Lake Oscawana 2019 Water Quality & Aquatic Plant Monitoring Report

Prepared for the Lake Oscawana Management Advisory Commission,
Town of Putnam Valley, NY

May 16, 2020

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Executive Summary

This summary assumes readers have a basic understanding of lake monitoring components and historical Oscawana data. For more explanation and detailed data interpretation, please refer to the body of this report.

<u>Key Points from 2019 Monitoring Report</u>

- 2019 water clarity was average.
- Lake thermocline development began early in the season, prior to the first April visit.
- The peak anoxic boundary was 5.7m in August, which is fairly consistent to past years, and only slightly beyond the target threshold of 6.0m.
- Anoxia is not the main driver of overall lake nutrients in recent years. For this reason, among others, no recommendations were made to aerate or oxygenate bottom-waters.
- All monitoring stations exceeded the 20 µg/L surface total phosphorus concentration target for more than one month of the season. Concentrations of phosphorus greater than 20 µg/L in the surface waters (*epilimnion*) make the lake vulnerable to harmful cyanobacteria blooms.
- Bottom-water (*hypolimnetic*) total phosphorus was higher than the average of the past six years at all three monitoring stations.
- Late-summer and fall total nitrogen in surface waters was below the long-term average but was high compared to the values seen in recent years.
- The three monitoring stations behaved more similarly in terms of surface nitrogen compared to phosphorus throughout the 2019 season, suggesting the nutrients have slightly different sources.
- Nutrients in Inlets 3, 4, 5, and 7 were too high. Fecal coliform and E. coli bacteria were found in Inlets 3, 4, and 7. The after-rain E. coli levels were much higher than the baseflow stream bacteria levels.
- Cyanobacteria was the most abundant phytoplankton throughout the entire season, with the maximum cells/mL at just over 20,000. This level does not constitute a harmful bloom condition.
- Cladoceran zooplankton counts in 2019 were higher than in the past three years, but large-bodied *Daphnia* were still scarce.
- The fisheries survey results indicate that alewife are highly abundant throughout the lake and that walleye are in low abundance. The fisheries survey results and zooplankton data indicate that walleye stocking has not worked to improve water quality through biomanipulation, and recent biomanipulation case studies at other NY lakes demonstrate that the technique is largely infeasible for financial and ecological resasons. The bass population at Oscawana is good.
- The July 24, 2019 aquatic plant survey results indicate that Grass carp have not been detrimental to native plants in the lake. Invasive Eurasian milfoil appears to be less dense in some areas, but further density comparisson to past years of data is needed.
- The harvester tracker data is a very accurate way to track the efficiency and effectiveness of Eurasian milfoil cutting at Oscawana. The data indicates that weed-cutting in Wildwood and Abele Coves consituted nearly 50% of the total harvester operation time in 2019.
- Residents should refer to the Lake Oscawana Management Plan for a list of potential watershed improvement projects needed for continued nutrient reduction and improved lake water quality.

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Northeast Aquatic Research

Description of Monitoring Parameters

All measurements should be taken at the deepest open-water location in a lake.
Large or irregularly shaped lakes often require more than one testing site.

Secchi Disk Clarity

Water clarity measurements use an 8-inch circular **Secchi disk** attached to a measuring tape. The disk should be lowered into the water on the shady side of the boat. Using a view scope to shade out light in one's peripheral vision, the Secchi disk is lowered until it disappears from view in the water column. The depth at which the Secchi disk disappears from view is considered the water clarity measurement. Secchi clarity is dependent on light penetration. Light penetration is affected by phytoplankton, suspended sediments, and microscopic organic matter in the water column. Clearer waterbodies have greater Secchi transparency values. Lakes and ponds experience fluctuations in Secchi clarity throughout the season, typically driven by increases or decreases in nutrients that stimulate phytoplankton growth. Ideally, water clarity should be tracked at least monthly from April to October.

Lake Profile Measurements

Temperature in lakes and ponds in the northeast follows a seasonal pattern of warming and cooling. Following ice-melt in early spring, lakes and ponds will be more or less uniform in temperature from top to bottom. Temperature measurements should be made at one-meter increments from the lake surface to the bottom on a monthly basis. Combined, measurements at all 1-meter depth increments are referred to as a lake profile. Profile measurements change as the sun's rays penetrate into the water column. Clearer water allows for greater sunlight penetration and deeper warming during the summer months. The depth and development of a **thermocline**, or the zone of rapid temperature change, is dependent on water depth, surface area of the lake, climatic conditions, and water clarity. A thermocline effectively isolates top and bottom waters during summer months because warm water at the surface is less dense than the cold water at the bottom of the lake. In the fall, the lake cools off as air temperatures drop, resulting in a weakening thermocline and eventually water "turn-over." Lake turnover simply means that the temperature becomes uniform from top to bottom and that there is no longer a thermocline. In lakes deeper than 20ft in the northeast, this turnover traditionally occurs in the spring and the fall. Shallower lakes are more dependent on weather and may experience multiple thermal mixing events in a season. Very large and deep lakes often have more complicated temperature dynamics that require multiple monitoring sites.

Dissolved oxygen in a lake is essential to aquatic organisms. At the surface of a lake, the water is in direct contact with the air, and atmospheric oxygen is dissolved into the water as a result of diffusion. Water mixing, driven by wind and temperature currents, circulates this oxygen throughout the water column during spring and fall mixing periods. Yet because lakes warm non-uniformly, the thermocline that develops in summer months will temporarily cut off the bottom waters from surface water circulation of oxygen. In lakes with very little decomposing plant material at the bottom, this is not usually a problem because there is enough oxygen to sustain the lake through the summer months. More nutrient-rich lakes, however, can be depleted of oxygen in the bottom waters below the thermocline. This phenomenon results in **anoxic** (<1mg/L) conditions in deeper waters of many lakes. An absence of oxygen changes the bottom chemistry for multiple months. It is critical to track oxygen loss beneath the thermocline and/or the level of the **anoxic boundary**. 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 lakes. Anoxia also tends to worsen over time, increasing incrementally for years and years. Organisms like fish and invertebrates that need oxygen to survive are not able to inhabit deeper waters in many lakes during the summer. Lakes and ponds with severe oxygen problems during summer months also experience increased nutrient levels at the lake bottom. This is the result of changing chemistry between the presence or absence of oxygen.

Lake Nutrients Samples

Water samples should be 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 the fall. Sampling depths usually incorporate top, middle, and bottom depths. Deeper lakes may need more samples, and 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, a number of 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. 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.

Description of Monitoring Parameters Continued…

Calculated Values

Relative Thermal Resistance to Mixing (RTRM) is a unit-less ratio that describes the difference in water density between each meter. Higher numbers indicate stronger thermal **stratification**. Stratification is the result of density differences as warming surface waters become less dense than cold deeper water. The RTRM is a relative number that distinguishes the intensity and depth of the thermocline. RTRMs describe how the lake is or is not mixing with respect to layers of water at specific depths. RTRMs also show when the lake becomes de-stratified as the result of temperature changes or excessive wind energy that can overcome thermal density boundaries.

Percent Oxygen Saturation is the percentage of dissolved oxygen at a given depth, relative to the water's capacity to hold oxygen, which is based on its temperature. For instance, 50% O_2 saturation means that the water contains only half of the dissolved oxygen that it is able to hold at its current temperature. In essence, anything less than 100% means that the biological oxygen demand, or rate at which oxygen is used up, is depleting the water of oxygen at a rate faster than it can be replenished. A percentage greater than100% is frequently a result of excessive phytoplankton production of oxygen that causes the water to be supersaturated.

Additional Important Profile Measurements

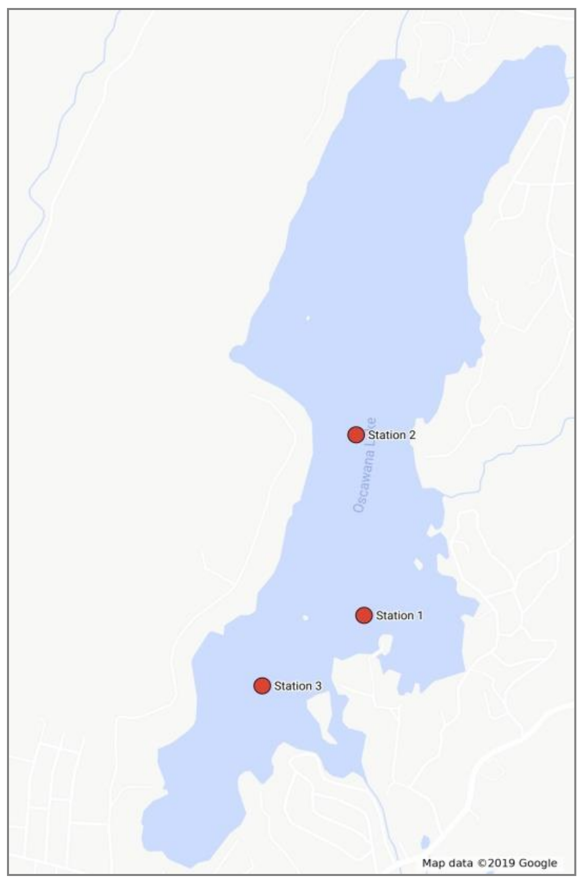
Specific Conductance, also referred to as conductivity, measures the quantity of dissolved ions in water that conduct electricity. Conductivity measurements can also be taken at one-meter increments from surface to lake bottom with calibrated probes. Alternatively only surface samples may also be collected and tested in the lab. Conductivity generally increases with dissolved salt content in the lake, which can be traced to either natural mineral sources or to human inputs from road salting and septic systems.

Station 1: The "Deep Hole" is approximately 35-ft deep and is the primary water quality monitoring site.
(41.39063, -73.84836)

Station 2: The northern monitoring station is located in approximately 27-ft of water.
(41.39553, -73.84824)

Station 3: The southern station is also located in roughly 27-ft of water and represents water quality near some of the most populated and disturbed areas of the lake.
(41.38817, -73.85275)

All water quality monitoring stations are too deep to support aquatic plant growth. All stations lose oxygen from late spring to late summer. The three sites differ substantially depending variable lake conditions.



Water Clarity

Water clarity, measured as Secchi disk transparency, at Lake Oscawana in 2019 was average.

The goal is to have greater than 2m of clarity for the entire season, and to have at least one month with greater than 4m clarity. Clarity less than 2m is considered very poor. Clarity greater than 4m is considered good for Lake Oscawana. These boundaries are shown in the image below, which also depicts the seasonal pattern in clarity for each monitoring station from 2016 through 2019.

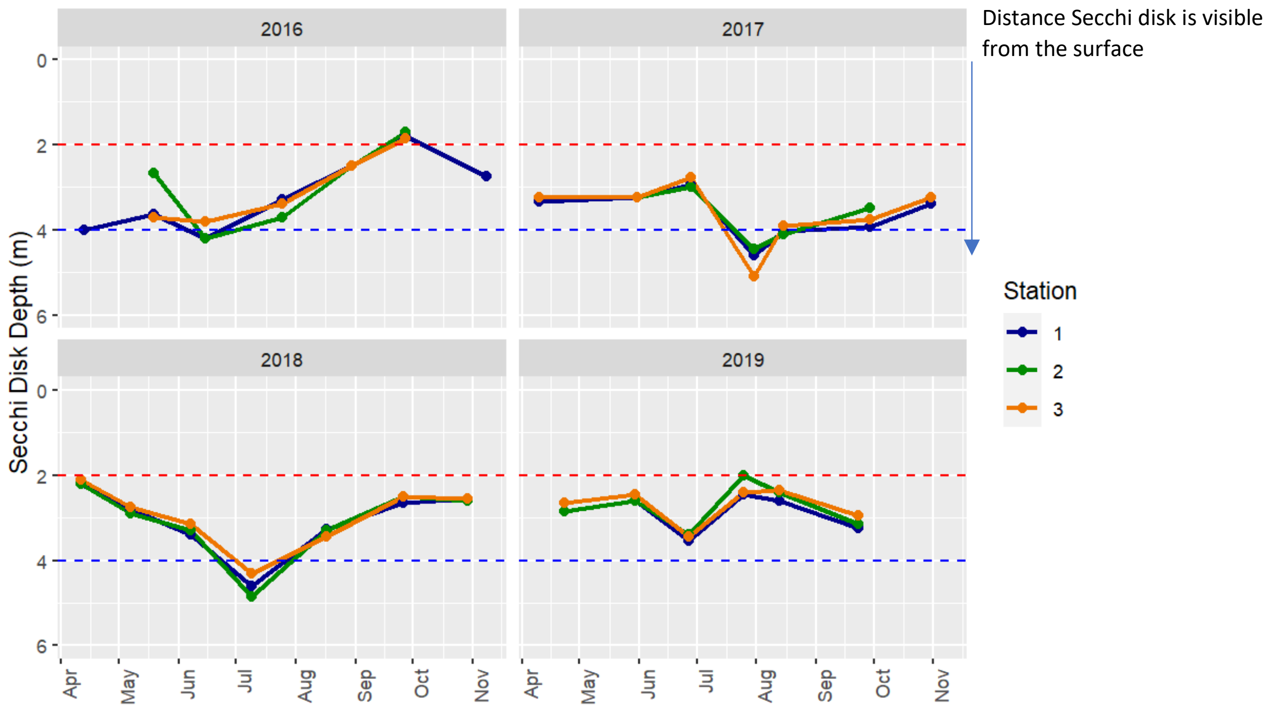


Figure 1 Water Clarity 2016-2019 Seasonal Pattern, St 1-3

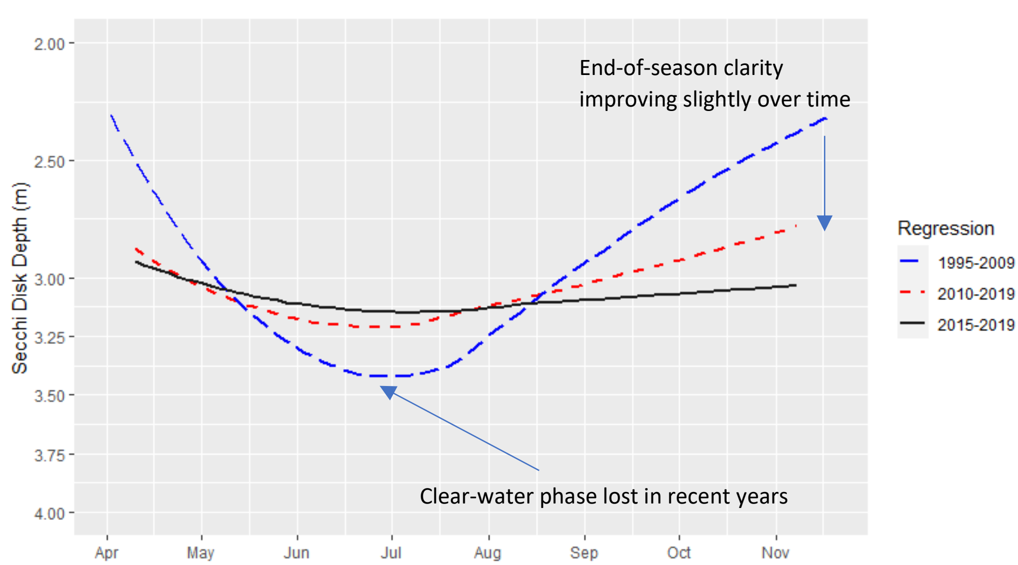


Figure 2 Seasonal Clarity Pattern
(Polynomial Regression Models of Historical vs. Recent Years Values)

Temperature

Temperature profiles demonstrated that the thermocline formation began before the April 23rd monitoring visit. The lake was thermally stratified by June. Stratification persisted until the end of September, and by the end of October, the lake was completely mixed and uniform in temperature from the top the bottom. Stratification at the shallower Stations 2 and 3, was less dramatic than at the deep hole Station 1 site, which is to be expected based on past years of data.

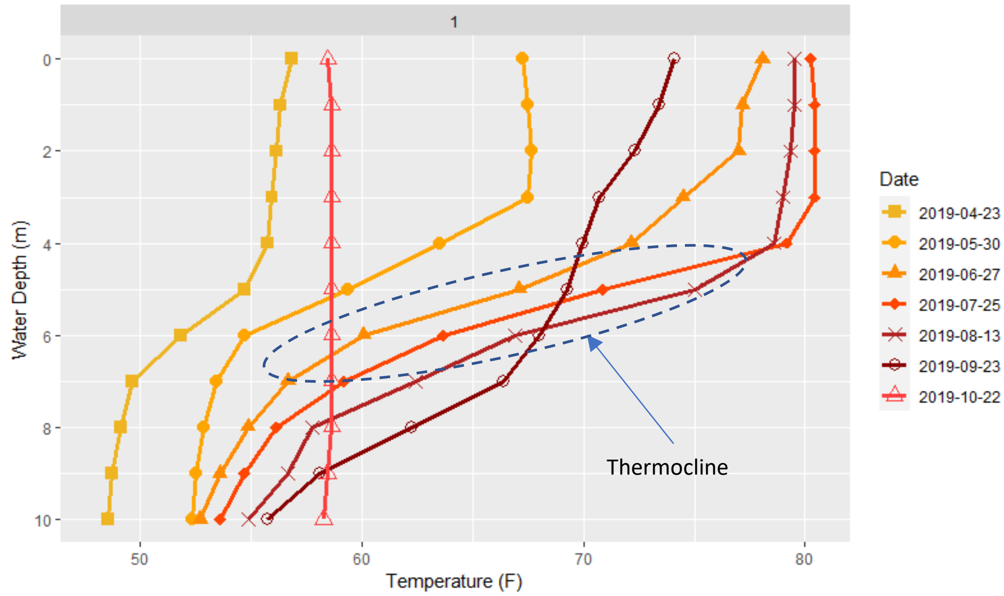


Figure 3 Station 1 Temperature 2019

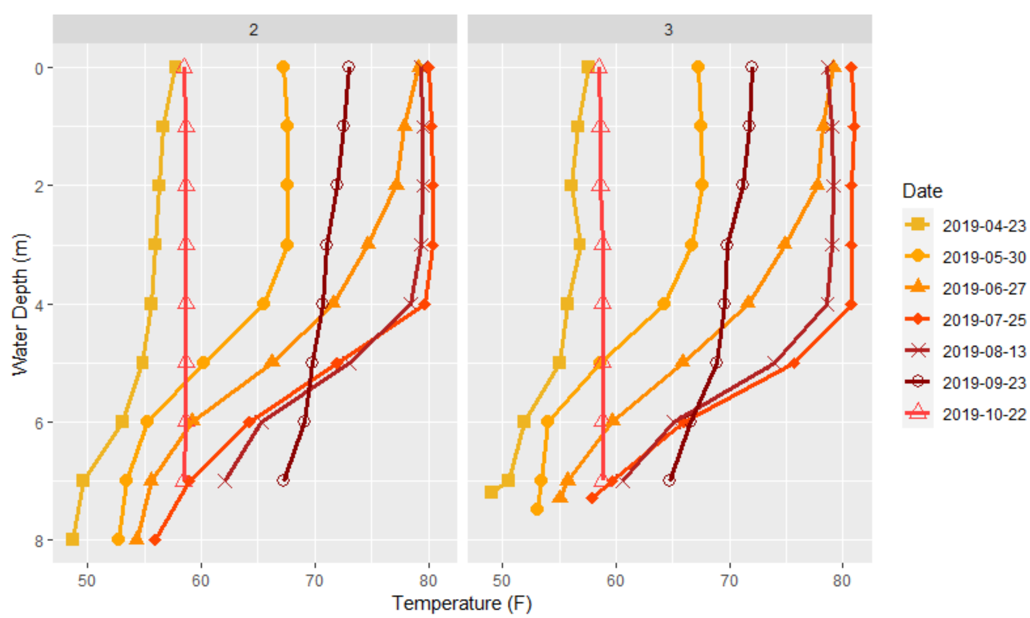


Figure 4 Station 2 & 3 Temperature (F)

Dissolved Oxygen

Bottom-water dissolved oxygen loss began before the April 23rd monitoring visit. By the end of May, anoxia was present below eight meters at Station 1. Results from 2019 oxygen profile monitoring are graphed below.

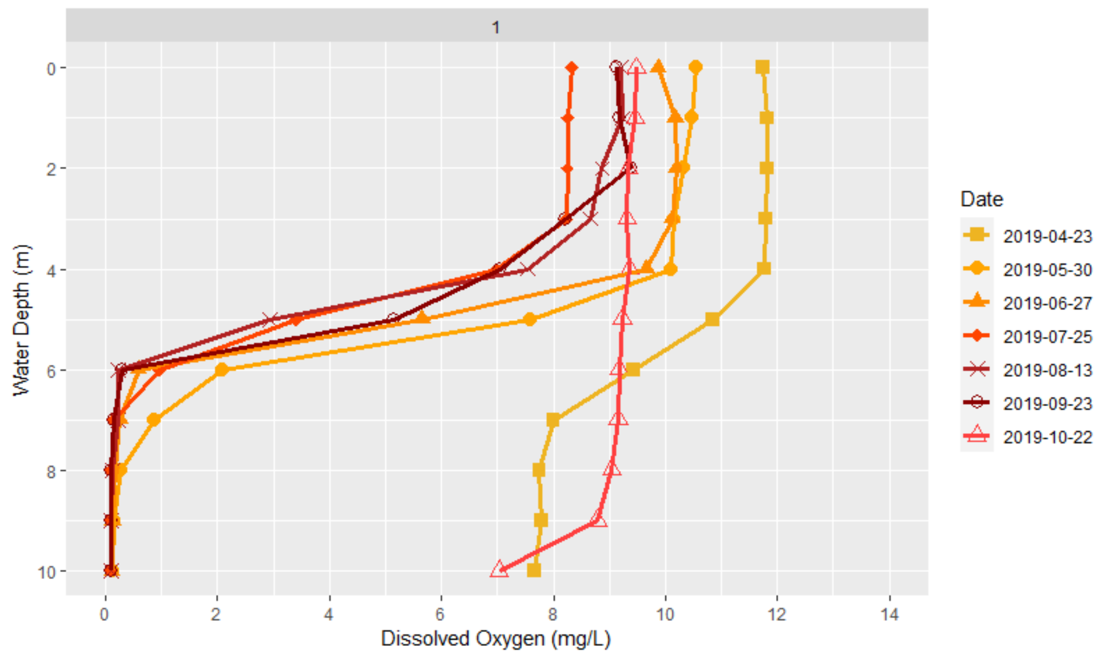


Figure 5 2019 Station 1 Dissolved Oxygen

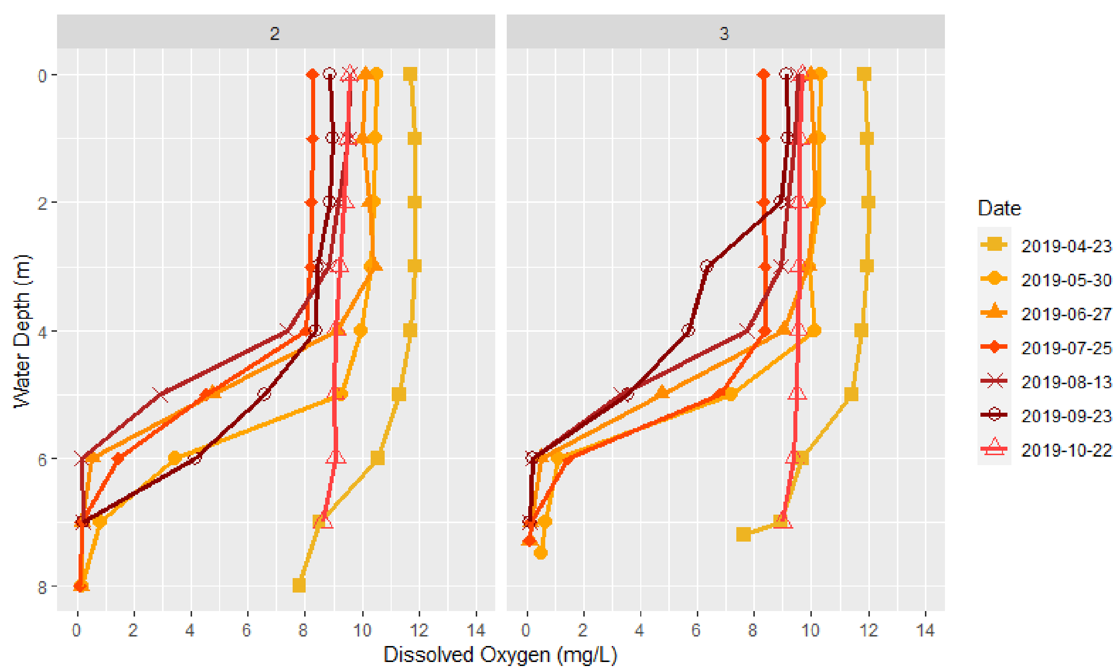


Figure 6 2019 Station 2 & 3 Dissolved Oxygen

The peak anoxic boundary was 5.7m in August, which is fairly consistent with past years, and only slightly beyond the target threshold of 6.0m. This target threshold of 6m is related to the fact that the lake temperature thermocline is just shallower than 6m, and it is important that anoxia remains below the thermocline, so as not to allow excess bottom-water nutrients into the surface waters during the summer.

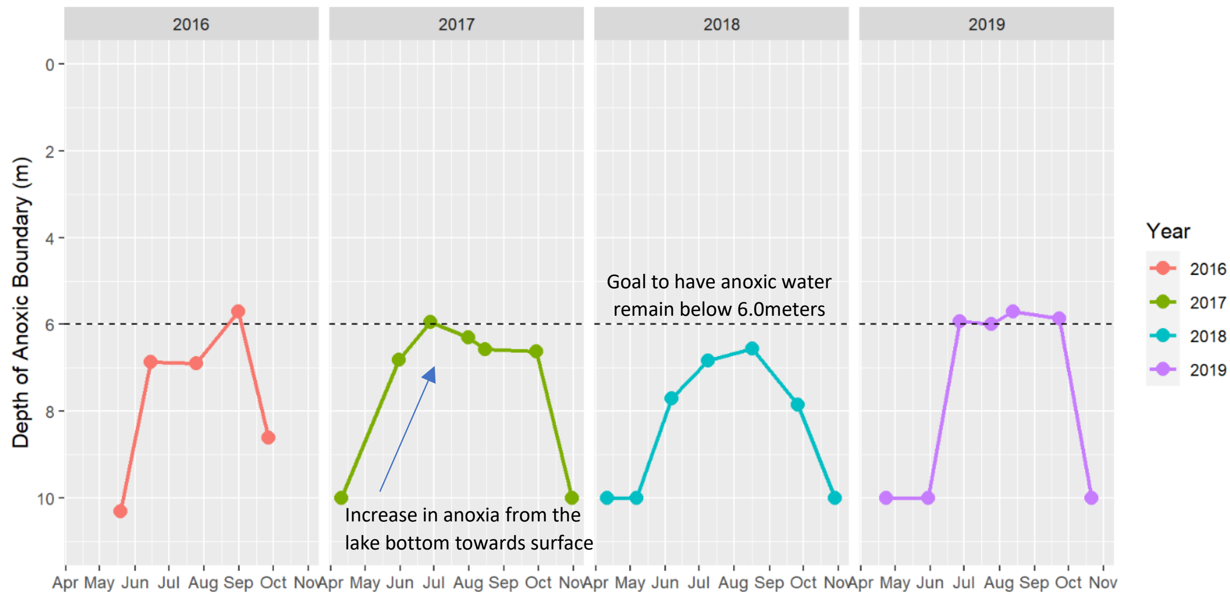


Figure 7 Seasonal Anoxic Boundary Pattern 2016-2019

As stated in the recently published Oscawana Lake and Watershed Management Plan, the summer anoxia has not been the main driver of overall lake nutrients in recent years. For this reason, no recommendations were made to aerate or oxygenate the lake. Instead, the long-term goal is to ensure that the anoxic boundary remains below 6m, which should be achieved through improved water clarity resulting from watershed improvements and reduced weed-harvesting. Improved water clarity will allow deeper warming of the sun's rays, which would then permit thermal mixing in a larger volume of water (the *epilimnion* would increase in thickness). Hence, increased oxygen in the 6m range to counter the sediment biochemical oxygen demand.

This topic is complex and is best explained in person with proper diagrams, but the main take-away from recent monitoring data is that Lake Oscawana can have improved water clarity and lower nutrients without the need for artificial oxygenation. For now, the goal is to maintain oxygen greater than 1.0mg/L at 6m for the entire season, with more than 6mg/L dissolved oxygen in water shallower than 6m.

Nutrients

The phosphorus concentration at Oscawana should remain below 20 µg/L in the surface waters for the entire season in order to minimize the likelihood of harmful cyanobacteria (blue-green algae) blooms. Yet in 2019, all monitoring stations exceeded the 20 µg/L target for more than one month.

There was a distinct difference in the late 2019 summer phosphorus surface concentrations at Station 1 versus Stations 2 & 3. Station 3 had the most consistently high summer surface phosphorus. Stations 2 and 3 surface phosphorus concentrations were reduced in late September despite both stations maintaining high phosphorus in bottom waters and persistent late-season anoxia.

The increase in phosphorus in October is due to bottom-water nutrients mixing into the surface waters during fall lake 'turn-over,' which occurs when the lake temperature is once again the same from the top to the bottom. There was no Station 1 October sample, a result of laboratory error. Raw nutrient data values are included in the Appendix. Spring phosphorus was relatively high at all Stations.

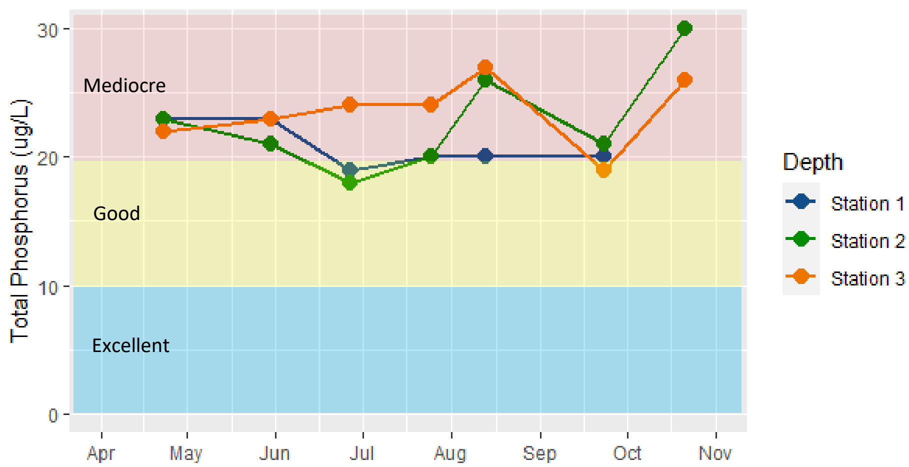


Figure 8 Surface Total Phosphorus 2019

The long term surface phosphorus concentrations are shown in the figure below (2008-2019).

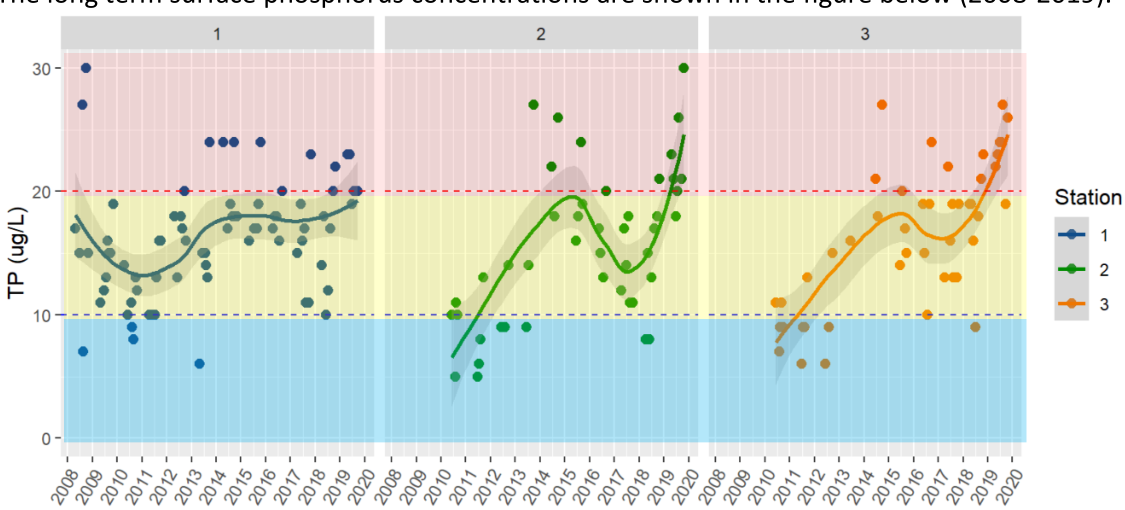


Figure 9 Long Term Surface Total Phosphorus (St.1,2,&3)

The long term pattern of increasing phosphorus in surface waters over the last decade is particularly visible at Stations 2 and 3. Today, Lake Oscawana surface phosphorus concentrations are more often above the 20 µg/L threshold that is needed to maintain adequate water quality.

As explained in previous water quality reports, bottom-water phosphorus increases seasonally due to internal loading, which is the chemical release of nutrients from bottom sediments in the absence of oxygen. The bottom-water phosphorus is always higher than surface waters during summer months, but the thermocline density gradient prevents some of that bottom-water phosphorus from mixing into the surface waters. This is the reason why the target goal is to prevent oxygen loss in water shallower than 6m, by limiting early-season nutrient inputs and improving clarity to expand the epilimnion.

In Figure 10, below, the lines indicate an average measurement of bottom-water phosphorus values over the last six years, as measured at Station 1 (9-meters deep), Station 2 (7-meters), and Station 3 (7-meters). The 2019 bottom total phosphorus concentrations, indicated by triangles, were higher for most of the season than the mean 2014-2019 monthly values. Station 1 values are normally much higher than bottom phosphorus at Stations 2 and 3 because the Station 1 sampling point is deeper (note difference in scale from Figure 10A to 10B).

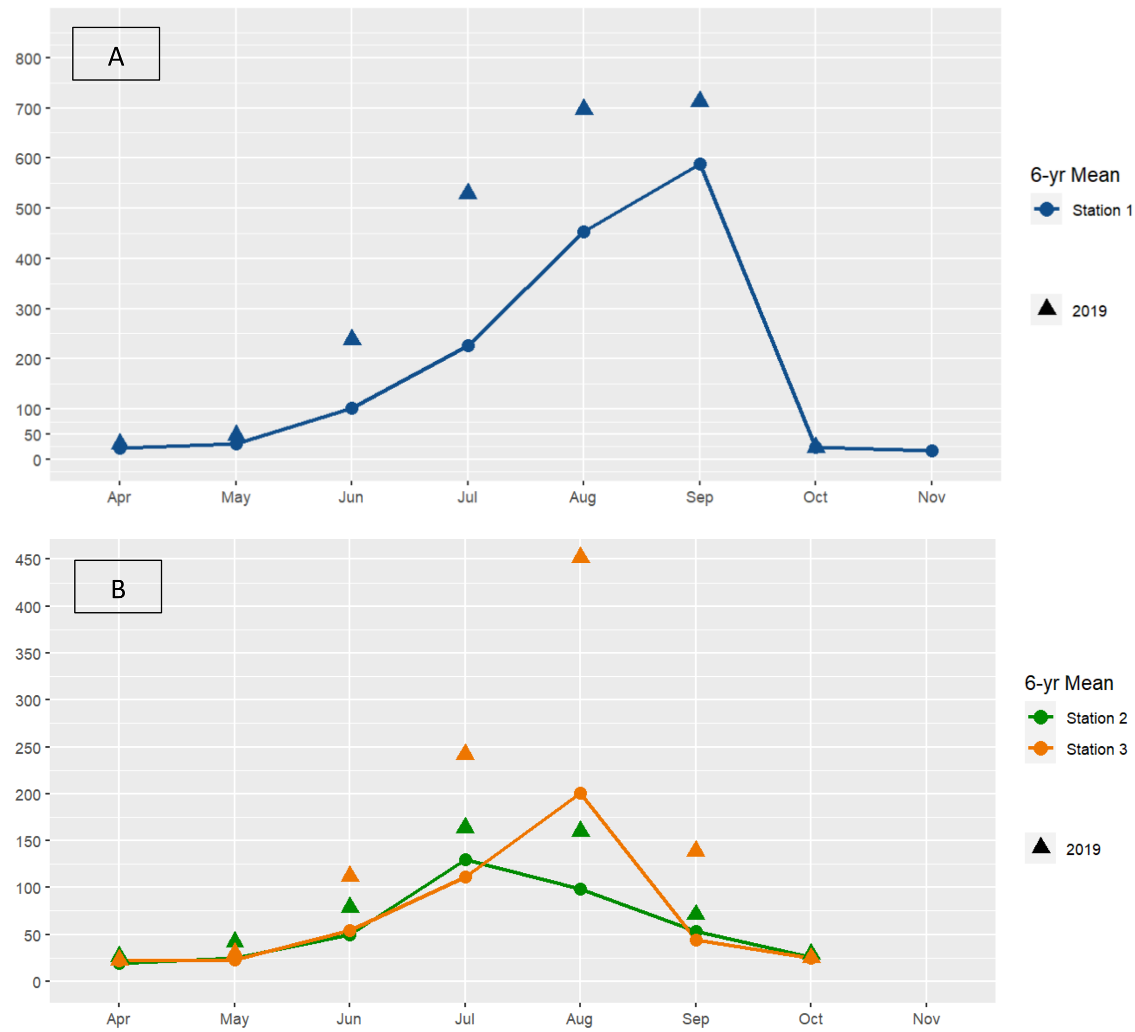


Figure 10 Station 1 (A) & Station 2 & 3 (B) Bottom Total Phosphorus 6yr Mean vs. 2019

To reiterate, high levels of 2019 bottom phosphorus are related to internal loading, which is a combination of settling organic material and internal sediment phosphorus release due to the loss of oxygen in deep waters. Management recommendations in the Oscawana Lake and Watershed Management Plan aim to reduce sedimentation, increase water clarity, and thereby increase oxygen to decrease internal loading without artificial aeration.

As referenced in the Monitoring Components section, nitrogen is the secondary principal plant and algae nutrient in lakes. The mean surface total nitrogen in 2019 across all three stations was 288 µg/L, considerably below the long-term historical mean of 354 µg/L.

However, nitrogen levels in Oscawana have been steadily decreasing over the last two decades, so it is more appropriate to compare the 2019 data to the recent six-year surface nitrogen mean of 284 µg/L (2014-2019). Overall, nitrogen in Oscawana was average in 2019. Also note that nitrogen testing at Stations 2 and 3 only began in 2017.

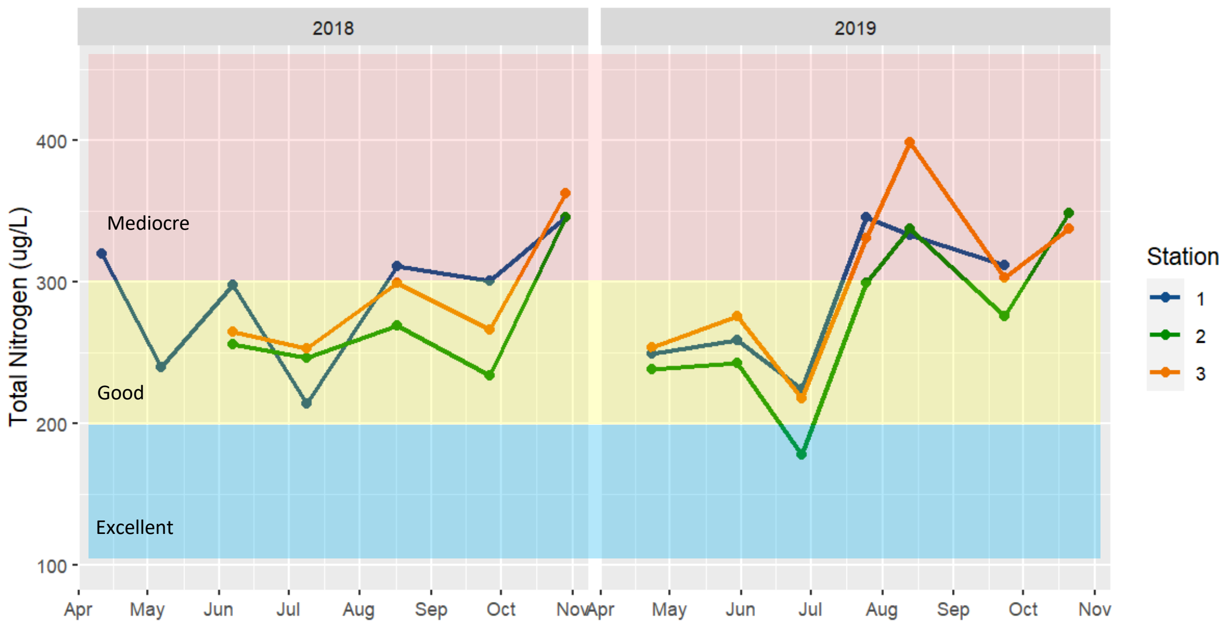


Figure 11 Surface Total Nitrogen 2019

The figure above demonstrates that all Stations behaved similarly across the 2019 season, but Station 3 had the highest surface nitrogen in late summer. There was more nitrogen in the surface waters in August 2019 compared to 2018. The reasons for the increase are not known at this time, but it is clear that, in the late summer, Station 3 exhibited the highest nitrogen and phosphorus concentrations. The high nutrients in surface waters at Station 3 could be related to the heavy sediment disturbances from weed-harvesting in the shallow waters of Abele Cove. This wind-driven sediment plume has been documented in years past and Station 3 also had slightly reduced clarity in 2019.

Raw data for nitrogen test results are included in the Appendix. Various measurements for ammonia (NH3) and nitrate (NOX) nitrogen forms were also tested in 2019.

Inlet Nutrient & Bacteria Data

Seasonal inlet phosphorus concentrations are displayed in the figure below. As usual, Inlet 4 is the highest, while Inlet 7 also has relatively high phosphorus. The samples collected from Inlet 3 in 2019 were collected from a slightly different location, closer to the lake than in past years. The change in sampling location is in an attempt to sample below the farm area. This will be the permanent Inlet 3 monitoring station and is a more accurate representation of the concentration of nutrients entering the lake than sampling farther upstream.

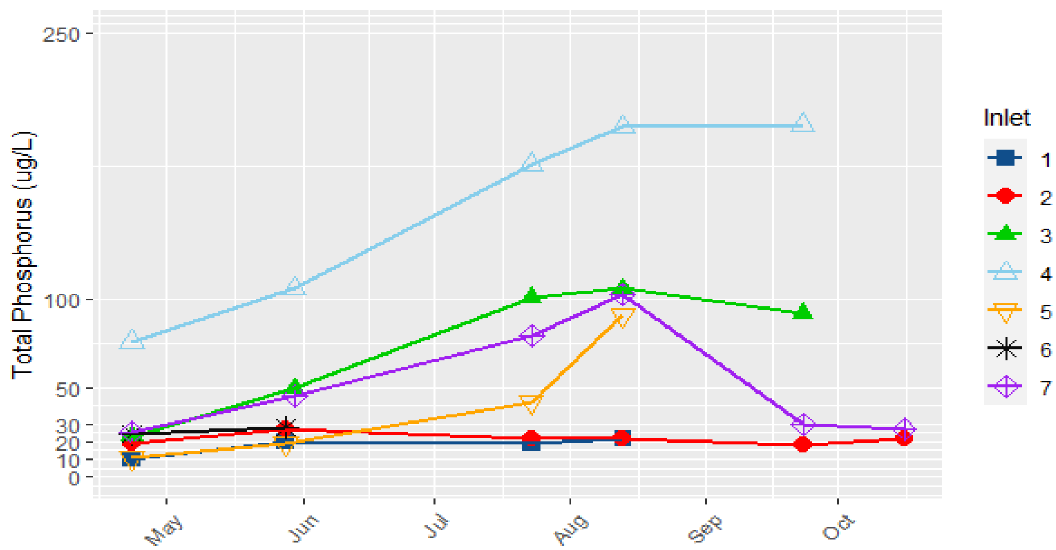


Figure 12 Inlet Phosphorus Results 2019

The range of values across all sampling years is displayed in the boxplots in Figure 13. Note the difference in scales between the two graphs, which is simply because the 2019 data had a lower seasonal range than some of the past years. Inlet 4 is the only inlet that frequently exceeds 250 µg/L of total phosphorus during non-storm conditions.

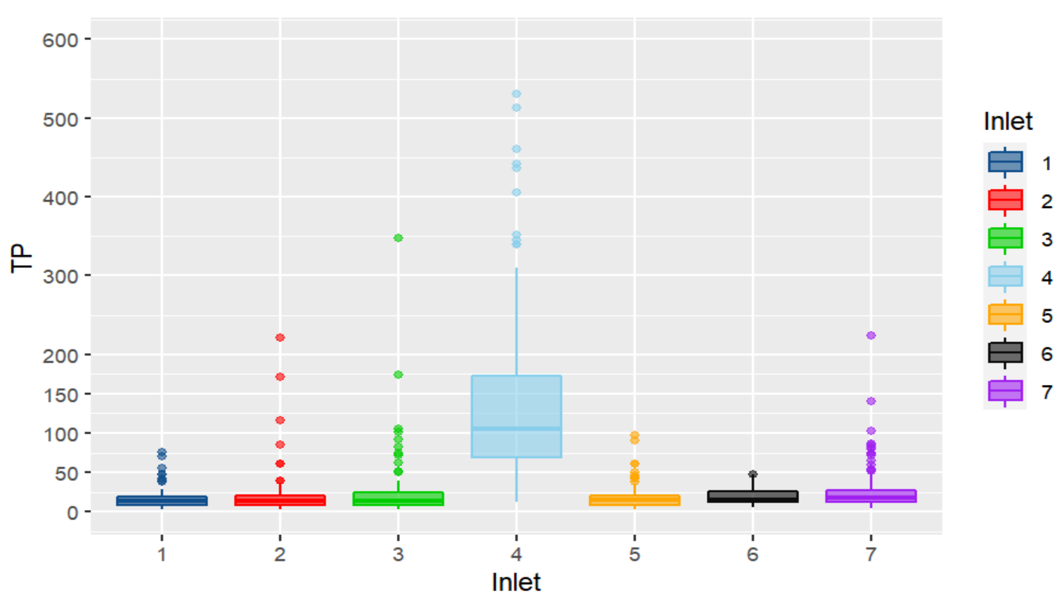


Figure 13 Historical Range of Inlet Phosphorus Concentrations

The nitrate nitrogen concentrations at Inlet 4 were highest in the spring at several stations. Inlets 4 and 7 were the two streams that had excessively high nitrate nitrogen. The values of nitrate nitrogen greater than 1000 µg/L indicates contamination, either from onsite wastewater, agriculture, or fertilizer. Inlet 4 has been the subject of many previous conversations regarding potential contamination from onsite wastewater. Densely populated areas are vulnerable to nitrate nitrogen groundwater pollution.

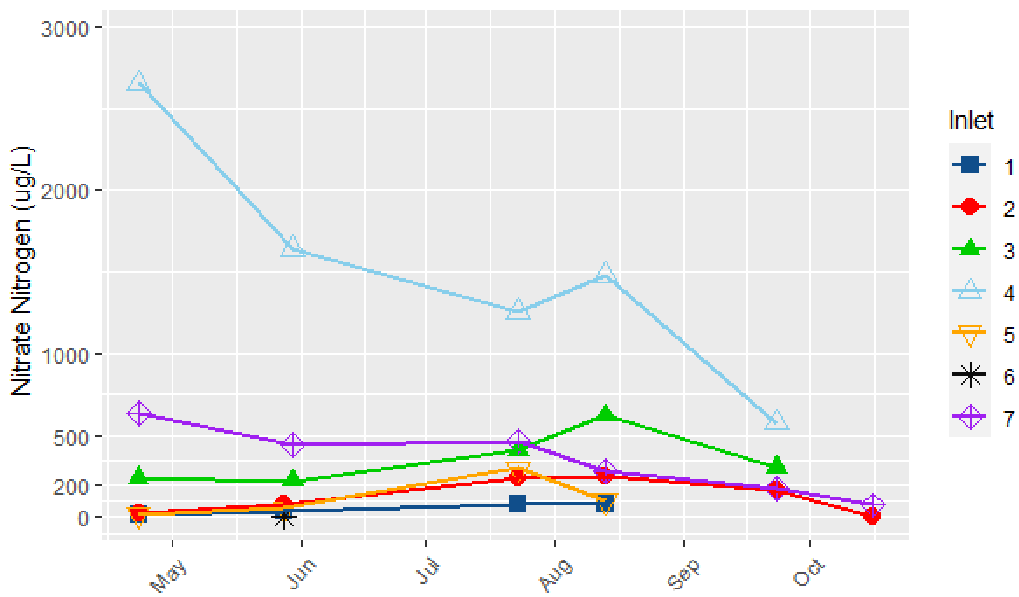


Figure 14 Inlet Nitrate nitrogen Concentrations 2019

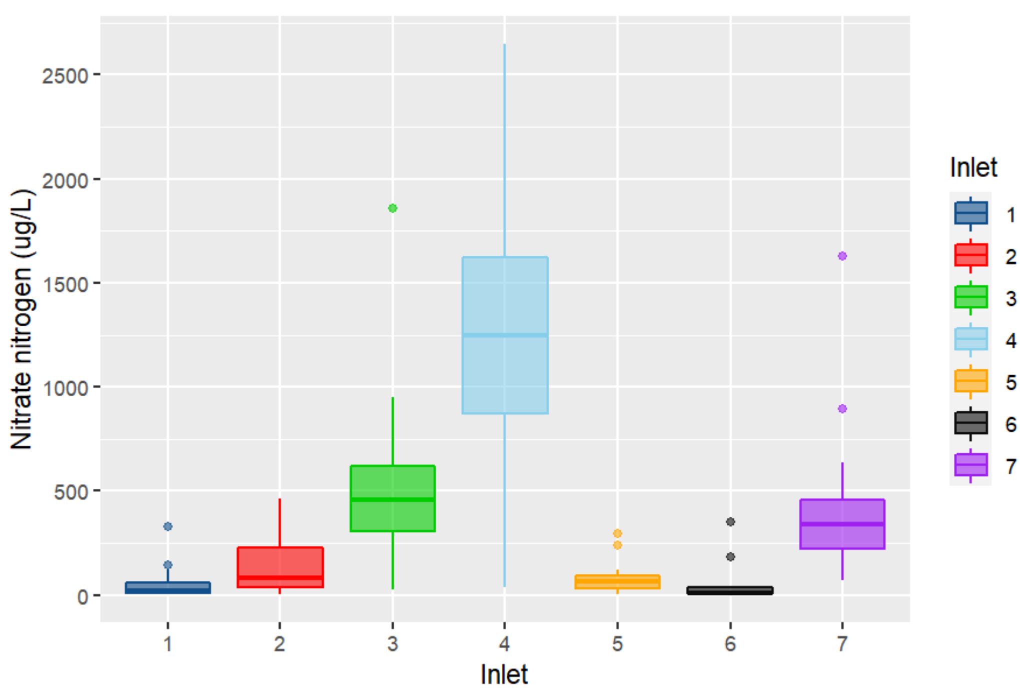


Figure 15 2015-2019 Ranges in Nitrate nitrogen

The following table lists all bacteria samples collected from the lake's 7 main inlets. "NA" indicates that a sample was not tested for a particular parameter. The units for Total and Fecal Coliform are Most Probable Number of Viable Cells (MPN) per 100mL of sample water. Units for E. coli are Colony Forming Units (CFU) per 100mL sample water. Limited budget only allowed for bacterial testing at Inlets 3, 4, and 7 – which are suspected to have septic or agricultural pollution, based on nitrate nitrogen values. The 2019 season was the first year E. coli testing was performed on any inlets around Oscawana, at the recommendation of the county health officials. Discussion about continued updates to residential onsite wastewater in the watershed will rely on county health recommendations based on E. coli tests. For reference, over 100 E. coli CFU/100mL constitutes a potential health risk for swimming areas.

Table 1 Inlets Bacteria Test Results 2019

Date	Station	TotalColiform	FecalColiform	E.coli	Units
4/23/2019	Inlet 3	NA	41	NA	MPN/100mL
4/23/2019	Inlet 4	NA	86	NA	MPN/100mL
4/23/2019	Inlet 7	NA	74	NA	MPN/100mL
5/29/2019	Inlet 3	NA	NA	13	CFU/100mL
5/29/2019	Inlet 4	NA	440	490	MPN/100ml CFU/100mL
5/29/2019	Inlet 7	NA	NA	110	CFU/100mL
6/25/2019	Inlet 3	>2420	NA	610	MPN/100ml CFU/100mL
6/25/2019	Inlet 4	>2420	NA	690	MPN/100ml CFU/100mL
6/25/2019	Inlet 7	>2420	NA	730	MPN/100ml CFU/100mL
7/23/2019	Hilltop Beach	NA	610	NA	MPN/100mL
7/23/2019	Inlet 3	NA	NA	>2420	CFU/100mL
7/23/2019	Inlet 4	NA	NA	2000	CFU/100mL
7/23/2019	Inlet 7	NA	NA	2400	CFU/100mL
8/13/2019	Inlet 3	NA	NA	450	CFU/100mL
8/13/2019	Inlet 4	NA	980	350	MPN/100ml CFU/100mL
8/13/2019	Inlet 7	NA	>2420	3700	MPN/100ml CFU/100mL
9/23/2019	Inlet 3	NA	20	170	MPN/100ml CFU/100mL
9/23/2019	Inlet 4	NA	<10	20	MPN/100ml CFU/100mL
9/23/2019	Inlet 7	NA	<10	410	MPN/100ml CFU/100mL
10/16/2019	Inlet 7	NA	190	220	MPN/100ml CFU/100mL

August 23, 2019:

Samples collected after a precipitation event

Plankton

Zooplankton are the tiny animals that live in open water. Phytoplankton are the microscopic plants that live in the water column. Plankton serve as the base of the food chain and are related to everything from water clarity to fisheries populations. Monitoring of plankton at Oscawana has traditionally been limited to just one monitoring station. However, concerns around adequate representation and the 2019 fisheries study supported a second zooplankton monitoring station in 2019.

For both Stations 1 and 2, Rotifers were the most abundant group collected in most months, as has been seen in past monitoring years. Though in May 2018 and July 2019, Copepods were slightly more abundant. Rotifers were dominant during the early and late season in 2019, inversely related with Cladoceran and Copepod abundance. The overall Cladoceran population in 2019 was higher than has been counted in the past three years. Copepod concentrations peaked at roughly 50 animals per liter in 2019, very similar to 2018 results, but the Copepods maintained elevated numbers for a longer duration this year.

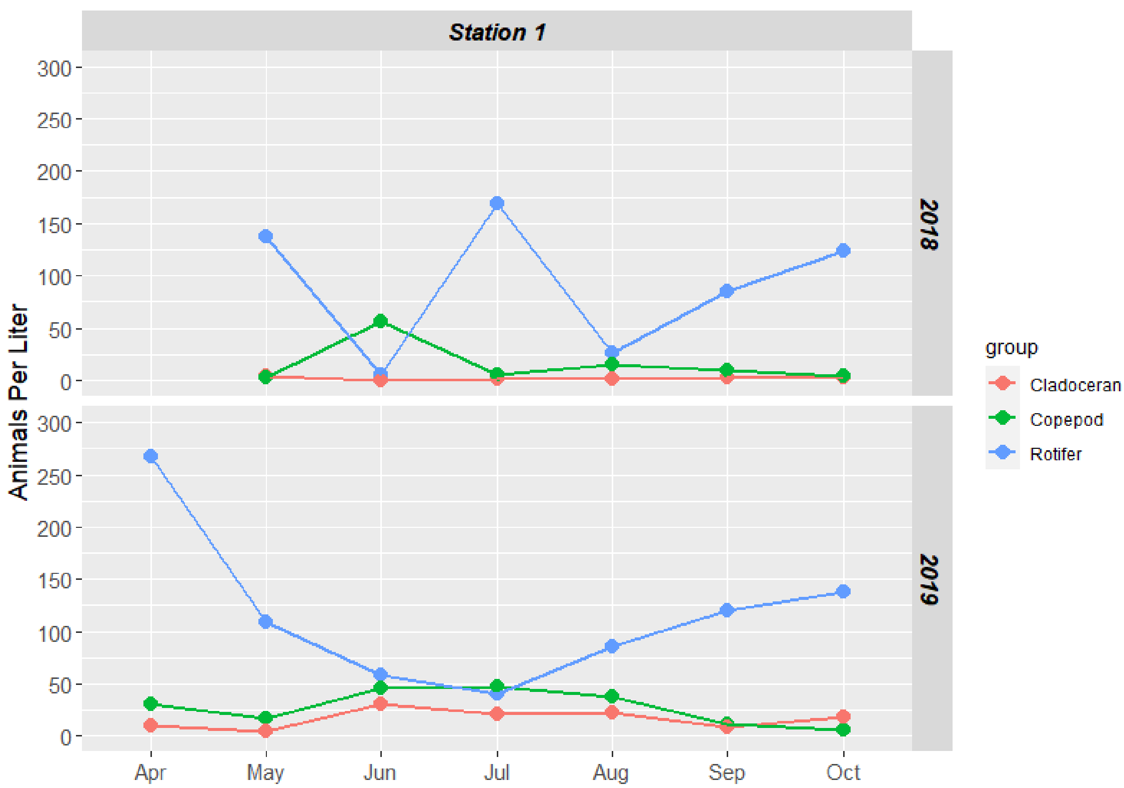


Figure 16 Station 1 Zooplankton (2018 and 2019 Comparison)

While Figure 16 is arranged by zooplankton group, Figure 17 demonstrates the genus abundance within the Cladoceran group across Stations 1 and 2. The seasonal comparison to genus level of Cladocerans demonstrates that the *Bosmina* and *Ceriodaphnia*, two small-bodied genera, are in much higher density than *Daphnia*, a large-bodied zooplankton. *Daphnia* are the genera most associated with filter-feeding of algae and improved water quality. As in other recent years, *Daphnia* were rare in all samples, with only a maximum of 2.8 animals per liter in the end of June at station two. Overall, there was not a significant difference between stations for most genera.

Daphnia length distribution from both stations indicates a small-bodied population, with the majority of individuals under 1.0 mm. If mean daphnia body size is under 0.6 mm, predation from planktivores (i.e. alewife fish) is assumed to be significant[1]. This concept will be discussed further in the fisheries section.

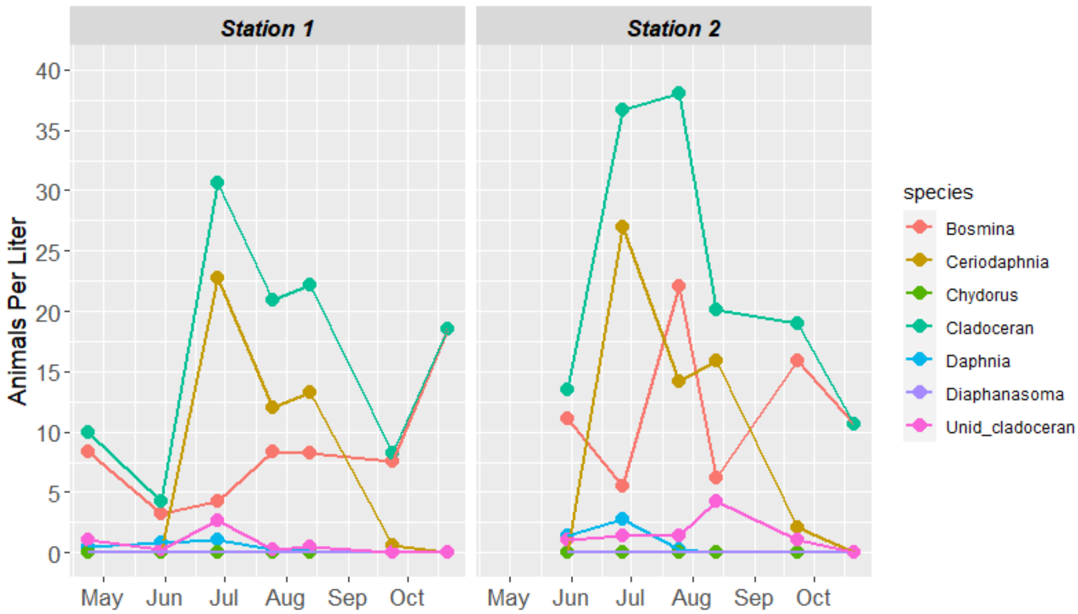


Figure 17 Seasonal Trend in Cladocerans by Genus

Phytoplankton counts are displayed in Figure 18, below.

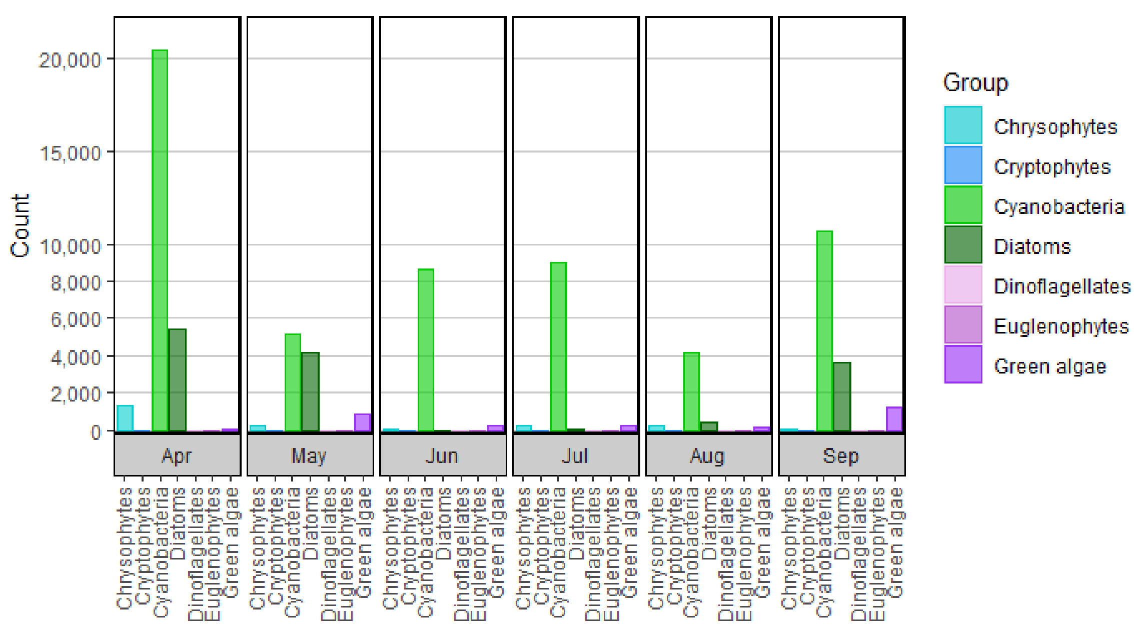


Figure 18 Phytoplankton Algae Total Cells/mL by Group 2019

[1] Brooks, J.L. and Dodson, S.I., 1965. Predation, body size, and composition of plankton. *Science*, *150*(3692), pp.28-35.

The most abundant groups of phytoplankton were Chrysophytes, Cyanobacteria, Diatoms, and Green algae. Cyanobacteria was the most abundant throughout the entire season with the maximum cells/mL at just over 20,000, which does not constitute a harmful bloom condition. Harmful cyanobacteria surface blooms typically occur only when the open-water count (cells/mL) exceeds 70,000. Diatoms were abundant in the spring and fall, which is typical for dimictic temperature lakes like Oscawana.

Figure 19 parses out the Cyanobacteria genera from the overall counts in Figure 18.

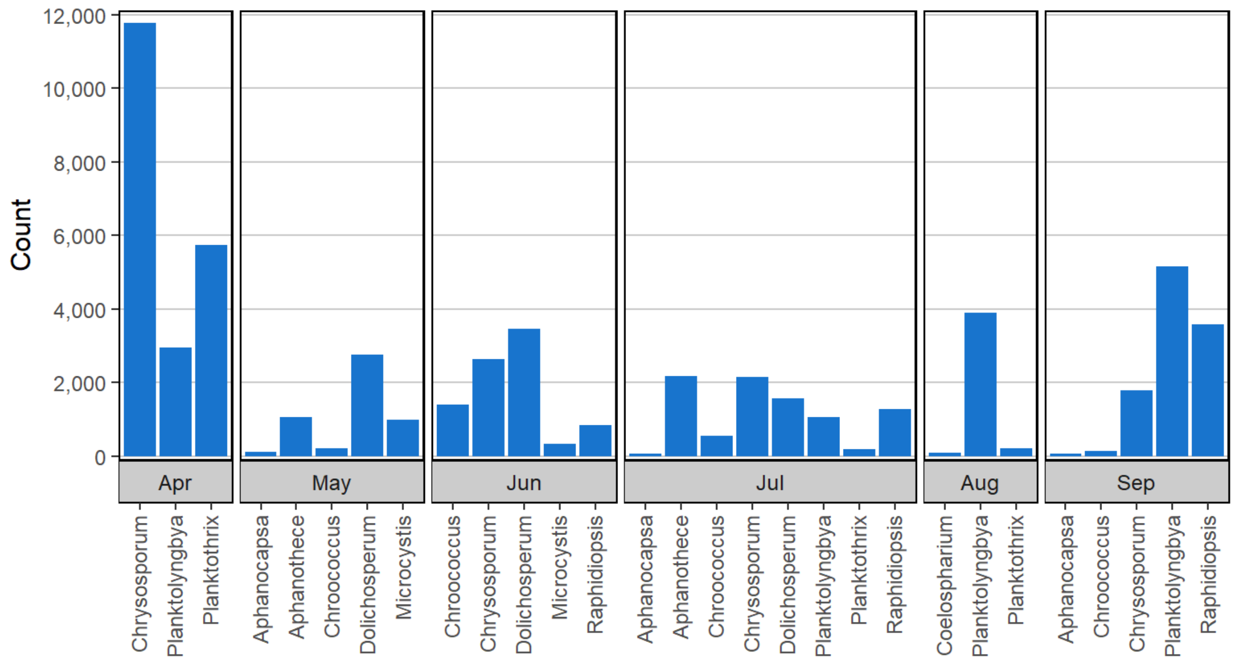


Figure 19 Cyanobacteria (Blue-green algae) Genus Counts Per Month 2019

Fisheries

The 2019 fisheries study was conducted by Dr. Mark Cornwell from SUNY Cobleskill. The University provided equipment and field personnel. Northeast Aquatic Research helped with field work and was responsible for the data analysis and interpretation. This fisheries study was the first conducted since the initial survey in 1998 performed by the NY Department of Environmental Conservation (DEC).

The 2019 fisheries survey came to fruition after many years of attempted biomanipulation of the Oscawana fishery, through stocking of predatory walleye. The initial goal of walleye stocking was to reduce alewife populations in the lake. Alewife prey on large-bodied zooplankton like *Daphnia* and can impact water quality through the top-down food chain cascade, leaving an overgrowth of phytoplankton. Yet, the results of the recent Oscawana fisheries survey, in concert with zooplankton monitoring data, demonstrate that the years of walleye stocking has not been effective at reducing the alewife population.

Furthermore, recent research suggests that very few biomanipulation projects have documented successful reductions in alewife or substantial increases in zooplankton. The results of the fisheries survey and newly published research both indicate that the biomanipulation technique is largely infeasible for Oscawana. This concept is expanded upon in the ‘Alewife and Walley Interactions’ subsection.

Methodology

Sampling occurred during June and October. The June sampling covered most of the shoreline and the October sampling covered the entire shoreline.

In June, samples were classified as either ‘all fish runs,’ where all fish observed were collected, counted, and measured to the nearest mm, or as ‘gamefish runs,’ where only select species were collected. Game fish species collected included black crappie, chain pickerel, largemouth bass, walleye, and alewife. A subset of largemouth bass (n = 61) were weighed to the nearest gram.

The October electrofishing targeted the following species: black crappie, alewife, triploid grass carp, and walleye. Other species were caught but were not included in catch per unit effort (CPUE) or size structure analysis. CPUE is defined as the number of fish caught per hour of sampling.

Species Abundance

Species abundance is measured by raw counts and CPUE for a select number of species.

The data from 1998 show the bass CPUE of 65 fish per hour; the 2019 bass CPUE value was 34 fish per hour. The 2019 value, however, is still higher than the state mean CPUE for largemouth bass (mean: 16.75, SD = 18.86)[2]. The range for CPUE in New York is 0-114 fish per hour.

The amount of alewife caught in both June and October signifies that alewife are present in the lake in high abundance despite their lower abundance relative to other species. This is because alewife are

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[2] Perry, P.C., Loukmas, J.J., Fisher, W.L., Sullivan, P.J. and Jackson, J.R., 2014. Characterizing the status of black bass populations in New York. *Final Report. New York State Department of Environmental Conservation, Albany, NY*.

predominantly an open water species, so electrofishing, which is geared toward shallow water fish, will underestimate abundance as CPUE.

Only one walleye was caught during each sampling visit, at 580 and 588 mm respectively. These are considered to be large, older walleye.

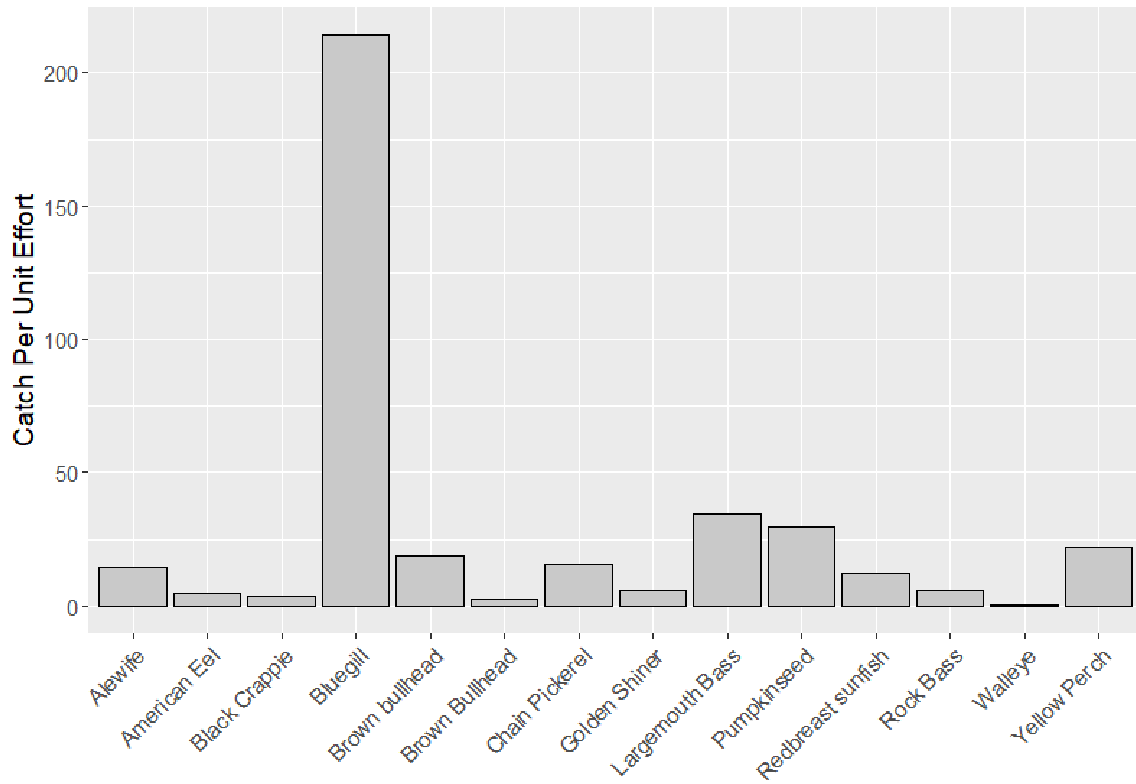

Figure 20 Catch Per Unit Effort (CPUE) June 2019 - Electrofishing Results

Table 2 June 2019 Fisheries Results

Common name	Number of Fish	Catch Per unit Effort
Alewife	46	14.6
American Eel	11	4.7
Black Crappie	11	3.5
Bluegill	496	214
Brown bullhead	50	21.6
Brown Bullhead	6	2.6
Chain Pickerel	49	15.5
Golden Shiner	13	5.6
Largemouth Bass	108	34.3
Pumpkinseed	69	29.8
Redbreast sunfish	29	12.5
Rock Bass	14	6.0
Walleye	1	0.4
Yellow Perch	51	22.0

Table 3 October 2019 Fisheries Results

Common name	Number of Fish	Catch Per Unit Effort
Alewife	47	12.5
Black Crappie	15	3.9
Largemouth Bass	13	3.5
Triploid Grass Carp	9	2.4
Walleye	1	0.3
Yellow Perch	14	3.7

Oscawana Game Fishery Details

This fisheries assessment specifically analyzed Largemouth bass, black crappie, and alewife populations.

Largemouth Bass

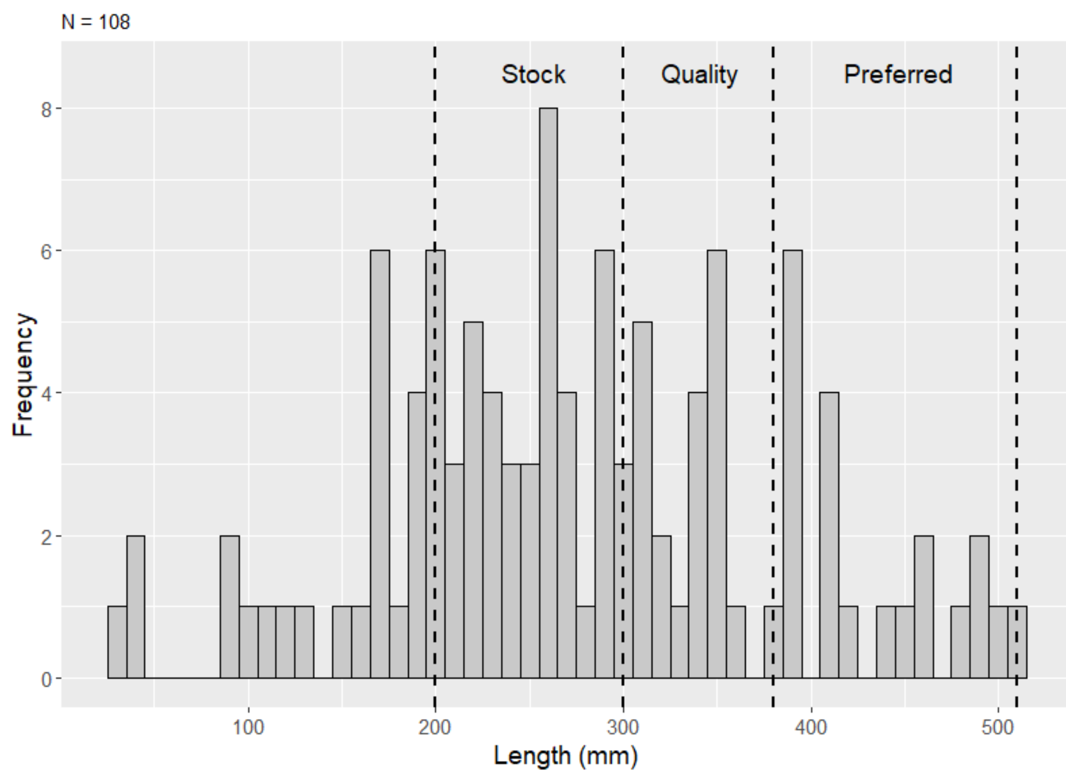

Figure 21 Length Frequency Histogram of Largemouth Bass (June data)

Largemouth bass size structure shows a good distribution of small and large fish with 4-5 distinct size classes represented. Multiple size classes indicate there have been no significant disruptions in young of the year recruitment over the past few years. Each dashed line, in Figure 21 above, indicates length categories used to assess the quality of fish.

Fisheries managers separate fish stocks into 5 different length categories which are percentages of the world record length. These 5 length categories are stock, quality preferred, memorable, and trophy. The recreational quality of a fish population can be quantified using proportional stock density (PSD), defined as the number of fish in a population that are a quality size compared to the number of fish that are a stock size. Generally, as PSD increases, there is a larger population of fish that anglers would desire to catch. Largemouth bass size categories are as follows stock: 200mm, quality: 300mm, preferred: 380mm, memorable: 510mm, trophy: 630mm. Largemouth bass PSD is at 50, which is slightly below the state mean PSD, but well within the first standard deviation (mean = 55, SD = 24).

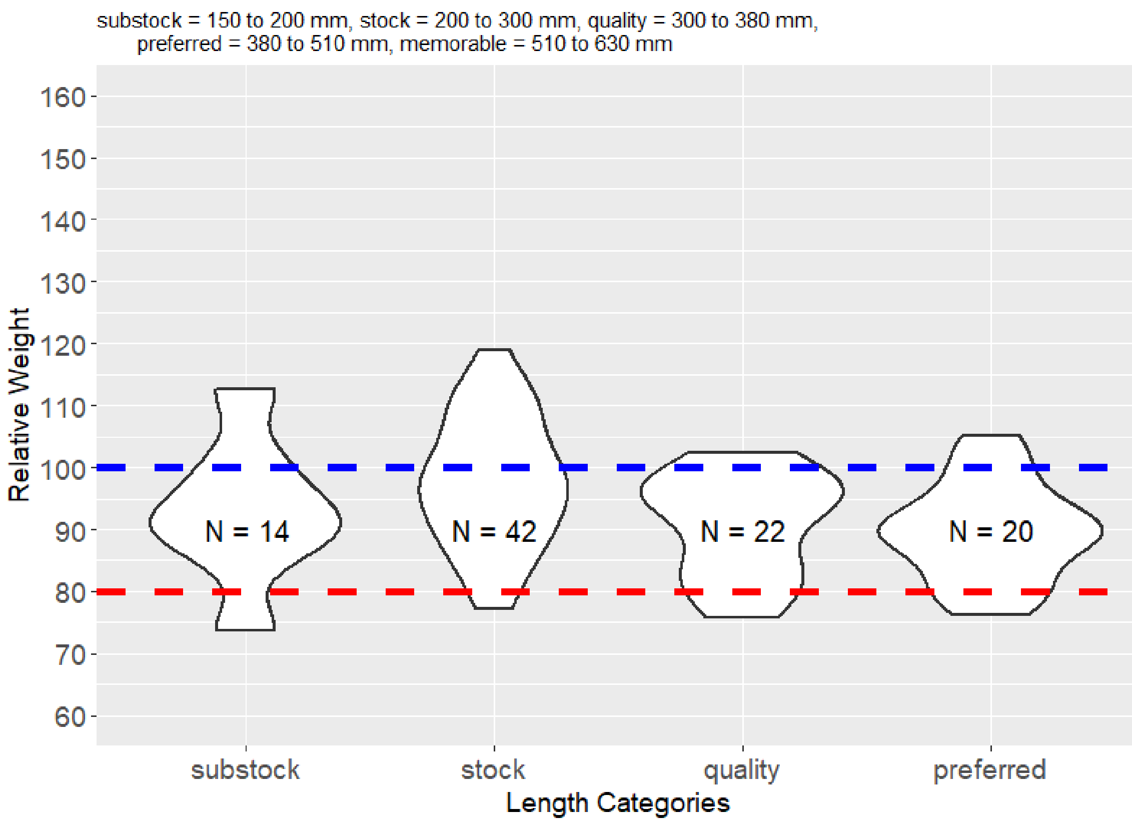

Figure 22 Largemouth Bass Relative Weight Among Size Classes

Relative weight of largemouth bass, which is a ratio of the actual weight of a fish to what a rapidly growing healthy fish of the same length should weigh, is an indicator for the condition of the population. Fish with a relative weight <80 are considered skinny fish, which may indicate problems with forage base or overcrowding. Bass relative weights were almost entirely above that 80 threshold at Oscawana (Figure 22). Fish with a relative weight between 80-100 are within national variation. Fish with a relative weight >100 are ideal, in terms of evaluating the overall bass fishery.

The above graph shows that the bass population is in good condition overall. All but four individuals had a relative weight over 80 and most fish were well between 80 to 100. Fish of stock and quality size were in the best condition of the size classes, with sub stock and preferred fish being skinnier, but still well within the favorable range for a bass fishery.

Black Crappie

Black crappie population size structure skews toward larger size classes, indicating there are preferred and memorable fish present. The lack of smaller fish may be due to the fact that 1) black crappie recruitment in lakes can be highly variable, leading to frequent boom and bust years, and 2) electrofishing did not capture the smaller members of the population, which is a frequent issue when sampling crappie populations.

Alewife

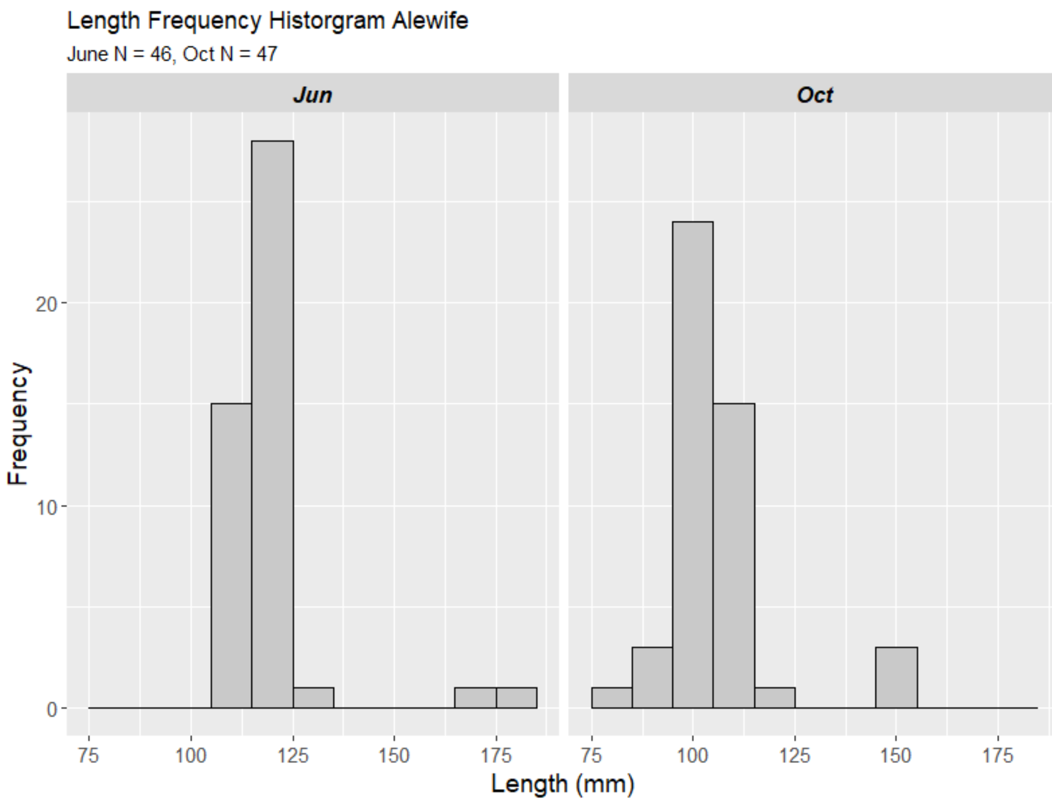

Figure 23 Length Frequency Histogram of Alewife

The alewife length frequency histogram shows one size class at 100-120mm with a very small class at 165-185 mm. This may indicate a stunted population, but gill-net sampling would have provided a better alewife estimate if it were permitted by the NY DEC. There was a similar pattern in October, one dominant size class at 100-120 mm size range.

Alewife and Walleye Interactions

To reitterate, the impetus for the fisheries survey was to investigate the impacts of past walleye stocking on the baitfish population. The rationale behind the stocking was to reduce baitfish populations to increase the population of large-bodied *Daphnia* zooplankton, which would then theoretically filter a tremendous amount of water, consuming algae and increasing water clarity. However, years of walleye stocking in the range of 1000 to 5000 fingerlings per year, did not improve water clarity or the *Daphnia* zooplankton population. The overall zooplankton population continues to be dominated by small bodied Cladocerans such as *Bosmina* and *Ceriodaphnia.*

The fisheries survey results indicate three key conclusions regarding biomanipulation attempts:

1) Alewife are highly abundant throughout the lake.
2) Walleye are in low abundance and are most likely not reproducing.
3) Biomanipulation via Walleye stocking has not worked in Oscawana and the technique is largely infeasible for finanial and ecological reasons.

Only one walleye was found during each sampling event, and both fish were over 20 inches long, indicating the fish are at least from the last stocking period. Furthermore, Oscawana Lake lacks traditional spawning habitat for walleye. Walleye require large windswept rocky shorelines or large tributaries for spawning. The Oscawana Largemouth bass population also suggests potential bass predation on stocked walleye fish[3] [4]. Walleye seem to have a difficult time surviving in Oscawana.

In order to increase the abundance of walleye to an amount that can meaningfully reduce the alewife population, a significant increase in annual stocking would be needed. But even if LOMAC could drastically increase the amount of fish stocked, there is no guarantee that the walleye would successfully reduce the alewife population. An example of failed walleye biomanipulation is Cayuta Lake (Schuyler County, New York), which is of comparable size and depth to Oscawana.

From 2002 to 2006, 266,000 walleye were stocked into Cayuta Lake[5], which also had a previous, smaller walleye stocking of 76,000 fish from 1992 to 1996. This equates to 53,200 and 15,200 fish per year in the 2002-2006 and the 1992-1996 time-frames, respectively. Despite these large stocking numbers, water clarity, zooplankton mean size, and zooplankton density did not change. Zooplankton composition was very similar to Oscawana, with *Bosmina, Ceriodaphnia, Chydorus* and Cyclopoid copepods as the dominant crustacean zooplankton. Calanoid copepods, which filter feed in open-water, were rare and *Daphnia* was not found in any samples examined. Alewife were reduced in Cayuta Lake from 2002 to 2007, but the reduction was short-lived, unsuccessful at impacting zooplankton populations, and alewife increased again from 2008 to 2009, despite remaining high walleye population.

As a management technique, biomanipulation using walleye to reduce alewife populations is highly complex and can be disrupted at multiple links in the food chain. Shallow, vegetated lakes with large populations of largemouth bass and limited walleye spawning habitat, like Oscawana, are not optimal for this biomanipulation approach. With walleye priced at roughly $2.00 per fish, the financial investment to even come close to a chance to improve water quality is exorbitant and unrealistic. Funding should, instead, be directed towards continued watershed improvement projects that will have a more long-term and profound impact on water quality.

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[3] Santucci, V. J., Jr., and D. H. Wahl. 1993. Factors influencing survival and growth of stocked walleye Stizostedion vitreum virteum, in a centrarchid dominated impoundment. Canadian Journal of Fisheries and Aquatic Sciences 50:1548–1558.

[4] Fayram, A.H., Hansen, M.J. and Ehlinger, T.J., 2005. Interactions between walleyes and four fish species with implications for walleye stocking. *North American Journal of Fisheries Management*, *25*(4), pp.1321-1330.

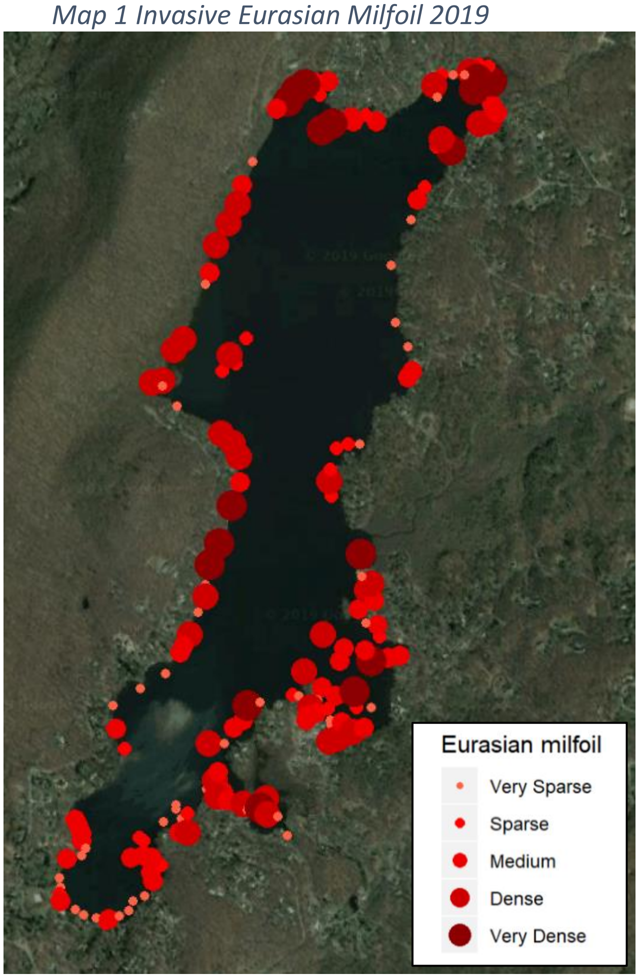
[5] Rudstam, L.G., Brooking, T.E., Krueger, S.D., Jackson, J.R. and Wetherbee, L., 2011. Analysis of compensatory responses in land-locked alewives to walleye predation: a tale of two lakes. *Transactions of the American Fisheries Society*, *140*(6), pp.1587-1603.

Aquatic Plant Management

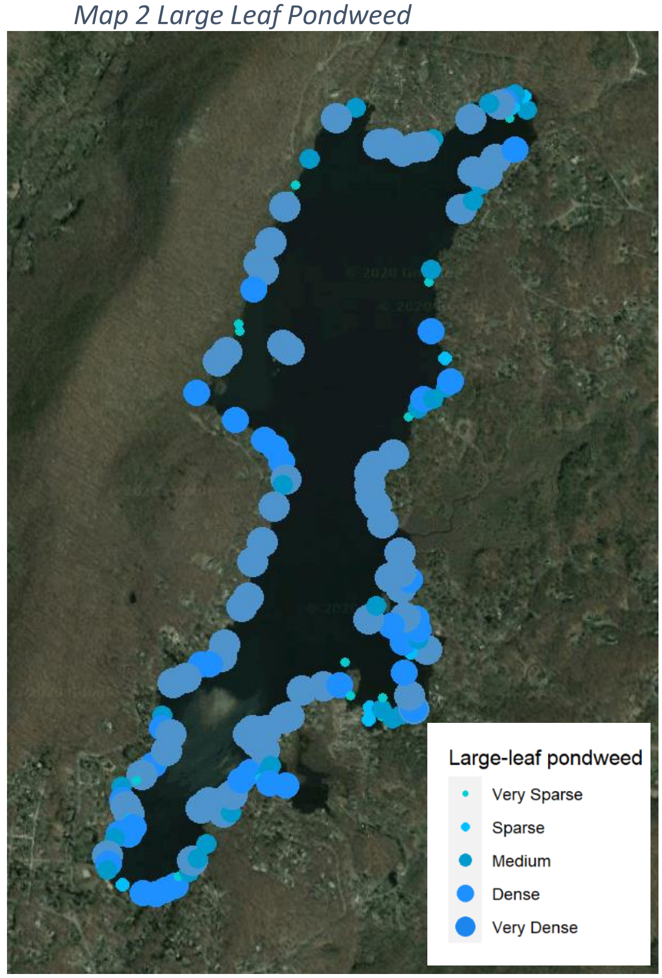
Oscawana Lake was surveyed for aquatic plants on July 24, 2019. The following maps are slightly different than those provided in previous years. The new maps provide species density at all observation points throughout the littoral zone. Overall, the distribution of invasive Eurasian milfoil *(Myriophyllum spicatum)* has not changed since 2018, but the density and growth height in the water column appears to be slightly impacted from the triploid Grass carp. Though, it is difficult to gague the impact of Grass carp on the plant height in the water column in areas that are also frequently mechanically harvested.

The conservative stocking of Grass carp has not hurt the native Large-leaf pondweed *(Potamogeton amplifolius)* populations. Large-leaf pondweed has consistently been the second most dominant plant in Oscawwana since the early 2000s, and 2019 had considerably more Large-leaf pondweed than documented in 2015-2018. The frequency and density of Robbin's pondweed (*Potamogeton* robbinsii) and Tapegrass *(Vallisneria americana*) have not changed considerably since 2015. The 2019 frequency and densities of both species were higher than in 2018, and on par with earlier values. The frequency of these two species seems to be more variable from year to year. Coontail (*Ceratophyllum demersum*) was present at a slightly higher percent of the waypoints in 2019 than in years past.

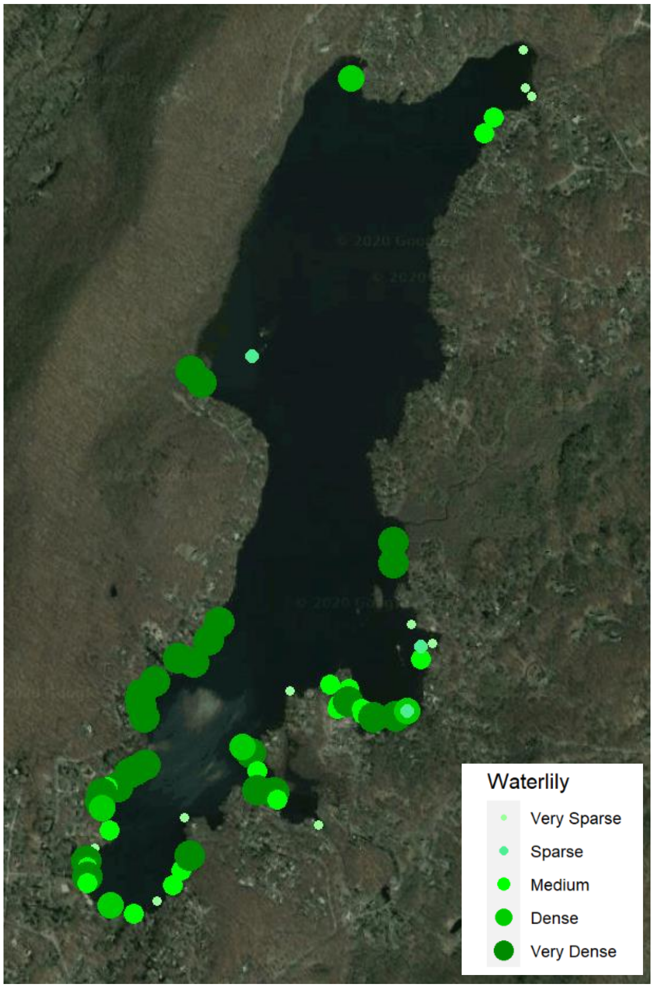
Map 1 Invasive Eurasian Milfoil 2019



Map 2 Large Leaf Pondweed



Map 3 Waterlilies 2019



Map 4 Robbin's pondweed 2019

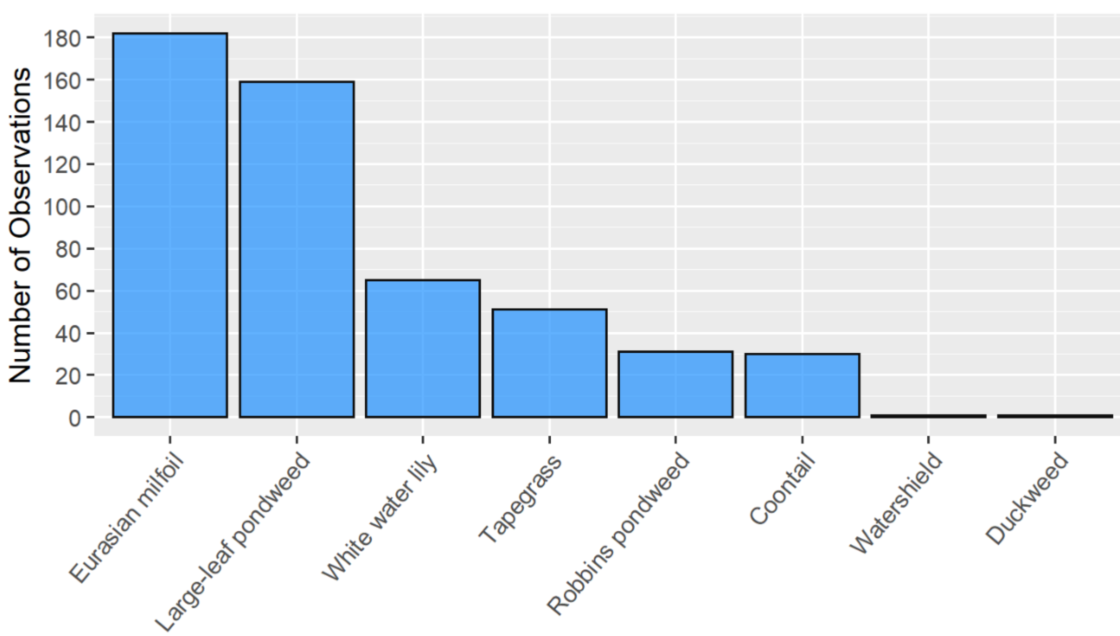


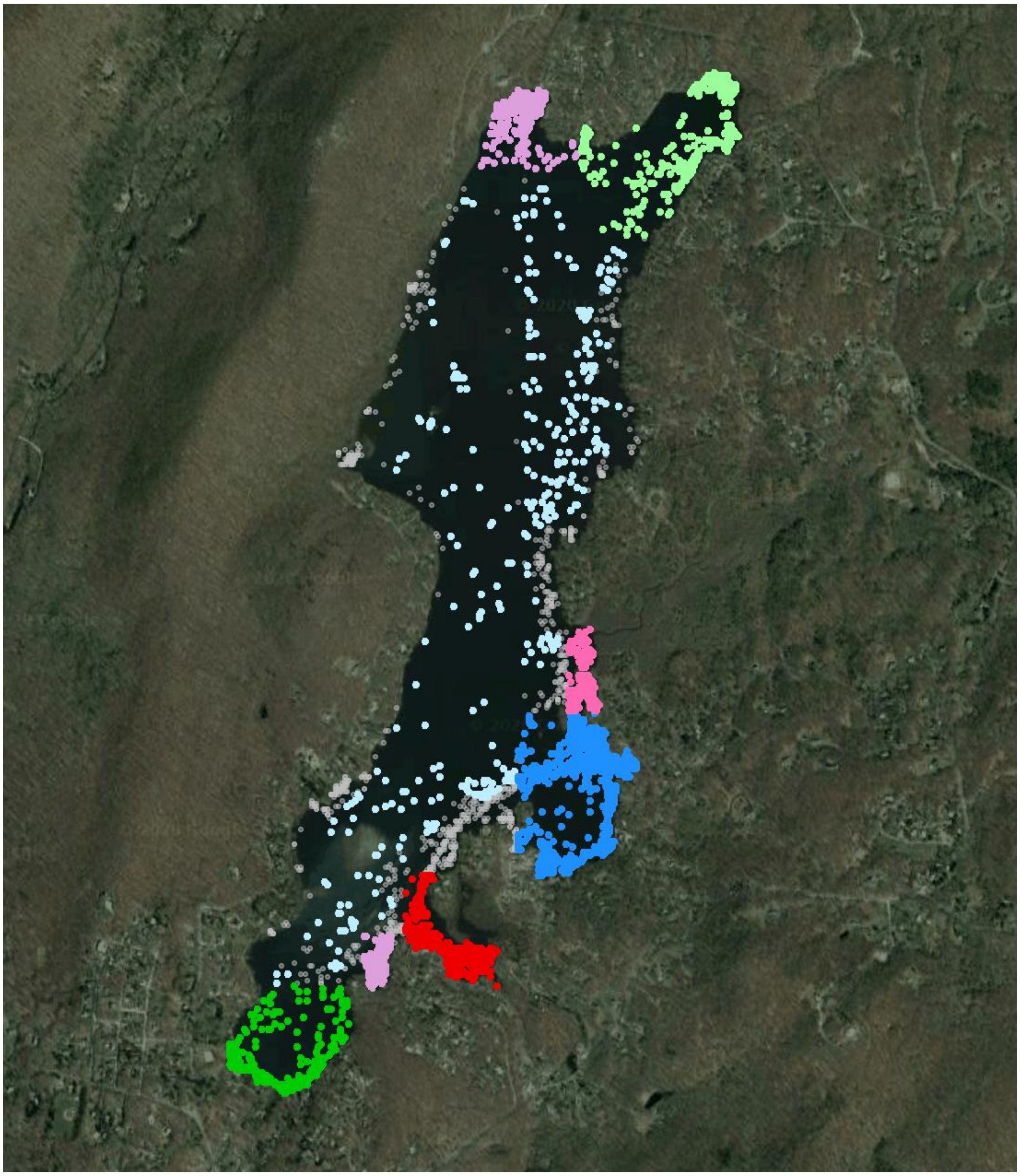
Figure 24 Aquatic Plant Observations; July 24, 2019

Weed-Harvesting Tracker Data

The 2019 season was the first year in which LOMAC implemented a method for tracking the work of the mechanical weed-harvesters. The GPS tracker data automatically records the harvester's position at regular intervals. The tracker also indicates if the machine is turned on or off, whether it is moving, idling, or completely stopped.

The harvester tracker data was used to determine the exact amount of time spent harvesting in select areas, the amount of travel time between operation areas, as well as the differences in time spent harvesting per month or week of the season.

Map 5 Mechanical Weed Harvesting Tracker Data Points from 2019 Season



Map 5 depicts the various main harvesting areas in the lake that were used to calculate the number of hours of active harvest time per site (Figure 25). The overall 2019 harvester logs by month and movement status are tallied in Figure 26.

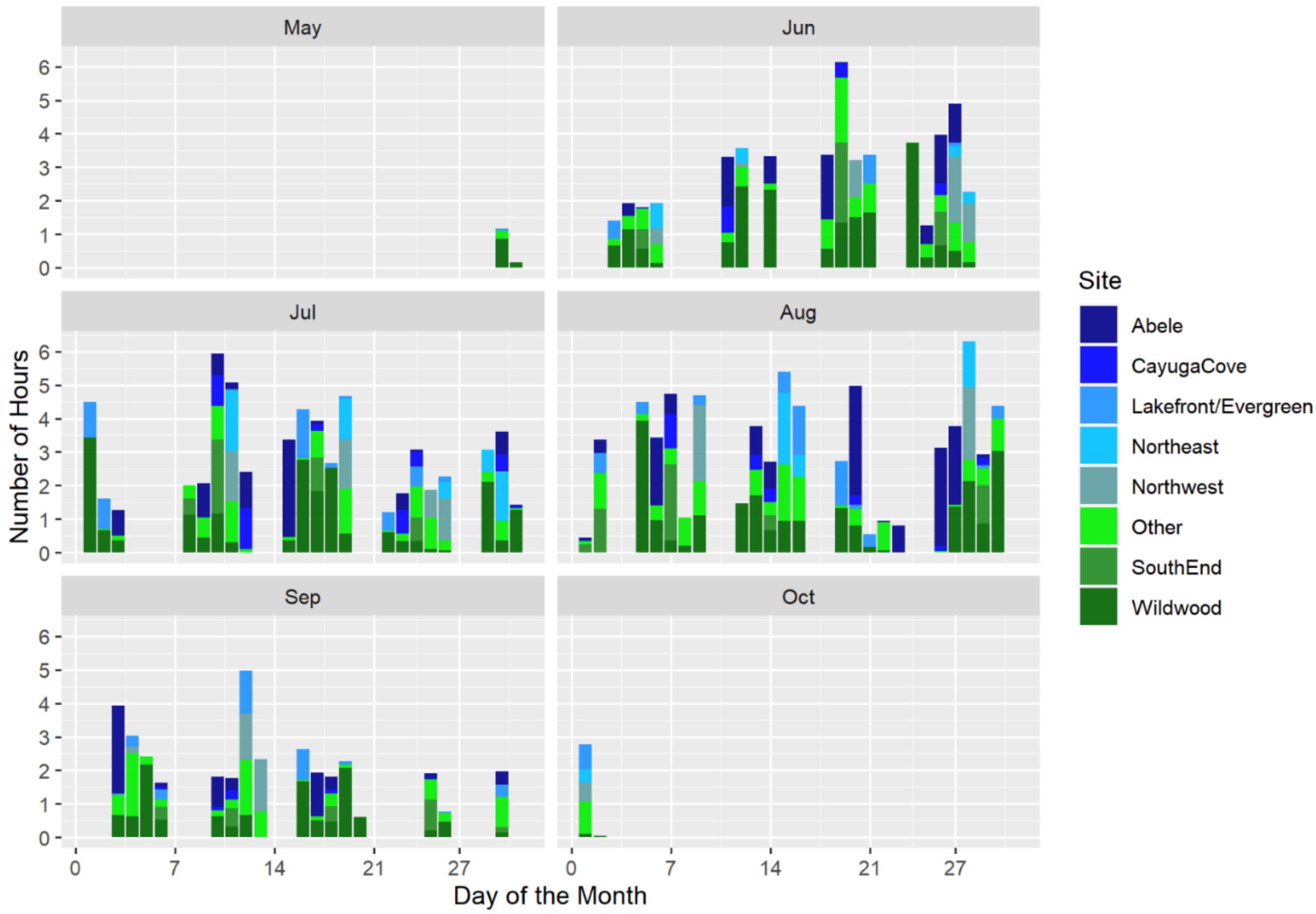


Figure 25 Active Harvester Hours Spent per Day of the Month

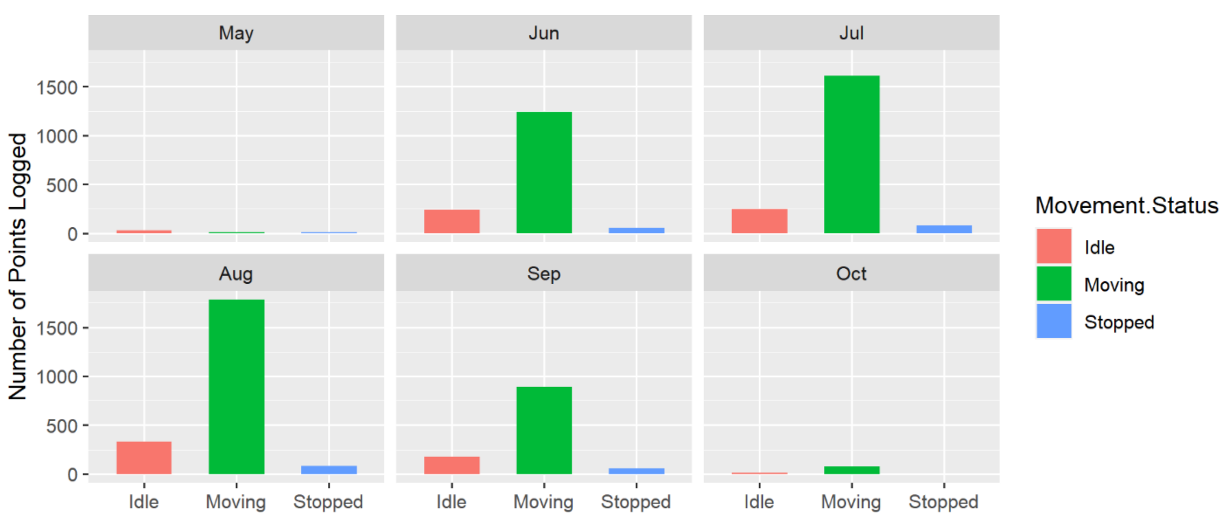


Figure 26 Weed Harvester Overall Activity Level Per Month

The figures demonstrate that overall, the harvester operated around 4-5 days a week from mid-June through mid-September, and ranged from 1-6hrs of daily operation. Table 4 and Figure 27 both show the total 2019 number of hours of operation per main site. Table 4 also includes the "Travel" category, which indicates travel time to and from harvesting and offload sites when the harvester was in water deeper than 20ft, and the "Other" category, which includes time when the harvester was active in shoreline areas not within the main sites graphed below.

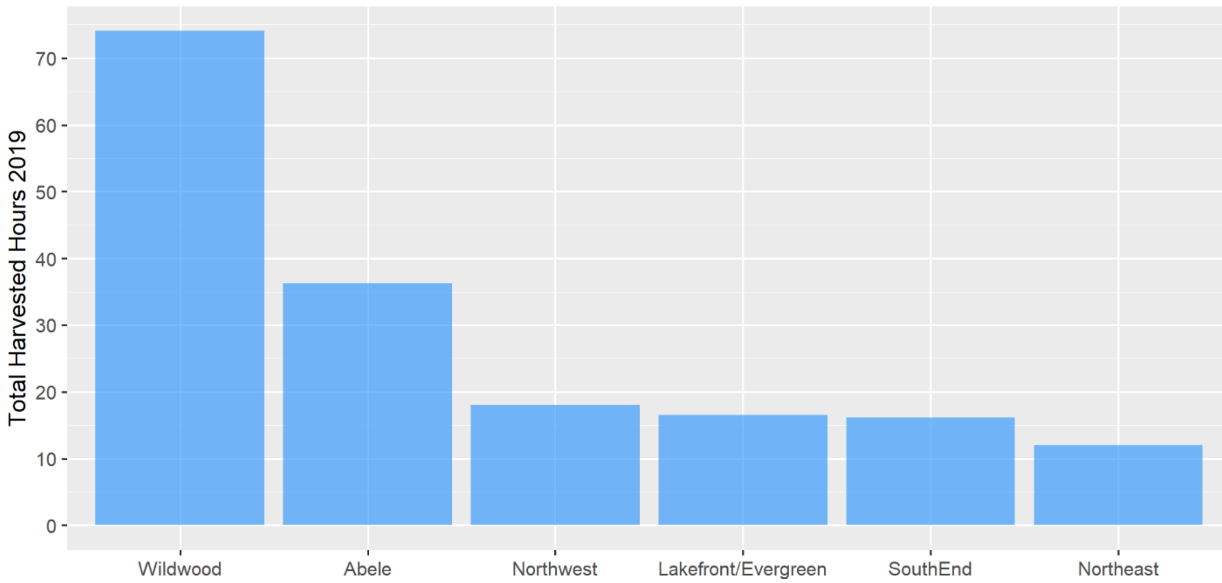


Figure 27 Total Harvesting Hours at Main Sites

Table 4 Total Harvesting Hours & Percentages 2019

Total with Ignition Status On (2019)		
Site	Hours	%
Abele	36	16
Northeast	12	5
Northwest	18	8
SouthEnd	16	7
Wildwood	74	33
Travel/DeepWater	14	6
Other	*51*	*23*
Total	222	100

One of the main take-aways from the harvester tracker data is nearly 50% of the operation time is in Wildwood and Abele Coves. As previously discussed in the Lake Oscawana Management Plan, there are ongoing water quality concerns with such a large amount of operation in the shallow coves. Sediment disturbances from Abele Cove may contribute to the lake-wide nutrient concentrations and may exasperate internal loading if sediment plumes are wind-blown into open water.

The harvester operator time sheets and logs of the number of loads were also reviewed, but the 2019 number of loads per total number of hours worked seems incomparable to previous years. Preliminarily, it seems as though it took longer to collect a full load in 2019 than it did in previous years. The number of loads collected in 2019 does not at all match up with the previous correlation of maximum bottom-water phosphorus concentration because despite a similar number of hours worked, there were roughly half as many loads recorded. This analysis of harvester operator logs needs more scrutiny to decide if 2019 logs are or are not comparable to prior years. One hypothesis is that Eurasian milfoil density *is* less due to Grass carp and that it now takes more time to accumulate a full harvester load.

Conclusions & Recommendations

The 2019 plant survey results indicate that Grass carp have not been detrimental to the native plant population of the lake from 2016-2019. Aquatic plant species diversity at Oscawana has been low for nearly two decades, and it seems that the native plants that do inhabit Oscawana (Large-leaf pondweed, Coontail, Robbin's pondweed, Tapegrass) have not yet been reduced by Grass carp. The invasive Eurasian milfoil acreage has also not changed significantly since the 2016 stocking. The Eurasian milfoil plant height in the water column, however, did appear to be reduced in 2019, and plants were also "thinner" and of slightly lesser density in some areas compared to previous years.

Additional comparison of milfoil density from historical survey records will be completed in 2020. This type of impact from Grass carp feeding has been observed in other lakes, but at Oscawana, the active weed-harvesting efforts make it difficult to determine the true impacts of Grass carp.

Part of the plant and harvester tracker data analysis included investigation of specific areas harvested one and two weeks prior to the July 2019 plant survey. Though, one week prior to the plant survey, the harvester had spent time in all of the major milfoil sites, so it is likely that the plant height in the water column was influenced by mechanical cutting.

Overall, the plant data demonstrates that a second small Grass carp stocking for continued plant control may be appropriate. This effort must be permitted by the NY DEC and coordinated with other suggested plant management actions, such as a potential test herbicide application in Abele or Wildwood Coves. Please see the Lake Oscawana Management Plan for additional discussion and information regarding future plant management recommendations, as well as the scientific and economic factors that support a trial herbicide treatment. Of course, any change to current plant management efforts would be collectively decided by LOMAC and the Oscawana residents.

In terms of water quality, the 2019 season was average, and was not as good as 2017-2018. However, the completion of the Lake Oscawana Management Plan marks a great milestone for the Town. The plan includes a detailed section with suggested watershed improvement projects. State and Federal grants are available for Low Impact Development (LID) stormwater improvements and should be pursued. Continued onsite wastewater upgrades in the watershed are also critical for preventing harmful cyanobacteria blooms.

Toxin-producing cyanobacteria are present in Oscawana, yet the cell counts are low enough so that it is not presently a human health concern. If efforts to reduce watershed nutrient inputs continue, nutrients in the lake should remain low enough to prevent dense cyanobacteria blooms. Oscawana has had cyanobacteria blooms in the past, but lake management efforts aim to prevent future blooms so that residents may continue to enjoy the exquisite natural resource.

Appendix

				Phosphorus	AmmoniaN	Nitrogen	NitrateN
Date	Station	Secchi_m	Depth_m	TP_ug/L	NH3_ug/L	TN_ug/L	NOX_ug/L
4/23/2019	1	2.85	1	23	3	249	
4/23/2019	1		4	24		237	
4/23/2019	1		6	22	6	241	
4/23/2019	1		9	31	12	240	
5/30/2019	1	2.6	1	23		259	
5/30/2019	1		4	28		302	
5/30/2019	1		6	24		229	
5/30/2019	1		9	48	95	389	
6/27/2019	1	3.55	1	19		224	
6/27/2019	1		4	33		263	
6/27/2019	1		6	63		347	
6/27/2019	1		9	238		164	
7/25/2019	1	2.45	1	20		346	
7/25/2019	1		4	32	4	364	
7/25/2019	1		6	105	7	1049	
7/25/2019	1		9	529	712	740	
8/13/2019	1	2.6	1	20	3	333	
8/13/2019	1		4	35	11	338	3
8/13/2019	1		6	57	5	543	
8/13/2019	1		9	697	1230	1325	
9/23/2019	1	3.25	1	20	21	312	
9/23/2019	1		4	29	22	347	
9/23/2019	1		6	51	185	605	
9/23/2019	1		9	713	2440	2826	
10/21/2019	1	2.6	1				
10/21/2019	1		4	26	38	328	21
10/22/2019	1		6	26	39	322	22
10/22/2019	1		9	24	46	299	23
4/23/2019	2	2.85	1	23		238	
4/23/2019	2		7	26		247	
5/30/2019	2	2.6	1	21		243	
5/30/2019	2		7	42		272	
6/27/2019	2	3.4	1	18		178	
6/27/2019	2		7	79		213	
7/25/2019	2	2	1	20		299	
7/25/2019	2		7	164		436	
8/13/2019	2	2.4	1	26		338	
8/13/2019	2		7	160		542	
9/23/2019	2	3.15	1	21		276	
9/23/2019	2		7	71		855	
10/22/2019	2	2.65	1	30		349	
10/22/2019	2		7	29		340	
4/23/2019	3	2.65	1	22		254	
4/23/2019	3		7	23		247	
5/30/2019	3	2.45	1	23		276	
5/30/2019	3		7	30		240	
6/27/2019	3	3.45	1	24		218	
6/27/2019	3		7	112		180	
7/25/2019	3	2.4	1	24		331	
7/25/2019	3		7	242		481	
8/13/2019	3	2.35	1	27		399	
8/13/2019	3		7	452		991	
9/23/2019	3	2.95	1	19		303	
9/23/2019	3		7	139		1414	
10/22/2019	3		1	26		338	
10/22/2019	3		7	25		318	