LAKE WALLENPAUPACK

COMMUNITY-LED MONITORING PROGRAM

2020

POCONO LAKE ECOLOGICAL OBSERVATORY NETWORK – LACAWAC SANCTUARY

POCONO LAKE ECOLOGICAL OBSERVATORY NETWORK

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 COMMUNITY SCIENCE 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 Community Science program has 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. 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.

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.

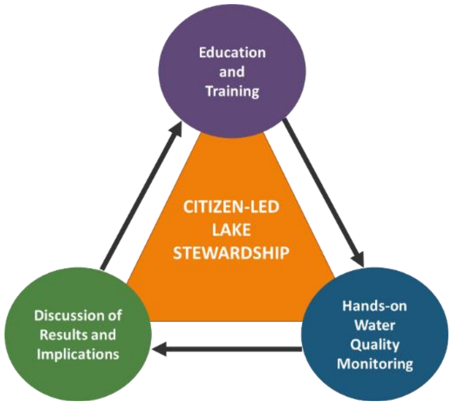

Figure 1: Three stages of the PLEON Community Science Program

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 potential differences in water quality across space. Working together, participants 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. Map from http://wallenpaupackwatershed.org/maps/.

2020 COMMUNITY SCIENTISTS

Thank you to all of the community scientists who participated in the 2020 Wallenpaupack program and to PLEON's funding sources!

BILL LEISHEAR	VAL PATE
SHERYL McCLOSKY	BILL BAINES
SINCLAIRE OGOF	RICK SHEMA
THE HECK FAMILY	CARA SCHWEITZER
CATHERINE BOLTON	KAREN FELIX
OWEN GILLESPIE	THE KRYZAN FAMILY
BEN BRUNELLI	MARIA DRAKE

pennsylvania DEPARTMENT OF ENVIRONMENTAL PROTECTION

NSF

LACAWAC SANCTUARY & BIOLOGICAL FIELD STATION

2020 SAMPLING SITES

Participants sampled 20 different sites along the shores of Lake Wallenpaupack during the summer of 2020 (Figure 3). Data were collected from the same location every Saturday (±1 day) in June through August.

Ten sites were located at the southwest (SW) end of the lake, 3 sites were located at the northeast (NE) end, and 7 sites were located mid-lake. Six sites were along the eastern shore and 14 sites were located along the western shore. Not all of the sites were sampled every week.

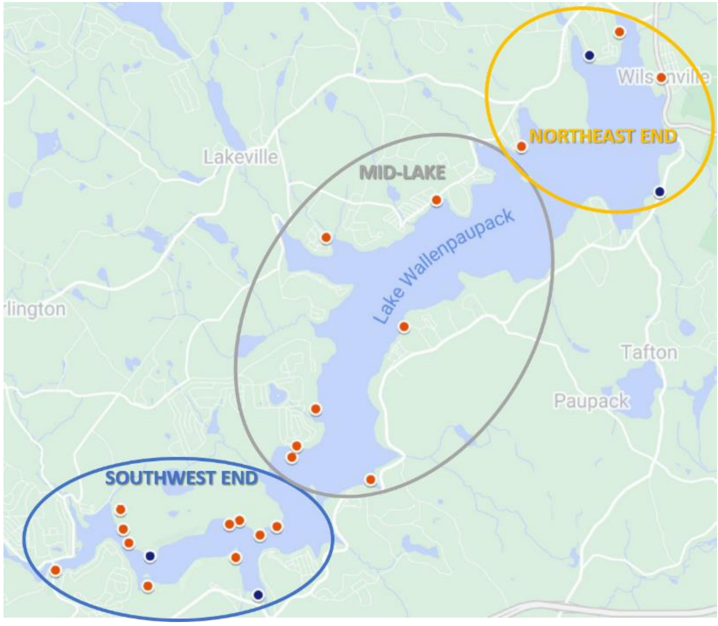

Figure 3: Wallenpaupack sampling sites. Sites shown in red were sampled in 2020 while those in blue were sampled only in 2019.

Participants collected qualitative and quantitative data. Qualitative data are simple but important data that describe and 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 collected include Secchi depth, water temperature, and chlorophyll a concentration. Both types of data are useful for assessing water quality.

2020 HIGHLIGHTS

Key Findings

As in 2019, there was a lake-wide algal bloom that started in mid-late July and lasted through August and beyond with a corresponding decrease in water clarity.

The bloom appeared to be more severe at the southwest end of the lake.

The participants' perception of recreational suitability and physical condition of the lake declined over the course of the summer.

Future Questions

Are summer algal blooms becoming the "norm" for Wallenpaupack?

How long into the fall do lake-wide algal blooms last?

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 ~72ºF or ~22ºC). 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 the summer?

Average surface water temperature in Wallenpaupack ranged from 18-27°C (or ~64-81°F) across all sites over the summer (Figure 4a). Water temperature was generally higher and more stable than average air temperature (measured at Lake Lacawac).

How did water temperature change over space?

Spatial trends in surface temperature are difficult to assess due to the small number of sampling sites at the northeast end of the lake. It appears that temperature patterns over time were fairly similar in all three lake sections (Figure 4b). The northeast end of the lake appears to have been

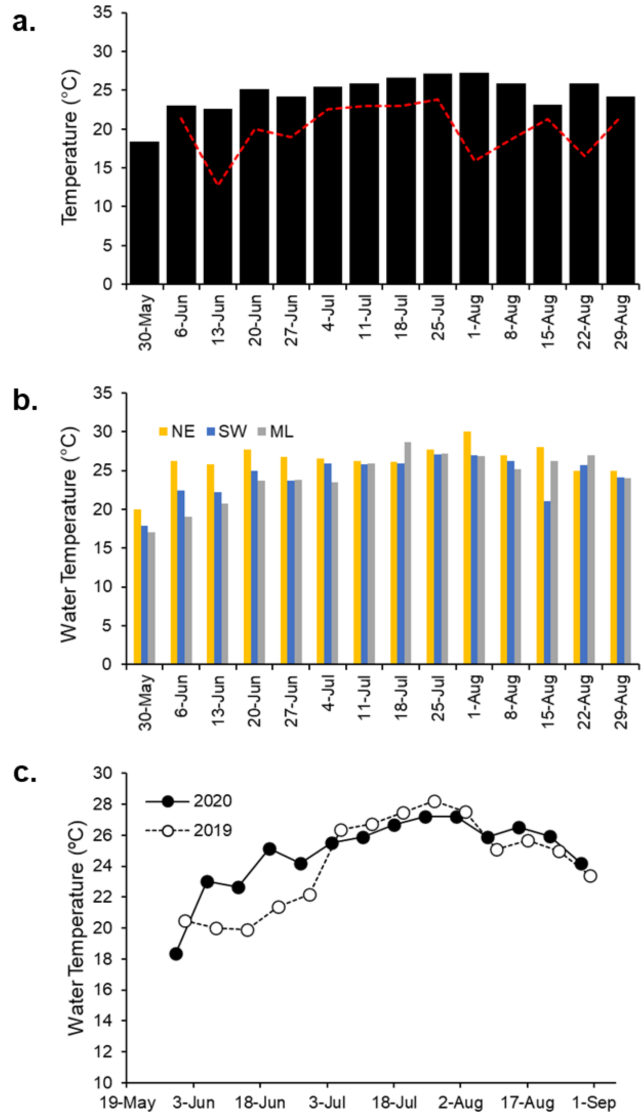

Figure 4: Average 2020 surface water temperature across all Wallenpaupack sites (a) and in northeast (NE), southeast (SE), and mid-lake (ML) sites (b). Red dashed line in Panel a is average air temperature measured at Lake Lacawac. 2020 temperature is compared to 2019 temperature panel c. Note that not all sites contributed data on all dates and the number and location of sites sampled differ between years.

warmer in early summer compared to the other sections, but the small sample size makes it impossible to test this statistically.

How did 2020 water temperature compare to 2019?

Average water temperature across all sites in 2020 appears to have been slightly warmer in June compared to 2019 but fairly similar to that of 2019 in July and August (Figure 4c). A robust comparison is not possible due to the small number of sites sampled, particularly early in the summer. It is also important to note that the averages for some days in both years are composed of only 1-2 samples, making statistical comparisons difficult.

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 5).

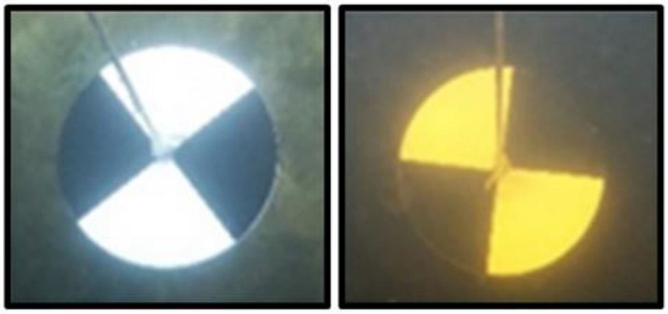

Figure 5: Secchi disk in a clear (left) and dark colored lake (right). Photo credit: Craig Williamson

According to the North American Lake Management Society (NALMS), a theoretical lake with absolutely pure water would have a Secchi depth of 70-80 m (or 230-262 feet). Several factors decrease 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 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 ¼ of a meter according to a pre-marked rope.

How did Secchi depth change over the summer?

Average Secchi depth ranged from 0.85 m to 2.05 m (or 2.8 to 6.7 feet) through the summer of 2020 (Figure 6a). Secchi depth began to decline in late July, decreasing from an average of ~1.8 m in early summer to ~1 m through August. These data show that water transparency in Wallenpaupack declined in late summer.

How did Secchi depth change over space?

While Secchi depth of the southwest end, northeast end, and mid-lake sections followed similar patterns, the decline in Secchi depth was most pronounced in the northeast and mid-lake sections (Figure 6b). Average Secchi depth declined by approximately 1.25 m and 1 m (~4.1 and 3.3 feet) in the northeast and mid-lake sections, respectively. In contrast, average Secchi depth declined by approximately 0.3 m (~1 foot) in the southwest section. Differences in Secchi depth among sections in early summer drove this discrepancy; Secchi depth in the southwest section was roughly 0.5 m (~1.6 feet) more shallow in June compared to the other sections.

However, more sampling points are needed, particularly in the northeast section, to determine if differences between the lake sections are statistically and ecologically significant.

How did 2020 Secchi depth compare to 2019?

Comparisons between 2020 and 2019 are difficult due to the small sample size. In general, Secchi depth in 2020 was slightly deeper than in 2019, suggesting slightly clearer water. A decline in Secchi depth occurred in mid-late July in both years (Figure 6c). However, as with temperature, the averages for some days in both years are composed of only 1-2 samples, making statistical comparisons difficult

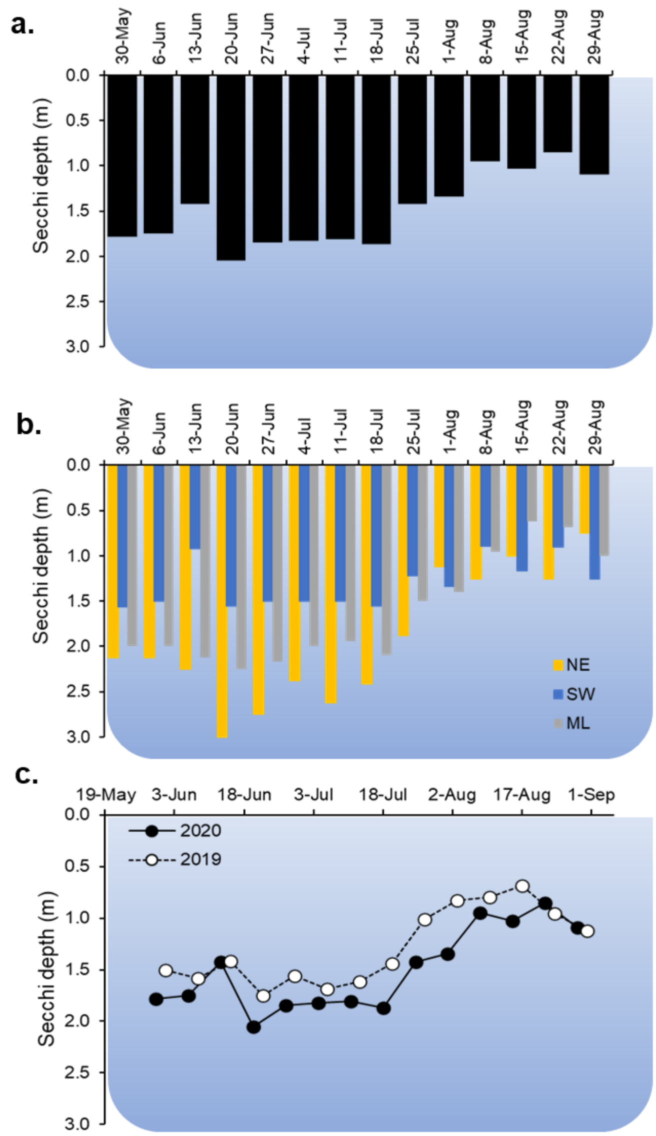

Figure 6: Average 2020 Secchi depth at across all Wallenpaupack sites (a) and in northeast (NE), southeast (SE), and mid-lake (ML) sites (b). 2020 Secchi depth is compared to 2019 Secchi depth in Panel c. Note that not all sites contributed data on all dates and the number and location of sites differ between years.

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].

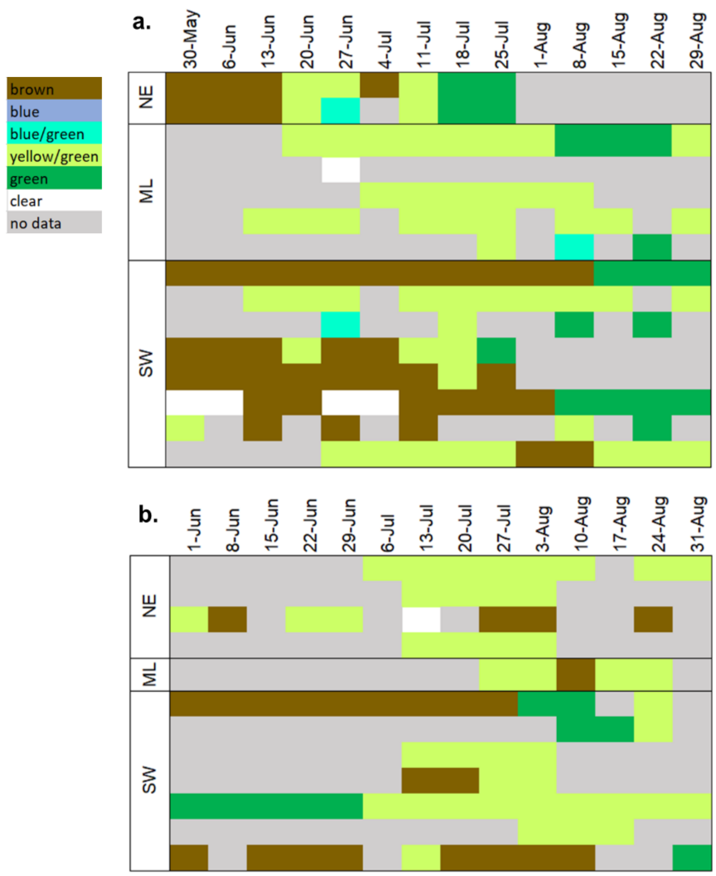

Figure 7: Water color observed in northeast (NE), mid-lake (ML), and southwest (SW) sites in 2020 (a) and 2019 (b). Each row depicts water color at a single site over time. Note that the number and location of sites differed among years.

How did water color change over the summer?

There were no clear patterns in water color over time, partly due to the amount of missing data (gray cells in Figure 7). The color of Wallenpaupack water was most frequently described as “green”, “yellow/green”, or “brown” in 2020 (Figure 7a). The water was described as “clear”, “blue” or “blue/green” 8 times over the summer.

How did water color change over space?

Again, lack of data made detecting spatial patterns of water color difficult. However, water color was described as “brown” most frequently at the northeast and southwest sections of the lake as opposed to the mid-lake section in 2020 (Figure 7a). This could be due to the presence of inflows at either end of the lake.

How did 2020 water color compare to 2019?

The southwest section of the lake seems to have been described as “brown” more often in 2020 than in 2019, particularly in early summer. However, as with other variables, meaningful differences between 2019 and 2020 were difficult to assess due to lack of water color data in both years (gray cells in Figure 7).

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

ALGAL ABUNDANCE

Why are algae important?

Algae are a diverse group of aquatic plant-like organisms that use the energy in sunlight to convert carbon dioxide into starch during a process called photosynthesis. Algae are an important part of open water food webs (Figure 8). 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.

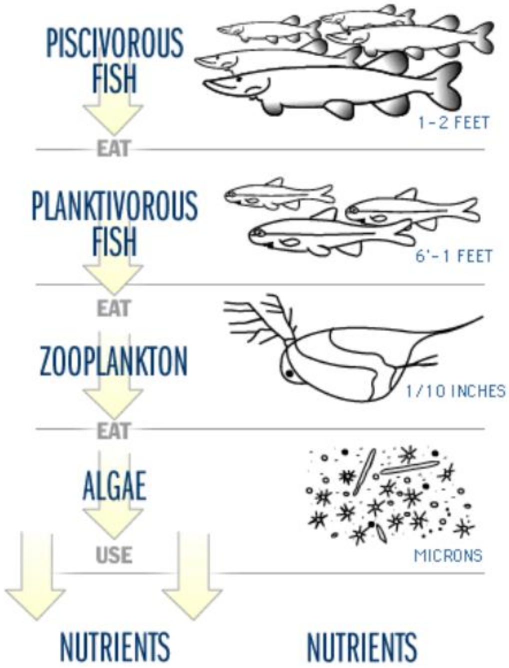

Figure 8: Typical lake food web. Image from lakeaccess.org

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 “algae bloom” occurs when algae populations grow quickly and reach high abundances. Algae 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 a mixture of acetone and methanol 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 change over the summer?

Average algal abundance across all sites (as measured by chlorophyll *a* concentration) increased dramatically starting in August (Figure 9a). The average algal abundance on August 22nd was over 2x greater than the average algal abundance in early August and over 4x greater than in June. The increase in algal abundance corresponded with the decrease in Secchi depth observed later in the summer.

How did algal abundance change over space?

Generally, algal abundance in the southwest section increased more dramatically in August compared to the northeast and mid-lake sections (Figure 9b). Average chlorophyll *a* concentration in southwest sites were 26 µg/L and 20 µg/L greater on Aug 22nd than northeast and mid-lake sites, respectively. However, there was only one site sampled from the northeast section on this date. Comparisons of algal abundance among lake sections should be made cautiously given the small number of sites sampled in some sections on some dates.

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.

How did algal abundance in 2020 compare to 2019?

As with other variables, direct comparisons of algal abundance between 2020 and 2021 is difficult due to the small number of sites sampled. Generally, algal abundance followed similar patterns in both years, increasing dramatically in mid-late summer (Figure 9c). The 2019 bloom appears to have started earlier in the summer than the 2020 bloom, while the 2020 bloom appears to have been more severe.

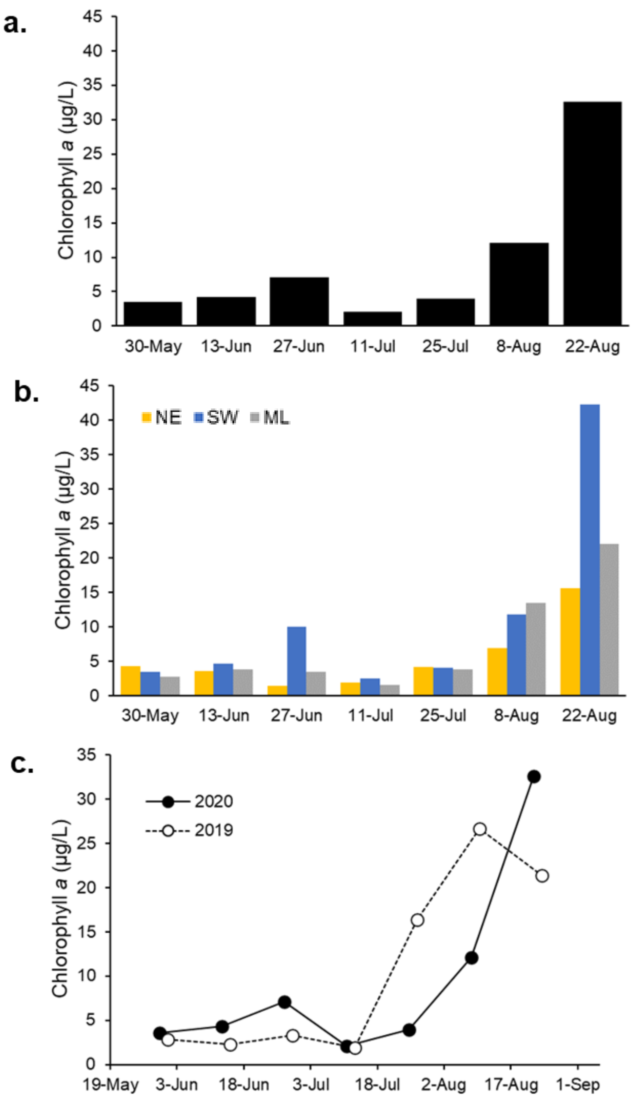

Figure 9: Average 2020 chlorophyll *a* concentration across all Wallenpaupack sites (a) and in northeast (NE), southeast (SE), and mid-lake (ML) sites (b). 2020 chlorophyll *a* concentration is compared to 2019 chlorophyll *a* concentration in Panel c. Note that not all sites contributed data on all dates and the number and location of sites sampled differ between years.

ADDITIONAL QUALITATIVE ASSESSMENT OF WATER QUALITY

Participants who recorded their data using the Lake Observer App had the opportunity to make additional qualitative assessments of water quality at their sites. These observations described their perception of the recreational suitability of the lake.

Note that not all participants used Lake Observer and not all who did chose to record these additional observations. However, these records provide insight into how the water quality of Lake Wallenpaupack was perceived by frequent lake users, many of whom own lake front property.

VISIBLE 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. 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, or blue-green algae. As a group, cyanobacteria can produce over 40 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.

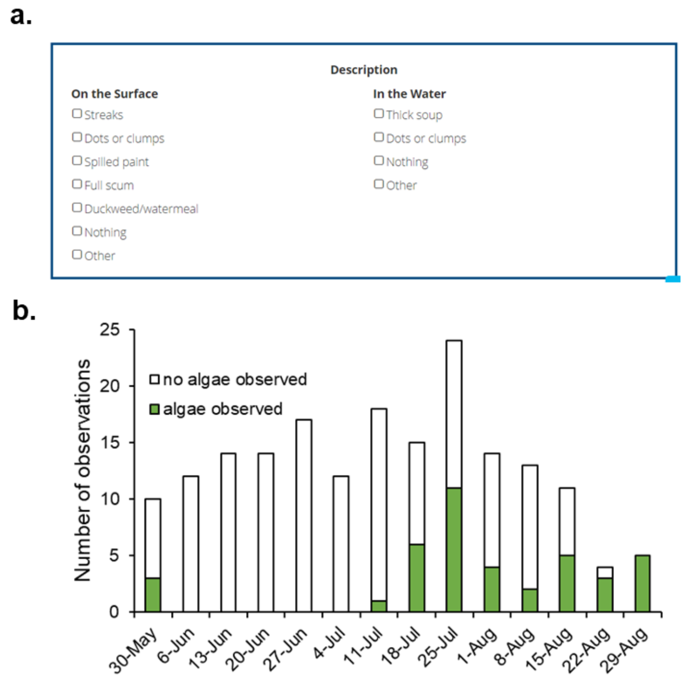

Figure 10: Description options provided by Lake Observer (a) and the number of observations describing water with and without visible algae (b). Observations include both surface and water column descriptions and may include more than one observation per site.

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 10a). Participants could select more than one option and could include a photograph.

Description of algal blooms in 2020

Participants frequently did not observe algae in the water or at the surface (Figure 10b). However, observations of visual algae were made most frequently in the later part of the summer, coincident with the increase in algal abundance measured via chlorophyll (Figure 9). It is important to note that not all participants recorded their observations and the same number of observations were not made on each date.

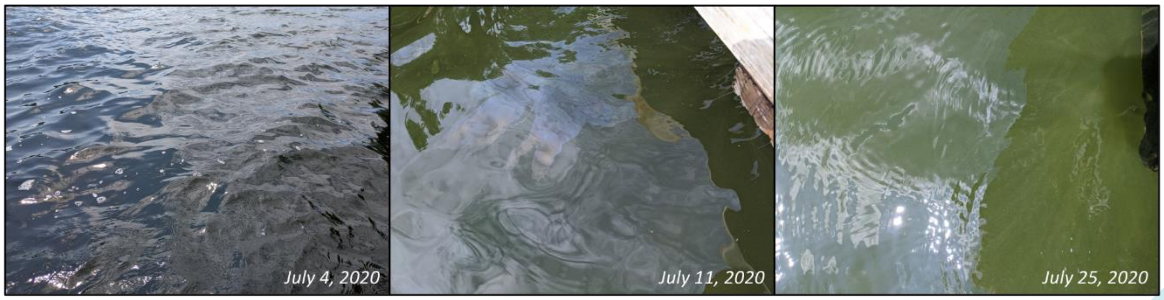

Figure 11: Photographs from a single site illustrating the change in visual assessment in algae over time.

RECREATIONAL SUITABILITY AND PHYSICAL CONDITION

Why is recreational suitability and physical condition important?

As anyone who lives near or on a lake knows, lakes are fun! And as anyone who lives near or on Lake Wallenpaupack knows, people come from all over to have fun on this lake! The appearance and physical condition of a lake can make people want to come back or can make them want to find a new lake to enjoy. Wallenpaupack is cornerstone of tourism and recreation in the Pocono region and how visitors perceive the lake can have an economic impact.

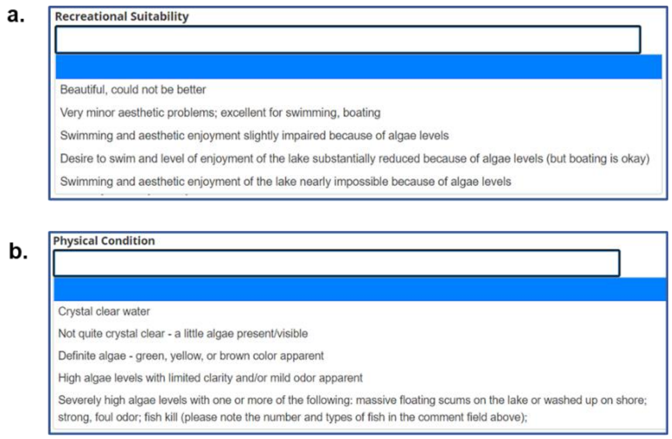

Figure 12: Description scales of recreational suitability (a) and physical condition (b) provided by Lake Observer.

How was the perception of recreational suitability and physical condition assessed?

Participants had the opportunity to record their perceptions of recreational suitability and physical condition around their site. Lake Observer provided drop down menus from which participants chose the option that best described their site (Figure 12).

Assessment of recreational suitability and physical condition in 2020

The perception of recreational suitability by participants became worse over the summer (Figure 13a). The lake was described as “beautiful” most frequently in June but rarely in August. In contrast, the lake was described as having “minor aesthetic problems” and as “enjoyment slightly impaired” most frequently in July and August. Several observations of “substantially reduced enjoyment” were made on Aug 22nd.

Similarly, participant observations describe a deterioration in their perception of the physical condition of the lake over the summer (Figure 13b). The lake was described as “crystal clear” most frequently in June and July but never in late August. Observations of “definite algae” were common in July and August.

It is important to note that not all participants recorded their observations and the same number of observations were not made on each date.

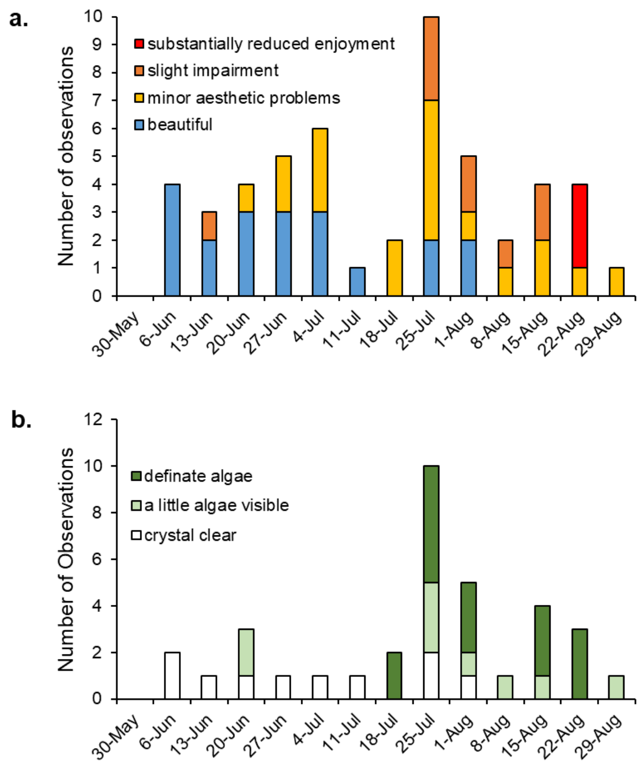

Figure 13: Descriptions of recreational suitability (a) and physical condition (b) over time. The number and location of sites observed differed among dates.

LOOKING FORWARD: 2021 WALLENPAUPACK COMMUNITY SCIENCE PROGRAM

CHANGES FOR 2021

We are exploring several modifications to the 2021 program:

- Participants will continue to be able to enter their data using their smartphones or computers via the Lake Observer App (https://www.lakeobserver.org/). Through Lake Observer, Wallenpaupack data will be a part of a global water quality dataset available to researchers and lake enthusiasts all over the world.
- Data collection will continue through September in order to better assess the duration of lake-wide algal blooms.
- We are exploring the possibility of collecting additional weather data, including precipitation and wind speed and direction.

HOW TO JOIN THE 2021 CREW

We are looking for volunteers for the 2021 Wallenpaupack Community 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 hosted by Lacawac Sanctuary. The workshop schedule is posted on the PLEON web site: https://www.lacawac.org/pleon.html. Workshops include a brief introduction to lake ecology, instructions on how to use the Lake Observer app, and hands-on training in proper sampling methods. Workshops will be held at Lacawac Sanctuary or will be offered virtually depending on the status of the COVID-19 pandemic.

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 2021 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: Beth Norman, PLEON Chief Scientist and Director of Science and Research at Lacawac Sanctuary

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570-689-9494