CLWA 2024-2025 SCIENCE REPORT
2024: A BLUE-GREEN YEAR FOR CANANDAIGUA LAKE

BY EMMA REED, PHD

Emma Reed is a Canandaigua-born climate scientist and a lifelong aficionado of the lake, and joined the CLWA Citizen Science committee in 2024. She received her PhD and MS in Geosciences from the University of Arizona, researching tropical Pacific climate variability and change with support from the National Science Foundation and co-authoring seven papers to date. Prior to that, received her BA in Earth Sciences from Cornell University. She now works as a researcher in the insurance industry, modeling changing natural catastrophe risk.

2024 marked the 7th year of the CLWA's cyanobacterial harmful algal bloom (cHAB) monitoring program. It was our most severe bloom season to date, but our 77 volunteers rose to the challenge, submitting 917 monitoring reports, which included 281 confirmed and 44 suspicious blooms. Our volunteers reported the earliest confirmed bloom (6/20) and the latest (11/17), and the longest consecutive streak of bloom days (14 days, from September 10th through September 23rd). These reports kept the watershed community apprised of lake-wide conditions and contributed to long-term scientific research efforts.

Cyanobacterial Harmful Algal Blooms & Canandaigua Lake

Cyanobacteria are microscopic organisms that are ubiquitous in lakes and oceans. Though they are sometimes called "blue-green algae," and photosynthesize like algae, they are technically bacteria. Favorable environmental conditions–including high nutrient availability and calm, sunny, and warm water–can promote rapid growth of cyanobacteria populations. Cyanobacteria colonies often aggregate at or near the water surface, and are visible as green paint-like streaks or pea-soup-like discoloration that are the telltale signs of a cHAB.

The first confirmed cHAB in Canandaigua Lake occurred in 2015, and blooms have been documented annually since. Blooms have occurred anytime from June to November, though cHABs are most common in August and September, when lake temperatures are warmest.

Though several types of cyanobacteria can form cHABs in Canandaigua Lake, the genus *Microcystis* is especially important for our monitoring efforts. *Microcystis* blooms produce a class of toxins known as microcystins, which can cause respiratory symptoms upon inhalation, skin and eye irritation with physical contact, and gastrointestinal issues and liver damage if consumed. These toxins have been known to kill wild animals and pets, and present water treatment challenges to remove from drinking water since they are not destroyed by boiling. For these reasons, cHABs are a significant public health concern.

CLWA cHABs Monitoring Program

Instituted in 2018, our volunteer monitoring program has kept the lake community informed of cHAB conditions. We train our volunteers in a state-approved protocol to monitor and report cHABs. These volunteers provide "eyes on the lake", reporting bloom presence/absence weekly (or daily if blooms are spotted) during peak season. The 2024 program ran from Friday, July 19th through Thursday, October 3rd. Volunteers also take photos of any suspected blooms, which are then submitted to the DEC for verification. Some of our volunteers are also trained to collect water samples of suspected cHABs, which are then measured for chlorophyll and/or the toxin microcystin to determine if it meets bloom criteria.

Since its inception, the cHABs monitoring program has expanded rapidly. As a result, though 2024 was a record-breaking bloom year for Canandaigua Lake, our program broke records of its own. The 2024 program comprised 77 volunteers–the largest number of participants yet. With more volunteers, our data pool has expanded significantly: in 2024, our volunteers submitted 917 bloom/no bloom reports, over 400 more than the previous year. The number of confirmed/suspicious bloom reports notably increased as well: 2024 saw 281 confirmed and 44 suspicious bloom reports, more than triple that of any previous year.

2024 cHABs, Continued from page 9

	2018	2019	2020	2021	2022	2023	2024
# Volunteers	16	26	42	70	64	67	77
# Reports	218	295	375	561	404	497	917
# Confirmed Blooms	54	65	79	80	33	77	281

2024: A Record-Breaking Bloom Year
These bloom/no bloom reports appraise the watershed community of lake-wide conditions during the summer months. We disseminate these reports widely, including near-real-time maps on the CLWA website, weekly water quality updates, public beach signage, social media posts, and communication with neighborhood organizations. We also provide this information to beach operators and water purveyors to facilitate safe operations. The data is also shared with the Canandaigua Lake Watershed Council (our local inter-municipal watershed organization) and the NYS Department of Environmental Conservation (DEC), contributing to the long-term research efforts on the lake.

In 2024, blooms did not wait for the official monitoring season to begin: the first cHAB of the season was reported on June 20th, after two days of heavy rain. This bloom–confirmed via chlorophyll measurement by our partners at the Finger Lakes Institute–was short-lived, but is the earliest confirmed Canandaigua Lake cHAB to date.

Nonetheless, the early summer was fairly normal, with no confirmed blooms in early to mid July. Sporadic blooms were reported in late July and early August, particularly after Debby brought 3-5.5 inches of rainfall to the region, but cooler and windier weather generally kept blooms in check until late August.

Conditions deteriorated quickly in late August, with lake-wide blooms reported by the 27th. Blooms sampled during this week showed microcystin toxin levels ranging from 24 to 700 µg/L, substantially higher than the DEC limit for recreational water (8 µg/L).

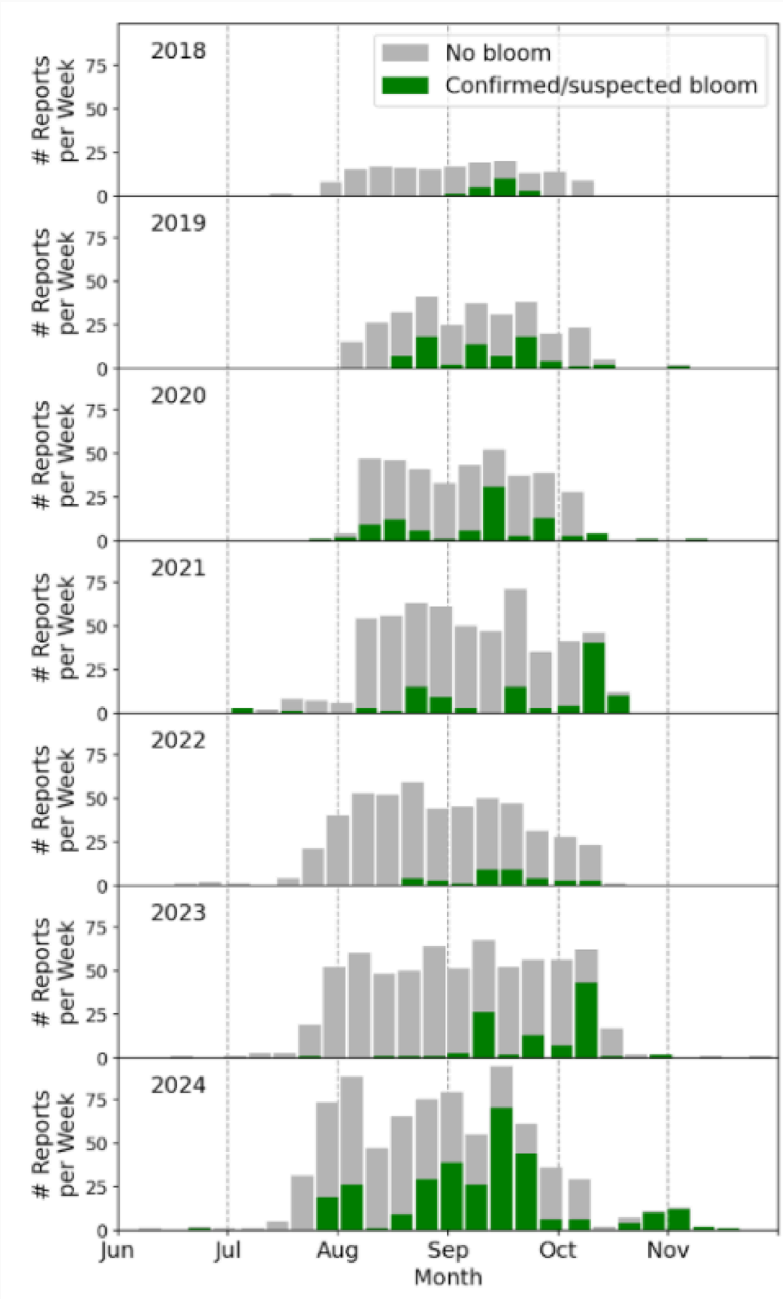
Widespread blooms persisted through Labor Day and well into September. During two of these weeks, volunteers from every sector of the lake reported at least one bloom. Volunteers also reported an unprecedented 14 consecutive days of cHABs from September 10th through the 23rd – the longest continuous bloom activity the CLWA monitoring program has ever recorded. However, by late September, bloom reports were mainly constrained to the north end of the lake. Bloom reports continued sporadically even after the monitoring program officially concluded on October 3rd. The last suspicious bloom was reported on November 17th, the latest in the season we have ever seen.

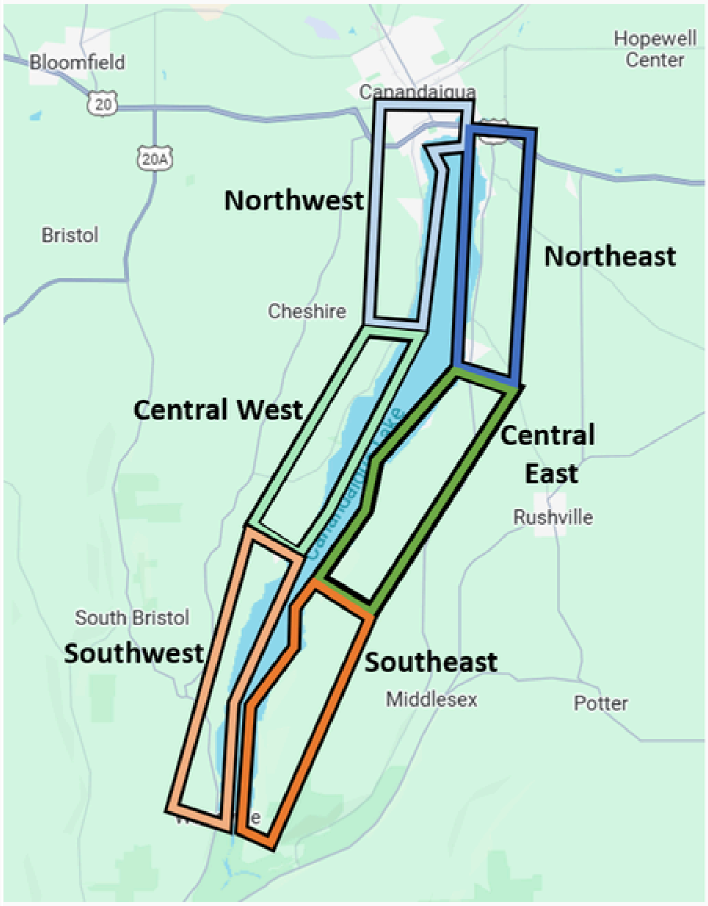
We can place the 2024 season into historical context by looking at weekly bloom reports for each year of the CLWA cHABs reporting system. Each panel shows the bloom months for a given year. Within each panel, the gray bars denote the total number of volunteer reports–bloom or no bloom–for each week. The green bars show the total number of reported blooms that were categorized as either “confirmed” by independent sources, such as the DEC or Finger Lakes Institute, or “suspicious”, which were likely blooms but unable to be independently confirmed.

We can see how the total numbers of reports have skyrocketed over the years. These increases are a testament to our growing team–more than quadruple the number of volunteers in 2024 compared to 2018. Indeed, 2024 is remarkable for the record-breaking volume of bloom/no bloom reports submitted, and for the number of confirmed bloom reports, more than triple that of any previous year. This truly impressive amount of data reflects the dedicated efforts of our volunteers, and has ultimately kept our lake community informed during this busy bloom season.

It is important to note that more confirmed bloom reports does not necessarily translate to more blooms. For example, volunteers can submit multiple reports in a given week, so some blooms can be over-reported, and volunteers are more heavily concentrated on the bloom-prone northern end of the lake, so southern blooms may be underreported. Nonetheless, these reports show the unusual length of this year's bloom season–from late June to mid-November. We also see that 2024's early-season bloom in late July and early August was exceptional (though with the caveat that our official reporting season used to begin in late July). Taken together, these reports also show how rarely Canandaigua Lake experiences any completely bloom-free weeks between late August and early October–and that bloom season was much longer than in 2018, when our program began.

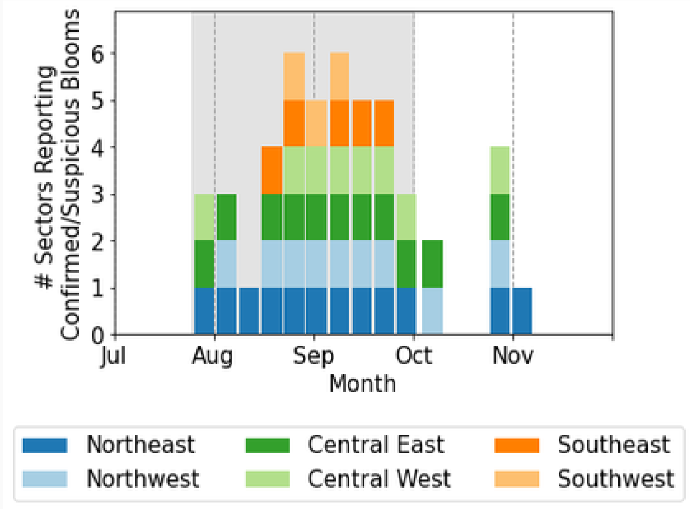
Our volunteer reports also reveal which parts of the lake are more susceptible to blooms. Again, the caveat here is that more volunteers are situated on the northern end and therefore blooms in the central/southern areas are less likely to be reported. Nonetheless, these reports show the widespread nature of the blooms in late August and September. For multiple weeks, these blooms were truly lake-wide, with at least one report during a given week from all six monitoring regions. Outside of the main bloom season, however, the southern end of the lake rarely reports cHABs. In contrast, the northern and central eastern portion of the lakes report longer bloom seasons, extending from July into late October/early November. Because the northern end is shallower, and prevailing westerly winds generally push blooms eastward, the north/central eastern areas appear to be especially prone to blooms.





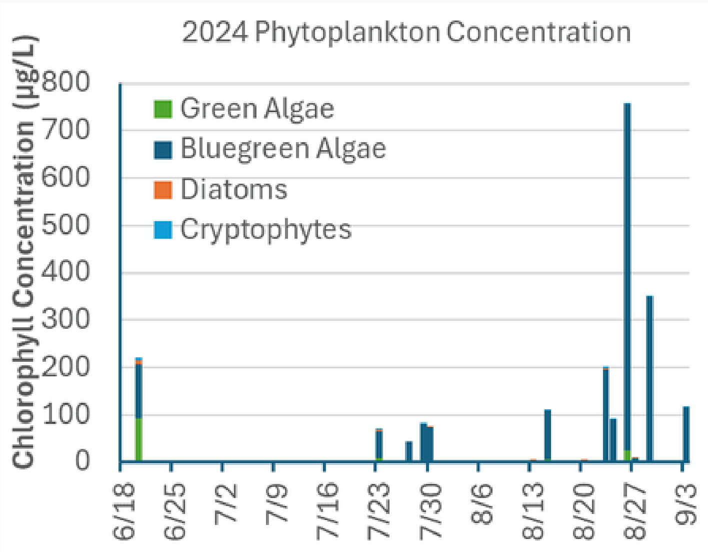
2024 cHABs, Continued from page 11

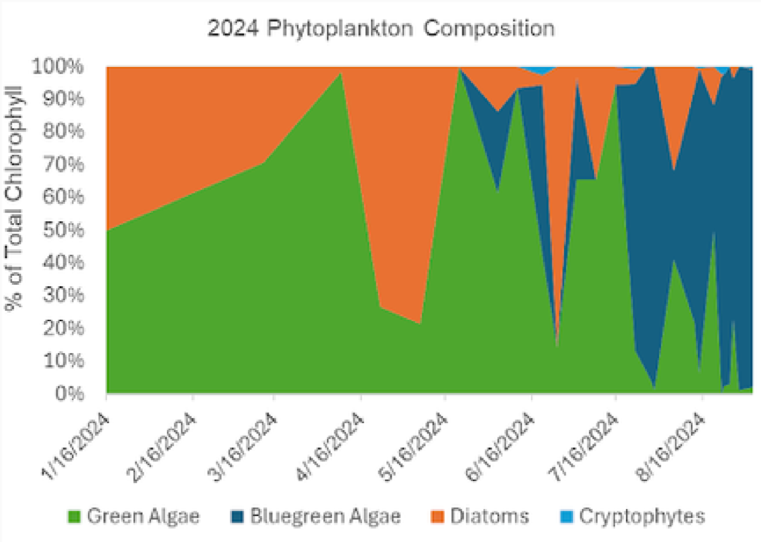
Plot to the side: The number of sectors of the lake (colored according to the map at right) reporting at least 1 confirmed/suspicious bloom during any given week in 2024. Gray shading denotes the official CLWA cHABs reporting season, from 7/21 through September. Only weeks when all regions are submitting bloom/no bloom reports are included.



As part of our collaboration with SUNY College of Environmental Science and Forestry (ESF), water samples were also regularly collected from all six lake sectors and, when possible, directly from cyanoHABs.

BoChlorophyll concentrations, measured from these samples with a device called a fluoroprobe, allow us to track what fraction of the lake's phytoplankton comprises green algae, cyanobacteria, or other plankton (such as diatoms). Data from 2023 and 2024 both show that Canandaigua Lake's phytoplankton composition shifted seasonally: green algae and diatoms were most common in spring and early summer, but cyanobacteria were generally predominant afterward. What's more, samples from active algae blooms were overwhelmingly composed of toxin-producing cyanobacteria.





Above: Left: Chlorophyll concentrations averaged across sites for each date from ESF samples Right: Percentage of total chlorophyll levels comprising each type of phytoplankton.

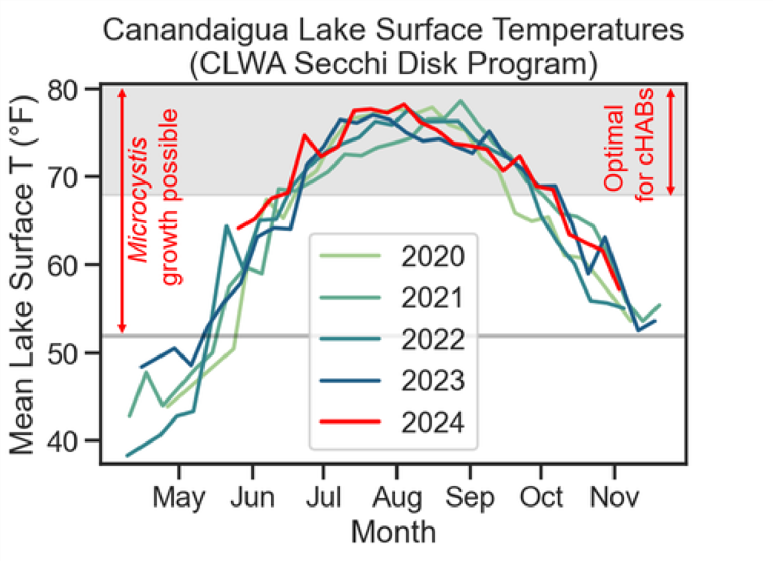
Beyond Canandaigua Lake, 2024 was a record-breaking cHAB season for many lakes in the northeast US. Every Finger Lake except Canadice reported widespread blooms (since Canadice and its watershed are undeveloped, blooms are less likely to be observed). Seneca, Cayuga, and Skaneateles Lakes, like Canandaigua, each had over 100 reported cHABs. Even Lake Superior–the deepest and coldest of the Great Lakes–experienced blooms. The research on the increasing frequency and severity of these blooms is still evolving, but we know that climate change, stormwater runoff/nutrient input, and ecological factors (such as quagga and zebra mussels) can contribute. Let's take a deeper look at some of those contributors.

What Drives cHAB Trends? What we know, and what we're still learning:

CyanoHABs require a combination of environmental and biological conditions in order to form:

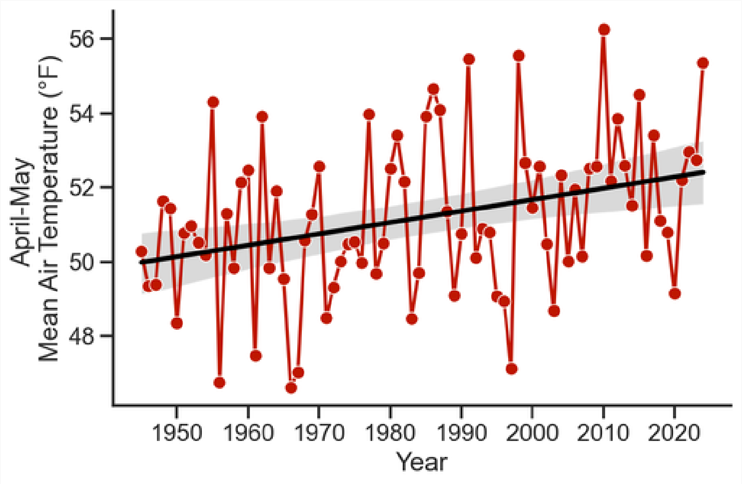
A longer, hotter warm season promotes cHAB growth.

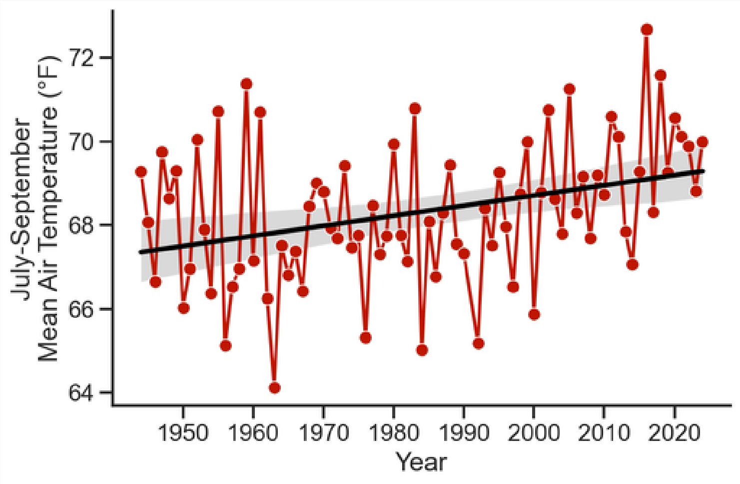
In general, warm, sunny, and calm conditions promote the formation of cyanoHABs, and many of these criteria have become more favorable for blooms in recent years. With regards to temperature, the toxin-producing Microcystis cyanobacteria can begin growing and reproducing when water temperatures reach about 52°F, but reaches optimum growth between 68 and 86°F. Studies suggest that higher average summer temperatures can increase total phytoplankton abundance, while the length of the warm season (mainly due to warmer spring temperatures and selective feeding by zebra and quagga mussels) can increase the proportion of cyanobacteria relative to other phytoplankton. Since 2020, the CLWA Secchi disk program has measured lake surface temperatures from late spring through fall. These measurements show that Canandaigua Lake tends to reach the 68°F growth threshold by late June, and stays within that range for an average of 16 weeks until late September/early October, coinciding with peak bloom season. In 2024, lake temperatures surpassed 68°F by mid-June, peaked in July (fairly early compared to previous years), and stayed above this threshold for 18 weeks. This prolonged warmth likely contributed to the unusual length of this year's bloom season.



To the right: Weekly lake surface temperatures averaged across CLWA Secchi disk program sites for each year of the monitoring period (2020-2024). Microcystis growth becomes possible above approximately 52°F (gray line), but is optimal between 68 and 86°F (gray shading).

This begs the question of how climate change influences cHAB frequency and intensity. Unfortunately, our records of lake temperatures do not span the 30+ years we need for a robust trend analysis. Fortunately, because lake temperatures ultimately depend on the temperature of the overlying air, we can look for trends in nearby long air temperature datasets. The water treatment plant on West Lake Road has collected weather observations since 1946. Though its measurement methods have changed slightly over the decades, a strong warming trend is nonetheless visible: spring and summer mean air temperatures have both warmed by about 2°F since the early 1950s. Together, these trends indicate that the length and the intensity of the warm season have increased in recent decades. These results align with region-wide trends, and are expected to continue: the NYS Department of Environmental Conservation (DEC) climate projections for western NY anticipate a 4-6°F increase in annual average temperatures by the 2050s compared to a historical baseline (1971-2000).





2024 cHABs, Continued from page 13

Charts on P13: Historical Canandaigua Water Treatment Plant mean air temperatures during spring (April-May) and summer (July-September), with linear trend (+/- 95% confidence intervals, shaded).

More extreme storms increase nutrient loads

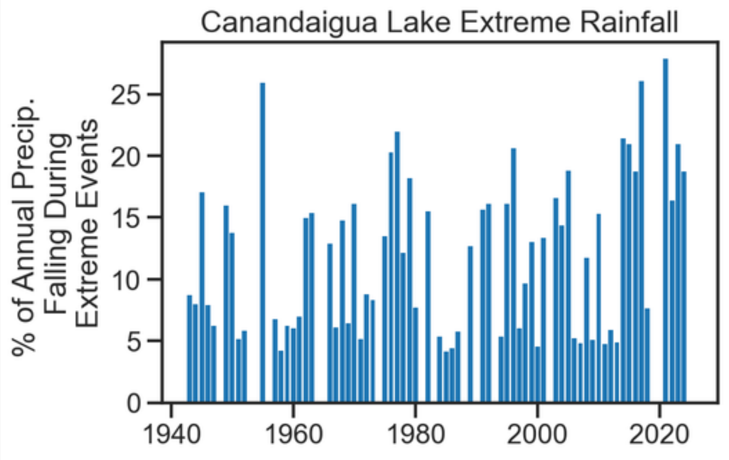
Like other photosynthesizing organisms, cyanobacteria require nutrients, especially nitrogen and phosphorus, to grow. The ratio of nitrogen to phosphorus can influence what types of phytoplankton are most prevalent, as well as the toxin production within individual species. Canandaigua Lake is considered an "oligo-mesotrophic" lake, with generally low phosphorus and nitrogen concentrations. However, nitrogen is plentiful enough to make phosphorus the main limiting nutrient for cyanobacterial growth in Canandaigua Lake. Our partners at SUNY ESF, the Finger Lakes Institute (FLI) at Hobart and William Smith Colleges, and Global Aquatic Research are currently investigating the role of nitrogen and phosphorus as cHAB triggers in Canandaigua Lake, but studies of multiple Finger Lakes show that total phosphorus is strongly correlated with chlorophyll-A concentrations.

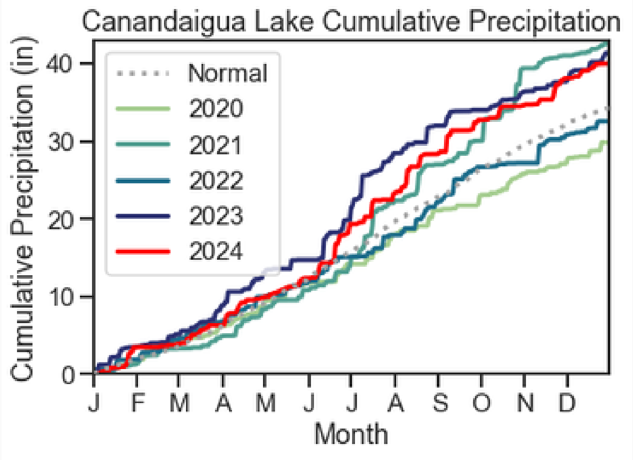
Both nitrogen and phosphorus commonly enter the lake from agricultural and residential properties via sewage, fertilizer and manure. Roughly ⅓ of the Canandaigua Lake watershed is used for agriculture. Fertilizer from row crops and manure from dairy farms can enter waterways during storm events and increase nitrogen and phosphorus concentrations in the lake. Residential fertilizer and stormwater/septic discharge can also contribute to lake nutrient levels. Though the watershed has seen substantial residential development in recent years, DEC and local regulations are in place for new residential/commercial development to reduce nutrient discharge into the lake.

Extreme rainfall can increase runoff and resulting nutrient input to the lake, which can ultimately fuel cyanobacterial growth. Precipitation data from the Canandaigua water treatment station shows that 2024 was unusually wet in terms of both total and extreme precipitation. Total precipitation was 16% higher than normal (where "normal" is the average over 1981-2010). For comparison, 2021 and 2023–both severe bloom years–were similarly wet, whereas 2020 and 2022 (which saw comparatively few blooms) were drier than normal. These totals were driven partly by several extreme rainfall events between June and September, including major named storms such as Beryl and Debby.

In recent decades, extreme rainfall has also become more intense and frequent. During 1950-1980, an average of 1.5 extreme events occurred each year (where we define an extreme event as the top 1% of daily precipitation totals), and those events accounted for 9% of annual total precipitation. Since 2010, however, 2.7 events have occurred on average each year, contributing 14% of annual total precipitation. 2024 was even higher: 19% of last year's total rainfall fell during four extreme events.

Since warmer air can hold more water vapor, climate models project these rainfall trends to continue. For the northeast US, total annual precipitation is expected to increase about 5% by mid-century compared to 1981-2010 and extreme rainfall (defined as the annual maximum daily precipitation) is expected to become 5-10% more intense by mid-century. The corresponding increase in runoff can potentially further increase phosphorus and nitrogen input to the lake, providing additional fuel for cyanobacteria blooms.





Charts on P14: Canandaigua Water Treatment Plant precipitation. Left: the percentage of annual precipitation contributed by extreme events, where an extreme event is defined by the 99th percentile of daily precipitation during the 1981-2010 period. Right: cumulative precipitation for 2024 (red) compared to recent years (blues). The climatological average cumulative rainfall (1981-2010) is shown by the dotted gray line.

Ecological changes can promote cyanobacterial blooms

Changes in the Canandaigua Lake ecosystem in recent decades can also worsen cHABs. The "state of the science" is discussed in more detail at this link: canandaigualakeassoc.org/wp-content/uploads/2020/07/HABS-Newsletter-Article.pdf, but to summarize, many invasive species, like starry stonewort and zebra/quagga mussels, can potentially increase nutrient availability to fuel blooms. In addition, zebra and quagga mussels are filter feeders, consuming microscopic plankton–including green algae. However, these mussels selectively reject most cyanobacteria, allowing them to proliferate and decrease competition for nutrients from green algae by depleting their populations during late summer. At the same time, filter feeding can increase water clarity, which in turn increases the availability of sunlight for cyanobacteria to photosynthesize.

What can we do?

- Continue to stay informed about cHABs and how to safeguard your family's health, as well as your friends and neighbors. Pets too. If you or your neighbors are not signed up for the free bloom alerts that are sent out by the CLWA and our watershed partners, consider signing up at canandaigualakeassoc.org.
- Communicate your concerns with your elected officials and support the efforts of local cities, towns and villages who are working to restore wetlands and natural stormwater management systems, such as stream buffers and diverting fast moving water into fields and upland settlement ponds. These efforts are aimed at reducing the speed of stormwater runoff and nutrient flow into the lake. Working with the Canandaigua Lake Watershed Council, our local officials are actively applying for and securing important grants to assist them with their efforts. Public-private partnerships are also key, as are private-private partnerships. What happens upland matters.
- Practice Lake Friendly Living: canandaigualakeassoc.org/education-outreach/lake-friendly-living
    - Practice lake-friendly lawn care by saying no to harmful chemicals and excess fertilizers
    - Manage runoff on your own property by adding "dry wells," rain barrels or rain gardens
    - Maintain septic systems
    - Reduce the size of your lawn and plant native species
    - Keep organic materials (leaves, mulch, debris) out of streams/roadside ditches, and pick up pet waste
    - Reduce household hazardous waste
    - Avoid flushing medications
    - Take your vehicle to a car wash instead of cleaning it in your driveway
    - Identify and report terrestrial invasive species

Consider volunteering. We have one of the most respected and active citizen science programs in the country. Volunteers are provided with training, ongoing support, and a ready-made community of informed colleagues. The importance of citizen scientists cannot be overstated. The data they collect is instrumental to the ongoing protection of our watershed. If you might be interested, please reach out (canandaigualakeassoc.org/get-involved/volunteer).