

# LAKE WALLENPAUPACK

## WATER QUALITY IN ACTION

A COMMUNITY-LED MONITORING PROGRAM

2019 - 2024 UPDATE

POCONO LAKE ECOLOGICAL OBSERVATORY NETWORK – LACAWAC SANCTUARY



## PLEON: MONITORING LAKE ECOSYSTEMS IN A CHANGING WORLD

Lakes are the economic backbone of tourism in the Pocono region. They provide both recreational enjoyment and critical wildlife habitat. Lakes are also some of the world’s most vulnerable ecosystems, often acting as sentinels of climate change and other human impacts. The Pocono Lake Ecological Observatory Network, or PLEON, is a lake stewardship program focused on educating the public on water quality and lake management. PLEON is based at Lacawac Sanctuary & Biological Field Station. Our mission is to:

*Empower the public to better understand and manage their freshwaters*

*Create a community of scientists, students, educators, and landowners working to preserve Pennsylvania’s lakes*

*Collect and communicate ecological data that help inform responsible lake management*

## PLEON’S WATER QUALITY IN ACTION PROGRAM: GENERATING DATA AND CREATING PARTNERSHIPS BETWEEN SCIENTISTS AND THE COMMUNITIES THEY SERVE

### WHY COMMUNITY SCIENCE?

PLEON’s hands-on, community-led water quality monitoring program connects scientists who study lakes with the communities who live on and enjoy lakes. Too often, these two groups are isolated from each other; scientists can struggle to communicate effectively with non-scientists while lake communities can feel as though scientific data are inaccessible and unintelligible to “regular” people. This disconnect can have real consequences for lake communities facing emerging management challenges.

We believe that these groups have much to learn from each other during this time of rapid environmental change. Members of lake communities are often the first to notice changes in water quality and lake scientists have the training and expertise to interpret water quality data and place them in a larger context. Working together, these groups can advance our understanding of effective lake management and preservation.

### HOW THE PROGRAM WORKS

The PLEON Water Quality in Action program has three stages (Figure 1). First, participants are trained to properly measure several water quality variables and collect water samples.

Next, participants receive a kit containing all of the equipment needed for the sampling program. They choose a location from which to collect data, such as a dock or moored boat, and collect data through the summer according to a standardized schedule.

Finally, PLEON scientists summarize the data and communicate the results and their implications to program participants and the larger community. This vital part of the program connects the conceptual learning that occurs in the trainings to the data gathering component with the goal of equipping participants to become change-makers in their communities.



Figure 1: Components of the Water Quality in Action program.

## THE LAKE WALLENPAUPACK PROGRAM

### THE LAKE

Lake Wallenpaupack is an impoundment created in 1926 for hydroelectric power. It is the 3<sup>rd</sup> largest lake in Pennsylvania and a major source of tourism and recreation in the region. Wallenpaupack has 5,700 acres of open water, a length of 13 miles, 52 miles of largely residentially developed shoreline, and a 219 square mile watershed.

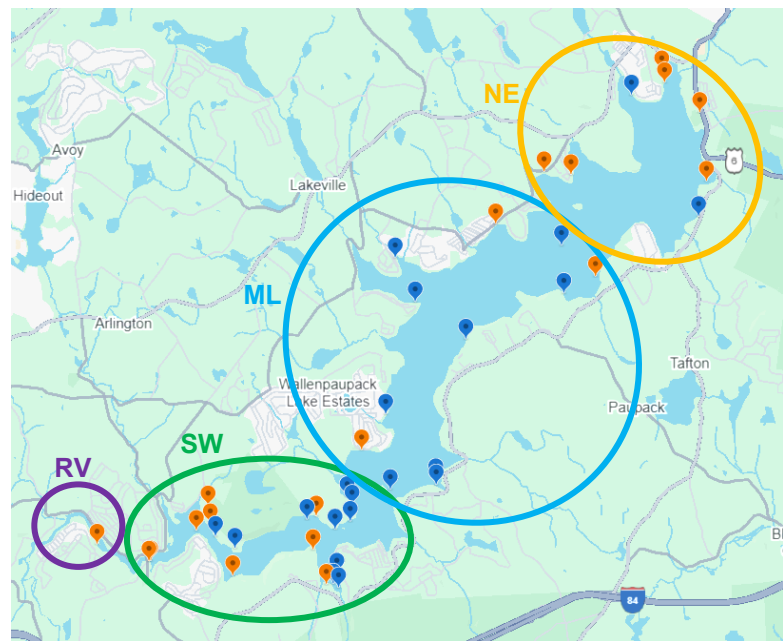
Working together, participants collect data from many locations many times over the summer, capturing water quality dynamics over space and time. These data can then be used to identify pristine or problem areas and identify trends in water quality.

### SAMPLING SITES

Participants sampled 41 different sites along Lake Wallenpaupack between 2019 and 2024 (Figure 2). Data were collected from the same location every Saturday ( $\pm 1$  day) in June through September.

Nineteen sites were located at the southwest (SW) end of the lake, 9 sites were located at the northeast (NE) end, 12 sites were located mid-lake (ML), and 1 site was located in the river (RV), Wallenpaupack Creek. Not all sites were sampled every year.

Participants collected qualitative and quantitative data. Qualitative data are simple but important data that characterize water quality, such as water color. Quantitative data are data that express an amount or quantity using standardized units of measure. Examples of quantitative data include Secchi depth, water temperature, and chlorophyll *a* concentration. Both types of data are useful for assessing water quality.



**Figure 2: Sampling sites on Wallenpaupack. Open ellipses denote lake zones. Orange dots were sampled in 2024; many of these sites were sampled in previous years as well. Blue dots denote sites that were sampled only in years prior to 2024.**

COMMUNITY SCIENTISTS

Thank you to all the community scientists who have participated in the Wallenpaupack program over the years:

AIDEN & BONNIE BOUCHARD	KRYZAN FAMILY
VERA DEMCHENKO & MELANIE STOCKWELL	BILL LEISHEAR
BILL BAINES	TERRI MARCELLUS
BETTINA BONSALL	SHERYLL MCCLOSKEY
CATHERINE BOLTON	KAREN MAYER
MARY ELLEN BENTLER	VAL PATE
BEN BRUNELLI & JEAN MARIE BROZZESE	MARY BETH & JOHN SECOY
OWEN & AMY GILLESPIE	RICK SHEMA
NAOMI DRUCKER	JENNIFER SLADE
JULIE DEVRIES	REILLY SEELEY
KAREN FELIX	SARAH STRAUSE
CHARLES GREEN	DAVE SAVAGE
JAMES HECK FAMILY	CARA SCHWEITZER
SHELLY & WES HUME	LINDA TUCKMANTEL
ROB JAEGER	MIKE & MERRILEE ULISNEY
CAROL KUHN	SUSAN & DEREK WARNER
BETH KULIK	ROBERT WASYLYK & CARMELA FOX

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**Overlook Estate Foundation**



## KEY FINDINGS

Algal abundance increased in 2024 and was higher than all previously sampled years (2019 through 2023). Algal blooms have typically occurred in August and September each year. Higher algal abundance was most often seen in the southwest section of the lake.

Secchi depth tends to decrease throughout the summer, indicating decreasing water clarity. Year-to-year trends are variable. There does not appear to be a correlation between Secchi depth and algal levels.

The participants' perception of recreational suitability and physical condition of the lake declined over the course of the summer in each sampled year. 2023 and 2024 perceptions of recreational use have declined relative to previous years (2020 through 2022).

## DETAILED RESULTS

### WATER TEMPERATURE

#### *Why is water temperature important?*

Water temperature plays a key role in the physical structure of temperate lakes during the summer. Surface water, or the epilimnion, is warmed by the sun while deeper water, or the hypolimnion, remains cool. These layers remain distinct because warm and cold water have different densities and so layers of different temperatures do not mix easily. The depths of these two layers and the difference between their temperatures can affect many aspects of lake ecosystems, including the amount of oxygen in the water.

Lake organisms have specific temperature tolerances impacting survival. Many species of sport fish, including trout and salmon, require cool water (less than ~72°F or ~22°C). Cyanobacteria, the algae that cause harmful algal blooms, have a higher temperature tolerance than other algae groups and often thrive in warm water.

Water temperature is affected by air temperature, sun exposure, inflows and outflows, wind speed, and dissolved materials that can trap heat. Underwater springs and stream inflows can also affect local water temperature.

#### *How was water temperature measured?*

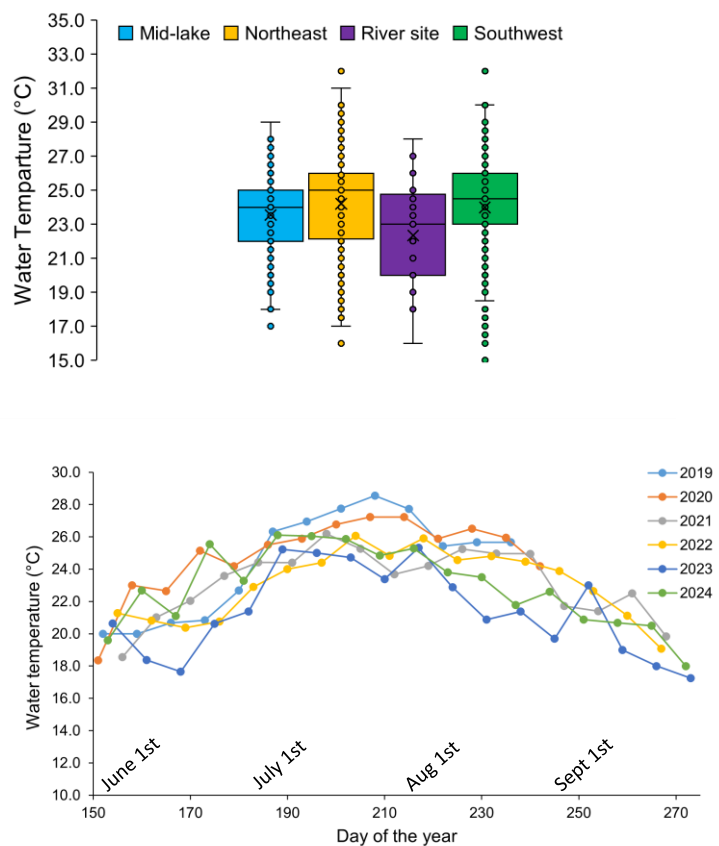
A weighted thermometer was lowered to a depth of 1 m (~3.3 ft) for a minimum of 5 minutes. Temperature was recorded to the nearest ½ degree Celsius.

#### *How did temperature compare among different areas of the lake?*

Average water temperature was about 0.5°C cooler in the ML section (23.5°C average) compared to the NE and SW sections (24.2°C and 24.0°C, respectively; Figure 3, top panel). The RV site had the lowest average temperature at 22.3°C. Differences among lake sections should be interpreted with caution due to the different number of sites sampled.

#### *How did temperatures compare over the sampled years?*

Summer water temperatures were greatest in 2019 and 2020 and lowest in 2023 (average of all sites on each sampling date, RV site is excluded; Figure 3, bottom panel). Water sampling was extended into the fall in 2021



**Figure 3: Water temperature measured at 1 m depth. Top panel: Water temperature distribution by lake zone, 2019-2024. Horizontal lines and X symbols within boxes show the median and mean temperature within zones, respectively. Bottom panel: Average water temperature over the summer in 2019-2024.**

through 2024, with temperature values recorded through the end of September. Fall water temperatures were greatest in 2022. The lowest fall water temperatures were recorded in 2023, following a cool summer.

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## SECCHI DEPTH

### *Why is Secchi depth important?*

Secchi depth is a measure of water transparency. It is measured using an 8-inch diameter black and white disk that is lowered straight down into the water. The depth at which the disk disappears from view is the Secchi depth. Lakes with clear water have deeper Secchi depths than those with more murky or dark water (Figure 4).

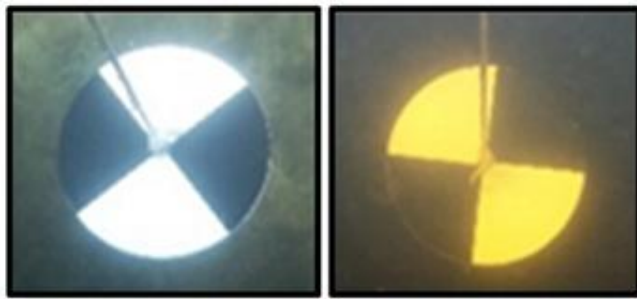


Figure 4: Secchi disk in a clear lake (left) and a dark-colored lake (right).  
Photo credit: Dr. Craig Williamson.

According to the North American Lake Management Society (NALMS), a theoretical lake with pure water would have a Secchi depth of 70-80 m (or 230-262 feet). Several factors decrease water transparency in lakes, including the abundance of algae, the amount of suspended particles, and the amount and color of dissolved compounds. Secchi depth is not an exact measure of transparency and can be affected by factors such as sun glare, surface roughness, and differences among users. However, Secchi depth is an inexpensive and widely used method of monitoring changes in lake condition over time and space.

### *How was Secchi depth measured?*

Secchi depth was measured by lowering a Secchi disk off the shady side of a boat or dock from a standing position until just out of sight. Depth was measured to the nearest  $\frac{1}{4}$  of a meter according to a pre-marked rope.

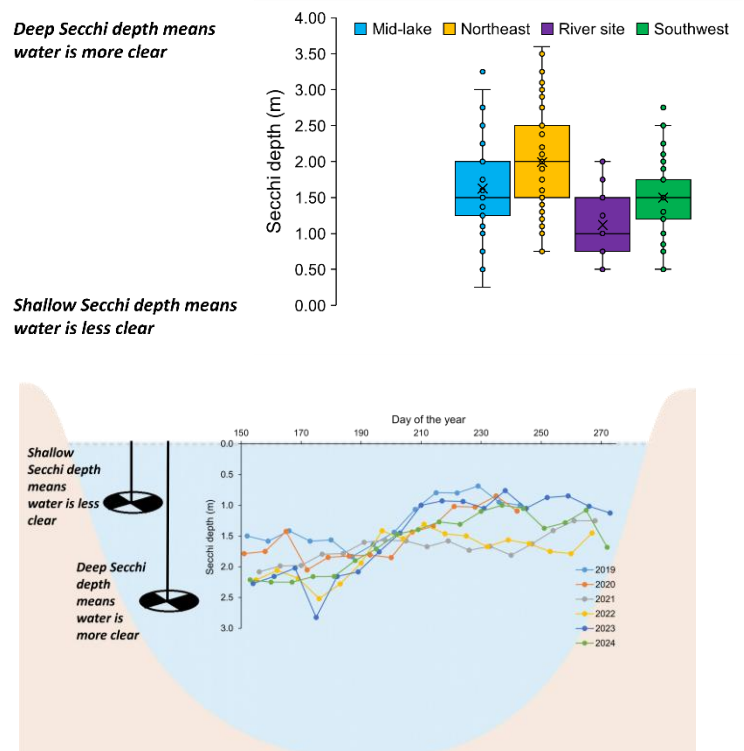
Lake scientists often graph Secchi depth in reverse order with the surface, or zero depth, at the top of the vertical axis with depth increasing down the page (see Figure 5, top and bottom panels). This orientation is intuitive if one imagines the top of the graph as the surface of the lake.

### *How did Secchi depth compare among different areas of the lake?*

The NE section of the lake had the deepest average Secchi depth (1.99 m or ~6.5 feet), followed by the ML section with an average of 1.62 m (~5.3 feet; Figure 5, top panel). The SW section averaged 1.50 m (~4.9 feet). As with water temperature, differences among lake sections should be interpreted with caution due to the different number of sites sampled.

*How did Secchi depth compare over the sampled years?*

Secchi depth, averaged across all sites on a specific date, was compared across the entire sampling season, from 2019 to 2024, including fall data from 2021 to 2024 (Figure 5, bottom panel). The deepest Secchi depth, indicating the clearest water, generally occurred during early June. Secchi depth steadily decreased from early July to early September during most sampled years, with a steady or increasing level of clarity in September. This pattern is typical of a recreational lake like Wallenpaupack. Clarity is impacted by algal blooms and by boat activity, both of which tend to increase across the summer with boat activity decreasing into the fall. Variability in Secchi depth from year to year is also related to precipitation differences. Heavy precipitation before a sampling date will lead to increased sediments in the water and a lower Secchi depth.



**Figure 5: Secchi depth in Wallenpaupack. Top panel: Secchi depth distribution by lake zone, 2019-2024. Horizontal lines and X symbols within boxes show the median and mean Secchi depth within zones, respectively. Bottom panel: Average Secchi depth over the sampling season in 2019-2024. RV sites were excluded from data in bottom panel.**

**WATER COLOR**

*Why is water color important?*

The color of lake water can be indicative of the types of compounds in the water. Lakes with few particles can appear blue because water molecules absorb longer, red wavelengths of light. Lakes with a lot of algae can appear green because algae, like terrestrial plants, contain green pigments called chlorophyll. Lakes that receive a lot of sediment can appear cloudy while lakes that have a high amount of dissolved material such as tannins may be tea-colored.

Sediment plumes or algal blooms can cause temporary and localized changes in color. Lakes experiencing eutrophication, or an increase in algal productivity, may permanently change color from blue to green. Many clear blue lakes in the Northern Hemisphere are becoming increasingly brown due to an increase in the amount of dissolved organic matter entering the lakes from their watersheds.

*How was water color measured?*

A Secchi disk was lowered to ½ the Secchi depth and the color of the water covering the white sections of the disk was observed. Water color was assigned to one of the following categories according to a standardized color chart: “clear”, “blue”, “blue/green”, “yellow/green”, or “brown”<sup>1</sup>.

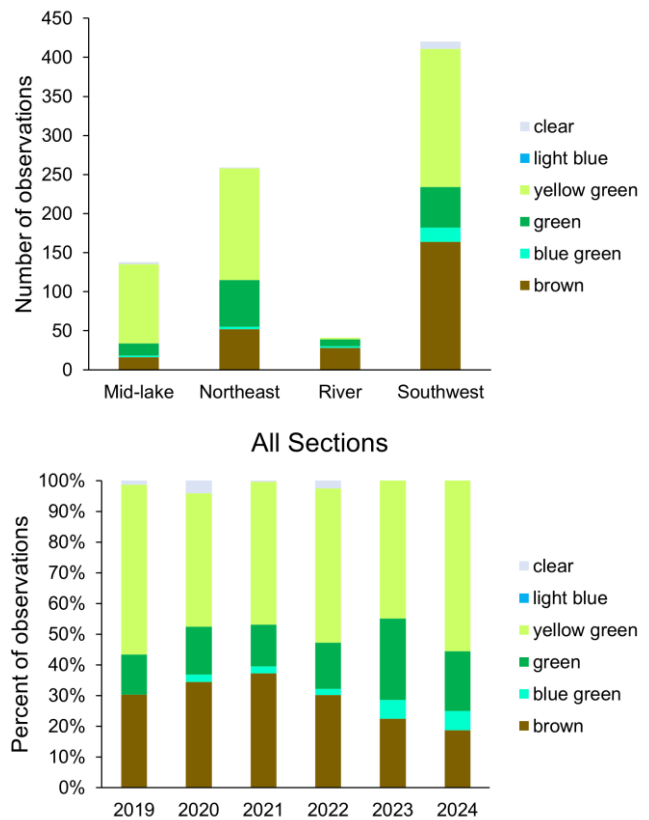
<sup>1</sup> Klug et al. 2017. Tool-kit for implementing a Citizen-led Environmental Observatory (CLEO) on your lake. CES4Health.info

*How did water color compare among different areas of the lake?*

Again, lack of data and the different number of sites among lake sections made detecting spatial patterns of water color difficult. “Yellow-green” was the most commonly reported color across all lake sections. Brown was reported most frequently in the SW section and green was reported most frequently in the NE. The RV site reported brown as the most frequent water color.

*How did water color compare over the sampled years?*

In general, the water color of Wallenpaupack was most frequently described as yellow-green, brown, or green during all six years (Figure 6, bottom panel). The frequency at which these colors were observed were similar among the years, with yellow green being most frequent in all six years. Blue green was higher in frequency in 2023 and 2024. Clear coloration ranged from 0.5% to 4.1% between 2019 and 2022 but was not reported at all in 2023 and 2024. However, the number of observations were different among years, with a much lower number of observations in 2023.



**Figure 6: Water color in Wallenpaupack. Top panel: observations by lake zone, 2019-2024. Bottom panel: frequency of each color observed in all lake zones in 2019-2024.**

**ALGAL ABUNDANCE**

*Why are algae important?*

Algae, including phytoplankton, are a diverse group of aquatic plant-like organisms that use the energy in sunlight to convert carbon dioxide into sugars during a process called photosynthesis. Algae are an important part of open water food webs (Figure 7). Algae provide food for the microscopic animals called zooplankton, who in turn are food for fish.

Algae are also key drivers of oxygen dynamics in lakes. Many lake organisms require oxygen to breath. Algae produce oxygen during photosynthesis. Because photosynthesis also requires light, algae are actively producing oxygen in the well-lit surface waters. When algae cells die, they sink to the dark, deep waters where they are decomposed by bacteria. Decomposition uses oxygen and the lack of sunlight prevents photosynthesis. Therefore, deep waters can be depleted of oxygen.

Algae require nutrients such as nitrogen and phosphorus to grow. Human activities within a watershed such as the use of fertilizers, leaky septic systems, and changes in land use can increase the amount of nutrients in a lake and influence the amount of algae. Although algae are critical components of a healthy lake ecosystem, too much algae can be problematic. An “algal bloom” occurs when algae populations grow quickly and reach high abundances. Algal blooms can decrease water clarity and exacerbate deep water anoxia. In addition, algae called cyanobacteria are capable of producing toxins that are harmful to humans and pets.

#### *How was algal abundance measured?*

Surface water samples (wrist deep) were collected every other week and brought to Lacawac Sanctuary. Algae were captured on glass fiber filters. Chlorophyll *a*, a pigment in algal cells, was extracted using acetone and was quantified using fluorometry, a technique where the sample is illuminated with a certain wavelength of light. When chlorophyll *a* absorbs this energy, it emits light that can be measured. Chlorophyll *a*, expressed as a concentration (or amount per volume), is a proxy for the amount of algae in the water: the greater the chlorophyll *a* concentration, the more algae.

#### *How did algal abundance compare among different areas of the lake?*

The SW section of the lake had the highest in-lake algal levels, with an average of 10.4 µg/L of chlorophyll *a* concentration across all sampled years (Figure 8, top panel). The ML section had an average of 7.8 µg/L, while the NE section had an average chl *a* 6.9 µg/L.

The RV site on the Wallenpaupack Creek was sampled from 2021 to 2024. Two very high chlorophyll *a* concentrations were obtained from the site in 2024; the highest chl *a* concentrations recorded over the data set (July 27 at 251.5 µg/L and August 26 at 317.2 µg/L). These values are not considered to be an error, but rather evidence of a large algal bloom in late July through August. In years prior to 2024, the RV site had the lowest average chlorophyll *a* concentration of 4.2 µg/L (average of 2021 to 2023 only). Including 2024, that average is 29.0 µg/L.

The amount of algae can vary over space for several reasons. There may be point source nutrient inputs that affect localized areas of the lake. Algae can also be pushed to one area by prevalent winds and waves.

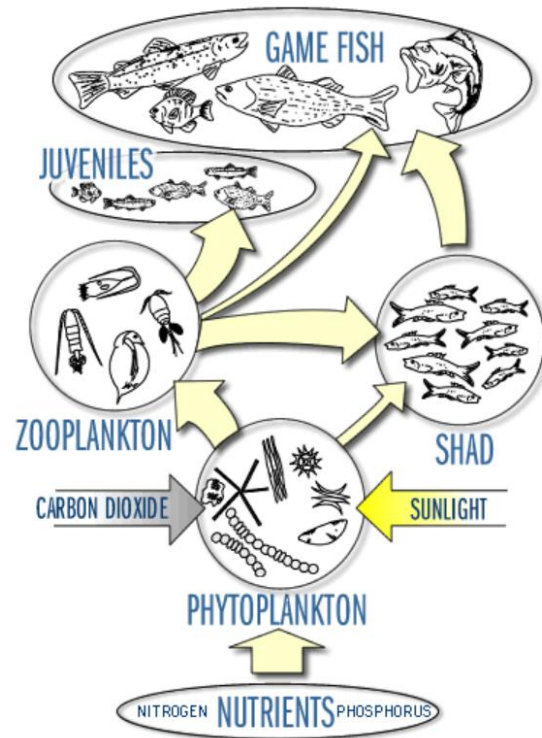


Figure 7: Basic lake food web. Figure from [www.waterontheweb.org](http://www.waterontheweb.org).

*How did algal abundance compare over the sampled years?*

From the beginning of the sampling season to the second week of July 2024 algal levels were only exceeded by those obtained in 2023 (Figure 8, bottom panel). From the second week of July through the end of September, 2024 algal levels rose to the highest levels obtained through PLEON’s six years of data. This trend remains even when excluding the very high Wallenpaupack Creek algal levels.

VISUAL ASSESSMENT OF ALGAL BLOOMS

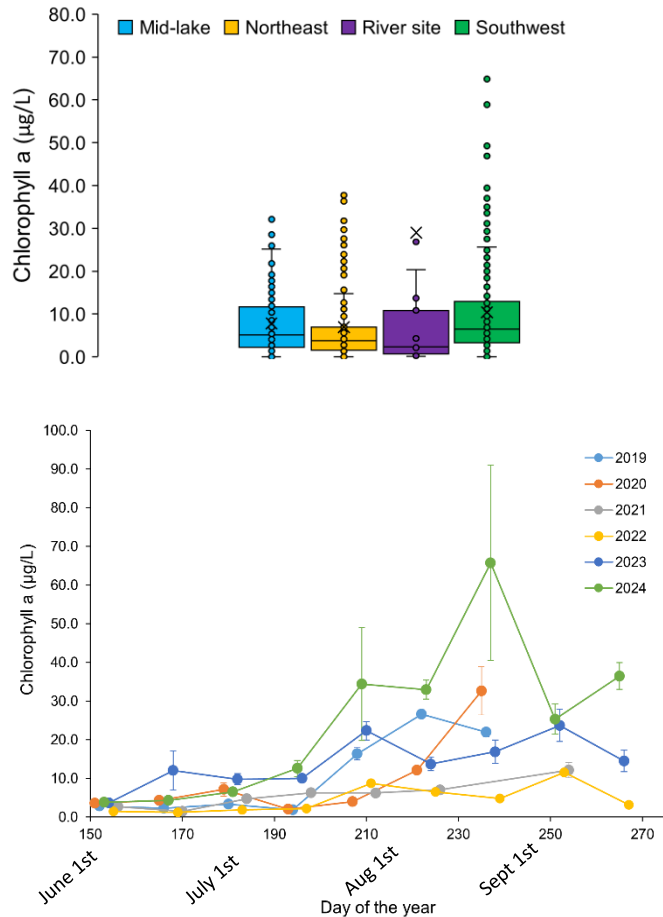
*Why is looking for algal blooms important?*

Algal blooms occur when algae populations rapidly achieve high abundances. Blooms can be visible in or on the water (Figure 9). Blooms that cause direct or indirect harm to humans or other animals are called “harmful algal blooms” or HABs. HABs can be aesthetically displeasing, release unpleasant odors, or impair recreation. HABs can exacerbate oxygen depletion in lakes because decomposition is a process that uses oxygen. When a HAB dies and decomposes, the decrease in oxygen can be severe, leading to fish kills and dead zones.

Some algae are capable of producing toxins that affect humans, pets, and wildlife. In freshwater, toxic HABs are commonly made up of cyanobacteria, also called blue-green algae. As a group, cyanobacteria can produce many types of toxins that affect the nervous system, liver, kidneys, and skin. The only way to know if a HAB is composed of cyanobacteria is to look at the algae using a microscope and the only way to know if cyanobacteria are producing toxins is to measure the toxin concentration in the water. However, visual assessment is often used to quickly identify potential toxic HABs.

*How were algal blooms visually assessed?*

Participants could record their observations of algae in the water column and at the surface by choosing from a list of options (Figure 10). Participants could select more than one option and could include a photograph. This data was recorded from 2020 to 2024.



**Figure 8: Algal abundance in Wallenpaupack as chlorophyll *a* concentration.**  
**Top panel: Chlorophyll *a* distribution by lake zone, 2019-2024. Horizontal lines and X symbols within boxes show the median and mean concentration within zones, respectively. Outliers for the River Site in 2024 are not shown.**  
**Bottom panel: Average chlorophyll *a* concentration over the sampling season in 2019-2024. Vertical lines are standard error. RV sites were excluded from data.**



**Figure 9: Photos of visual algal blooms in 2024. Left: Photo displaying green color of lake at a sampling site in the north-eastern section of the lake on September 15, 2024. Algae was described as consisting of both streaks and dots/clumps. Photo by Rick Shema. Right: Algae with the appearance of spilled paint at the Ledge Dale dock site, on the southwest section of the lake. Photo by Theresa Black, taken on September 27, 2024.**

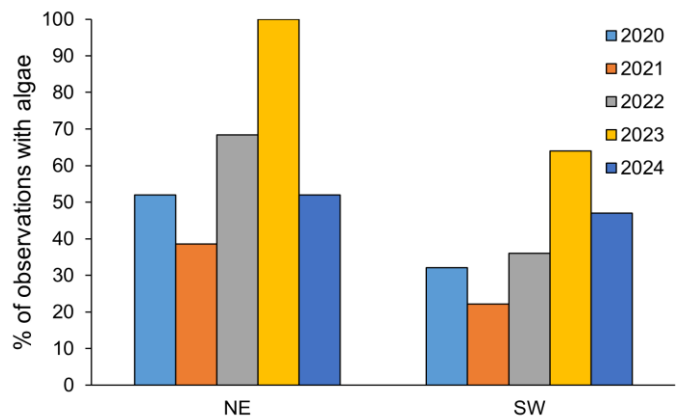
*How did visible algal blooms compare over the sampled years?*

Comparisons of visible algal blooms (which included all descriptions listed in Figure 10 except “nothing”) between 2019 and 2024 are difficult due to differences in the number of sampling sites between the years. Sampled sites ranged from a low of 52 visual assessments of algae in 2023 to 265 visual assessments in 2021. However, the data point to some potential differences over time and space that further monitoring may clarify.

Visible algae were present in 50% of the assessments done in 2024, compared to 77% in 2023 (as discussed previously, there was a low number of observations in this year), 44% in 2022, 29% in 2021, and 31% in 2020 (Figure 11). There is an increase in observations of visible algae over time, although more data will need to be collected to determine if this is a trend. Breaking up these data by location, NE sites have consistently had a greater percentage of visible algae observations relative to sites in the SW section of the lake. The most common description of algae appearance across all locations was “dots/clumps”.

Description	
<b>On the Surface</b>	<b>In the Water</b>
<input type="checkbox"/> Streaks	<input type="checkbox"/> Thick soup
<input type="checkbox"/> Dots or clumps	<input type="checkbox"/> Dots or clumps
<input type="checkbox"/> Spilled paint	<input type="checkbox"/> Nothing
<input type="checkbox"/> Full scum	<input type="checkbox"/> Other
<input type="checkbox"/> Duckweed/watermeal	
<input type="checkbox"/> Nothing	
<input type="checkbox"/> Other	

**Figure 10: Standardized descriptions of algae on the surface and in the water column for visual assessment.**



**Figure 11: Observations of algae on surface and in water column. Top panel: total observations of algae on each 2024 sampling date. Middle panel: Percentage of observations with algae on each 2024 sampling date. Bottom panel: Percentage of observations with algae by year, over the entire sampling season 2020-2024.**

**RECREATIONAL SUITABILITY**

Participants utilizing the Lake Observer website to document conditions were asked to rank the recreational suitability of the lake at their specific location and date. Participants chose from a list of five options (Table 1). For clarity, these options have been summarized for the tables below.

**Table 1: Recreational Suitability Options on Lake Observer.**

Recreational Suitability Option	Summary Term
Beautiful, could not be better	Ideal
Very minor aesthetic problems; excellent for swimming, boating	Minor aesthetic impairment
Swimming and aesthetic enjoyment slightly impaired because of algae levels	Moderate impairment
Desire to swim and level of enjoyment of the lake substantially reduced because of algae levels (but boating is okay)	Substantial impairment to use
Swimming and aesthetic enjoyment of the lake nearly impossible because of algae levels	Substantial impairment to use

*How did reported recreational suitability change over the sampled years?*

Recreational suitability of the lake was recorded by citizen scientists from 2020 to 2024. Although these data are subjective, there are some interesting trends across these five years of recorded data. Participants observed fewer ideal conditions in 2023 and 2024 compared to 2020 through 2022; about a 25% decrease in ideal condition reports (Table 2). Minor impairments increased by about 10% from 2022 to 2023 and 2024. Reports of substantial impairment to use increased greatly in 2023 and 2024, compared to earlier years.

**Table 2: Recreational Use Conditions by year, 2020-2024, given as percentage of each reported condition and total number of observations in sampling season.**

	2020	2021	2022	2023	2024
<b>Ideal</b>	35%	34%	39%	4%	10%
<b>Minor aesthetic impairment</b>	37%	35%	33%	45%	44%
<b>Moderate impairment to use</b>	18%	25%	28%	17%	13%
<b>Substantial impairment to use</b>	11%	6%	0%	34%	33%
<b>Total observations in calendar year</b>	57	77	57	47	39

*How did reported recreational suitability change over the course of the summer?*

Table 3 includes the total number of observations of each recreational use condition reported by month from 2020 to 2024. Reports of ideal conditions decreased through the summer into fall, while substantial impairment was reported with increasing frequency each season. Although this is subjective, data indicates that those using the lake find conditions to be less suitable in late summer and early fall.

**Table 3: Recreational Use Conditions by month, sum of total observations 2020 through 2024.**

	Ideal	Minor	Moderate	Substantial	Total Observations
<b>June</b>	39	22	12	1	74
<b>July</b>	19	33	18	9	79
<b>August</b>	10	27	17	14	68
<b>September</b>	6	22	10	16	54

## LOOKING FORWARD: WALLENPAUPACK COMMUNITY SCIENCE PROGRAM

### HOW TO JOIN THE CREW

We are always accepting volunteers for the next sampling season! The program requires sampling from the same location(s) every Saturday during June, July, August, and, if possible, September. Water samples collected bi-weekly need to be brought to Lacawac Sanctuary or a pre-determined drop-off location within 24 hours of collection. Missing a few sampling dates is ok, but remember that the more data you collect, the stronger the conclusions we can make.

Sampling methods are easy to learn and are appropriate for school age children and adults of all ages. This program makes a great summer school science project or a citizen science participation badge.

#### *How to join:*

Scheduled training events will be offered at Lacawac. Check the citizen science website for details:

<https://www.lacawac.org/citizen-science.html>

Or, if you cannot attend a scheduled event, contact Theresa Black to arrange a training session. Trainings include a brief introduction to lake ecology, instructions on how to use the Lake Observer app, and hands-on training in proper sampling methods.

Each participant will receive a sampling kit following the training. If you have participated previously and already have a kit, PLEON will provide you with a “kit refill”, which includes a sampling schedule and clean bottles, labels, and baggies for water sample collection.

The training workshops are free of cost. We kindly suggest a \$50 donation for new kits and a \$15 donation for kit refills. Donations help offset the cost of sample analysis.

### Questions about PLEON or the Wallenpaupack Citizen Science Program?

Contact: Theresa Black, PLEON Manager at Lacawac Sanctuary

[theresa.black@lacawac.org](mailto:theresa.black@lacawac.org)

570-689-9494