Lake Oscawana 2020 Water Quality & Aquatic Plant Monitoring Report

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

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Executive Summary

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

<u>Key Points from the 2020 Monitoring Report</u>

- Secchi disk transparency was better than the long-term average and was consistently better than in 2019.
- There were no observable trends in the 2006-2020 lake thermal stratification (RTRM) analysis, despite regional research pointing towards impacts of climate change on lake mixing and stratification. We intend to elaborate on this analysis with data pre-2006, and by comparing RTRM and anoxia to air temperatures over time. Profile data pre-2006 must be reorganized to suit the type of analysis required.
- The peak anoxic boundary was 5.81m in July 2020. This value is only slightly above the target threshold of 6.0m. Anoxia is not the main driver of overall lake nutrients in recent years, hence, no recommendations were made to aerate or oxygenate bottom-waters in the 2020 Lake Oscawana Management Plan.
- The 2020 surface TP was generally better than average, and remained at or below 20 µg/L for almost all stations and sampling dates.
- Bottom-water (*hypolimnetic*) total phosphorus was moderate, with early-season values lower than average at all Stations.
- Only 2 of the total 21 surface total nitrogen samples exceeded the 300 µg/L target threshold.
- The seasonal pattern of surface nutrients across all stations was more consistent in 2020 than in 2019.
- Stormwater TN was high at inlets 3, 4, and 7. 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. These values should be reported to local public health officials.
- The Oscawana zooplankton assemblage still shows impacts of alewife over-predation, but there were some mid-sized and large-bodied Cladocerans. Size classes were reviewed more carefully in 2020. Peak Copepod densities have been higher in 2018-2020 than in 2016-2017.
- Cyanobacteria was the most abundant phytoplankton throughout during summer months. Despite high cells/mL in September, the lake maintained moderate water clarity and the high cells/mL did not constitute a harmful bloom condition.
- Oscawana Lake was surveyed for aquatic plants on July 16th and 17th, 2020. The 2020 survey confirmed that Grass carp have not been detrimental to native plants in the lake, given the conservative stocking rate. We support an additional conservative stocking of 600 grass carp, as explained in the September 10th, 2020 letter to NY DEC Fisheries.
- There was no mechanical weed harvesting in 2020. No tracker data was available.
- The 2020 plant survey allowed for a maximum frequency/biomass assessment, given the lack of mechanical harvesting in 2020. The major differences were noted in Wildwood Cove, where it was actually native plant species that dominated shallow waters. Invasive Eurasian milfoil was on average more dense in 2020 than in 2019, and had a slightly higher mean growth form (water column height).
- 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.

Contents

Figures

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.

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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

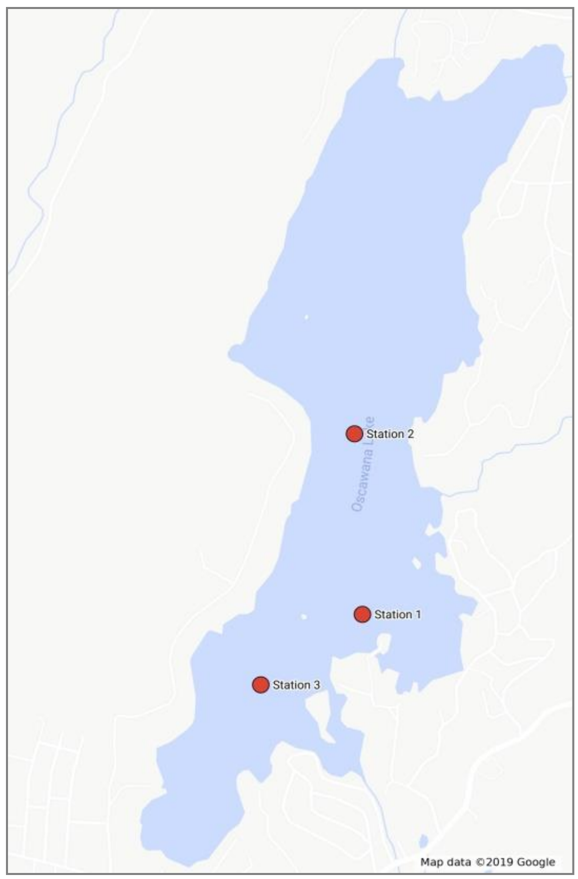
Specific Conductance, also referred to as conductivity, measures the quantity of dissolved ions in water that conduct electricity. Conductivity measurements can also be taken at one-meter increments from surface to lake bottom with calibrated probes. Alternatively only surface samples may also be collected 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

The 2020 Lake Oscawana water clarity, measured as Secchi disk transparency, was better than the long-term average and was consistently better than in 2019. There were two sampling dates where the recorded clarity was near the 4-meter “excellent” threshold. The worst clarity was 2.8m, recorded at Station 2 in October. The best recorded clarity in 2020 was 4.1m at Station 1. Water clarity remained better than 2m during all sampling visits. Figure 2 demonstrates how the seasonal pattern of clarity appears to be changing over time. This figure was first referenced in the 2020 Lake Oscawana Management Plan report.

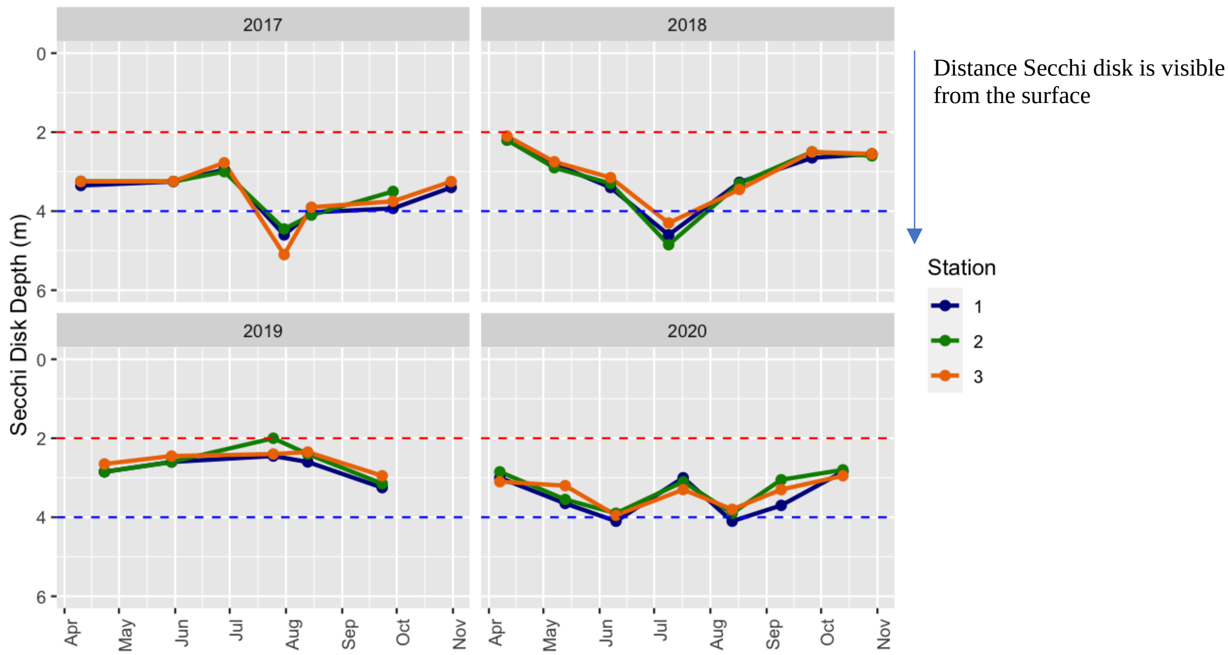


Figure 1. Water Clarity 2017-2020 Seasonal Pattern, St 1-3

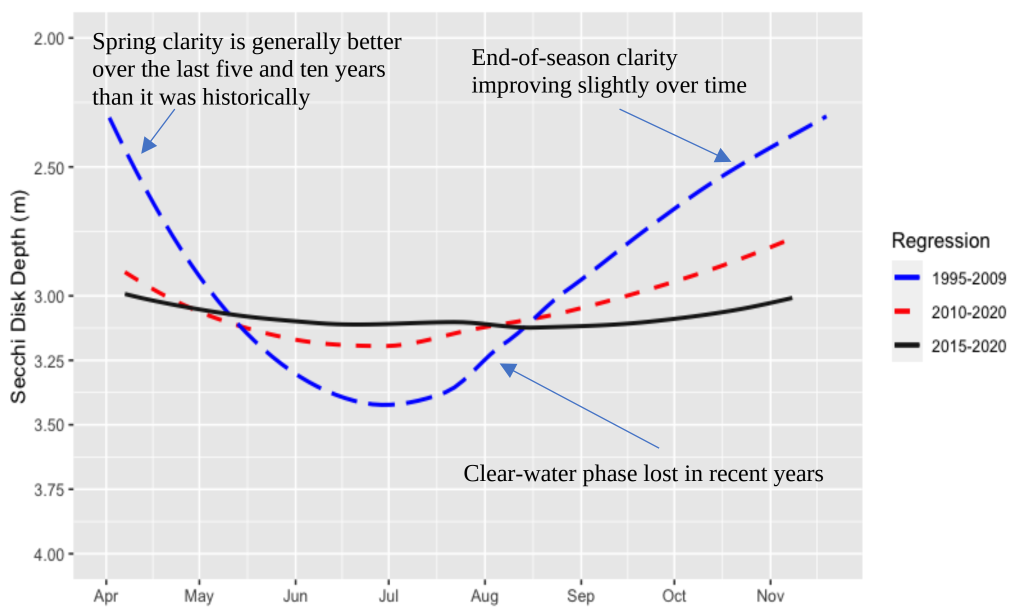


Figure 2. Seasonal Clarity Pattern (Polynomial Regression Models of Historical vs. Recent Years Values)

Temperature

The 2020 temperature profiles at Station 1 indicated the lake was mixed and relatively uniform in temperature from the surface to the bottom waters during the April and May sampling visits. This was not the case in 2019, where a warmer spring had resulted in earlier stratification. The lake was thermally stratified by June. Stratification persisted through the September 9th visit, and by the middle of October, the lake was once again completely uniform in temperature from top to bottom.

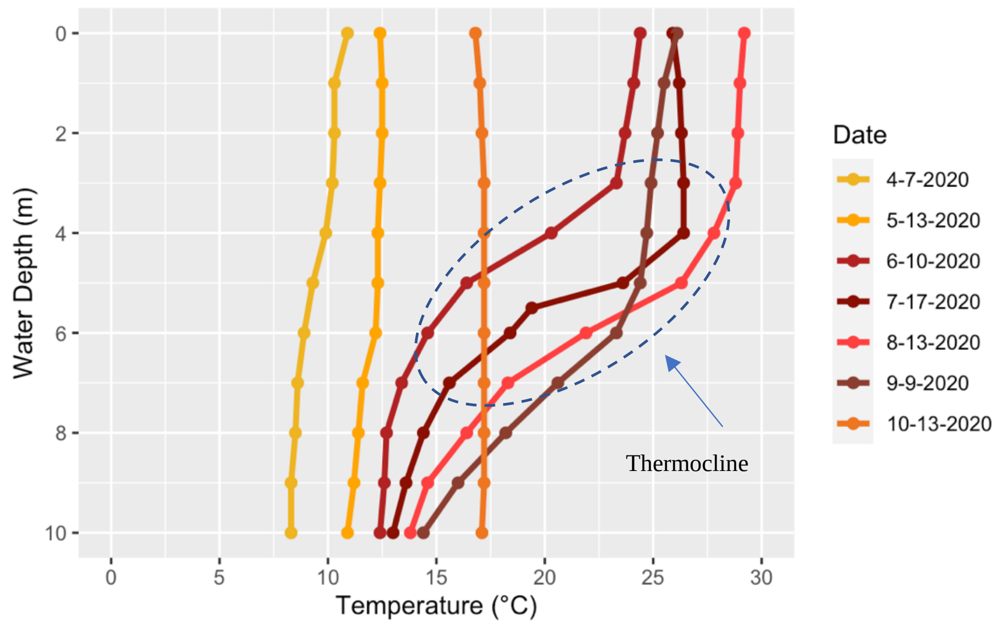


Figure 3. Station 1 Temperature (°C) 2020

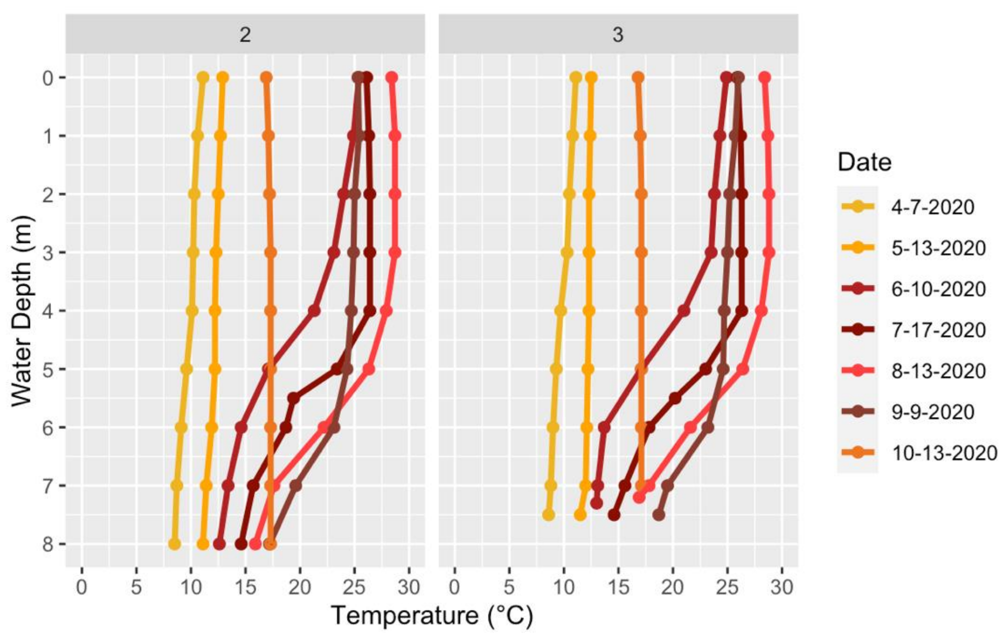


Figure 4. Station 2 & 3 Temperature (°C) 2020

The intensity of the thermal stratification is quantified using Relative Thermal Resistance to Mixing (RTRM), a dimensionless value that is calculated using the density differences between layers of water. The greater the temperature difference between the top and bottom of one meter of water, the greater the RTRM. When water temperature is the same from one meter to the next, RTRM is close to zero. The figure below demonstrates the strength and width of the thermocline, also known as the metalimnion, or the middle water layer of the lake. In April and May 2020, the RTRM values at each depth in the water column were very low because the temperature is similar from top to bottom. As the surface water warms, the density gradient that constitutes the summer thermocline intensifies. The density gradient starts to weaken in September, and by October there is no more thermocline and RTRM units near zero at all water column depths.

In recent years, there has been regional research that indicates summer thermal stratification is intensifying in some lakes. Regional trends in lake temperature indicate that climate change may be driving certain lakes towards earlier stratification, and that stratification may begin to last longer into the fall than decades past. This is particularly concerning for the length and intensity of anoxia in temperate lakes, where climate change could increase anoxia in the future. As part of this 2020 data analysis, we revisited the historical 2006-2020 RTRM data, but no alarming trends were observed in the preliminary analysis. We intend to elaborate on this analysis in future years with historical data pre-2006, and by comparing RTRM and anoxia to air temperatures over time.

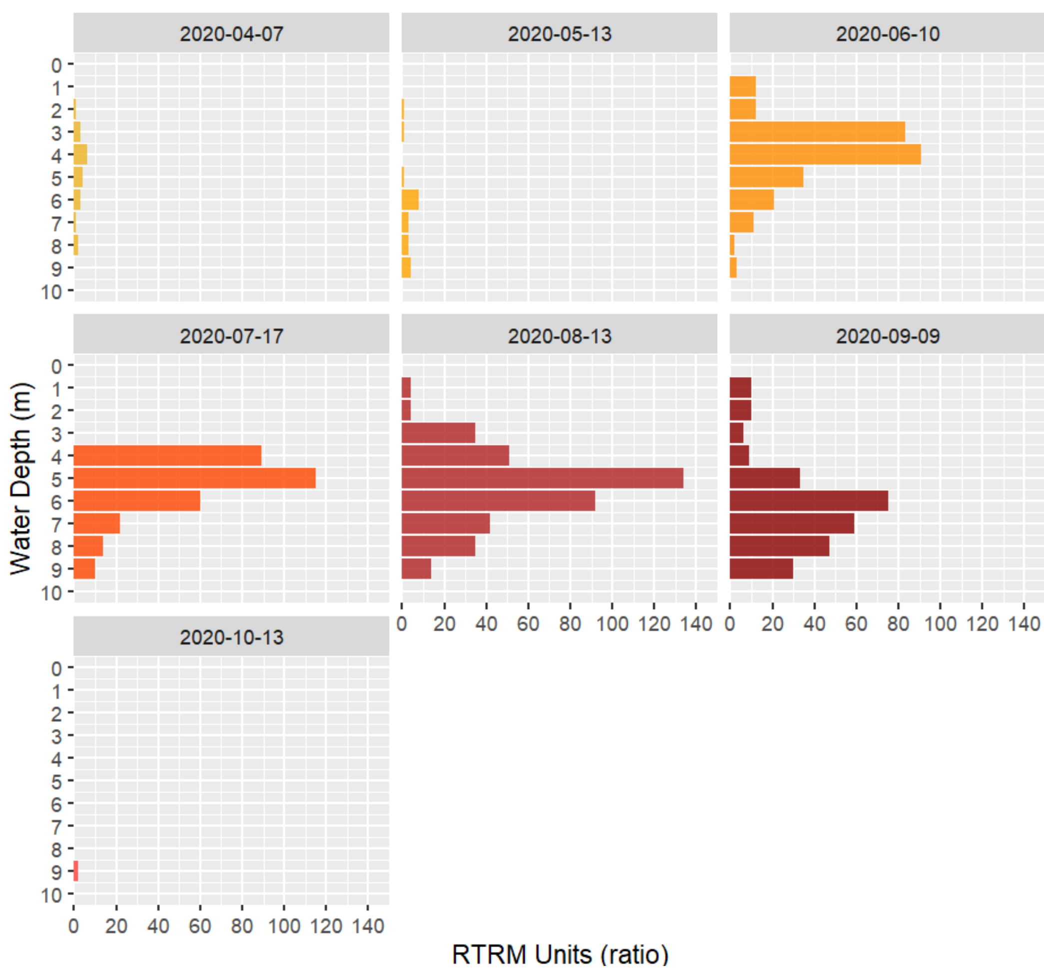


Figure 5 Station 1 Relative Thermal Resistance to Mixing (RTRM) - Intensity of Thermal Stratification

Dissolved Oxygen

Bottom-water dissolved oxygen loss was present by our June 10th sampling visit at Station 1. The lake remained anoxic until the October 13th sampling visit, at which point the lake was fully oxygenated from surface to bottom at all stations and no anoxic water was present. Results from the 2020 oxygen monitoring are graphed below. Raw profile data tables from 2020 are included at the end of this monitoring report. There was nothing unusual about the 2020 oxygen profiles.

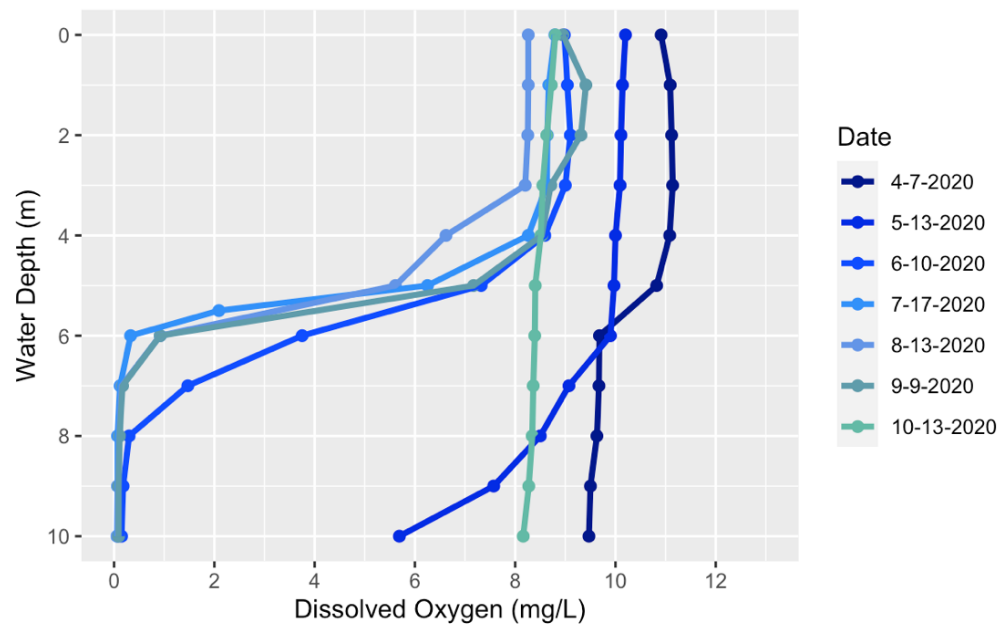


Figure 6. 2020 Station 1 Dissolved Oxygen

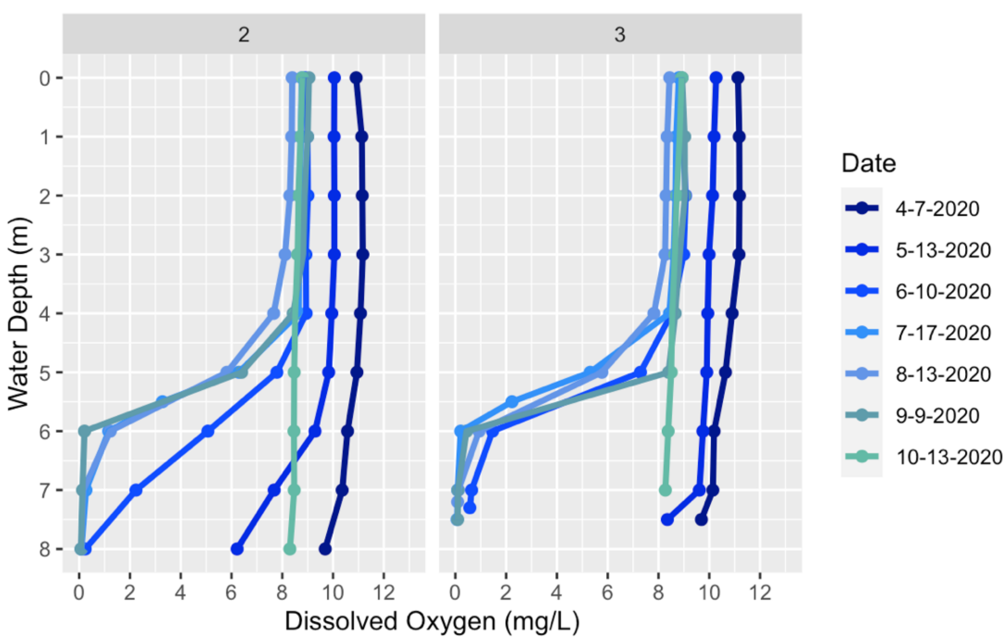


Figure 7. 2020 Station 2 & 3 Dissolved Oxygen

The peak anoxic boundary was 5.81m in July 2020. This value is only slightly above the target threshold of 6.0m. The 6m threshold 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.

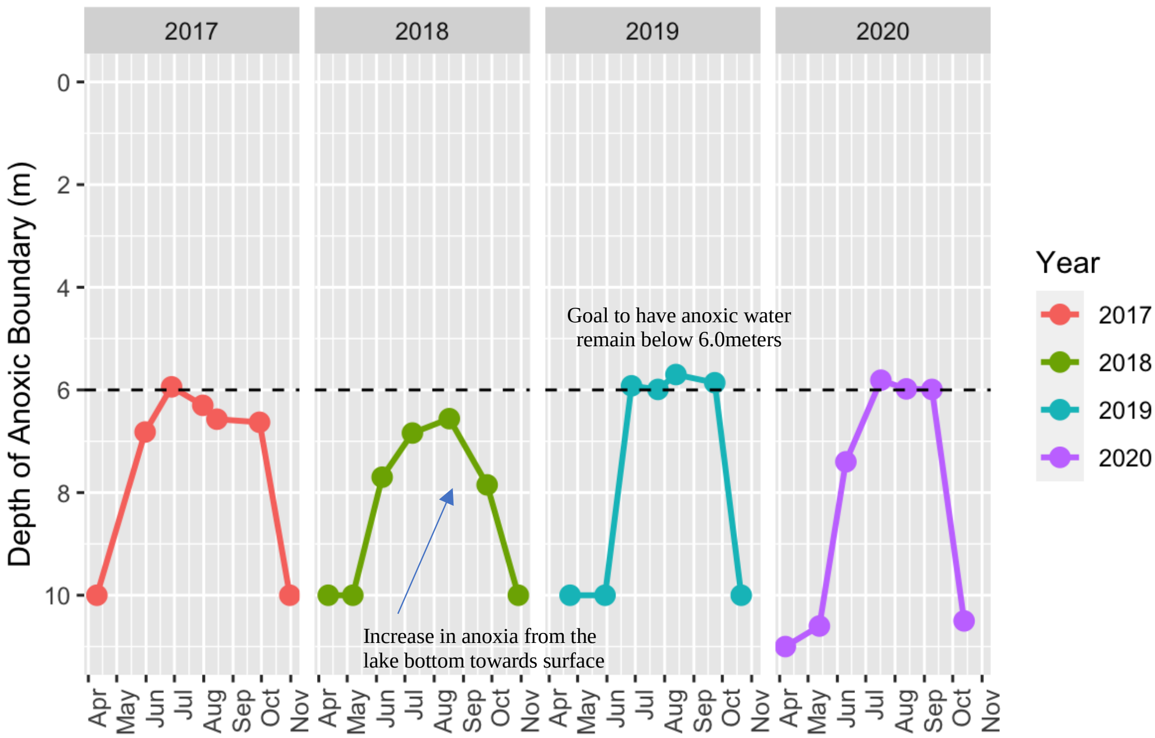


Figure 8. Seasonal Anoxic Boundary Pattern at Station 1 2017-2020

As stated in the recently published Lake Oscawana Management Plan, the summer anoxia has not been the main driver of overall lake nutrients or water clarity in recent years. For this reason, no recommendations were made to aerate or oxygenate the lake. To reiterate, the long-term goal for anoxia at Oscawana 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 Total Phosphorus (TP) 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. The overall 2020 TP was substantially better than in 2019, with the exception of one high value at Station 1 in May, of 27 µg/L. We do not have a good explanation for the significant difference between stations on this sampling date at this time. The 2020 surface TP was generally better than average, and remained at or below 20 µg/L for almost all stations and sampling dates. Raw nutrient data values are included at the end of this report.

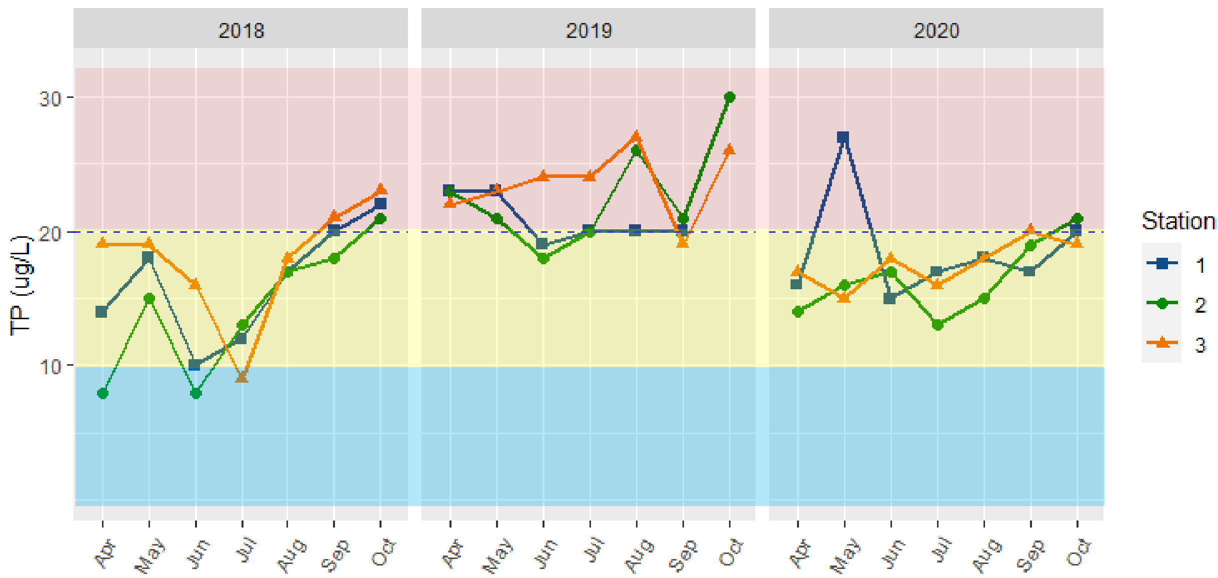


Figure 9. Surface total phosphorus 2018-2020 at all stations

The long term surface phosphorus concentrations are shown in the figure below (2008-2020).

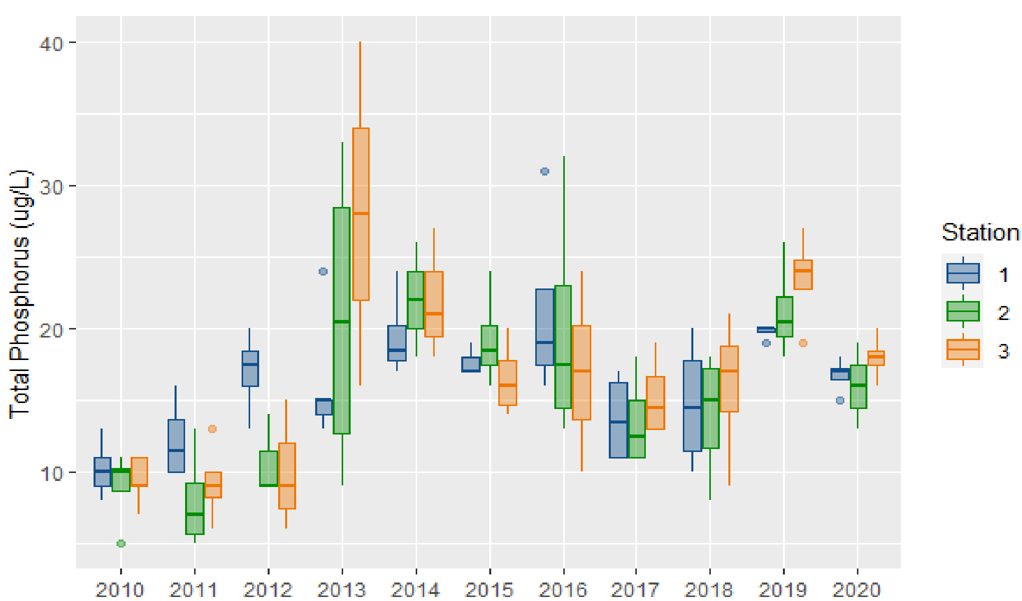


Figure 10. Long Term Surface Range in Total Phosphorus (St.1, 2, & 3)

In Figure 11, below, the lines indicate an average measurement of bottom-water phosphorus values over 2014-2019, 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. The 2020 values, marked as circle points on the figures, demonstrate that May, June, and July bottom-water TP were lower than average across all stations. Late summer values, with respect to the 6yr-mean, varied across stations. Recall that Station 1 values are normally much higher than bottom phosphorus at Stations 2 and 3 because the Station 1 sampling point is deeper (hence figures 11A and 11B use difference vertical axis scales).

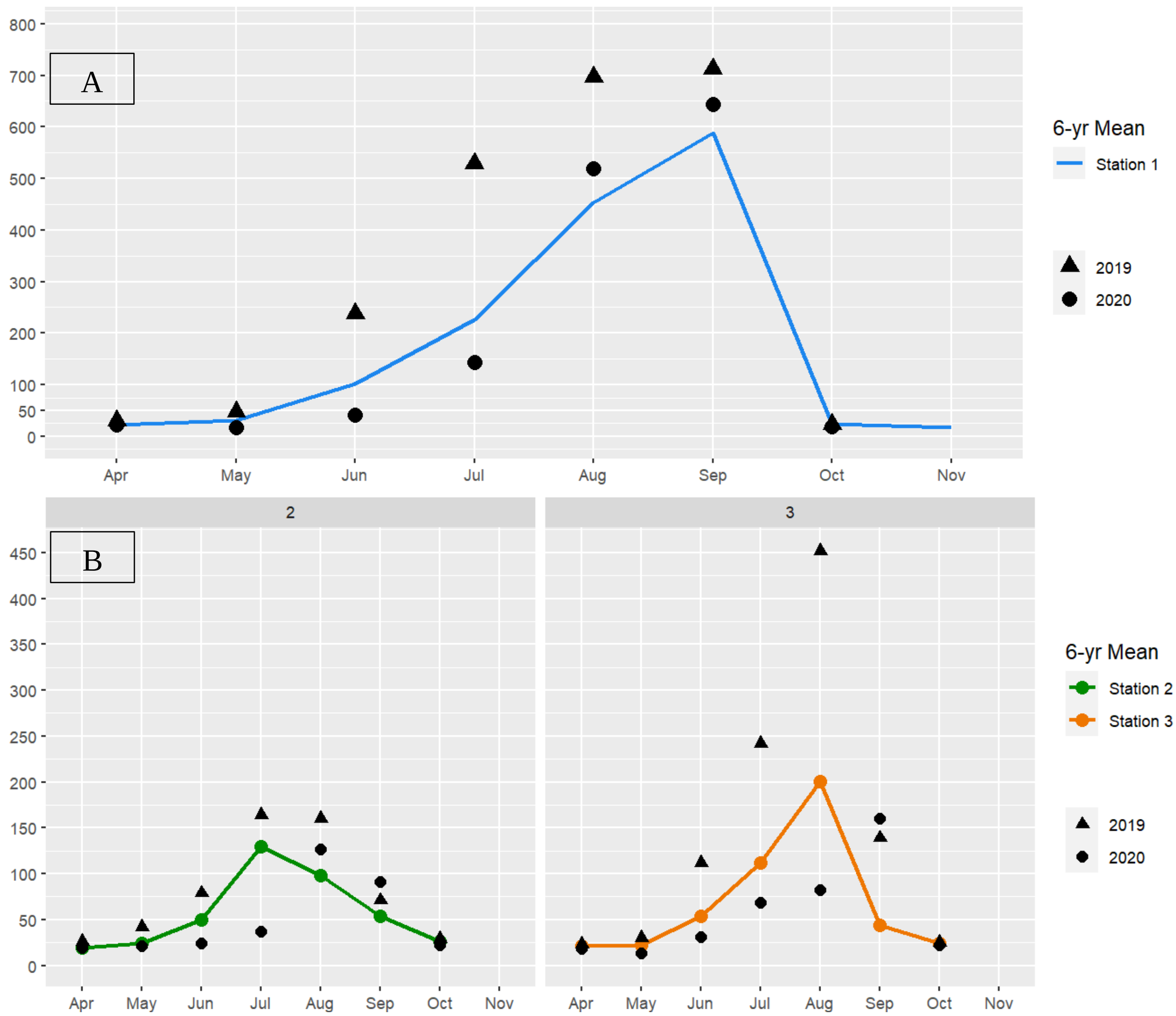


Figure 11. Station 1 (A) & Station 2 & 3 (B) Bottom Total Phosphorus 6yr Mean vs. 2019 & 2020 Data

To reiterate points made in the 2020 Lake Oscawana Management Plan, high levels of bottom phosphorus are related to internal loading during periods of anoxia. Yet, the lake’s internal load does not appear to be the primary driver of water quality every year. For that reason, management should focus on aquatic plants and watershed improvements before attempting to control the internal load. If cyanobacteria blooms were to become more common in future years, it would be appropriate to revisit the methods available to mitigate internal loading.

Nitrogen is the secondary principal plant and algae nutrient in lakes. The mean surface total nitrogen in 2020 across all three stations was 269 µg/L, below the 300 µg/L target threshold for all but two Station 1 samples.

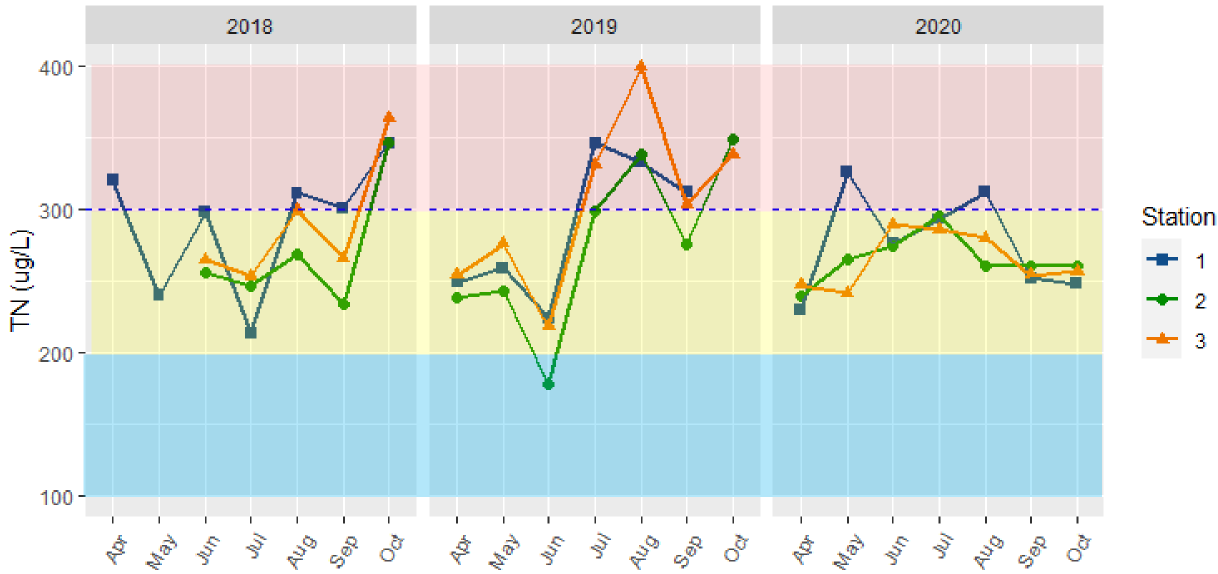


Figure 12. Surface total nitrogen 2018- 2020 at all stations

The increased nitrogen at Station 1 in May corresponded to a similar increase in phosphorus, but that was not the case given the August phosphorus data. Total nitrogen monitoring at Stations 2 and 3 only began in 2017, and thus long-term nitrogen trends are not readily available for Stations 2 and 3.

Raw data for nitrogen test results are included in the Appendix.

Inlet Nutrient & Bacteria Data

The 2020 seasonal inlet phosphorus concentrations are displayed in **Tables 1 & 2**. Blank cells indicate that no sample was collected. Samples were only collected when water was actively flowing. The June 11th sampling occurred towards the end of a small precipitation event, and only inlets 3, 5, and 7 were sampled. Stormwater and wet-weather inlet sampling will almost always result in higher nutrient concentrations. Inlets 4 and 7 had the highest wet-weather total phosphorus concentrations; and inlets 3, 4, and 7 all had high nitrogen at that time. Nitrogen >1000 µg/L is concerning, even for stormwater events. Generally, the 2020 baseflow samplings for all inlets was moderate and within range of historical values. Baseflow TP concentrations above the 75th percentile of all historical measurements are highlighted in red. The same summary statistics are not valid for TN because nitrogen measurements only began in 2018 and there are not yet enough data points.

Table 1. Inlet total phosphorus (TP) concentrations (µg/L) in 2020.

	Weather	Inlet 1	Inlet 2	Inlet 3	Inlet 4	Inlet 5	Inlet 6	Inlet 7
4/9/20	Dry/Baseflow	11	24	19	50	10	12	25
5/15/20	Dry/Baseflow	15	27	28	62	14		38
6/11/20	Moderate Rain			120	776			950

Table 2 Inlets total nitrogen (TN) concentrations (µg/L) in 2020

	Weather	Inlet 1	Inlet 2	Inlet 3	Inlet 4	Inlet 5	Inlet 6	Inlet 7
4/9/20	Dry/Baseflow	215	200	533	2587	105	32	851
5/15/20	Dry/Baseflow	251	203	433	2275	108		796
6/11/20	Moderate Rain			1121	2210			1247

The range of values across all sampling years is displayed in the boxplots below.

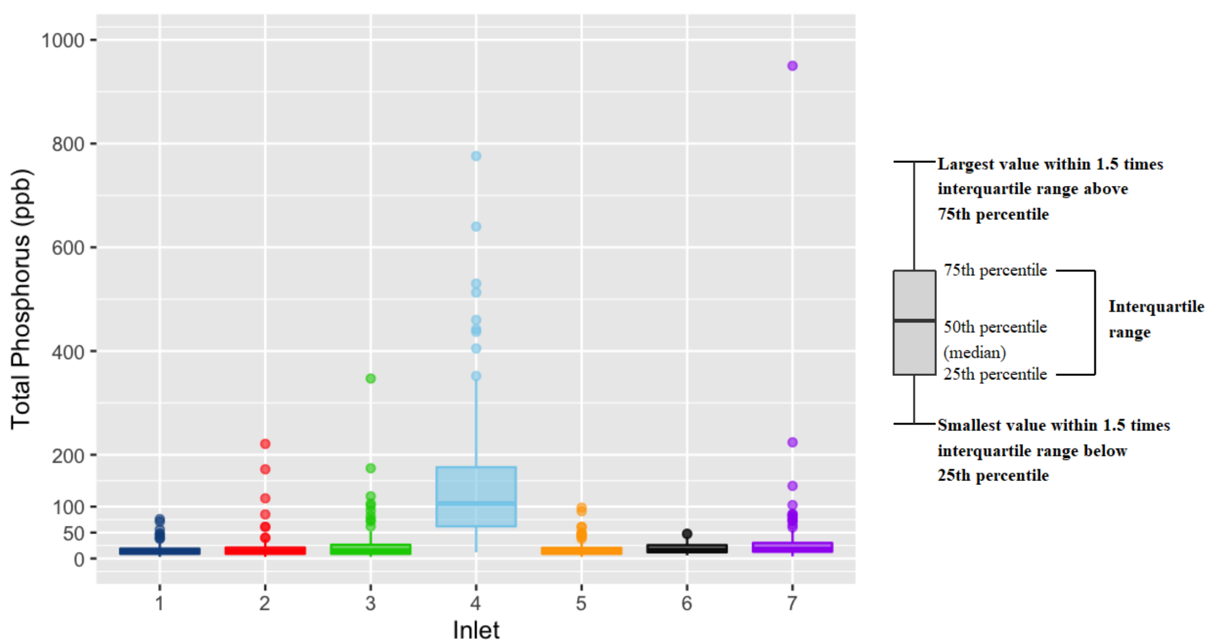


Figure 13. Historical range (1994-1997, 1999-2020) of inlet total phosphorus (µg/L) concentrations

The following table lists all bacteria samples collected in 2020 from the lake's 7 main inlets. Limited budget only allowed for bacterial testing at inlets 3, 4, and 7 – which are suspected to have septic or agricultural pollution, based on 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 235 E. coli CFU/100mL constitutes a NYS state standard exceedance for swimming beaches and public health.

Table 3. Inlets Bacteria Test Results 2020

Date	Weather	Station	Fecal Coliform	E.coli
4/8/20	Dry/Baseflow	Inlet 7	120	250
4/8/20	Dry/Baseflow	Inlet 4	170	260
4/9/20	Dry/Baseflow	Inlet 7	240	340
4/9/20	Dry/Baseflow	Inlet 4	140	96
4/9/20	Dry/Baseflow	Inlet 3	<10	20
5/15/20	Dry/Baseflow	Inlet 7	420	150
5/15/20	Dry/Baseflow	Inlet 4	31	85
5/15/20	Dry/Baseflow	Inlet 3	41	10
6/11/20	Moderate Rain	Inlet 3	230	410
6/11/20	Moderate Rain	Inlet 7	6100	7300
6/11/20	Moderate Rain	Inlet 4	87000	58000
Units for 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.				

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, but in 2019, zooplankton was monitored at both Stations 1 and 2. It was decided that the results from both stations were similar, and that baseline monitoring at Station 1, alone, would be appropriate moving forward. We acknowledge that zooplankton sampling on an academic level requires more frequent and spatially distinct samplings to adequately estimate lake-wide populations. Yet, given limited monitoring funds and the practical scope of LOMAC priorities, zooplankton monitoring at the deep-water site provides a window into the plankton size classes and dominant types over time.

For many years, the zooplankton assemblage has been dominated by small Rotifers and lacked large-bodied Cladocerans, like Daphnia. Daphnia numbers are still low, but there does appear to be a small increase in Cladoceran and Copepod numbers. The maximum seasonal peak Copepod numbers are higher in 2018-2020 than in 2016 and 2017, but the size classes are still low throughout the season. The Oscawana zooplankton assemblage shows impacts of alewife over-predation.

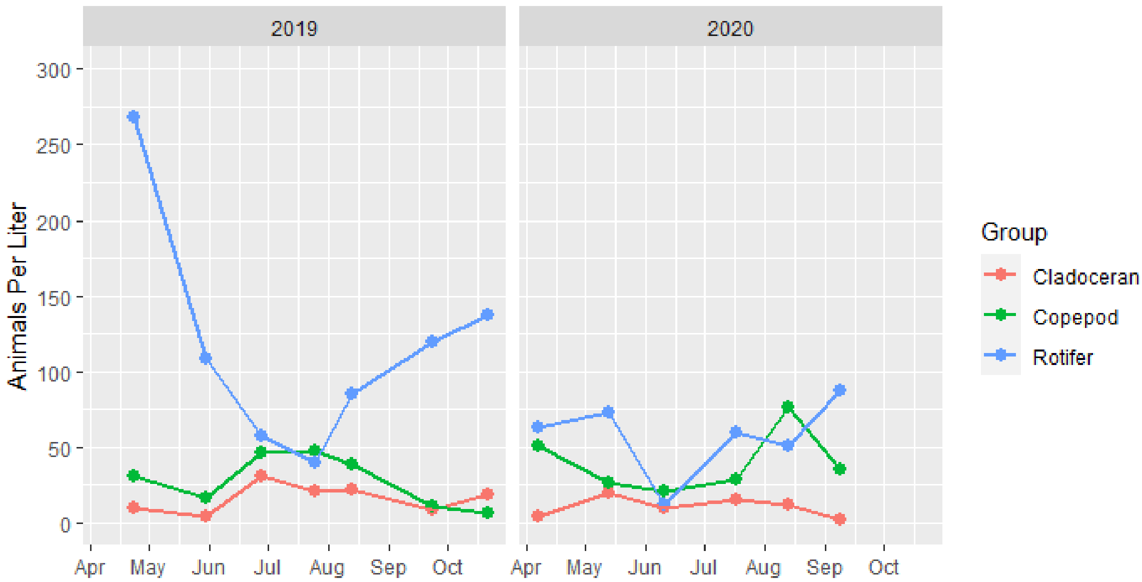


Figure 14 Station 1 Zooplankton (2019 and 2020 Comparison)

Maximum seasonal zooplankton type numbers are recorded in Table 4.

Table 4 Annual Maximum Zooplankton Densities 2016-2020

Type	**2016**	**2017**	**2018**	**2019**	**2020**
Cladoceran	16	24	8	31	20
Copepod	13	10	56	50	76
Rotifer	>500	120	170	270	87

The most dominant Cladocerans in 2020 were small-bodied *Bosmina* and *Cerodaphnia*. Mid-sized *Daphnia* were present, but there were few *Daphnia* over 0.6mm. Most zooplankton were less than 0.6mm across the season. As in previous years, there were very few Calanoid Copepods.

Size classes for Cladocerans and Cyclopoid Copepods are shown in the figures below. The number of organisms is the total counted in the entire zooplankton net tow at Station 1, not the back-calculated organisms per Liter. Size class data from 2020 is similar to previous years, with the majority of zooplankton being less than 0.6mm in body length.

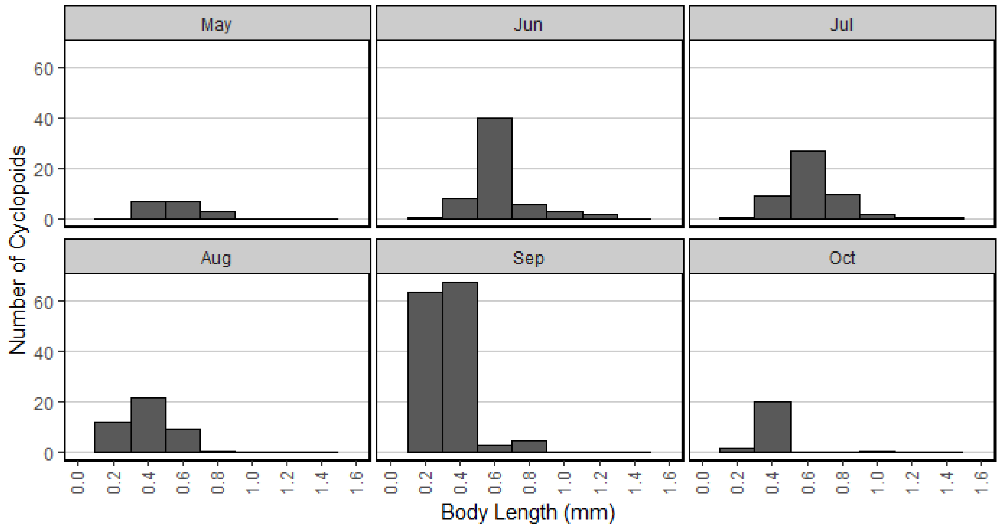


Figure 15 Cyclopoid Copepod Seasonal Size Classes 2020

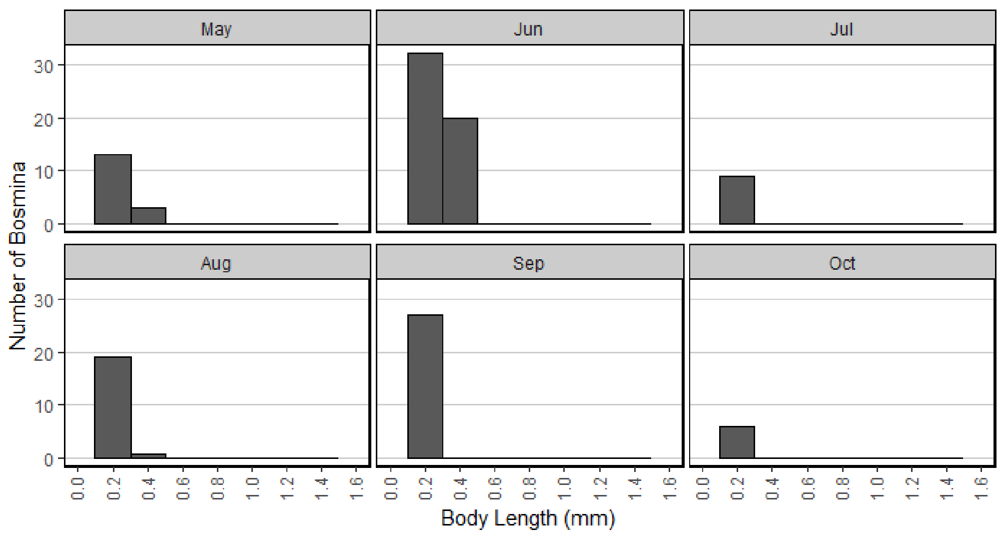


Figure 16 Bosmina Cladocerans Seasonal Size Classes 2020

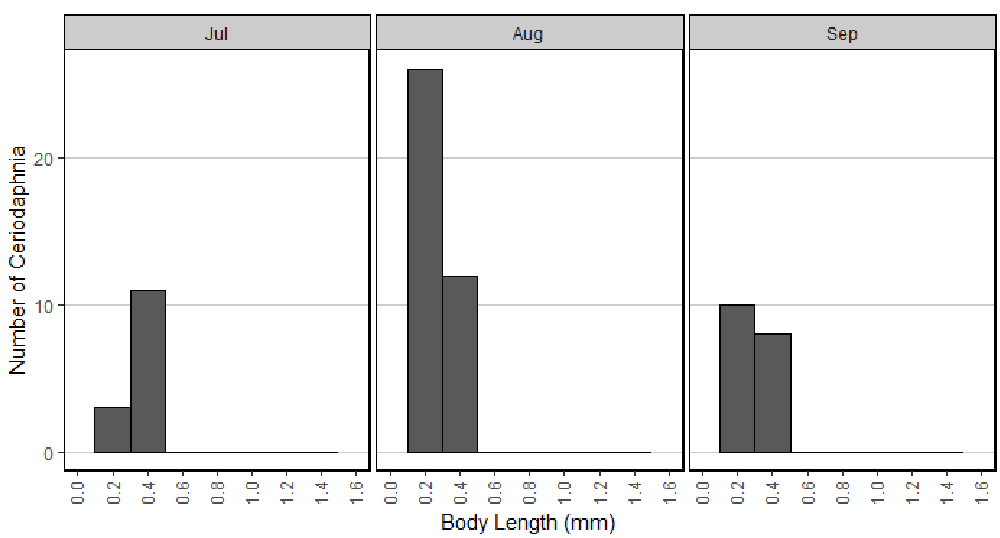
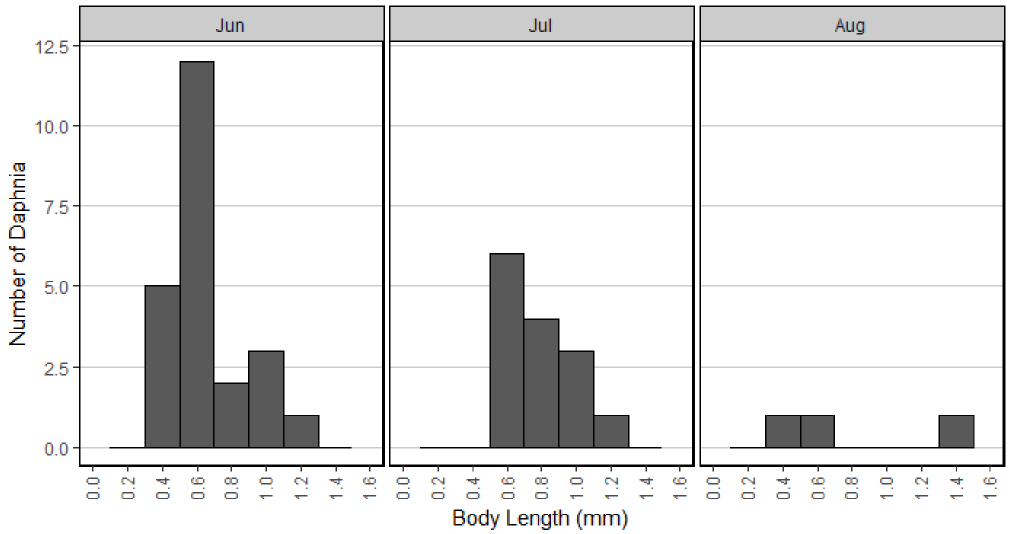


Figure 17 Cerodaphnia Cladocerans Seasonal Size Classes 2020



Figures 18. Daphnia Cladocerans Seasonal Size Classes 2020

Total phytoplankton counts (cells/mL) by group for 2020 are displayed in Table 5, below.

Table 5. Phytoplankton Algae Total Cells/mL by Group 2020

	4/7/20	**5/13/20**	**6/10/20**	**7/17/20**	**8/13/20**	**9/9/20**	**10/13/20**
Cyanobacteria	8,455	612	0	6,560	2,187	136,565	40,408
Green algae	175	1,224	1,691	1,341	437	4,932	1,224
Diatoms	5,248	6,472	1,895	408	29	2,891	7,755
Chrysophytes	437	204	437	233	15	4,252	204
Dinoflagellates	0	0	0	58	0	0	0
Euglenophytes	0	0	0	0	0	340	0

The most abundant types of phytoplankton were Cyanobacteria, Diatoms, Green algae, and Chrysophytes. In 2019 and 2020, cyanobacteria were the most abundant during summer, but Green algae and Diatoms were also dominant in spring and fall. The 2020 maximum cyanobacteria cells/mL were much higher than in 2019, but that is a direct result of one particular species of cyanobacteria that has very small cells (*Planktothrix sp.*). Despite high cell counts, water clarity during September remained moderately good, and these high cell counts did not constitute "bloom" conditions based on visual observations. There were no shoreline scums observed.

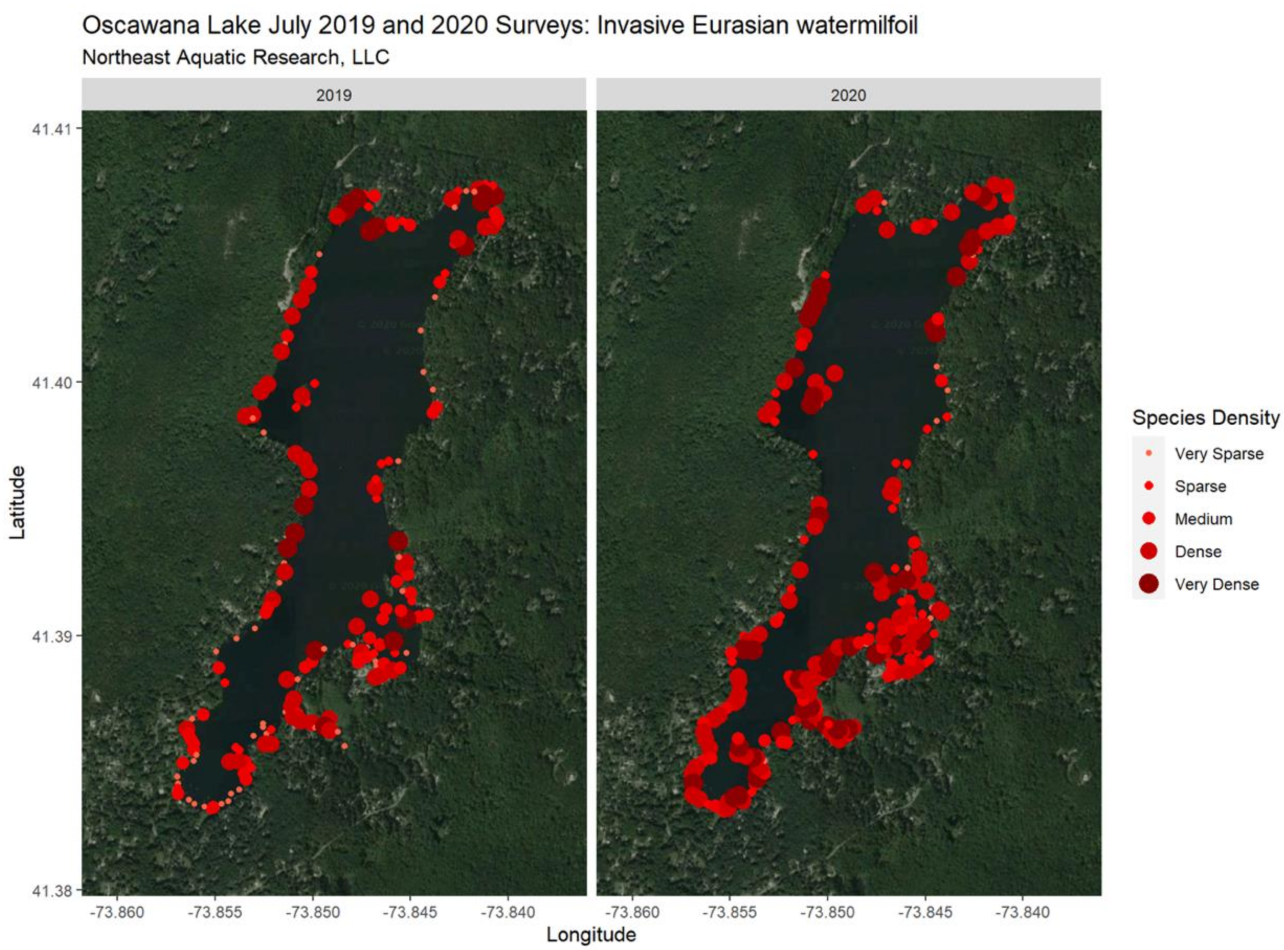
Table 6. Cyanobacteria (Blue-green algae) by Genus Counts Per Month 2020

	4/7/20	**5/13/20**	**7/17/20**	**8/13/20**	**9/9/20**	**10/13/20**
Chrysosporum	3,499	612	87	0	0	5,714
Planktothrix	3,790	0	0	0	133,503	22,449
Planktolyngbya	1,166	0	0	1,312	0	12,245
Chroococcus	0	0	58	0	0	0
Dolichosperum	0	0	6,414	875	3,061	0

Aquatic Plant Management

Oscawana Lake was surveyed for aquatic plants on July 16th and 17th, 2020. The following maps provide species density at all observation points throughout the littoral zone. Overall, the distribution of invasive Eurasian milfoil *(Myriophyllum spicatum)* in 2020 was more abundant and dense compared to 2019. There was also more cyanobacteria mat (*Lyngbya wollei*) in 2020 than in 2019, particularly in Wildwood Cove and the southern shoreline. Residents also voiced complaints of more green floating filamentous algae in 2020, which may have been a result of the lack of mechanical harvesting and disturbance in cove areas.

As mentioned in the 2019 report, the 2016 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 Oscawana since the early 2000s. The frequency and density of Robbin's pondweed (*Potamogeton robbinsii*) and Tapegrass *(Vallisneria americana*) have not changed considerably since 2015, but Robbin's pondweed was notably less frequent in 2020. Coontail (*Ceratophyllum demersum*) was more frequent and dense in Wildwood Cove in 2020 than in 2019. Frequency values for all species in 2019 and 2020 are compared in Table 7.



Map 1. Invasive Eurasian Milfoil (Myriophyllum spicatum) 2019 and 2020

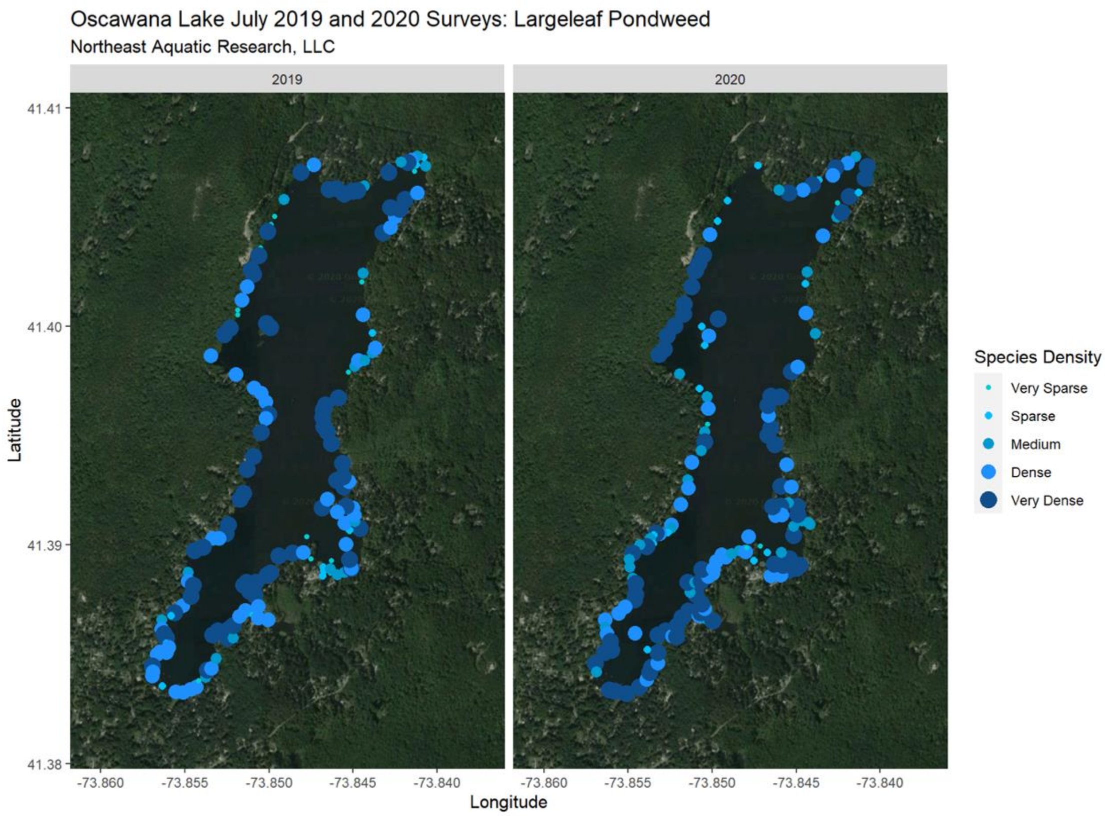
Table 7 Comparison of 2019 & 2020 Plant Survey Data

2019					
Scientific Name	**Common Name**	**Year**	**Frequency %**	**Avg. Density %**	**Avg. Growth Height**
Brasenia schreberi	Watershield	2019	0.2	15	NA
Ceratophyllum demersum	Coontail	2019	7.1	33	4.3
Filamentous algae	--	2019	0.2	30	NA
Lemna sp.	Duckweed	2019	0.2	NA	NA
Lyngbya	Cyanobacteria mats	2019	2.4	67	NA
Myriophyllum spicatum	Eurasian Watermilfoil	2019	42.9	33	3.3
Nymphaea odorata	White Water Lily	2019	15.3	55	NA
Potamogeton amplifolius	Largeleaf pondweed	2019	37.5	61	4.3
Potamogeton robbinsii	Robbins Pondweed	2019	7.3	27	NA
Sagittaria graminea	Grassy Arrowhead	2019	0.9	15	NA
Vallisneria americana	Eel grass	2019	12.0	52	3.5

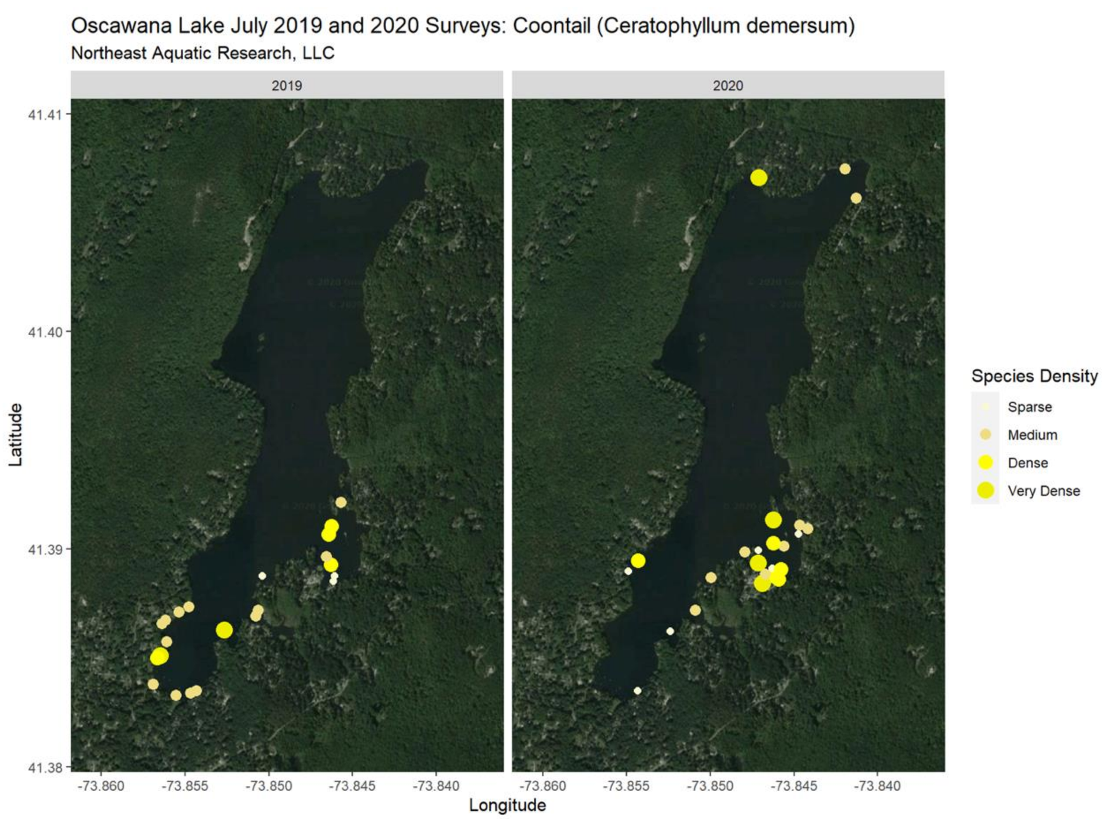
2020					
Scientific Name	**Common Name**	**Year**	**Frequency %**	**Avg. Density %**	**Avg. Growth Height**
Brasenia schreberi	Watershield	2020	0.7	73	NA
Ceratophyllum demersum	Coontail	2020	6.4	39	2.3
Filamentous algae	--	2020	2.4	42	4.0
Lyngbya	Cyanobacteria mats	2020	6.1	66	NA
Myriophyllum spicatum	Eurasian Watermilfoil	2020	49.5	51	3.8
Najas minor	Brittle Naiad	2020	0.2	10	NA
Nuphar variegata	Yellow Water Lily	2020	0.7	12	NA
Nymphaea odorata	White Water Lily	2020	16.0	64	4.5
Potamogeton amplifolius	Largeleaf Pondweed	2020	37.3	62	4.3
Potamogeton crispus	Curly Leaf Pondweed	2020	0.5	50	3.0
Potamogeton robbinsii	Robbins Pondweed	2020	2.1	26	2.0
Sagittaria graminea	Grassy Arrowhead	2020	0.5	10	NA
Vallisneria americana	Eel grass	2020	12.7	53	3.9
Blue shaded is dominant species (>20% frequency)			Red text = Invasive species		

Note that NEAR wrote a letter to the NY DEC Fisheries Department on September 10, 2020. The purpose of this letter was to encourage the DEC to permit the additional stocking of 600 grass carp in 2021. The letter explained grass carp annual mortality rates and estimated that approximately 197 adult grass carp remain in Oscawana Lake. The suggested 600 additional grass carp is considered a conservative re-stocking that will prevent total elimination of aquatic plants, and will also allow for continued targeted and integrated aquatic plant management into the future.

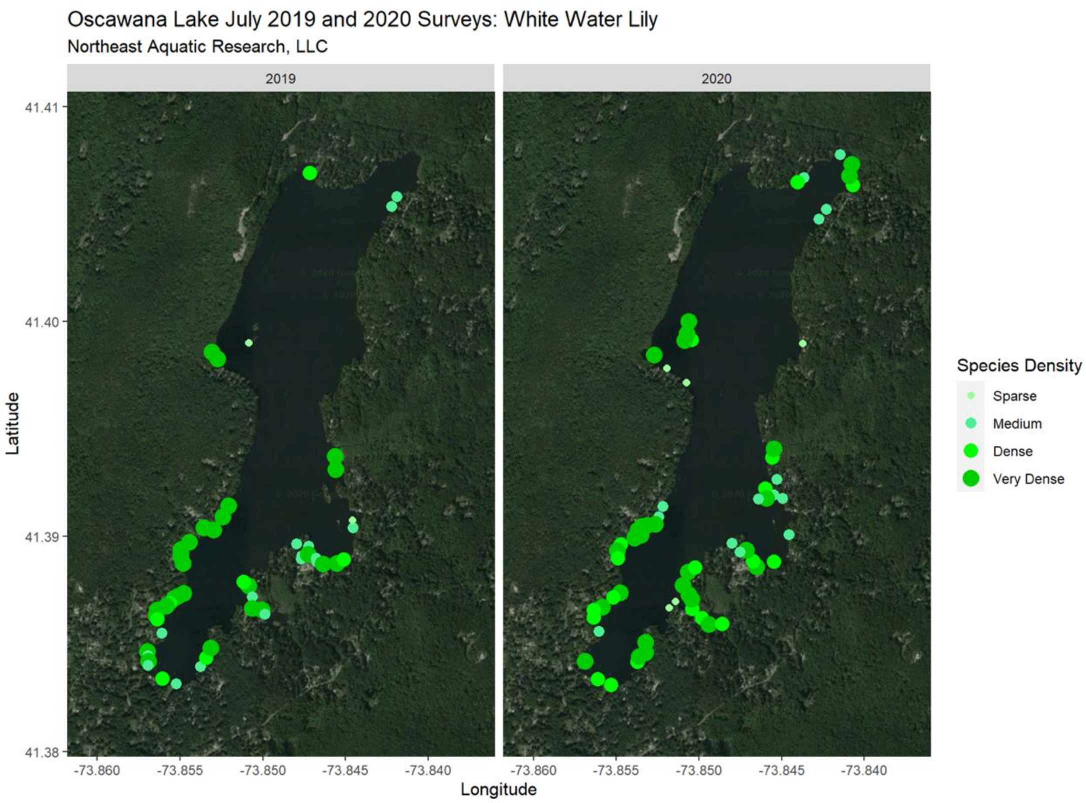
Additional plant maps are displayed below.



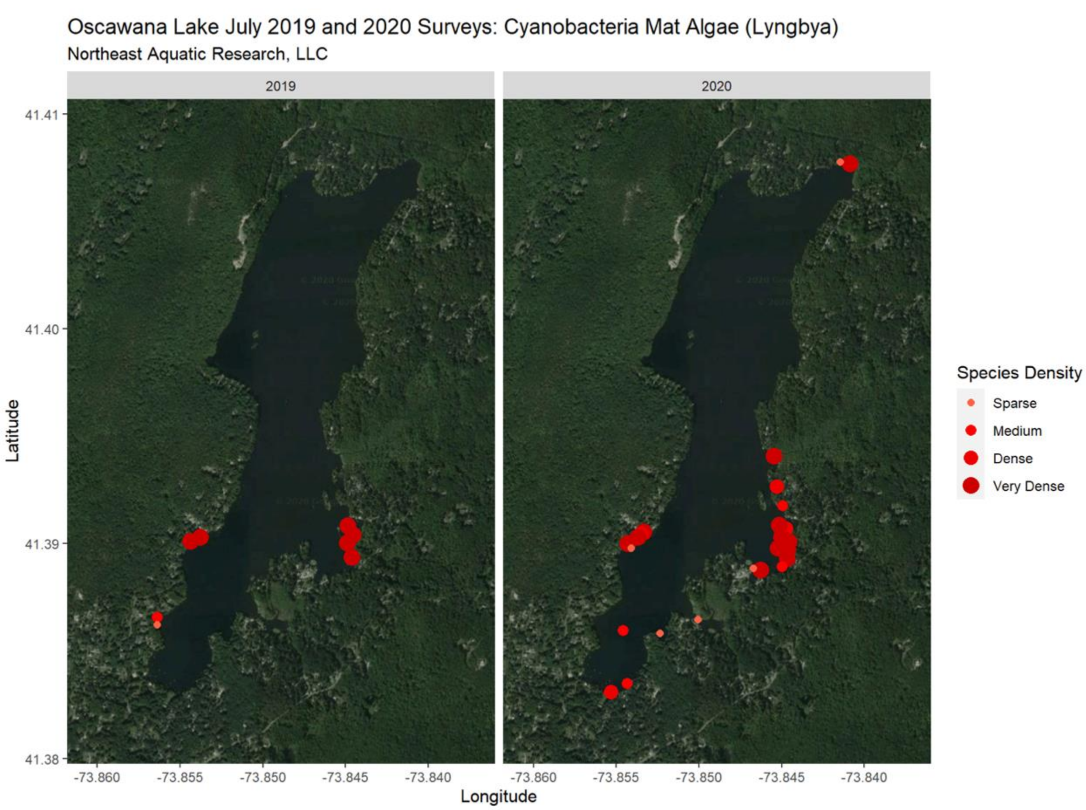
Map 2. Largeleaf Pondweed (Potamogeton amplifolius) 2019 and 2020



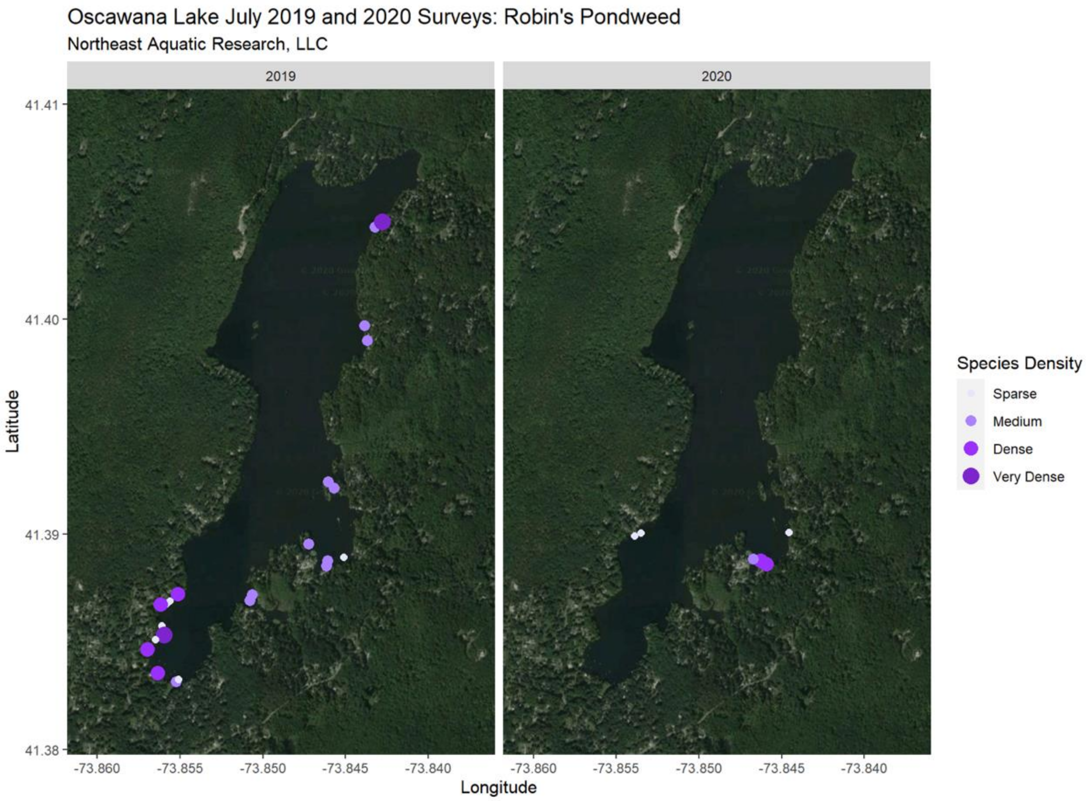
Map 3. Coontail (Ceratophyllum demersum) 2019 and 2020



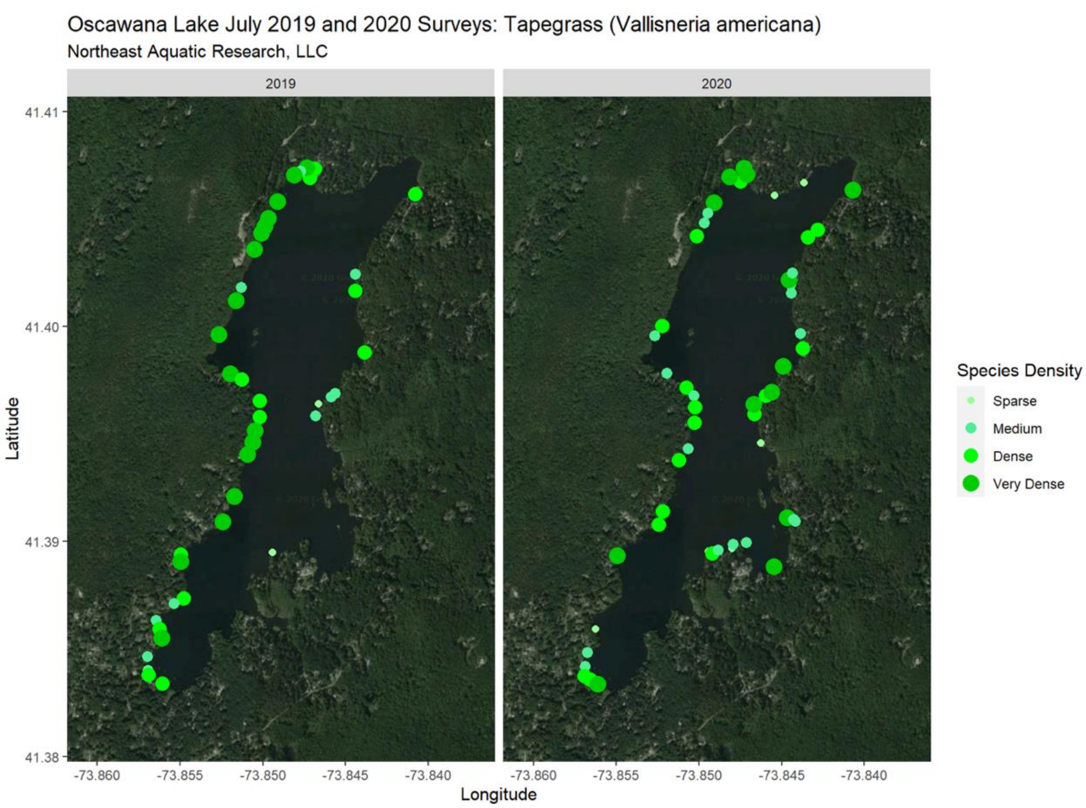
Map 4. White Water Lily 2019 and 2020



Map 5. Cyanobacteria mats (Lyngbya) 2019 and 2020



Map 6. Robin's Pondweed 2019 and 2020



Map 7. Tapegrass 2019 and 2020

Weed-Harvesting Tracker Data

There was no weed-harvester operation or tracker data in 2020, due to the COVID-19 pandemic and inability to get essential harvester repairs. The Town put out a competitive bid for private mechanical harvesting operation, but unfortunately there were no qualified bidders. During the annual aquatic plant survey, we noticed that most beach associations had taken their own plant control measures by raking and hand-removal of floating aquatic vegetation. The large amount of floating aquatic vegetation seen in Wildwood Cove was native Tapegrass (*Vallisneria americana*), which is a robust native plant that can be easily uprooted by boat propellors.

The 2020 aquatic plant survey results demonstrated that the mechanical harvesting program at Oscawana is not just targeting invasive Eurasian milfoil. In fact, it was noted that Coontail, Tapegrass, and Large-leaf pondweed were all dominant in Wildwood Cove, one of the major areas for annual mechanical harvesting. The shallow waters were particularly dominated by native aquatic plants, not invasive Eurasian milfoil. Eurasian milfoil was more common in deeper waters. Similarly, there was more green filamentous algae and cyanobacteria mats in Wildwood Cove in 2020. We also observed that the Eurasian milfoil average plant height in the water column was greater in 2020 than 2019. It was previously difficult to determine if the plant height changes observed were related to grass carp or to mechanical harvesting, but based on the 2020 data, we presume that milfoil plant height is more a factor of mechanical harvesting than of grass carp, particularly in Wildwood Cove.

Conclusions & Recommendations

Based on the aquatic plant survey results in 2020, we support another conservative stocking of grass carp – 600 fish. Details behind this decision are explained in the September 10th, 2020 letter to NY DEC. Overall, our recommendations for long-term aquatic plant management have not changed. We believe that mechanical harvesting is not the most cost-effective or efficient means of aquatic plant control. We encourage LOMAC and the Town of Putnam Valley to increase public awareness around aquatic herbicides and other types of targeted plant management that would be more effective than mechanical harvesting, particularly in Wildwood and Abele Coves. Various plant management techniques were described in the final draft of the Lake Oscawana Management Plan published last year.

We understand that it may take several years of increased community involvement and understanding in order to move forward with any modified aquatic plant management techniques, but we are committed to helping LOMAC engage residents and move towards more effective long-term plant control, without extensive sediment disturbances. The 2020 water quality data demonstrated that the connection between mechanical harvesting and internal loading may not be as dramatic as previously hypothesized, but the 2020 water quality was overall better than 2019, and many parameters were better than average. We believe that continued sediment disturbances from mechanical harvesting in shallow areas impacts surface and bottom water nutrient concentrations, as well as water clarity, depending on the area and intensity of use in the lake. The historical method for tracking harvester plant removal, via "loads" is not sufficient, and any future use of the harvester must utilize the GPS/tracker. Time and location of operation is the most effective way to measure use. The size of the "loads" will become supplementary information.

The completion of the Lake Oscawana Management Plan marks a major 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 in the future. In addition to a potential new direction for aquatic plant management, there is a large need for continued watershed improvements. We anticipate that our involvement in 2021 will require more watershed consulting and potential aid in grant-applications and communication with the Town MS4 Coordinator and Town Engineer.

Appendix

2020 raw nutrient data.

Blank rows indicate samples were not run for that analysis.
"ND" indicates sample was not detected.

				TP	NH3	TN	Fe
Date	**Station**	**Secchi (m)**	**Depth (m)**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
4/7/2020	1	3	1	16		230	
4/7/2020	1		4	17		233	
4/7/2020	1		6	19		266	
4/7/2020	1		9	22		263	
4/7/2020	2	2.85	1	14		240	
4/7/2020	2		7	19		252	
4/7/2020	3	3.1	1	17		247	
4/7/2020	3		7	18		246	
5/13/2020	1	3.65	1	27		326	
5/13/2020	1		4	15		240	
5/13/2020	1		6	21		252	
5/13/2020	1		9	17		302	
5/13/2020	2	3.55	1	16		265	
5/13/2020	2		7	21		237	
5/13/2020	3	3.2	1	15		242	
5/13/2020	3		7	13		236	
6/10/2020	1	4.1	1	15	ND	276	
6/10/2020	1		4	19	9	308	
6/10/2020	1		6	27	31	305	
6/10/2020	1		9	41	113	295	
6/10/2020	2	3.9	1	17		275	
6/10/2020	2		7	24		267	
6/10/2020	3		1	18		289	
6/10/2020	3		7	31		283	
7/17/2020	1	3	1	17	110	293	
7/17/2020	1		4	20	121	312	
7/17/2020	1		6	34	110	473	
7/17/2020	1		7	48		380	
7/17/2020	1		9	143	258	453	
7/17/2020	2	3.1	1	13		295	
7/17/2020	2		7	37		306	
7/17/2020	3	3.3	1	16		286	
7/17/2020	3		7	68		347	
8/13/2020	1	4.1	1	18	18	312	
8/13/2020	1		4	25	41	310	
8/13/2020	1		6	56	30	506	
8/13/2020	1		9	519	976	978	9726
8/13/2020	2	3.9	1	15		261	
8/13/2020	2		7	127		590	

8/13/2020	3	3.8	1	18		280	
8/13/2020	3		7	82		515	
9/9/2020	1	3.7	1	17	3	252	
9/9/2020	1		4	24	ND	263	
9/9/2020	1		6	59	7	375	
9/9/2020	1		9	644	2000	1726	
9/9/2020	2	3.05	1	19		260	
9/9/2020	2		7	91		530	
9/9/2020	3	3.3	1	20		254	
9/9/2020	3		7	160		664	
10/13/2020	1	2.85	1	20	12	248	
10/13/2020	1		4	18	17	256	
10/13/2020	1		6	20	13	257	
10/13/2020	1		9	19	18	257	
10/13/2020	2	2.8	1	21		261	
10/13/2020	2		7	22		256	
10/13/2020	3	2.95	1	19		257	
10/13/2020	3		7	22		246	

2020 raw profile data from Station 1

Date	Depth_m	Temp	DO	RTRM
4/7/2020	0	10.9	10.9	7
4/7/2020	1	10.3	11.1	0
4/7/2020	2	10.3	11.1	1
4/7/2020	3	10.2	11.1	3
4/7/2020	4	9.9	11.1	6
4/7/2020	5	9.3	10.8	4
4/7/2020	6	8.9	9.7	3
4/7/2020	7	8.6	9.7	1
4/7/2020	8	8.5	9.6	2
4/7/2020	9	8.3	9.5	0
4/7/2020	10	8.3	9.5	1
4/7/2020	11	8.2	9	0
5/13/2020	0	12.4	10.2	0
5/13/2020	1	12.5	10.1	0
5/13/2020	2	12.5	10.1	1
5/13/2020	3	12.4	10.1	1
5/13/2020	4	12.3	10	0
5/13/2020	5	12.3	10	1
5/13/2020	6	12.2	9.9	8
5/13/2020	7	11.6	9.1	3
5/13/2020	8	11.4	8.5	3
5/13/2020	9	11.2	7.6	4
5/13/2020	10	10.9	5.7	4
5/13/2020	11	10.6	2.8	0

6/10/2020	0	24.4	9	9
6/10/2020	1	24.1	9	12
6/10/2020	2	23.7	9.1	12
6/10/2020	3	23.3	9	83
6/10/2020	4	20.3	8.6	91
6/10/2020	5	16.4	7.3	35
6/10/2020	6	14.6	3.8	21
6/10/2020	7	13.4	1.5	11
6/10/2020	8	12.7	0.3	2
6/10/2020	9	12.6	0.2	3
6/10/2020	10	12.4	0.2	4
7/17/2020	0	25.9	8.8	0
7/17/2020	1	26.2	8.7	0
7/17/2020	2	26.3	8.6	0
7/17/2020	3	26.4	8.6	0
7/17/2020	4	26.4	8.3	89
7/17/2020	5	23.6	6.3	115
7/17/2020	6	18.4	0.3	60
7/17/2020	7	15.6	0.1	22
7/17/2020	8	14.4	0.1	14
7/17/2020	9	13.6	0.1	10
7/17/2020	10	13	0.1	5
8/13/2020	0	29.2	8.3	7
8/13/2020	1	29	8.3	4
8/13/2020	2	28.9	8.3	4
8/13/2020	3	28.8	8.2	35
8/13/2020	4	27.8	6.6	51
8/13/2020	5	26.3	5.6	134
8/13/2020	6	21.9	0.9	92
8/13/2020	7	18.3	0.2	42
8/13/2020	8	16.4	0.1	35
8/13/2020	9	14.6	0.1	14
8/13/2020	10	13.8	0.1	15
9/9/2020	0	26.1	9	20
9/9/2020	1	25.5	9.4	10
9/9/2020	2	25.2	9.3	10
9/9/2020	3	24.9	8.7	6
9/9/2020	4	24.7	8.5	9
9/9/2020	5	24.4	7.2	33
9/9/2020	6	23.3	0.9	75
9/9/2020	7	20.6	0.2	59
9/9/2020	8	18.2	0.1	47
9/9/2020	9	16	0.1	30
9/9/2020	10	14.4	0.1	10

10/13/2020	0	16.8	8.8	0
10/13/2020	1	17	8.7	0
10/13/2020	2	17.1	8.6	0
10/13/2020	3	17.2	8.6	0
10/13/2020	4	17.2	8.5	0
10/13/2020	5	17.2	8.4	0
10/13/2020	6	17.2	8.4	0
10/13/2020	7	17.2	8.4	0
10/13/2020	8	17.2	8.3	0
10/13/2020	9	17.2	8.3	2
10/13/2020	10	17.1	8.2	0