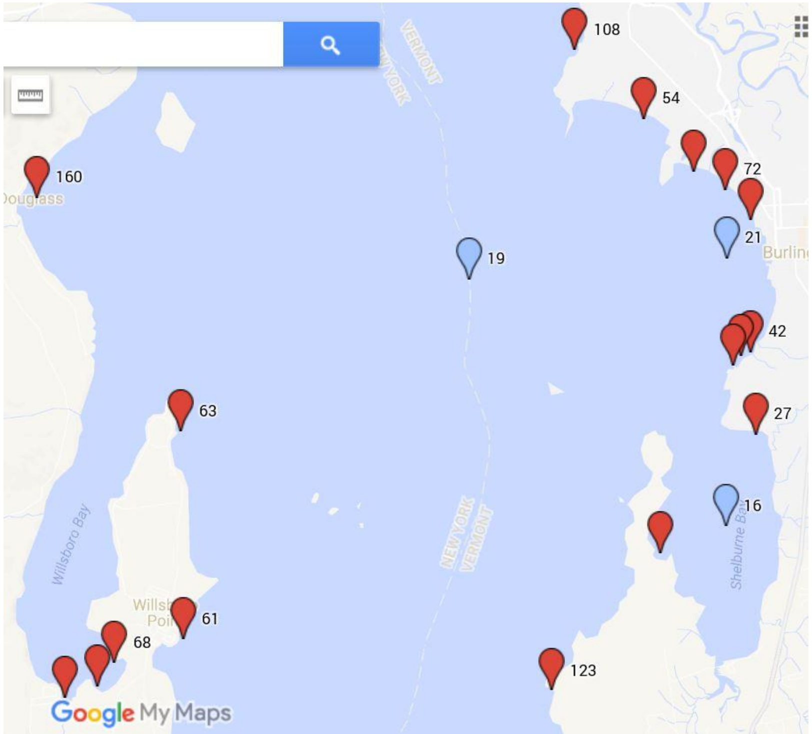
Champlain – Inland Sea (northern portion)



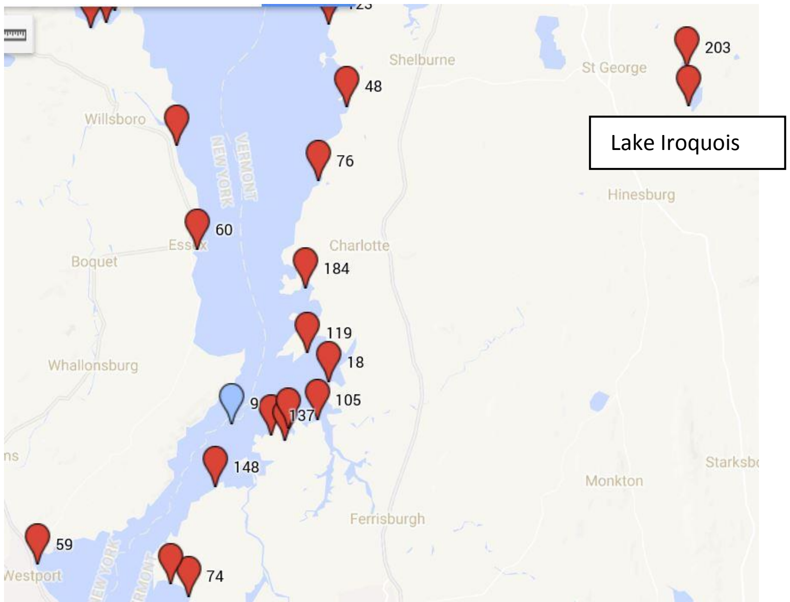
Champlain – Main Lake North (northern portion)



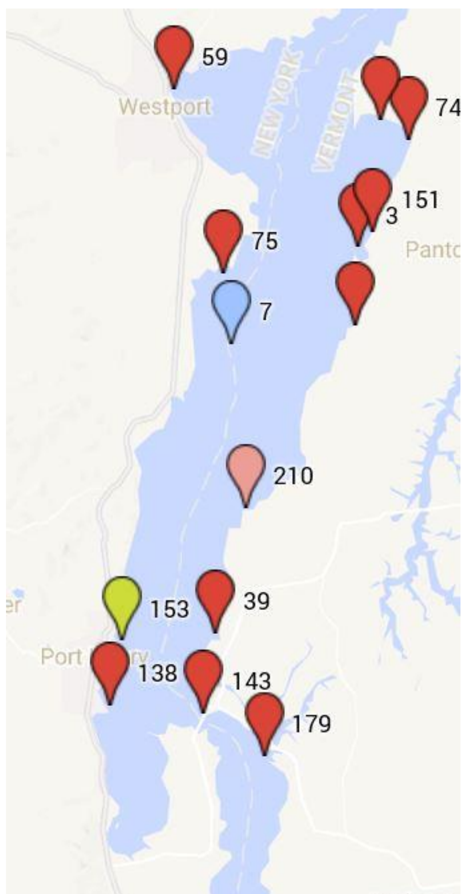
Champlain – Main Lake North (southern portion), Main Lake Central (northern portion), Inland Sea (southern portion), Malletts Bay



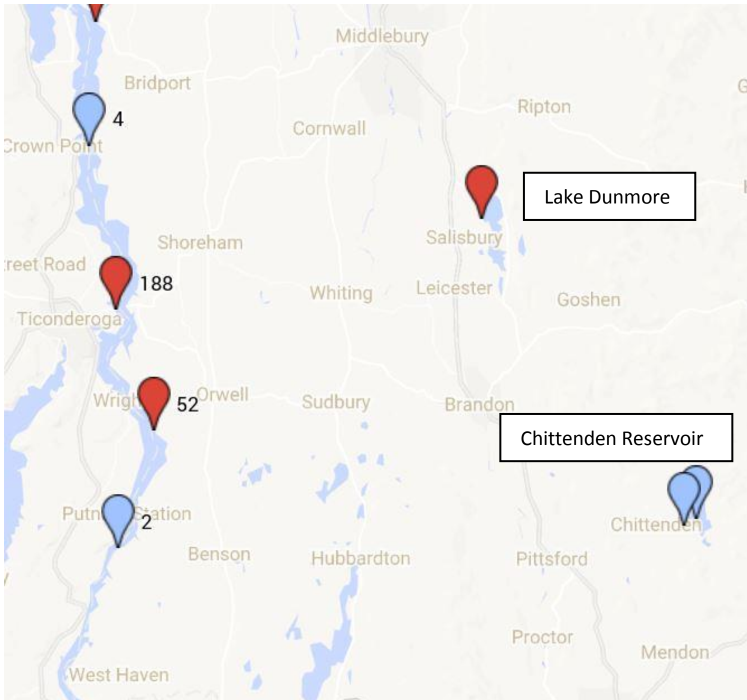
Champlain – Main Lake Central (Burlington area)



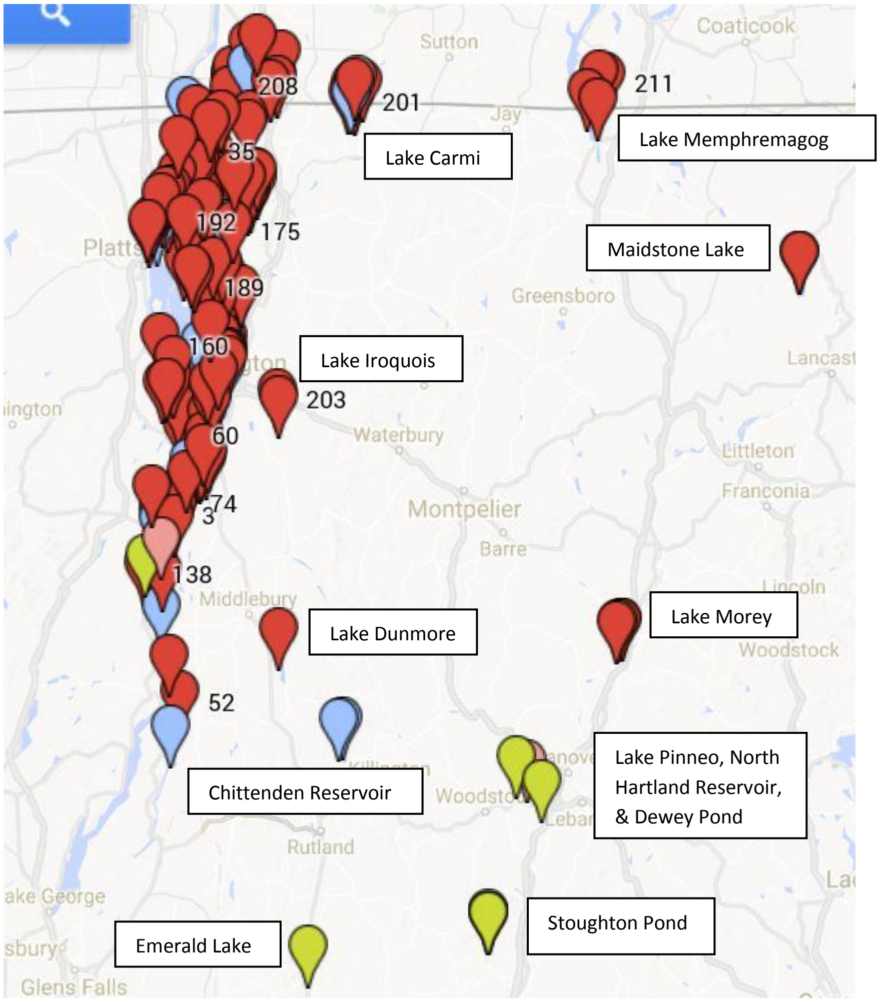
Champlain – Main Lake Central (southern portion), Main Lake South (northern portion), Lake Iroquois



Champlain – Main Lake South (southern portion)



Champlain – South Lake, Lake Dunmore, Chittenden Reservoir



Lake Carmi
Lake Memphremagog
Maidstone Lake
Lake Iroquois
Lake Dunmore
Lake Morey
Chittenden Reservoir
Lake Pinneo, North Hartland Reservoir, & Dewey Pond
Stoughton Pond
Emerald Lake
208
201
211
35
192
175
189
160
203
60
74
3
138
52
Sutton
Coaticook
Jay
Platts
Greensboro
Lancast
Waterbury
Littleton
Franconia
Montpelier
Barre
Lincoln
Middlebury
Woodstock
Rutland
ake George
Glens Falls

Appendix B. Visual assessment protocols from the Lake Champlain Committee website

B.1. LCC On-line reporting form

Algae Reporting Form

ALGAE REPORTING FORM - 2016

Please Complete Form Below

Type of report

- ○ Regular weekly
- ○ Supplemental

Site name/water body or section of Lake Champlain or GPS coordinates*

Municipality of observation

Date of observation*

Time of observation*

Please choose the category (see links above) that best describes conditions and intensity of any bloom present*

- ○ 1a - Little or no blue-green algae present - clear water
- ○ 1b - Little or no blue-green algae present - brown or turbid water
- ○ 1c - Little or no blue-green algae present - other material present
- ○ 1d - Little blue-green algae present but enjoyment of water not impaired
- ○ 2 - Blue-green algae present -less than bloom levels - enjoyment of water slightly impaired (include photos)
- ○ 3 - Blue-green algae bloom in progress - enjoyment of water substantially impaired (include photos)

Photo - water surface close-up

Choose File No file chosen

Photo - water surface broad view

Choose File No file chosen

Photo - water sample in clear container

Choose File No file chosen

Photo - water sample in clear container	Browse... No file selected.
Extent of algae bloom on open water (Evaluate the area within 100 yards of where you are).	○ No Bloom ○ Very Limited ○ <50% cover ○ Between 50 and 75% cover ○ Coverage greater than 75%
Algae Color	○ None ○ Green ○ Turquoise ○ Reddish ○ Yellow ○ Other (add details below)
Other details	
Water temperature	
Water Surface	○ Calm ○ Rolling ○ White-caps
Name	
Email	
Address	
Telephone	

Submit Form

B.2. LCC Guidance for Determining Algae Bloom Intensity

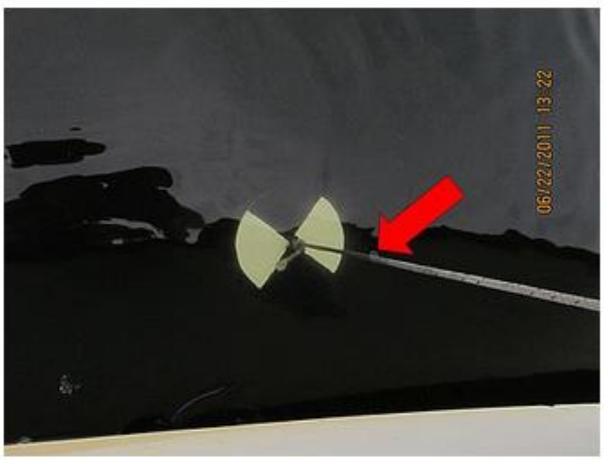
General Instructions

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. Only observations submitted online **by noon on Wednesday** will be included in the weekly report. 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 blue-green algae present and three being a blue-green algae bloom in progress.

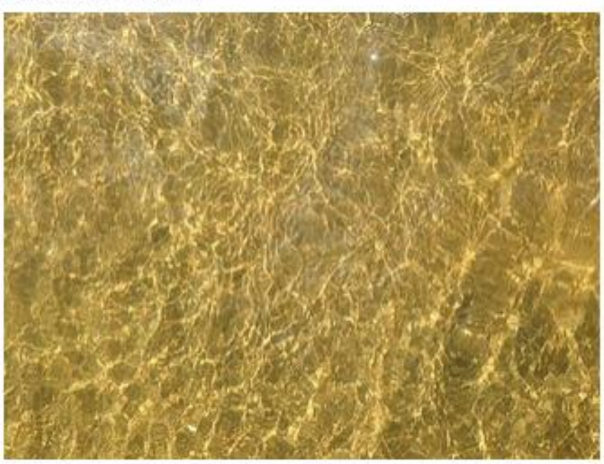
For category 2 and 3 conditions, three digital photographs should be submitted via the online form. Remember to avoid direct contact if the bloom is well developed.

Category 1a: Little to no blue-green algae 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 - Little to no blue-green algae present - brown and turbid

Brown turbid low visibility through water column

Brown and cloudy does not indicate presence of blue-green algae

Category 1c - Little to no blue-green algae present - other material

Other material that doesn't count as blue-green algae 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 blue-green algae

From a distance duckweed can look like algae

Stringy algae attached to the bottom are not blue-greens

Duckweed up close

Category 1d - Little blue-green algae present - enjoyment of water not impaired

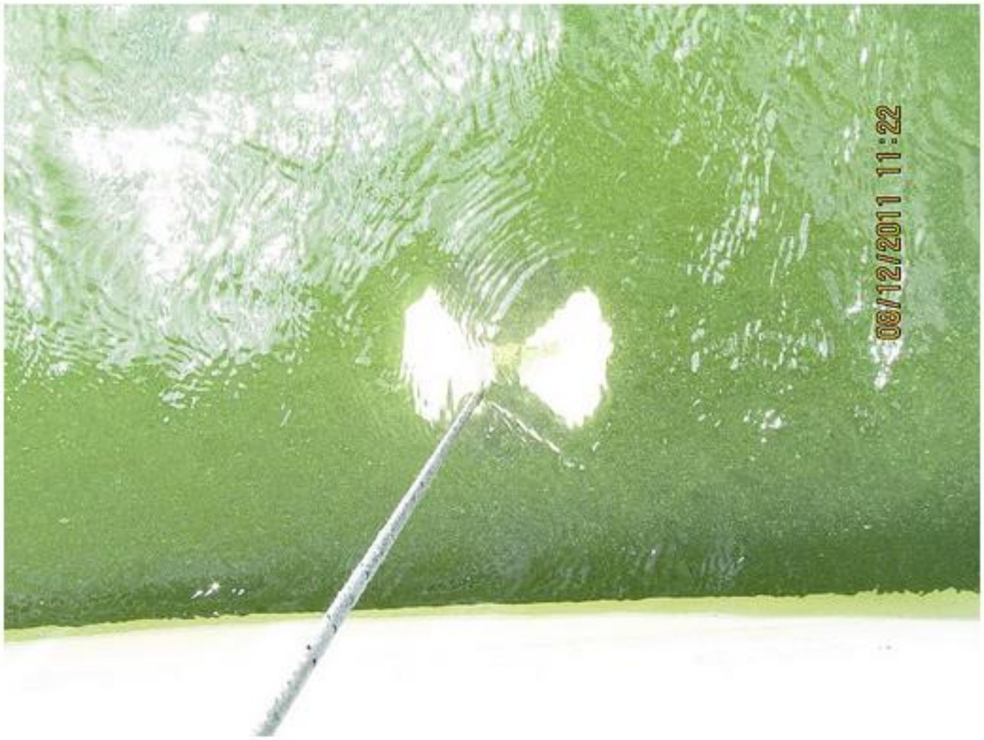
Green floating balls may be visible, but only on close inspection and in densities so low that they do not impair recreational enjoyment of the water. There are no surface or near shore accumulations of blue-green algae.

Water appears perfectly clear

But close inspection shows some blue-green algae present

Category 2: Blue-green algae present, but at less than 'bloom' levels - enjoyment of water slightly impaired

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 algae accumulation at shoreline.



Some algae in water but not a uniform layer

Possible narrow band of algae at shoreline

Category 3: Blue-green algae bloom in progress - enjoyment of water substantially impaired

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 algae at the surface - not stringy

Thick surface scum present

Open water surface green to turquoise

B.3. LCC Guidelines for Photographic Documentation

Instructions for Photographing Algae Blooms

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 background that provides contrast such as a sheet of paper or a wall. Darker colors provide more contrast.

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

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

3. For close-ups, take a sample of water in a clear container and photograph against a contrasting background. Over about 1/2 hour algae will rise toward the surface; detritus will sink.

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

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 using the year, month, day-photographer's name-location-photo type.

Example file name: 2014-07-15_MWinslow_DonaldsonPt_Closeup

Appendix C – QA/QC Sample Data for 2016.

LCC volunteer data

Date	Waterbody	Station	Affiliation	Bloom Intensity	Cyano-bacteria Density (cells/mL)	Micro-cystin (µg/L)	Anatoxin (µg/L)
6/19/2016	Champlain	North Beach	LCC	1c - Little or no BGA present - other material present	0	<0.16	<0.5
6/27/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
7/5/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
7/11/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
7/18/2016				1a - Little or no BGA present - clear water	2020	<0.16	<0.5
8/1/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
8/8/2016				1a - Little or no BGA present - clear water	1430	<0.16	<0.5
8/15/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
8/22/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
8/29/2016				1a - Little or no BGA present - clear water	5020	<0.16	<0.5
9/6/2016				1a - Little or no BGA present - clear water	7960	<0.16	<0.5
9/13/2016				1a - Little or no BGA present - clear water	746	<0.16	<0.5
6/20/2016	Champlain	Red Rocks Beach	LCC	1b - Little or no BGA present - brown or turbid water	0	<0.16	<0.5
6/27/2016				1b - Little or no BGA present - brown or turbid water	0	<0.16	<0.5
7/4/2016				1b - Little or no BGA present - brown or turbid water	0	<0.16	<0.5
7/11/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
7/18/2016				1c - Little or no BGA present - other material present	267	<0.16	<0.5
7/25/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
8/1/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
8/8/2016				1b - Little or no BGA present - brown or turbid water	1070	<0.16	<0.5
8/15/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
8/22/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
8/29/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
9/6/2016				1a - Little or no BGA present - clear water	2100	<0.16	<0.5
9/12/2016				1a - Little or no BGA present - clear water	6070	<0.16	<0.5
6/27/2016	Champlain	Shipyard, Highgate Springs	LCC	1b - Little or no BGA present - brown or turbid water	0		
7/4/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
7/12/2016				1b - Little or no BGA present - brown or turbid water	0	<0.16	<0.5
7/18/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
7/25/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
8/1/2016				1a - Little or no BGA present - clear water	12600	<0.16	<0.5
8/8/2016				1d - Little BGA present - recreation not impaired	99600	<0.16	<0.5
8/16/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
8/22/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
8/29/2016				1a - Little or no BGA present - clear water	4800	<0.16	<0.5
9/6/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
9/12/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5

Date	Waterbody	Station	Affiliation	Bloom Intensity	Cyano-bacteria Density (cells/mL)	Micro-cystin (µg/L)	Anatoxin (µg/L)
6/27/2016	Champlain	St. Albans Bay Park	LCC	1a - Little or no BGA present - clear water	0	<0.16	<0.5
7/5/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
7/12/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
7/18/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
7/26/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
8/2/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
8/8/2016				1a - Little or no BGA present - clear water	8720	<0.16	<0.5
8/15/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
8/22/2016				1d - Little BGA present - recreation not impaired	2	<0.16	<0.5
8/29/2016				1d - Little BGA present - recreation not impaired	11900	<0.16	<0.5
9/6/2016				1d - Little BGA present - recreation not impaired	100600	<0.16	<0.5

VDH Data

Report Date	Waterbody	Station	Affilia-tion	Bloom Intensity	Cyano-bacteria Density (cells/mL)	Micro-cystin (µg/L)	Anatoxin (µg/L)
8/5/2016	Chittenden Reservoir	Chittenden Reservoir Boat Launch	VDH	2 - BGA present - less than bloom levels	10900	-	-
8/22/2016				1d - Little BGA present - recreation not impaired	3	<0.16	<0.5
9/6/2016				1d - Little BGA present - recreation not impaired	38100	<0.16	<0.5
9/12/2016				1d - Little BGA present - recreation not impaired	30200	<0.16	<0.5
6/28/2016	Carmi	Lake Carmi State Park	VDH	1a - Little or no BGA present - clear water	0	<0.16	<0.5
7/6/2016				1b - Little or no BGA present - brown or turbid water	640	<0.16	<0.5
7/12/2016				1b - Little or no BGA present - brown or turbid water	0	<0.16	<0.5
7/19/2016				1a - Little or no BGA present - clear water	1	<0.16	<0.5
7/26/2016				1a - Little or no BGA present - clear water	1	<0.16	<0.5
8/2/2016				1b - Little or no BGA present - brown or turbid water	1	<0.16	<0.5
8/9/2016				1b - Little or no BGA present - brown or turbid water	174900	<0.16	<0.5
8/17/2016				1a - Little or no BGA present - clear water	5	<0.16	<0.5
8/23/2016				1d - Little BGA present - recreation not impaired	4	<0.16	<0.5
8/30/2016				1d - Little BGA present - recreation not impaired	96200	<0.16	<0.5
9/7/2016				1d - Little BGA present - recreation not impaired	116300	<0.16	<0.5
9/13/2016				1a - Little or no BGA present - clear water	156200	<0.16	<0.5
6/28/2016		Lake Carmi, North Beach	VDH	1b - Little or no BGA present - brown or turbid water	0	<0.16	<0.5
7/6/2016			VDH	1a - Little or no BGA present - clear water	0	<0.16	<0.5
7/12/2016			VDH	1b - Little or no BGA present - brown or turbid water	2	<0.16	<0.5
7/19/2016			VDH	1a - Little or no BGA present - clear water	0	<0.16	<0.5
7/26/2016			VDH	1a - Little or no BGA present - clear water	0	<0.16	<0.5
8/2/2016			VDH	1b - Little or no BGA present - brown or turbid water	4	<0.16	<0.5

8/9/2016			VDH	2 - BGA present - less than bloom levels (include photos)	570400	<0.16	<0.5
8/17/2016			VDH	1b - Little or no BGA present - brown or turbid water	1	<0.16	<0.5
8/23/2016			VDH	1d - Little BGA present - recreation not impaired	8	<0.16	<0.5
8/30/2016			VDH	1d - Little BGA present - recreation not impaired	90200	<0.16	<0.5
9/7/2016			VDH	1d - Little BGA present - recreation not impaired	97600	<0.16	<0.5
9/13/2016			VDH	1c - Little or no BGA present - other material present	94500	<0.16	<0.5
6/28/2016	Lake Champlain	Alburgh Dunes State Park	VDH	1a - Little or no BGA present - clear water	0	<0.16	<0.5
7/6/2016				1d - Little BGA present - recreation not impaired	0	<0.16	<0.5
7/12/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
7/19/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
7/26/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
8/2/2016				1a - Little or no BGA present - clear water	1	<0.16	<0.5
8/9/2016				1a - Little or no BGA present - clear water	1480	<0.16	<0.5
8/17/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
8/23/2016				1c - Little or no BGA present - other material present	0	<0.16	<0.5
9/7/2016				1a - Little or no BGA present - clear water	4990	<0.16	<0.5
9/13/2016				1c - Little or no BGA present - other material present	2010	<0.16	<0.5
6/27/2016	Lake Champlain	Tri-Town Road, West Addison	VDH	1b - Little or no BGA present - brown or turbid water	10600	<0.16	<0.5
7/5/2016				1c - Little or no BGA present - other material present	0	<0.16	<0.5
7/11/2016				1b - Little or no BGA present - brown or turbid water	0	<0.16	<0.5
7/18/2016				1c - Little or no BGA present - other material present	0	<0.16	<0.5
7/25/2016				1c - Little or no BGA present - other material present	0	<0.16	<0.5
8/1/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5
8/8/2016				1a - Little or no BGA present - clear water	400	<0.16	<0.5
8/15/2016				1d - Little BGA present - recreation not impaired	6	<0.16	<0.5
8/22/2016				1c - Little or no BGA present - other material present	0	<0.16	<0.5
8/29/2016				1d - Little BGA present - recreation not impaired	22100	<0.16	<0.5
9/6/2016				1c - Little or no BGA present - other material present	14400	<0.16	<0.5
9/12/2016				1a - Little or no BGA present - clear water	0	<0.16	<0.5

Appendix D – Historical Microcystin Data for Lake Champlain

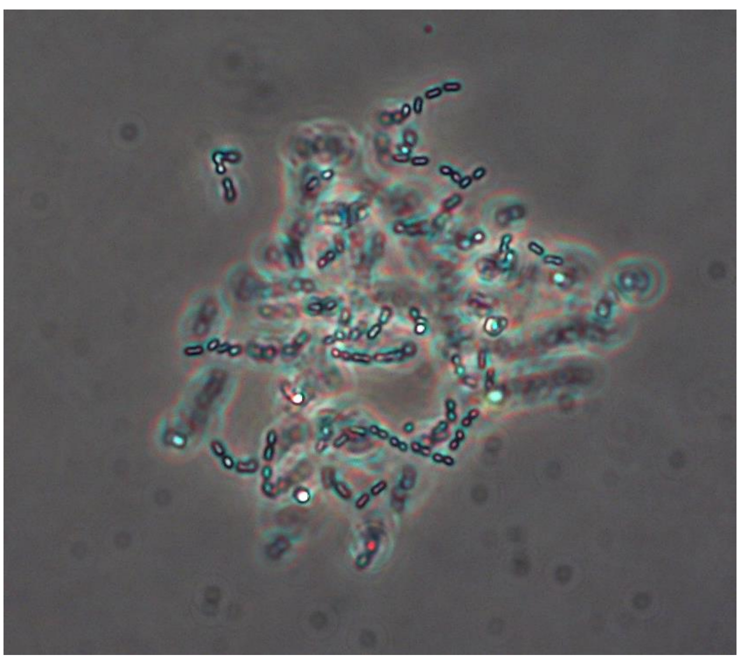
Lake Segment		2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Inland Sea	median	0.05	0.41	0.08	0.27	0.05	1.10	0.07	0.03	0.08	NA	<0.16	<0.16	<0.16
	range	0.05 - 0.18	0.08-17.56	0.01-0.19	0.04-42.14	0.04 - 0.07	0.03-22.50	0.06-0.08	0.03 - 0.13	0.01-0.82	NA	ND - 0.43	ND - 0.28	ND – 0.02
	#samples	6	8	8	16	4	11	2	3	9	0	45	56	26
	#stations	1	3	3	7	3	4	2	2	4	NA	4	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	<0.16	<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	<0.16 -0.19	All ND
	#samples	19	0	2	0	2	2	6	8	4	3	23	31	27
	#stations	4	NA	1	NA	2	2	3	5	4	1	2	2	2
Main Lake North	median	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	range	NA	NA	NA	NA	NA	1.56	0.03	NA	0.01	NA	NA	NA	NA
	#samples	0	0	0	0	0	1	1	0	1	0	0	0	0
	#stations	NA	NA	NA	NA	NA	1	1	NA	1	NA	NA	NA	NA
Main Lake South	median	NA	NA	0.04	NA	NA	NA	NA	NA	0.01	NA	<0.16	<0.16	<0.16
	range	0.07	NA	ND - 0.07	3.47	NA	NA	NA	NA	0.01	NA	ND - 0.16	ND-0.51	All ND
	#samples	1	0	2	1	0	0	0	0	2	0	22	33	28
	#stations	1	NA	1	1	NA	NA	NA	NA	2	NA	2	3	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	<0.16	<0.16
	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	ND - 0.2	ND – 0.77
	#samples	32	29	18	36	20	10	4	10	12	5	2	4	12
	#stations	1	2	1	2	4	3	2	3	2	1	2	2	2
Malletts Bay	median	NA	NA	NA	0.04	NA	NA	NA	NA	NA	NA	NA	NA	NA
	range	NA	NA	NA	0.04-0.08	NA	NA	NA	NA	0.04	NA	NA	NA	NA
	#samples	0	0	0	7	0	0	0	0	1	0	0	0	0
	#stations	NA	NA	NA	2	NA	NA	NA	NA	1	NA	NA	NA	NA
South Lake	median	0.96	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	range	0.53-1.38	NA	0.01	NA	NA	NA	NA	NA	0.02	NA	NA	NA	NA
	#samples	2	0	1	0	0	0	0	0	1	0	0	0	0
	#stations	2	NA	1	NA	NA	NA	NA	NA	1	NA	NA	NA	NA
Missisquoi Bay	median	0.09	0.84	0.66	0.52	NA	2.56	0.54	0.03	0.65	0.99	<0.16	<0.16	<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	ND - 1.3	ND - 2.29	ND – 0.43
	#samples	341	228	146	152	0	81	29	10	59	36	30	40	38
	#stations	14	11	10	12	NA	10	8	7	8	3	6	7	5

Appendix E – Images of New Potentially Toxic Cyanobacteria

Komvophoron spp.

Lake Carmi

July 8, 2016



Cyanodictyon spp.

Red Rocks Beach

August 8, 2016