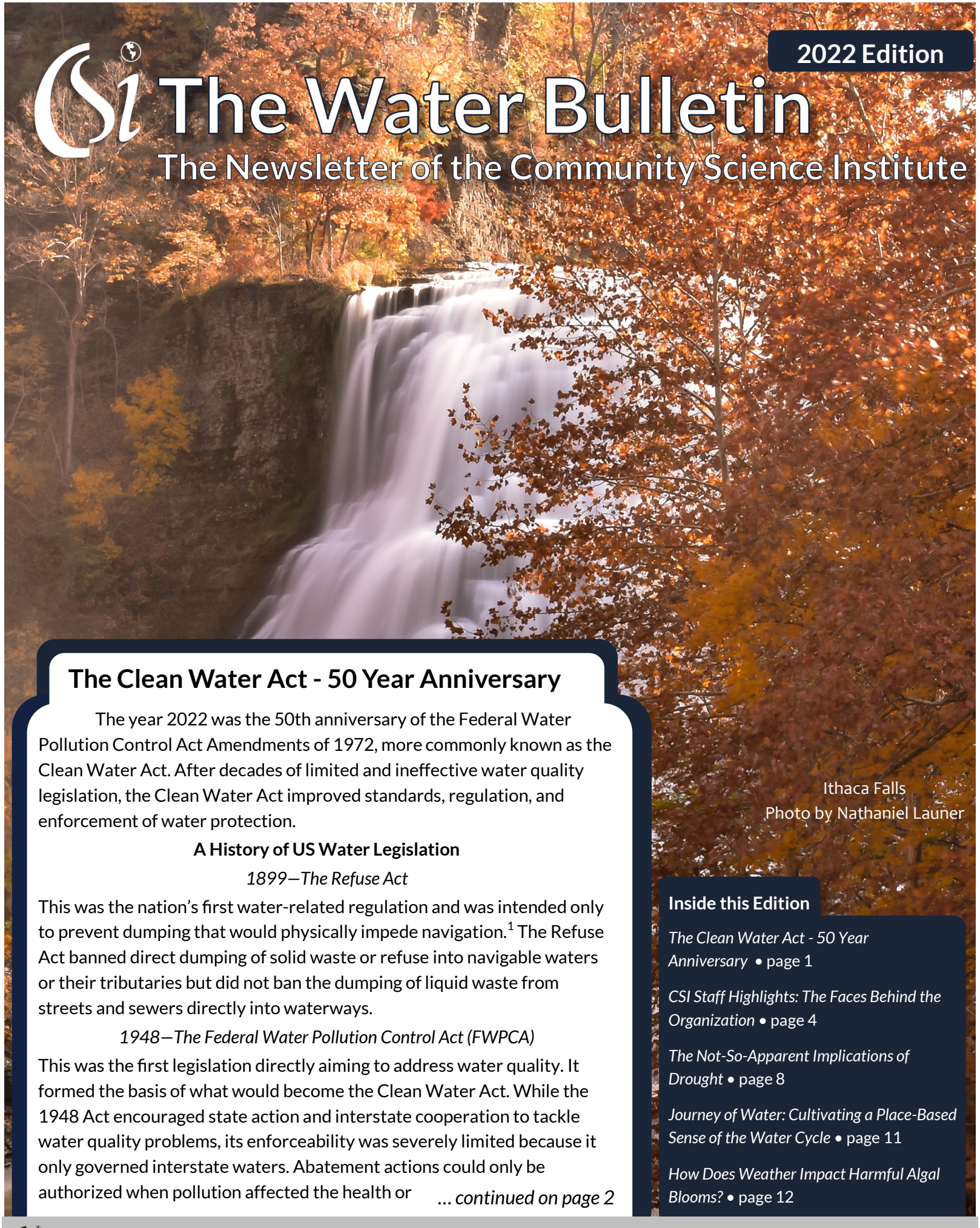
2022 Edition

The Water Bulletin

The Newsletter of the Community Science Institute



Ithaca Falls
Photo by Nathaniel Launer

The Clean Water Act - 50 Year Anniversary

The year 2022 was the 50th anniversary of the Federal Water Pollution Control Act Amendments of 1972, more commonly known as the Clean Water Act. After decades of limited and ineffective water quality legislation, the Clean Water Act improved standards, regulation, and enforcement of water protection.

A History of US Water Legislation

1899—The Refuse Act

This was the nation's first water-related regulation and was intended only to prevent dumping that would physically impede navigation.[1] The Refuse Act banned direct dumping of solid waste or refuse into navigable waters or their tributaries but did not ban the dumping of liquid waste from streets and sewers directly into waterways.

1948—The Federal Water Pollution Control Act (FWPCA)

This was the first legislation directly aiming to address water quality. It formed the basis of what would become the Clean Water Act. While the 1948 Act encouraged state action and interstate cooperation to tackle water quality problems, its enforceability was severely limited because it only governed interstate waters. Abatement actions could only be authorized when pollution affected the health or

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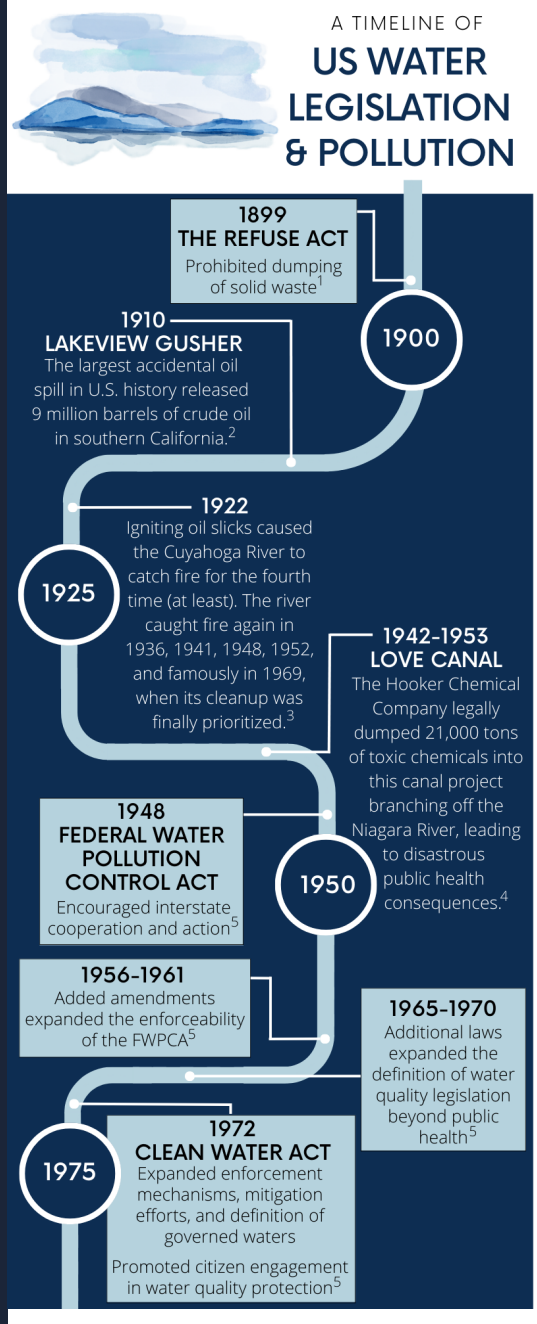
welfare of people outside the state where the pollution originated. Even in cases where abatement actions were authorized, the state where the pollution originated could veto them.



1956-1961—Amendments to the FWPCA

These aimed to improve the enforceability of the act, including allowing federal action on intrastate pollution. However, effective enforcement mechanisms were still lacking.

1965-1970—Laws Expanding the Federal Government's Reach

These broadened water quality standards to include chemical and biological indicators rather than just risks to public health, and these standards were expanded to address a broader range of pollutants. Enforcement was expanded by instituting reporting requirements for pollutant discharge and civil penalties for noncompliance. Despite this expansion of the federal government's regulatory reach, the enforcement mechanisms were still unwieldy and largely ineffective.

1972— The Federal Water Pollution Control Act Amendments, or the Clean Water Act

The Clean Water Act (CWA) expanded the scope of federal regulation of surface waters and empowered states to enforce water quality standards under the authority of the Environmental Protection Agency (EPA). It established a basic regulatory structure for controlling pollutant discharges, giving both the EPA and the states enforcement authority. Furthermore, it provided funding for the construction of wastewater treatment plants and encouraged programs for mitigating non-point source pollution. While previous legislation governed only interstate waters, the CWA expanded federal and state jurisdiction to cover all waters considered waters of the United States (WOTUS). The exact definition of WOTUS has been the subject of legal battles in recent years. The currently accepted definition includes all interstate waters and wetlands, any intrastate waters and wetlands the degradation of which could affect interstate commerce, such as by inhibiting interstate tourism or fishing, as well as any tributaries of these waters. Each water body included in WOTUS is defined by its designated uses, which describe how the water body has been or is likely to be used (e.g. drinking water, fishing, recreation, etc.), which therefore determines what water quality standards are necessary to maintain those uses. A broad definition of WOTUS significantly increases the scope of surface waters and wetlands that are subject to regulation by EPA and the states. One of the cornerstones of the CWA is the combined National Pollutant Discharge Elimination System (NPDES) and State Pollutant Discharge Elimination System (SPDES), which govern the issuance of permits for the discharge of pollutants.

Implementation of the CWA and Citizen Involvement

The CWA does not ban the discharge of pollutants into WOTUS entirely. Instead, it tracks point source discharge of pollutants through permits issued through the NPDES or SPDES programs. All point sources of pollution such as factories, boats, landfill leachate systems, concentrated

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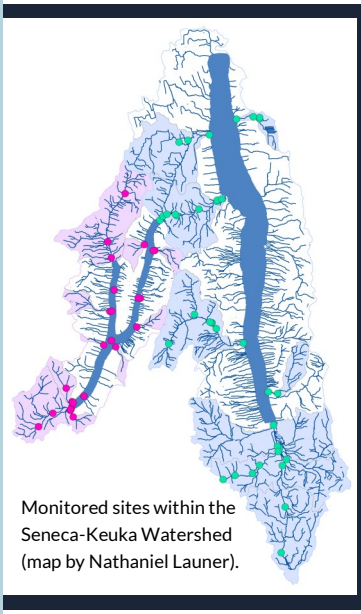
animal feeding operations, or sewage treatment plants that discharge water into WOTUS have to obtain a permit in order to operate. These permits must be renewed every five years and usually require either a monthly or yearly Discharge Monitoring Report (DMR) demonstrating that discharge is within the limits set by the permit. In addition to reviewing DMRs, state and federal agencies can perform on-site inspections.

The CWA specifically promotes citizen involvement as an important part of ensuring point sources are in compliance with their permits, as state and federal agencies are stretched thin and inspections tend to be relatively infrequent. The permits and DMRs are publicly available, allowing citizens to check whether a point source is in compliance. If citizens or grassroots organizations suspect a permit is being violated, they are encouraged by the CWA to collect data by monitoring the impacted waters and lodge a complaint requesting that the state or federal agency enforce compliance. The CWA allows citizens to sue the government if it fails to remedy the SPDES or NPDES permit violation. Many enforcement actions begin with a complaint brought forward by the community, meaning public awareness and concern are an essential part of addressing pollution. Due in large part to community engagement, the permitting system established by the CWA has been extremely successful in bringing the rampant point source pollution of the 1960s under control.

Concerned citizens can also take an active role in setting limits on pollution by taking part in the NPDES or SPDES permitting process or by participating in the establishment of a Total Maximum Daily Load (TMDL) for a waterbody. When water quality becomes degraded to the point where it is insufficient for one or more of a water body's designated uses, the CWA requires a TMDL to be established for the out of control pollutants. The TMDL is set to achieve certain water quality goals and is accompanied by a management plan for achieving them. The plan accounts for all point and non-point sources of pollution and adjusts discharge permits and watershed management practices to reduce pollutant loads and restore water quality. The pollutant load from point sources is relatively easy to determine, but pollutant load from non-point sources, such as agricultural runoff delivered through streams, is much more difficult to estimate. Estimates are difficult in large part because stream flow can vary dramatically throughout a year as well as between years. These estimates are likely to become more difficult as climate change progresses and rainfall becomes more erratic (see 2022 Water Bulletin article: "The Not-So-Apparent Implications of Drought").



Monitored sites within the Seneca-Keuka Watershed (map by Nathaniel Launer).

A 9 Element (9E)[6] watershed plan is similar to a TMDL. Taking into account a water body's potential sources of pollution and its designated use, a 9E plan creates a strategy for improving water quality for water bodies that are not included on the impaired waterbodies list. 9E plans have a special emphasis on local community involvement.

CSI is part of a group of stakeholders in and around Seneca and Keuka Lakes who joined together in 2018 to reduce nutrient loading[7] by designing a 9E plan. With logistical and laboratory support[8] from CSI, Seneca Lake Pure Waters Association (SLPWA), and Keuka Lake Association (KLA) finalized[9] the Seneca-Keuka Watershed 9E plan in October 2022.

Developing a TMDL is complicated, which is why the CWA requires public involvement in the identification of impaired water bodies and the development of TMDLs to mitigate impairments. Data collected by volunteers from grassroots organizations like Community Science Institute can support the identification of a water body as impaired with respect to its designated use. These data can also be used to determine when a water body is no longer impaired. For example, in 2014, CSI data were used to help demonstrate that the southern shelf of Cayuga lake was no longer impaired by pathogenic bacteria, and the lake was therefore removed from the list of impaired waterbodies.[10] Community collected data can also inform the design of the TMDL to restore the water body to its designated use. For example, CSI's data on phosphorus loading from Fall Creek were used to validate the Soil and Water Assessment Tool (SWAT) model for Cayuga Lake which is an integral component of the draft Cayuga Lake TMDL for total phosphorus.[11] In sum, community stewardship is essential to the success of the CWA.

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The Clean Water Act establishes a robust regulatory structure to determine what waters are polluted, what action needs to be taken to restore water quality, and how much pollution is permissible to allow economic activity while maintaining the health of the waters of the United States. Chronic underfunding of state agencies means that community involvement is more important than ever to meeting the goals of the CWA. While agencies like the DEC and the EPA play a role in monitoring, they are not able to monitor as many locations and as frequently as CSI volunteers. Check out our public online database to see just how many sites are monitored by CSI's dedicated volunteers. CSI's mission to empower community members to become stewards of their local water resources through water quality monitoring falls squarely within the framework of the Clean Water Act. We offer a range of programs to educate the public about water quality and foster stewardship, while partnering with volunteers to collect regulatory quality data to help improve water quality and inform water quality standards in and around our communities.

If you now feel spurred to action (or maybe just want more detailed information) please check out the programs on our website to get involved with monitoring water quality in your neighborhood. You can also read *The Clean Water Act Owner's Manual*[5] by The River Network, which describes the CWA's systems in more detail, shares some CWA success stories, and gets into the nitty gritty of the legal framework of the CWA. It's a great resource for anyone passionate about protecting natural waters and was hugely helpful in writing this article.

- Seth Bingham, *Water Quality Scientist*

CSI Staff Highlights: The Faces Behind the Organization

Grace Haynes - Outreach and Programs Coordinator, Cayuga Lake HABs Monitoring Program Coordinator

I recently moved from Minneapolis, MN to join the CSI team. With a B.A. from UCLA in the humanities but a lifelong interest in natural science, it's been a bit of a journey to get here. Professionally-speaking, I found my way to the realm of science through community engagement and entomology. Over the years I've worked and researched in many different areas. I worked as an AmeriCorps member and crew leader at American Conservation Experience, a conservation corps in California, where we built trails, restored habitat for the threatened desert tortoise, and removed countless invasive species from habitats across the state of California. From there I explored the world of research, supporting scientific studies ranging from element limitation in hardwood forests to the way monarch butterflies use roadsides as habitat. Ultimately, I pursued an MS in Natural Resources Science and Management from the University of Minnesota, where I studied the ecology of the introduced velvet longhorn beetle.

Combining my background in Humanities and Science is highly fulfilling. I enjoy working towards integrating "soft" and "hard" skills and believe that the best science is done when we keep social implications in mind. An understanding of the way science works improves our communication with and understanding of each other. My role as Outreach and Programs Coordinator at CSI affords me the opportunity to make science more accessible and understood by a broader community. It also allows me to continue collecting and analyzing scientific data while building community connections.

Grace enjoying the boundary waters in northern Minnesota.

Charlene Mottler - Administrative and Laboratory Assistant

Charlene enjoying the sunset at Myers Point on Cayuga Lake

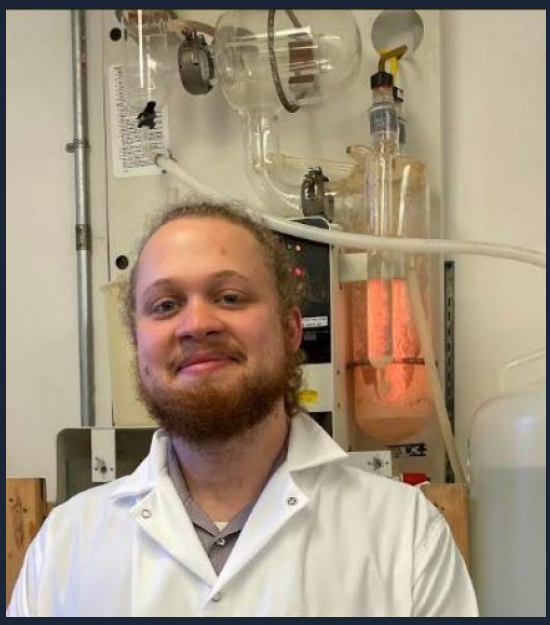
Throughout my career, I've donned many hats in a wide range of scientific disciplines, but the driving force behind my choice of projects has always remained the same; a deep desire to be involved in meaningful work that positively impacts the greater good both globally and in my little corner of the world. I hail from a small farming community in New York that borders Lake Ontario and spent my childhood on its shores as well as summers in the Adirondacks. The forests, lakes, and streams have always been intertwined in my everyday life. When I am able, I visit them daily to recharge. Here at CSI, I am honored to have the opportunity to protect our waters and the life that they sustain.

Having previously worked 15 years in various Cornell University research laboratories, and with a deep appreciation for the natural world and all its beauty, I am excited to combine my love of science and nature to further CSI's mission. With a B.S. degree in Plant Sciences from Cornell University along with a diverse research background in Molecular Biology, Biochemistry, Chemistry, Entomology, and Horticulture, I enjoy my role as analyst in the laboratory testing the community's drinking water and our streams, lakes, and tributaries for indicators of the presence of pathogenic bacteria.

My role at CSI also includes that of administrative support which allows me to engage with a diverse clientele including the general public. Helping our community daily to find answers to their water quality concerns and determining if their water is safe to drink or to recreate in is a meaningful and rewarding endeavor. Contributing data to CSI's long-term database by continuing the work of those who came before for its current use as well as by those who will follow is my privilege.

In my spare time, I volunteer in animal rescue throughout the Finger Lakes, enjoy hiking, paddling, cross-country skiing, snow shoeing, fossil hunting, wood working, bird watching, studying geology, and spending time with my beloved dog and two cats.

Seth Bingham - Water Quality Scientist



Seth hard at work at 95 Brown Road

I only started work at CSI this past June, but I have been an upstate New York local my whole life. My family is from North Carolina, and I was born in Syracuse shortly after they moved there. I enjoyed every science class I took in high school, and went off to Colgate University with a broad interest in the sciences, but no specific plan. After experimenting with different disciplines, I ended up getting a BA in chemistry with a minor in geology. I enjoy chemistry and am fascinated by all the things it can tell us, but an unfortunate downside is that much of the work occurs inside. My geology minor helped remind me that I want to feel connected to the world around me. The sense of immersion in the natural world you get examining bedding structures while squatting in the mud can be hard to come by in the lab. My work at CSI allows me to enjoy the nitty gritty of lab work, refining processes to get work done quickly and minimize sources

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of error, while also being able to feel like the work I do is directly connected to the world I see when I look out the window.

Working at a state certified laboratory comes with its fair share of challenges, and this type of work is still relatively new to me. My research work in college was computational, meaning I spent my time in the lab looking at 3d models of molecules not even wearing closed toed shoes. There's been a lot to learn in my short time here, from developing proficiency in the techniques of wet chemistry, to understanding the quality control system required of a certified laboratory. At first I felt a bit like a fish out of water, but, especially now that I've settled in, I'm glad that each day brings an opportunity to learn and stretch myself while doing work that benefits my local community.

Grascen Shidemantle - Executive Director

From my upbringing to my education to my current role at Community Science Institute, water has always had an important presence in my life. I am originally from Slippery Rock, Pennsylvania, a small college town north of Pittsburgh, named after the stunning Slippery Rock Creek, which forms a gorge of its own in McConnells Mill State Park. As a student of biology, my studies regularly focused on how water quality impacts sensitive aquatic wildlife. I earned a B.S. in Biology from Slippery Rock University where I researched the effects of neonicotinoid insecticides (namely, imidacloprid) on amphibian development. I also had the opportunity to study weakly electric fish behavior through a National Science Foundation internship at Indiana University. From there, I earned my PhD at Binghamton University working in Dr. Jessica Hua's aquatic ecotoxicology lab. For my dissertation research, I studied the impacts of light pollution on native larval amphibians and their wetland communities. I also led and contributed to several research projects investigating the effects of road deicing salt runoff on amphibian physiology.

As the executive director of Community Science Institute, I am passionate about using scientific knowledge to empower and support the health of our community for the benefit of humans and wildlife. I believe that I have one of the most fun and meaningful jobs out there. Each day is different and engages my scientific curiosity and creativity in new ways. Perhaps one of my favorite parts of my job is that I get to work closely with so many people, including research scientists, government officials, and volunteers, who are dedicated to the protection of water quality in the Cayuga Lake watershed. I especially value the on-the-ground knowledge that our volunteers contribute to our monitoring programs including their personal observations and water quality concerns. Working alongside these diverse stakeholders as a community united in our effort to monitor and protect local water resources is truly inspiring. I am grateful that I can be a voice for the water quality data in our area. The Lorax may speak for the trees, but I get to speak for the streams.

When I'm not at 283 Langmuir Lab, you can find me hiking local trails with my partner, Taylor, and our dog, Kita. I have hiked many famous locations including the historic Camino de Santiago in Spain and the Ecuadorian Amazon Rainforest, but my favorite trails by far are right here in the Finger Lakes. I also enjoy crocheting and practicing yoga. Along with my dog, Kita, I also have two cats, Minerva and Hippie, and many aquarium animals including an axolotl.

Grascen at Buttermilk Falls.

Adrianna Hirtler - Biomonitoring Coordinator

As CSI's biomonitoring coordinator, I organize yearly, volunteer-driven evaluations of benthic macroinvertebrate (BMI) communities in Finger Lakes streams. CSI's biomonitoring program has collected BMI biodiversity-based water quality data on over 30 streams at nearly 100 individual locations since it started in the early 2000's. In recent years, the biomonitoring branch of CSI's work has also extended into the realm of Harmful Algal Blooms (HABs). As biomonitoring coordinator, I look at each of the volunteer-submitted HABs samples to verify and record the presence of cyanobacteria and other plankton and am always trying to pay attention to what's happening in and around water from the perspective of tiny forms of life.

I graduated from Cornell University with a B.S. in Natural Resources in 1999, but my love of water comes from the two gorge streams I grew up between near the Southeast end of Seneca Lake. I missed them terribly when I lived in the Western US and internationally for over a decade on international exchanges in Germany and Italy, earning an M.S. degree in Environmental Studies at the University of Oregon, working as a ranger-naturalist for the National Park Service, and studying relationships between "nature" and "culture" in Latvia. When I returned to the Finger Lakes seasonally in 2007 (still working summers in Yosemite National Park for another decade), I was excited to sign up as a volunteer with the Community Science Institute. My life experiences have convinced me that water, above all else, deserves our utmost reverence and attention. Getting involved with CSI's developing biomonitoring program, then led by the lab chemist Michi Schulenberg, I found a niche that brought together my passions for water, for the Finger Lakes region and for cultivating cultural connections between humans and the other-than-human world. I was eventually hired by CSI to manage the program. I have always been fascinated by the idea that if you pay close attention to one aspect of life on Earth (e.g. communities of tiny stream or lake-dwelling creatures) you can learn important things about other aspects of life on Earth that are not typically treated as being related (e.g. water quality as a reflection of human activities on the land).

I have worked as the part-time biomonitoring coordinator for CSI since 2011. The part-time nature of the job has allowed me to raise a water-loving child and to continue to work locally as an "interpreter" of nature and culture, leading walks and programs and developing interpretive materials.

Adrianna sharing her love of benthic macroinvertebrates. Photo by Hilary Lambert.

Noah Mark - Laboratory Director

As laboratory director, it's a given that the title carries a responsibility for the lab's performance. In a sense, a certified lab should work like a well-oiled machine that records every action it takes: samples submitted to the lab move efficiently from analysis to results reporting, passing through a series of checks along the way so that the lab feels confident in the data being produced. You, the reader, might get a militant impression of the lab's practices—in some respects, this is an apt description. Besides the strong emphasis on good performance and thorough documentation, chemistry's risky reputation (perhaps justifiable) supports the heightened need for vigilance in the lab. Despite these

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Noah in CSI's laboratory

concerns, the lab bench isn't without its nerdy and artisanal satisfactions. There is nothing like coating metal granules with a copper-based solution, separating the components of a mixture in two immiscible liquids, or watching a magenta color change unfold in a reaction.

Now, I should state that we are not reinventing the wheel to conduct water tests. My first brush with the "bible" of water quality, that is Standard Methods for the Examination of Water and Wastewater, was while obtaining my M.S. in Soil, Water, and Environmental Science. As a research assistant at Biosphere 2 in Arizona, I felt then as I do now the magic of chemistry, and although I am no longer investigating the behavior of emerging contaminants in my current role, leafing through an established method, there's still a standing-on-the-shoulders-of-giants feeling that pervades my work, as the toil of other scientists affords the convenience of adapting rather dependable test methods for CSI's lab.

Fortunately, I still clock a fair amount of time at the bench, gleaning what microbes and chemistry can tell about the quality of various kinds of water, and keeping sharp the necessary muscle memory needed to conduct certain analyses and preparations with relative speed. I believe some types of knowledge reside in the body. Coming from a farm family in western New York, and in another chapter of my life, having co-owned and operated a diversified vegetable farm, I feel that the knowledge of wet chemistry as well as raising food lies in the hands as well as the head. Although automation has its advantages, CSI's lab continues to see the benefits of methods that rely on hand-eye coordination.

As lab director, I am proud to play a part in CSI's vision of how to practice science, which as our mission suggests, places people (and data) more squarely at the center of things, both in how we conduct our brand of science and in striving to democratize science. As a former grassroots organizer for environmental issues and sexual assault prevention, I still admire working more directly with the community. Over the years, I am thankful to have participated in some outreach and fundraising events/projects, for this also allows me to advocate for our brand of science outside the lab.

- Curation by Charlene Mottler, *Administrative and Laboratory Assistant* and Grace Haynes, *Outreach and Programs Coordinator*

The Not-So-Apparent Implications of Drought

In the Finger Lakes region, we are fortunate to be surrounded by abundant freshwater resources in our glittering lakes, winding streams, and rushing waterfalls. Indeed, the eleven Finger Lakes alone hold 8.1 trillion gallons of freshwater.[12] However, if you visited any of our natural wonders this summer, you likely came across dry creek beds or trickling waterfalls. This August, under the direction of governor Kathy Hochul, the New York State Department of Environmental Conservation (NYSDEC) expanded the state's drought watch* to include most of western NY and other parts of the state.[13] During this drought watch (which was lifted on October 8th), areas throughout Cayuga and Seneca counties and all of Tompkins County faced abnormally dry to moderate drought conditions[14] (Fig. 1). Although the drought watch was expanded to our area officially in August, many Community Science Institute volunteers throughout the Cayuga Lake watershed remarked on the dry conditions prior to this.

Dry summer conditions significantly impacted CSI's synoptic stream monitoring program in 2022 (Box 1). To collect samples that are most representative of a stream's water quality, it is essential to have sufficient stream flow and depth so that volunteers can fully submerge sample bottles below the surface of the water and allow water to flow easily into the bottles. Unfortunately, five separate base flow monitoring events in the Cayuga Lake watershed were canceled or rescheduled this year due to dry or low flowing streams. Similarly, volunteers on the Cayuga Inlet, Milliken Creek, Yawger and Great Gully Creeks, and Six Mile Creek monitoring teams

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*NYSDEC defines a drought watch as "The first of four levels of state drought advisories ("watch," "warning," "emergency" and "disaster"). There are no statewide mandatory water use restrictions in place under a drought watch, but residents are strongly encouraged to voluntarily conserve water. Local public water suppliers may require conservation measures, depending upon local needs and conditions." You can find more information on drought, including definitions and classifications, here.

were forced to forgo sampling at several of their regularly monitored sites, citing insufficient flow or dry creek beds as the primary reason. USGS hydrographs, which depict stream flow, showed flows largely below the median daily statistic throughout much of the monitoring season (see Salmon Creek at Ludlowville, Fig. 2; note log scale on y-axis).

In addition to challenges collecting representative base flow stream samples, volunteers also faced hurdles in collecting stormwater samples. It is important to collect stream samples under stormwater conditions in order to understand the loading of pollutants into Cayuga Lake. Under stormwater conditions, levels of nutrients, total suspended solids, turbidity, and *E. coli* are elevated. High stream flows during storms also carry these elevated pollutants into the lake more quickly than under baseflow (i.e. non-stormwater) conditions. This year, it was not possible for CSI volunteers to collect stormwater samples from most of our regularly monitored streams and creeks in the Cayuga Lake watershed.

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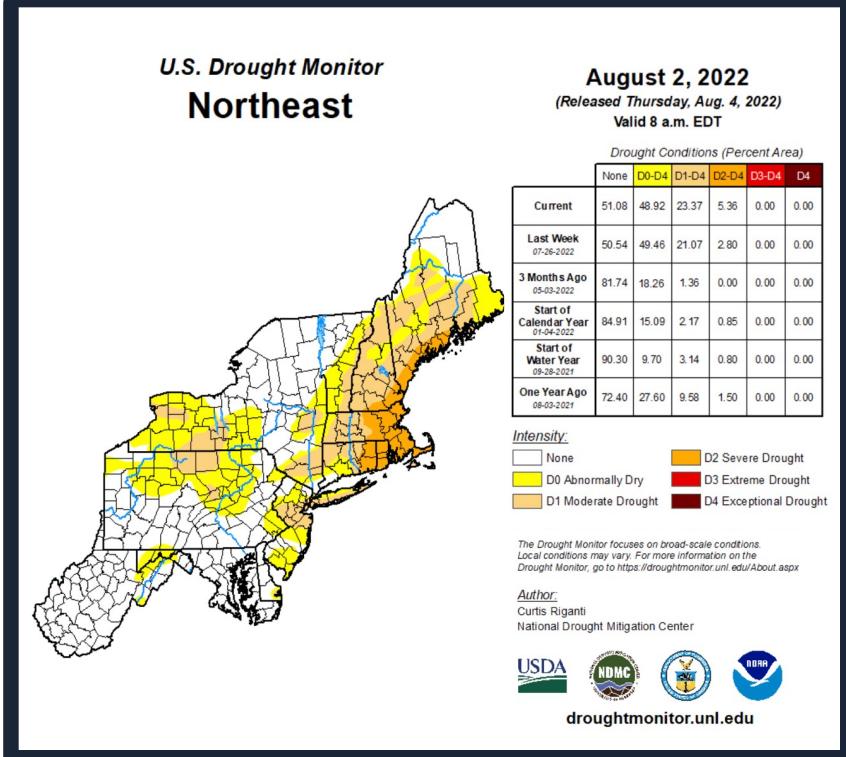

Figure 1. U.S. Drought Monitor map and table of drought conditions on August 2, 2022 in the northeast United States. Colors on the map and table reflect intensity in drought conditions. The U.S. Drought Monitor is jointly produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration. Map courtesy of NDMC.

Box 1. Volunteer Observations

CSI's Cayuga Inlet monitoring team volunteer, Barbara Chase, captured these photos which show the stark difference in stream conditions on Enfield Creek Upper Treman in 2021 (A) and 2022 (B). Featured in photo B is Bill George, Cayuga Inlet volunteer and CSI's own data entry specialist, taking detailed notes about the site. Barbara shared, "In the five or so years I have been collecting synoptic samples at this site, this is the first time I have seen that green algae on the surface of the right hand side of the stream (B). I think usually the water is flowing too fast for it to collect like that. One of the things I love about doing this is seeing the same sites on the streams in different seasons and flow conditions."

This year's dry conditions posed challenges for the Sheldrake Creek monitoring team, leading to several canceled monitoring events. This photo (C) by volunteer, Jody Price, shows the low flow and water level at the mouth of Sheldrake Creek on June 17, 2022. Jody remarked, "It was very early in the summer for the water level to be so low." Fellow Sheldrake Creek volunteer, Chuck Tauck noted, "Sheldrake Creek completely dried up during this year's lengthy dry spell with no noticeable flow at all."

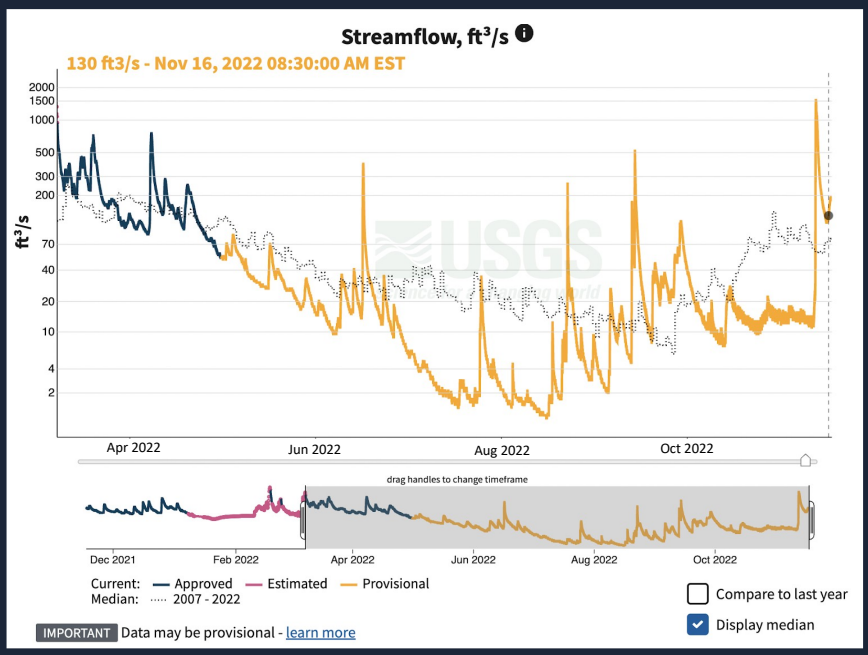

Figure 2. Screenshot of USGS hydrograph depicting streamflow measured in cubic feet per second on Salmon Creek at Ludlowville (42.5526111, -76.5338333) from March 2022 - November 2022. Solid lines refer to stream flow data from 2022 and dotted lines refer to the median stream flow from 2007-2022. Dark blue lines represent approved USGS stream-flow data, while orange line represent provisional data, meaning the data have not yet been reviewed and approved by USGS.

Similarly, our sister organizations on Seneca Lake (Seneca Lake Pure Waters Association) and Keuka Lake (Keuka Lake Association) faced challenges collecting stormwater samples within their watersheds. The only stormwater samples collected in the Cayuga Lake watershed this year were collected by the Canoga, Burroughs, and Williamson Creek monitoring team in Seneca County. The Fall and Virgil Creek team was able to collect water samples this November that fell somewhere between baseflow and stormwater, representing moderate, rather than true stormwater conditions. The only other year in CSI's history when there were so few stormwater events due to dry conditions was 2020, when only three out of the eleven volunteer monitoring teams were able to collect stormwater samples.

Unfortunately, 2022 will likely not be the last year that CSI volunteers have to contend with collecting water samples in dry, drought-like conditions. Global climate change is expected to lead to an increase in both the frequency and intensity of extreme weather events like drought and flooding.[15] Increasing global temperatures interfere with once predictable precipitation patterns and alter the timing and amount of snow accumulation and snow melt.[16] Although drought is a concern, our region is predicted to experience an overall increase in precipitation as a result of climate change.[17] When extreme precipitation events follow dry conditions, there can be cascading consequences on harmful algal blooms (HABs).[18] One of the many contributing factors to HABs formation are nutrients such as phosphorus and nitrogen. During dry years, excess nutrients can accumulate in soils, and, if followed by a wet year, those nutrients are flushed out of the soil, leading to elevated nutrient loads which can impact HABs formation several weeks after the storm event.[18-20] Similarly, drought conditions in 2016 were followed by the first year that community members started reporting significant HABs on Cayuga Lake. In 2021, a particularly wet year, CSI HABs Harriers reported a record number of HABs on Cayuga Lake.[21] In contrast, during this year's dry monitoring season, HABs Harriers spotted less than two thirds the number of blooms that were reported in 2021 (See 2022 Water Bulletin article: "How Does Weather Impact Harmful Algal Blooms?"). This poses the question: After a dry 2022, will we see a spike in HABs in 2023? We will have to rely on our dedicated HABs Harriers volunteers to find out!

When the Clean Water Act was established fifty years ago, not many scientists or legislators were thinking about climate change and how it would impact water quality, and in turn, the way water quality is monitored and regulated (see 2022 Water Bulletin Article: "The Clean Water Act - 50 Year Anniversary"). Many water quality standards in effect today are based on historical data which may no longer be meaningful under a changing climate.[5] This highlights the need for long-term monitoring and data-gathering like we do here at CSI. We rely on our dedicated community scientist volunteers to collect the most current water quality data on our streams to identify pollution and to contribute to the development of water quality standards that may be more appropriate for the emerging era of climate change. Many thanks to the volunteers who committed their time and energy to partnering with CSI in collecting this valuable data and for providing excellent descriptions of the dry creek conditions this year!

- Grascen Shidemantle, *Executive Director*

Journey of Water: Cultivating a Place-Based Sense of the Water Cycle

Through the Community Science Institute, volunteers have spent two decades documenting water quality in streams and lakes in the Cayuga Lake Watershed and throughout the Finger Lakes region. It's probably fair to say that many CSI volunteers are motivated by a sense that water is critical to our quality of life in this region. Through their monitoring work, CSI volunteers understand that our activities on land influence the quality of water in surrounding water bodies.

We wanted to highlight these connections of land and water for local youth through our 4-H20 2022 summer programming, so we adopted "the Journey of Water" as our theme. The Journey of Water series included nine free programs for youth and their families that were designed to give everyone a place-based sense of the water cycle, with opportunities to help monitor water quality along the way. Participants were given a Journey of Water "Passport" which they could get stamped at the end of each program they participated in. Kids who completed the whole passport received a CSI Journey of Water t-shirt.

The program kicked off with a "Build Your Own Water Filter" event where kids and families worked together to make water filters out of repurposed water bottles and natural materials. They then tested their filters by running different kinds of "dirty" water (muddy, salty, and acidic) through them and doing some basic water quality tests on the water before and after running them through the filters. It generated some interesting discussions about how living plants and wetlands in our watersheds do a lot of work toward maintaining good water quality in our streams and lakes.

Biomonitoring coordinator Adrianna Hirtler demonstrating the correct use of a kick net to collect a biomonitoring sample.

We also invited Journey of Water "travelers" to join us for tours of the City of Ithaca Drinking Water and Wastewater Treatment Facilities. At the Drinking Water Plant, our excellent tour guides, Roxy Johnston (Watershed Coordinator and Lab Director) and Alejandro Gonzalez (Assistant Chief Operator), showed us how water is taken from Six Mile Creek, piped to the plant and then journeys through a variety of processes that make it safe to drink when it ultimately comes out of faucets throughout the City of Ithaca. This left some kids thinking that it certainly takes a lot of work to get water "clean" enough to drink once there is any possibility of contamination. At the Wastewater Treatment Facility, we also had an amazing guide in Ed Gottlieb (Industrial Pretreatment Coordinator & Safety Manager) who led us through the processes that water goes through once we flush it down our toilets or when it leeches off of landfills and needs to be treated before it can be released back into the lake. This led some of us to marvel at the remarkable ways that bacteria (just like the myriad bacteria in our own guts and out in the natural environment) do a lot of work to break down and consume some of the "dirtier" parts of "wastewater" so that the water that they release back into the lake won't transmit disease or seriously increase nutrient loading in the lake. These tours should be required for all city residents! We are grateful to both facilities for accommodating our groups.

As in previous years, we also offered our regular suite of three Water Quality Monitoring Cruises on Cayuga Lake in partnership with Discover Cayuga Lake's Floating Classroom and three Biomonitoring Fun! events in partnership with New York State Parks. On the water monitoring cruises, kids get a chance to learn about the lake while helping to collect samples and analyze water quality at a number of different locations on Cayuga Lake, using scientific equipment such as Van Dorn samplers, Secchi disks, plankton nets and microscopes. The results of this monitoring contribute to CSI's long-term data sets and are publicly accessible through the CSI database. At Biomonitoring Fun! events, kids literally get their feet wet exploring four different State Park stream locations as they look for small organisms called benthic macroinvertebrates that tell us a lot about water

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quality. By trying to answer five questions about who they find living under rocks, they decide whether the water quality at each site is good or if the site warrants further investigation. Interested kids and families also help participate in collecting full biomonitoring samples at the end of each event that are analyzed by volunteers at Open Lab Nights over the winter (which kids and their families are also invited to join).

CSI's 4-H20 program grew out of a parent-led 4-H club that wanted to focus on water quality monitoring, working within CSI's existing volunteer monitoring structure. In recent years, with the specific families that had been involved aging out of the program, CSI has rejuvenated 4-H20 as more of a program-based offering in partnership with Tompkins County 4-H. For the past three years, the Park Foundation has helped fund this programming so that we can offer it free to all. The Journey of Water series this summer felt like a big success, coming out of the uncertainties and low program attendance of peak Covid times, with lots of interest expressed by folks who were new to our 4-H2O program. Even for CSI staff, the process of participating in all of these events that followed and highlighted water's journeys throughout our lives felt like an important summer ritual that we hope to be able to offer again in the future.

- Adrianna Hirtler, *Biomonitoring Coordinator*

How Does Weather Impact Harmful Algal Blooms?

Community Science Institute and our dedicated HABs Harriers* have now completed five years of monitoring cyanobacteria blooms, also known as Harmful Algal Blooms (HABs), along the shoreline of Cayuga Lake (See Box 1 for details and background on the program). Since the start of the program, the number of blooms reported to CSI has consistently increased.[21] This year, for the first time, we have instead seen this number *decrease* (Fig. 1).

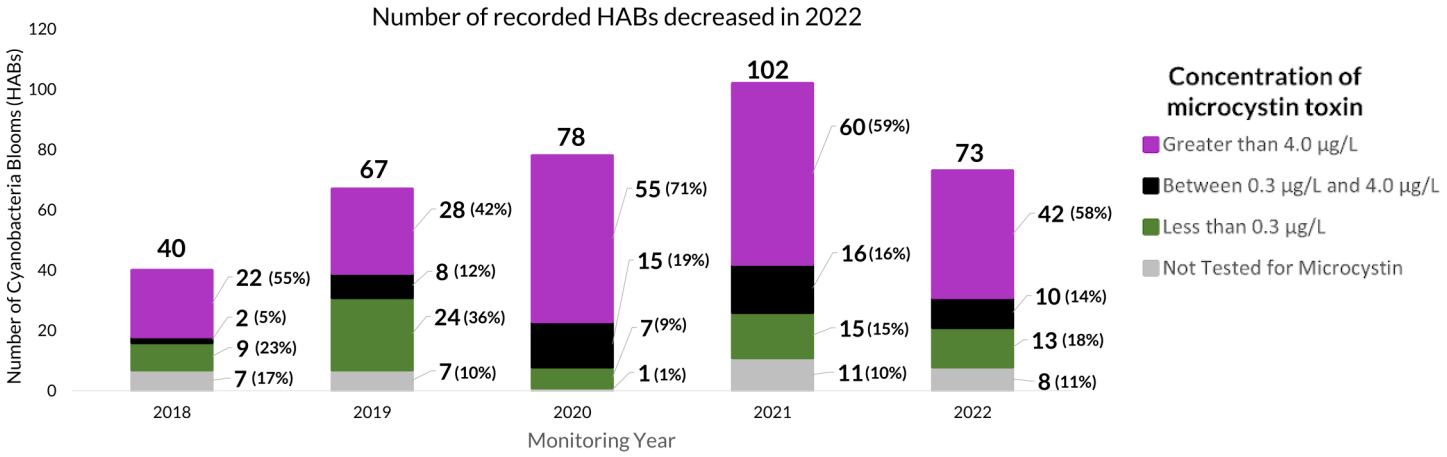

Figure 1 Number of harmful algal blooms on Cayuga Lake reported through our Cayuga Lake Harmful Algal Bloom Monitoring Program annually from 2018-2022. Note the different colors within each bar which correspond to different concentrations of microcystin toxin.

One of the most common questions we are asked at Community Science Institute is "what causes HABs?" The scientific literature on HABs implicates various, interacting factors in cyanobacteria bloom formation, including nutrient runoff, higher temperatures, and decreased mixing of lake layers due to low wind speeds or extended summers.[22] Increased precipitation has also been linked to bloom formation.[23] Given this context, it is interesting that the summer of 2022 was drier than recent years (see 2022 Water Bulletin article: "The Not-So-Apparent Implications of Drought") and also saw the first decrease in the number of blooms reported on Cayuga Lake since the onset of our program. However, any conclusions based on this correlation alone are merely speculation; collecting long-term, reliable data, like we do in our HABs monitoring program, is valuable because it allows us to observe and analyze trends over longer periods of time. While some patterns in HAB formation on Cayuga Lake are becoming clear (See Box 2), some trends, such as the impact of weather, are not as straightforward. Our case study demonstrates the complex relationship between weather and bloom formation on Cayuga Lake.

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**Harrier*: noun, from the verb harry, to harass or attack repeatedly. Example: A Harrier Hawk attacks small game. This term was applied to our HABs volunteers to describe their vigilance.

Box 1: How exactly does CSI's "HABs Harrier" program work?

Community Science Institute currently has a team of 88 volunteers, or "HAB Harriers," who monitor Cayuga Lake for harmful algal blooms (HABs). This comprehensive program, a collaboration between CSI, Cayuga Lake Watershed Network, and Discover Cayuga Lake, integrates community engagement with rigorous science. Our Harriers, most of them concerned community members, survey sections of the shoreline weekly for blooms. Blooms can look like parallel streaks, green clumps, spilled paint, or even pea soup. These cues signal to our harriers that explosive growth of cyanobacteria is taking place. Cyanobacteria are always present in the water, but usually at concentrations too low to be visible. They can produce various chemical compounds, which may be beneficial or harmful to humans.[24] In Cayuga Lake blooms, the cyanobacteria we see most commonly belong to the genera *Microcystis* and *Dolichospermum*. Once our volunteers observe a bloom, they collect a sample and bring it to CSI's laboratory. There, we confirm blooms by checking to see if and what kind of cyanobacteria are present. Approximately 94% of samples collected by volunteers in 2022 contained cyanobacteria. We also test the samples for chlorophyll *a* concentration (to estimate bloom density) and microcystin toxin concentration (to estimate bloom toxicity). Microcystin is the only toxin for which we test, but microcystin toxin levels are not necessarily predictive of concentrations of other toxins.

Case Study: King Ferry Blooms, 2019-2022

To begin looking at ways in which weather impacts HABs, we analyzed HAB trends over four years (2019-2022), concentrating on blooms reported just south of King Ferry, NY. This included HAB Harrier zones 3416, 3460, 3478, and 3492 and spanned Lake Ridge Point to Elmwood Point. This area was chosen for several reasons. First, there is a weather station near the shoreline of the Lake (KNYKINGF5, accessed via: www.wunderground.com) with data on wind speed, temperature, and precipitation going back to 2019 (no 2018 weather data were available). This area of shoreline also has broad volunteer coverage dating back through the beginning of our HAB monitoring program, giving us more certainty that the majority of blooms that occurred there were reported to us. Finally, this area had 18 blooms reported over the past four years, a large enough sample size to hopefully detect some patterns. In this case study, we compared the weather at the station on days when our volunteers reported blooms to days when they did not report blooms. On days when blooms were not reported, wind speeds tended to be higher than on days when blooms were reported (Fig. 2). No relationship was found between bloom observations (whether a bloom was observed or not) and temperature or precipitation on the same day as a bloom.

Our consideration of the presence or absence of bloom reports and weather data on any particular day of the 2019-2022 bloom seasons suggest that wind can impact a bloom's visibility. The windier a day is, the less likely a bloom is to be reported. This idea is consistent with anecdotal reports from our volunteers, who often observe that a bloom disappears quickly on a windy day. Scientific literature similarly demonstrates that higher wind speeds on a lake can be linked to smaller bloom extents on the surface of the water.[25]

Our exploration of the King Ferry HAB reports and weather data is one preliminary attempt to look at connections between weather and HABs on Cayuga Lake. This investigation did not take into account water temperature and only addressed air temperature and precipitation on the same day that the bloom occurred. Further, previously published work links precipitation and temperature with bloom formation over the course of days or weeks leading up to the bloom event, rather than the day of the bloom.[18, 23] This may explain

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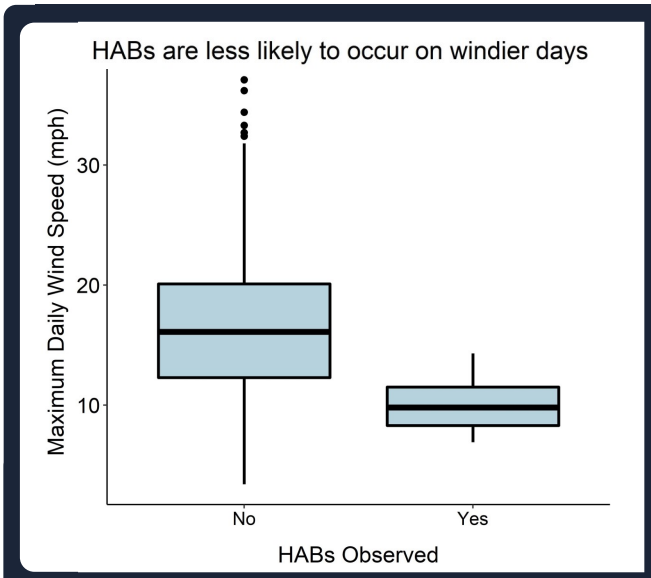

Figure 1 Maximum daily wind speed in King Ferry from 2019-2022 on days on which no blooms were observed vs. days on which blooms were observed. The boxes represent 50% of the data with the center line of each box demonstrating the median. Lines extending above and below the boxes represent the spread of the data, while dots depict outliers.

Box 2: Consistent trends 2018 - 2022

Some trends noted in previous years persisted in 2022. For example, blooms in the northern fifth of the lake tended to be more numerous and have higher microcystin toxin concentrations compared to blooms at the south end of the lake. While nutrients generally favor HABs formation, and northern tributary streams are known to transport significantly higher concentrations of bioavailable phosphorus and nitrogen compared to tributaries at the south end of the lake,[26] it is not clear that elevated nutrients are the cause of northern shoreline HABs. Consistently denser populations of cyanobacteria in the genus *Microcystis* (even when blooms are not occurring) have been documented in the northern end of Cayuga Lake,[27] and the lake is shallower on the north end, making it generally warmer. Either of these factors could also contribute to this observed pattern of higher microcystin concentrations being found in the northern end of Cayuga Lake.

As in previous monitoring seasons, in 2022 microcystin toxin concentration was correlated with total chlorophyll *a* concentration (Fig. 3) in blooms dominated by *Microcystis* sp. In contrast, we do not observe this same relationship between chlorophyll *a* and microcystin in blooms dominated by *Dolichospermum*, another cyanobacteria genus. Chlorophyll *a* concentration reflects the biomass of a bloom, while microcystin levels are one measure of a bloom's toxicity. Therefore, in *Microcystis*-dominated blooms, as biomass (or bloom density) increases, so too does the bloom's toxicity, whereas in blooms dominated by other cyanobacteria genera, there is no relationship between bloom biomass and toxicity. There are important caveats to this relationship, however. For example, chlorophyll *a* is present in all phytoplankton, not only cyanobacteria;[28] thus, chlorophyll *a* concentration may overestimate a bloom's biomass if other phytoplankton are present. Further, microcystin is not the only toxin that can be produced by cyanobacteria so there may be other toxins contributing to a bloom's toxicity that we are not capturing in our laboratory analyses.[29] CSI's lab analyzes bloom samples for microcystin concentration because microcystin is a common cyanotoxin with a relatively slow rate of degradation and the only one for which there is currently an ELAP-certified test. Microcystin is also the most commonly found cyanotoxin in New York State.[30]

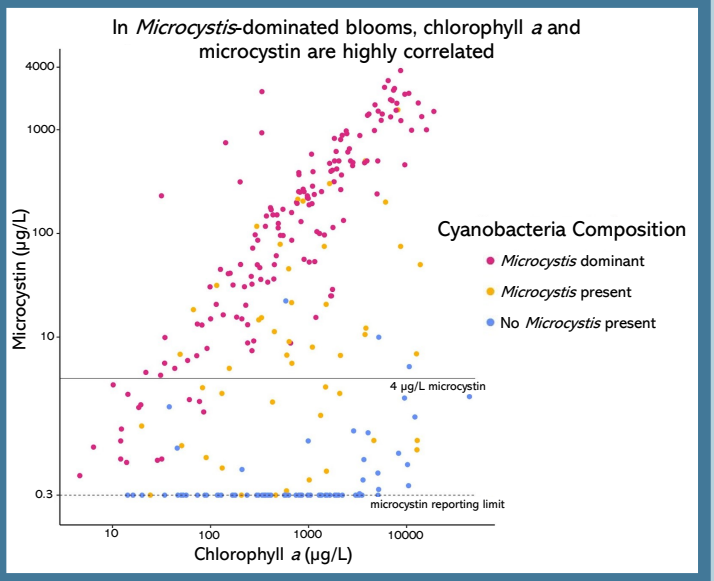

Figure 3. Relationship between chlorophyll *a* concentration and microcystin concentration in bloom samples collected from Cayuga Lake with data pooled from CSI HAB data 2018-2022. Color shows cyanobacteria composition: *Microcystis*-dominant blooms are shown in red, blooms with *Microcystis* sp. present but not dominant are in yellow, and blooms with no *Microcystis* sp. are in blue. Both axes use a logarithmic scale. The solid line denotes 4 µg/L of microcystin, or the contact recreation limit set by NYSDOH. The dotted black line denotes 0.3 µg/L, the CSI laboratory reporting limit and the drinking water limit set by NYSDOH for microcystin.

why precipitation on the day of the reported bloom was not associated with whether or not a bloom was observed. Finally, matching weather data to the bloom events observed by our volunteers is difficult because the weather conditions pulled from the weather station in King Ferry may not align precisely with the weather occurring in the exact location of a bloom. Recording weather conditions and water temperature at the time a bloom sample is collected would be preferable to pulling them from weather stations retroactively.

Exploring the impacts of weather on HAB formation and composition is an exciting area of research. It is especially interesting to consider the variability in how weather may impact HAB formation at different locations on Cayuga Lake as there may be geographical features that impact susceptibility to changes in wind, precipitation, and air temperature. The decrease in the number of lakeside blooms reported across all of Cayuga Lake in 2022 may be connected to the lack of precipitation experienced this year. However, our case study on blooms in King Ferry also showed that wind was a relevant factor in that region. To more definitively identify patterns in HABs formation, we need more years of data that reflect varying weather conditions. This is what makes broadly-collected, long-term data so important to scientific inquiry. With more Cayuga Lake shoreline coverage and additional years of data with our volunteer partners, effects of weather on HABs formation, as well as other factors such as bloom composition and characteristics, may come into clearer view.

- Grace Haynes, *Outreach & Programs Coordinator, Cayuga Lake HABs Monitoring Program Coordinator*

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This 2022 issue of the Water Bulletin highlights the capability of Community Science Institute (CSI) to help tackle these issues by supporting community-based efforts to understand water quality issues of local concern including *E.coli* contamination of public swimming areas, communicating fast and accurate HABs data necessary for people to make safe decisions, and helping develop regional water quality protection plans such as the Seneca-Keuka Nine Element Plan through the collection of regulatory-quality data. It highlights CSI's unique capabilities as a certified water testing laboratory that supports the work of over two hundred and fifty volunteers, to help connect community, science, and management so that we can protect our shared water resources.

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