Phytoplankton and Zooplankton
2018 Report

Lake Rippowam, Lake Oscaleta, & Lake Waccabuc

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Phytoplankton and Zooplankton Report

Lake Rippowam, Lake Oscaleta, & Lake Waccabuc

Introduction

The Three Lakes Council maintains an outstanding water quality monitoring program to properly manage its three lakes: Lake Waccabuc, Lake Oscaleta and Lake Rippowam. This includes conducting the CSLAP Water Quality Monitoring Program with assistance from the New York State Department of Environmental Conservation (NYSDEC) and the New York State Federation of Lake Associations (NYSFOLA), as well as further water quality testing beyond these programs. This data is reviewed and used to maintain the lakes as a resource for the community for recreation and aesthetic value. SOLitude Lake Management is pleased to provide services to the Three Lakes Council again in 2018. Phytoplankton and zooplankton samples for each of the three lakes were collected by the client on July 26th, 2018.

Phytoplankton Monitoring

Methodology

Phytoplankton samples were collected once in 2018. The sampling date aligned with the sampling events conducted in previous years in order to easily compare the data. The same historical sample sites were utilized and were established at the regular CSLAP sampling stations on all three lakes. Three Lakes Council volunteers collected a single sample from each basin on July 26, 2018 and delivered them to SOLitude Lake Management staff for laboratory analysis.

Phytoplankton samples were collected at a depth of 1.5 meters at each station using clean 1,000 mL HDPE or Nalgene plastic bottles. Immediately following collection, the bottles were placed in a dark cooler stocked with ice to chill the sample. The samples were returned to SOLitude Lake Management's laboratory for analysis within 24 hours. If the sample could not be examined within 24 hours, it was preserved using 0.5 mL of an iodine solution. A sub-sample was sand filtered and microscopically examined at 100X magnification using a compound microscope. Using regionally appropriate taxonomic keys, the phytoplankton was identified to genus level and enumerated. The results for each lake are discussed below and associated examination data is included in the appendix of this report. Further descriptions of the phytoplankton groups

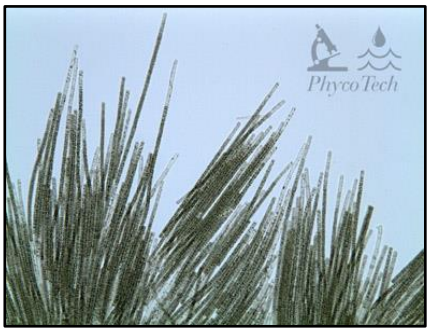
observed can also be found in the appendix along with full-sized versions of the abundance and distribution graphs and pie charts.

2018 Phytoplankton Results

Table 1: 2018 Phytoplankton Distribution

Phytoplankton Group	Lake Rippowam		Lake Oscaleta		Lake Waccabuc	
	Org./mL	%	Org./mL	%	Org./mL	%
Diatoms	250	14.2%			70	10.0%
Golden Algae	40	2.3%	50	6.1%		
Green Algae	80	4.5%	30	3.7%	160	22.9%
Blue-green Algae	**1,330**	**75.6%**	**660**	**80.5%**	**390**	**55.7%**
Euglenoids	10	0.6%	10	1.2%		
Protozoa	30	1.7%	10	1.2%		
Dinoflagellates	20	1.1%	60	7.3%	80	11.4%
Total Organisms	**1,760**	**100%**	**820**	**100%**	**700**	**100%**

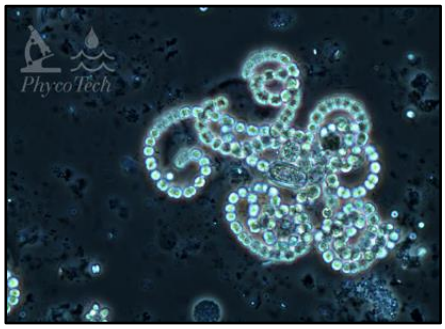
In 2018, the phytoplankton distribution at Lake Rippowam was the most diverse out of the three lakes. Diversity, or number of genera, was considered high with 12 different genera observed. Phytoplankton density was also considered high at 1,760 organisms/mL and was the highest overall abundance of the three lakes. Phytoplankton from all seven main groups (diatoms, golden algae, green algae, blue-green algae, euglenoids, protozoa, and dinoflagellates) were present in the assemblage at Lake Rippowam. The most abundant group of phytoplankton observed was nuisance blue-green algae (75.6%), specifically the genera *Aphanizomenon* (pictured), which accounted for 1,150 organisms/mL of the total blue-green algae (1,330 organisms/mL) recorded. Other genera of blue-green algae present at low levels were *Anabaena* (160 organisms/mL) and *Microcystis* (20 organisms/mL). The next most abundant group of phytoplankton in the sample was diatoms (14.2%) consisting of two different genera: *Cyclotella* and *Synedra*. Green algae represented 4.5% of the assemblage, specifically the genera, *Phytoconis*. The remainder of the assemblage was composed of trace amounts of golden algae, euglenoids, protozoa, and dinoflagellates. Water clarity at Lake Rippowam measured 1.85 meters, which is considered good, especially during July when algal abundance can be problematic. Visual observations conducted by the samplers stated that the water was greenish-brown in color with visible surface algae.



At Lake Oscaleta, the overall phytoplankton abundance was considered moderate with a total of 820 organisms/mL. Diversity was also moderate as eight different genera were recorded from all phytoplankton groups, except for diatoms. The phytoplankton group with the highest density was blue-green algae, consisting of 80.5% of the assemblage. The most abundant genera of blue-green algae observed was *Aphanizomenon* (580 organisms/mL) with a low presence of *Anabaena* (80 organisms/mL). Dinoflagellates consisted of 7.3% of the assemblage, specifically the genera

Peridinium. The next most abundant phytoplankton group was golden algae representing 6.1% of the assemblage (one genera: *Dinobryon*). Green algae, euglenoids, and protozoa were all recorded at trace amounts in the assemblage. Water clarity at Lake Oscaleta was measured at 3.0 meters, which is considered excellent. Samplers noted that the water column was visibly green, and clusters of filamentous algae were observed.

At Lake Waccabuc, phytoplankton density was the lowest of the three lakes. Phytoplankton density was considered moderate at 700 organisms/mL. Although this basin did not have the lowest diversity compared to the other two lakes, results did display Lake Waccabuc as having the least amount of richness among the several phytoplankton groups. Only four different groups were observed: diatoms, green algae, blue-green algae, and dinoflagellates. Phytoplankton diversity was considered moderate with ten different genera present. The most abundant phytoplankton group was blue-green algae consisting of 55.7% of the assemblage. Lake Waccabuc had the lowest abundance of blue-green algae out of the three lakes. This sample contained no *Aphanizomenon*, in comparison to the other two lakes where it was the most dominant genera. For this sample, the most abundant genera of blue-green algae was *Anabaena* (pictured) with 250 organisms/mL followed by *Coelosphaerium* (100 organisms/mL) and *Microcystis* (40 organisms/mL). Green algae was the next most abundant group of phytoplankton, consisting of 22.9% of the assemblage. The dominant genera of green algae observed was *Chlorella* (110 organisms/mL) with lesser amounts of *Staurastrum* and *Sphaerocystis*. The least abundant phytoplankton groups in this sample were dinoflagellates (11.4%) and diatoms (10.0%). The dominant genera of diatom was *Cyclotella* (40 organisms/mL) and the dominant genera of dinoflagellate was *Ceratium* (60 organisms/mL). Water clarity at Lake Waccabuc was measured at 1.55 meters, which is considered fair. The water column was notably green as observed by the samplers.



Phytoplankton Discussion 2013-2018

The 2018 season was the ninth season SOLitude Lake Management (formerly Allied Biological, Inc.) monitored phytoplankton at the Lake Rippowam, Lake Oscaleta, and Lake Waccabuc. The three graphs below, one for each basin, compare the phytoplankton results from 2013 through 2018. Since all samples were collected around the same time of year, utilizing the same sampling station and procedures, it should represent a consistent comparison. Full-sized versions of all three phytoplankton graphs can be found in the appendix, as well as 2018 distribution pie charts and microscopic examination data.

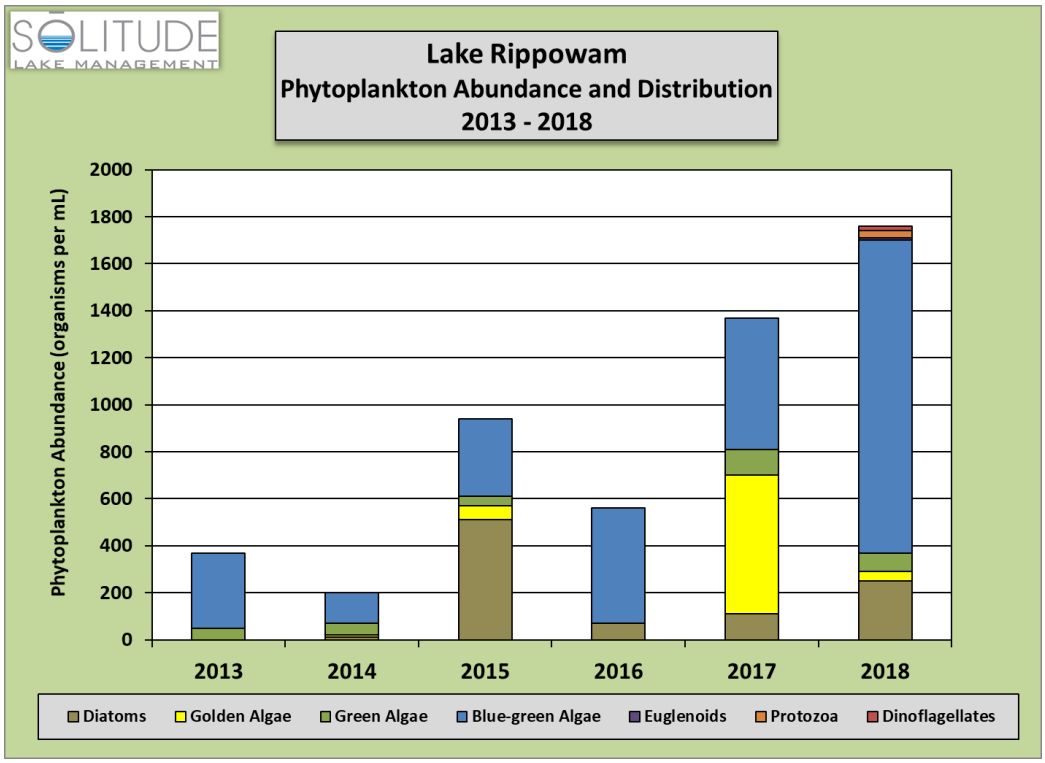


Figure 1. 2013-2018 Lake Rippowam Phytoplankton

At Lake Rippowam, phytoplankton abundance and distribution varied greatly over the years. Overall phytoplankton abundance appears to be on an increasing trend since it was lowest in 2013 and 2014 and highest in 2017 and 2018. Total phytoplankton was considered low in 2013 and 2014, moderate in 2015 and 2016, and high in 2017 and 2018. Blue-green algae was the dominant phytoplankton group in 2013, 2014, 2016, and 2018. Diatoms were the dominant group in 2015 and golden algae was the dominant group in 2017. Although the 2015 and 2017 assemblages were not dominated by blue-green algae, the amount present was still significant. The highest amount of blue-green algae observed at Lake Rippowam was in 2018 at 1,330 organisms/mL, more than double the amount of the second highest recording, which occurred in 2017 at 560 organisms/mL. From 2017 to 2018, golden algae experienced a significant decrease from 590 organisms/mL to 40 organisms/mL. Prior to 2018, the only phytoplankton groups observed at Lake Rippowam were diatoms, golden algae, green algae, and blue-green algae. This season was the first year that euglenoids, protozoa, and dinoflagellates were present in the sample. Blue-green algae had a significantly higher abundance than all other phytoplankton groups in 2018. Blue-green algae continues to consistently increase in Lake Rippowam, likely due to the limited aquatic plant community.

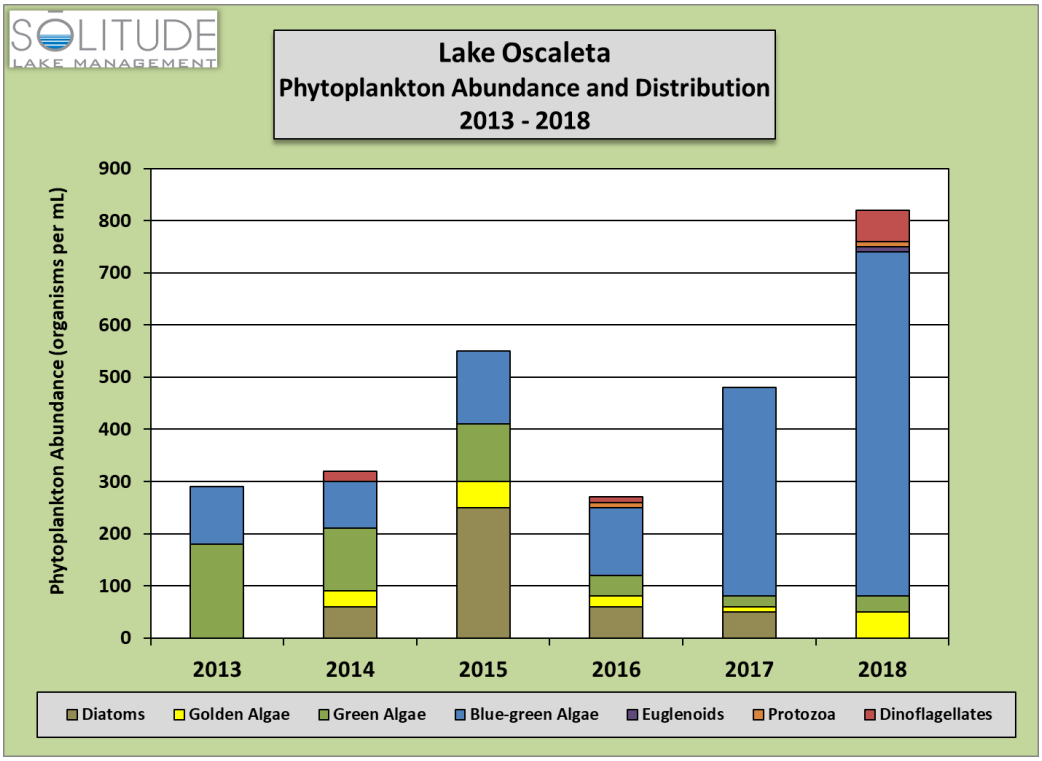


Figure 2. 2013-2018 Lake Oscaleta Phytoplankton

At Lake Oscaleta, overall phytoplankton increased from 2013 to 2015 before a steep decline in 2016, most likely due to seasonal variations and temperature fluctuations. Following 2016, the phytoplankton population has been consistently increasing, especially blue-green algae. Group dominance prior to 2016 mainly consisted of diatoms and green algae, but within the last three years blue-green algae has taken over the assemblage. The highest amount of blue-green algae was recorded in 2018 at 660 organisms/mL. This was also the first year on record that any genera of euglenoids were observed. Diatoms were present every sampling event except 2013 and 2018. Diatoms dominated the 2015 sample, which also had the second highest amount of overall phytoplankton abundance out of all six years. Although 2015 had the second highest overall, 2017 had the second highest amount of blue-green algae with 400 organisms/mL. The blue-green algae population in Lake Oscaleta is consistently increasing, especially within the last three years.

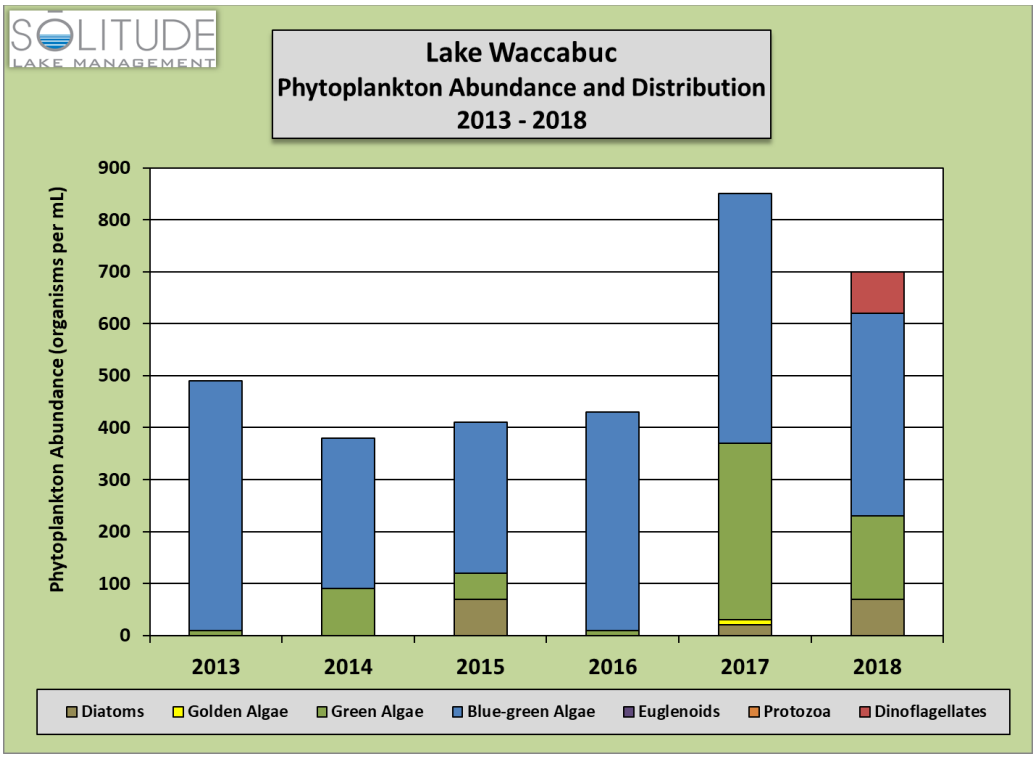


Figure 3. 2013-2018 Lake Waccabuc Phytoplankton

Based on the data in Figure 3, Lake Waccabuc contains the most consistent blue-green algae population over the past six years. Over 50% of each assemblage from all six years consisted of various genera of blue-green algae. Like Lake Rippowam and Oscaleta, 2017 and 2018 data displays the highest amounts of total phytoplankton, specifically blue-green algae, at Lake Waccabuc. All three lakes show overall increases in phytoplankton populations overtime. Lake Waccabuc, while not having the highest amount of blue-green algae in 2018, has held the most consistent and stable population compared to the other two basins. In 2017, we observed a significant increase in green algae genera, competing with the blue-green population. This year, dinoflagellates were observed for the first time at Lake Waccabuc at 80 organisms/mL. This basin contains the least diverse phytoplankton community of the three lakes. The high abundances of blue-green algae are most likely outcompeting the other algal groups in combination with seasonal variation. It is typical during the warmer months to experience an increased abundance of blue-green algae.

Zooplankton Monitoring

Methodology

Zooplankton samples were collected, by the client, with an 80 µm Nitex plankton net. At Lake Waccabuc and Lake Oscaleta, a single vertical tow was performed to a depth of 18 feet. At Lake Rippowam, two 10-foot vertical tows were composited into a single sample due to the water depth at the sampling station. Using as little site water as possible, the sides of the net were

rinsed of any trapped zooplankton, concentrating the organisms into the net bottom. This concentrate was then emptied into a clean 1,000 mL HDPE sample bottle. Immediately after collection, the sample was preserved with an equal amount of 10% sucrose formalin, to achieve a 5% solution. Sucrose was added to the preservative to help maintain carapace integrity. The samples were then placed in a cooler stocked with blue ice. On arrival at SOLitude Lake Management's laboratory, the samples were stored in a dark refrigerator until being identified and enumerated.

In the laboratory, each sample was manually mixed for about one minute, before a one mL subsample was removed using a calibrated syringe. The subsample was placed on a Sedgewick-Rafter counting cell and examined under a compound microscope at 100X magnification. By using calibrated guides on the microscope stage, the entire one mL sample was examined, and any zooplankton were identified and enumerated to the lowest practical taxa using regionally appropriate taxonomic keys. This procedure was repeated two more times to generate a total of three replicate counts. The counts were then averaged, and back-calculated to achieve an organism per liter density. The zooplankton examination data sheets are included in the appendix of this report. Also included in the appendix are descriptions of the zooplankton groups and individual lake distribution pie charts.

2018 Zooplankton Results

Table 2: 2018 Zooplankton Distribution

Zooplankton Group	Lake Rippowam		Lake Oscaleta		Lake Waccabuc	
	Org./L	%	Org./L	%	Org./mL	%
Rotifera	**1,808**	**70.5%**	**1,614**	**85.8%**	**2,025**	**53.9%**
Cladocera	330	12.9%	155	8.2%	955	25.4%
Copepoda	427	16.6%	111	5.9%	780	20.7%
Total Organisms	**2,565**	**100%**	**1,880**	**100%**	**3,760**	**100%**

At Lake Rippowam in 2018, zooplankton abundance was considered high at 2,565 organisms/L. A total of nine different species of zooplankton were observed in the sample. Zooplankton diversity would be considered moderate for this basin. Rotifers dominated the assemblage, accounting for 70.5% of the sample at 1,808 organisms/L. The most abundant species within the rotifer group was *Synchaeta oblonga* with 1,531 organisms/L. Copepods were the next most abundant group of zooplankton present in Lake Rippowam, consisting of 16.6% of the assemblage. With a total of 427 organisms/L, the density of copepods is considered low. Two different species of copepods were observed: *Microcyclops rubellus* and *Cyclopoid nauplius*. *Microcyclops rubellus* was the dominant species of copepod with 286 organisms/L. Cladocera were the least common group of zooplankton observed with a low abundance of 330 organisms/L (12.9% of the assemblage). Two different species of cladocera, *Bosmina longirostris* and *Ceriodaphnia lacustris*, were present at relatively similar amounts.

For Lake Oscaleta, the total zooplankton abundance was considered high at 1,880 organisms/L. Zooplankton diversity for this sample was moderate with ten different species recorded. The

dominant group of zooplankton, accounting for 85.8% of the assemblage, were rotifers with a high density of 1,614 organisms/L. The most abundant species of rotifers observed were *Keratella crassa* (572 organisms/L) and *Polyarthra remata* (465 organisms/L). Several other species were observed in lesser amounts. The next most abundant group of zooplankton was cladocera with a low abundance of 155 organisms/L (8.2% of the assemblage). Just one species of cladocera, *Bosmina longirostris*, was observed. Copepods were the least abundant group of zooplankton with 111 organisms/L, making up the remaining 5.9% of the assemblage. Two different species of copepods were observed in the sample: *Microcyclops rubellus* and *Cyclopoid nauplius*. Lake Oscaleta had the lowest total zooplankton abundance out of the three lakes.

At Lake Waccabuc, total zooplankton abundance was considered high with 3,760 organisms/L. A total of 14 different species were observed in the sample, making the zooplankton diversity high. Like the other two lakes, rotifers were the most abundant group of zooplankton in Lake Waccabuc with a density of 2,025 organisms/L (53.9% of the assemblage). Ten different species of rotifers were recorded when examining the sample. Some of the more prevalent species were *Synchaeta oblonga* (pictured, 586 organisms/L), *Keratella crassa* (315 organisms/L), and *Asplanchna priodonta* (228 organisms/L). The next most abundant group of zooplankton was cladocera with a moderate density of 955 organisms/L (24.5% of the assemblage). Two different species of cladocera were observed in the sample: *Bosmina longirostris* (640 organisms/L) and *Ceriodaphnia lacustris* (315 organisms/L). Copepods were the least abundant group of zooplankton with a moderate density of 780 organisms/L (20.7% of the assemblage). *Microcyclops rubellus* and *Cyclopoid nauplius* were the two different species of copepods present. Lake Waccabuc contained the highest number of zooplankton and highest diversity out of the three lakes.

Zooplankton Discussion 2013-2018

The three graphs below, one for each basin, compare the zooplankton results from the 2013 through 2018 sampling events. Since all samples were collected at about the same time of year, utilizing the same sampling station and procedures, it should represent a consistent comparison. Full-sized versions of all three zooplankton graphs can be found in the appendix along with the examination data and distribution pie charts.

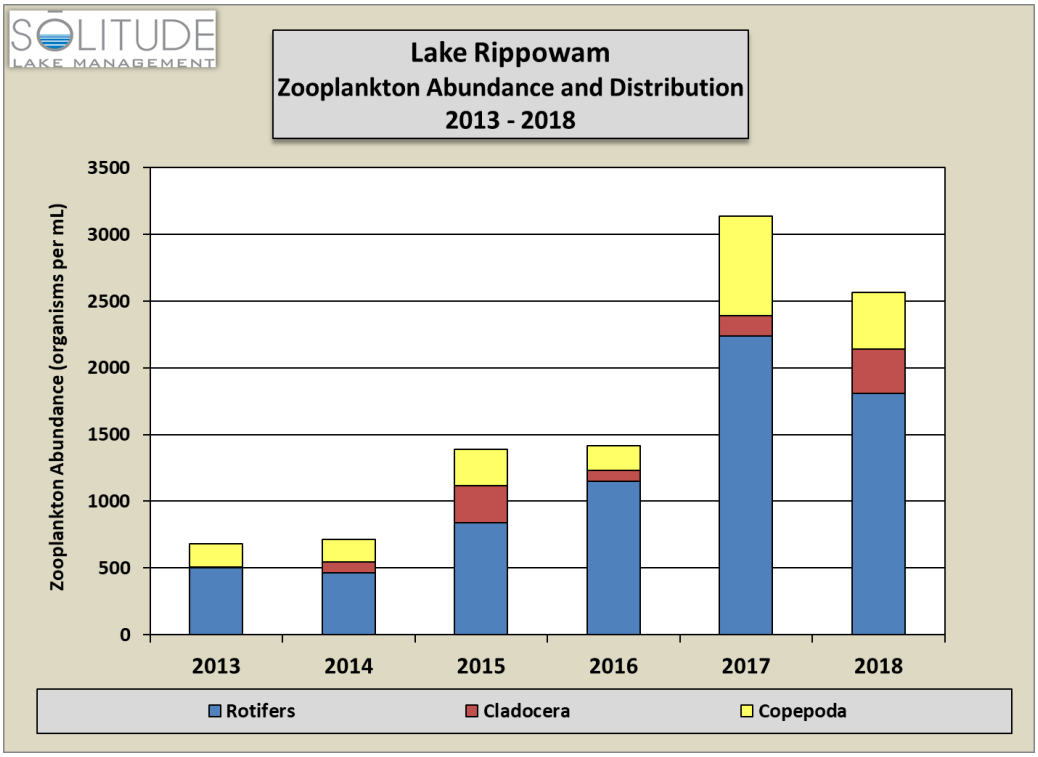


Figure 4. Lake Rippowam Zooplankton 2013-2018

The zooplankton abundance at Lake Rippowam has been consistently increasing since 2013. Zooplankton density was considered moderate in 2013 and 2014 with the majority of the assemblage being rotifers. From 2015 to 2018, zooplankton abundance was considered high. Rotifers have been the dominant zooplankton group every year since 2013. Copepods have continuously been the second most abundant group with the exception of 2015 where the density of copepods and cladocera were equivalent. Total zooplankton abundance reached a high of 3,134 organisms/L in 2017 before slightly decreasing to 2,565 organisms/L in 2018. Copepods and rotifers experienced this decrease, but cladocera increased from 155 organisms/L in 2017 to 330 organisms/L in 2018. Cladocera are a desirable group to have as they are highly effective feeders on phytoplankton populations.

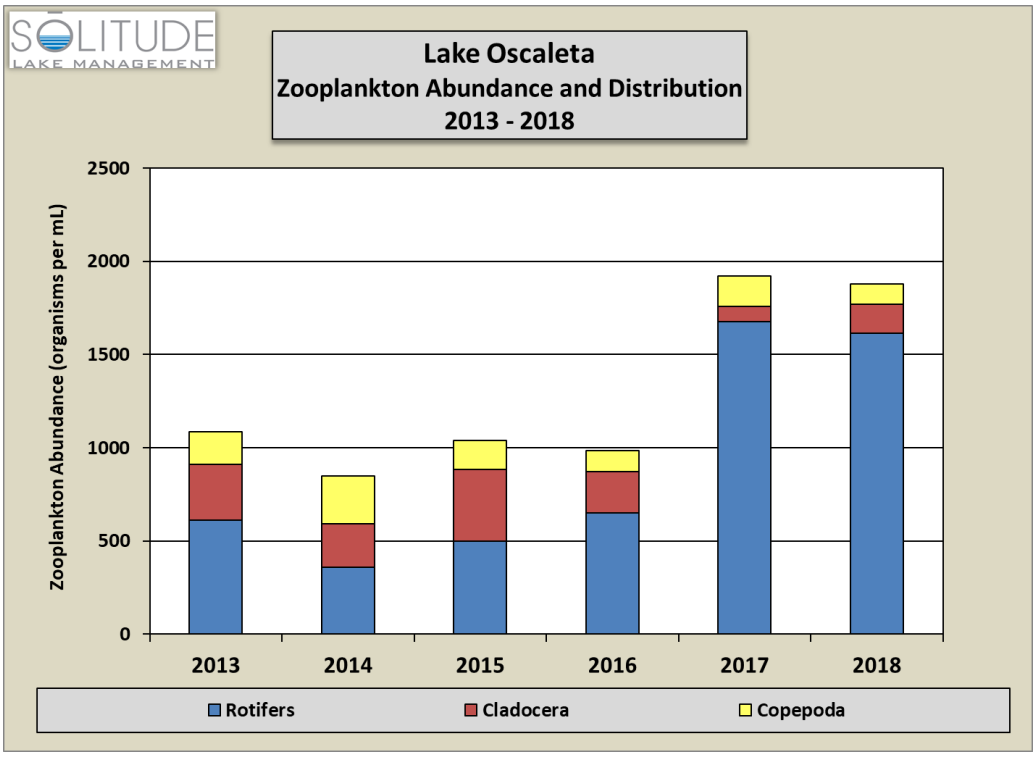


Figure 5. Lake Oscaleta Zooplankton 2013-2018

At Lake Oscaleta, high overall zooplankton results have been observed in the past two years, reaching a high of 1,923 organisms/L in 2017 and 1,880 organisms/L in 2018. Zooplankton density was considered moderate in both 2014 and 2016, and high all other years. Greater distribution between the three zooplankton groups are displayed from 2013 to 2016, but in the past two years rotifers have dominated the assemblages. Cladocera and copepod densities were very low in 2017 and 2018 while rotifer abundances were high. This trend is very similar to that of Lake Rippowam, where rotifers increased significantly within the past two years. In more recent years, Lake Oscaleta has had the lowest zooplankton abundance out of the three lakes.

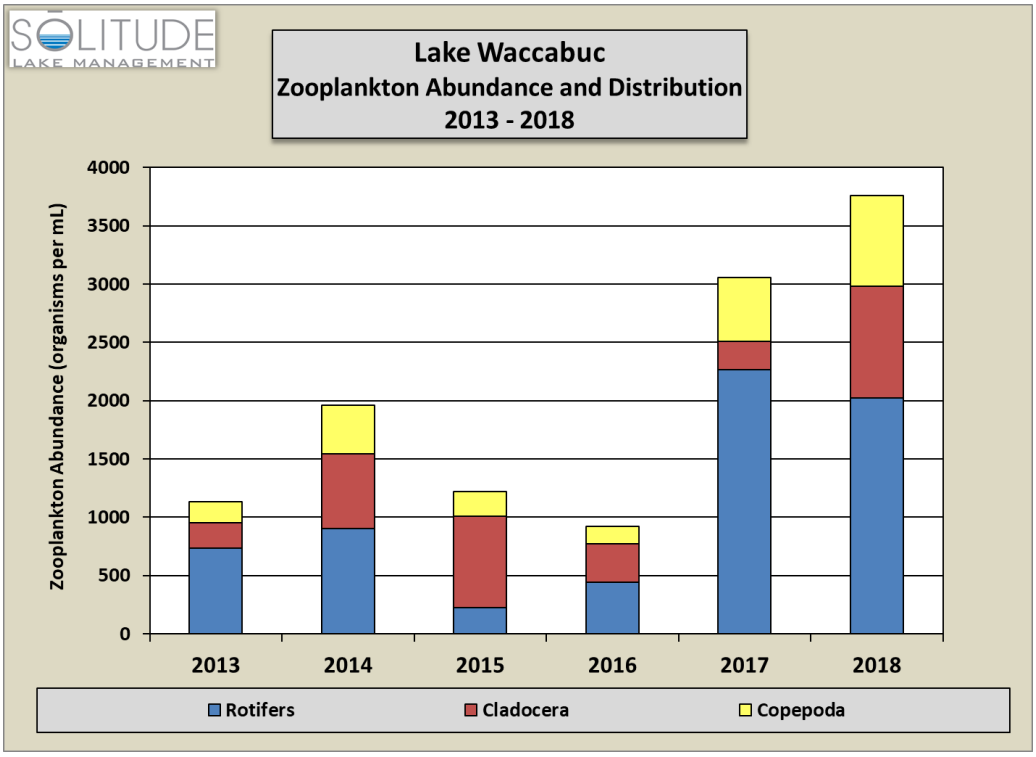


Figure 6. Lake Waccabuc Zooplankton 2013-2018

At Lake Waccabuc, zooplankton distribution has been the most diverse over the years compared to the other two lakes. Cladocera and copepods had increased abundance in comparison to Lake Rippowam and Lake Oscaleta. These two groups outnumbered rotifers in 2014, 2015, and 2016. Cladocera dominated the assemblage in 2015. Rotifers were the dominant group of zooplankton in 2013, 2014, 2016, 2017, and 2018. Overall zooplankton abundance was considered moderate in 2016 and was high all other years. Zooplankton abundance has been the highest in the past two years, over 1,000 organisms/L higher in density than the next highest year (2014). The rotifer community has developed significantly out of the three groups since 2017. In 2018, the distribution of the three groups was more evenly distributed compared to 2017 as cladocera and copepod abundance increased. Lake Waccabuc contains the highest zooplankton abundance out of the three lakes, peaking in 2018 at 3,760 organisms/L.

Lake Profiles

Table 3: 2018 Three Lakes Profiles

Depth (meters)	Lake Rippowam		Lake Oscaleta		Lake Waccabuc	
	Temp. (°C)	Dissolved Oxygen (mg/L)	Temp. (°C)	Dissolved Oxygen (mg/L)	Temp. (°C)	Dissolved Oxygen (mg/L)
0	26.6	9.00	25.9	8.87	25.8	9.15
1	25.8	8.78	25.7	8.90	25.8	9.17
1.5	25.7	9.15	25.6	8.84	25.8	9.00
2	25.7	8.56	25.6	8.72	25.7	8.93
3	25.4	7.34	25.0	7.88	25.4	7.23
4	21.0	5.84	21.2	8.84	23.3	1.82
4.5	17.4	0.20				
5	15.7	0.13	15.5	3.72	17.4	0.19
5.5	14.0	0.11				
6			11.7	0.24	13.8	0.12
7			9.9	0.15	11.0	0.09
8			9.0	0.12	9.8	0.08
9			8.4	0.11	8.9	0.07
10			8.0	0.10	8.2	0.08
10.5			7.8	0.10		
11					7.7	0.07
12					7.5	0.07
13					7.4	0.07
14					7.2	0.07

In 2018, temperature and dissolved oxygen profiles were measured at each lake station. Data was collected at one meter intervals with some extra measurements at half-meter marks, most likely based on depth measurements. All three profiles have an extra measurement at the 1.5 meter depth coinciding with the depth of the phytoplankton collection. Lake Rippowam has an added measurement of 4.5 and 5.5 meter depths. Lake Oscaleta has an extra measurement at the 10.5 meter depth.

At Lake Rippowam, dissolved oxygen reading were slightly elevated until reaching a depth of 3 meters. The highest dissolved oxygen occurred at a depth of 1.5 meters with 114.9% saturation. Dissolved oxygen consistently decreased from 1.5 meters until 4 meters before plummeting at 4.5 meters to 0.20 mg/L. From 4.5 meters to 5.5 meters, conditions were considered anoxic as saturation reached a low of 1.1%.

At Lake Oscaleta, dissolved oxygen levels were slightly elevated from the surface until a depth of 4 meters with saturation ranging from 101.8% to 111.7%. Dissolved oxygen levels dropped after a depth of 4 meters from 8.84 mg/L to 3.72 mg/L, reaching anoxic conditions at 6 meters (0.24 mg/L). Saturation fell below 1.0% after a depth of 9 meters. Elevated dissolved oxygen levels at the surface can indicate minor phytoplankton blooms.

At Lake Waccabuc, like the other two lakes, dissolved oxygen was elevated at the surface. This basin observed the highest dissolved oxygen level of the three lakes at 9.17 mg/L at a depth of 1 meter. This was also the highest saturation recorded at 115.2%. From the surface to a depth of 2 meters, saturation ranged from 112.0% to 115.2%. Dissolved oxygen began dropping after a depth of 3 meters (7.23 mg/L to 1.82 mg/L) and reached anoxic conditions by 5 meters. Saturation fell below 1.0% from a depth of 7 meters to 14 meters. The variations in dissolved oxygen and temperature for all three lakes were similar to each other and typical for basins in mid-summer.

Conclusion

Summary

Overall phytoplankton abundance at all three lakes have been increasing, especially within the last two years. Phytoplankton communities in all three lakes were dominated by nuisance blue-green algae in 2018, which is most likely caused by increased temperatures and potential eutrophication. Zooplankton abundance has followed with increasing trends in the last two years at all three lakes. Rotifers are now considered the most dominant zooplankton group within all three lakes. In 2018, Lake Oscaleta contained the lowest amount of both phytoplankton and zooplankton. Lake Rippowam observed the highest phytoplankton abundance and diversity and Lake Waccabuc had the highest zooplankton abundance and diversity.

Recommendations

The Three Lakes Council has now compiled six years of zooplankton and phytoplankton data for Lake Rippowam, Lake Oscaleta, and Lake Waccabuc, which should be considered a suitable baseline of data. Monitoring the health of a lake ecosystem requires sampling a diverse array of biological communities such as fish, aquatic plants, phytoplankton and zooplankton. The comprehensive water quality collected via the CSLAP program is suitable to be combined with available biological data, to assist with completing the picture of the overall ecological status of the three basins. SOLitude Lake Management recommends the 3LC to continue monitoring zooplankton and phytoplankton in the 2019 season. Although sampling throughout the growing season would be ideal, continuing the same sampling format and techniques applied in 2013 through 2018, a single sample should be collected in mid-July of 2019.

We now have suitable phytoplankton and zooplankton data for all three lakes, and we have developed a rotating schedule to survey the submersed aquatic plant community among the three lakes. However, we continue to lack baseline fishery data at any of the Three Lakes, and arguably this is one of the most important recreational resources for the Three Lakes community. This may provide some insight upon the fluctuating zooplankton populations within some of the basins. We strongly recommend a fish population study, at least in one basin, for 2019. This would allow us to evaluate the community structure, along with providing additional and alternative management strategies. For budget reasons, we could even rotate the basin sampled every three years, like we currently do with the SAV surveys. Following the collection of one set of detailed data, scientifically-sound fishery management techniques could be implemented.

SOLitude Lake Management (formerly Allied Biological from 2008 through 2015) has been actively collecting and analyzing data pertaining to the lakes from the Three Lakes since 2008. The Council may want to consider a summary report of this data collected to organize it all in one location and database, for ease of use by the Council or even volunteer groups. This data should be utilized to dictate the required management of the lakes for the benefit of the residents.

SOLitude Lake Management would like to take this opportunity to thank the Three Lakes Council for allowing us to provide lake management consulting services. We look forward to working with you again throughout the 2019 lake management season.

Sincerely,

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Appendix

Phytoplankton Primer

Zooplankton Primer

2018 Phytoplankton Examination Data and Pie Charts

2018 Zooplankton Examination Data and Pie Charts

2013-2018 Phytoplankton Abundance and Distribution Graphs

2013-2018 Zooplankton Abundance and Distribution Graphs

Three Lakes Profile Data and Graphs

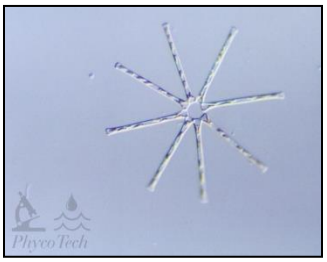
Phytoplankton Primer

Lakes typically contain three broad categories of phytoplankton (also sometimes referred to as algae). These include filamentous phytoplankton, macroscopic multi-branched phytoplankton (which appear like submersed plants), and unicellular phytoplankton. Each category shall be discussed in turn.

Filamentous phytoplankton are typically macroscopic (that is, visible with the naked eye), composed of long chains of cells that are attached to a substrate, typically the lake bottom, submersed or emergent vegetation, or rocks. This is called benthic filamentous algae (BFA), and rampant growth can become visible at the surface. As pieces of benthic filamentous algae break apart, it often floats on the surface as dense unsightly mats called floating filamentous algae (FFA). Typically, genera of green algae or blue-green algae develop into nuisance filamentous mats. Abundant nuisance growth of filamentous phytoplankton creates numerous negative impacts to a lake. These can include a decrease in aesthetics, a decrease in recreational uses, increased fishing frustration, and water quality degradation.

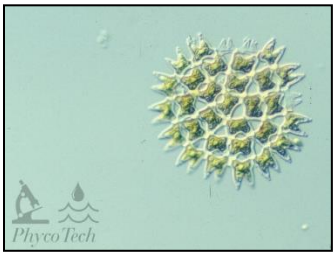
Macroscopic multi-branched phytoplankton appears to be submersed plants, especially when viewed in the water column. Physical examination reveals simple structures, no conductive tissue, and a lack of roots (instead having simplified rhizoids). Although typically only reaching heights of a few inches, under ideal conditions, this type of phytoplankton can reach lengths of several feet and create a dense carpet on the bottom of a lake. Therefore, it typically does not reach nuisance levels in a lake, save for high use areas such as beaches and other popular swim areas. Since this phytoplankton occupies a similar ecological niche as submersed plants, it's often included in detailed and visual aquatic plant surveys. It provides numerous benefits to a lake system, including sediment stabilization, acting as a nutrient sink, providing invertebrate and fish shelter and habitat, and is one of the first to re-colonize a disturbed area. In the Northeast, muskgrass (*Chara* sp.) and stonewort (*Nitella* sp.) are two of the most common macroscopic multi-branched phytoplankton.

Unicellular phytoplankton is typically microscopic and consists of individual cells or colonies of cells suspended in the water column. At high enough densities (often called a bloom), they can impart a green or brown (and sometimes, even red) tint to the water column. Unicellular phytoplankton belongs to several taxonomic groups with density and diversity of these groups often varying due to seasonality. When unicellular phytoplankton density becomes elevated it can reduce water clarity (giving the water a "pea soup" appearance) and impart undesirable odors. Usually blue-green algae are responsible for these odors, but other groups or extremely elevated densities can impart them as well. In addition to decreased aesthetics, unicellular phytoplankton blooms can cause degradation of water quality, increase the water temperature (turbid water warms faster than clear water), and can possibly produce a variety of toxins (in the case of blue-green algae), depending on the type of genera present and environmental conditions. Numerous groups of unicellular phytoplankton are common in the Northeast, including diatoms, golden algae, green algae, blue-green algae, euglenoids, and dinoflagellates. Each group shall be discussed in turn.



Diatoms are ubiquitous as a group, and often possess a rigid silica shell with ornate cell wall markings or etchings. The silica shells settle to the bottom substrate after they die, and under ideal conditions can become stratified. Limnologists can then study historical (and possibly even ancient) population characteristics of diatoms. Some are round and cylindrical (centric) in shape, while others are long and wing-shaped (pennales). They are usually brown in color and reach maximum abundance in colder or acidic water. Therefore, they tend to dominate in winter and early spring. Common diatoms in the Northeast include *Fragilaria, Cyclotella, Navicula*, and *Asterionella* (pictured).

Golden Algae are typically yellow or light brown in color. Cell size is usually small oval shaped with a partially empty area, but several genera create colonies of smaller cells. Most have two flagella, and some type of scales or a rigid coating that grants it a fuzzy appearance. However, a few filamentous forms are possible as well. They typically prefer cooler water, so they dominate in the late fall, winter, or early spring. They also tend to bloom at deeper (cooler) depths. They are common in low nutrient water, and numerous forms produce taste and odor compounds. Common golden algae in the Northeast include *Dinobryon* (pictured), *Mallomonas*, and *Synura*.

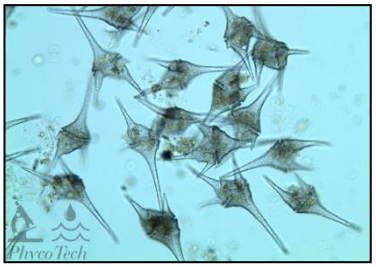


Green Algae are a very diverse group of unicellular phytoplankton. There is tremendous variability in this group which varies from family to family and sometimes even genus to genus. There are flagellated single cells, multi-cell colonies (some motile), filamentous forms and attached forms, typically with distinct cell shapes light green in color. Some prefer acidic waters, and others highly eutrophic (sewage) conditions. A green algae bloom usually occurs in water with high nitrogen levels. Green algae typically dominate in mid to late summer in the Northeast. Common genera include *Chlorella*, *Scenedesmus*, *Spirogyra* and *Pediastrum* (pictured).

Blue-green algae are photosynthetic bacteria. Therefore, they tend to be small, simple in structure and lacking interior cell details. Blue-green algae are typically encased in a mucilaginous outer layer. Some genera are adorned with heterocysts, swollen structures capable of fixing nitrogen, a competitive advantage. These types tend to bloom in nitrogen-poor or eutrophic systems. Yet, blue-green algae are tolerant of a wide variety of water chemistries and boast many oligotrophic forms as well. Blue-green algae often have gas vesicles which provide increased buoyancy another competitive advantage over other groups of phytoplankton, due to their propensity to shade out others by blooming at the surface. Numerous blue-green algae are documented taste and odor (T&O) producers, and under certain environmental conditions and high enough densities, can produce toxins dangerous to fish, livestock, and possibly humans. Blue-green algae typically dominate a lake system in late

summer to early fall. Common blue-green algae that occur in the Northeast include *Anabaena* (pictured)*, Aphanizomenon, Microcystis* and *Coelosphaerium.*

Euglenoids are typically motile with 0 to 3 (typically 2) flagella, one of which is longer. Euglenoids have plasticity of shape, and usually are grass green in color (although sometimes they are clear or even red). Most forms have a distinct red "eyespot." They are often associated with high organic content water, and eutrophic conditions. Common euglenoids that occur in the Northeast include *Euglena* (pictured), *Phacus,* and *Trachelomonas*.



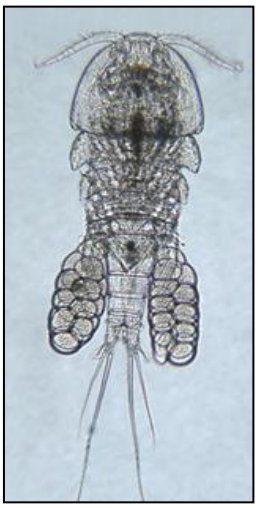
Dinoflagellates are very common in marine environments, in which they often cause toxic blooms. However, toxin production in freshwater genera is very rare. Dinoflagellates are typically single ovoid to spherical cells, but large compared to phytoplankton from other groups. They usually possess two flagella (one wrapped around the middle of the cell) which grant them rotation while they move through the water column. Cellulose plates (armored dinoflagellates) are more common, but genera without cellulose plates (naked dinoflagellates) also occur. They generally prefer organic-rich or acidic waters and can impart a coffee-like brown tint to the water at high enough densities. Common dinoflagellates in the Northeast include *Ceratium* (pictured) and *Peridinium*.

Zooplankton Primer

Zooplankton provides an important link in a typical lake's food web between phytoplankton and fish, especially developing and juvenile stages. In general, zooplankton feed on phytoplankton, while fish in turn feed on zooplankton. The rate of feeding efficiency is primarily based on body size, but zooplankton group, and to some effect specific genera, also plays an important role. There are three main groups of zooplankton found in freshwater systems: rotifers, cladocera, and copepods.

Rotifers are a diverse group of zooplankton, very common in lakes and marine environments alike. Rotifers are generally the smallest zooplankton of the three groups, and thus typically the least efficient phytoplankton grazers. Feeding preferences are determined primarily by mouth structures, and include generalist feeders (omnivores), which eat any small organic detritus encountered, and predators, which eat other smaller rotifers and small phytoplankton. Generalist feeders include *Filinia, Keratella, Lecane, Euchlanis*, and *Brachionus*. Predator genera include *Polyarthra* (larger species)*, Asplanchna, Synchaeta*, and *Trichocerca*.

Cladocera are less diverse, but also very common in freshwater lakes. They are sometimes called “water fleas”. They spend most of their lifecycle reproducing via parthenogenesis (asexual reproduction with an all female population) only switching to less efficient sexual reproduction when environmental conditions decline. Some genera (such as *Daphnia*) can be quite large (up to 5.0 mm long, visible without magnification), and thus can be classified as highly efficient phytoplankton grazers. Most cladocera are phytoplankton grazers, although their diet includes most organic matter ingested, including bacteria and protozoa. Body size (and thus mouth size) determines feeding efficiency, but ironically the larger-bodied genera are easier to see by predaceous fish, and thus typically have reduced numbers in populations of zooplanktivorous fish. *Daphnia* are the most efficient phytoplankton feeders, while *Ceriodaphnia, Bosmina* and *Eubosmina* are less efficient. There are a few predator genera as well, including *Polyphemus* and *Leptodora*.



Copepods are almost excusive to freshwater lake systems (not streams or rivers) and estuarine and marine systems. Of the six suborders native to the United States, three are parasitic, and three are free living. One of the free living, Harpacticoida are exclusively benthic and thus often not collected in traditional plankton tows (unless the bottom sediments are disturbed). The remaining two suborders, the Calanoida and the Cyclopoida are of primary concern during lake studies. All copepods have several naupilar stages, followed by several immature stages, before reaching an adult stage. Both suborders are considered large bodied zooplankton but have distinct feeding preferences. Calanoids are almost exclusively phytoplankton feeders and have even demonstrated selective feeding strategies. Cyclopoids have mouth parts suitable for biting and seizing prey. Their diet is primarily other crustacean zooplankton (including cannibalism on younger life stages), and phytoplankton and organic detritus ingestion (but less efficiently).

MICROSCOPIC EXAMINATION OF WATER

Sample from: Three Lakes

Collection Date: 7/26/2018	Examination Date: 7/27/2018	Amount Examined: 200 ml.
Site A: Lake Rippowam	Site B: Lake Oscaleta	Site C: Lake Waccabuc

BACILLARIOPHYTA (Diatoms)	**A**	**B**	**C**
Asterionella			
Cyclotella	200		40
Cymbella			
Diatoma			
Fragilaria			30
Melosira			
Navicula			
Nitzschia			
Pinnularia			
Rhizosolenia			
Stephanodiscus			
Stauroneis			
Synedra	50		
Tabellaria			
Cocconeis			

CHRYSOPHYTA (Golden Algae)	**A**	**B**	**C**
Dinobryon	30	50	
Mallomonas	10		
Synura			
Tribonema			
Uroglenopsis			

CHLOROPHYTA (Green Algae)	**A**	**B**	**C**
Ankistrodesmus			
Chlamydomonas			
Chlorella			110
Chlorococcum			
Closterium			
Coelastrum		10	
Eudorina			
Mougeotia			
Oedogonium			
Oocystis			
Pandorina			
Pediastrum			
Phytoconis	80		
Rhizoclonium			
Scenedesmus			
Spirogyra			
Staurastrum		20	30
Sphaerocystis			20
Ulothrix			
Volvox			
Zygnema			
Quadrigula			
Gloeocystis			
Cosmarium			
Treubaria			

CYANOPHYTA (Blue-green Algae)	**A**	**B**	**C**
Anabaena	160	80	250
Anacystis			
Aphanizomenon	1150	580	
Coelosphaerium			100
Gomphosphseria			
Lyngbya			
Microcystis	20		40
Oscillatoria			
Pseudoanabaena			
Synechocystis			
Agmenellum			
PROTOZOA			
Actinophyrs	30	10	

EUGLENOPHYTA (Euglenoids)	**A**	**B**	**C**
Euglena			
Phacus	10		
Trachelomonas		10	

PYRRHOPHYTA (Dinoflagellates)	**A**	**B**	**C**
Ceratium	10		60
Peridinium	10	60	20

SITE	**A**	**B**	**C**
TOTAL GENERA:	12	8	10
TRANSPARENCY:	1.85m	3.0m	1.55m
ORGANISMS PER MILLILITER:	**1,760**	**820**	**700**

NOTES: This was the 2018 sampling event. Algal density is considered high at Lake Rippowam and moderate at Lake Oscaleta and Lake Waccabuc. Algal diversity is high at Lake Rippowam and moderate at the other two lakes. The assemblage consists mainly of blue-green algae, mainly present in Lake Rippowam. Lower amounts of diatoms, golden algae, green algae, euglenoids, dinoflagellates, and protozoa were also observed at all three lakes. Water clarity is considered fair at site C, good at site A, and excellent at site B.

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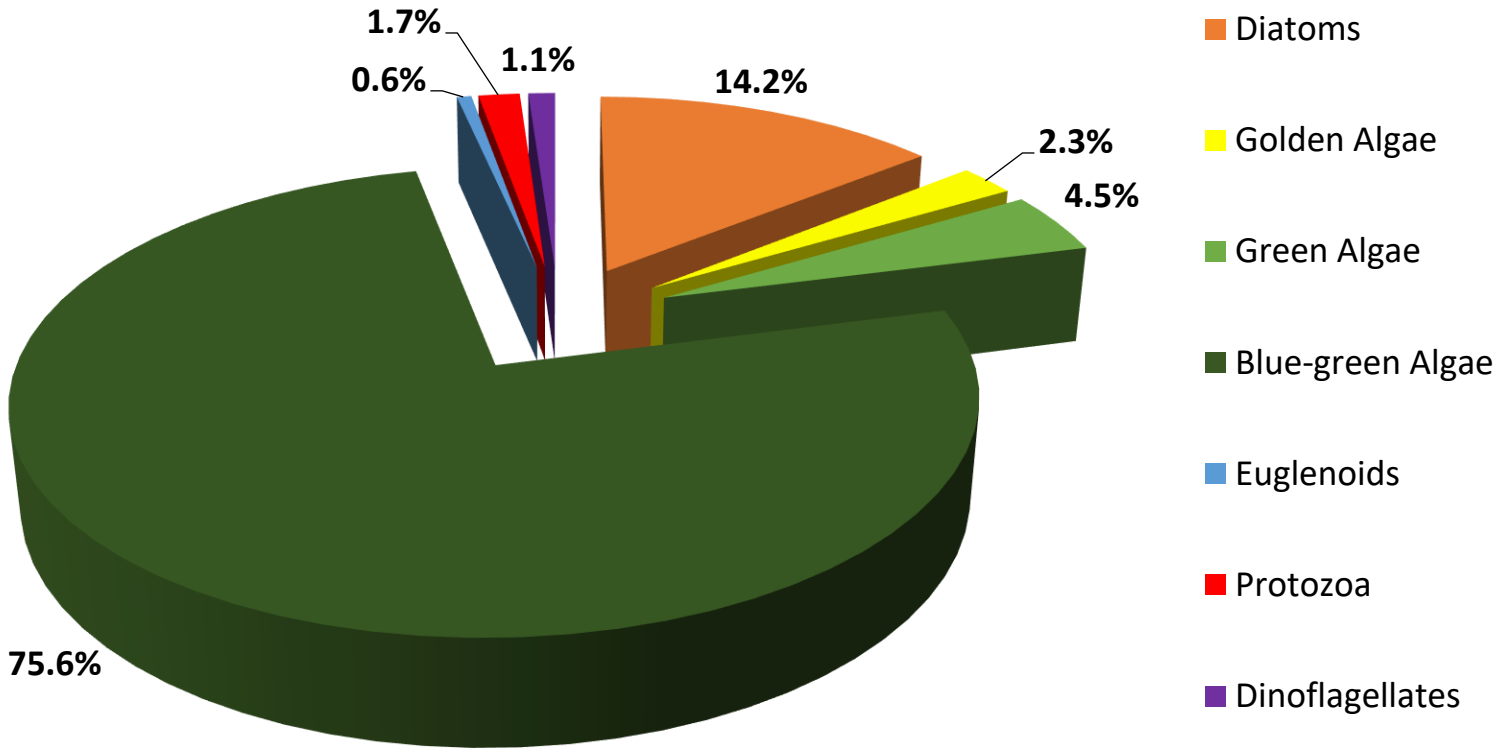
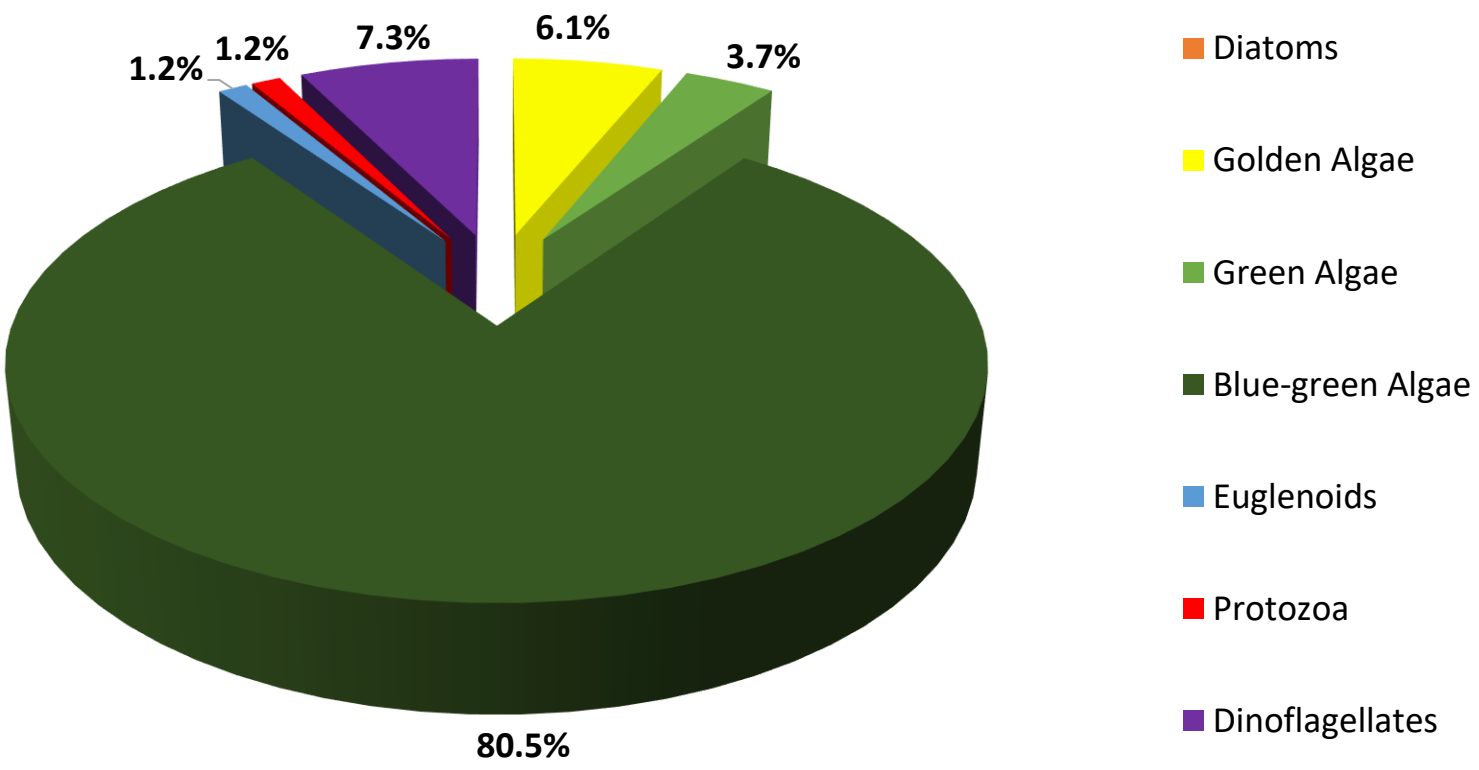
310 East Washington Ave, Suite C, Washington, NJ 07882
Phone (908) 850-0303 Fax (908) 850-4994

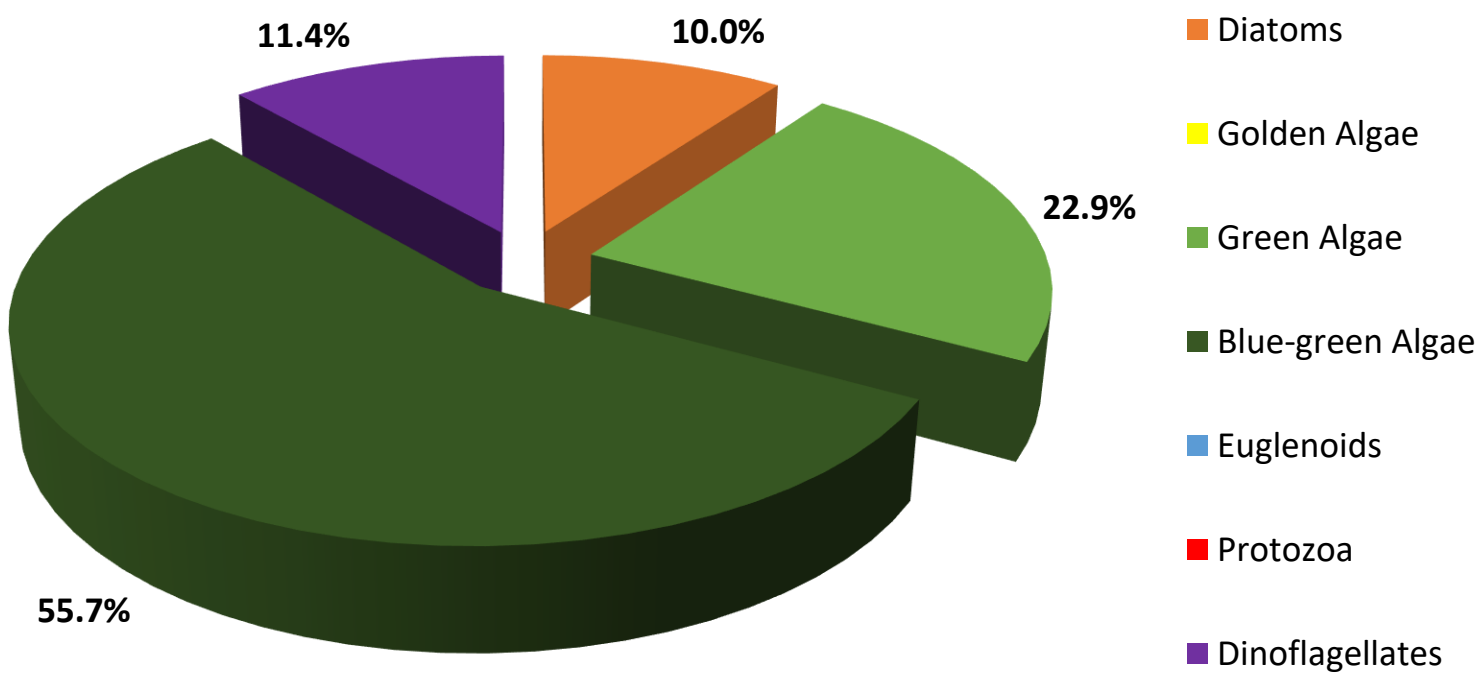
Lake Rippowam
Phytoplankton Distribution
July 26, 2018



Lake Oscaleta
Phytoplankton Distribution
July 26, 2018



Lake Waccabuc
Phytoplankton Distribution
July 26, 2018



Zooplankton Count Results

SOLITUDE LAKE MANAGEMENT

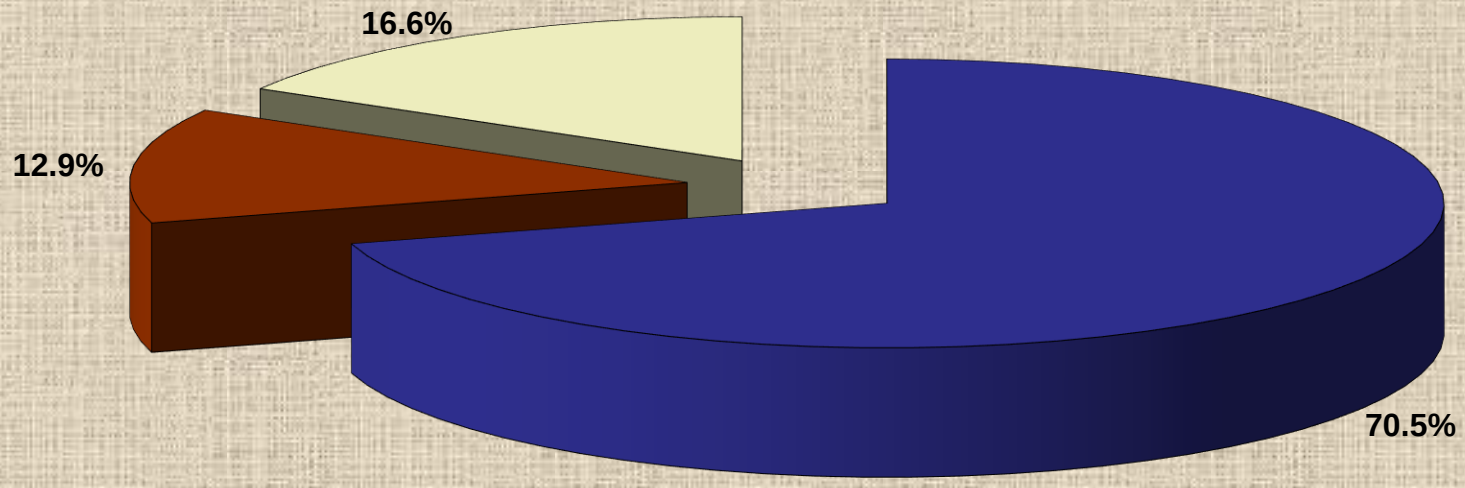
Site: Lake Rippowam **Date: 7/26/18**

Group	Order	Family	Genus	Replicate A	Replicate B	Replicate C	Total/3 (# per mL)	x1000 mL (= 1 L)	Water sampled (L)	# organisms per L
Rotifera	**Ploima**	Brachionidae	*Keratella crassa*	8	11	7	8.67	8667	68.8	126
		Synchaetidae	*Polyarthra remata*	4	3	2	3.00	3000	68.8	44
			Synchaeta oblonga	58	124	134	105.33	105333	68.8	1531
		Trichocercidae	*Trichocerca multicrinis*		3	3	2.00	2000	68.8	29
	Flosculariacea	Conochilidae	*Conochilus unicornis*	5	4	7	5.33	5333	68.8	78
									Total:	**1808**
Cladocera	**Cladocera**	Bodminidae	*Bosmina longirostris*	13	15	13	13.67	13667	68.8	199
		Daphniidae	*Ceriodaphnia lacustris*	7	9	11	9.00	9000	68.8	131
									Total:	**330**
Copepoda	**Cyclopoida**	Cyclopoidae	*Microcyclops rubellus*	8	26	25	19.67	19667	68.8	286
			Cyclopoid nauplius	5	13	11	9.67	9667	68.8	141
									Total:	**427**

Total Organisms per L	Rotifera	%	Cladocera	%	Copepoda	%
2565	1808	70.5%	330	12.9%	427	16.6%

Lake Rippowam
July 26, 2018
Zooplankton Distribution

Total Zooplankton: 2,565 organisms per L



Rotifera Cladocera Copepoda

Zooplankton Count Results

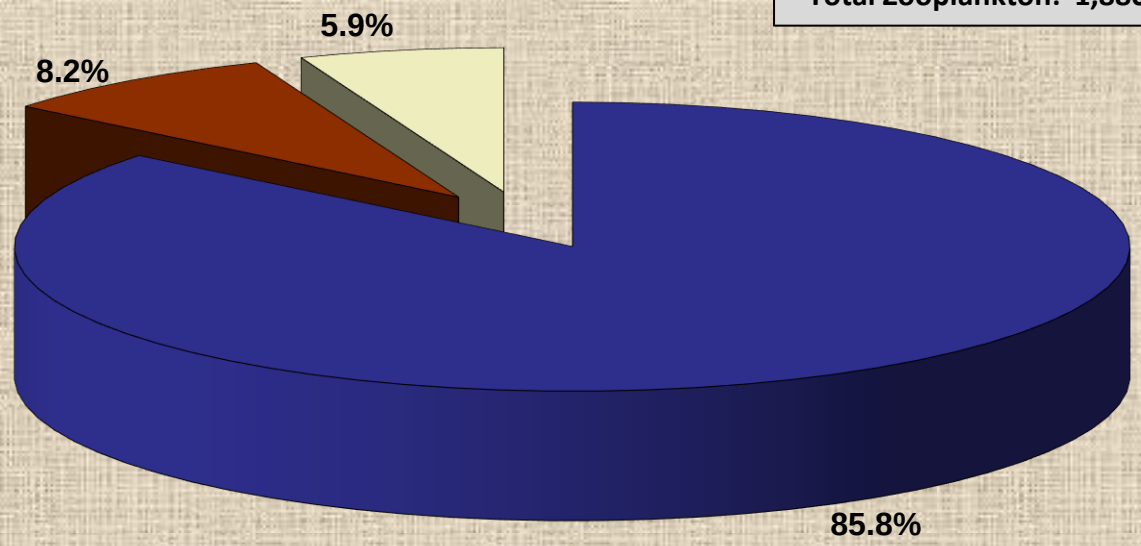
Site: Lake Oscaleta **Date: 7/26/18**

Group	Order	Family	Genus	Replicate A	Replicate B	Replicate C	Total/3 (# per mL)	x1000 mL (= 1 L)	Water sampled (L)	# organisms per L
Rotifera	**Ploima**	Brachionidae	*Keratella crassa*	35	40	43	39.33	39333	68.8	572
			Notholca caudata	17	9	8	11.33	11333	68.8	165
			Kellicottia bostoniensis	20	13	26	19.67	19667	68.8	286
		Synchaetidae	*Polyarthra remata*	35	35	26	32.00	32000	68.8	465
			Synchaeta oblonga	2			0.67	667	68.8	10
		Trichocercidae	*Trichocerca similius*	8	4	11	7.67	7667	68.8	111
	Flosculariacea	Conochilidae	*Conochilus unicornis*	1			0.33	333	68.8	5
									Total:	**1614**
Cladocera	**Cladocera**	Bodminidae	*Bosmina longirostris*	13	12	7	10.67	10667	68.8	155
									Total:	**155**
Copepoda	**Cyclopoida**	Cyclopoidae	*Microcyclops rubellus*	5	4	1	3.33	3333	68.8	48
			Cyclopoid nauplius	7	5	1	4.33	4333	68.8	63
									Total:	**111**

Total Organisms per L	Rotifera	%	Cladocera	%	Copepoda	%
1880	1614	85.8%	155	8.2%	111	5.9%

Lake Oscaleta
July 26, 2018
Zooplankton Distribution

Total Zooplankton: 1,880 organisms per L



Rotifera Cladocera Copepoda

Zooplankton Count Results

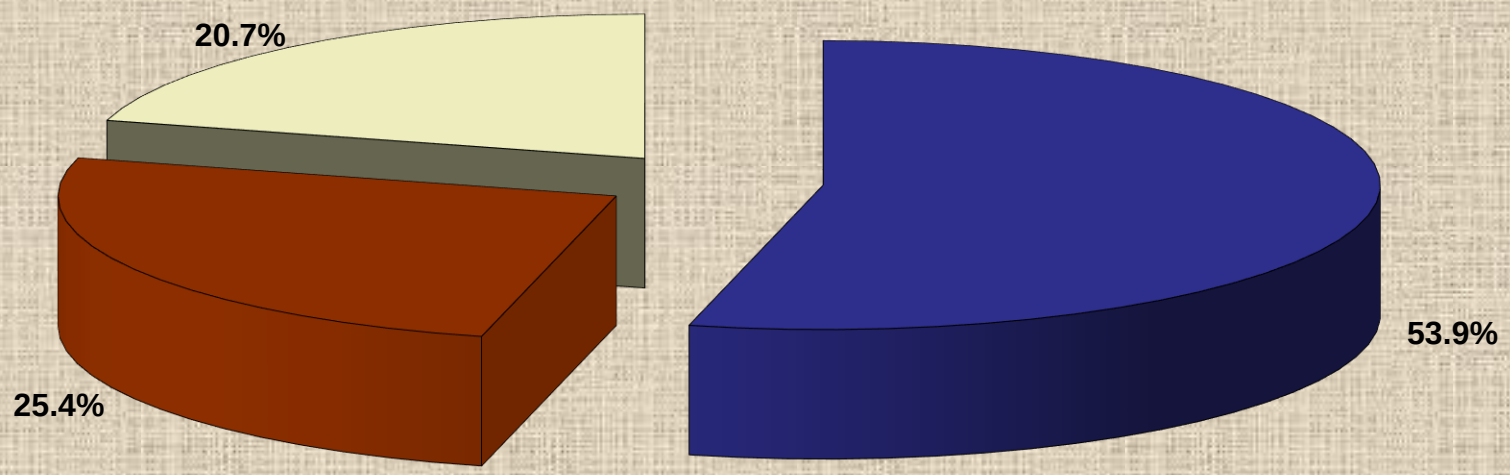
Site: Lake Waccabuc **Date: 7/26/18**

Group	Order	Family	Genus	Replicate A	Replicate B	Replicate C	Total/3 (# per mL)	x1000 mL (= 1 L)	Water sampled (L)	# organisms per L
Rotifera	**Ploima**	Brachionidae	*Keratella crassa*	24	25	16	21.67	21667	68.8	315
			Brachionus angularis	11	13	5	9.67	9667	68.8	141
			Kellicottia bostoniensis	5	2	1	2.67	2667	68.8	39
		Synchaetidae	*Polyarthra remata*	12	14	16	14.00	14000	68.8	203
			Synchaeta oblonga	35	49	37	40.33	40333	68.8	586
		Asplanchnidae	*Asplanchna priodonta*	34	6	7	15.67	15667	68.8	228
		Trichocercidae	*Trichocerca similis*	16	10	15	13.67	13667	68.8	199
			Trichocerca multicrinis	1	3		1.33	1333	68.8	19
	Flosculariacea	Conochilidae	*Conochilus unicornis*	15	8	15	12.67	12667	68.8	184
		Testudinellidae	*Filinia longiseta*	5	5	13	7.67	7667	68.8	111
									Total:	**2025**
Cladocera	**Cladocera**	Bodminidae	*Bosmina longirostris*	36	69	27	44.00	44000	68.8	640
		Daphniidae	*Ceriodaphnia lacustris*	16	30	19	21.67	21667	68.8	315
									Total:	**955**
Copepoda	**Cyclopoida**	Cyclopoidae	*Microcyclops rubellus*	12	23	19	18.00	18000	68.8	262
			Cyclopoid nauplius	41	30	36	35.67	35667	68.8	518
									Total:	**780**

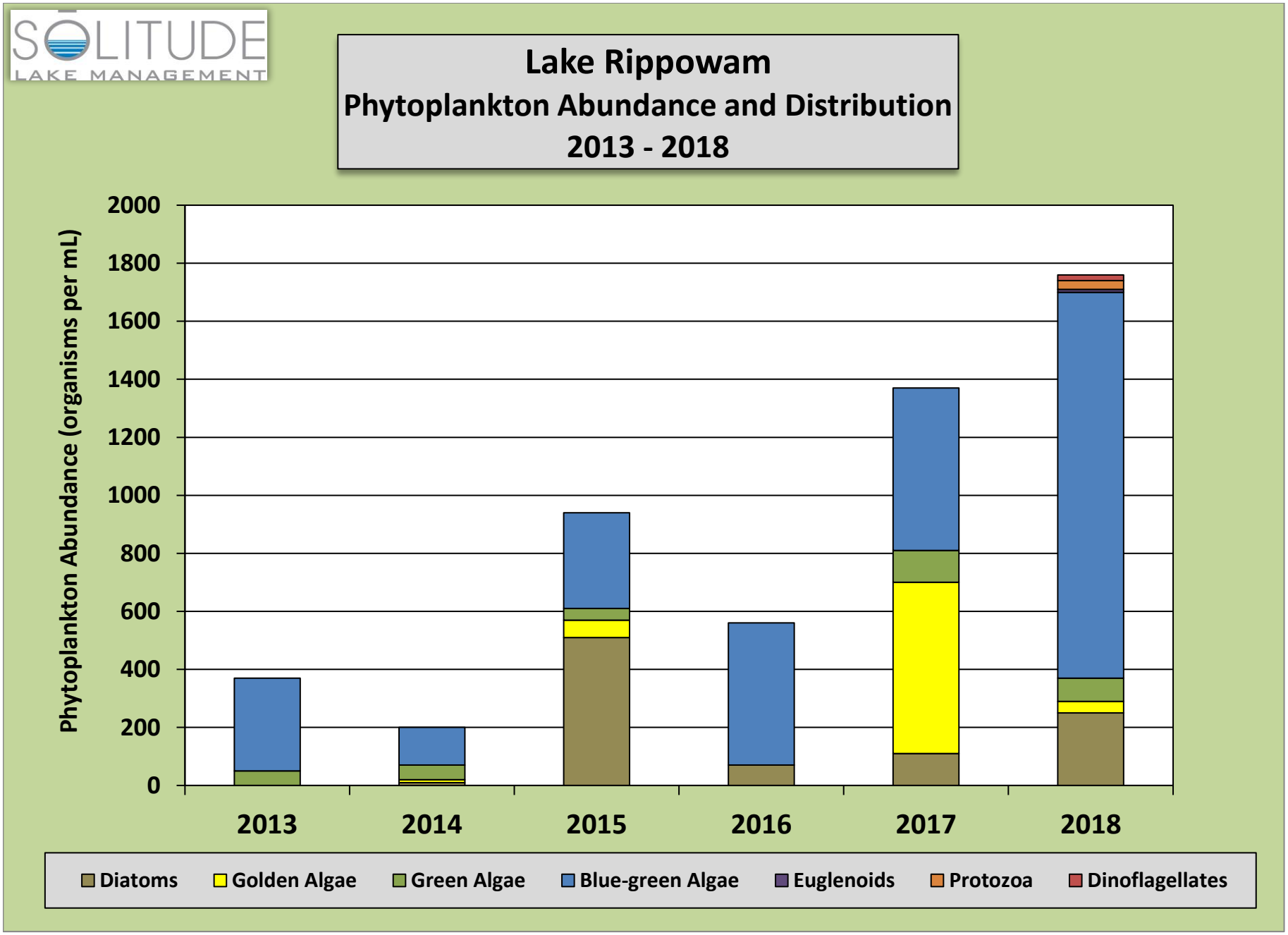
Total Organisms per L	Rotifera	%	Cladocera	%	Copepoda	%
3760	2025	53.9%	955	25.4%	780	20.7%

Lake Waccabuc
July 26, 2018
Zooplankton Distribution

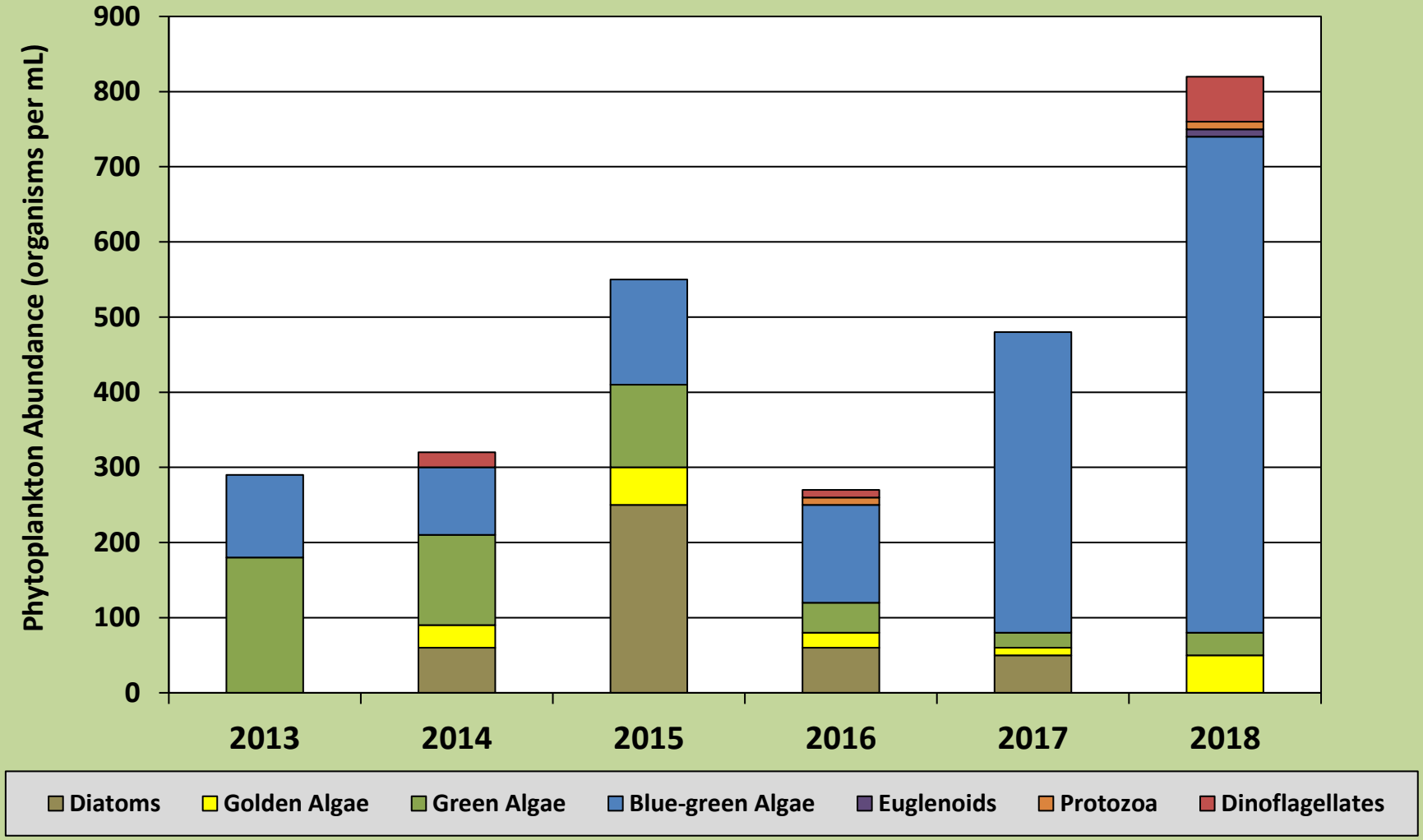
Total Zooplankton: 3,760 organisms per L

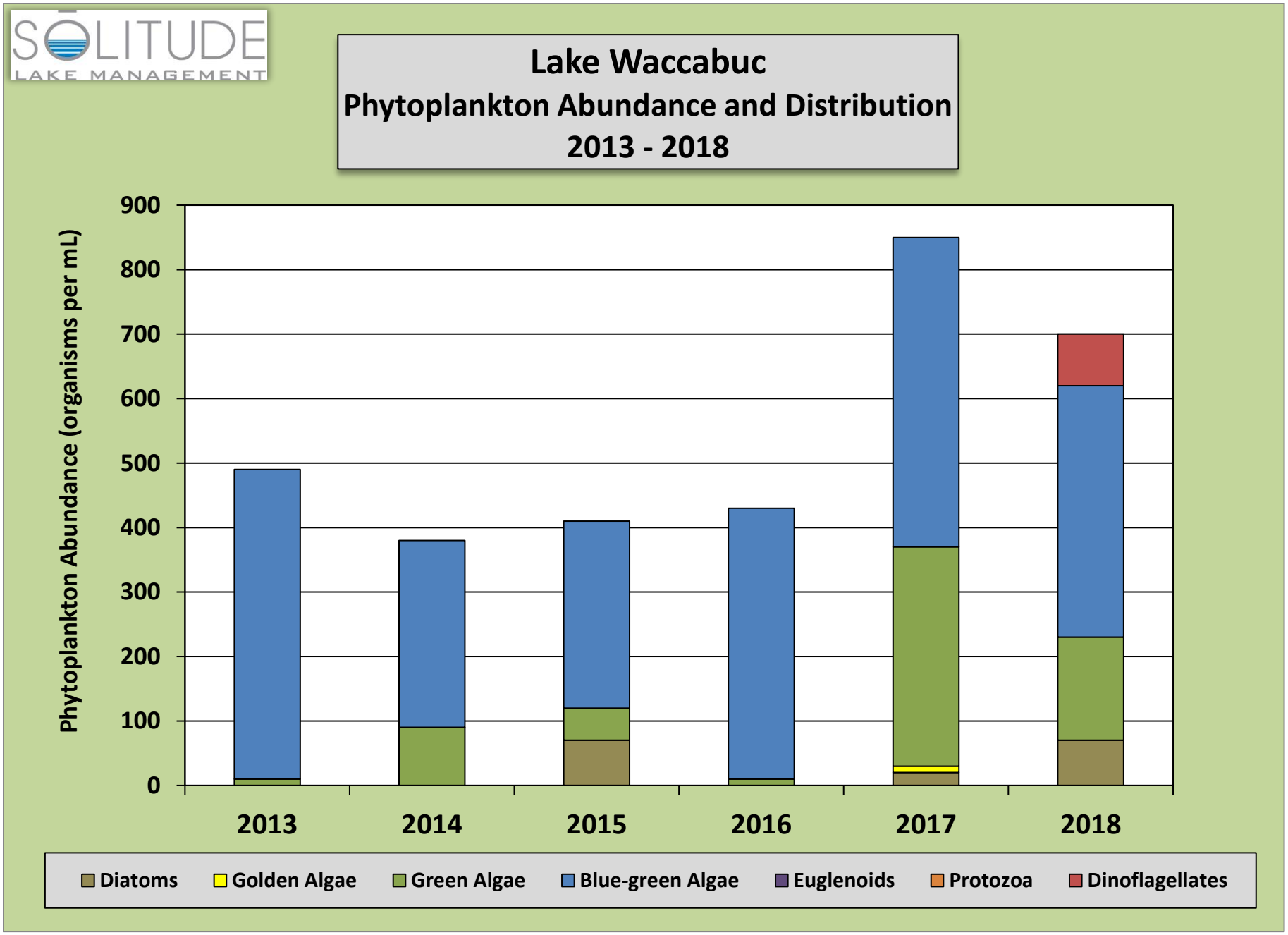


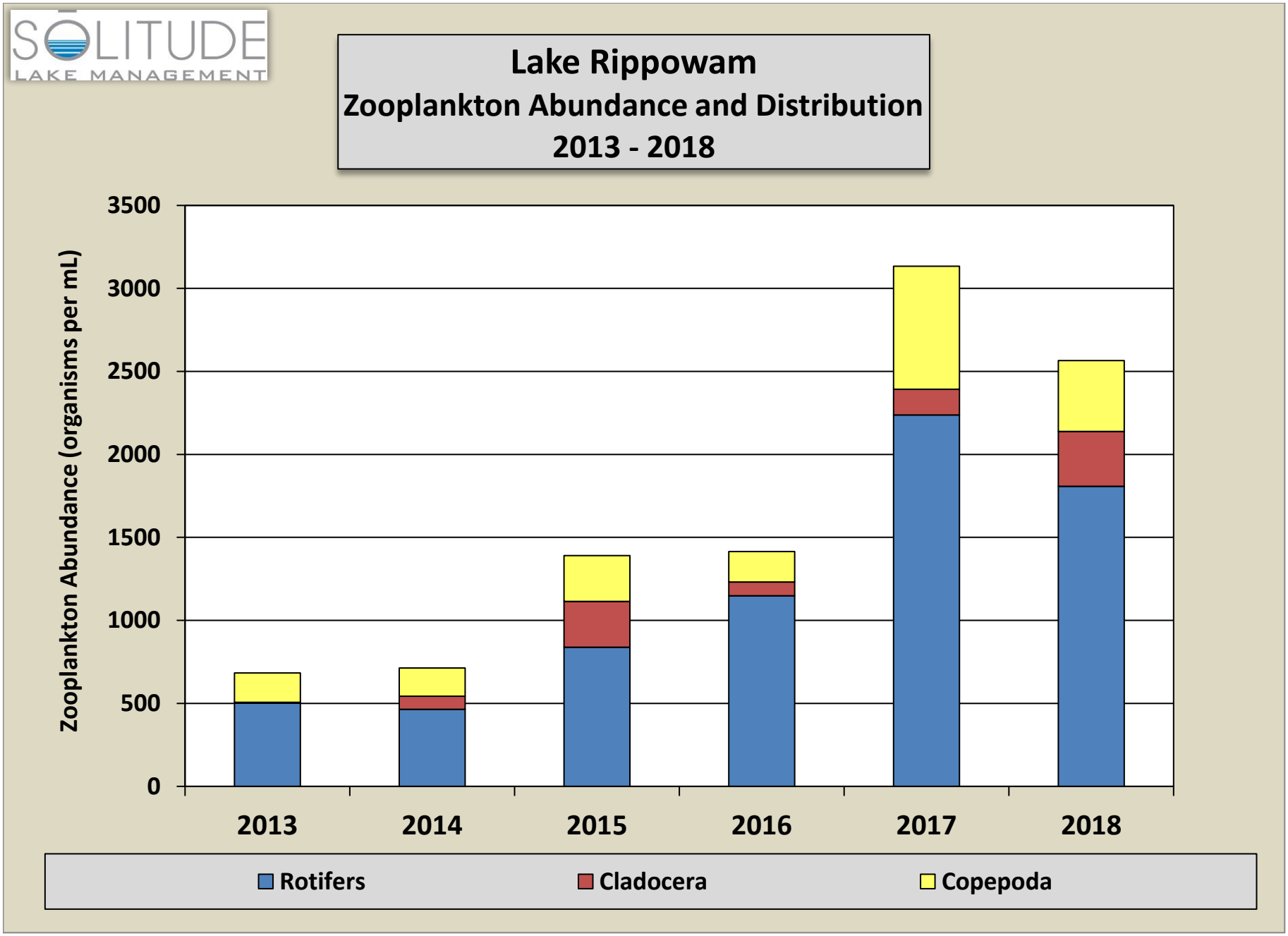
Rotifera Cladocera Copepoda

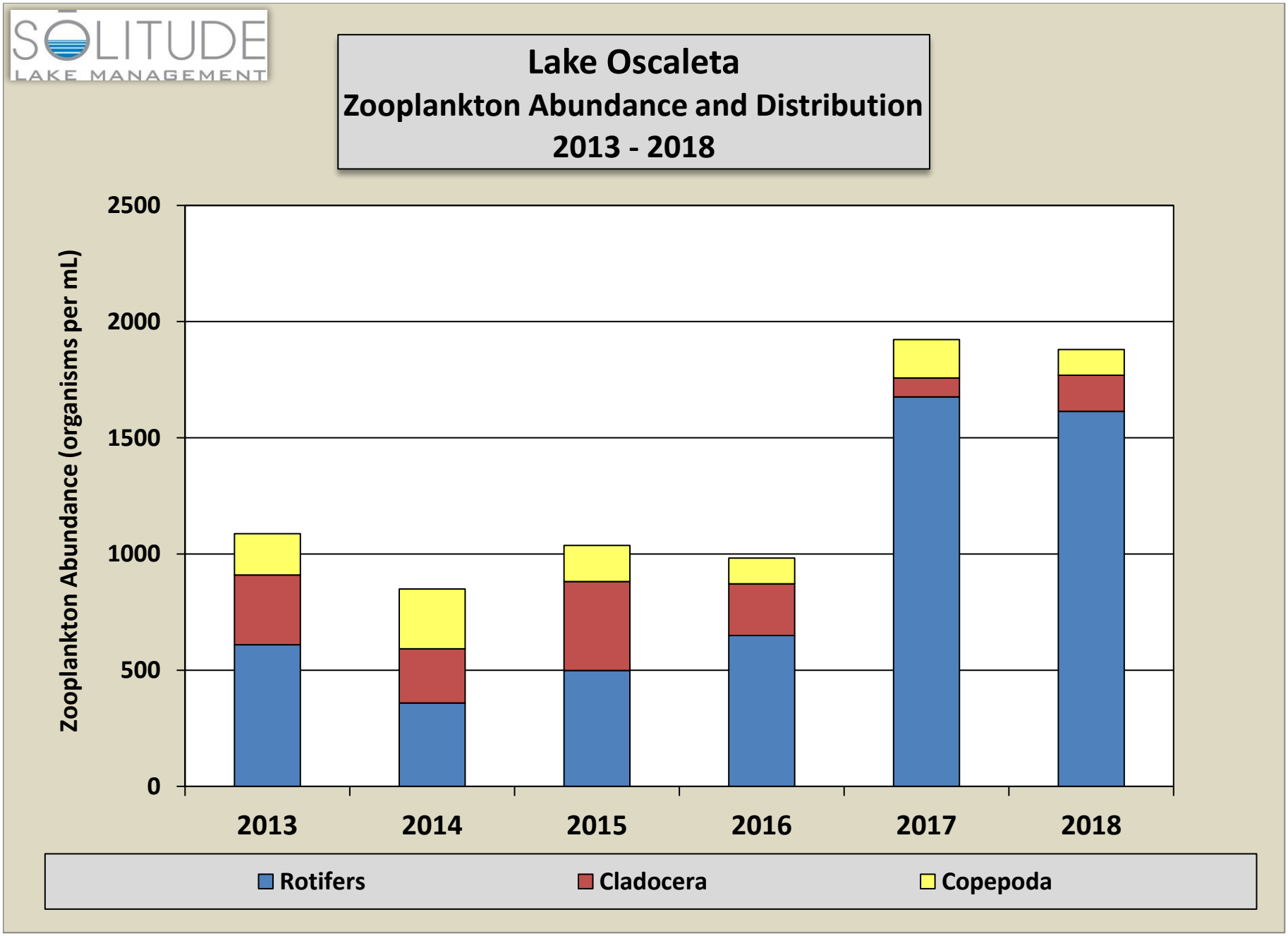

SOLITUDE
LAKE MANAGEMENT
Lake Rippowam
Phytoplankton Abundance and Distribution
2013 - 2018
Phytoplankton Abundance (organisms per mL)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
2013
2014
2015
2016
2017
2018
Diatoms
Golden Algae
Green Algae
Blue-green Algae
Euglenoids
Protozoa
Dinoflagellates

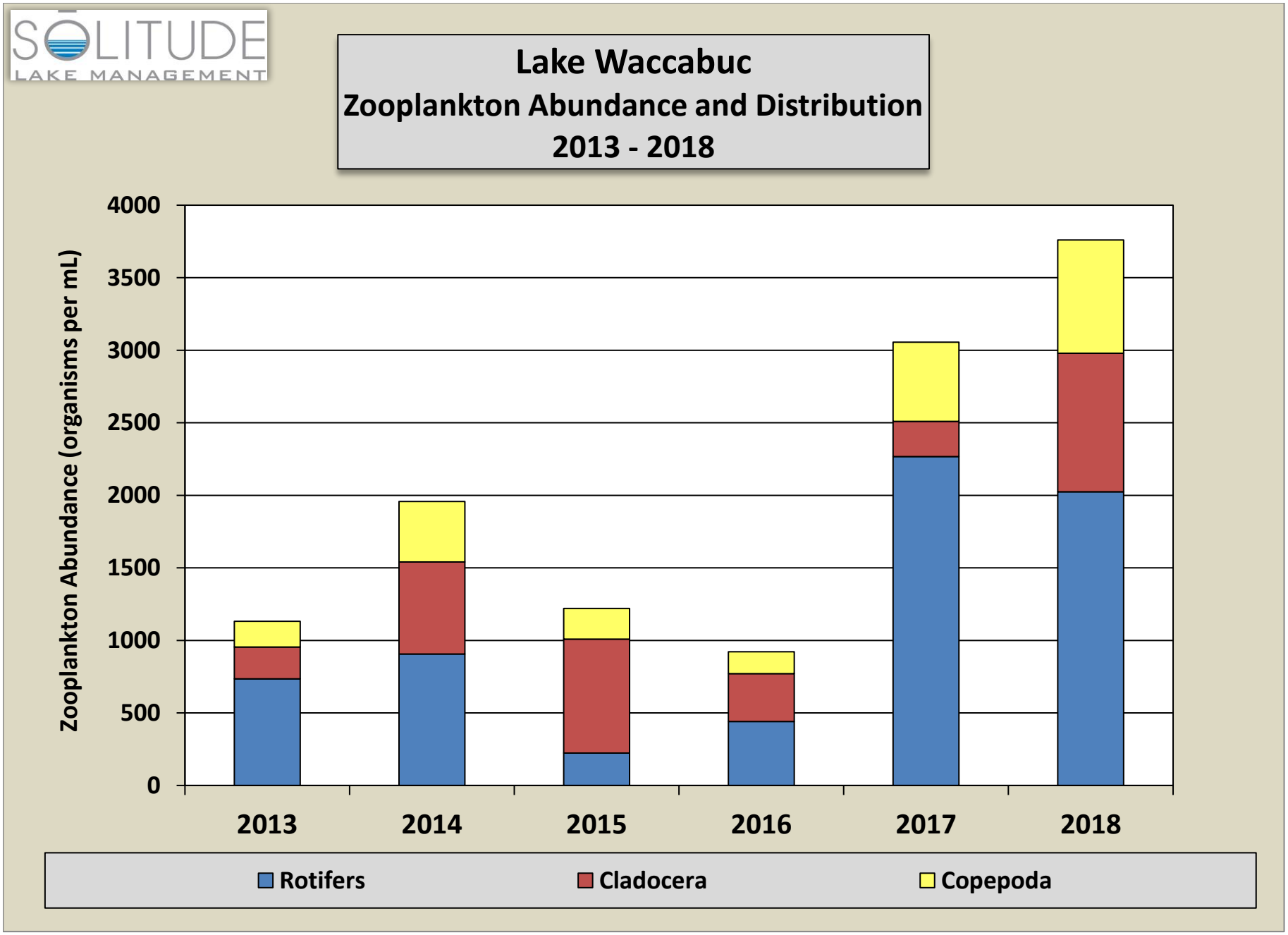
Lake Oscaleta
Phytoplankton Abundance and Distribution
2013 - 2018




SOLITUDE
LAKE MANAGEMENT
Lake Waccabuc
Phytoplankton Abundance and Distribution
2013 - 2018
Phytoplankton Abundance (organisms per mL)
900
800
700
600
500
400
300
200
100
0
2013
2014
2015
2016
2017
2018
Diatoms
Golden Algae
Green Algae
Blue-green Algae
Euglenoids
Protozoa
Dinoflagellates


SOLITUDE
LAKE MANAGEMENT
Lake Rippowam
Zooplankton Abundance and Distribution
2013 - 2018
Zooplankton Abundance (organisms per mL)
3500
3000
2500
2000
1500
1000
500
0
2013
2014
2015
2016
2017
2018
Rotifers
Cladocera
Copepoda


SOLITUDE
LAKE MANAGEMENT
Lake Oscaleta
Zooplankton Abundance and Distribution
2013 - 2018
Zooplankton Abundance (organisms per mL)
2500
2000
1500
1000
500
0
2013
2014
2015
2016
2017
2018
Rotifers
Cladocera
Copepoda


SOLITUDE
LAKE MANAGEMENT
Lake Waccabuc
Zooplankton Abundance and Distribution
2013 - 2018
Zooplankton Abundance (organisms per mL)
4000
3500
3000
2500
2000
1500
1000
500
0
2013
2014
2015
2016
2017
2018
Rotifers
Cladocera
Copepoda

Three Lakes

Date:	7/26/2018
Biologist:	3LC

SOLITUDE LAKE MANAGEMENT

Lake Rippowam

Depth (Meters)	Temp. (ºC)	Dissolved Oxygen (mg/L)
0	26.1	9.00
1	25.8	8.78
1.5	25.7	9.15
2	25.7	8.56
3	25.4	7.34
4	21.0	5.84
4.5	17.4	0.20
5	15.7	0.13
5.5	14.0	0.11

Total Depth (m):	5.7
Secchi (m):	1.85

Lake Oscaleta

Depth (Meters)	Temp. (ºC)	Dissolved Oxygen (mg/L)
0	25.9	8.87
1	25.7	8.90
1.5	25.6	8.84
2	25.6	8.72
3	25.0	7.88
4	21.2	8.84
5	15.5	3.72
6	11.7	0.24
7	9.9	0.15
8	9.0	0.12
9	8.4	0.11
10	8.0	0.10
10.5	7.8	0.10

Total Depth (m):	10.7
Secchi (m):	3.00

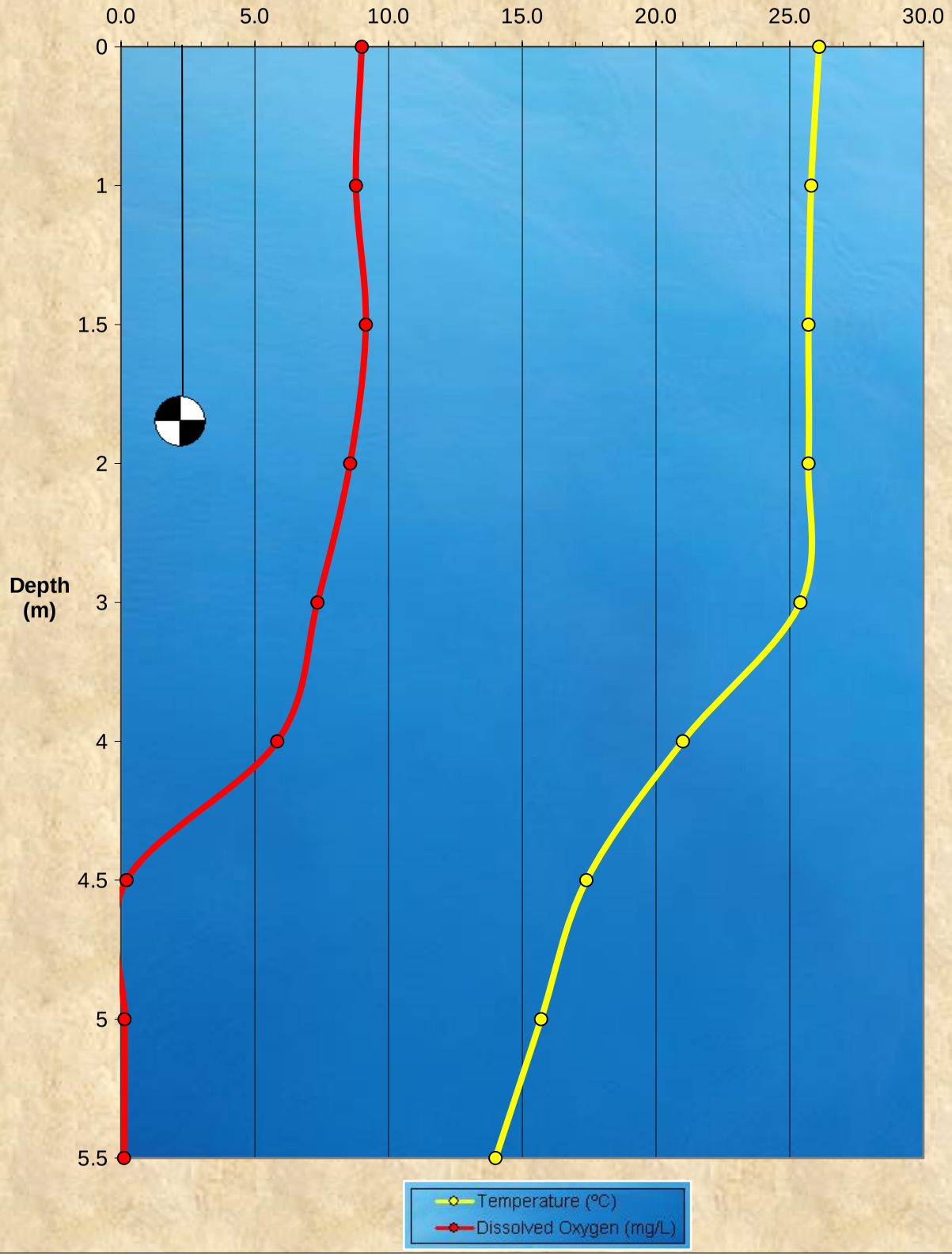
Lake Waccabuc

Depth (Meters)	Temp. (ºC)	Dissolved Oxygen (mg/L)
0	25.8	9.15
1	25.8	9.17
1.5	25.8	9.00
2	25.7	8.93
3	25.4	7.23
4	23.2	1.82
5	17.4	0.19
6	13.8	0.12
7	11.0	0.09
8	9.8	0.08
9	8.9	0.07
10	8.2	0.08
11	7.7	0.07
12	7.5	0.07
13	7.4	0.07
14	7.2	0.07

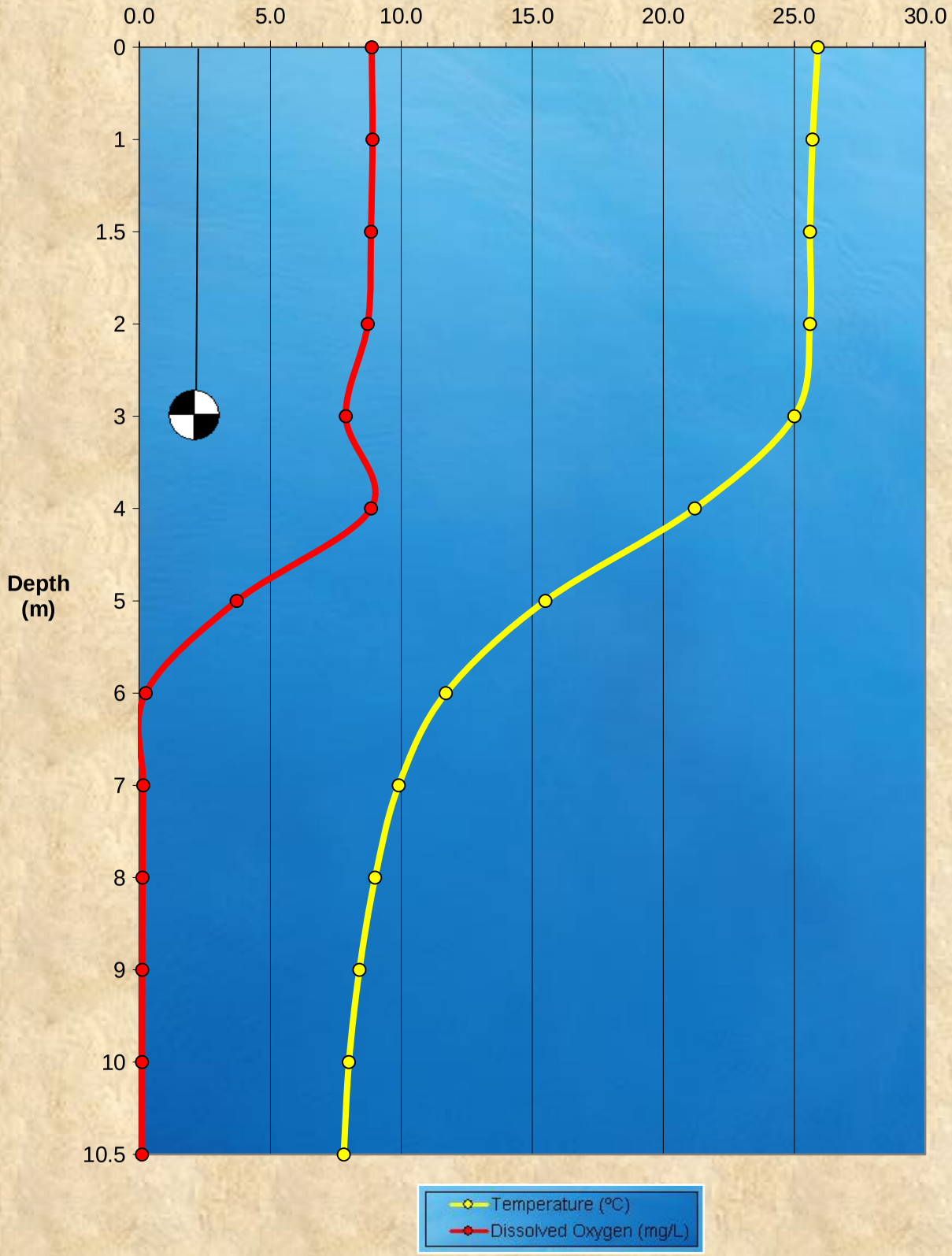
Total Depth (m):	14.2
Secchi (m):	1.55

Notes:

Three Lakes Profile
Lake Rippowam
July 26, 2018



Three Lakes Profile
Lake Oscaleta
July 26, 2018



Three Lakes Profile
Lake Waccabuc
July 26, 2018