Fall 2018

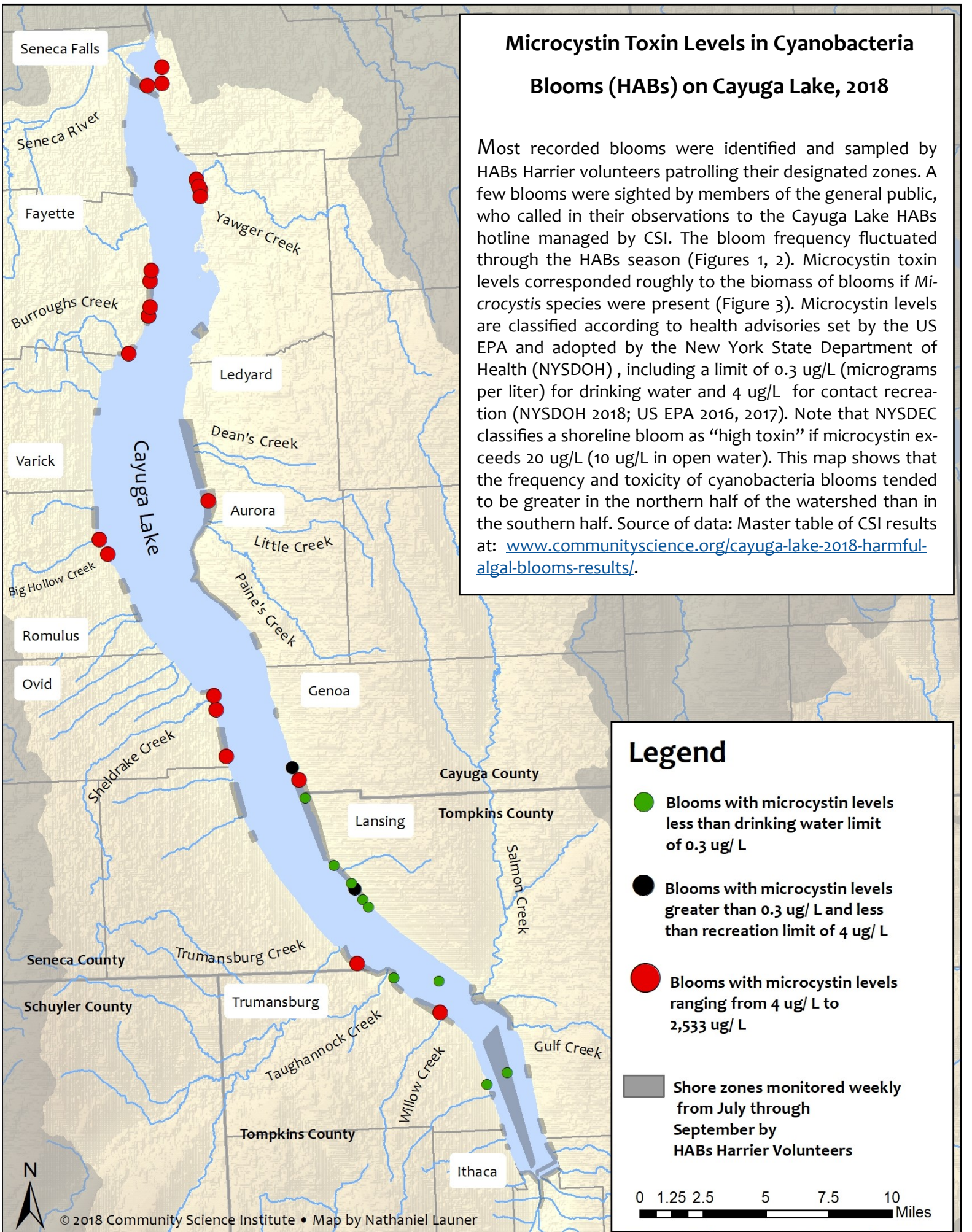
The Water Bulletin
Community Science Institute Newsletter

Harmful Algal Blooms (HABs) On Cayuga Lake

Meet the Cyanobacteria (HABs)

Although cyanobacteria are often referred to as "Blue-Green Algae," they are not really algae. They are bacteria, a more ancient type of organism. Unique among bacteria, cyanobacteria contain the pigment chlorophyll, which makes it possible for them to conduct photosynthesis, capturing energy from sunlight and releasing oxygen from water into the atmosphere. Chlorophyll often gives cyanobacteria blooms a distinctive green appearance. Among the most ancient life forms on earth, cyanobacteria may have emerged as early as 3.5 billion years ago (Gerhart, 2011), at a time when the earth's atmosphere contained virtually no oxygen. In addition to being the ancestors of modern plants (they were assimilated by other organisms to BECOME the chloroplasts in plant cells!), cyanobacteria produced oxygen as a waste product that accumulated in the atmosphere. Over the course of some 2.5 billion years, cyanobacteria made it possible for life forms that depend on oxygen, including eventually humans, to evolve. Cyanobacteria are a diverse group of organisms with a range of morphologies and adaptations. Some genera can fix nitrogen, an essential nutrient, from the atmosphere into a biologically available form. Others have gas vacuoles that enable them to move up and down in the water column to seek out conditions of temperature and light that optimize their growth. Many species of cyanobacteria produce chemical compounds whose purposes are not fully understood. A few of these natural compounds, cyanotoxins, are toxic to humans and other animals (Graham, Dubrovsky, & Eberts, 2017). Their presence is what makes a cyanobacteria bloom harmful.

Under the right conditions, freshwater cyanobacteria experience explosive growth, dividing rapidly and increasing their population until they become a visible bloom. Three common groups of bloom-forming cyanobacteria are *Microcystis*, *Dolichospermum* (formerly known as *Anabaena*), and *Aphanizomenon*. While these groups have distinctive features that can be recognized under a microscope, the blooms they form may be indistinguishable to the naked eye. They may look like parallel streaks or green clumps on the water, or they may have a spilled paint or pea soup appearance (NYSDEC, 2018). At the CSI lab we examined under a microscope all of the Cayuga Lake bloom samples submitted to us over the course of the summer and noticed a shift in the dominance of two groups of cyanobacteria, from *Dolichospermum* to *Microcystis* (see page 5).



Microcystin Toxin Levels in Cyanobacteria Blooms (HABs) on Cayuga Lake, 2018

Most recorded blooms were identified and sampled by HABs Harrier volunteers patrolling their designated zones. A few blooms were sighted by members of the general public, who called in their observations to the Cayuga Lake HABs hotline managed by CSI. The bloom frequency fluctuated through the HABs season (Figures 1, 2). Microcystin toxin levels corresponded roughly to the biomass of blooms if *Microcystis* species were present (Figure 3). Microcystin levels are classified according to health advisories set by the US EPA and adopted by the New York State Department of Health (NYSDOH) , including a limit of 0.3 ug/L (micrograms per liter) for drinking water and 4 ug/L for contact recreation (NYSDOH 2018; US EPA 2016, 2017). Note that NYSDEC classifies a shoreline bloom as "high toxin" if microcystin exceeds 20 ug/L (10 ug/L in open water). This map shows that the frequency and toxicity of cyanobacteria blooms tended to be greater in the northern half of the watershed than in the southern half. Source of data: Master table of CSI results at: www.communityscience.org/cayuga-lake-2018-harmful-algal-blooms-results/.

Legend

- Blooms with microcystin levels less than drinking water limit of 0.3 ug/ L
- Blooms with microcystin levels greater than 0.3 ug/ L and less than recreation limit of 4 ug/ L
- Blooms with microcystin levels ranging from 4 ug/ L to 2,533 ug/ L
- Shore zones monitored weekly from July through September by HABs Harrier Volunteers

0 1.25 2.5 5 7.5 10 Miles

Photo of a bloom that occurred on September 4th, 2018, on Cayuga Lake.

What is Driving Cyanobacteria Blooms on Cayuga Lake?

Cyanobacteria are part of the normal phytoplankton community of Cayuga Lake, and they have been for a very long time. Why, then, the sudden increase in cyanobacteria blooms? Here on Cayuga Lake, the number of suspicious bloom reports to NYSDEC increased from three in 2014 to 32 in 2017, of which eight were confirmed to be cyanobacteria (NYSDEC, 2018). This year, 40 cyanobacteria blooms were documented by the Community Science Institute lab and confirmed by NYSDEC, five times more than in 2017. It is impossible to say how much of this increase may be due to the systematic HABs surveillance program initiated on Cayuga Lake in 2018 and described in this Water Bulletin. Nevertheless, it appears that the overall trend is toward more HABs, not fewer.

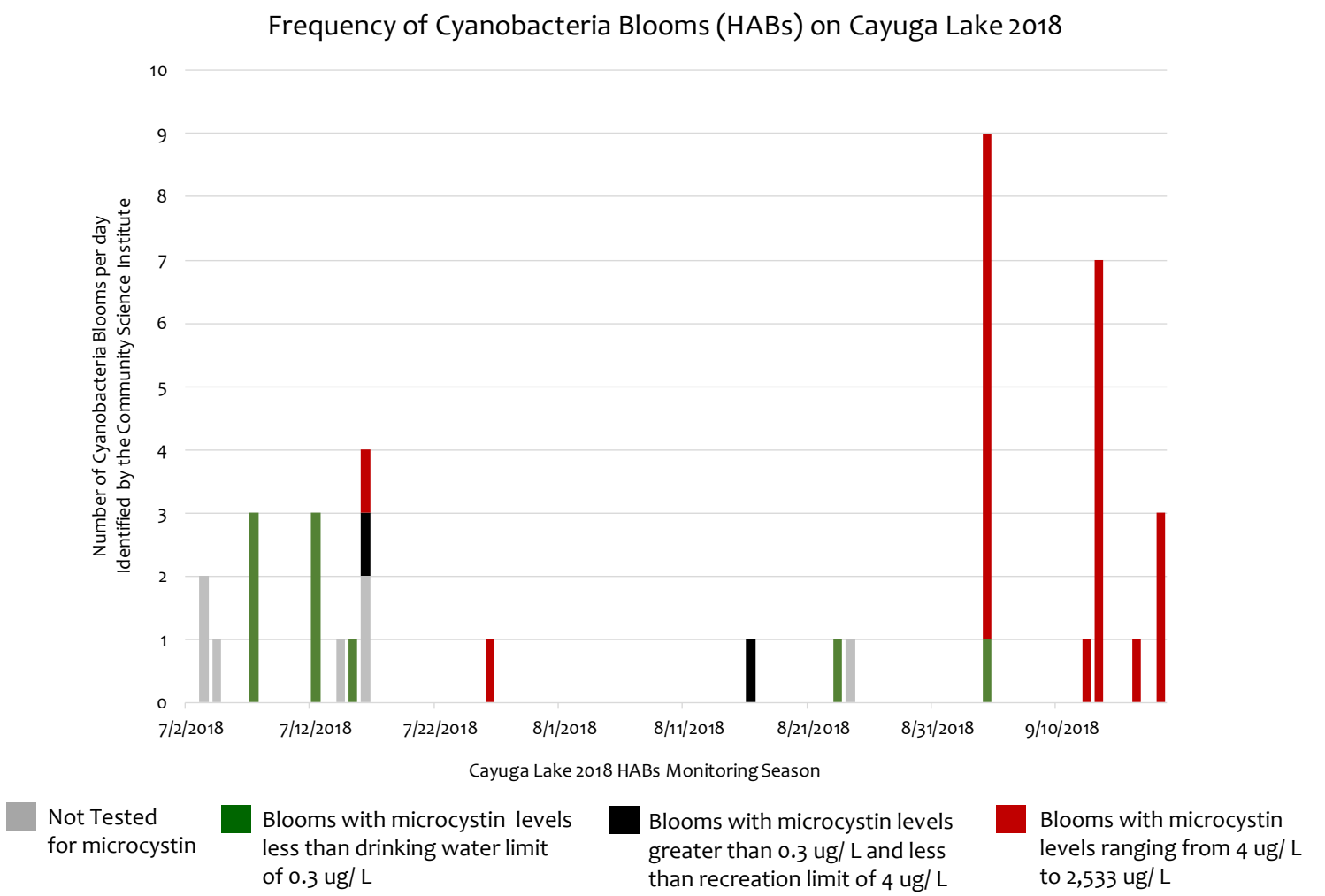


Figure 1. There were numerous cyanobacteria blooms in the first half of July followed by a lull that lasted through August. Blooms reappeared in September, and their concentrations of microcystin toxin were generally much higher than in July. A total of 40 suspicious bloom samples were confirmed to be cyanobacteria by the CSI lab. Of these, CSI tested 34 for microcystin. Source of data: Master table of CSI results at www.communityscience.org/cayuga-lake-2018-harmful-algal-blooms-results/.

Increasing numbers of cyanobacteria blooms are a national and global issue. While there is general agreement in the scientific community that excessive nutrient loading to lakes and coastal waters is a major factor (Graham et al., 2017), blooms in low nutrient conditions such as Skaneateles Lake indicate that other factors are in play, as well. Small increases in water temperature resulting from climate change might combine with local conditions such as calm water and increased clarity due to trophic interactions with invasive species, e.g., zebra and quagga mussels, to promote blooms (NYSDEC, 2018). Anecdotal accounts from our trained Harrier volunteers dropping off bloom samples at the CSI lab this summer suggested similar weather patterns leading up to bloom events on Cayuga Lake – a rainstorm a few days earlier followed by rising temperatures and a hot, clear, and calm day when the blooms would appear. If HABs continue to occur, careful observations of weather patterns as well as measurements of water temperature, clarity and nutrient levels could contribute to a better understanding of factors that promote cyanobacteria blooms on Cayuga Lake.

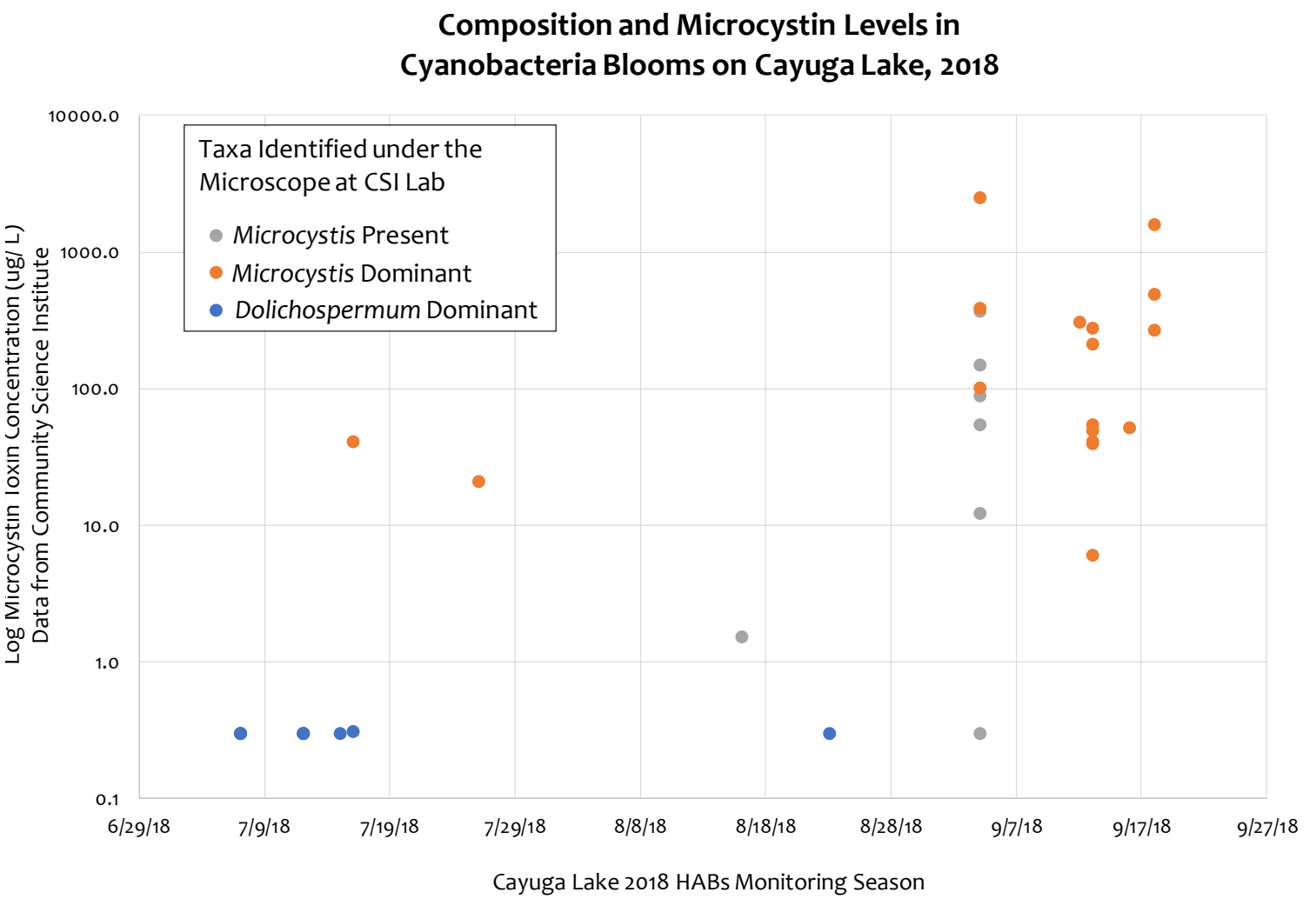


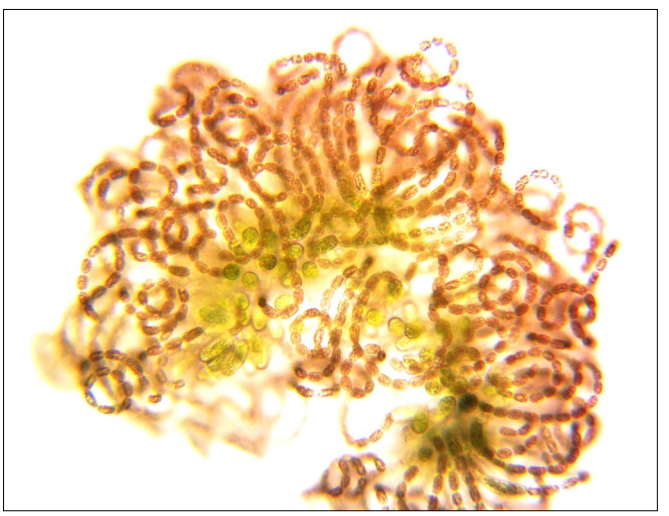
Figure 2. In the course of the 2018 season on Cayuga Lake, the composition of cyanobacterial blooms shifted from predominantly *Dolichospermum* in the first half of July to either mixed *Dolichospermum* and *Microcystis* or predominantly *Microcystis* from late July through September. As bloom composition shifted toward more *Microcystis*, the concentration of microcystin toxin increased greatly - note the logarithmic scale on the y-axis. Source of data: Master table of CSI and NYSDEC results at www.communityscience.org/cayuga-lake-2018-harmful-algal-blooms-results/.

By Nathaniel Launer, Outreach Coordinator

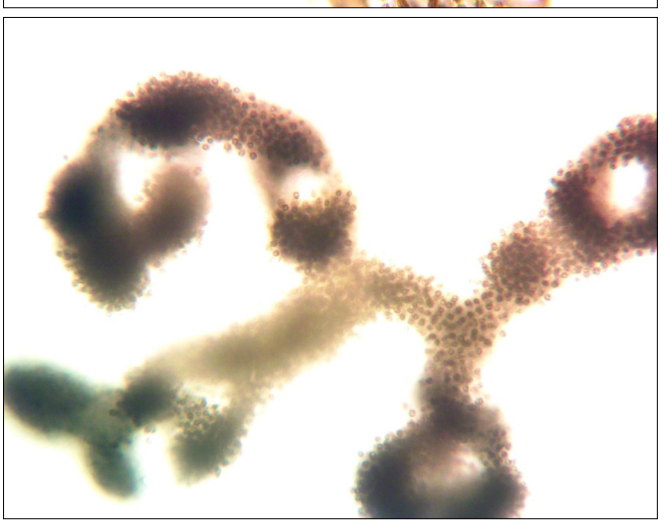
Blooms Under the Microscope

The Changing Dominance of Cyanobacteria Taxa and Microcystin Toxin Levels

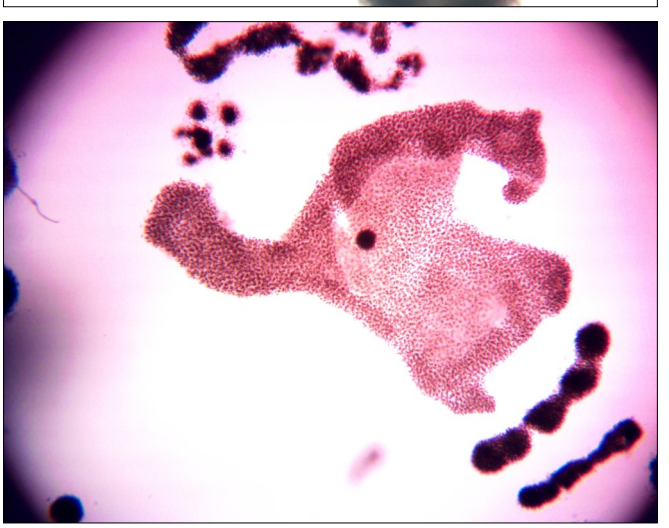
Peering into a drop of lake water under a microscope, the universe of the very small invites a humble lake-lover to a new perspective on Harmful Algal Blooms. The lake is teeming with life at a scale that most of us never notice. Peering at *many* drops over the summer of 2018, and pairing those observations with tests for microcystin and analysis of chlorophyll in suspicious bloom samples, provided preliminary evidence of a possible connection between specific genera of cyanobacteria and the presence of microcystin toxin.



July 3, 2018 – We received our first suspicious bloom report. Back at the lab we discovered that a sample of this bloom was dominated by *Dolichospermum,* a genus of cyanobacteria. This sample, and others dominated by *Dolichospermum* that were tested for microcystin over the summer, contained levels of toxin near or below the drinking water limit of 0.3 ug/L.



July 16, 2018 – We received a few different suspicious bloom samples. Most of them were dominated by *Dolichospermum,* but one that also had a lot of duckweed, when looked at under the microscope, proved to be dominated by *Microcystis*, another genus of cyanobacteria. This sample tested at 41 ug/L for microcystin, well above the NYSDOH limit of 4 ug/L for swimming and the NYSDEC "high toxin" threshold of 20 ug/L.



September 13, 2018 – By mid-September, a number of bloom samples such as this one were dominated by the cyanobacteria genus *Microcystis*. The sample shown in the photograph tested at 281.7 ug/L for microcystin, more than 70 times the limit of 4 ug/ L for swimming and more than 14 times the NYSDEC "high toxin" threshold of 20 ug/L.

By Adrianna Hirtler, Biomonitoring Coordinator

Monitoring Microcystin

A relatively small number of cyanobacteria can produce one or more natural compounds that are harmful to the health of humans and other species. Some of these cyanotoxins can cause death at high doses by damaging the liver or interfering with nervous system function. Exposure to others can result in uncomfortable skin rashes. Yet other cyanobacteria can produce compounds that taste or smell bad but that have no known health effects. Which compound is present depends on the particular species and strain of cyanobacteria that constitutes a bloom.

One of the most common cyanotoxins is the liver toxin microcystin (Graham et al., 2017). Because of its prevalence in lakes in New York as well as its relatively slow rate of degradation in the environment compared to other similarly harmful cyanotoxins, microcystin is used routinely to assess public health risks due to cyanobacteria blooms (NYSDOH, 2018). Microcystin levels are determined by EPA Method 546, which is based on antibody binding to the toxin. The Community Science Institute is currently one of only six labs in New York State that is certified to test for microcystin.

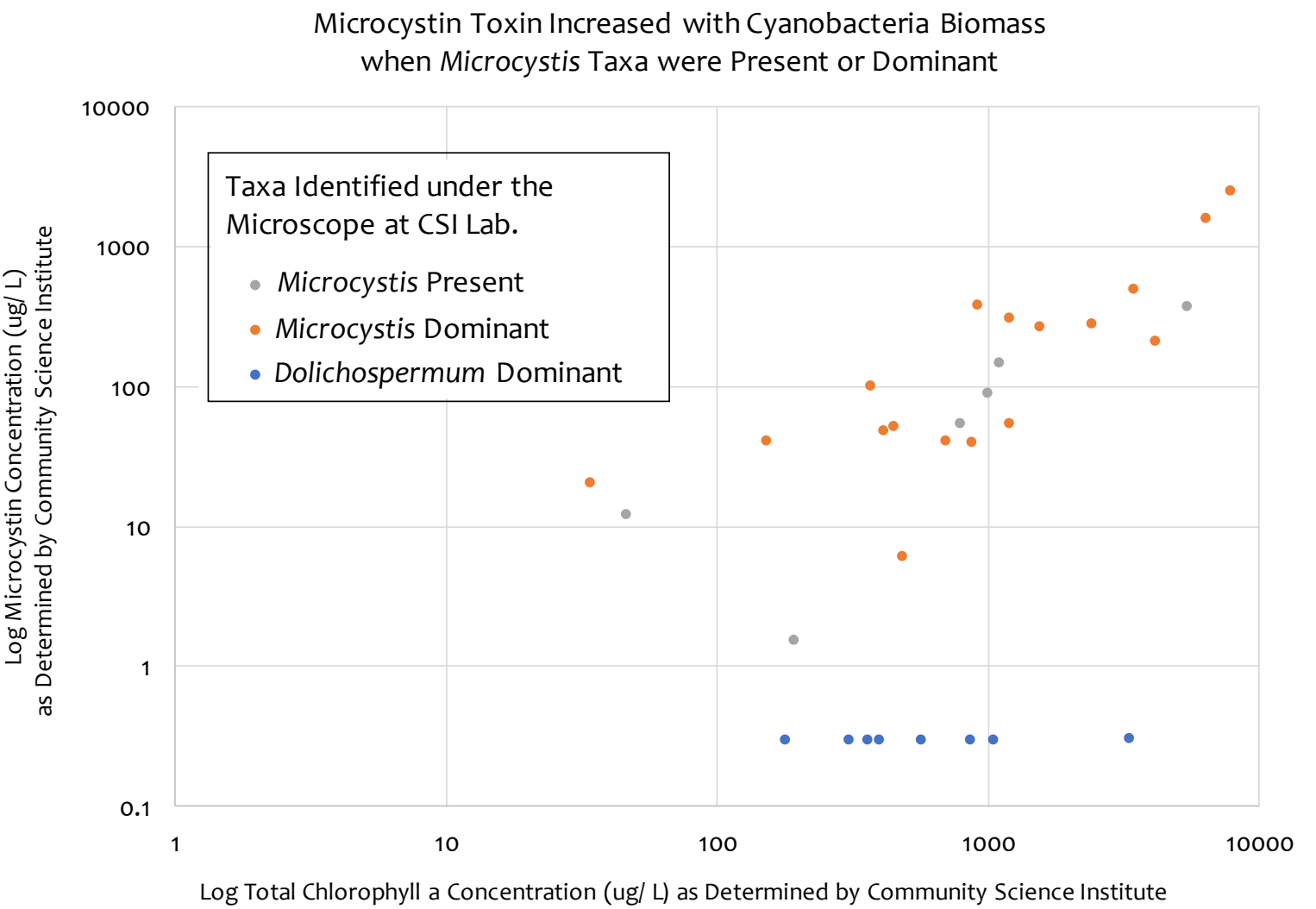


Figure 3. The concentration of microcystin toxin correlated roughly with cyanobacteria bloom biomass, but only when the cyanobacteria genus *Microcystis* was present in the bloom. When the cyanobacteria genus *Dolichospermum* was dominant, microcystin levels were near or below the drinking water limit of 0.3 ug/L. This observation implies that the *Microcystis* strain(s) present in the blooms may produce microcystin at more or less the same rate throughout the season, so that higher toxin levels may be a function of greater bloom density, not increased toxin production within blooms. Note the logarithmic scales on the x and y-axes. Source of data: Master table of CSI results at www.communityscience.org/cayuga-lake-2018-harmful-algal-blooms-results/.

As part of the 2018 Cayuga Lake HABs Monitoring Program, suspicious algal bloom samples collected by HABs Harrier volunteers were analyzed for total chlorophyll a, an indicator of bloom biomass, and microcystin, *if* microscopic analysis showed cyanobacteria was present in the sample. During the 2018 season, the CSI lab analyzed 38 cyanobacteria bloom samples from Cayuga Lake for total chlorophyll a and 34 of those for microcystin. Chlorophyll provided a rough indication of microcystin levels but only if the genus *Microcystis* was present in the bloom. If *Dolichospermum* predominated, microcystin was consistently low or not detectable, regardless of the biomass of *Dolichospermum* in the bloom. These observations are consistent with an earlier study of a mixture of *Microcystis* strains showing that correlations between microcystin and chlorophyll a depended on the presence of *Microcystis* strains that produce the toxin (Davis, Berry, Boyer, & Gobler, 2009). While we are not able to distinguish among strains of cyanobacteria, the general correlation we observed between the presence of organisms of the genus *Microcystis* and microcystin toxin reinforces the importance of identifying specific cyanobacteria taxa in each bloom in order to evaluate which ones produce microcystin toxin in Cayuga Lake and which ones do not. As shown in Figure 3, when the toxin-producing genus *Microcystis* was present, biomass as indicated by total chlorophyll a was found to be a rough indicator of microcystin levels. Total chlorophyll a determined by the CSI lab and BGA (blue-green algae) chlorophyll a determined by the DEC contract lab gave generally comparable results for bloom biomass (see Master Table of Results at www.communityscience.org/cayuga-lake-2018-harmful-algal-blooms-results/)

Another important observation made by the 2018 Cayuga Lake HABs Monitoring Program was the dramatic increase in microcystin toxin concentrations as the summer progressed. In July, blooms were dominated by *Dolichospermum* producing little or no microcystin (Figure 2). Beginning in August and into September, blooms were increasingly dominated by *Microcystis*. With this transition came a sharp rise in microcystin concentrations, from less than 0.30 ug/ L to the season high of 2,533 ug/ L. These results echo a previous report that higher temperatures increase growth rates of toxin-producing *Microcystis* (Davis et al., 2009). It will be of considerable interest to investigate whether the transition from *Dolichospermum* to *Microcystis* and from low to high microcystin toxin concentrations that we observed this year on Cayuga Lake will repeat itself in the future.

By Nathaniel Launer, Outreach Coordinator

Photo of a bloom that occurred on September 13th, at the northern tip of Cayuga Lake. The microcystin concentration was 214.7 ug/ L.

The Community Behind the Cayuga Lake HABs Monitoring Program

Reflections by Claire Weston, Outreach Coordinator Emerita

I moved to Ithaca in the summer of 2016 during the worst drought that the Finger Lakes Region had seen in decades. Initially working as a Field Manager with the New York Public Interest Research Group (NYPIRG), I was quickly introduced to a passionate community of laborers, educators, activists, and environmental stewards devoted to protecting local water resources. It was fortuitous, then, that I soon became the Outreach Coordinator at the Community Science Institute (CSI), allowing me to continue working with this engaged populace. We have accomplished a great deal together since my tenure at CSI began, and during this time I've grown to have a high regard for the Finger Lakes Region and its people. Now, with the opening year of the Cayuga Lake Harmful Algal Blooms (HABs) Monitoring Program in the books, this appreciation has never been so palpable.

As Outreach Coordinator at CSI, my job was to move the Cayuga Lake HABs Monitoring Program from conception to reality, in collaboration with folks from the Cayuga Watershed Network (CLWN) and Discover Cayuga Lake (DCL). This was an undeniably daunting task. In 2017, Cayuga Lake saw an unprecedented number of HABs, leaving the community confused, frightened, and generally in need of answers and intervention. In September 2017 alone, over 50 calls came in from citizens concerned about possible blooms, but without a formal monitoring program in place, only a handful of samples were collected. CLWN Director Hilary Lambert received dozens of calls from concerned community members and worked tirelessly to sample as many suspicious blooms as possible. The New York State Department of Environmental Conservation (NYSDEC) also responded to suspicious bloom reports, but the transient nature of blooms meant that they often dissipated before a sample could be collected. At CSI, which operates a certified water quality testing lab, I fielded many questions from community members, the most common being, "Can you test for cyanobacteria?" Callers were dismayed when I explained that our lab was not yet equipped to test for cyanotoxins and the labs that could – the NYSDEC contract lab in Syracuse and the NYSDOH Wadsworth lab in Albany– would likely take a week or longer to process bloom samples and release results. I sensed frustration growing in the community, and with it, an unmistakable determination to address this seemingly new threat.

The collective inability of the Cayuga Lake community to properly respond to the 2017 HABs outbreak was the catalyst that prompted the recently formed Cayuga Lake Water Quality Consortium to develop the 2018 Cayuga Lake HABs Monitoring Program. The Consortium – composed of CSI, CLWN, and DCL – decided to address the bloom problem by launching a robust public education campaign, outfitting the lab at CSI to test for cyanobacteria and microcystin toxin and recruiting a large network of volunteers. As the point person for the consortium, I wrote and submitted a project plan to NYSDEC outlining the proposed program's structure and stakeholders. With guidance from NYSDEC and support from other lake associations, our Consortium developed a program that built on existing HABs monitoring programs and made modifications designed to incorporate CSI lab analyses and facilitate greater efficiency in sample collection and reporting.

Continued on page 9…

Photo of a bloom that occurred on September 4th, 2018, on Cayuga Lake. The microcystin concentration was 54.8 ug/ L.

Our goal was to recruit and train at least 50 volunteer shoreline monitors, dubbed HABs Harriers, who would patrol their assigned length of shoreline, or "zone," from mid-July to late September. If Harriers observed a bloom, they would collect and transport a sample to CSI's lab for analysis. Once available, bloom location and lab results would be published on CSI's website followed by the dissemination of public notices. CSI would also split all bloom samples with the NYSDEC contract lab in Syracuse for analyses that paralleled those performed at CSI and served as a check on our lab work.

The program's framework was solidifying but large gaps in understanding still existed in the community. To kick off our public education campaign, Consortium members collaborated to host a public HABs Forum on September 30th, 2017. Representatives from nearly a dozen local NGOs and government entities – including NYSDEC, the Department of Health, and the Finger Lakes Institute – engaged with over 100 attendees. In an inspiring display of community engagement, the forum yielded our first volunteer sign-ups and marked the start of a community-wide effort to understand and combat what would likely be a persistent environmental issue.

The public was ready to act, but outfitting CSI's lab remained a daunting challenge. CSI's Executive Director, Steve Penningroth, committed to obtaining the equipment, knowledge, and funding needed to test for the cyanotoxin microcystin. After months of research, dozens of email exchanges, and endless preparation, CSI became one of only six labs in New York State that are certified by the New York State Department of Health to test for the microcystin toxin using EPA Method 546. This accomplishment was due in large part to the superb talent and dedication of CSI's lab analysts, Noah Mark and Alex Sopilniak. In addition to setting up the microcystin assay, CSI also committed to identifying cyanobacteria in blooms using microscopy and measuring total chlorophyll a concentration. While CSI had been performing the total chlorophyll a assay for years, cyanobacteria taxonomy proved to be a new and exciting challenge. Dr. Greg Boyer's lab at SUNY-ESF generously agreed to host a cyanobacteria taxonomy workshop for CSI staff. Though we all learned a great deal, one person in particular took ownership of the practice. Adrianna Hirtler, known as our resident Biomonitoring Specialist, donned a new hat as cyanobacteria taxonomist extraordinaire. Her observations of bloom composition and phytoplankton succession would become increasingly important as the program progressed.

Claire leading a HABs Harrier Volunteer Training session at Wells College in June, 2018.

The success of the HABs Monitoring Program depended on public education, in-house bloom sample testing at CSI, and more logistics management than there is space to recount here, but it cannot be overstated that the Program would have been "dead in the water" without community participation. In May, CLWN's Hilary Lambert and Jenn Tufano put forth the call for volunteers, and the response was magnificent. By mid-June, nearly 50 prospective HABs Harriers had signed up and enthusiastically awaited training. Training workshops were conducted in partnership with NYSDEC and covered everything from the ecology of cyanobacteria to recognizing and sampling algal blooms. HABs Harriers were scheduled to monitor their zones every weekend from July 14th until the end of September. This July 14th start date was meant to align with the historic start of HABs season, but alas, Mother Nature had other plans. Following a heat wave around Independence Day, a rash of blooms occurred ten days before our planned start date. Though they weren't meant to begin monitoring for another couple of weeks, Harriers nevertheless kept a keen eye on the lake, resulting in the collection of valuable data.

As the season progressed, the HABs Harriers' vigilance and dedication never wavered, and our Consortium continued to communicate results and publish program updates within hours to days of receiving suspicious bloom samples and analyzing them at the CSI lab. I was overjoyed to see that Harriers were not only diligently monitoring their zones, they were also speaking with their friends and neighbors about cyanobacteria, the HABs monitoring program, and their role within it. There are countless examples of Harriers going above and beyond their formal duties. Jim Gossett often looked at samples under his personal microscope and provided us with valuable pictures that will remain in our catalogue for use in future research. David Atwell, like many volunteers at the northern end of the lake, regularly travelled over 30 miles to deliver samples to CSI's lab in Ithaca. On September 14th, a particularly nasty bloom was reported at the northern tip of Cayuga Lake in the same area where, just a week earlier, a bloom with a microcystin concentration 125 times greater than NYSDEC's "confirmed with high toxins" threshold was observed. After explaining the circumstances to David, not only did he travel north of his home to collect the sample, but he also drove the sample south to Ithaca without a second thought.

The Cayuga Lake HABs Monitoring Program also worked with Women Swimmin', the annual fundraising event for Hospicare, to ensure that this year's course was bloom-free before swimmers took to the water. HABs Harriers Glenn Ratajczak, Michelle Bamberger, Don Sargent, and Shannon Barrett patrolled parts of the swim course in the days leading up to the event and at 5:00 AM the day of. The extra time and early hours they put in were appreciated by many in the community and contributed to the safety and success of the event. All these efforts – the long drives, extra sampling, and unwavering vigilance – happened under the leadership of our four Quadrant Leaders. Bill Ebert, Christy Van Arnum, Steve Knapp, and Andy Yale gave up countless hours of their time to attend meetings, respond to inquiries from Harriers in their quadrant, and step in to collect samples when needed. Their leadership and commitment to the health of Cayuga Lake made the Cayuga Lake HABs Monitoring Program possible.

In its pilot year, the Cayuga Lake HABs Monitoring Program was a resounding success. We surpassed our goal of 50 volunteers and ended up with 76 HABs Harriers surveying 56 unique zones. Over the course of three months, 40 bloom samples were collected by HABs Harriers, 16 of which were "confirmed with high toxin." Thanks to the stewardship and dedication of the Cayuga Lake Community, a solid baseline dataset has been established that can begin to inform future research. As described elsewhere in this Bulletin, preliminary analyses of these data have already yielded new insights into phytoplankton succession, microcystin distribution, and how bloom sample composition might predict toxicity. I have also observed a significant change in the public's perception and understanding of HABs. Over the past year, the fear and frustration that defined the community following the summer of 2017 has been broken down and repackaged into something far more productive: collective determination to address the HABs issue.

When I took the lead in developing the 2018 Cayuga Lake HABs Monitoring Program, I never imagined that it would be shaped so profoundly by the individuals who took part. To the HABs Harriers, the Quadrant Leaders, and all those who were so integral to the success of this program, I would like to say that leading the Cayuga Lake HABs Monitoring Program with CLWN and Discover Cayuga Lake was an honor, but the program's success is your victory. You can be proud of the impact you have made, and will continue to make, because you are not done yet! My tenure as Cayuga Lake's HABs Monitoring Program Coordinator and CSI's Outreach Coordinator has come to an end, but my successor, Nathaniel Launer, and all those in the Consortium have big plans for next year. I feel truly blessed to have been a part of the Finger Lakes community and look forward to following your future accomplishments.

Warm Regards,

Claire Weston

Above. Drone photo of bloom that occurred on September 18th near Canoga.

Below. Harrier volunteer Tom Casella collecting a sample of cyanobacteria bloom shown in the drone photo above. The microcystin concentration was 1,604 ug/ L.

Looking Ahead

Building on our initial success in 2018, we intend to expand the Cayuga Lake HABs Monitoring Program in 2019. A top priority will be to work with our Consortium partners, the Cayuga Lake Watershed Network and Discover Cayuga Lake, to recruit more HABs Harrier volunteers. Volunteers covered 30% of the Cayuga Lake shoreline in 2018. Our goal for 2019 is to monitor at least 50%, with an emphasis on adding Harriers at the north end of the lake where many of the blooms with high levels of microcystin toxin occurred. We envision training all of our Harriers in the collection and reporting of field data, specifically water temperature as well as wind and light conditions that might reveal environmental factors conducive to HABs as well as weather patterns in the days preceding a bloom. In addition to identifying cyanobacteria in blooms, our lab will track overall seasonal changes in the phytoplankton community by collecting weekly samples at points in the southern and northern halves of Cayuga Lake and recording the populations of microscopic organisms they contain. Changes in the phytoplankton community could provide clues to when in the HABs season to anticipate blooms with high toxin levels and where. Finally, we will continue our long-term partnerships with ten volunteer groups to monitor water quality in Cayuga Lake tributary streams, particularly phosphorus and nitrogen nutrients, which are considered by many scientists to be major factors in promoting harmful algal blooms. We realize that these are ambitious goals. We respectfully ask that you consider making a donation to support our long-term project to understand and, ultimately, to manage water quality in the Cayuga Lake watershed, including harmful algal blooms.

By Steve Penningroth, Executive Director

We gratefully acknowledge the support of the Park Foundation and the Tompkins County Legislature who provided funding on an emergency basis to help staff our unexpectedly large HABs surveillance program and to test for microcystin toxin.

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Community Science Institute

Water Bulletin - Harmful Algal Bloom (HABs) on Cayuga Lake Edition

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Partnering with Communities to Protect water Since 2002

This Fall 2018 edition of the Water Bulletin highlights the results of a successful first year for the Harmful Algal Bloom Monitoring Program on Cayuga Lake. Recognition for this important work must be given to each and every one of our dedicated volunteers who helped monitor the lake this summer. This program would not have been possible without you.

Cayuga Lake and its tributary streams are an invaluable natural resource and part of our local heritage. As a certified lab collecting long-term water quality data, partnering with communities, and coordinating a large volunteer network, the Community Science Institute is uniquely positioned to help protect Cayuga Lake as well as other lakes and streams in the region by producing certified data to inform stakeholder decision-making. The water quality data we produce with our volunteer partner groups is simply not available anywhere else. You can support our efforts by volunteering, by renewing your Community Science Institute membership or by becoming a new member today. Together, we can take action to understand and protect our irreplaceable waters - now and in the future.

Nathaniel Launer

With sincere thanks,

Nathaniel Launer

Outreach Coordinator and Cayuga Lake HABs Monitoring Program Coordinator

Membership Levels

- ☐ $25 (Creek)
- ☐ $50 (Stream)
- ☐ $100 (River)
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- ☐ $500 (Estuary)
- ☐ $1000 (Watershed)
- ☐ > $1000 (Ocean)
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