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Lake Oscawana 2024 Monitoring Report

Prepared for the Town of Putnam Valley, NY
& Lake Oscawana Management Advisory Committee (LOMAC)

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Executive Summary

- The seasonal clear-water phase at Oscawana occurred in late May, where water clarity at Stations 1 and 2 exceeded the 4-meter "excellent clarity" threshold. This is an important seasonal occurrence.
- Late summer and fall clarity readings were generally sub-optimal but did not fall to less than the 2-meter "poor clarity" threshold. The 2022 and 2023 seasons had worse overall clarity than 2024.
- The temperature sensor data shows higher than expected daily variability in temperature in the middle of the water column, down to about 7-meters. The reason behind the high daily temperature fluctuation at depth is unknown and should be investigated in 2025, as it has implications for water column stability and subsequent nutrient entrainment to surface waters.
- The thermocline was strong by the end of May and persisted through September 2024.
- Algae growth was prominent on the temperature sensors around ~5-6m deep. Higher cyanobacteria cell counts were also confirmed in deeper water layers with a 6m sample taken on July 30, 2024. Cell counts on this sample were 119,317 cells/mL, indicating cyanobacteria use of deep-water nutrients near the anoxic boundary. If certain weather patterns occur, deep-water layers of cyanobacteria could migrate to surface waters and result in public health concerns from shoreline accumulations.
- Anoxia in 2024 was generally less severe than in 2023.
- Specific conductivity increased in the deeper waters as the summer progressed, concurrent with increased nutrients and internal loading.
- Fluorometry algae pigment monitoring was explored at Oscawana in 2024. Preliminary results indicate the CHL and PC measurements are very useful for estimating algae biomass in real time throughout the water column. Fluorometry pigment monitoring should continue in 2025 to relate algae cell counts to in-situ fluorometry. Fluorometry has high error and interference possibilities, and AWS plans to compare in-situ 2025 readings to freeze-thaw samples, similar to the methods used by the EPA Region 1 monitoring collaborative.
- Epilimnetic (surface waters) cyanobacteria cell counts exceeded the 20,000 cells/mL target threshold in several months, but never exceeded the World Health Organization (WHO) public health risk threshold of 100,000 cells/mL in open water. A deep-water layer of >100,000 cells/mL was documented on July 30th, but no cyanobacteria-related beach advisories lasted longer than one week.
- Water outflow was noted on each sampling visit. AWS plans to formally document the water level height in 2025, including the lake's short-term response to precipitation. A staff gauge will be installed in various locations and checked regularly.
- Aquatic plant biomass decreased in 2024; no rooted invasive Eurasian milfoil was found. Native plant coverage and density have declined considerably over the past several years due to additional grass carp stocking in 2021. Native Tapegrass (*Vallisneria americana*) is the primary remaining native submersed aquatic plant in the lake, while surface floating-leaf Waterlilies remain widespread.
- Despite reductions in aquatic plants, grass carp mortality modeling indicates that the lake should reach a steady state in the next couple of years, with the hope that the lake will slowly regain native plants without having to remove any grass carp.
- LOMAC should consider limited mechanical harvesting operations for the next two years; at the very least LOMAC can have the harvester operators provide more detail about how much plant and/or cyanobacteria mat material is being removed daily. With the carp-related plant decline, harvesting likely targets cyanobacteria mats in Wildwood Cove, but this assumption needs confirmation.
- A newly developed index for Lake Oscawana surface water quality is explained in this report. The 2024 score was 8 out of a maximum 12 points, where 12 is the best-case scenario.

Introduction

Applied Watershed Sciences (AWS) was hired to perform water quality sampling and management consulting for Lake Oscawana in 2024. Please refer to the *Basic Lake Monitoring Parameters Descriptions* in the Appendix for a refresher on lake terminology and general explanations of the various monitoring components.

In-situ profile measurements were taken using calibrated probes at 1-meter increments from top to bottom of the water column at three stations. Temperature, dissolved oxygen (DO mg/L), and dissolved oxygen percent saturation (DO%) were the primary monthly profile parameters; other profile parameters measured throughout the season included specific conductivity (SPC), pH, and algae pigment fluorometry. The algae fluorometry provided values for total chlorophyll (CHL) and total phycocyanin (PC) in both relative fluorescence units (RFU) and as calculated µg/L concentrations using an YSI concentration model internal to the meter.

Water samples were collected from four distinct depths in the water column at the deep hole site (Station 1): 1 (top), 4, 6, and ~9.5m (bottom). Top and bottom water samples (1m and ~7m) were collected from Station 2 and 3.

Samples were all tested for total phosphorus (TP). Total nitrogen (TN) was tested on St1 samples. Ammonia nitrogen (NH_3) was only tested in bottom water St1 samples on select late summer dates.

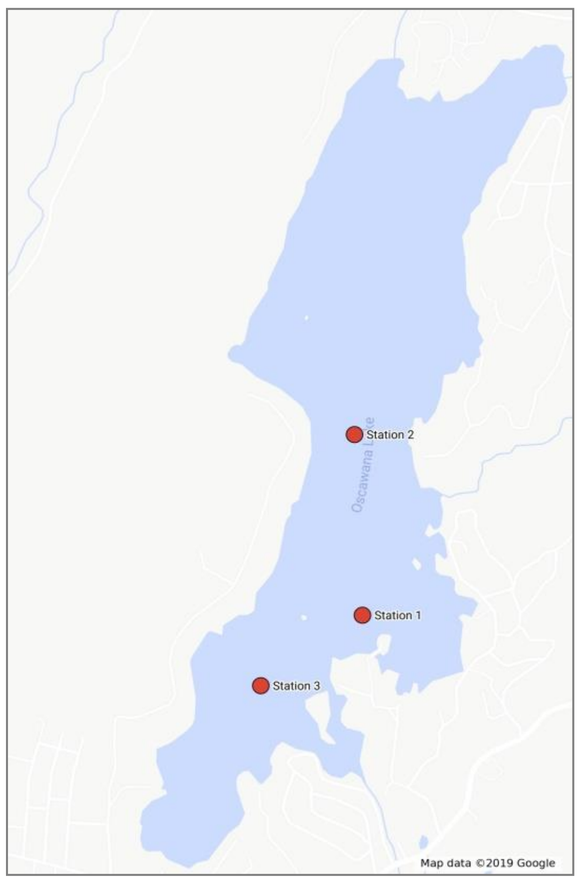
Station 1: The "Deep Hole" is approximately 35-ft deep and is the primary water quality monitoring site. The St1 temperature buoy and line of sensors was placed in 2023 and 2024 slightly north of the deep hole site, out of the main navigation channel but still in 33ft of water.

Station 2: The northern monitoring station is located in approximately 27-ft of water.

Station 3: The southern station is also located in roughly 26-ft of water and represents water quality near some of the most populated and disturbed areas of the lake.

All water quality monitoring stations are too deep to support the growth of aquatic plants. All stations experience a loss of oxygen from late spring to late summer in bottom waters. At specific points during the season, the three sites have differed substantially depending on variable lake conditions.

Map 1. Sampling Sites



Water Clarity

Data collected in 2024 is displayed below. All measurements were taken with a view scope. The March clarity was poor at all stations. The late May 2024 measurements at all Stations were good; the 4m "excellent clarity" threshold was reached for Stations 1 and 2 during the seasonal clear-water phase. Clarity was reduced considerably from the beginning to the end of August. The late summer and fall clarity hovered around the 2m target threshold. Secchi measurements less than 2m at Oscawana indicate high algae turbidity and high likelihood for cyanobacteria blooms.

Figure 1. 2024 Water Clarity (Secchi Measurements in meters)

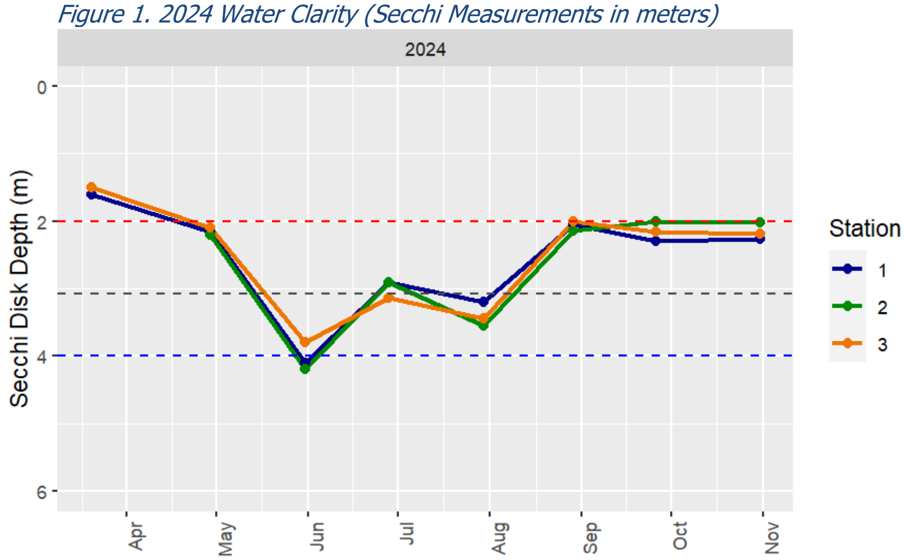


Figure 2. 1995-2024 Box Plots compared to 2024 Values by Station (black triangles)

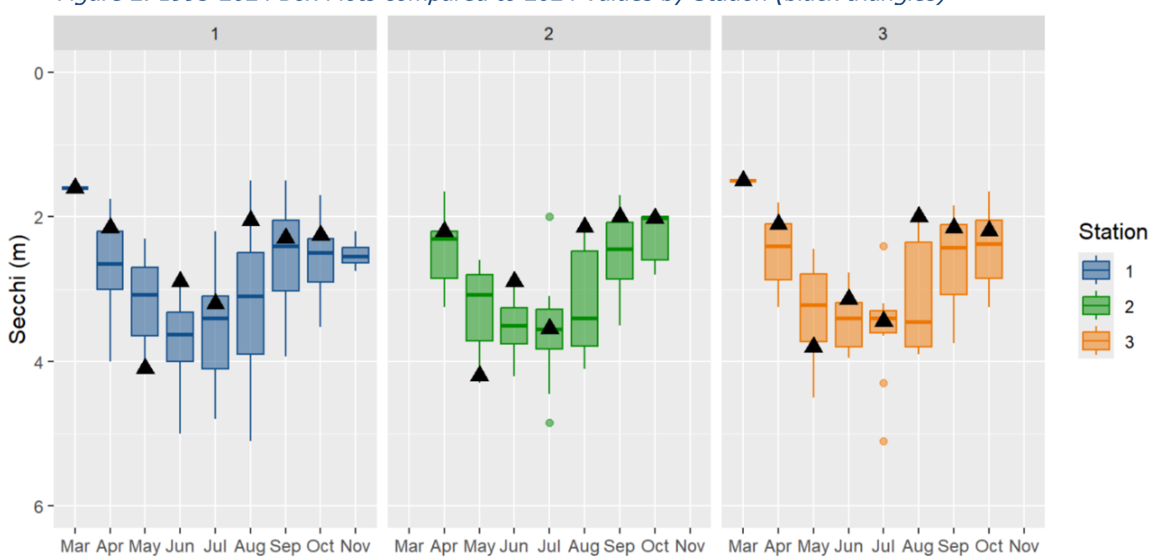
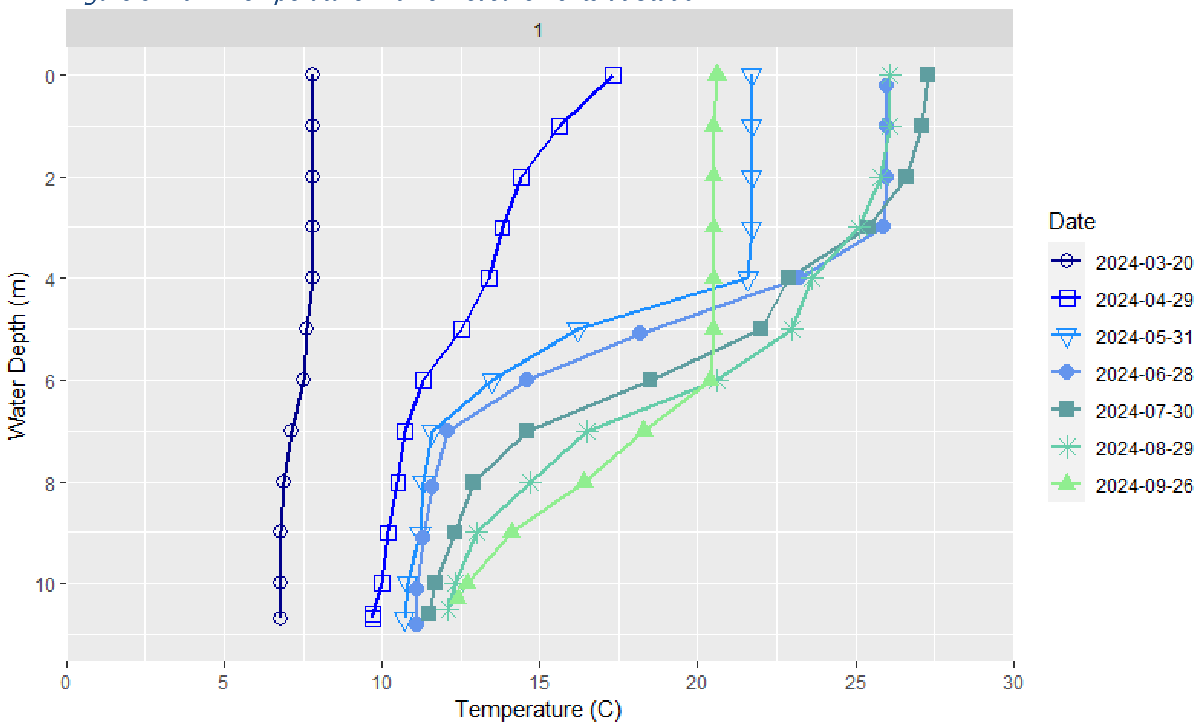


Figure 2 demonstrates that 2024 Secchi clarity was worse than the long-term monthly average (mean) in all months except May. The 2024 June and August clarity at all stations was within the 25% worst clarity for these months (1995-2024 data). Still, no summer or fall values were worse than the 2-meter target threshold established for Lake Oscawana. Summer clarity was worse in 2022 and 2023. Comparing the 2024 Secchi values to the historical range from the past decade alone did not significantly alter the boxplot comparison.

Temperature

The 2024 water temperature profiles measured at Station 1 are shown in Figure 3. Profiles show that the lake was thermally mixed during the late March sampling visit. The lake had begun to thermally stratify by the end of April. The surface waters reached their maximum temperature in mid-July, exceeding 30°C for a short period, as shown by the continuous temperature logger sensor data (Figure 4). Peak summer surface temperatures were similar to 2023. The lake cooled considerably by September, with a deepening of the thermocline and uniform temperature between the surface and approximately 6 meters.

Figure 3. 2024 Temperature Profile Measurements at Station 1



In addition to the monthly profile measurements, continuous temperature data loggers were deployed at various depths to record water temperature every hour at the deepest location in the lake at Station 1. Sensors were deployed on the April 2024 monitoring visit and serviced twice throughout the season. On the late September monitoring date, multiple temperature sensors were not connecting to Bluetooth due to considerable bio- and chemical fouling on several of them. Therefore, AWS decided to remove the sensors in late September.

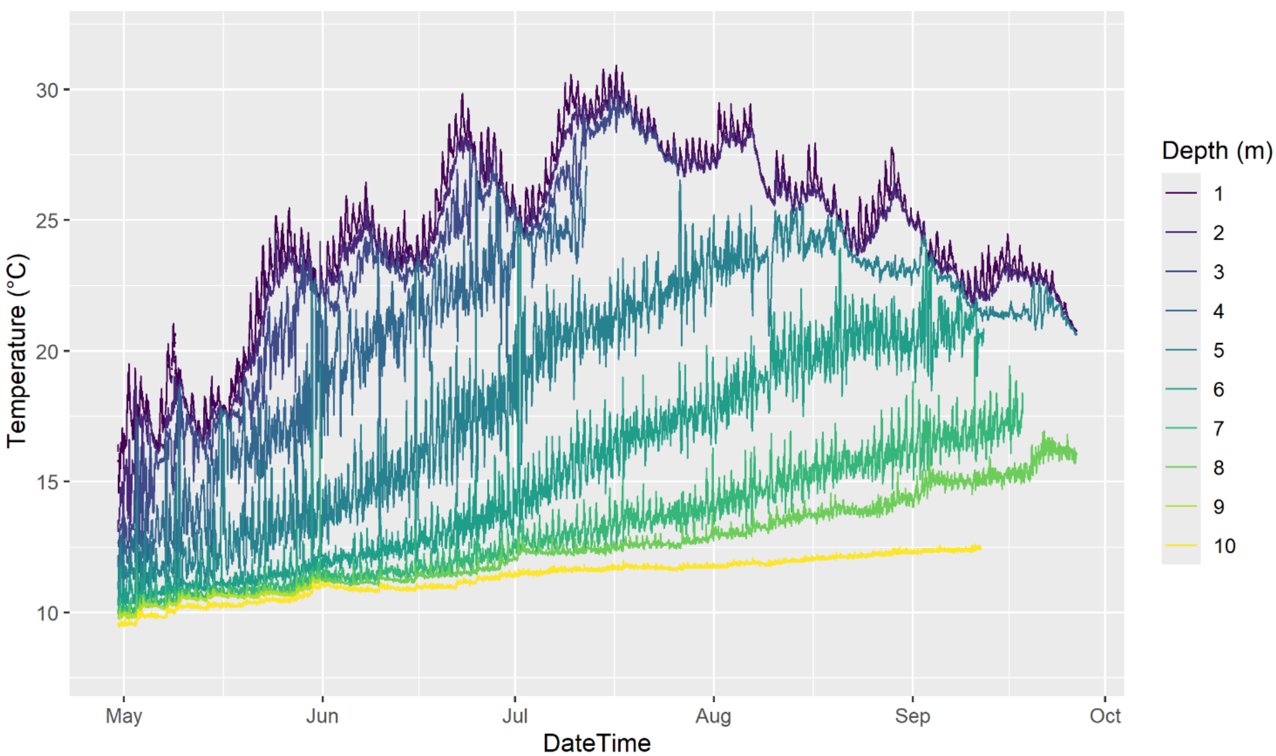
Photo 1. Sept 26th: 10m temperature sensor iron-sulfide coating

The sensors needed to be cleaned and dried before the batteries were changed. AWS recovered data for most sensors through the beginning of September, but considerable water infiltration was evident on one of the sensors (9m depth). Iron-sulfide precipitate was found on the surface of the hypolimnetic sensors, indicative of anoxic water with very low oxidation-reduction potential. Algae growth was most prominent on the metalimnetic sensors (middle of the water column, ~5-6m deep), indicating the potential for deep-water algae layering.

Figure 4 shows the temperature sensor array data for 2024. Slight temperature stratification was present for the entire time sensors were in the water in 2024. By the end of September the lake had yet to reach full water column mixing conditions. The full turnover event likely occurred in October.

The temperature sensors data shows two partial water column mixing events, down to 6-meters, in August. The temperature data also shows considerably more daily variability in temperature in the middle of the water column, down to about 7-meters, than AWS has observed at other water bodies in similar depth ranges. The reason behind the larger-than-anticipated daily temperature fluctuation at depth is unknown. It could be that the Station 1 site is heavily influenced by near-shore thermal bars, where warming of nearby shallow waters occurs much more rapidly and dramatically on a daily basis. Warmer temperatures from thermal bars can travel laterally and affect open waters at Station 1. The large daily temperature fluctuation could also result from long wind fetches at Station 1.

Figure 4. 2024 Temperature Data Logger Results



In early May, surface temperatures were around 16-18°C, but as summer progressed, they steadily increased, reaching a peak of approximately 30.8°C on July 14th. The spring clear-water phase corresponded to the rapid warming of surface waters in late May and diatoms sinking out of the surface waters at the onset of temperature stratification.

Dissolved Oxygen

The first 2024 monitoring date on 03/20/2024 already showed some reduction in hypolimnetic dissolved oxygen (DO in mg/L). Anoxic water was present below 8 meters by the end of May. The peak period of anoxia was later in the season than normal, at the end of August. The anoxia in late July was lower in the water column than it normally is around this time period, potentially due to weather and high winds extending the depth of oxygen mixing.

Figure 5. Dissolved Oxygen Monthly Profile Measurements 2024

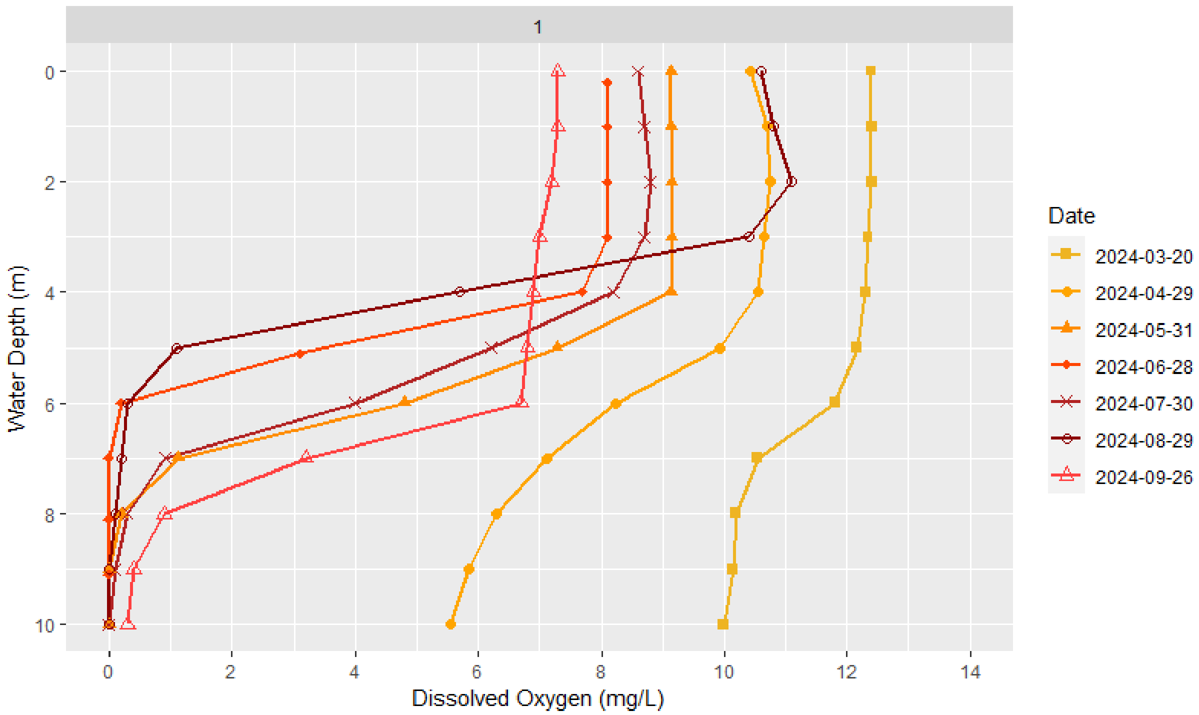
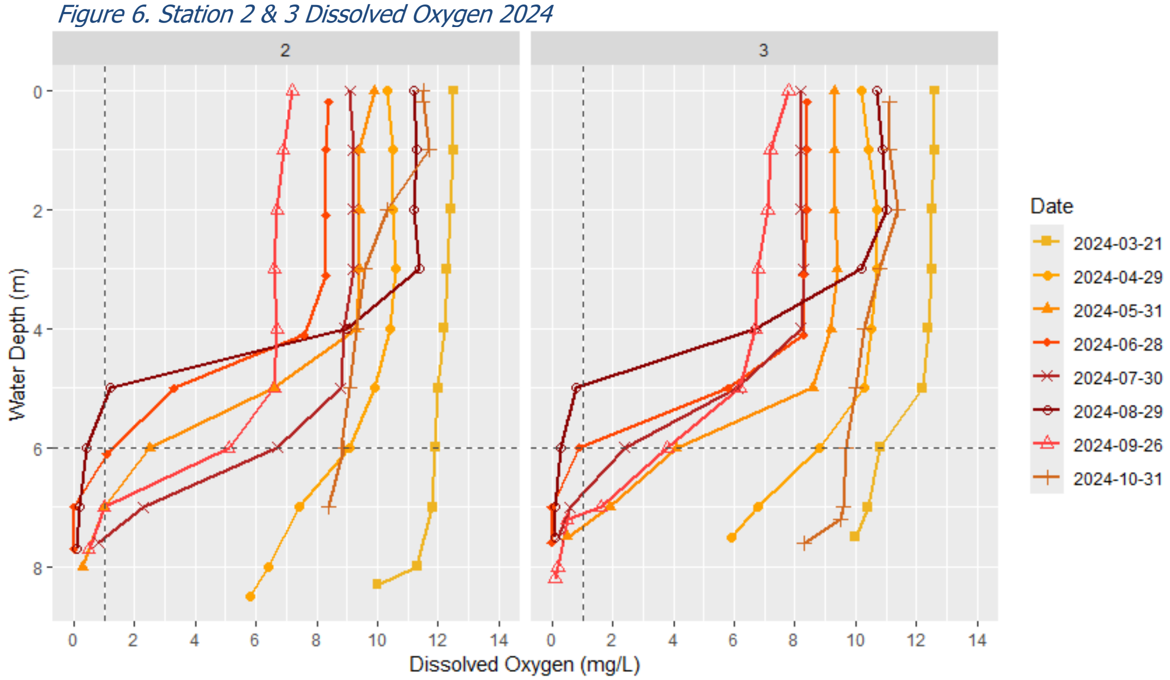


Figure 6. Station 2 & 3 Dissolved Oxygen 2024



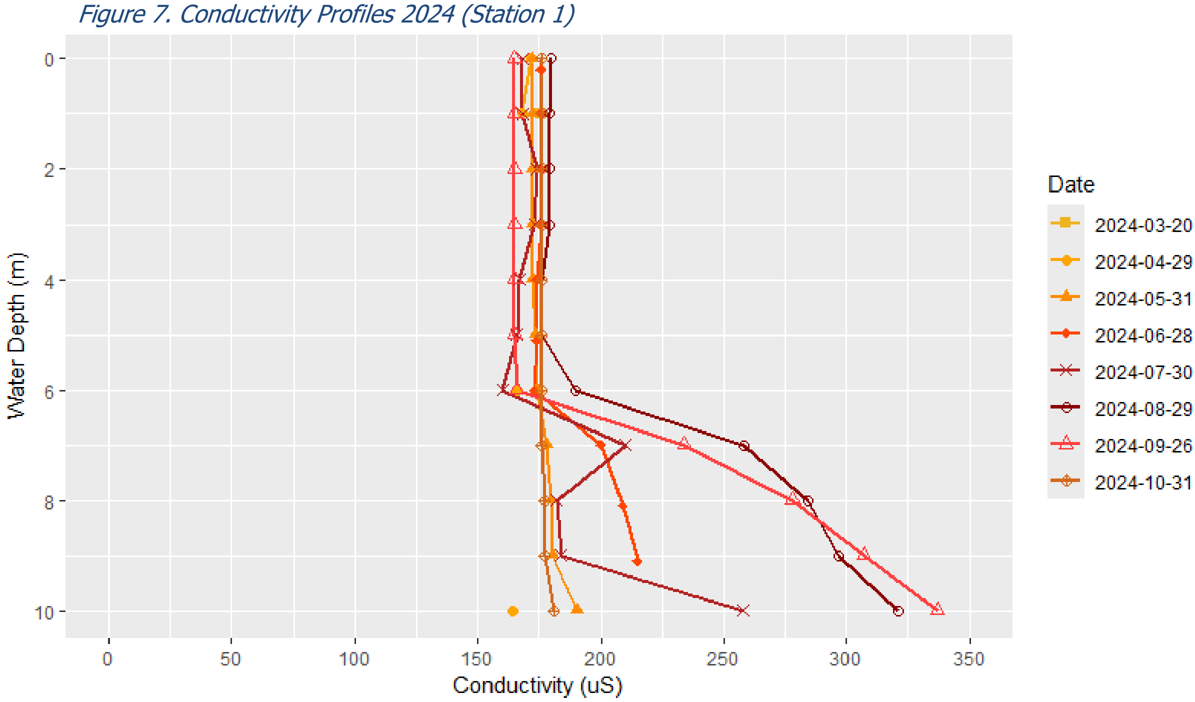
Specific Conductivity

Specific conductivity was measured as a profile measurement at Station 1 throughout 2024. The data shows a seasonal hypolimnetic increase in conductivity at the same time as anoxic bottom-water conditions. From 2018 to 2024, the surface (0-1m) conductivity at Oscawana ranged from about 165-325 µs, a large range for lake surface measurements. Most historical surface measurements were greater than 225 µs, and there was a considerably lower range in surface measurements in 2024 compared to other years. At this time, there is not enough data to determine long-term trends in surface water conductivity. It is likely that surface water conductivity increases dramatically just after fall water column turnover.

Background conductivity concentrations are dependent on the soils and geology of an area. Conductivity is also related to road-salting and salt runoff from watersheds. It is also sometimes associated with septic system leachate. Many northeastern lakes are experiencing increases in conductivity over time, but that is not clear at Oscawana. The range of values measured at Oscawana is not concerning for aquatic life. In lakes with less direct surface water runoff and low development, surface conductivity is usually reduced after rainfall. The opposite tends to be true for urban lakes with more significant runoff. A range of +/- 30 µS in surface waters across a season is expected.

Despite uncertain long-term trends in surface water conductivity, each season where conductivity profiles were measured had a distinct increase in hypolimnetic conductivity in summer, as was seen in 2024. The bottom-water (8-10m) summer (August and September) conductivity range was about 284 to 375 µS.

Figure 7. Conductivity Profiles 2024 (Station 1)



pH

The pH profiles measured at Lake Oscawana in 2024 were considered normal. In summer, pH values greater than 8 on the surface may result from increased phytoplankton and photosynthetic consumption of dissolved CO_2. Cyanobacteria can both cause and thrive in high >8.5 pH conditions.

Understanding the seasonal pH range from the top to the bottom of the water column is particularly important if any in-lake phosphorus binding treatments were to be considered in the future. Historically, the NY Department of Environmental Conservation (NYSDEC) has not permitted such in-lake treatments, but various pilot projects were done in recent years, and NYDEC may begin to allow more phosphorus-remediation treatments in the future. The pH of a lake dictates the potential dosage buffering requirements of any future aluminum-based phosphate binding treatments. It is also essential to monitor real-time pH during any such future treatment.

The 2020 Lake Oscawana Management Plan did not include phosphate binders as part of the remediation recommendations for various reasons that have been previously discussed with LOMAC, but if NYSDEC were to open a regular permitting pathway to use various phosphate binding products in NY lakes, it would be worth considering as a future in-lake management option. The NYDEC is still reviewing the relative successes of the pilot projects from 2019-2022, and no formal review report or permitting guidance has yet been released.

In addition to pH monitoring, additional alkalinity samples should be measured in 2025. Alkalinity samples were taken many years ago at Oscawana, but at least the top and bottom St1 summer samples should be tested in 2025. Alkalinity is reported in mg/L of calcium carbonate.

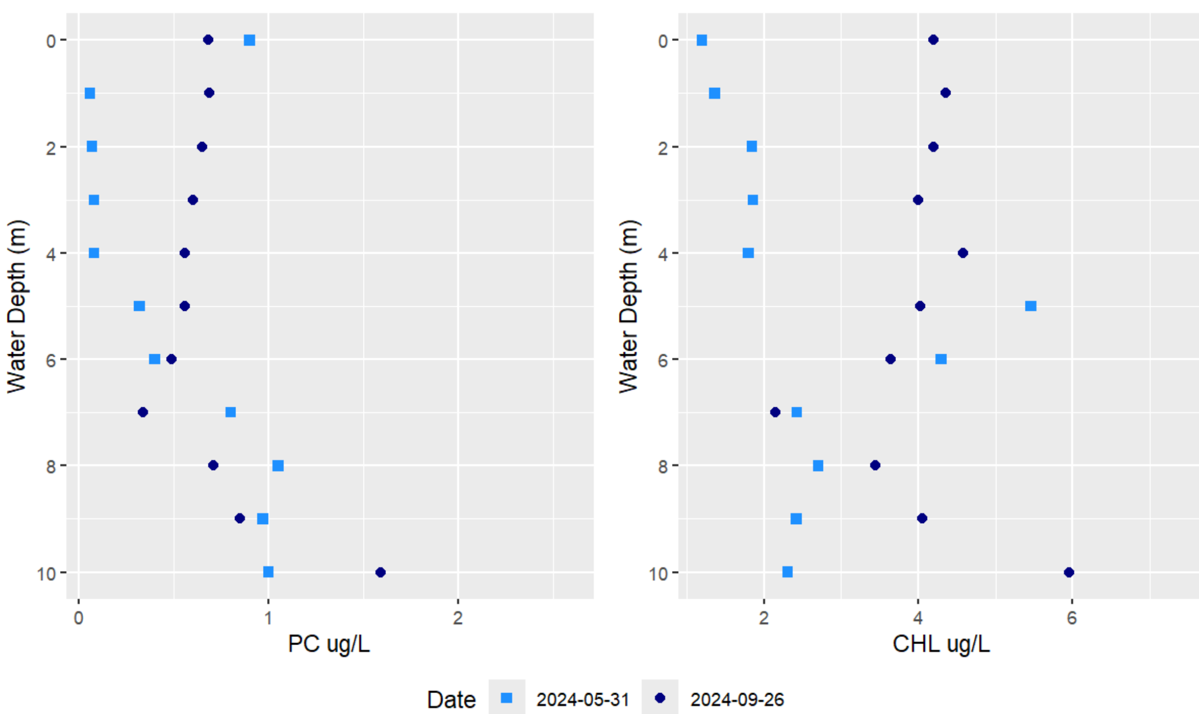
Figure 8. 2024 Station 1 pH profile measurements

In-situ Algae Pigments

Algae fluorometry monitoring was done using a YSI dual-pigment algae probe and meter. This probe provided in-situ values for total chlorophyll (CHL) and total phycocyanin (PC) in both relative fluorescence units (RFU) and as calculated µg/L concentrations using an YSI concentration model internal to the meter. In-situ fluorometry is typically considerably lower than filtered and frozen spectrophotometry lab results for CHL or PC, because freezing samples lyses the algae cells to release additional pigment. The in-situ CHL fluorometry results are not directly comparable to lab-tested CHL-a thresholds, often used to establish a waterbody's trophic state (alongside TP and water clarity). PC is a pigment that is produced by freshwater cyanobacteria. The in-situ fluorometry can provide relative qualitative information about phytoplankton in the water column. Elevated PC fluorometry can also serve as an early indicator for cyanobacterial blooms.

Cyanobacteria blooms often begin lower in the water column in layers, or evenly distributed throughout, before migration to the surface to form scums. PC monitoring can pick up deep layers of cyanobacteria if they are present before surface blooms occur. PC data from 2024 at Oscawana were fairly low throughout the water column (<2µg/L). Additional monitoring will be required before developing accurate PC thresholds for concern for Oscawana. AWS has noted bloom conditions with a high likelihood of cyanobacteria cell counts >100,000 cell/mL corresponding to 8-12 µg/L PC at other waterbodies. The CHL fluorometry was more than 2x higher at the end of September than the late May sampling date across most water depths. Both dates had a CHL water column peak in the metalimnion and a peak in both PC and CHL in September at the lake bottom. The peak at the lake bottom may be caused by the inference of organic matter and colloidal iron-sulfide near the sediment surface. In-situ fluorometric CHL > 5µg/L also indicates strong potential for dense phytoplankton, including some cyanobacteria. Fluorometry monitoring should continue in 2025 at least twice per year at St1, and in the event of a visible cyanobacteria bloom or surface scum along shore.

Figure 9. In-situ St 1 Total Algae Sensor Fluorometry for Phycocyanin (PC) and Chlorophyll (CHL)



Plankton

Phytoplankton

Phytoplankton samples are collected as integrated samples from the top three meters of the lake in open water at Station 1. Identification and cell counts are done via microscope at the lab post-sampling. Viewers should note that Diatom algae and Dinoflagellate cells are typically much larger than cells of Cyanobacteria and some Green algae. Therefore, a smaller number of Diatom cells can correlate to reduced water clarity. In some cases, particularly in spring, high amounts of organic and inorganic debris in the water column impact clarity similarly to the phytoplankton.

Algae cell counts allow for monitoring the presence and quantities of cyanobacteria. The World Health Organization and US Environmental Protection Agency provide guidance on cyanobacteria exposures and toxins presence. The consensus is that when cyanobacteria cell counts are less than 20,000 per mL, the risk of cyanotoxin recreational contact exposure is low. AWS has also observed that when open water cell counts are less than 20,000 cell/mL of cyanobacteria, there is a considerably reduced likelihood of onshore surface scums formation. It is the shoreline surface accumulations of cyanobacteria that are the greatest risk for swimmers, particularly children and pets. If the water in a swim area is generally clear of wind-blown surface accumulations, the risk of cyanotoxin exposure is generally low.

Table 1 demonstrates that Diatoms were present throughout the year, but that they were most dominant in March, April, June, and October. Cyanobacteria were present throughout most of the season as well. Historically, cyanobacteria increases did not occur in spring at Lake Oscawana, but warm springs seem to increase the likelihood of cyanobacteria presence over the last several years. The highest open water epilimnetic cyanobacteria cell count occurred in late August (8/29/2024) at 30,500 cells/mL, similar to what was observed in 2022 and considerably lower than the maximum cell counts from 2023 and 2021. For comparison to recent years, the 2021-2023 Northeast Aquatic Research cell count data was copied here from their 2023 report (Table 2).

Table 1. 2024 Phytoplankton Algae Counts (cells/mL by group)

2024	3/20/2024	4/29/2024	5/31/2024	6/28/2024	7/30/2024	8/29/2024	9/24/2024	10/31/2024
Cyanobacteria	672	22,500	0	2,200	22,300	30,500	21,084	8,774
Green algae	292	3,286	0	6,000	1,740	6,444	4,700	6,250
Diatoms	10,472	7,563	440	16,750	780	1,200	168	6,875
Chrysophytes	0	0	86	0	0	0	0	0
Dinoflagellates	0	0	0	250	20	20	0	0
Euglenophytes	0	0	40	0	0	0	168	0

The dominant cyanobacteria taxa present throughout the 2024 season were Planktothrix, Dolichospermum, and Planktolyngbya. Microcystis and several other taxa were also present in smaller numbers. On July 30, 2024, AWS also took a deep-water sample at 6-meters, corresponding to near top of the anoxic boundary. The 6m sample had considerably higher cyanobacteria, 119,317 cells/mL, primarily Planktothrix cells. Recent research indicates that Planktothrix, and occasionally other types of cyanobacteria can accumulate at the depth of the anoxic boundary during periods of strong thermal stratification. At this depth, the cyanobacteria are able to use deep-water nutrients that are not available in surface waters. AWS hopes that the new use of the in-situ fluorometry algae sensors (CHL & PC) will be able to track deep-water algae and cyanobacteria without additional cell counts from multiple depths.

Table 2. Northeast Aquatic Research Historical 2021-2023 phytoplankton cell count data

A) 2023	4/19/2023	5/11/2023	6/12/2023	7/12/2023	8/10/2023	9/12/2023	10/12/2023
Cyanobacteria	0	0	2,886	5,248	37,026	159,389	19,766
Green algae	0	0	160	466	292	0	0
Diatoms	4,548	2,828	467	991	1,866	350	2,362
Chrysophytes/Golden	0	0	4,374	1,020	0	0	0
Dinoflagellates	0	0	15	0	0	0	0
Euglenophytes	0	0	0	29	0	0	0

B) 2022	4/21/2022	5/31/2022	6/22/2022	7/19/2022	9/2/2022	9/27/2022	10/24/2022
Cyanobacteria	33,820	350	875	6,706	30,321	34,054	27,988
Green algae	0	0	0	2,274	0	0	0
Diatoms	9,504	9,330	19,825	2,128	7,697	0	321
Chrysophytes/Golden	292	0	0	0	0	0	0
Dinoflagellates	0	0	0	0	0	0	0
Euglenophytes	0	0	0	0	0	0	0

C) 2021	4/12/2021	4/28/2021	5/12/2021	6/11/2021	7/12/2021	8/11/2021	9/10/2021	10/14/2021
Cyanobacteria	4,927	6,531	466	379	3,557	10,262	56,647	77,114
Green algae	0	933	146	321	175	0	87	0
Diatoms	4,344	379	4,315	1,720	583	525	525	2,478
Chrysophytes	641	3,061	233	321	0	0	0	0
Dinoflagellates	0	0	0	29	0	0	0	0
Euglenophytes	0	0	0	0	0	0	0	0

Zooplankton

Rotifers have been the dominant zooplankton present in Lake Oscawana in most months. They are smaller than most other zooplankton. It is typical for rotifers to be present and potentially exceed 300 organisms per liter at Oscawana, but it is less common for the rotifers to exceed 600 organisms per liter like in 2024. Higher rotifer numbers are typically associated with more eutrophic waterbodies with lower flushing rates. Rotifers are known to respond quickly to environmental and ecological changes. They have short life spans with highly fluctuating populations. Reduction in aquatic plant biomass, extreme weather events (droughts vs. floods), and other water quality variables will all affect zooplankton populations, including rotifers. At this time no direct causative relationships can be drawn and the high 2024 rotifer counts are not overly concerning, but if dramatically higher rotifer population maximums occur again in 2025, this topic may deserve more attention.

Adult copepods were generally lower in abundance across the season than in the last few years, but copepod nauplii were very abundant at certain points in the season, potentially indicating high predation rates. Cladoceran abundance was overall moderate, but dominated by smaller size classes, mostly less than 0.5mm.

Figure 10. 2024 Rotifer Counts

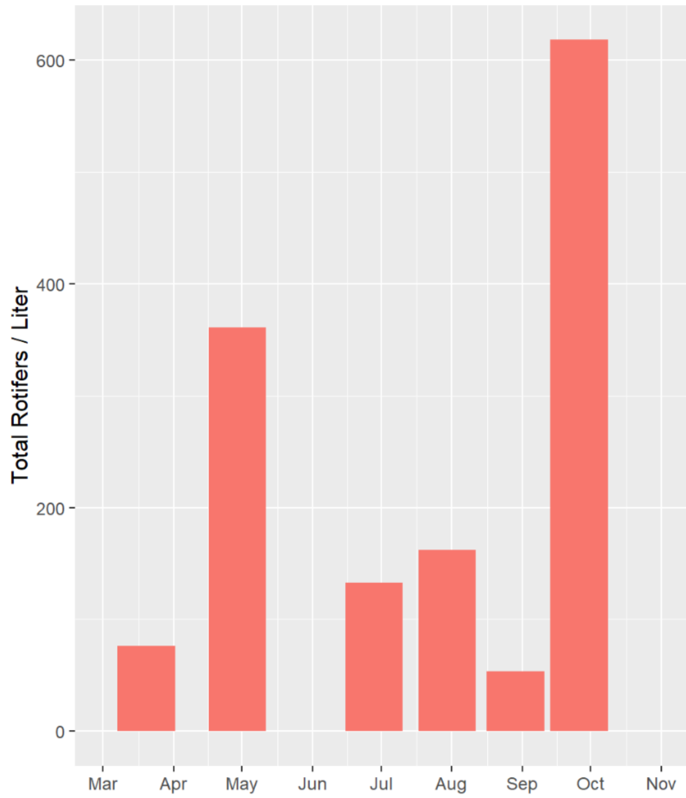
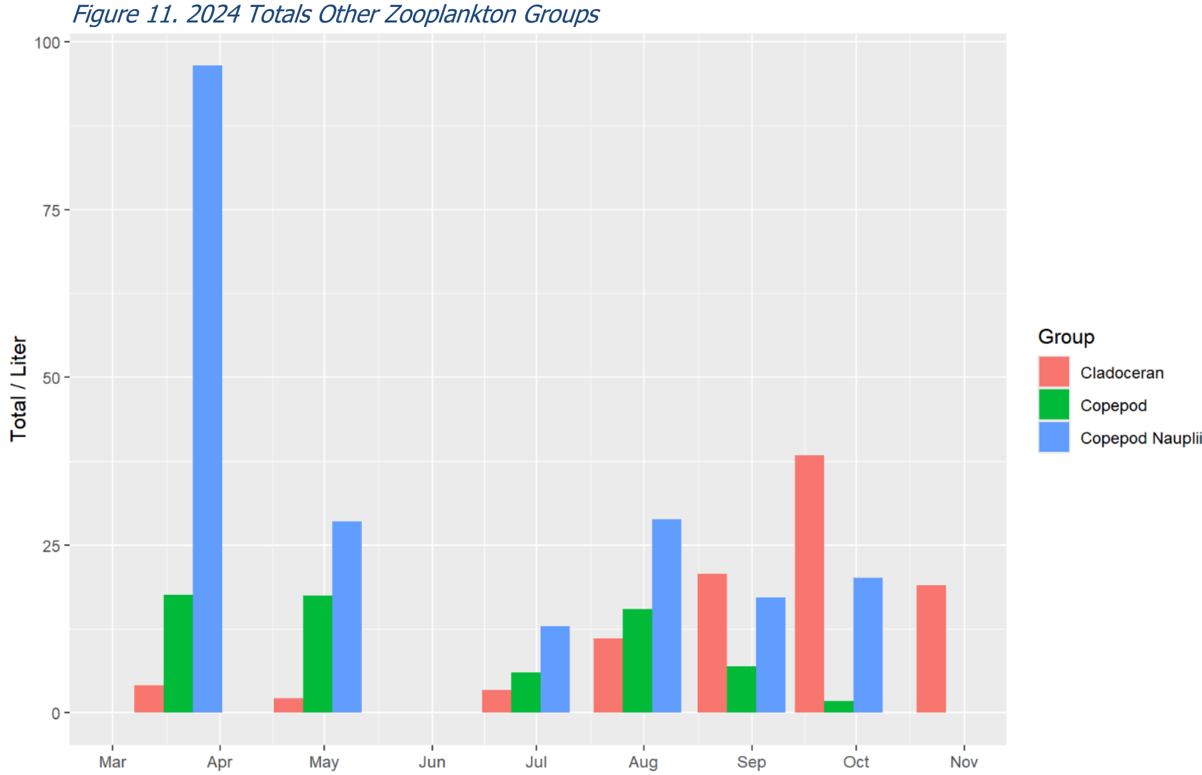


Figure 11. 2024 Totals Other Zooplankton Groups



Nutrients

Nutrient samples were collected monthly from the three long-term monitoring stations. Total phosphorus (TP) was measured at four depths at Station 1, and at the top and bottom of Stations 2 and 3. Total nitrogen (TN) was only measured at Station 1. The bottom samples were taken to remain consistently 0.5 m off the lake bottom, maintaining the same distance from the sediment surface on each sampling. In lakes that experience annual summer internal nutrient loading from anoxic sediments, like at Lake Oscawana, sampling closer to the sediment surface would yield higher TP results. Nutrient results are shown below in Table 3.

Table 3. Laboratory Total Phosphorus Concentrations 2024 (µg/L)

FIELD ID	3/20	4/29	5/31	6/28	7/30	8/29	9/26	10/31
Station 1								
St1 1 m	22	16	16	13	12	25	45*	13
St1 4 m	22	20	17	53	13	35	28	32
St1 6 m	21	21	31	149	86	57	26	24
St1 ~9.5-10 m	31	40	48	568	963	1209	1638	23
Station 2 & 3								
St2 1 m	25	20	18	20	12	25	31	27
St2 ~7-7.8 m	23	28	54	168	157	166	291	27
St3 1 m	30	17	35	20	17	23	33	31
St3 ~6.5-7.1 m	23	24	44	242	348	299	315	32

[Concentrations displayed in µg/L, ~ppb equivalent; NSS = Not Sampled, ND = Not Detected (below laboratory detection limits; *uncertain if laboratory error or true value, field duplicate not tested on this date]

Figure 12, below shows a generally increasing trend in surface TP concentration in surface waters over time since the early 2000s, despite a high overall concentration range throughout a season. The horizontal dashed lines indicate the range of TP expected for mesotrophic lakes (10-20 ppb, µg/L). When surface TP exceeds 20 µg/L (ppb) there is an increased risk of algae and cyanobacteria blooms. It is common for surface TP to exceed 20 µg/L in early spring at Lake Oscawana, due to a combination of high spring watershed loading and winter anoxic loading under prolonged ice cover. Late summer to fall high surface TP at Oscawana is typically related to internal sediment nutrient loading, as can be seen with a dramatic increase in bottom-water (6-10m) TP that occurs before increases in surface TP in late August and September (Table 3).

Figure 12. Long-term Surface Total Phosphorus (1-meter depth)

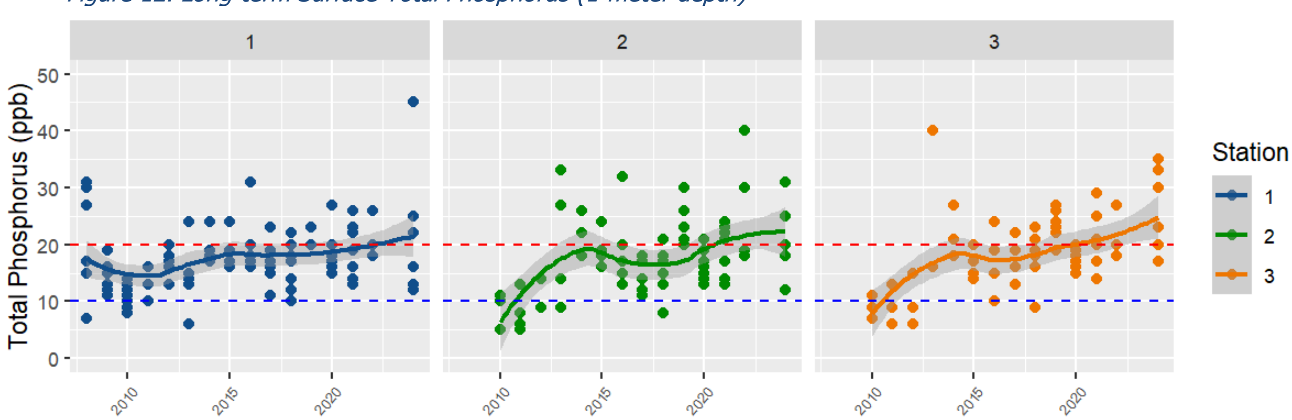


Figure 13. Surface Total Phosphorus 2023-2024 Comparison

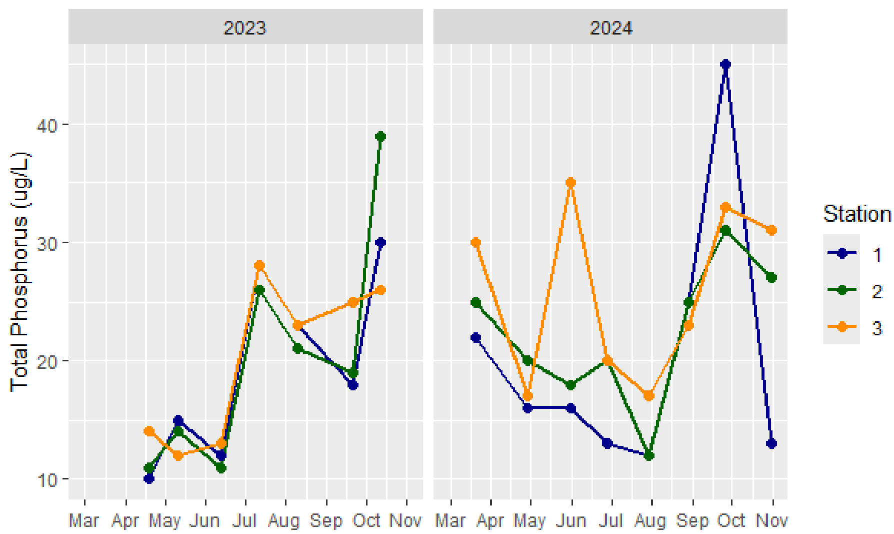
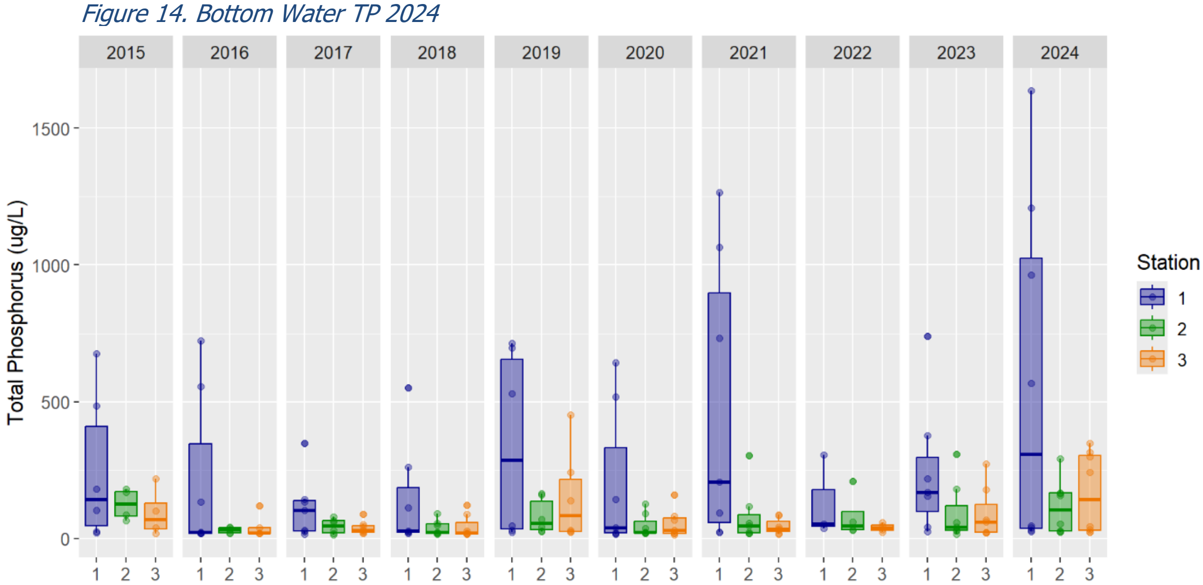


Figure 13, above, compares the surface (1-meter) TP at all three stations across the last two seasons. The pattern of TP change across the season was very similar for Stations 1 and 2, but there was more variability at Station 3 in 2024. At Station 1 and 2 there was high TP in spring, followed by a steady reduction in surface TP as the lake stratified through the end of July. In August, the lakewide TP had increased considerably, above the summer target threshold of 20 µg/L. Late summer and fall TP was high, similar to 2023. Late season TP seems to have little to do with the spring TP. Over the last five years, spring TP has ranged from 10-40 µg/L, and in each respective year, the late summer TP has exceeded the 20 µg/L target threshold regardless of early season conditions. Over the last five years, surface TP has not significantly increased, and the seasonal patterns have been different year to year, indicating high dependence on weather.

Figure 14. Bottom Water TP 2024



Bottom-water TP reached very high concentrations in late summer 2024, but it appears that the majority of the phosphorus mass remained below the thermocline and did not impact surface waters as substantially as what occurred in 2023. This is often a result of unique weather events in a season.

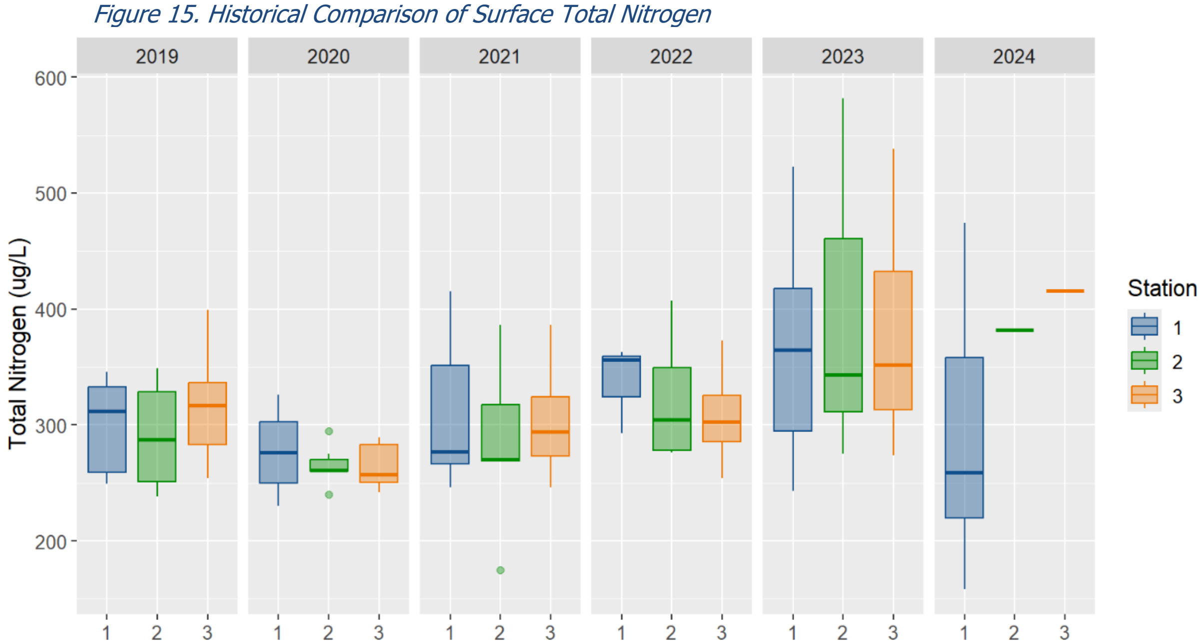
Table 4. Total Nitrogen, Station 1 - 2024

FIELD ID	3/20	4/29	5/31	6/28	7/30	8/29	9/26	10/31
St1 1 m	250	158	189	274	259	-	442	474
St1 4 m	242	166	152	291	257	-	412	408
St1 6 m	256	212	150	648	756	-	381	391
St1 ~9.5-10 m	295	-	203	1234	1723	2705	5325	481

The ammonia nitrogen (NH_3) was also tested at the bottom samples in late summer to confirm that the majority of the increase in bottom TN was a result of increasing ammonia nitrogen during periods of anoxia. Ammonia production in the bottom waters is a combined result of decomposing organic matter and a release of ammonia from bottom sediments. Bottom TN was also considerably elevated when tested at Stations 2 and 3 on the September sampling date (9/26 TN: St 2 = 1626 µg/L, St 3 = 1807 µg/L).

Compared to the past five years of TN data, the 2024 surface (1m) values were significantly lower at Station 1 (no 2024 comparison for St 2 & 3 because TN sampling at these stations was discontinued for cost savings). TN less than 200 µg/L in surface waters is excellent.

Figure 15. Historical Comparison of Surface Total Nitrogen



Inlets

AWS sampled baseflow at the inlets in April, May, July, and September, on the same dates as the in-lake water testing. The raw concentration data from 2024 is shown in the table below. Values colored red indicate that these 2024 samples had concentrations of TP or TN that exceeded the 75th percentile of the respective samples collected over the prior five years.

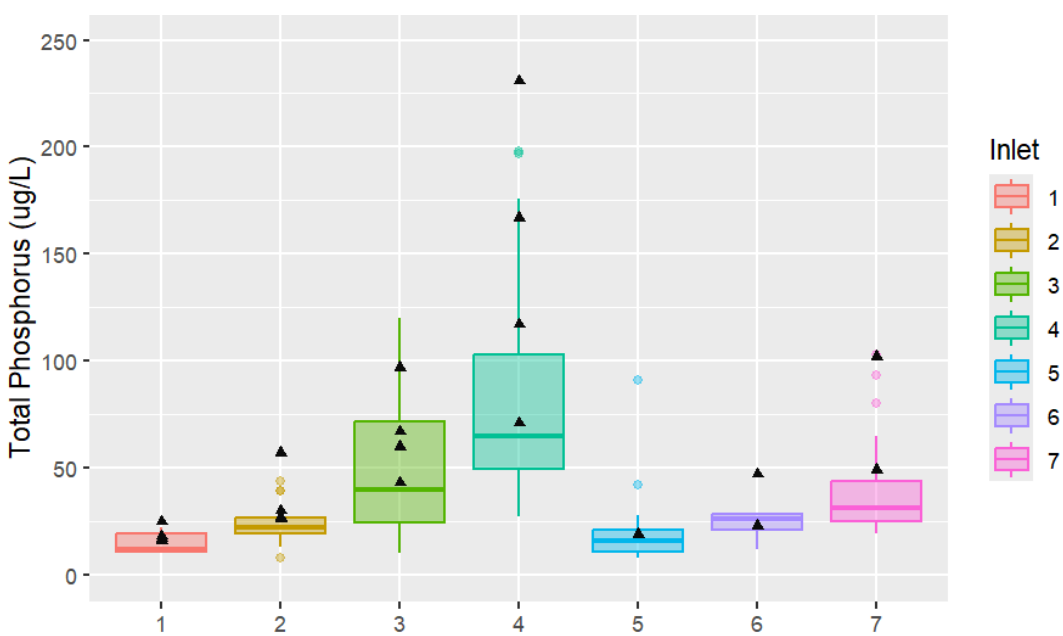
Historically, the concentration range at some of the inlets, mainly Inlets 4 and 7, have been very high. For the purposes of graphical comparison, the historical outliers where TP > 350 µg/L were removed from Figure 16. No outliers were removed from the historical TN comparison figures. Figures 9 and 10 show boxplots of data collected in 2024 as black triangles overlain on boxplots of data from 2019-2023.

Table 5. Inlet Nutrient Concentrations, TP & TN 2024

Conditions	Baseflow		Baseflow		Baseflow		Baseflow		75th percentile	
Date	**4/29/24**		**5-31-24**		**7-30-24**		**9-26-24**		**2019-2023**	
Site	**TP**	**TN**	**TP**	**TN**	**TP**	**TN**	**TP**	**TN**	**TP**	**TN**
Inlet 1	16	141	17	ND	18	366	25	416	19	456
Inlet 2	26	78	27	187	30	312	57	393	27	308
Inlet 3	43	311	60	657	67	615	97	831	72	784
Inlet 4	71	1648	117	1375	167	860	231	1525	106	2535
Inlet 5	19	ND	NF	187	NF	NF	NF	NF	21	NA
Inlet 6	23	ND	47	72	NF	NF	NF	NF	29	NA
Inlet 7	NSS	NSS	49	457	NF	NF	102	361	80	864

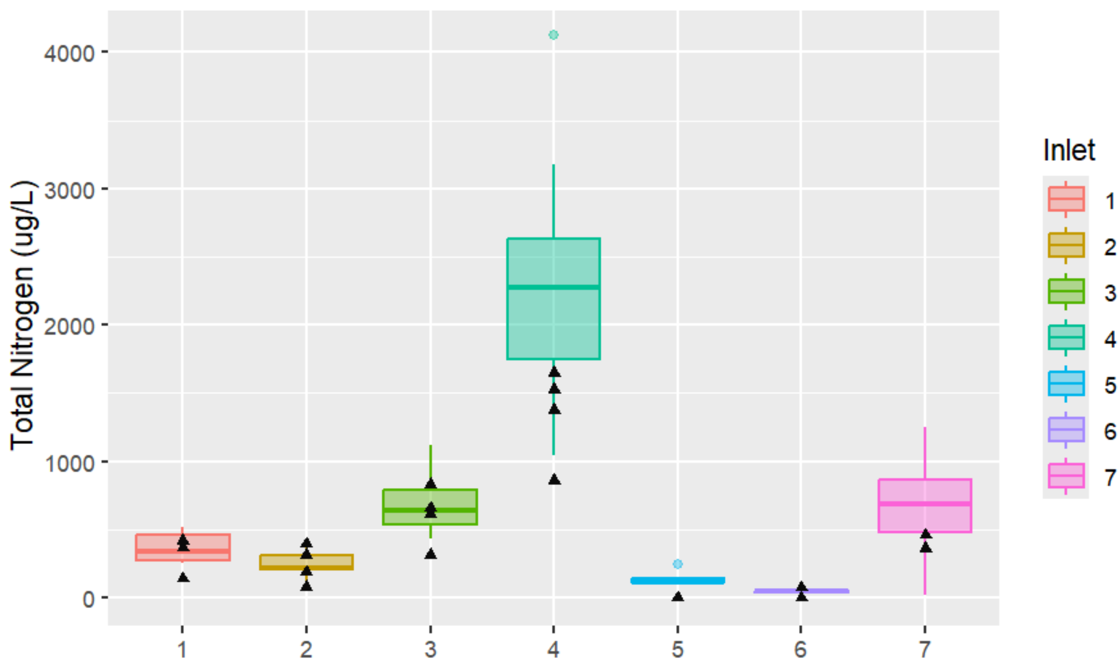
NF = Not flowing, ND = Not Detected (below limit of detection), NSS = No Sample Sent, NA = Not Enough for comparison

Figure 16. Historical Total Phosphorus Stream Data Compared to 2024 (black triangles), outliers removed



Total Nitrogen (TN) 2019-2023 boxplot inlet comparisons are shown below. In contrast to the 2024 TP results, the TN for Inlets 1, 2, and 3 were all within the normal moderate range for the past five years of data. Inlets 5 and 6 did not have sufficient TN samples to make a meaningful comparison over the last five years, as TN levels at these sites were frequently below the laboratory's limit of detection. Both Inlets 5 and 6 are small streams that also dry up for a large part of the summer. While TN at Inlet 4 is still considerably higher than at the other sites, the 2024 results were significantly lower, and all were below the 25th percentile of the 2019-2023 TN concentrations measured at this site. The recently updated septic systems in the upper watershed of Inlet 4 likely drive concentration reductions at this site. In general, TN concentrations greater than 1000 µg/L indicate upstream fertilizer or septic system impairment. It could take another several years for Inlet 4 TN to fully respond to upstream septic improvements, as soils reach a new equilibrium.

Figure 17. Historical Total Nitrogen Stream Data Compared to 2024 (black triangles)



Post-storm E. coli bacteria samples were taken at Inlets 3 (upper and lower sites), 4, and 7 on April 3rd. These sites have had, historically, the highest TN concentrations, and also tested positive for very high E. coli in recent years. The upper Inlet 3 site is at Oscawana Lake Road, above the horse farm. Inlet 3 lower site is off of Lost River Road below the farm, where there was a recent considerable stormwater management construction project underway at the time. The Inlet 4 E. coli sample was collected at the road as the stream goes under Lee Ave. The Inlet 7 E. coli test was taken at Lake Front Road, just north of the High Street intersection. Results are included in the table below. Given the stormwater sampling conditions, these values are fairly low. Only the Inlet 4 result exceeds guidance from the public health department, but the values are considerably lower than what had been previously measured at this site in 2019-2022, before the health department ordered a septic upgrade higher up in the watershed.

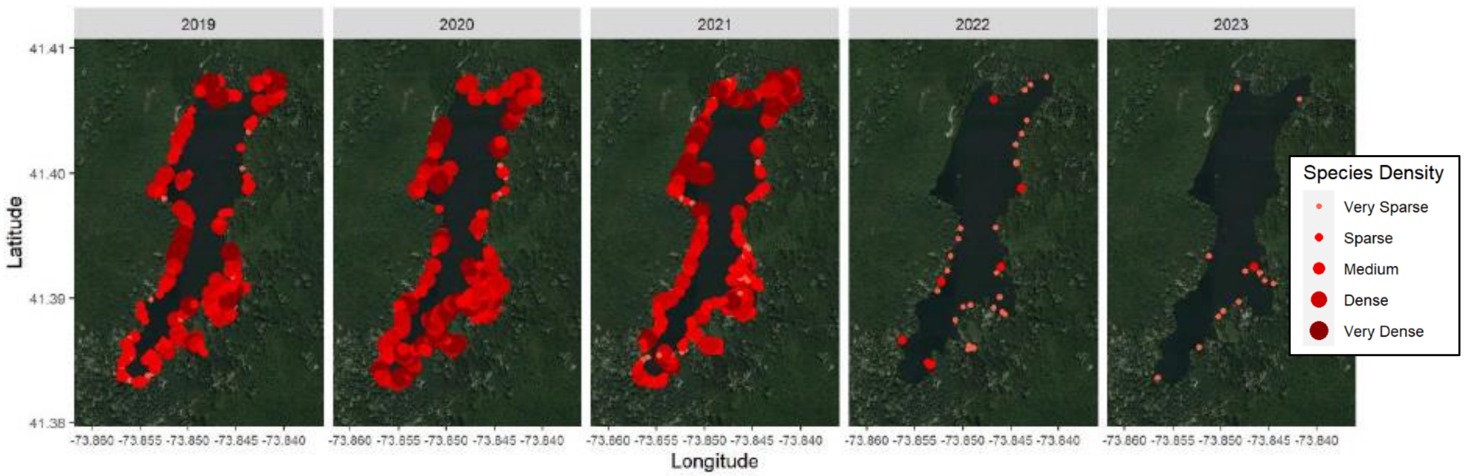
Table 6. Inlet E. coli Test Results, April 3, 2024

Sample ID	Parameter	Result	Method
Oscawana Inlet 3 upper	E. coli	71.7 MPN/100mL	SM9223B-2016
Oscawana Inlet 3 lower	E. coli	34.5 MPN/100mL	SM9223B-2016
Oscawana Inlet 4	E. coli	178.5 MPN/100mL	SM9223B-2016
Oscawana Inlet 7	E. coli	52.1 MPN/100mL	SM9223B-2016

Aquatic Plants

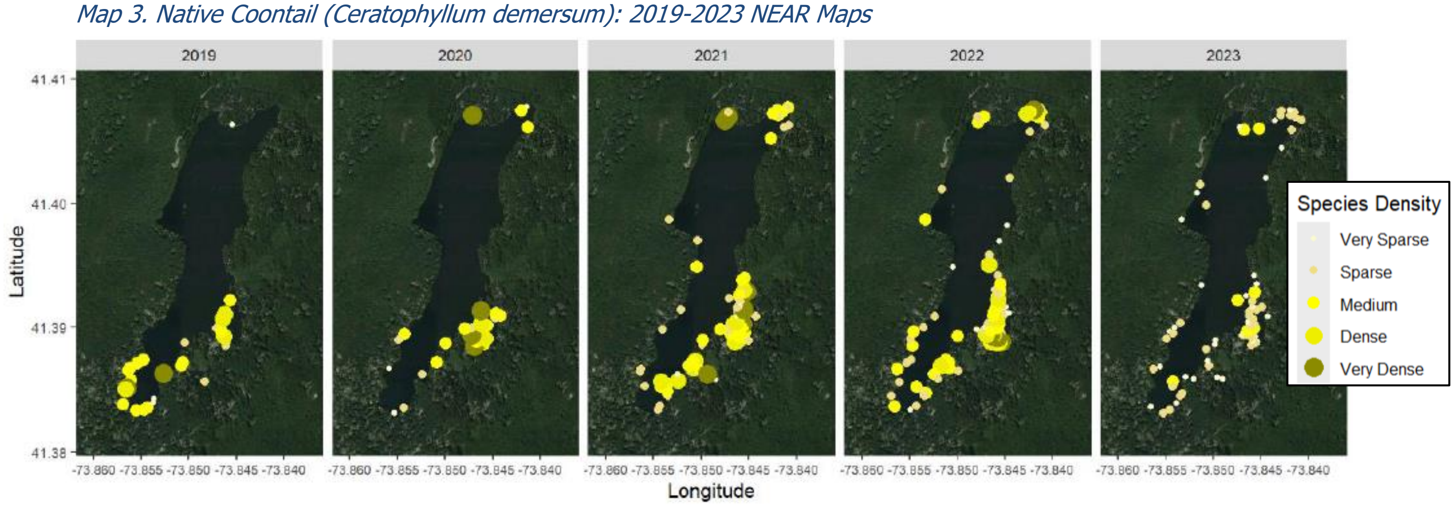
The following maps from 2019 through 2023 replicate the aquatic plant survey data, as mapped by Northeast Aquatic Research (NEAR) in their 2023 annual report. Please note that Hillary Kenyon was the primary surveyor on these plant surveys at NEAR from 2019 to 2022 but not in 2023. The relative continuity of these surveys increases confidence in comparability over time. The GPS points in 2019 were used as the core survey waypoints for every year, with a few additional waypoints added as needed. Frequency percentages are based on the core 278 survey waypoints.

Map 2. Invasive Eurasian milfoil: 2019-2023 NEAR Maps

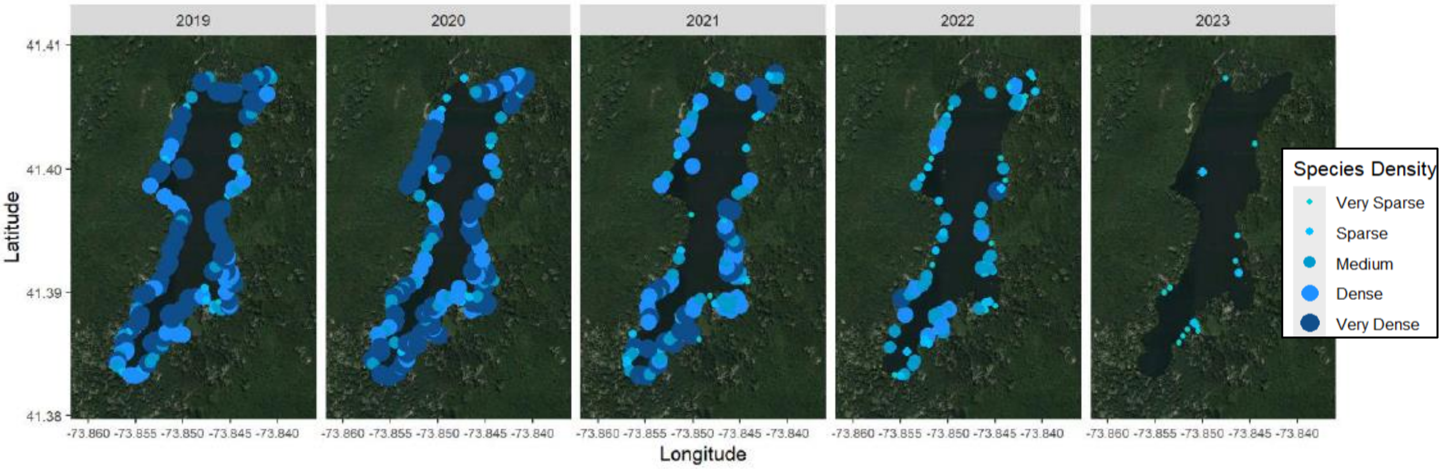


AWS found no rooted Eurasian milfoil in the lake during the 2024 plant survey. All milfoil is presumed to have been eaten by Grass carp. AWS noted a couple of milfoil plant fragments floating at the surface, so it is likely that milfoil regrowth is occurring but that carp are actively eating the milfoil before the plants become detectable. If the grass carp were removed in the near future, it is likely that invasive milfoil will become reestablished after a period of time. Additional discussion on this topic is provided in the recommendations section of this report.

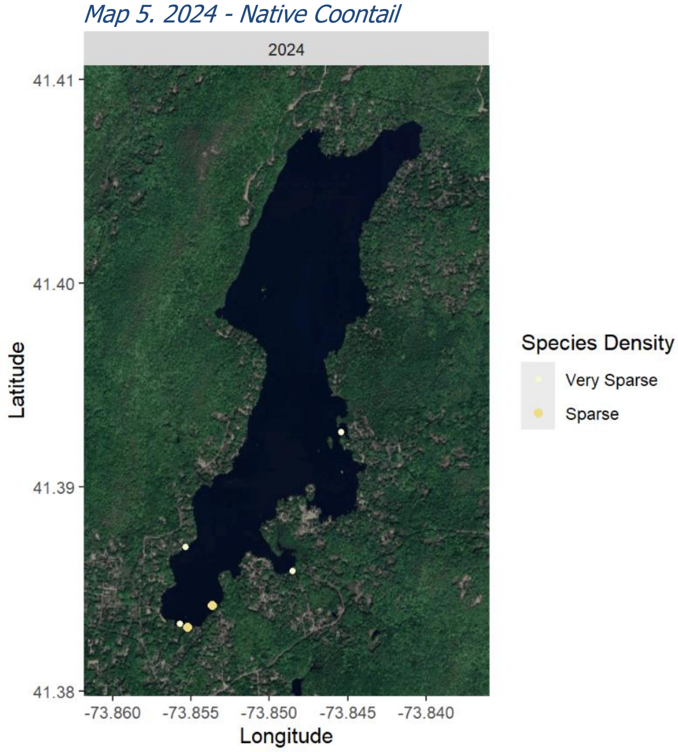
Map 3. Native Coontail (Ceratophyllum demersum): 2019-2023 NEAR Maps



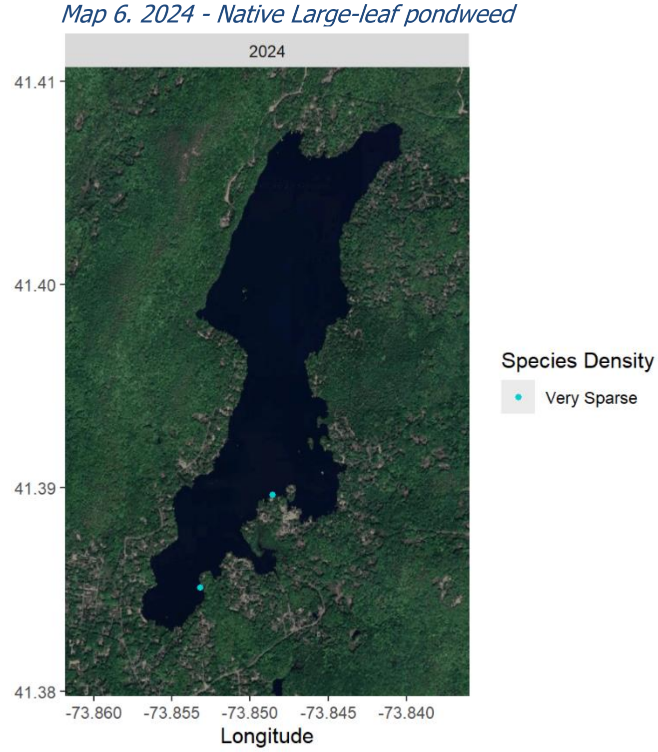
Map 4. Native Large-leaf pondweed: 2019-2023 NEAR Maps



Map 5. 2024 - Native Coontail



Map 6. 2024 - Native Large-leaf pondweed

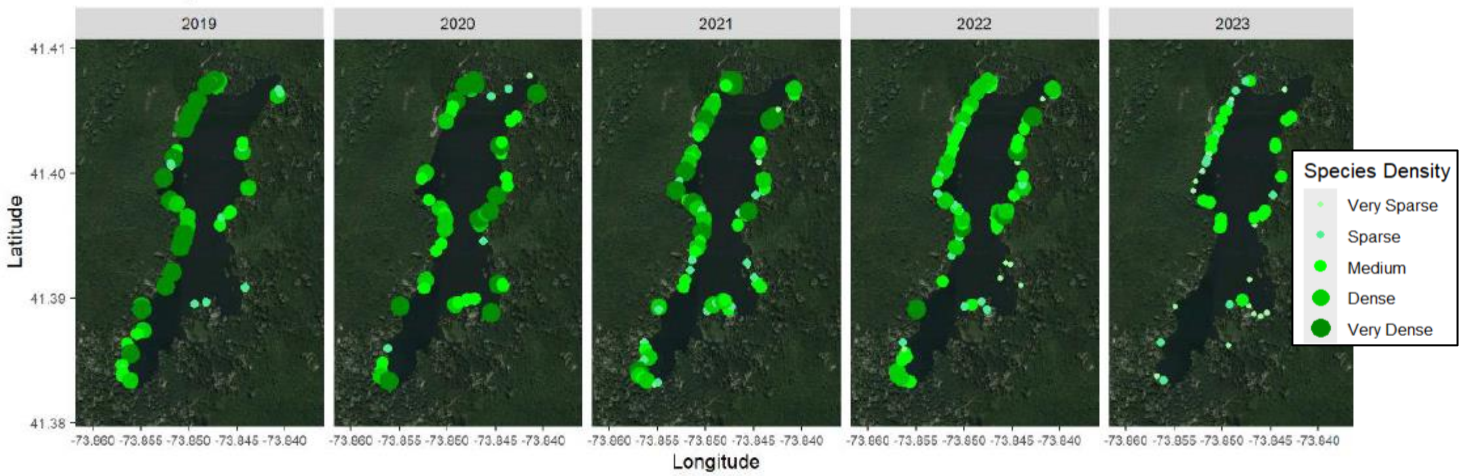


The 2024 maps above show the decline in native Coontail and Large-leaf pondweed.
There were only about six general locations where Coontail was found in the lake in 2024 and only two areas where Large-leaf pondweed remained in 2024. In 2021 and 2022 it appeared that Coontail was replacing other species because it is less palatable to Grass carp. However, as the carp have fewer choices for species, they seem to have eaten most of the lake's Coontail as of 2024. The decline in these native plants opens up the lake's littoral zone to increased filamentous algae growth, including harmful benthic cyanobacterial mats. Reduced native plant growth can eventually have implications for fish habitats that could potentially change the fisheries' size class structure and reproductive success in future years, but these changes would take years. The general scientific consensus is that existing fish will seek cover in other places when aquatic plant biomass is reduced, like rocks, docks, and along the edges of remaining water lilies. Fish behavioral changes may make it more challenging for anglers.
The dramatic decline in native Robbin's pondweed (*Potamogeton robbinsii*) in Lake Oscawana began

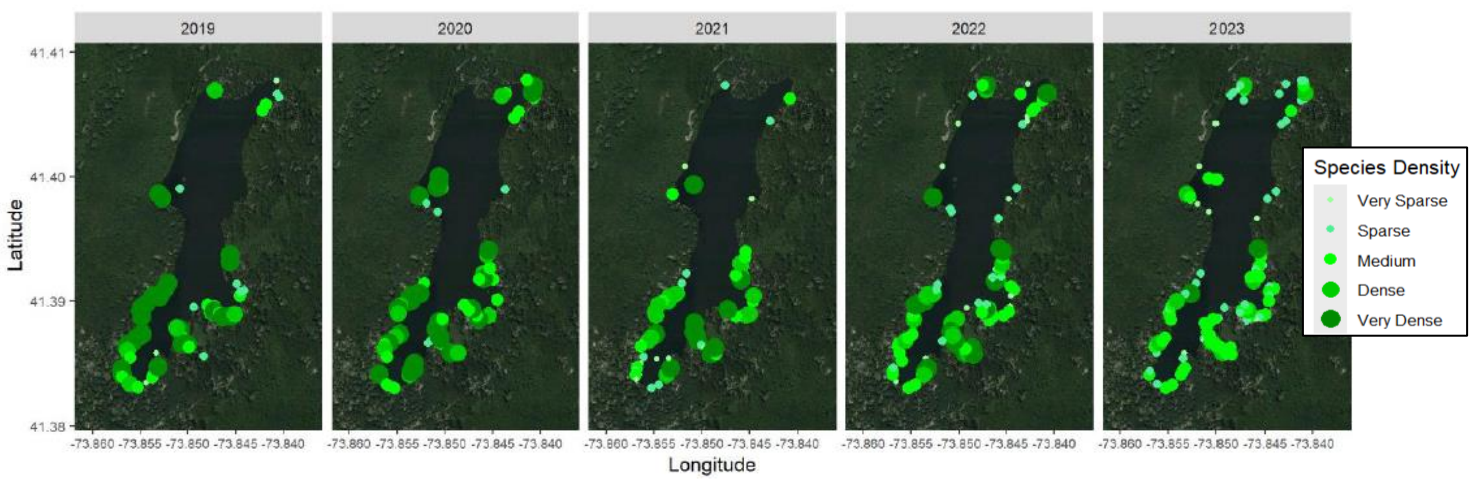
in 2020, as one of the first plant species to show decreased presence potentially related to Grass carp stocking. This species had been historically widespread, but from 2020 to 2022, it occupied only a few locations in the lake. No Robbin's pondweed was found in 2023 and 2024.

Native Tapegrass appears to have been, so far, less impacted by Grass carp than other submerged aquatic plants. This plant often occupies shallow water, growing in Oscawana in rocky and windswept areas in less than 3ft. The carp may have difficulty feeding in these high wave-action zones along open shores, permitting continued Tapegrass growth and reduced predation. The annual surveyed frequency of Tapegrass has not changed considerably, but the yearly average density across all survey waypoints has notably declined since 2021.

Map 7. Native Tapegrass (Vallisneria americana): 2019-2023 NEAR Maps

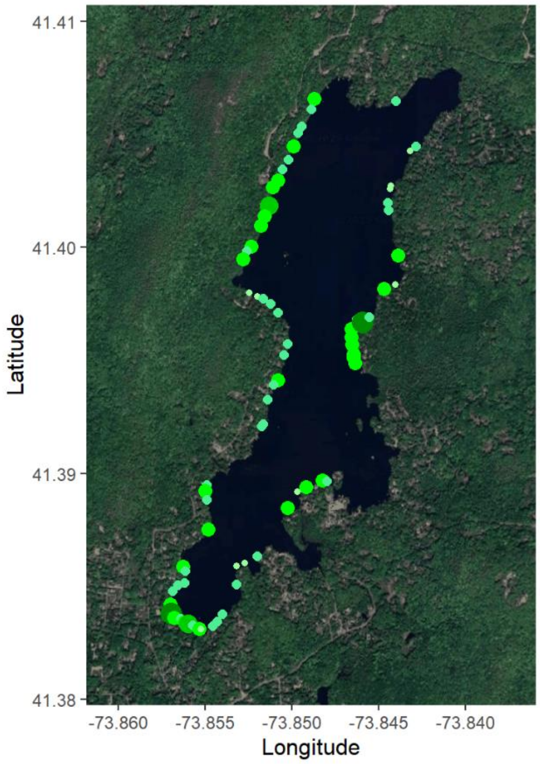


Map 8. Native White Waterlily (Nymphaea odorata): 2019-2023 NEAR Maps

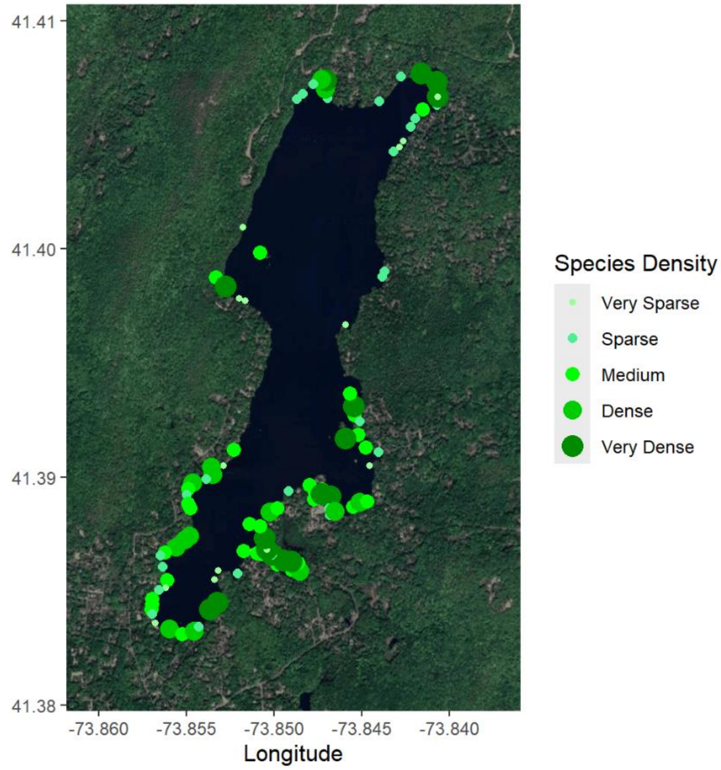


There has not been a considerable difference in the presence and density of White water lily in the past several years. This plant is generally not considered palatable by Grass carp, and it is expected that the carp will only feed on lilies once they have consumed all other submersed aquatic plant species in the lake. In cases where waterbodies may have been severely overstocked with Grass carp, White water lilies can exhibit a precipitous decline due to predation, but it is rare. If Oscawana starts to see reductions in the density and frequency of lilies in 2025, that could justify a carp removal effort.
The 2024 maps of Tapegrass and White waterlily are shown below in Maps 9 and 10.

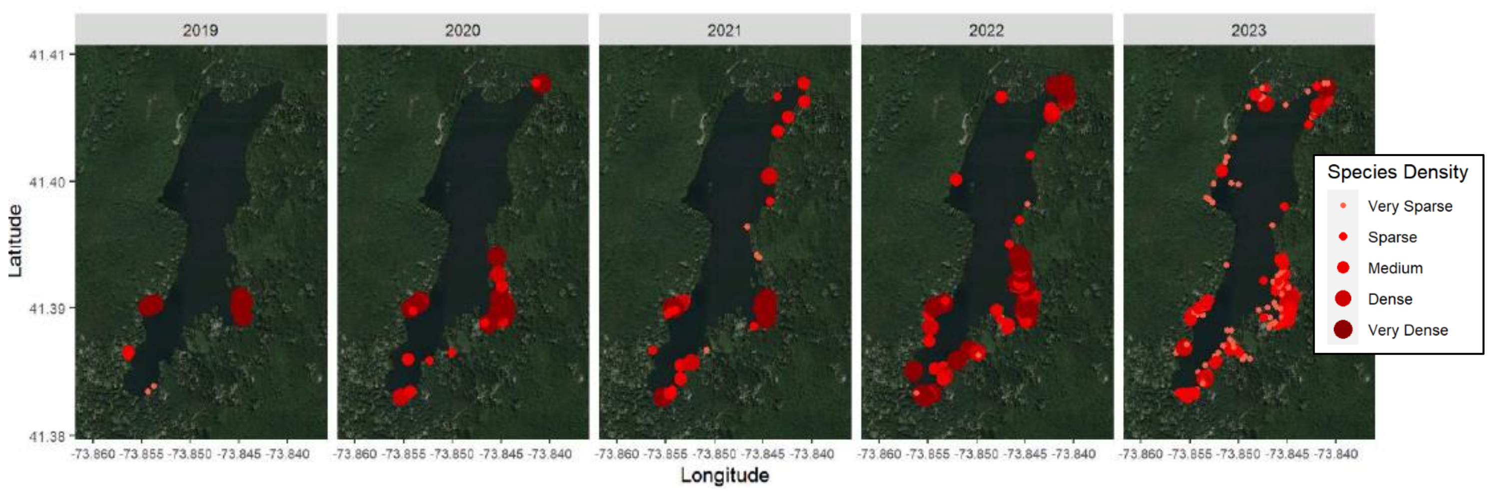
Map 9. 2024 – Native Tapegrass



Map 10. 2024 - Native White Water Lily



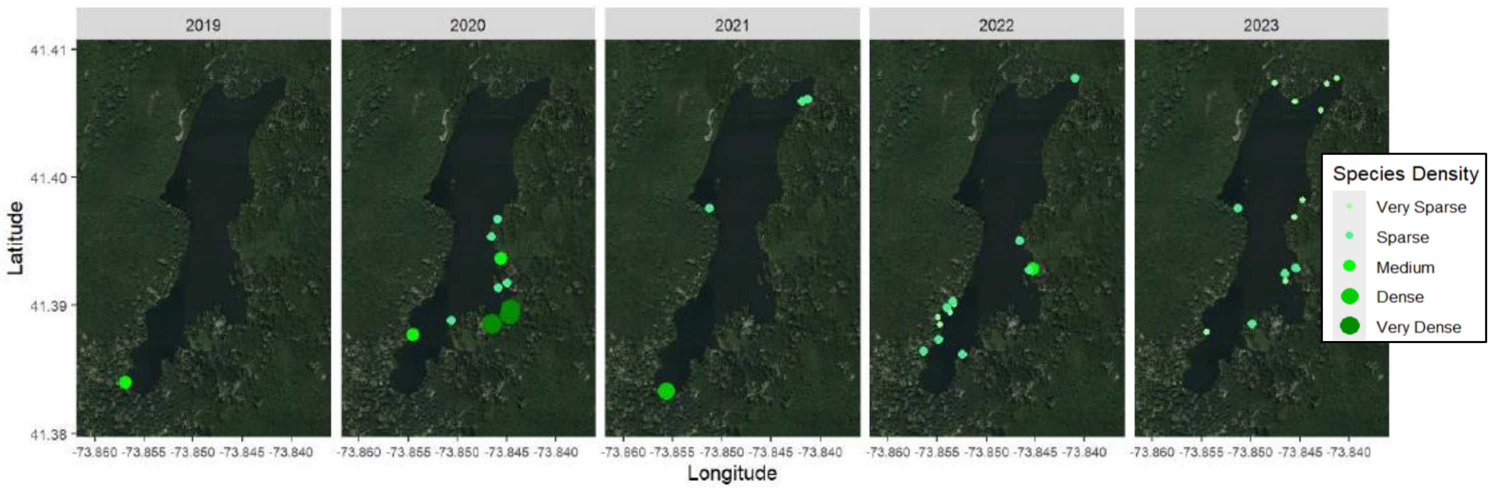
Map 11. Cyanobacteria mat: NEAR 2019-2023 Maps



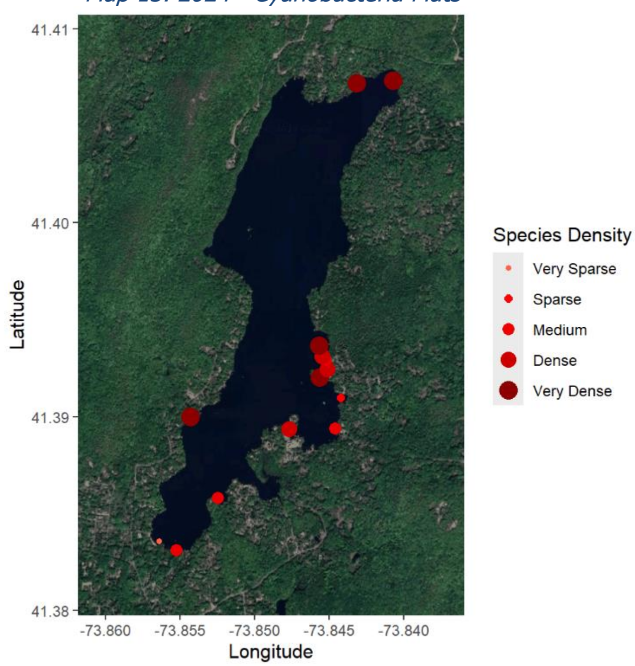
The general trend of increasing benthic cyanobacteria mats from 2019 through 2022 was concerning. The NEAR 2023 survey data suggest a similar prevalence of cyanobacteria mats but reduced density at many locations, particularly in Wildwood Cove. AWS found a lower amount of cyanobacteria mat in 2024. At this time, it is unknown if this is an actual reduction or if the mechanical harvester operator is now spending more time removing cyanobacteria mats in the absence of other submersed plants. Without mechanical harvesting, the cyanobacteria mats in the Wildwood Cove and northern coves frequently float to the surface, which tends to happen when the mats are very dense. Once the mats come to the surface, the mechanical harvester can work to remove them. AWS will make a point to check the Wildwood Cove area throughout the summer for potential changes in cyanobacteria mat density in 2025.

Green filamentous algae growth in Lake Oscawana has been variable over time. The NEAR historical maps show a dramatic increase in filamentous algae in Wildwood Cove in 2020, when there was no mechanical harvesting before the 2020 survey. As Grass carp consume more submersed aquatic plants, filamentous algae and cyanobacteria may increase in littoral zones. The green filamentous algae was denser in 2024 than in prior years. Cyanobacteria mats are easier to remove via mechanical harvesting, which may foster more green algae. Green algae, while unsightly, is not toxic or harmful to swimmers, but cyanobacteria mats do produce toxins that commonly cause rashes and skin irritation for swimmers. While uncommon, cyanobacteria mats are also toxic if accidentally ingested by humans or dogs.

Map 12. Green filamentous algae: 2019-2023 NEAR Maps



Map 13. 2024 - Cyanobacteria Mats



Map 14. 2024 - Filamentous green algae

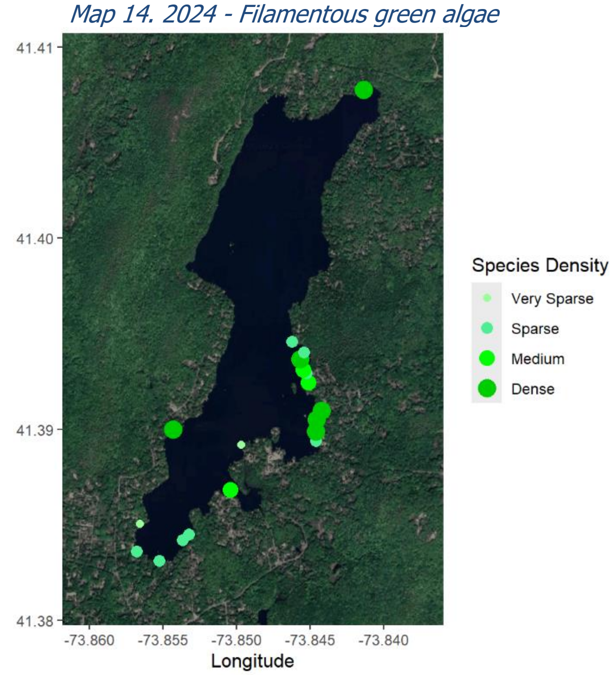
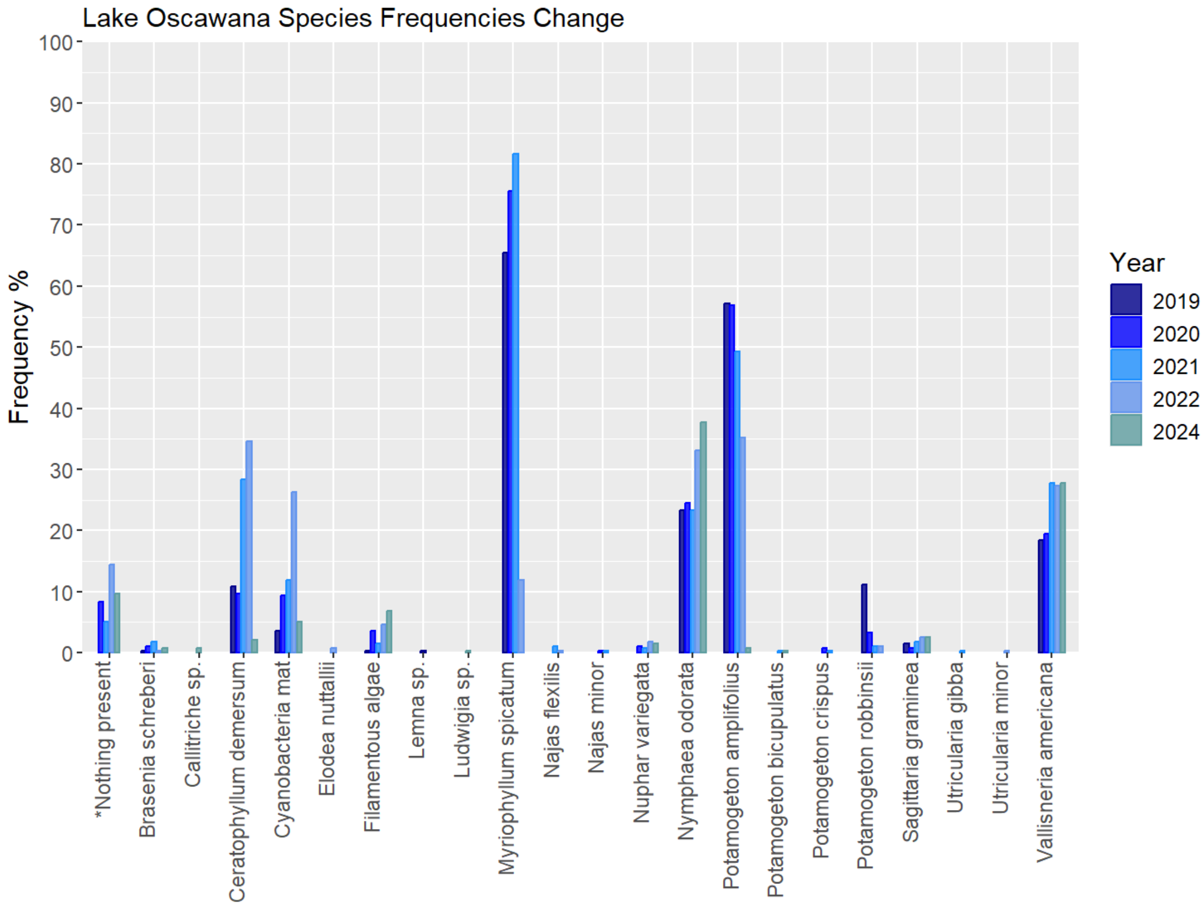


Figure 18. Aquatic Plant Species Frequencies Change 2019-2024



The decline in frequency is obvious for invasive Eurasian milfoil and many native species. For species where there appears to have been an increase in frequency observed over time, there is, however, a corresponding decline in average lake-wide density (such as for White waterlily and Tapegrass).

Please note that the frequencies figure does not include shoreline emergent wetland vegetation. The following emergent species were also present during each survey: *Pontederia cordata, Typha sp., and Phragmites australis* (invasive Common reed).

Discussion & Recommendations

Grass Carp Discussion & Plant Management

One of the most pressing issues at hand is the fact that Lake Oscawana has seen consecutive years of aquatic plant reduction as a result of the 2021 additional grass carp stocking. At that time, carp stocking was the preferred and most cost-effective method for invasive Eurasian milfoil management for Oscawana. The detriments and inadequacies of mechanical harvesting alone have been visible in the aquatic plant annual surveys and water quality data. The invasive Eurasian milfoil had continued to expand in range and density throughout the lake for decades, despite considerable annual mechanical harvesting investment. The community also seriously considered an aquatic herbicide treatment and sought a permit from NYDEC, but herbicides were not viewed favorably by a fraction of the Oscawana resident community and it soon became evident that milfoil treatment would no longer be necessary because the carp were finally working to reduce plant growth.

The decision to stock additional grass carp in 2021 was not made lightly. Ample scientific literature was considered, and carp mortality modeling informed the decision, which was supported by the NYDEC Fisheries Division when they issued the permit. The grass carp ultimately produced intended results: they consumed all of the invasive Eurasian milfoil in the lake. A reduction in native aquatic plant biomass was also expected, but it is concerning that the carp have severely diminished both native pondweeds and Coontail. Native Waterlilies and Tapegrass remain the most frequent species in the lake. There does not appear to be significant grass carp impacts to Waterlilies yet. Native Tapegrass density has been reduced over the last several years, but it is still widespread in the lake.

Although a prolonged, widespread reduction in native plant coverage may have negative implications for the aquatic ecosystem, those changes are varied in the literature case studies. It seems too early to resort to a systematic grass carp removal effort at this time. The original grass carp mortality modeling that was done assumed roughly a 20% carp mortality rate, which is based on various peer-reviewed scientific publications and is explained in detail in the updated Oscawana grass carp permit application provided to NYDEC in September 2020. The table is copied below for reference (Table 7).

From the table, one can see that in 2025, the estimated number of grass carp remaining in the lake will be nearly 60% less than the number estimated in the lake in 2021, after the second stocking. Even if the modeling was adjusted to 10% annual mortality, the lake would still have 50% less fish in 2025 compared to 2021. The years 2021 through 2024 were the highest population years for grass carp in Lake Oscawana. In the next few years there should naturally come a point where the remaining grass carp are no longer able to keep up with the regrowth of aquatic plants. Even with a low 10% annual mortality rate presumption, it is still possible that the carp population reaches a stability point with aquatic plants in the next two years. At that time Lake Oscawana will slowly regain its aquatic plant population over a period of years.

Alternatively, if the lake’s remaining native species begin to show further decline in 2025, it would then be prudent to attempt to remove some of the carp. If Waterlilies begin to show any declines due to grass carp feeding pressure, that will be the indicator that carp removal is warranted. If carp removal is pursued, it is likely that only one or two days of electro-corralling and netting would be required. Grass carp control of aquatic plants after adequate stocking is generally for about three to five years; 2025 represents four years post stocking.

Table 7. Grass Carp Population Modeling - 2020 permit application

20% mortality	Grass carp age																				Population size
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
2016	600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	600
2017	0	480	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	480
2018	0	0	384	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	384
2019	0	0	0	307	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	307
2020	0	0	0	0	246	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	246
2021	443	0	0	0	0	197	0	0	0	0	0	0	0	0	0	0	0	0	0	0	640
2022	0	354		0	0	0	157	0	0	0	0	0	0	0	0	0	0	0	0	0	512
2023	0	0	284	0	0	0	0	126	0	0	0	0	0	0	0	0	0	0	0	0	409
2024	0	0	0	227	0	0	0	0	101	0	0	0	0	0	0	0	0	0	0	0	327
2025	0	0	0	0	181	0	0	0	0	81	0	0	0	0	0	0	0	0	0	0	262
2026	0	0	0	0	0	145	0	0	0	0	64	0	0	0	0	0	0	0	0	0	210
2027	0	0	0	0	0	0	116	0	0	0	0	52	0	0	0	0	0	0	0	0	168
2028	0	0	0	0	0	0	0	93	0	0	0	0	41	0	0	0	0	0	0	0	134
2029	0	0	0	0	0	0	0	0	74	0	0	0	0	33	0	0	0	0	0	0	107
2030	0	0	0	0	0	0	0	0	0	59	0	0	0	0	26	0	0	0	0	0	86
2031	0	0	0	0	0	0	0	0	0	0	48	0	0	0	0	21	0	0	0	0	69
2032	0	0	0	0	0	0	0	0	0	0	0	38	0	0	0	0	17	0	0	0	55
2033	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	14	0	0	44
2034	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0	0	0	0	11	0	35

It is also important to note that the risk to fisheries is across multiple years of dramatically reduced cover, translating to a threat of reproductive success year over year. However, there are also research studies that have concluded minimal negative impacts to fish populations in lakes that have been stocked with grass carp. A seventeen-year review of Ball Pond in Connecticut found that total abundance and diversity of the fish community did not change significantly despite considerable reductions in aquatic plant biomass (both native and invasive species). The notable exceptions in this study were bluegill, where population increased while size class decreased. Various species of perch capture declines over that 17-years was also documented but perch populations are inherently variable. Largemouth bass populations were relatively unchanged after many years of reduced plant coverage at Ball Pond[1].

Mechanical Harvesting

The Town-owned mechanical harvester is an asset. It was still used extensively in 2024. A review of the 2024 mechanical harvesting work time sheet logs from the operators did not include more detail about what material was being removed, as the logs had recorded in previous years. Based on the abundance and apparent reduction in cyanobacteria mats and dense filamentous algae in Wildwood Cove and other areas in 2024, it is reasonable to presume that the harvester is spending time removing these cyanobacteria mats because there is less submersed aquatic plant biomass to manage. The total number of hours recorded for mechanical harvesting labor at Oscawana was 940.25 hours from May through October. The seasonal labor cost is significant and it will be essential for LOMAC to determine if limited harvester operations is warranted for the next several years. The recorded 2024 total labor hours is on par with how many hours of work was completed in years before grass carp stocking.

AWS does not have records for each year, but the efficiency of mechanical harvesting over time goes down considerably with reduced plant coverage and densities. If no change is made to mechanical harvesting in 2025, the operators must record more detail about how much material and what type of

[1] June-Wells M, T. Simpkins, A.M. Coleman, W. Henley, R. Jacobs, P. Aarrestad, G. Buck, C. Stevens and G. Benson. 2017. Seventeen years of grass carp: an examination of vegetation management and collateral impacts in Ball Pond, New Fairfield, Connecticut, Lake Reserv Manage, 33(1): 84-100.

material is being removed. The harvester tracker data was not consistent with the labor records for 2024, meaning it likely was not consistently running or that there was an issue with the tracker's data records or download. But the tracker data did show that the majority of harvesting time was in and around Wildwood and Abele Coves. The tracker originally exported GPS coordinates data in addition to a summary, but the subscription no longer appears to have that as a data extra option. Site data is reported as addresses and in summaries that did not accurately tabulate total hours of work.

Surface Water Quality Simplified Indexing

To simplify the water quality data into an easily understandable annual score, AWS devised an index for Lake Oscawana water quality. The index uses surface Total Phosphorus (TP), surface Total Nitrogen (TN), water clarity (Secchi), and cyanobacteria cell counts and presence of shoreline scums that cause recreational beach advisories. Each of the four components counts equally towards this index. The TP and TN nutrient components consist of the possibility of each scoring 3 points based on: if the mean seasonal 1-meter concentration was lower than the 50th percentile (median) of all 1-meter values from the previous 5 years, if the 2024 means were lower than the target threshold to maintain relatively good water quality, and if the 2024 surface mean was below a critical threshold of *eutrophic* conditions. The respective threshold values are included in the table below. Values that meet the criteria receive 1 point each. If they do not meet the criteria, they receive 0 points.

The third component of the index is water clarity (Secchi transparency). If the 2024 mean is better than the 50th percentile of the past five years of values, 1 point is scored. The second criterion is if there was at least one value taken during the season that exceeds 4 meters, indicating that the lake maintains a clear-water phase, which typically occurs in late spring to early summer. The final point is awarded if the seasonal mean clarity exceeds the critical *eutrophic* threshold of 2m.

The final index component is based on the presence and quantity of cyanobacteria. If the seasonal maximum cyanobacteria cell count is less than 20,000 cells/ml, 1 point is scored. If the seasonal maximum cyanobacteria cell count is less than 100,000 cells/ml, another point is scored. If there are no cyanobacteria-related beach advisories or closures lasting more than one week, a third point is scored. The reasoning behind the 1-week criteria versus the complete absence of surface scums is the fact that even *oligotrophic* generally clear-water lakes can have occasional small and short-lived cyanobacteria shoreline scums. It is not possible to them avoid completely.

In total each component has 3 possible points, for a total of 12 possible points. For the 2024 season, Lake Oscawana scored 8 of the 12 points.

Table 8. Lake Oscawana Water Quality Index Scoring Sheet

2019-2023 Summary Stats for TP (Top) 1m										
	Min	Q1	Median (Q2)	Q3	Max		2024 1m Mean	< 50th percentile	< Target Threshold (20)	< Critical Threshold (30)
Stations AVG	11	16	20	24	33		23	0	0	1
								No	No	Yes
2019-2023 Summary Stats for TN (Top) 1m										
Station	Min	Q1	Median	Q3	Max		2024 1m Mean	< 50th percentile	< Target Threshold (400)	< Critical Threshold (600)
1	234	266	302	356	523		*292*	1	1	1
								Yes	Yes	Yes
2019-2023 Summary Stats for Secchi (m)										
Station	Min	Q1	Median (Q2)	Q3	Max	2024 Max	2024 Mean	> 50th percentile	Any values >4m	> Critical Threshold (2m)
AVG	1.4	2.3	2.8	3.5	4.3	4.2	2.6	0	1	1
								No	Yes	Yes
2024 Cyanobacteria Bloom Score							(Epi 3m-int)	Max < 20,000 cells/m	Max < 100,000 cells/mL	Beach Closures <1 week?
								0	1	1
								No	Yes	Yes
Overall 2024 Score		Points	MaxPoints							
		8	12							

AWS considered adding a dissolved oxygen component to this index, but ultimately, the nutrients, water clarity, and amount of cyanobacteria in the lake were inter-related and influenced by the dissolved oxygen conditions. Dissolved oxygen is more challenging to use in a simplified index because of the spatial and temporal complexity of the data. Bottom water nutrients were also not used in the index, namely because Lake Oscawana has shown to have mixed influence of deep-water nutrients on surface conditions. There are many years of data that demonstrate that hypolimnetic TP and TN can be very high while the surface conditions are still favorable. Bottom nutrients will continue to be used in more detailed assessments but not a part of the simplified surface water quality index.

The index was purposely created using the nutrient target thresholds that indicate mesotrophic conditions. It is impractical to use a scoring target threshold value associated with *oligotrophic* (lower nutrient concentrations) conditions because Lake Oscawana is not an *oligotrophic* lake. Over the past 20+ years, the surface nutrient concentrations have rarely been lower than 10 µg/L TP or 200 µg/L TN, so these thresholds were deemed unrealistic to use in this lake-specific index.

Overall, the index is meant to more effectively communicate the annual status of the complex surface water quality data. In addition to this index, the more detailed data is consistently compared to historical values, ensuring that if any significant negative change is occurring over time, that would be detected in the more long-term analyses. All lake management and monitoring efforts aim to consistently improve water quality and prevent long-term degradation.

Water Quality Management

Internal Nutrient Recycling Load

As explained in previous annual monitoring reports and presentations, there are limited options for in-lake nutrient reductions. Circulation aeration is unsuitable for Lake Oscawana because it would likely cause an accelerated release of deep-water nutrients and mix more nutrients into the surface waters, stimulating consistent algae blooms. Circulation is best used in small shallow ponds, not large lakes with distinct hypolimnetic zones. Other types of aeration or oxygenation are very costly and have inconsistent case study results. The shape of Lake Oscawana also makes aeration/oxygen difficult.

Every season, Oscawana maintains at least one month with excellent water clarity. That has not changed over the past five years. However, the degree to which the internal load impacts surface waters in the late season does change annually, as evidenced by the high variation in late season TP. In-lake phosphorus binding agents like buffered aluminum sulfate (Alum), poly-aluminum chloride (PAC), or lanthanum clay-based products like Phoslock and EutrosorbG are highly effective in permanently binding and inactivating phosphorus in the water column and sediments. These products have been used all over the world for over 40 years. Several pilot projects in New York were completed in the last five years, but the NYDEC has yet to release a public report on their case study reviews. NYDEC has also still not established a permitting pathway to use these products despite decades of successful uses in lakes and reservoirs of the northeastern US.

At this time, internal nutrient management remains in a holding pattern because these technologies are not readily permitted for NY waterbodies. This may legislatively change soon, at which time LOMAC should consider the viability of these products for water quality maintenance. It is important to note that the amount of product used determines the effectiveness and longevity of water quality improvements. A full sediment-locking dosage treatment is unlikely to be cost-effective for Lake Oscawana at this time, but smaller water column treatments would be beneficial if cyanobacterial blooms become more common in the near future.

Right now, Lake Oscawana handles its annual nutrient load well, and cyanobacteria blooms are relatively rare. The blooms at Oscawana in the past several years were typically short-lived and very late in the season, sometimes past the swimming period. When deciding to use phosphate binding products, one must weigh the cost-benefit of treatment dosing. Lake Oscawana still has a large annual watershed phosphorus load. The 2020 Lake Oscawana Management Plan estimated that the internal P load was only about 30% of the total annual P load. Use of in-lake phosphorus binding treatments can also bind P in the water column in spring, binding a fraction of annual watershed-derived P. However, high watershed P loading will eventually, depending on the dose, negate the added treatment product. Again, higher P-binding treatment dosages provide longer water quality improvement. If a treatment were to be pursued in Oscawana in the future, sediment core samples should be taken in spring, before the onset of anoxia, to aid in appropriate dose determination.

Watershed Management

LOMAC and the Town of Putnam Valley have been active in enforcement of septic maintenance, inspection, and pump out requirements given the Town ordinance. LOMAC has also used sampling data collected from various inlets to aid the Department of Public Health in finding failing and short-circuiting systems in need of upgrades and considerable repairs.

The Town recently completed a large stormwater management project to attenuate and reduce pollution entering the Inlet 3 Lost River stream. Large stormwater retention basins trap both road runoff and potential runoff from the horse stables, which have been a concern in previous years. The Town has also continued to follow through with catch basin cleaning and emptying. LOMAC has had ongoing discussions with the Town regarding improvements to catch basin nutrient filtration, such as installing particle separators to better retain fines and organic material from the stormwater drainage system.

LOMAC has also continued to advocate for responsible homeowner property management, minimizing fertilizer use in the whole watershed but especially on lakefront properties. Homeowners are encouraged to trap stormwater runoff from their homes, driveways, and patios to minimize water runoff onto the streets or directly flowing to the lake. Small raingardens and increased infiltration are key to minimizing the impacts of phosphorus pollution from residential properties. Ongoing maintenance and watershed management is essential for the long-term health of Lake Oscawana.

Appendix

Basic Lake Monitoring Parameters Descriptions

Lake measurements are typically taken at the deepest open-water location, but large or irregularly shaped lakes frequently require more than one sampling site to achieve representative data for lake management decision-making.

Water Clarity

A **Secchi disk**, an 8-inch circular black and white disk attached to a measuring tape, is commonly used to measure **water clarity**. The Secchi disk is lowered into the water on the shady side of the boat and is observed using a view scope to shade out light in one's peripheral vision. The depth at which the Secchi disk disappears from view is considered the water clarity measurement. This visual-based measurement is a simple yet effective method of assessing a basic parameter of water quality.

Secchi transparency is related to water column turbidity; it is a measure of light penetration. Factors like phytoplankton, suspended sediments, and microscopic organic matter influence light penetration and water turbidity. Clearer waterbodies possess higher Secchi transparency values. Open-water measurements above 6 meters (around 20ft) indicate very clear water, while measurements less than 2 meters (about 6 ft) suggest a high likelihood of impaired water quality and a higher likelihood of harmful cyanobacteria blooms. Water clarity and Secchi disk transparency are often lower in near-shore areas compared to central open-water monitoring sites, so you cannot directly compare the clarity at a shoreline dock to a measurement taken in open water. Secchi clarity fluctuates throughout the season, especially for larger waterbodies. These changes can be driven by variations in sediment and organic matter levels in the water, but clarity change is most often linked to nutrient increases that stimulate phytoplankton (microscopic algae) growth.

Monthly water clarity monitoring, ideally from April to October, is recommended. Secchi disk measurements are the simplest and most affordable method of tracking water quality and serve as the foundation for many volunteer monitoring programs. However, transparency measurements should be combined with more comprehensive monitoring to diagnose water quality issues or to assess the success of strategic lake management practices over time.

Lake Profile Measurements

Profile measurements involve taking multiple readings as conditions change from the top to the bottom of the water column. Ideally, profile measurements should be made at least one-meter increments from the lake surface to the bottom, on a monthly or biweekly basis. Alternatively, temperature profile data can be acquired by using relatively low-cost continuous data sensors set on a vertical buoy array in open water. Profile measurements are typically taken in the deepest location in the waterbody, but large or irregularly shaped lakes and reservoirs often require more than one location to adequately measure how the water column changes throughout a season or year over year.

Water temperature in lakes and ponds in the northeast follows a predictable seasonal pattern of warming and cooling. In early spring, following ice melt, lakes and ponds will exhibit a more or less uniform temperature from top to bottom. However, as the sun's rays penetrate the water column, profile measurements begin to change. The development and depth of a thermocline, a zone of rapid temperature change with depth, depends on the overall waterbody bathymetry (depth contours), lake surface area, climatic conditions, and water clarity. A **thermocline** indicates a strong temperature-driven density difference between the water above and below. Warmer surface water is less dense than cooler water at the bottom of the lake, which triggers a cascade of changes in other lake parameters during the "thermal stratification period."

In the northeast, lakes deeper than 20ft typically experience a thermal stratification period from late May to October. In the fall, as air temperatures drop, lake water temperature also drops, weakening the thermocline (stratification) and eventually leading to water "turnover." Lake turnover simply means that the temperature becomes uniform from top to bottom and that the thermocline disappears. Shallower lakes are more weather-dependent and may experience multiple thermal mixing events (partial turnover events) in a season. Very large and deep lakes often have more complex temperature dynamics. The temperature of a waterbody drives many other water quality parameters and lake conditions, including how plants and algae grow.

Dissolved oxygen (DO) is an essential parameter for aquatic life and plays a critical role in the health of a lake. DO levels vary throughout the year and are influenced by several factors, including temperature, plant and algae productivity, and aerobic respiration processes. In general, DO levels are highest in the spring and fall when the water is well-mixed and lowest at the bottom of the lake in summer when the lake is thermally stratified. The thermocline, a layer of water with a rapid temperature change with depth, acts as a barrier to oxygen transfer between the surface and bottom of the lake, leading to low DO levels in the hypolimnion, also known as the bottom layer of the lake. Lakes shallower than 20ft typically do not form a true hypolimnion layer, but they can still exhibit similar oxygen loss conditions at the bottom.

Lakes with very little decomposing material (muck/sediment) at the bottom, do not usually present a severe oxygen loss problem. More nutrient-rich lakes, however, can be completely depleted of oxygen in the bottom waters below the thermocline. This physical water column stratification and consumption of bottom-water DO during summer results in **anoxic** (<1mg/L) conditions in deeper waters of many lakes. Such conditions change the bottom nutrient chemistry of the lake. It is critical to track oxygen loss beneath the thermocline and/or the level of the **anoxic boundary** because DO loss has implications for surface water algae conditions. The anoxic boundary is defined as the depth of water at which dissolved oxygen is depleted in the summer. Anoxia worsens towards the end of summer, just before fall 'turn-over,' which will eventually replenish oxygen to the bottom, even in polluted northeastern lakes. Anoxia also tends to worsen over time, increasing incrementally for years and years. Anoxia can also form under winter ice in eutrophic waterbodies.

DO concentrations are typically reported in milligrams per liter (mg/L). A healthy lake should have DO levels of at least 6 mg/L throughout the water column. However, DO levels can vary significantly depending on the time of day, weather conditions, and the lake's biological activity. Each lake is unique and low DO levels are sometimes natural and not an immediate concern for certain waterbodies. However, low DO levels can hurt aquatic life and such conditions may stimulate algae blooms because of the way the sediment chemistry changes in the absence of oxygen (internal recycling of nutrients from muck to the water column). Certain fish and other organisms are more resilient to lower oxygen concentrations than others, which is why scientists often associate certain species with worsened water quality. Monitoring DO levels is an important part of lake management. By tracking DO levels over time, managers can identify potential problems and take corrective measures to protect the health of the lake.

Lake Nutrients Samples

Water **nutrients** samples should be ideally collected monthly from April to October in at least the deepest part of the lake. The most critical times for sampling are early spring, mid to late summer, and fall. Sampling depths usually incorporate top, middle, and bottom depths. Deeper lakes may need more samples arranged vertically in the water column. Shallower lakes may only need top and bottom samples. Water samples are typically analyzed for total phosphorus, total nitrogen, ammonia nitrogen, and nitrate nitrogen.

In baseline assessments, several additional parameters are also needed. **Phosphorus** and **Nitrogen** are the two principal plant nutrients that drive aquatic plant and algae growth. Due to lake temperature stratification, these nutrients are not usually present in the same quantities throughout the lake. Typically, the bottom of the lake has more phosphorus and nitrogen as the summer progresses because bottom sediments release nutrients when oxygen is depleted (internal loading). Just as anoxia increases over time, phosphorus and nitrogen also tend to increase over time as a waterbody becomes more eutrophic, or dominated by plants and algae.

Additional Important Measurements

The following parameters can be taken as profile measurements or as depth-specific measurements.

The **pH** of a lake is more or less a measure of its acidity or basicity, determined by the balance between hydrogen (H+) and hydroxide (OH-) ions in the water. A pH of 7 is neutral, while values below 7 indicate acidity and those above 7 signify alkaline conditions. The pH of a lake plays a pivotal role in its overall conditions, influencing the availability of nutrients for aquatic life and impacting the toxicity of various pollutants. Fluctuations of lake pH result from the underlying bedrock and soil composition, the extent of vegetation, and human activities. Typically, the pH of most lakes in the northeast falls between 6 and 8. pH generally decreases with depth in thermally stratified lakes, as a result of plant and algae photosynthetic consumption of dissolved CO2 in the surface waters. pH measurements require careful calibration of both in situ and laboratory probes. Not all methods of pH testing are accurate enough for lake monitoring purposes.

<u>Specific conductance (conductivity)</u> is a measure of the ability of water to conduct an electrical current. It is influenced by the concentration of dissolved ions in the water, such as salts, minerals, and organic matter. In a lake water column, conductivity typically increases slightly with depth as there are more dissolved ions in the deeper water. High conductivity can indicate that a lake is polluted with salts or other contaminants. High conductivity can often be traced to road salting practices or pollution from shoreline septic systems. Conversely, low conductivity can indicate that a lake is oligotrophic, or very low in nutrients. A conductivity meter measures the electrical resistance of a sample of water. The results are typically reported in units of microsiemens per centimeter (μS/cm).

<u>Metals & other compounds:</u> Other metals that are involved in the amount and availability of phosphorus (the key plant nutrient), are Iron, Manganese, and Aluminum.

Appendix 2

2024 Lake Oscawana Profiles Data

Station	Date	Depth_meters	Temperature_C	DO_mg/L	DO%_sat	SPC_uS/cm
1	3/20/2024	3	7.8	12.3	106	
1	3/20/2024	4	7.8	12.3	106	
1	3/20/2024	5	7.6	12.2	104	
1	3/20/2024	6	7.5	11.8	101	
1	3/20/2024	7	7.12	10.5	89	
1	3/20/2024	8	6.9	10.2	86	
1	3/20/2024	9	6.8	10.1	85	
1	3/20/2024	10	6.8	10.0	84	
1	3/20/2024	10.7	6.8	9.5	79	
1	4/29/2024	0	17.3	10.4	110	172
1	4/29/2024	1	15.6	10.7	109	168
1	4/29/2024	2	14.4	10.8	107	
1	4/29/2024	3	13.8	10.7	104	
1	4/29/2024	4	13.4	10.6	102	
1	4/29/2024	5	12.5	9.9	85	
1	4/29/2024	6	11.3	8.2	76	166
1	4/29/2024	7	10.7	7.1	65	
1	4/29/2024	8	10.5	6.3	57	
1	4/29/2024	9	10.2	5.8	53	
1	4/29/2024	10	10	5.6	50	164
1	4/29/2024	10.6	9.7	3.1	28	
1	4/29/2024	10.7	9.7	2.6	23	
1	5/31/2024	0	21.7	9.1	104	172
1	5/31/2024	1	21.7	9.1	104	172
1	5/31/2024	2	21.7	9.2	104	172
1	5/31/2024	3	21.7	9.2	104	172
1	5/31/2024	4	21.6	9.1	104	172
1	5/31/2024	5	16.2	7.3	74	174
1	5/31/2024	6	13.5	4.8	46	174
1	5/31/2024	7	11.6	1.1	10	178
1	5/31/2024	8	11.3	0.2	2	180
1	5/31/2024	9	11.2	0.0	0	181
1	5/31/2024	10	10.8	0.0	0	190
1	5/31/2024	10.7	10.7	0.0	0	196
1	6/28/2024	0.2	26	8.1	101	176
1	6/28/2024	1	26	8.1	101	176
1	6/28/2024	2	26	8.1	101	176
1	6/28/2024	3	25.9	8.1	101	176
1	6/28/2024	4	23.2	7.7	92	174

1	6/28/2024	5.1	18.2	3.1	33	174
1	6/28/2024	6	14.6	0.2	2	173
1	6/28/2024	7	12.1	0.0	0	200
1	6/28/2024	8.1	11.6	0.0	0	209
1	6/28/2024	9.1	11.3	0.0	0	215
1	6/28/2024	10.1	11.1	0.0	0	222
1	6/28/2024	10.8	11.1	0.0	0	253
1	7/30/2024	0	27.3	8.6	108	168
1	7/30/2024	1	27.1	8.7	109	168
1	7/30/2024	2	26.6	8.8	110	174
1	7/30/2024	3	25.4	8.7	109	173
1	7/30/2024	4	22.9	8.2	100	167
1	7/30/2024	5	22	6.2	71	166
1	7/30/2024	6	18.5	4.0	43	160
1	7/30/2024	7	14.6	0.9	10	210
1	7/30/2024	8	12.9	0.3	3	182
1	7/30/2024	9	12.3	0.1	1	184
1	7/30/2024	10	11.7	0.0	0	258
1	7/30/2024	10.6	11.5	0.0	0	271
1	8/29/2024	0	26.1	10.6	131	180
1	8/29/2024	1	26.1	10.8	132	179
1	8/29/2024	2	25.8	11.1	136	179
1	8/29/2024	3	25.1	10.4	126	179
1	8/29/2024	4	23.6	5.7	67	176
1	8/29/2024	5	23	1.1	12	176
1	8/29/2024	6	20.6	0.3	4	190
1	8/29/2024	7	16.5	0.2	2	258
1	8/29/2024	8	14.7	0.1	1	284
1	8/29/2024	9	13	0.0	0	297
1	8/29/2024	10	12.3	0.0	0	321
1	8/29/2024	10.5	12.1	0.0	0	329
1	9/26/2024	0	20.6	7.3	82	165
1	9/26/2024	1	20.5	7.3	81	165
1	9/26/2024	2	20.5	7.2	80	165
1	9/26/2024	3	20.5	7.0	78	165
1	9/26/2024	4	20.5	6.9	77	165
1	9/26/2024	5	20.5	6.8	75	165
1	9/26/2024	6	20.4	6.7	74	166
1	9/26/2024	7	18.3	3.2	34	234
1	9/26/2024	8	16.4	0.9	9	278
1	9/26/2024	9	14.1	0.4	4	307
1	9/26/2024	10	12.7	0.3	2	337
1	9/26/2024	10.3	12.4	0.1	1	350

1	10/31/2024	0	15.7	10.8	110	176
1	10/31/2024	1	14.9	10.9	109	176
1	10/31/2024	2	14.6	10.3	102	176
1	10/31/2024	3	14.5	9.7	96	176
1	10/31/2024	4	14.2	8.4	83	176
1	10/31/2024	5	14.2	8.6	85	176
1	10/31/2024	6	14.1	8.8	86	176
1	10/31/2024	7	14.1	8.8	86	176
1	10/31/2024	8	14	8.2	80	177
1	10/31/2024	9	14	8.0	79	177
1	10/31/2024	10	14	6.0	58	181
1	10/31/2024	10.2	14	4.7	46	184
2	3/21/2024	0	7.3	12.5	106	
2	3/21/2024	1	7.4	12.5	106	
2	3/21/2024	2	7.4	12.4	106	
2	3/21/2024	3	7.4	12.3	105	
2	3/21/2024	4	7.5	12.2	105	
2	3/21/2024	5	7.5	12.0	102	
2	3/21/2024	6	7.3	11.9	101	
2	3/21/2024	7	7.3	11.8	100	
2	3/21/2024	8	7.2	11.3	96	
2	3/21/2024	8.3	7.6	10.0	85	
3	3/21/2024	0	7.3	12.6	108	
3	3/21/2024	1	7.5	12.6	108	
3	3/21/2024	2	7.5	12.5	107	
3	3/21/2024	3	7.6	12.5	107	
3	3/21/2024	4	7.6	12.4	107	
3	3/21/2024	5	7.6	12.2	105	
3	3/21/2024	6	7.2	10.8	91	
3	3/21/2024	7	7.1	10.4	88	
3	3/21/2024	7.5	6.8	10.0	85	
2	4/29/2024	0	18.6	10.3	112	
2	4/29/2024	1	16.6	10.5	109	
2	4/29/2024	2	15.3	10.5	107	
2	4/29/2024	3	14.2	10.6	105	
2	4/29/2024	4	13.7	10.4	101	
2	4/29/2024	5	12.3	9.9	96	
2	4/29/2024	6	12.1	9.1	85	
2	4/29/2024	7	11.1	7.4	68	
2	4/29/2024	8	10.6	6.4	58	
2	4/29/2024	8.5	10.3	5.8	53	
3	4/29/2024	0	19.1	10.2	111	
3	4/29/2024	1	17.1	10.4	110	

3	4/29/2024	2	15.6	10.7	109	
3	4/29/2024	3	14.3	10.7	106	
3	4/29/2024	4	13.9	10.5	103	
3	4/29/2024	5	13	10.3	99	
3	4/29/2024	6	11.9	8.8	85	
3	4/29/2024	7	11	6.8	62	
3	4/29/2024	7.5	10.6	5.9	55	
2	5/31/2024	0	21.7	9.9	106	172
2	5/31/2024	1	21.7	9.4	106	172
2	5/31/2024	2	21.6	9.4	106	172
2	5/31/2024	3	21.5	9.4	106	172
2	5/31/2024	4	21.4	9.3	106	172
2	5/31/2024	5	14	6.6	64	174
2	5/31/2024	6	11.8	2.5	23	178
2	5/31/2024	7	11.2	1.0	9	181
2	5/31/2024	8	10.8	0.3	3	188
3	5/31/2024	0	22.6	9.3	108	172
3	5/31/2024	1	22	9.3	108	172
3	5/31/2024	2	22.5	9.3	108	172
3	5/31/2024	3	22.5	9.4	107	172
3	5/31/2024	4	21.9	9.2	105	172
3	5/31/2024	5	17.9	8.6	91	174
3	5/31/2024	6	12.6	4.1	38	177
3	5/31/2024	7	11.5	1.9	16	180
3	5/31/2024	7.5	11.4	0.5	5	180
2	6/28/2024	0.2	26.1	8.4	104.5	179
2	6/28/2024	1.0	26.1	8.3	104.0	179
2	6/28/2024	2.1	26.1	8.3	103.7	179
2	6/28/2024	3.1	26.0	8.3	103.2	179
2	6/28/2024	4.1	23.6	7.6	90.2	169
2	6/28/2024	5.0	18.3	3.3	35.3	151
2	6/28/2024	6.1	14.6	1.1	11.4	137
2	6/28/2024	7.0	12.4	0.0	0.0	142
2	6/28/2024	7.7	11.6	0.0	0.0	156
3	6/28/2024	0.2	26.0	8.4	105.3	178
3	6/28/2024	1.0	26.1	8.4	104.5	179
3	6/28/2024	2.0	26.1	8.4	104.3	179
3	6/28/2024	3.1	26.0	8.3	103.9	179
3	6/28/2024	4.1	25.9	8.3	103.5	178
3	6/28/2024	5.0	19.8	5.8	63.8	156
3	6/28/2024	6.0	15.5	0.9	9.6	141
3	6/28/2024	7.0	13.1	0.0	0.0	147
3	6/28/2024	7.6	12.3	0.0	0.0	159

2	7/30/2024	0	27.1	9.1	115	168
2	7/30/2024	1	27	9.2	115	168
2	7/30/2024	2	27	9.2	115	168
2	7/30/2024	3	26.9	9.2	115	168
2	7/30/2024	4	26.1	8.9	109	167
2	7/30/2024	5	25	8.8	107	167
2	7/30/2024	6	18.7	6.7	72	161
2	7/30/2024	7	14.3	2.3	23	169
2	7/30/2024	7.6	12.9	0.8	7	238
3	7/30/2024	0	26.9	8.2	103	168
3	7/30/2024	1	26.8	8.2	103	168
3	7/30/2024	2	26.7	8.2	103	168
3	7/30/2024	3	26.5	8.3	103	168
3	7/30/2024	4	26.5	8.2	101	168
3	7/30/2024	5	20.9	6.1	68	169
3	7/30/2024	6	17.5	2.4	25	159
3	7/30/2024	7	14.5	0.6	5	174
3	7/30/2024	7.5	13.3	0.2	2	183
2	8/29/2024	0	26.2	11.2	138	
2	8/29/2024	1	26	11.3	140	179
2	8/29/2024	2	25.7	11.2	137	178
2	8/29/2024	3	25	11.4	138	178
2	8/29/2024	4	24.1	9.0	107	176
2	8/29/2024	5	23.1	1.2	13	175
2	8/29/2024	6	21	0.4	4	180
2	8/29/2024	7	17.4	0.2	2	235
2	8/29/2024	7.7	14.4	0.1	0	280
3	8/29/2024	0	26.7	10.7	132.8	179
3	8/29/2024	1	26.4	10.9	135.1	180
3	8/29/2024	2	26.3	11.0	135.7	180
3	8/29/2024	3	24.5	10.2	121.5	178
3	8/29/2024	4	23.7	6.7	79.6	176
3	8/29/2024	5	23	0.8	9.9	176
3	8/29/2024	6	20.9	0.3	3.2	189
3	8/29/2024	7	17.8	0.1	1.2	239
3	8/29/2024	7.5	17.1	0.1	0.7	253
2	9/26/2024	0	20.6	7.2	79.9	165
2	9/26/2024	1	20.6	6.9	76.4	165
2	9/26/2024	2	20.6	6.7	74.0	165
2	9/26/2024	3	20.6	6.6	73.2	165
2	9/26/2024	4	20.5	6.7	74.1	166
2	9/26/2024	5	20.4	6.6	73.1	166
2	9/26/2024	6	20.3	5.1	56.5	166

2	9/26/2024	7	18.3	1.0	11.3	229
2	9/26/2024	7.7	16.5	0.5	4.8	280
3	9/26/2024	0	20.6	7.8	87.2	165
3	9/26/2024	1	20.6	7.2	80.2	165
3	9/26/2024	2	20.6	7.1	78.8	165
3	9/26/2024	3	20.5	6.8	75.8	166
3	9/26/2024	4	20.5	6.7	74.0	166
3	9/26/2024	5	20.5	6.2	68.8	166
3	9/26/2024	6	20.3	3.8	42.1	169
3	9/26/2024	7	18.2	1.6	16.5	236
3	9/26/2024	7.2	18.1	0.5	5.3	237
3	9/26/2024	8	16.7	0.2	1.6	275
3	9/26/2024	8.2	16.7	0.1	0.8	278
2	10/31/2024	0	15.9	11.5	117.9	177
2	10/31/2024	0.2	15.9	11.5	117.6	176
2	10/31/2024	1.0	15.1	11.7	102.0	177
2	10/31/2024	2.0	14.5	10.3	95.1	176
2	10/31/2024	3.0	14.3	9.6	91.3	176
2	10/31/2024	4.0	14.2	9.3	89.3	176
2	10/31/2024	5.0	14.2	9.1	89.3	176
2	10/31/2024	5.0	14.2	9.1	87.8	176
2	10/31/2024	6.0	14.1	8.9	87.0	176
2	10/31/2024	6.0	14.1	8.8	82.7	176
2	10/31/2024	7.0	14.1	8.4	81.2	177
3	10/31/2024	7.6	14.1	8.3	114.7	177
3	10/31/2024	0.2	16.4	11.1	113.6	176
3	10/31/2024	1.0	15.5	11.1	113.9	176
3	10/31/2024	2.0	14.8	11.4	106.8	176
3	10/31/2024	3.0	14.4	10.8	102.1	176
3	10/31/2024	4.0	14.2	10.3	98.4	176
3	10/31/2024	5.0	14.1	10.0	95.6	176
3	10/31/2024	6.0	14.1	9.7	94.0	177
3	10/31/2024	7.0	14.0	9.6	93.5	177