LAKE WALLENPAUPACK

CITIZEN-LED MONITORING PROGRAM

2019

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 monitoring 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 CITIZEN SCIENCE PROGRAM: GENERATING DATA AND CREATING PARTNERSHIPS BETWEEN SCIENTISTS AND THE COMMUNITIES THEY SERVE

WHY CITIZEN SCIENCE?

PLEON's hands-on, citizen-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, information that is vitally important to scientists attempting to understand how lakes respond to environmental pressures. Lake scientists have the training and expertise to interpret water quality data and place these data in a larger context. Working together, these groups can advance our understanding of effective lake management and preservation.

HOW THE PROGRAM WORKS

The PLEON Citizen Science program progresses in three stages (Figure 1). First, participants attend a training where they learn 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. Citizen scientists choose a location from which to collect samples, such as a dock or moored boat. They then collect data through the summer according to a standardized schedule.

At the end of the summer, PLEON scientists summarize the data and communicate the results and their implications to program participants and the larger community. This is a vital part of the program as it 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.

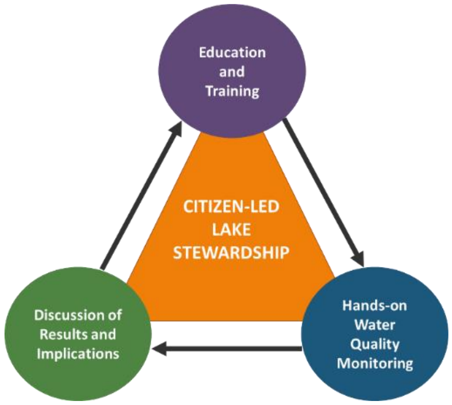

Figure 1: Three stages of the PLEON Citizen Science Program

THE LAKE WALLENPAUPACK PROGRAM

THE LAKE

Lake Wallenpaupack is an impoundment created in 1926 for hydroelectric power. It is the 3rd 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.

Wallenpaupack's irregular shape (Figure 2) leads to differences in water quality across space. Working together, citizen scientists collect data from many locations many times over the summer, capturing water quality dynamics over large spatial scales. These data can then be used to identify pristine or problem areas and identify changes in water quality over time.

Figure 2: Shoreline communities on Lake Wallenpaupack

2019 CITIZEN SCIENTISTS

Thank you to all of the citizen scientists who participated in the 2019 Wallenpaupack program and to PLEON's funding sources!

BILL LEISHEAR

PETER PAUL OLSZEWSKI

SHERYL McCLOSKY

THE BOUCHARD FAMILY

TERRI MARCELLUS

QUINN WILLIAMS

SINCLAIRE OGOF

MARY ELLEN BENTLER

THE HECK FAMILY

pennsylvania DEPARTMENT OF ENVIRONMENTAL PROTECTION

NSF

LACAWAC SANCTUARY & BIOLOGICAL FIELD STATION

2019 SAMPLING SITES

Program participants sampled 12 different sites along the shores of Lake Wallenpaupack during the summer of 2019 (Figure 3). Data were collected from the same location (either a dock or boat) every Saturday (±1 day) in June through August.

Seven sites were located at the southwest (SW) end of the lake, 4 sites were located at the northeast (NE) end, and 1 site was located mid-lake. Six sites were along the eastern shore and 6 sites were located along the western shore. Not all of the sites were sampled every week.

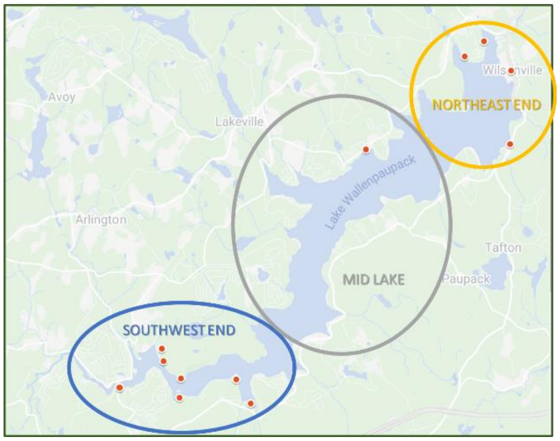

Figure 3: 2019 sampling sites.

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

2019 HIGHLIGHTS

Key Findings

Wallenpaupack had a lake-wide algal bloom that started in mid-July and lasted through the rest of the sampling season

Water clarity decreased substantially during the bloom

Locations at the southwest end of the lake appeared to have more algae sooner compared to the northeast end

Future Questions

How often does Wallenpaupack experience algal blooms of similar duration and severity as that observed in 2019?

Are differences in bloom conditions between the SW and NE end of the lakes consistent across years?

2019 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 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. 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 that other algae groups and often thrive in warm water.

Water temperature is affected by air temperature, sun exposure, 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 for a minimum of 5 minutes. Temperature was recorded to the nearest ½ degree Celsius.

How did water temperature change over time?

Surface water temperature (depth of 1 m or ~3 feet) in Wallenpaupack ranged from ~15°C to ~25°C (or ~59°F to ~77°F) in June, from ~25°C to over 30°C (or ~77°F to 86°F) in mid-July, and from ~22°C to ~28°C (or ~71°F to ~82°F) in late August (Figure 4). Surface water temperature generally followed the trend of maximum air temperature (measured at Lake Lacawac).

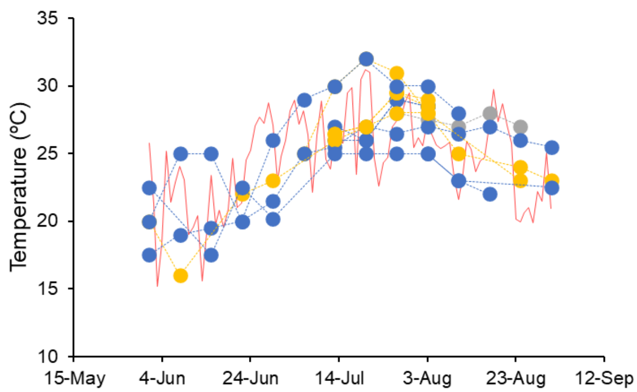

Figure 4: Water temperature at each site. Blue, yellow, and gray symbols are from SW, NE, and mid lake sites, respectively. Red line shows maximum air temperature measured at Lake Lacawac.

How did water temperature change over space?

Surface water temperature varied by up to 10°C among sampling sites (Figure 4). The variance did not appear to be driven by lake section (NE end, SW end, and mid-lake; Figures 5,6), although significant patterns are difficult to detect due to missing data and the small number of sampling sites. Other factors including the time of day the measurement was taken and differences among thermometers likely contributed to the variance among sites.

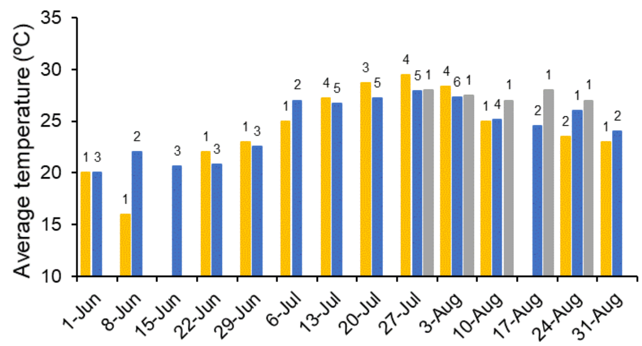

Figure 5: Average water temperature of SW, NE, and mid-lake sites. Numbers above bars show the number of sites contributing to the average.

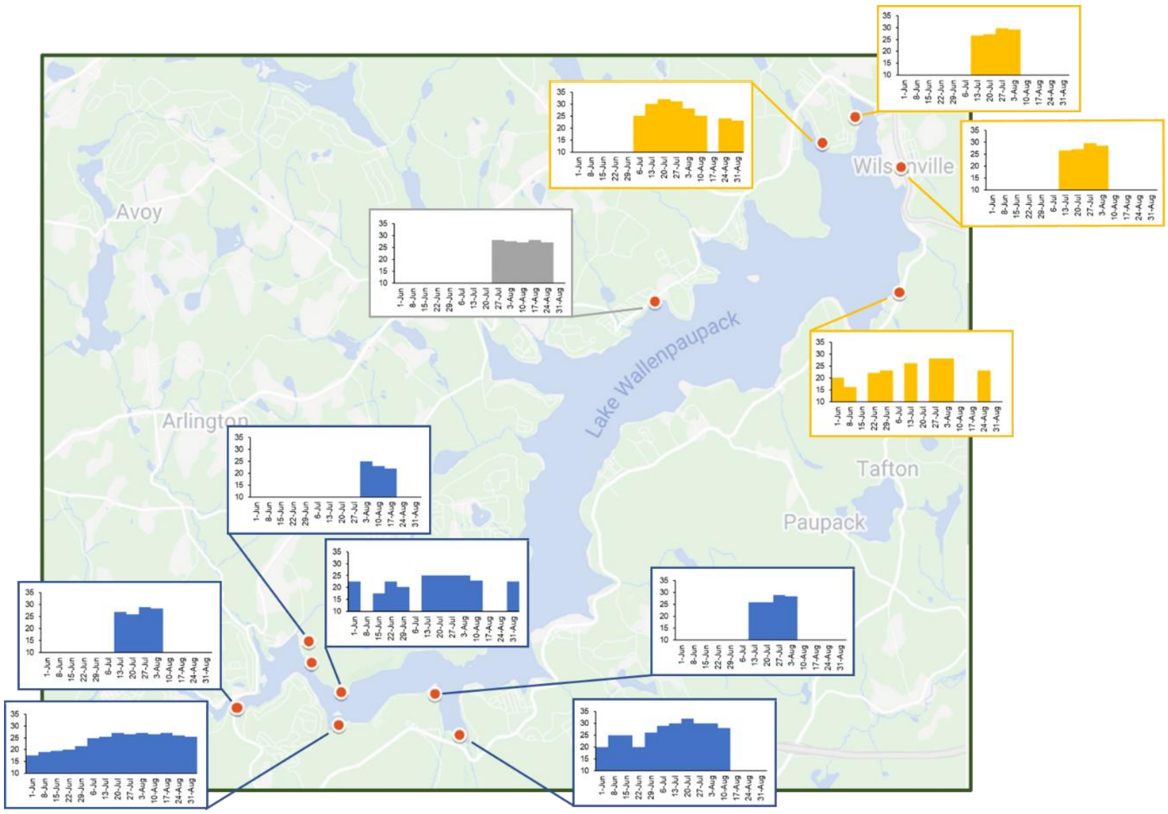

Figure 6: Trends in temperature (°C) over time at each sampling location. Missing bars indicate no data recorded for that site. Graphs outlined in blue, yellow, and gray correspond to SW, NE, and mid-lake sites, respectively. One site is missing temperature data.

SECCHI DEPTH

Why is Secchi depth important?

Secchi depth is a measure of water transparency. It is measured using a black and white disk that is 8 inches in diameter. The disk is lowered straight down into the water. The depth at which the disk just disappears from view is the Secchi depth. Lakes with clear water have deeper Secchi depths than those with more murky or dark water (Figure 7).

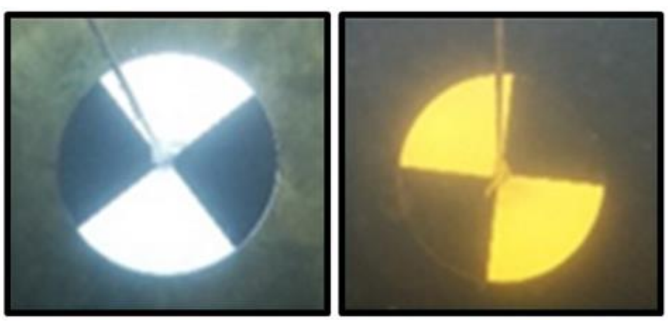

Figure 7: Secchi disk in a clear (left) and dark colored lake (right). Photo credit: Craig Williamson

According to the North American Lake Management Society (NALMS), a theoretical lake of absolutely pure water would have a Secchi depth of 70-80 m (or 230-262 feet). Several factors contribute to water transparency in real 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 turbulence, and differences among users. However, Secchi depth is an inexpensive and widely used method of monitoring changes in lake condition over time and space. For example, the volunteers with the NALMS Secchi Dip

In program have been measuring Secchi depth in lakes all over the world since 1995. The Dip In database now includes 41,000 measurements over 7,000 waterbodies, providing a powerful tool for understanding how lakes are changing at regional, national, and global scales. For more information, visit the NALMS Secchi Dip In web site: https://www.nalms.org/secchidipin/.

How was Secchi depth measured?

Secchi depth was measured from a standing position off the shady side of the dock or boat. The Secchi disk was lowered until just out of sight. The depth was measured to the nearest ¼ of a meter according to a pre-marked rope.

How did Secchi depth change over time?

Secchi depth ranged from 1.25 m to 2.25 m (or 4.1 to 7.4 feet) in June through early July across all sites (Figure 8). In mid-July, Secchi depth decreased dramatically, ranging from 0.5 m to 1.25 m (or 1.6 to 4.1 feet) through late July and August. These data show that Wallenpaupack experienced a fairly abrupt decline in transparency in mid-summer.

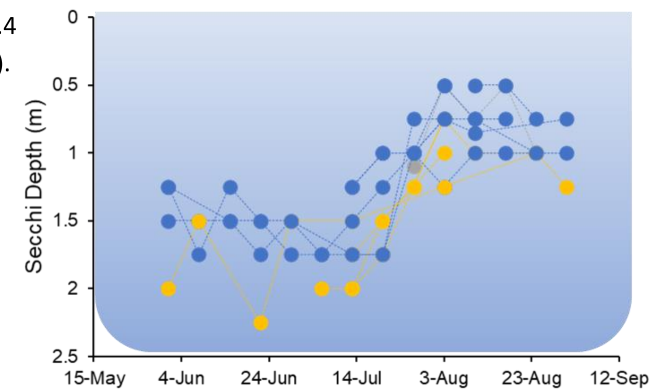

Figure 8: Secchi depth at each site over time. Blue, yellow, and gray symbols are SW, NE, and mid-lake sites, respectively. The top of the graph corresponds to the surface of the lake.

How did Secchi depth change over space?

Secchi depth at SW, NE, and mid-lake sites seemed to follow a similar pattern over time, although the incomplete datasets at some sites make this difficult to say for certain. Generally, Secchi depth at the NE end of the lake tended to be deeper compared to the SW end, suggesting clearer water at the NE end of the lake (Figures 9,10).

The weeks of July 13 through Aug 3 have at least 3 datapoints for both the SW and NE ends of the lake. During each of these weeks, the average Secchi depth from the SW end of the lake was 0.2 to 0.3 m (or 0.65 to 0.98 feet) less than the NE end of the lake.

More sampling points are needed to determine if differences between the ends of the lake are statistically and ecologically significant.

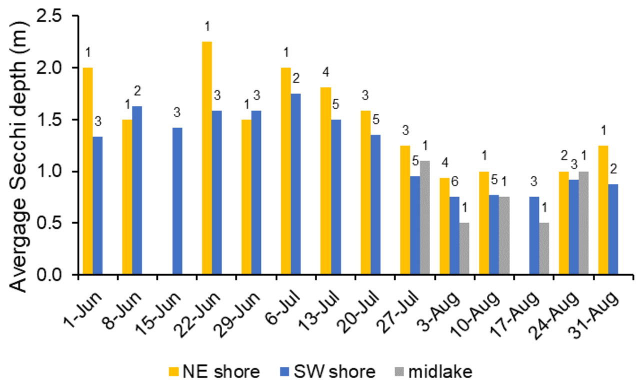

Figure 9: Average Secchi depth at SW, NE, and mid-lake sites. Numbers above bars show the number of sites contributing to the average.

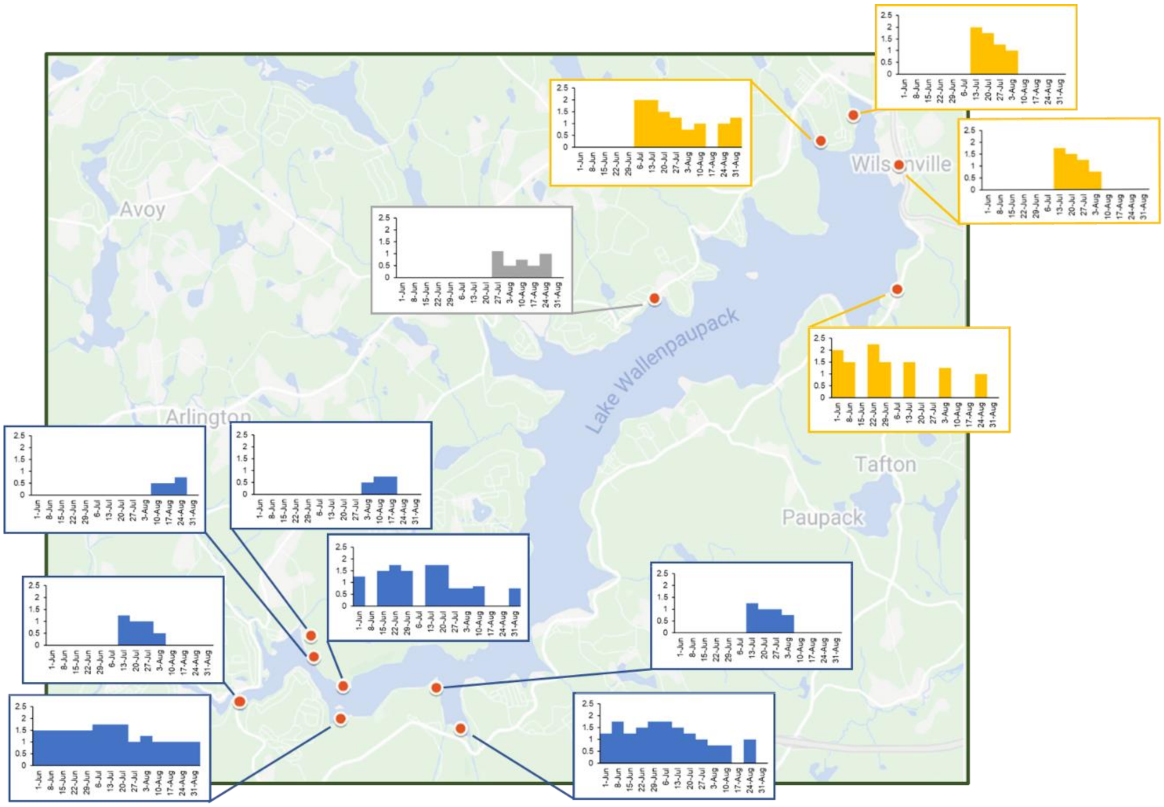

Figure 10: Trends in Secchi depth (m) over time at each sampling location. Missing bars indicate no data recorded for that site. Graphs outlined in blue, yellow, and gray correspond to SW, NE, and mid-lake sites, respectively.

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 more 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”[1].

[1] **Klug et al. 2017. Tool-kit for implementing a Citizen-led Environmental Observatory (CLEO) on your lake. CES4Health.info**

How did water color change over time?

There were no clear patterns in color over time. The color of Wallenpaupack water was described as “green”, “yellow/green”, or “brown” over the majority of the summer (Figure 11). The water was described as “clear” at one location during one sampling point. No participant recorded “blue” or “blue/green” color.

How did water color change over space?

There were no clear spatial patterns in water color (Figure 11). Water at NE-end sampling locations tended to be more consistently described as “yellow/green” while water at SW-end sampling locations was more frequently described as “brown”. However, incomplete datasets at many sites make spatial patterns difficult to discern.

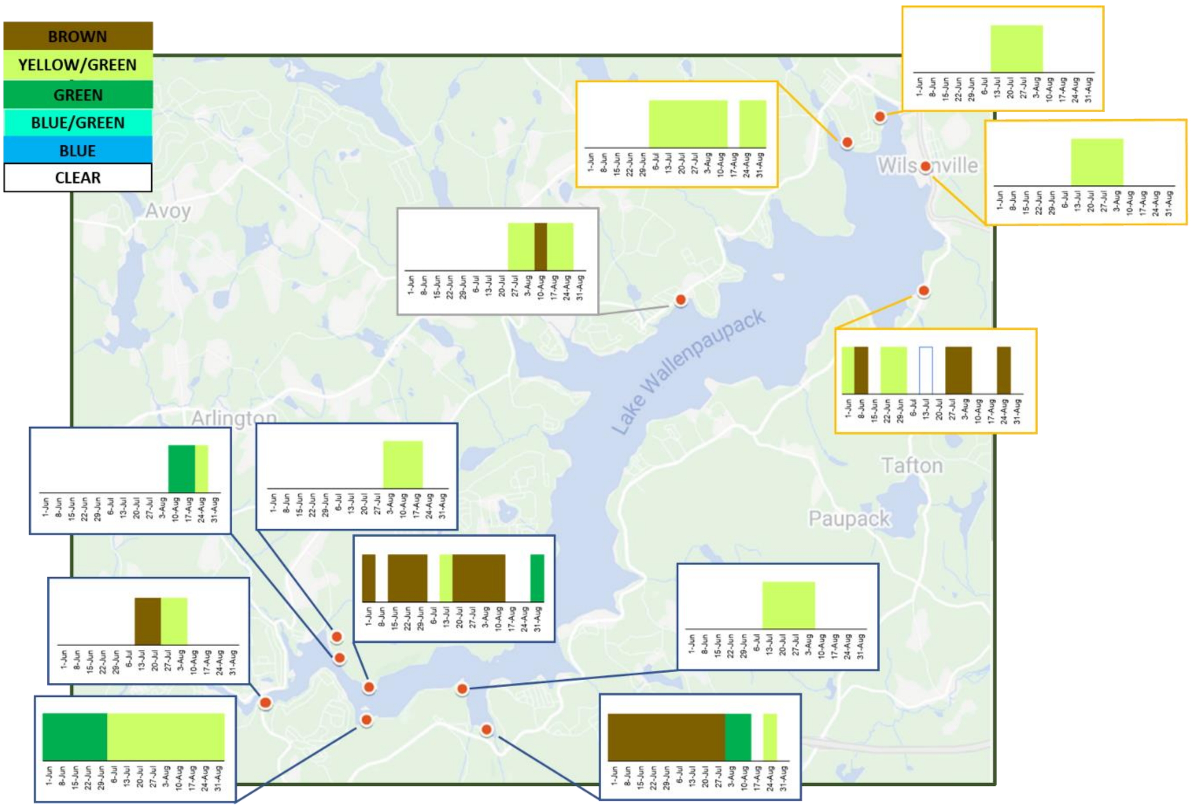

Figure 11: Trends in water color over time at each sampling location. Missing bars indicate no data recorded for that site. Graphs outlined in blue, yellow, and gray correspond to SW, NE, and mid-lake sites, respectively.

WATER PARTICLES

Why are particles in the water important?

Lake water contains many types of suspended particles, including algae, bacteria, microscopic animals, sediments, and detritus. The abundance of different types of particles is indicative of lake productivity and affects water clarity. Sources of particulates include runoff from the watershed, increases in algae populations, and re-suspension of lake sediments. Erosion can be a significant source of particles in lakes with developed watersheds.

Particles are removed from the water column when they sink to the bottom, are consumed by filter feeders (such as mollusks and some types of fish), or degraded by bacteria or sunlight.

How were particles measured?

A Secchi disk was lowered to ½ the Secchi depth and the particles in the water covering the white sections of the disk were observed. Particle type was described according to the following categories using a standardized chart: "none", "unidentified particles" (particles present but unable to identify as algae), "visible algae" (distinct green particles present), and "dense algae" (high density of green particles, no space between them)[2].

How did particles change over time?

Trends in particle type over time were difficult to assess due to incomplete datasets at many sites. Late summer particles tended to be categorized as "unidentified" or "algae" at most sites while many observations of the "none" category were recorded in early summer (Figure 12).

How did particles change over space?

Incomplete datasets also made identifying trends in particle type over space difficult. Most "algae" classifications occurred at SW or mid-lake sites while NE sites recorded "none" or "unidentified particles" (Figure 12).

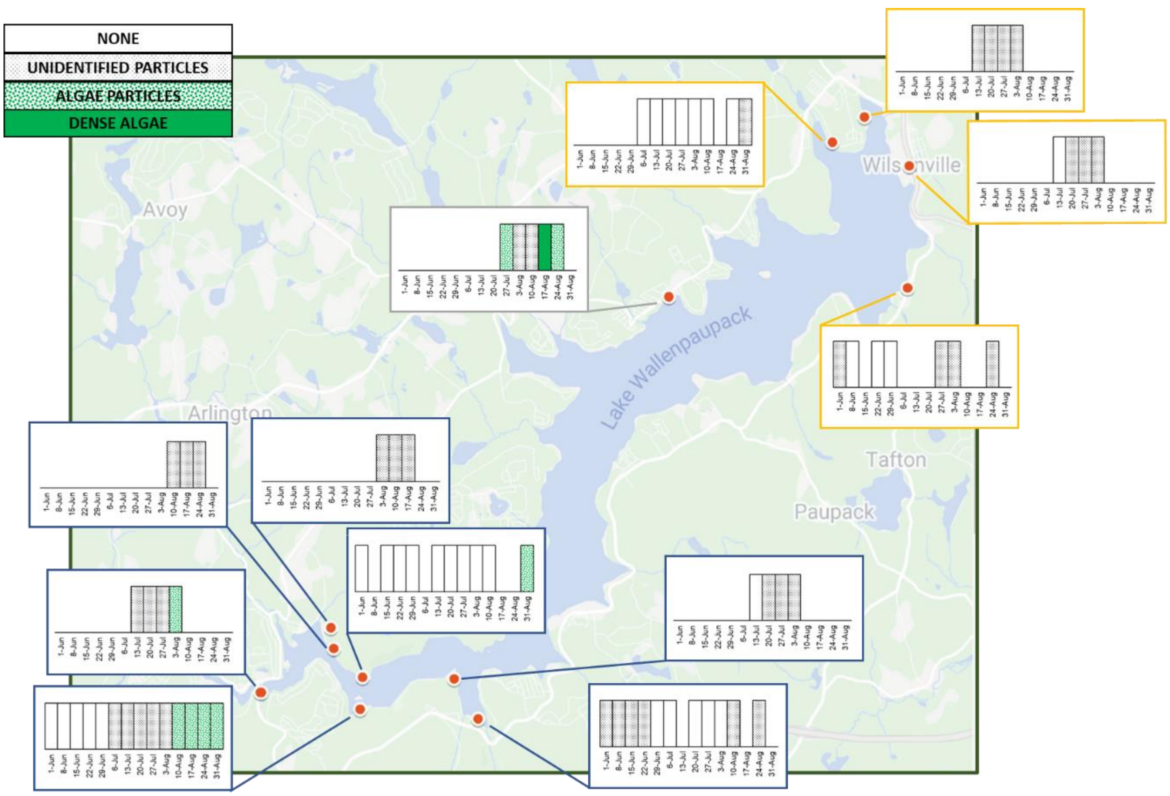

Figure 12: Trends in water particles over time at each sampling location. Missing bars indicate no data recorded for that site. Graphs outlined in blue, yellow, and gray correspond to SW, NE, and mid-lake sites, respectively.

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[2] **Klug et al. 2017. Tool-kit for implementing a Citizen-led Environmental Observatory (CLEO) on your lake. CES4Health.info**

ALGAE ABUNDANCE

Why is algae important?

Algae are a group of aquatic plant-like organisms that use energy in sunlight to convert carbon dioxide into starch, a process called photosynthesis. Planktonic algae are an important part of open water food webs (Figure 13). Algae provide food for the microscopic animals called zooplankton, who in turn are food for fish.

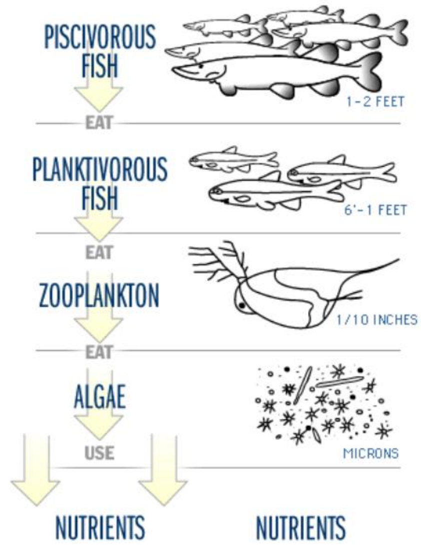

Figure 13: Typical lake food web. Image from lakeaccess.org

Algae are also key drivers of oxygen dynamics in lake water. Oxygen is essential to most lake organisms. The process of photosynthesis produces oxygen and requires sunlight. Therefore, algae are important sources of oxygen in the surface waters where there is plenty of light. When algae cells die, they sink to the dark, deep waters where they are decomposed by bacteria. This process 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 many algae can be problematic. Algae can decrease water clarity and exacerbate deep water anoxia. Algae called cyanobacteria are capable of producing toxins that are harmful to humans and pets.

How was algae abundance measured?

Surface water samples (wrist deep) were collected every other week and brought to Lacawac Sanctuary. Algae was captured on glass fiber filters. Chlorophyll *a*, a pigment in algal cells, was extracted using a mixture of acetone and methanol. The amount of chlorophyll *a* in the sample was measured using fluorometry, a technique where the sample is illuminated with a certain wavelength of light. When excited by this wavelength, chlorophyll *a* 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.

How did algae abundance change over time?

The amount of algae (as measured by chlorophyll *a* concentration) increased dramatically in mid-July across all sites (Figure 14). Chlorophyll *a* concentration before the July 27th sampling was between 0.25 µg/L and 4.4 µg/L across all sites. After the July 27th sampling, chlorophyll *a* concentration was between 9.6 µg/L and 31.7 µg/L, a 2-5x increase across all sites.

The increase in algae corresponded with the decrease in Secchi depth and observed algal particles later in the summer.

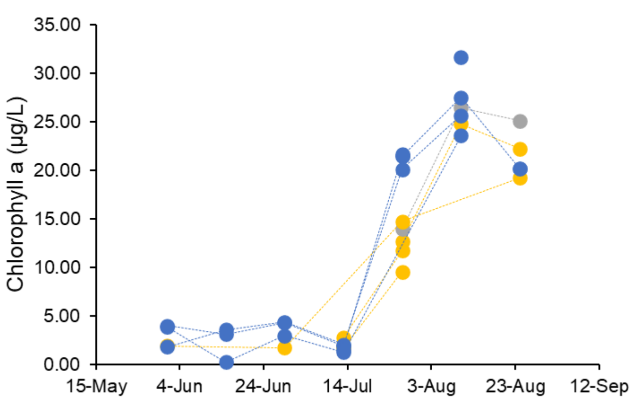

Figure 14: Chlorophyll *a* concentration over time in all sites. Blue, yellow, and gray symbols represent SW, NE, and mid-lake sites.

How did algae abundance change over space?

As with the other variables, detecting ecologically significant differences in the amount of algae over space is difficult due to the small number of sites and incomplete datasets at some sites. Generally, SW sites tended to have more algae at the peak of the lake-wide algal bloom (later July, early August; Figures 15,16). The July 27 sampling had 4 data points from both the SW and NE end of the lake. On this date, the average chlorophyll *a* concentration of the SW sites was 10 µg/L more than the average of the NE sites.

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.

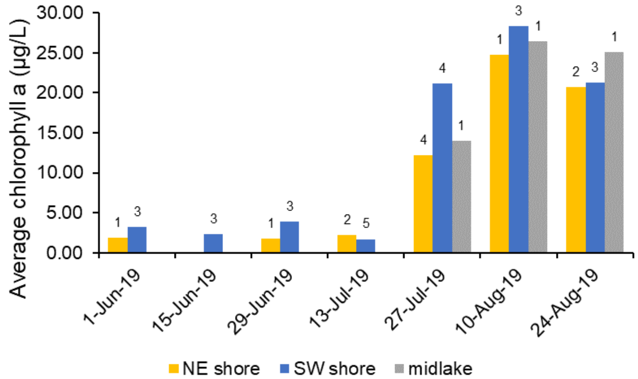

Figure 15: Average chlorophyll a concentration at SW, NE, and mid-lake sites. Numbers above bars show the number of sites contributing to the average

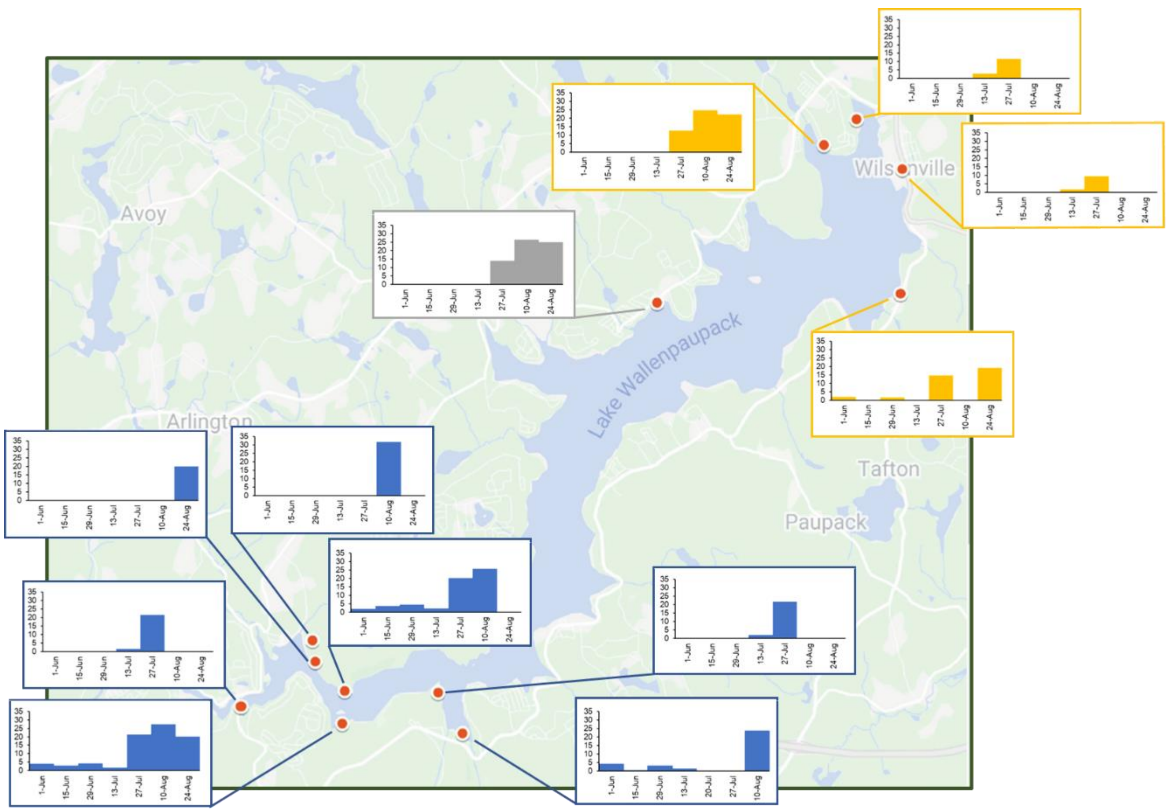

Figure 16: Trends in chlorophyll a concentration (µg/L) over time at each sampling location. Missing bars indicate no data recorded for that site. Graphs outlined in blue, yellow, and gray correspond to SW, NE, and mid-lake sites, respectively.

LOOKING FORWARD: 2020 WALLENPAUPACK CITIZEN SCIENCE PROGRAM

CHANGES FOR 2020

We are making the following changes to the Wallenpaupack Citizen Science program for 2020.

- Participants will be able to enter their data using their smartphones or computers via the Lake Observer App (https://www.lakeobserver.org/). Using Lake Observer will allow the Wallenpaupack Citizen Science Program to contribute to a global dataset of water quality observations available to researchers and lake enthusiasts all over the world.
- Participants will be asked to record some more observational data including descriptions of cloud cover, wind strength, and recent precipitation.
- Participants will have the option of tracking ice cover on Wallenpaupack through the winter months.

HOW TO JOIN THE 2020 CREW

We are looking for volunteers for the 2020 Wallenpaupack Citizen Science Program! The program is requires sampling from the same location(s) every Saturday during June, July, and August. Water samples collected bi-weekly need to be brought to Lacawac Sanctuary 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.

Here is how to join:

Attend one of the training workshops at Lacawac Sanctuary. The workshop schedule is posted on the PLEON web site: https://www.lacawac.org/pleon.html. Workshops are approximately 2 hours in length and include a brief introduction to lake ecology, instructions on how to use the Lake Observer app, and hands-on training in proper sampling methods in Lake Lacawac, a pristine glacial lake reserved for lake research.

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 2020 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 $10 donation for kit refills. Donations help offset the cost of sample analysis.

Questions about PLEON or the Wallenpaupack Citizen Science Program?

Contact: Beth Norman, PLEON Chief Scientist and Director of Science and Research at Lacawac Sanctuary

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