Phytoplankton and Zooplankton Report

2017 Summary Report – Lake Waccabuc, Lake Rippowam, and Lake Oscaleta

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Introduction

The Three Lakes Council (3LC) continues an outstanding water quality monitoring program to support the management of 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 applied as a resource to support the lakes for recreational uses and aesthetic value. SOLitude Lake Management is pleased to provide services to the 3LC again in 2017. Phytoplankton and zooplankton samples (one sample at each lake) were collected on 08/02/17.

Phytoplankton Monitoring

Methods

Phytoplankton samples were collected once each season in 2017. The sampling date in 2017 aligned with the initial sampling date in 2011 (when three samples were collected throughout the season), and was similar to the dates conducted in 2013, 2014, 2015, and 2016 which will allow for comparison with the previous data. Sample sites were consistent with the sites utilized historically and were established at the regular CSLAP sampling stations on all three lakes. 3LC volunteers collected a single sample from each basin on each date and delivered them to Solitude Lake Management staff for laboratory analysis.

During each water quality sampling event, phytoplankton samples were collected at a depth of 1.5 meters at each station using clean 1000 ml HDPE or Nalgene plastic bottles. Immediately following collection, the bottles were placed in a dark cooler stocked with ample blue 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 then 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 full-size pie graphs are included in the Appendix of this report. Further descriptions of the phytoplankton groups observed can be found in the Appendix of this report.

2017 Phytoplankton Results

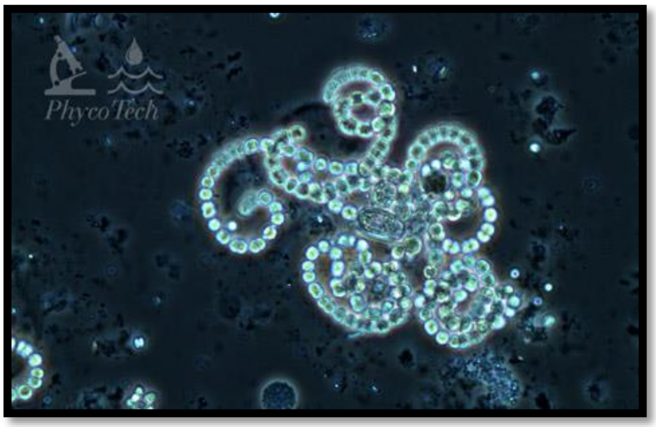
Phytoplankton Group	Waccabuc	Rippowam	Oscaleta
Diatoms	20	110	50
Golden Algae	10	**590**	10
Green Algae	340	110	20
Blue-green Algae	**480**	560	**400**
Euglenoids			
Protozoa			
Dinoflagellates			
Total Phytoplankton	**850**	**1,370**	**480**

Table 1: 2017 Phytoplankton Summary at Three Lakes

In 2017, temperature and dissolved oxygen profiles were measured at each lake station. Data was collected at one-meter intervals with extra measurements taken at the 1.5 meter depth coinciding with the depth of the phytoplankton collection. At Lake Waccabuc, dissolved oxygen readings were slightly elevated as depth increased to 3.0 meters, representing about 110% saturation. Then from 4.0 meters to 6.0 meters, we observed a decrease in dissolved oxygen. At 7.0 meters, dissolved oxygen plummeted, and was anoxic. This is a typical curve for this basin. At Lake Oscaleta, we observed ideal conditions at the surface with slightly elevated readings from 1.5 m to 2.5 m. From 3.5 m to 4.5 m we observed elevated dissolved oxygen readings, which could indicate a minor phytoplankton bloom at this depth. Dissolved oxygen readings significantly decreased at 5.0 meters. At 6.0 meters we observed a rapid decline, with anoxic conditions trending until 10.5 meters revealing 1.0% saturation. At Lake Rippowam, dissolved oxygen was slightly elevated at the surface down to 3.0 meters reading at ranging from 111.5% to 96.0% saturation. At the 4.0-meter depth, we saw a decrease in dissolved oxygen (from 8.00 mg/L to 0.96 mg/L). All three of these curves are typical for mid-summer in these basin’s.

Water clarity varied throughout the three basins on this date. At Lake Oscaleta and Lake Rippowam, we observed the highest water clarity readings (measured at 2.5 meters), which is considered ideal for mid-summer. Lake Oscaleta traditionally has the best water clarity, likely attributed to the well-established submersed aquatic vegetation community and increased littoral zone percentage (compared to the other two basins). At Lake Waccabuc, water clarity was 2.95 meters, which is excellent for mid-summer. Biologists observed an abundance of plant growth this year, which may attribute a reduction in algae within the water column. However, field notes indicate there was a light green tint to the water at Lake Waccabuc.

At Lake Waccabuc, the phytoplankton abundance was considered to be moderate at 830 organisms per mL with moderate (eight different genera) sample diversity. The assemblage on this date was dominated by nuisance blue-green algae, although the moderate overall abundance translated to be non-problematic conditions at the time of the sampling. This was likely a function of open water sampling (where the CSLAP station is established). The blue-green algae present was a mixture of *Anabaena* with various genera of green algae, with traces of golden algae and diatoms rounding out the assemblage on this sampling date.



At Lake Oscaleta, the overall phytoplankton abundance was considered low to moderate at 540 organisms per mL. Sample diversity was moderate with seven different genera observed, from all groups except for Euglenoids and dinoflagellates. The assemblage was dominated by blue green algae (two genera; *Anabaena* and *Aphanizomenon*) on this date, accounting for 83.33% of the total phytoplankton. Trace amounts of diatoms, specifically *Synedra*, was observed on this sampling date. Green algae (two genera; *Eudorina* and *Scenedesmus*) were observed at low enough numbers to be considered non-problematic. One genera of golden algae, *Mallomonas,* was also observed at low abundances. Water clarity was excellent on this date, especially for late July.

At Lake Rippowam, overall phytoplankton abundance was considered to be high with 1,310 organisms per mL. This was the highest phytoplankton abundance of the three lakes in 2017. This was the only site that was dominated by golden algae, specifically *Mallomonas* (pictured). However, the nuisance blue-green algae, *Aphanizomenon* and *Anabaena*, made up a significant part of the assemblage at 560 organisms per mL (or 40.87% of the total phytoplankton). Green algae (8.02%) and diatoms (8.02%) were also observed on this date. Water clarity was measured at 2.5 meters, which is considered good.

Phytoplankton Discussion 2013-2017

The 2017 season was the eighth season Solitude Lake Management (formerly Allied Biological, Inc.) monitored phytoplankton at Lake Waccabuc, Lake Oscaleta and Lake Rippowam. The three graphs below, one for each basin, compare the phytoplankton results from the 2013 through 2017 sampling years. 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.

At Lake Waccabuc, consistent overall phytoplankton abundance was observed during all five sampling years. In both 2013 and 2016, blue-green algae were the dominant phytoplankton group observed, counting for nearly 100% of the community. In 2017 blue-green algae accounted for 57% of the assemblage. This supports visual reports of blue-green algae within the water column observed during the summer months in this basin. A presence of green algae was significant this year (40%), in comparison to previous sampling years. It should also be noted that all samples were collected via sampler at 1.5 meters below the surface of the water. Samples collected at this depth could be altering the blue-green algae abundance results. Many blue-green algae possess other methods and strategies, such as gas vesicles, to out competing desirable algal groups. Blue-green algae that may be collected right at the surface (or accumulating in windswept coves or shorelines) could lead to higher results.

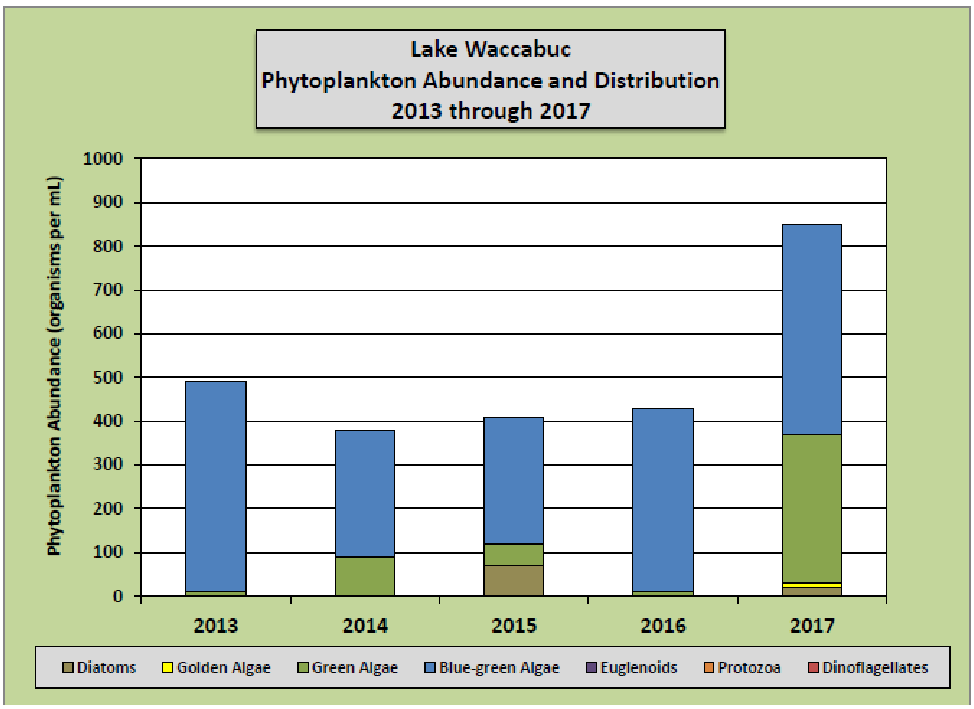


Figure 1: 2013-2017 Lake Waccabuc Phytoplankton

At Lake Oscaleta, overall phytoplankton counts were around 300 organisms per mL in 2013 and 2014. In 2015, overall phytoplankton abundance nearly doubled, peaking at 550 organisms per mL. However, in 2016, the overall abundance decreased to 270 organisms per mL. In 2017, an increase in abundance was observed at 480 organisms per mL. Group dominance varied throughout the four years examined, indicating a changing system. In 2013 and 2014, green algae dominated the community, while in 2015 a shift in the dominance of diatoms was observed. An increase in blue green algae was observed in 2015 and coincides with 2016, which the assemblage was clearly dominated with blue green algae. During all five years, significant blue-green algae were observed. In 2017 this pattern continued dominance of blue-green algae. Also, in 2014, 2015, and 2016 an increase in group diversity was observed. Of the three lakes, Lake Oscaleta has the highest group diversity. Trace amounts of green algae, diatoms, and golden algae were also observed in 2017.

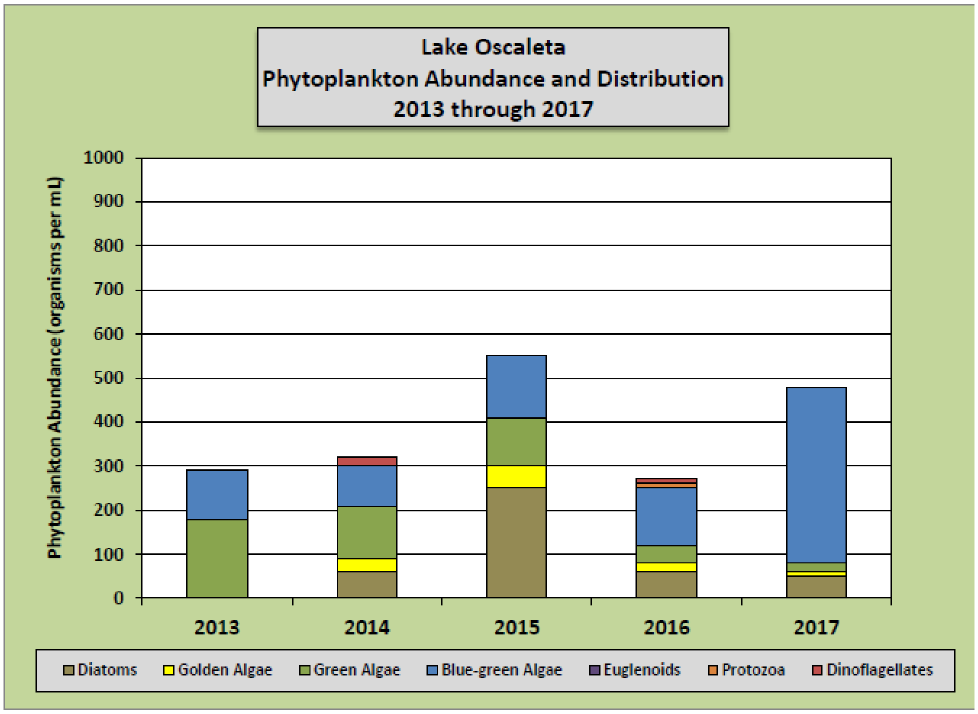


Figure 2: 2013 through 2017 Lake Oscaleta Phytoplankton

Finally, at Lake Rippowam, overall phytoplankton abundance was considered low in 2013 and 2014. In 2013, phytoplankton abundance was just under 400 organisms per mL, while in 2014, overall phytoplankton was 200 mg/L. Both of these years saw nuisance blue-green algae being the dominant group. In 2015, we observed a significant increase in overall phytoplankton abundance, to 940 organisms per mL. This is considered moderate abundance and represents about a three-fold increase from 2013, and over a four-fold increase from 2014. In 2013 and 2014, nuisance blue-green algae dominated the phytoplankton community; In 2015, the overall phytoplankton community was dominated by diatoms, similar to data observed at Lake Oscaleta within the same year. We have seen consistently higher phytoplankton abundances in this basin over the years and is likely attributed to the reduced littoral zone and associated aquatic plant growth. In 2016, blue green algae continued to dominate the assemblage. In 2017, golden algae dominated the assemblage by 43%, however, blue-green algae accounted for nearly 40% of the assemblage.

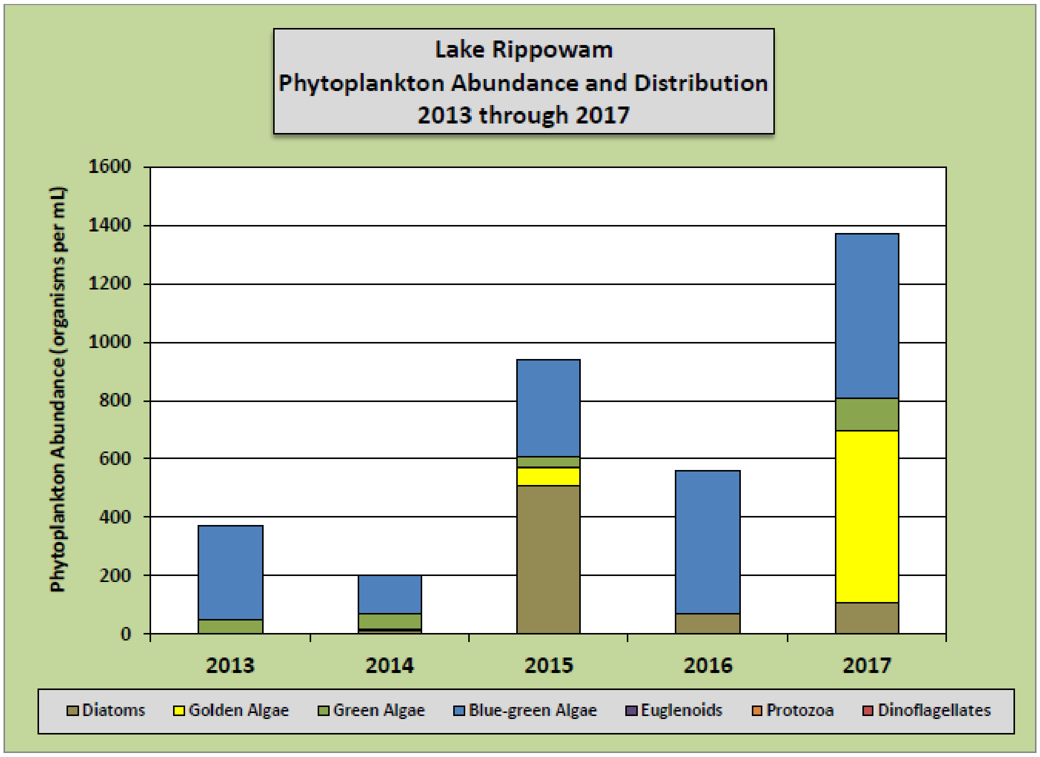


Figure 3: 2013 through 2017 Lake Rippowam Phytoplankton

Zooplankton Monitoring

Methods

Zooplankton samples were collected, by the client, with an 80 um 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 1000 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 SLM's laboratory, the samples were stored in a dark refrigerator until the samples were 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 three replicate counts. The counts were then averaged, and back-calculated to achieve an organism per liter density. The zooplankton count data sheets are included in the Appendix of this report. Also, included in the Appendix are pie charts depicting the individual lake zooplankton group distribution.

2017 Zooplankton Results

In 2017 zooplankton samples were collected in conjunction with phytoplankton samples and water quality monitoring. Samples were collected by 3LC, preserved in the field and returned to Solitude Lake Management for identification and enumeration. The 2017 results are summarized in Table 2, below. A zooplankton primer appears in the appendix of this report.

Table 2: 2017 Zooplankton Summary at Three Lakes

Zooplankton Group	Waccabuc	Rippowam	Oscaleta
Rotifers	**2,267**	**2,240**	**1,677**
Cladocera	243	155	83
Copepoda	547	741	165
Total Zooplankton	3,057	3,136	1,925

At Lake Waccabuc in 2017, the total zooplankton density was considered high with 3,057 organisms per liter (org/L). In comparison to last three years of data, results indicated this was the highest abundance of total zooplankton. Sample diversity was moderate to high with several different species noted. Typically, in this basin, rotifers are the most common zooplankton group observed. In 2017, the zooplankton community was again dominated by rotifers, accounting for 74.2% of the total zooplankton. High overall abundance rotifers could explain a continuing trend of reduced phytoplankton grazing. The dominant species observed at Lake Waccabuc was *Synchaeta oblonga*. Two species (*Cerodaphnia lacustris* and *Bosmina longirostris*) of Cladocerca were also observed. Most copepods observed were in naupilar stages of Cyclopoids (predators), but there was an abundance of adult grazers *Microcyclops rubellus*.

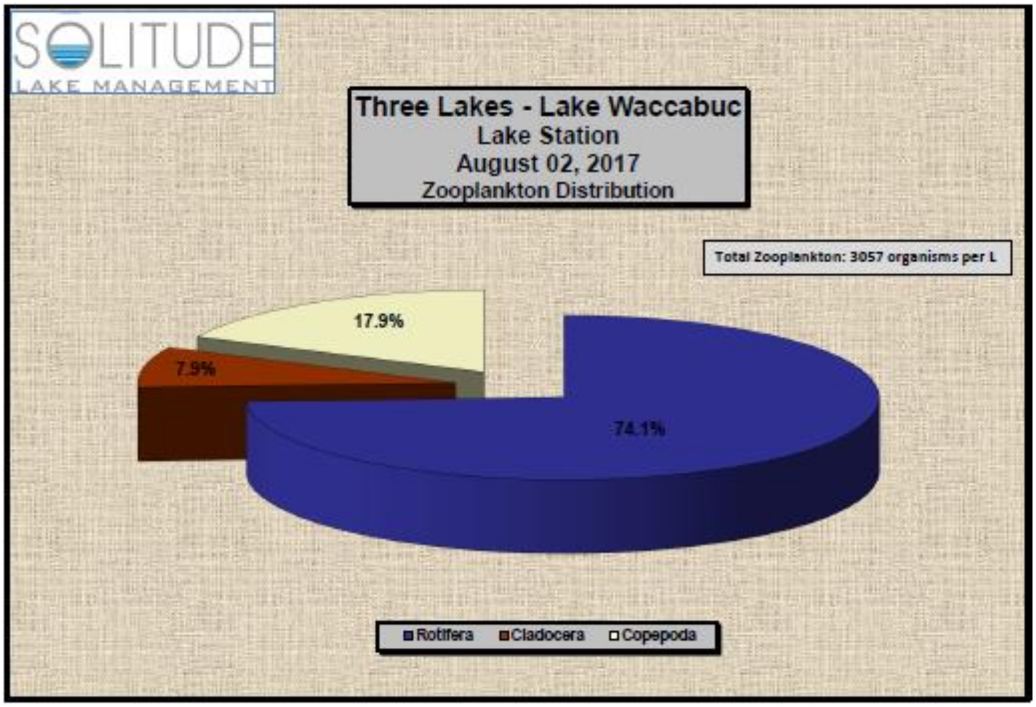


Figure 4: 2017 Lake Waccabuc Zooplankton

The zooplankton abundance at Lake Oscaleta was considered high in 2017, with 1,925 org/L. The lowest distribution of zooplankton was observed in 2014, while 2016 resulted in the second lowest distribution of the four years and 2017 accounting for the highest distribution. Sample diversity was high at this basin, with 14 different genera observed. Rotifers were the dominant group represented, accounting for nearly 87.2% of the assemblage with ten different genera observed. The dominant species was the generalist-feeder, *Synchaeta oblonga*. Most of the remaining rotifers observed were predator-feeders. A decrease of cladocera was observed in comparison to 2016, from 22.7% down to 4.3% in 2017. Copepods rounded out the zooplankton community with 8.3%, comprised a mixture of both naupii and adult copepods.

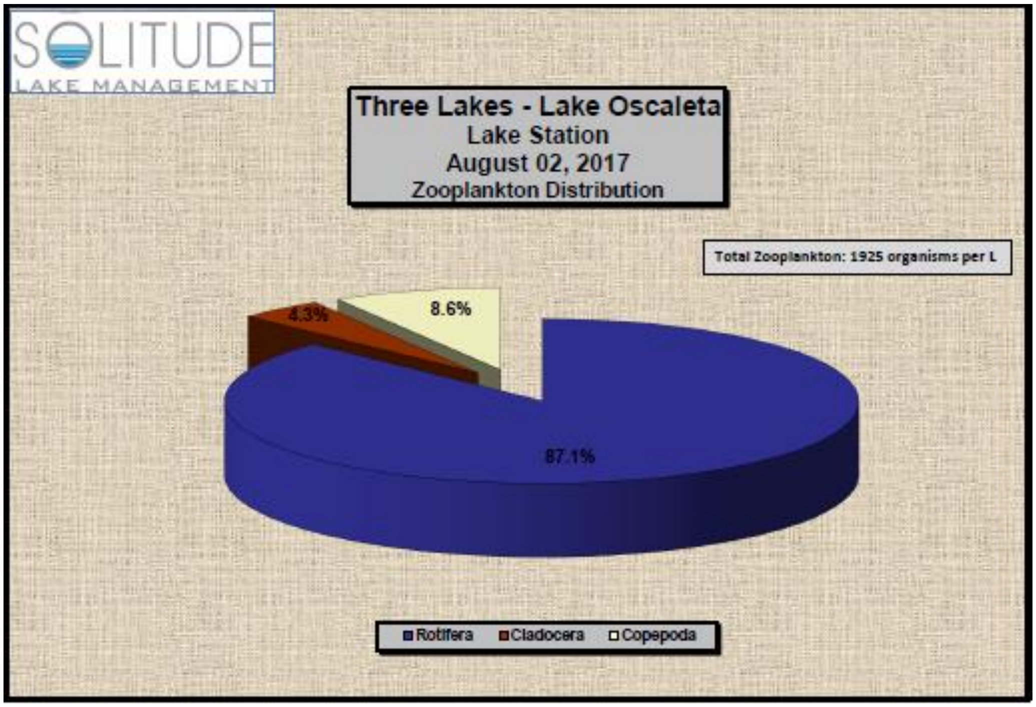


Figure 5: 2017 Lake Oscaleta Zooplankton

Lake Rippowam had the highest distribution of the three basins with 3,136 org/L observed, which is considered high, as shown in Figure 6. This was the highest abundance of the Three Lakes in 2017 but had moderate to high sample diversity (12 genera). Rotifers were the dominant group, which is typical for this basin over the years. Rotifers accounted for just over 71.4% of the total zooplankton, with eight different genera observed. *Synchaeta oblonga* was the most common rotifer observed, a generalist feeder, typically observed in the other basins as well. Cladocera accounted for 4.9% of the assemblage, and copepods for the remaining 23.6% of the zooplankton community. The cladocera were a mixture of *Ceriodaphnia* and *Bosmina* species observed in the other two basins. A mixture of both naplii and adult copepods were observed.

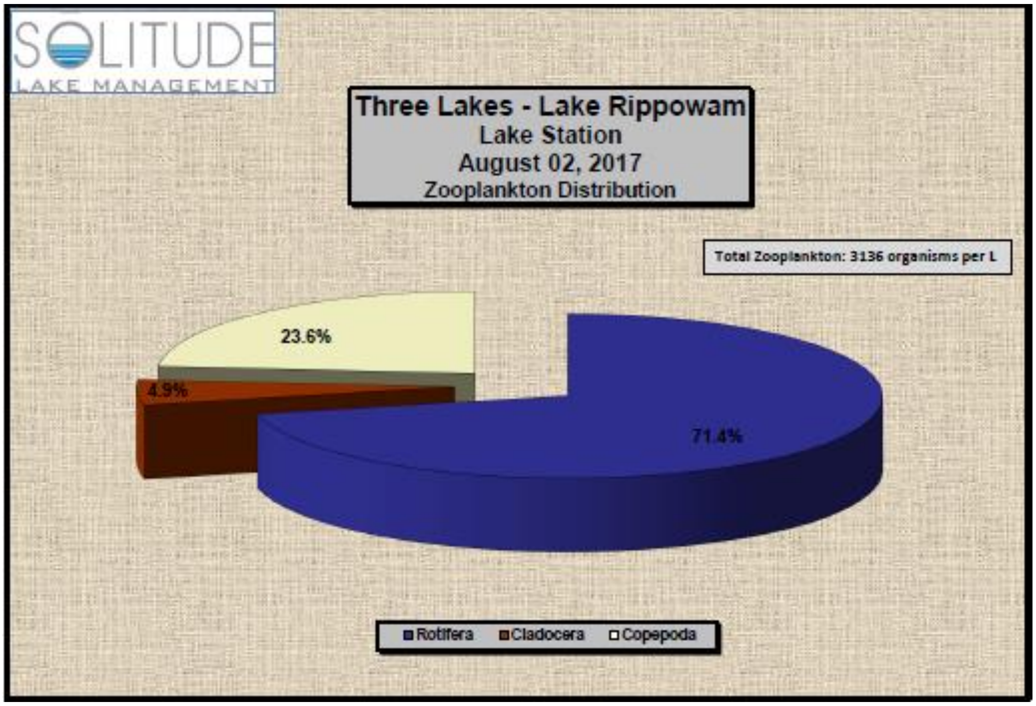


Figure 6: 2017 Lake Rippowam Zooplankton

Zooplankton Discussion 2013-2017

At Lake Waccabuc, in 2013 and 2014, rotifers were the dominant zooplankton group observed. But in 2015, Cladocera were the dominant group, which is highly desirable since these larger bodied organisms are much more efficient phytoplankton grazers compared to rotifers and adult copepods. In 2016, the abundance of Cladocera decreased and rotifers became dominate again, similar data in comparison to previous seasons. In 2017, the community continued to be dominated by rotifers. Copepods were the second most abundant group of zooplankton observed this past summer. 2017's data revealed the overall zooplankton counts were at its highest (3,057 organisms per Liter), similar to 2014, which was nearly 2,000 organisms per Liter.

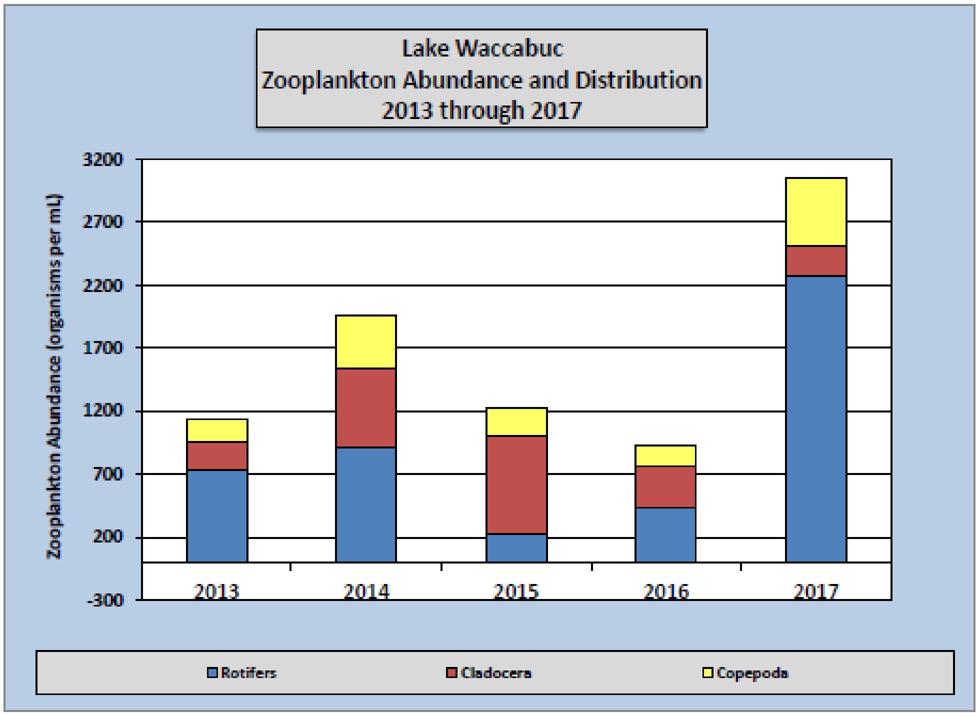


Figure 7: 2013 through 2017 Lake Waccabuc Zooplankton

At Lake Oscaleta, we observed a very similar overall abundance from 2013 through 2017. Rotifers continued to dominate the assemblage in 2017 and we continue to observe a mixture of groups within the total distribution. Cladocera were the second most abundant group at Lake Oscaleta, which has been fairly consistent throughout the years. This likely indicates a more stable environment for this trophic group. The abundance of submersed aquatic plants could be providing suitable zooplankton refuges, encouraging the desirable diversification of zooplankton groups.

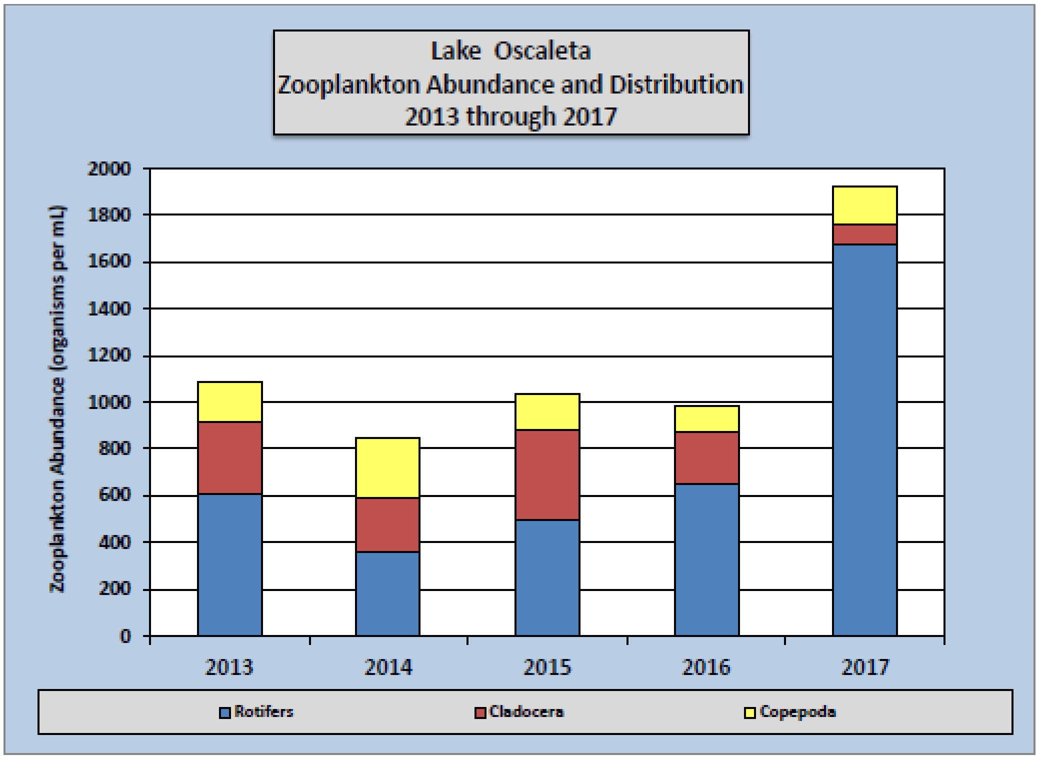


Figure 8: 2013 through 2017 Lake Oscaleta Zooplankton

At Lake Rippowam, we observed low overall zooplankton abundance in 2013 and 2014. However, in 2015 we would consider the overall abundance more like moderate-high, which occurred again in 2016. Rotifers continued to dominate the assemblage in this basin throughout all five seasons. Cladocera tend to struggle in this basin, typically being the lowest group abundance, and in the case of 2013, were nearly absent. Cladocera abundance was observed to be highest out of all the seasons (276 organisms per Liter) in 2015 but decreased in 2016 to 83 organisms per Liter. In 2017, rotifers (71.4%) and cladocera (4.9%) doubled, except for copepods which increased but did not double (23.6%). In Lake Rippowam, overall total zooplankton abundance continues to increase with each season, trending in a positive direction.

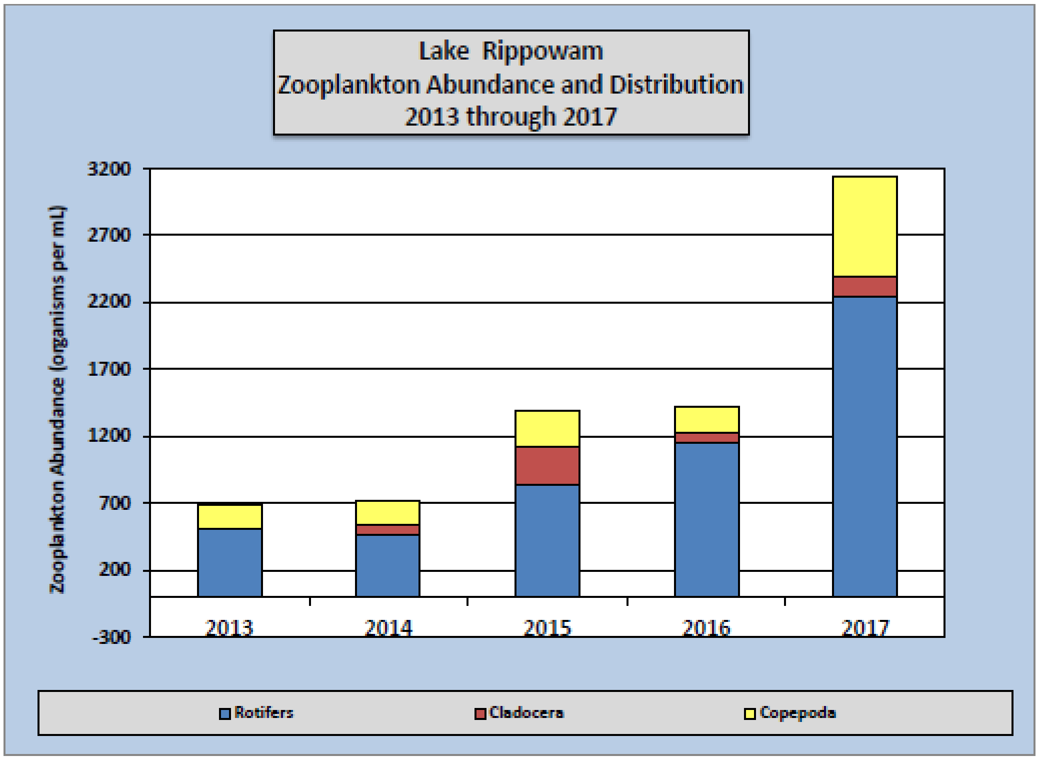


Figure 9: 2013 through 2017 Lake Rippowam Zooplankton

Recommendations

The Three lakes Council has now compiled five years'+ worth of zooplankton and phytoplankton data for all three lakes, 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 2018 season. Although sampling throughout the growing season would be ideal, at least using the same format applied in 2013 through 2017, a single sample should be collected in mid-July.

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. However, we still lack baseline fishery data at any of the Three Lakes, and arguably this is the most important recreational resource for the residents. This may provide some insight upon the fluctuating zooplankton populations within some of the basins. We strongly recommend a scientific fish population survey, at least in one basin, for 2018. This would allow us to evaluate the community structure, along with providing additional management recommendations. For budget reasons, we could even rotate the basin sampled every three years. Following the collection of one set of data, detailed, scientifically-sound fishery management techniques would be recommended.

Since 2008, Solitude Lake Management (as Allied Biological from 2008 through 2015) has been actively collecting data pertaining to Three Lakes. A compilation of the data collected over the years may serve the Council or volunteers, best in a summary report that can be referenced to in one centralized resource in the future. This data should be utilized to dictate the required management of the lakes for the benefit of the residents.

APPENDIX A: Phytoplankton

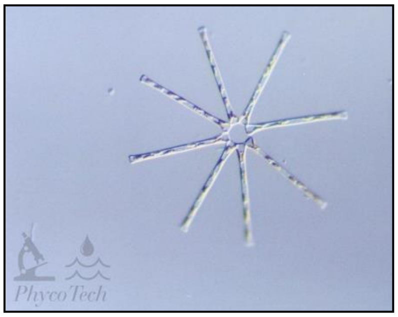
A Phytoplankton Primer

Lakes typically contain three broad categories of phytoplankton (also sometimes referred to as algae). These include filamentous phytoplankton, macroscopic multi-branched phytoplankton (which appear similar to submersed plants), and unicellular phytoplankton.

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.

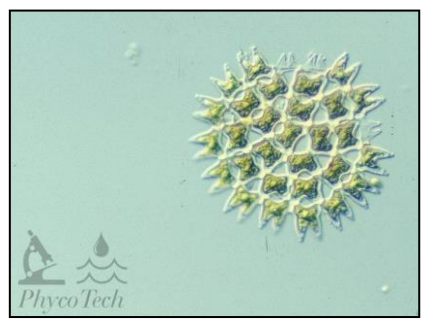
Unicellular phytoplankton are typically microscopic, and consist of individual cells or colonies of cells suspended in the water column. At high enough densities (often called a bloom), they can impart a green or brown (and sometimes, even red) tint to the water column. Unicellular phytoplankton belongs 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. The Appendix of this report contains a picture gallery of all of the phytoplankton observed in 2010 at the Three Lakes.



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).

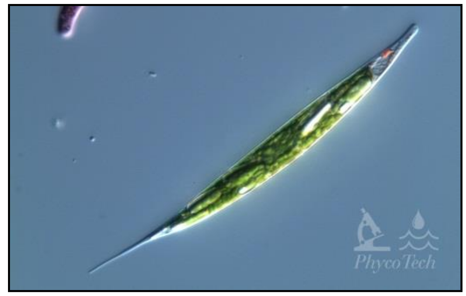
Golden Algae are typically yellow or light brown in color. Cell size is usually small oval shaped with a partially empty area, but several genera create colonies of smaller cells. Most have two flagella, and some type of scales or a rigid coating that grants it a fuzzy appearance. However, a few filamentous 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*.

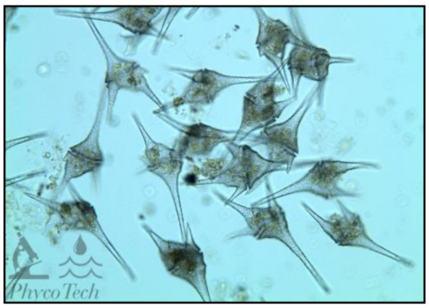
Green Algae are a very diverse group of unicellular phytoplankton. There is tremendous variability in this group which varies from family to family and sometimes even genus to genus. There are flagellated single cells, multi-cell colonies (some motile), filamentous forms and attached forms, typically 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 actually 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 has plasticity of shape, and usually are grass green in color (although sometime 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*.

APPENDIX B: Zooplankton

A 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).

APPENDIX C: 2017 Data

2017 Phytoplankton Data

2017 Zooplankton Data

2013-2017 Phytoplankton Data Summary Graphs

2013-2017 Zooplankton Data Summary Graphs

2017 Temperature/Dissolved Oxygen Graphs

MICROSCOPIC EXAMINATION OF WATER

Sample from: Three Lakes

Collection Date: 08/02/17	Examination Date: 08/04/17	Amount Examined: 200 ml.
Site A: Lake Rippowam	Site B: Lake Oscaleta	Site C: Lake Waccabuc

BACILLARIOPHYTA (Diatoms)	**A**	**B**	**C**	**CHLOROPHYTA (Green Algae)**	**A**	**B**	**C**	**CYANOPHYTA (Blue-green Algae)**	**A**	**B**	**C**
Asterionella				*Ankistrodesmus*				*Anabaena*	210	230	420
Cyclotella				*Chlamydomonas*				*Anacystis*			
Cymbella				*Chlorella*				*Aphanizomenon*	350	170	40
Diatoma				*Chlorococcum*				*Coelosphaerium*			
Fragilaria				*Closterium*				*Gomphosphseria*			
Melosira				*Coelastrum*	60		160	*Lyngbya*			
Navicula				*Eudorina*		10	20	*Microcystis*			20
Nitzschia				*Mougeotia*				*Oscillatoria*			
Pinnularia				*Oedogonium*	30			*Pseudoanabaena*			
Rhizosolenia				*Oocystis*				*Synechocystis*			
Stephanodiscus				*Pandorina*				*Agmenellum*			
Stauroneis				*Pediastrum*							
Synedra	110	50	20	*Phytoconis*				**PROTOZOA**			
Tabellaria				*Rhizoclonium*				*Actinophyrs*			
Cocconeis				*Scenedesmus*		10					
CHRYSOPHYTA (Golden Algae)	**A**	**B**	**C**	*Spirogyra*				**EUGLENOPHYTA (Euglenoids)**	**A**	**B**	**C**
				Staurastrum			160				
Dinobryon				*Sphaerocystis*				*Euglena*			
Mallomonas	590	10	10	*Ulothrix*				*Phacus*			
Synura				*Volvox*				*Trachelomonas*			
Tribonema				*Zygnema*							
Uroglenopsis				*Quadrigula*							
				Gloeocystis	20			**PYRRHOPHYTA (Dinoflagellates)**	**A**	**B**	**C**
				Cosmarium							
				Treubaria				*Ceratium*			
								Peridinium			

SITE	**A**	**B**	**C**
TOTAL GENERA:	6	7	8
TRANSPARENCY:	2.5m	2.5m	2.95m
ORGANISMS PER MILLILITER:	**1,370**	**480**	**850**

NOTES: This was the first sampling event of 2017. Algal diversity is considered to be moderate at all three sites. Algal density is considered to be high at site A while sites B and C are moderate. Site A is dominated by golden algae while sites B and C are dominated by blue-green algae. Green algae and diatoms were also observed. Water clarity is considered to be poor at each site.

Zooplankton Count Results

Site: Lake Oscaleta **Date: 08/02/17**

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*	22	20	22	21.33	21333	68.8	310
			Kellicottia bostoniensis		1	2	1.00	1000	68.8	15
			Brachionous angularis	5	8	8	7.00	7000	68.8	102
			Notholca caudata	14	21	30	21.67	21667	68.8	315
		Synchaetide	*Synchaeta oblonga*	29	27	31	29.00	29000	68.8	422
			Polyarthra remata	8	13	4	8.33	8333	68.8	121
		Trichocercidae	*Trichocerca similius*	19	27	22	22.67	22667	68.8	329
	Flosculariacea	Testudinellidae	*Pompholyx sulcata*	1			0.33	333	68.8	5
		Asplanchnidae	*Asplanchna priodonta*		4	2	2.00	2000	68.8	29
		Conochiliidae	*Conochilus unicornis*	1	2	3	2.00	2000	68.8	29
									Total:	**1677**
Cladocera	**Cladocera**	Daphniidae	*Ceriodaphnia lacustrius*		3		1.00	1000	68.8	15
		Bosminidae	*Bosmina longirostris*	2	7	5	4.67	4667	68.8	68
									Total:	**83**
Copepoda	**Cyclopoida**	Cyclopoidae	*Cyclopoid* nauplius	1	8	7	5.33	5333	68.8	78
			Microcyclops rubellus	2	9	7	6.00	6000	**68.8**	87
									Total:	**165**

Total Organisms per L	Rotifera	%	Cladocera	%	Copepoda	%
1925	1677	87.1%	83	4.3%	165	8.6%

Zooplankton Count Results

Site: Lake Rippowam **Date: 08/02/17**

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*	3	3	2	2.67	2667	68.8	39
			Notholca caudata	6	1	2	3.00	3000	68.8	44
			Brachionous angularis	7	6	7	6.67	6667	68.8	97
		Synchaetide	*Synchaeta oblonga*	125	147	146	139.33	139333	68.8	2025
			Polyarthra remata	1	1		0.67	667	68.8	10
		Trichocercidae	*Trichocerca multicrinis*			1	0.33	333	68.8	5
		Asplanchnidae	*Asplanchna priodonta*	1			0.33	333	68.8	5
	Flosculariacea	Conochiliidae	*Conochilus unicornis*	3			1.00	1000	68.8	15
									Total:	**2240**
Cladocera	**Cladocera**	Daphniidae	*Ceriodaphnia lacustrius*	8	3	10	7.00	7000	68.8	102
		Bosminidae	*Bosmina longirostris*	5	3	3	3.67	3667	68.8	53
									Total:	**155**
Copepoda	**Cyclopoida**	Cyclopoidae	*Cyclopoid nauplius*	25	32	27	28.00	28000	68.8	407
			Microcyclops rubellus	24	24	21	23.00	23000	**68.8**	334
									Total:	**741**

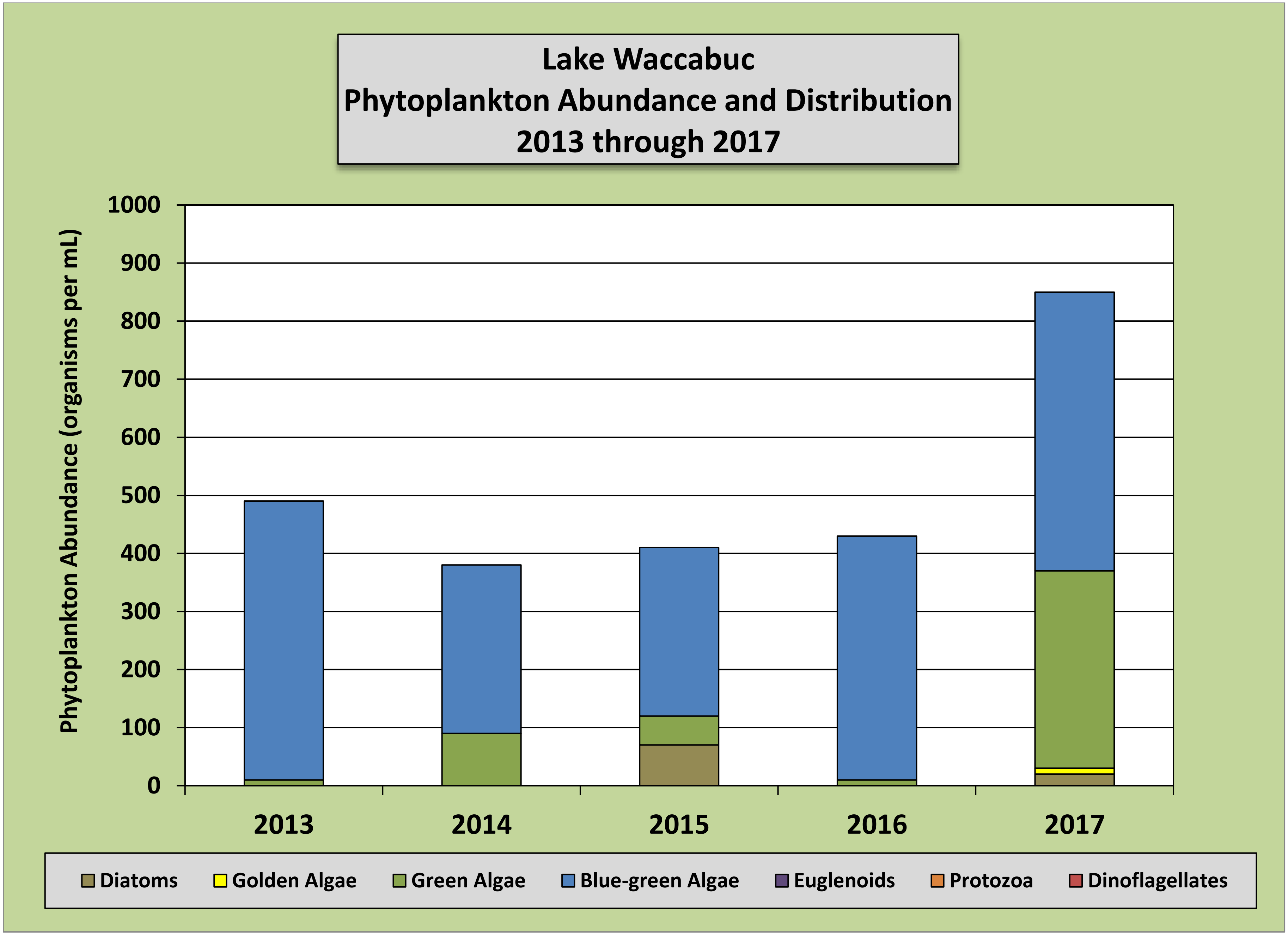
Total Organisms per L	Rotifera	%	Cladocera	%	Copepoda	%
3136	2240	71.4%	155	4.9%	741	23.6%

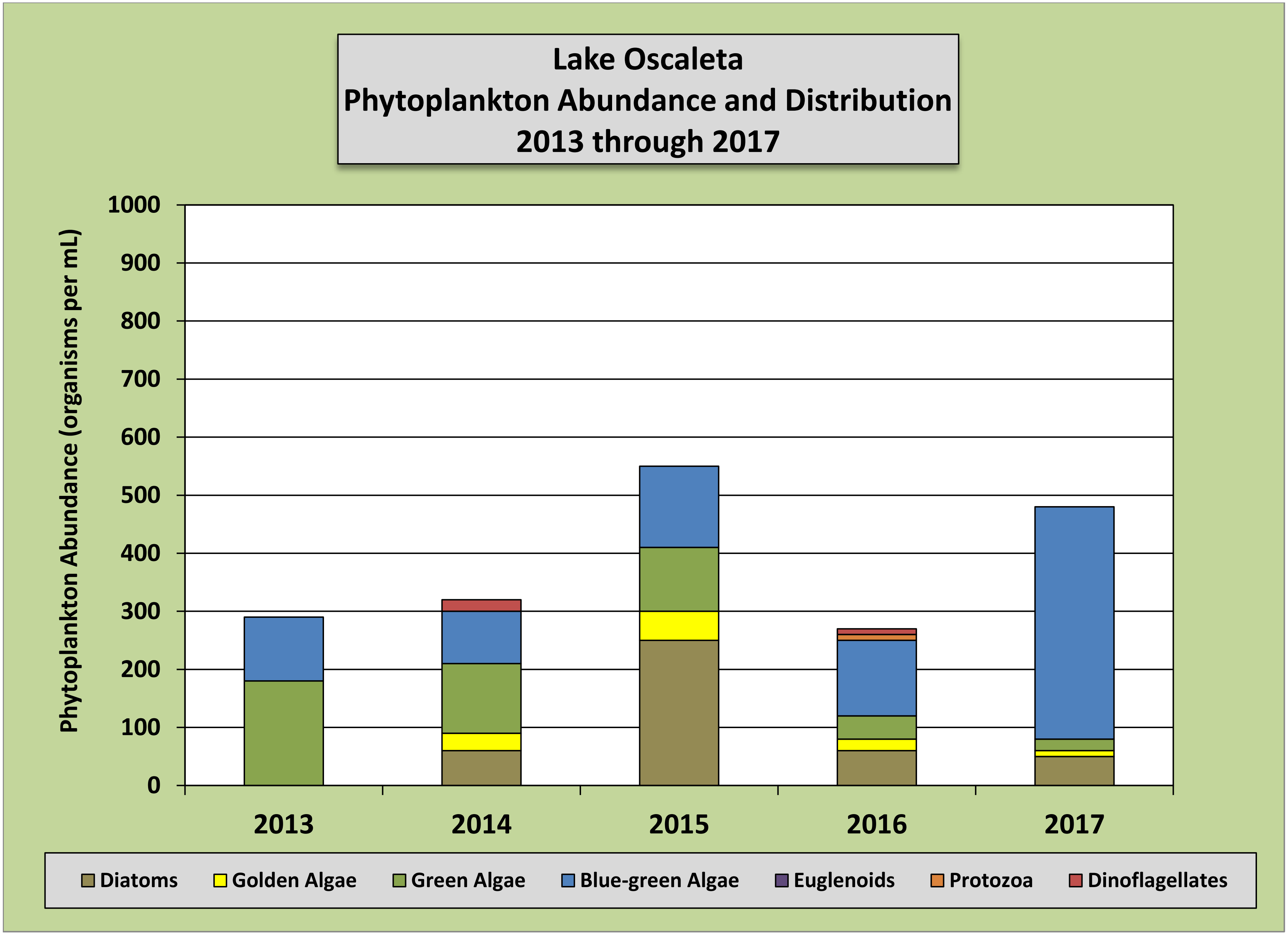
Zooplankton Count Results

Site: Lake Waccabuc **Date: 08/02/17**

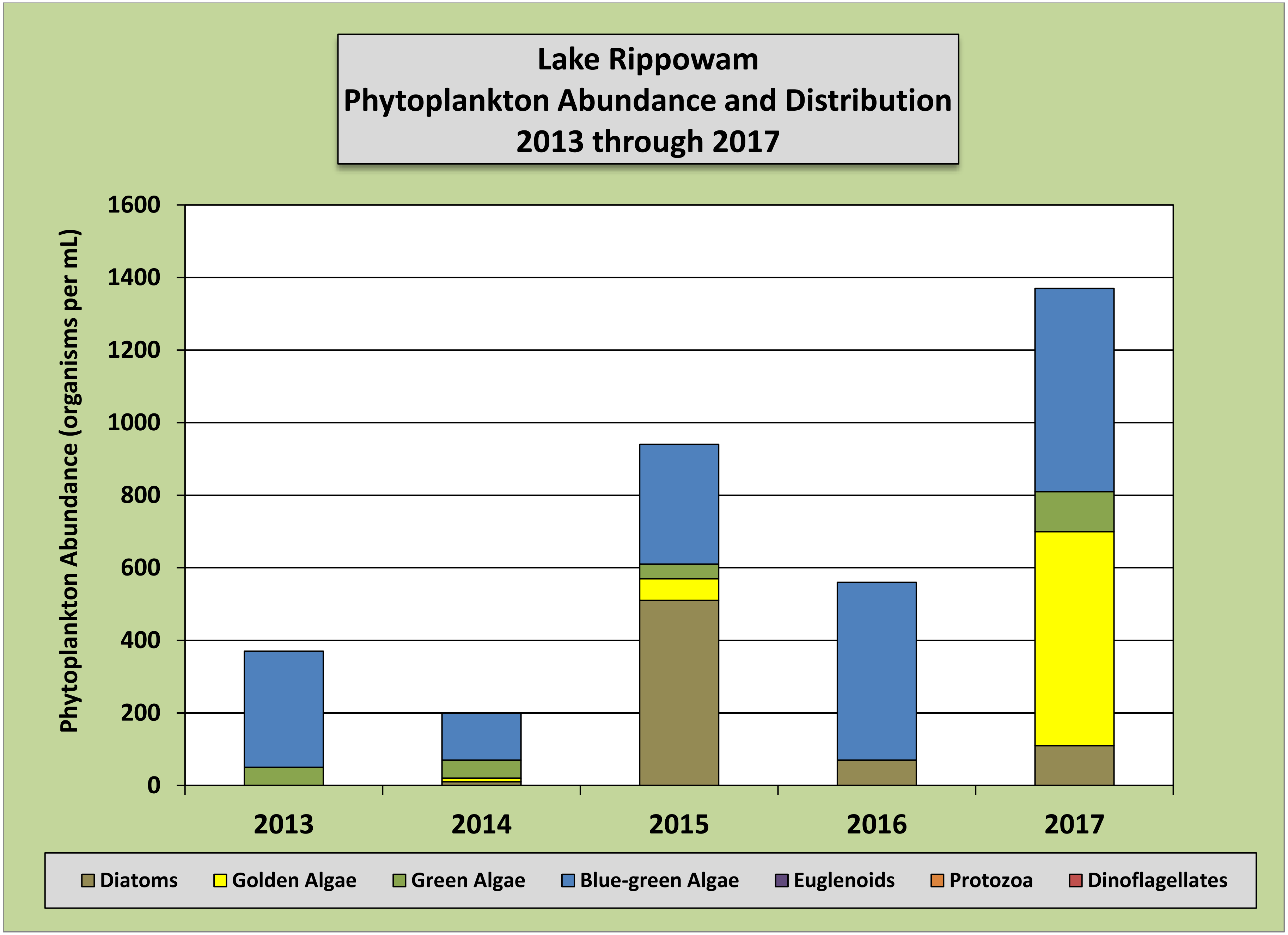
Group	Order	Family	Genus	Replicate A	Replicate B	Replicate C	Total/3 (# per mL)	x1000 mL (= 1 L)	Water sampled (L)	# organisms per L
Rotifera	**Ploima**	Brachionidae	*Keratella crassa*	6	5	9	6.67	6667	68.8	97
			Kellicottia bostoniensis	2	5	4	3.67	3667	68.8	53
			Brachionous angularis	30	16	13	19.67	19667	68.8	286
		Asplanchnidae	*Asplanchna priodonta*	1	1	3	1.67	1667	68.8	24
		Synchaetide	*Synchaeta oblonga*	80	73	88	80.33	80333	68.8	1168
			Polyarthra remata	12	11	13	12.00	12000	68.8	174
		Trichocercidae	*Trichocerca similius*	12	5	9	8.67	8667	68.8	126
	Flosculariacea	Conochilidae	*Conochilus unicornis*	12	25	33	23.33	23333	68.8	339
									Total:	**2267**
Cladocera	**Cladocera**	Daphnidae	*Ceriodaphnia lacustrius*	8	1		3.00	3000	68.8	44
		Bosminidae	*Bosmina longirostris*	19	16	6	13.67	13667	68.8	199
									Total:	**243**
Copepoda										
	Cyclopoida	Cyclopoidae	*Cyclopoid nauplius*	14	16	21	17.00	17000	68.8	247
			Microcyclops rubellus	22	13	27	20.67	20667	**68.8**	300
									Total:	**547**

Total Organisms per L	Rotifera	%	Cladocera	%	Copepoda	%
3057	2267	74.2%	243	7.9%	547	17.9%


Lake Waccabuc
Phytoplankton Abundance and Distribution
2013 through 2017
Phytoplankton Abundance (organisms per mL)
1000
900
800
700
600
500
400
300
200
100
0
2013
2014
2015
2016
2017
Diatoms
Golden Algae
Green Algae
Blue-green Algae
Euglenoids
Protozoa
Dinoflagellates

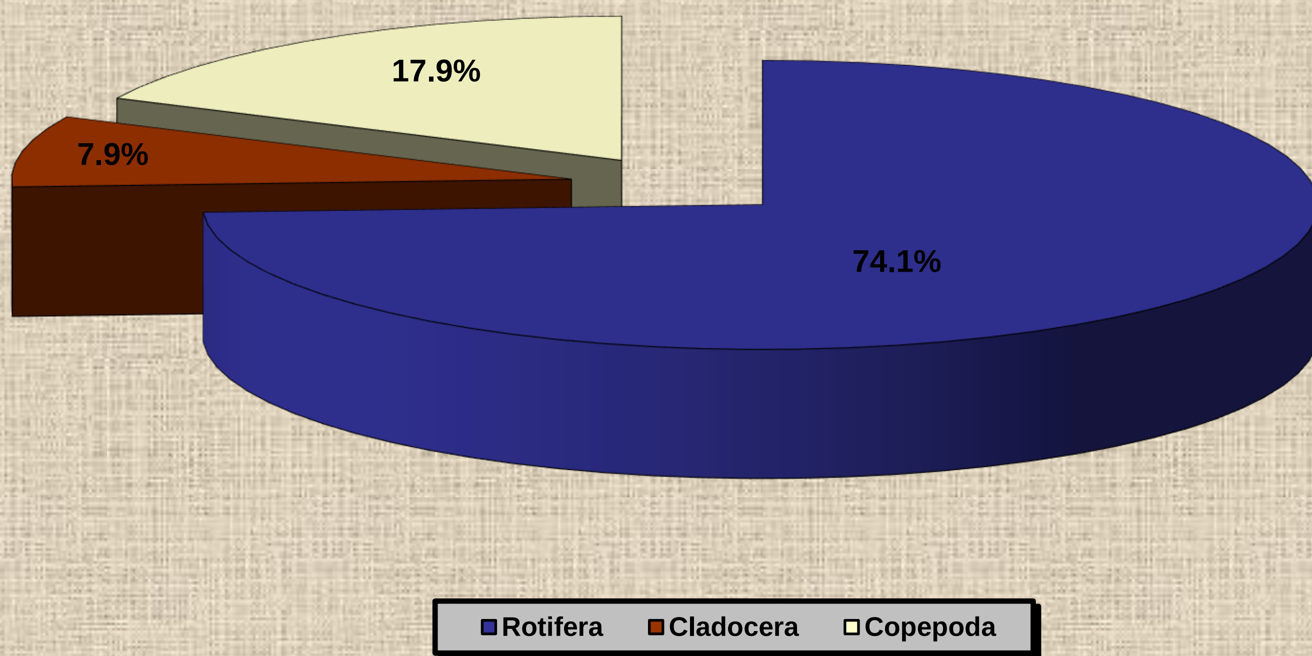


Lake Oscaleta
Phytoplankton Abundance and Distribution
2013 through 2017
Phytoplankton Abundance (organisms per mL)
1000
900
800
700
600
500
400
300
200
100
0
2013
2014
2015
2016
2017
Diatoms
Golden Algae
Green Algae
Blue-green Algae
Euglenoids
Protozoa
Dinoflagellates


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

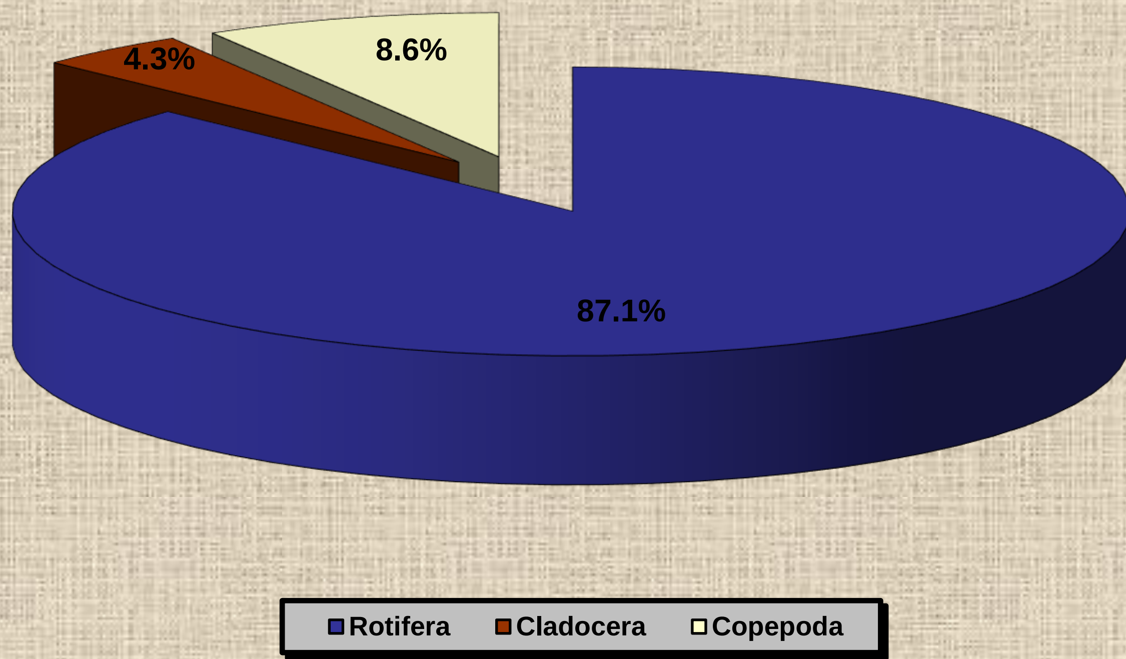
Three Lakes - Lake Waccabuc
Lake Station
August 02, 2017
Zooplankton Distribution

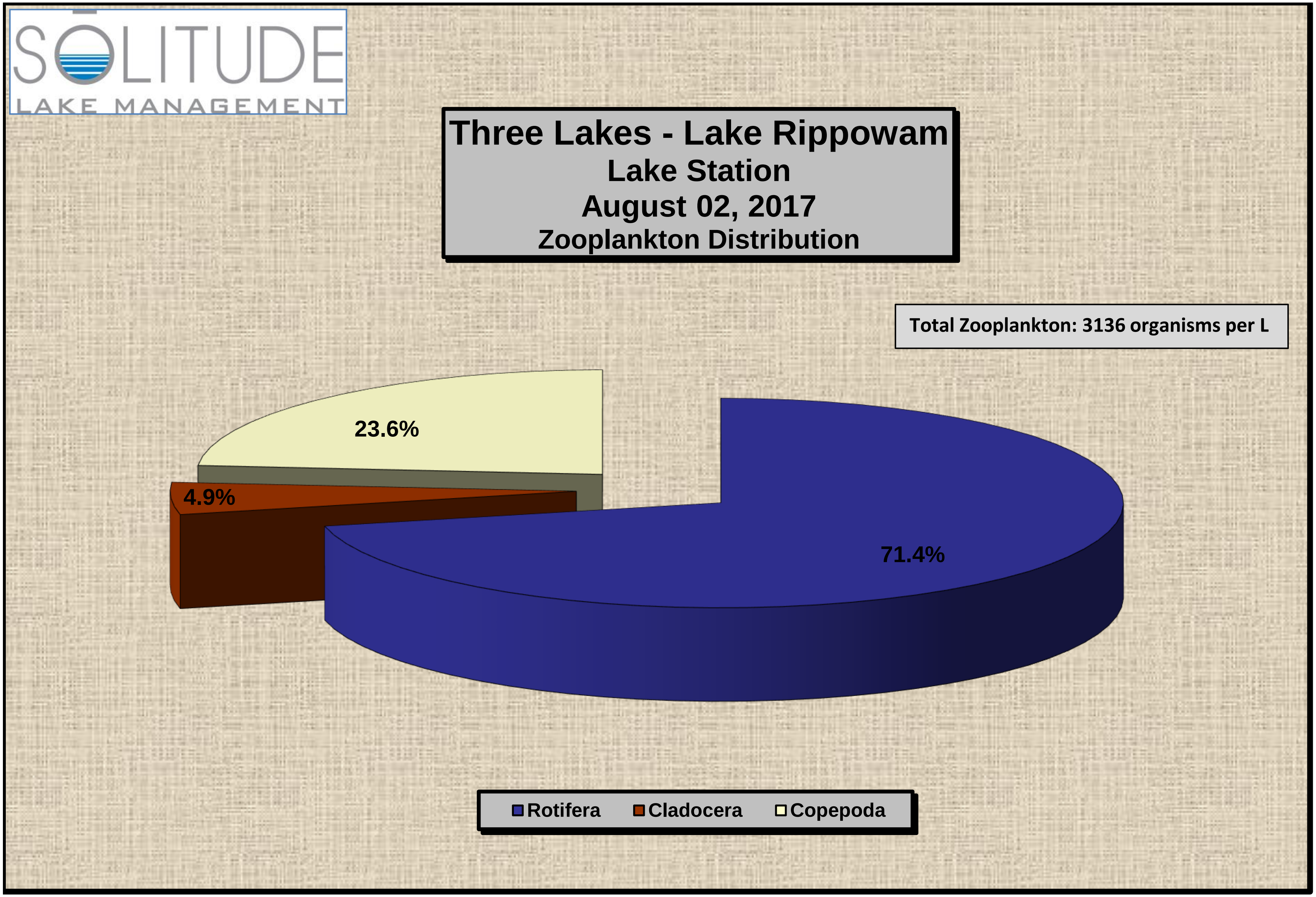
Total Zooplankton: 3057 organisms per L



Three Lakes - Lake Oscaleta
Lake Station
August 02, 2017
Zooplankton Distribution

Total Zooplankton: 1925 organisms per L





Three Lakes - Lake Rippowam
Lake Station
August 02, 2017
Zooplankton Distribution
Total Zooplankton: 3136 organisms per L
23.6%
4.9%
71.4%
Rotifera
Cladocera
Copepoda

The Three Lakes

Date:	8/2/2017
Biologist:	3LC

Lake Rippowam

Depth (Meters)	Temp. (ºC)	Dissolved Oxygen (mg/L)
0	26.2	8.87
1	25.7	8.73
1.5	25.3	8.75
2	24.9	8.92
2.5	24.2	8.50
3	23.6	8.00
4	18.4	0.96
5	14.3	0.23
5.5	13.3	0.15

Total Depth (ft):	NA
Secchi (m):	2.5

Lake Oscaleta

Depth (Meters)	Temp. (ºC)	Dissolved Oxygen (mg/L)
0	26.8	10.21
1	26.3	10.23
1.5	25.6	11.27
2	25.0	11.38
2.5	24.5	11.23
3	23.9	9.34
3.5	22.8	10.33
4	20.7	11.47
4.5	17.9	10.62
5	14.7	3.40
6	10.9	0.23
7	9.2	0.16
8	8.4	0.13
9	7.9	0.13
10	7.5	0.12
10.5	7.3	0.12

Total Depth (ft):	NA
Secchi (m):	2.5

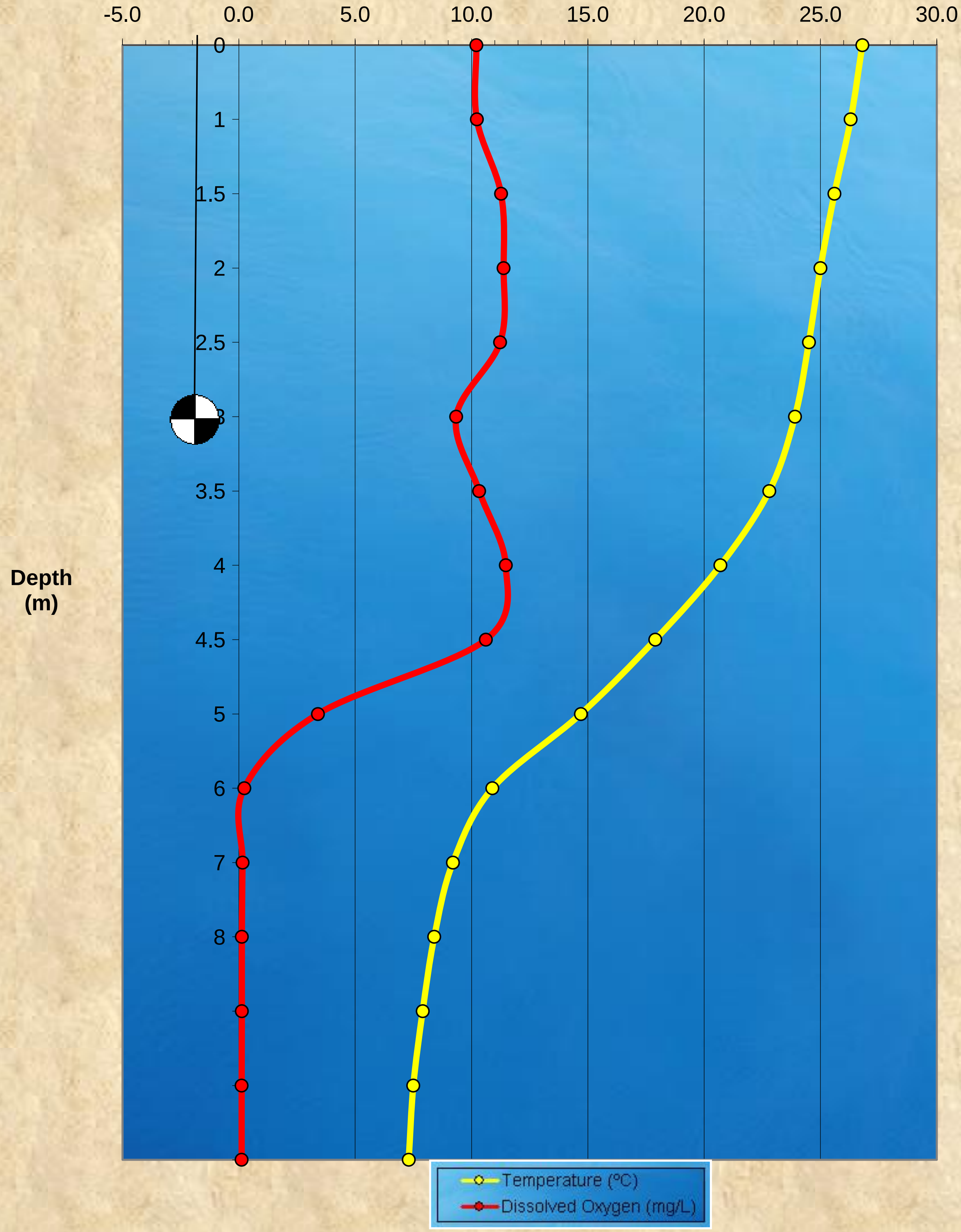
Lake Waccabuc

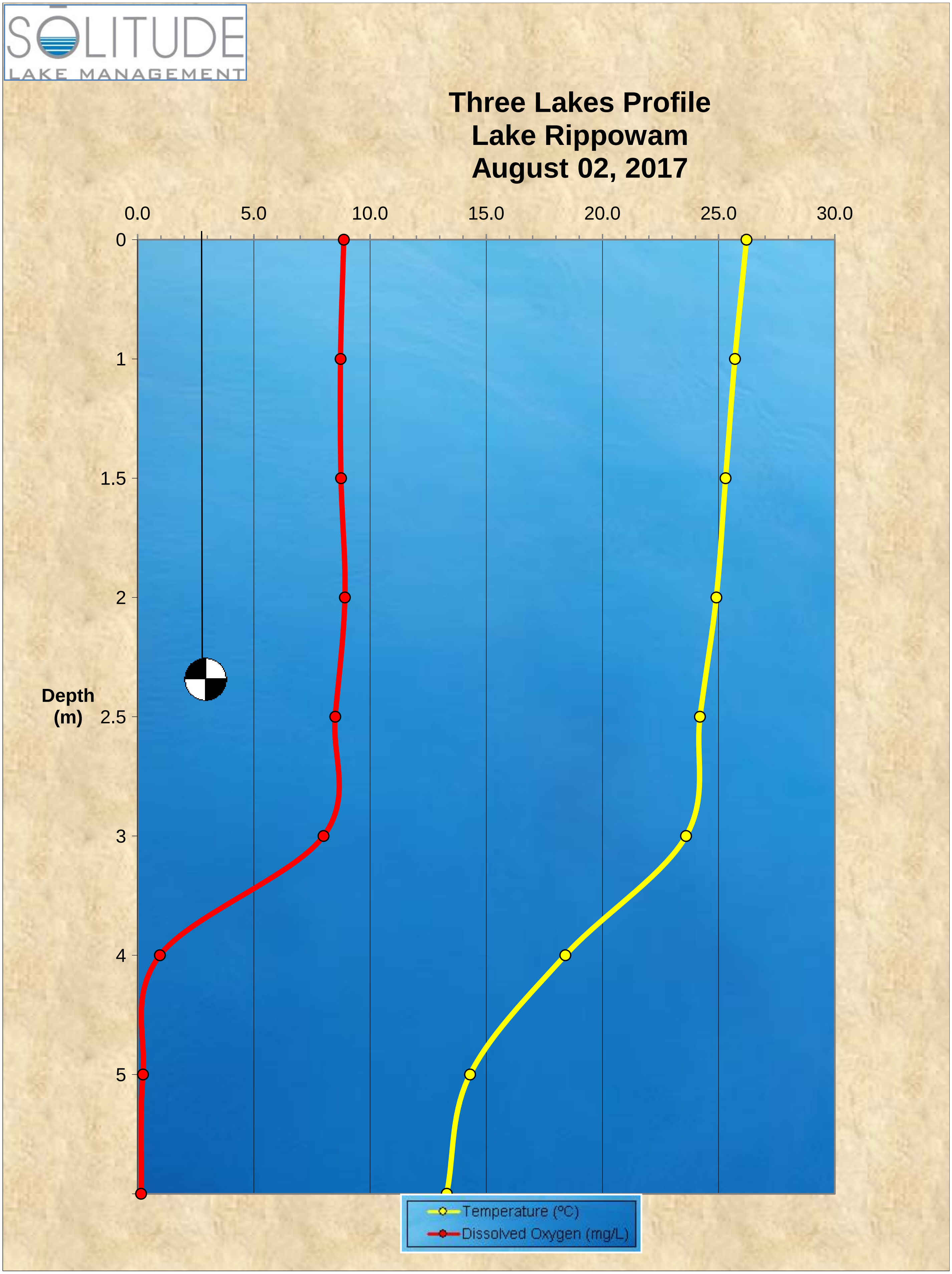
Depth (Meters)	Temp. (ºC)	Dissolved Oxygen (mg/L)
0	26.9	8.95
1	26.2	9.13
1.5	26.0	9.07
2	25.7	9.29
2.5	25.4	9.15
3	24.9	8.99
3.5	24.3	8.09
4	23.6	7.23
5	20.4	4.08
6	16.5	3.17
7	11.4	0.25
8	9.4	0.14
9	8.1	0.10
10	7.6	0.09
11	7.2	0.09
12	7.0	0.08
13	6.9	0.08
14	6.8	0.08

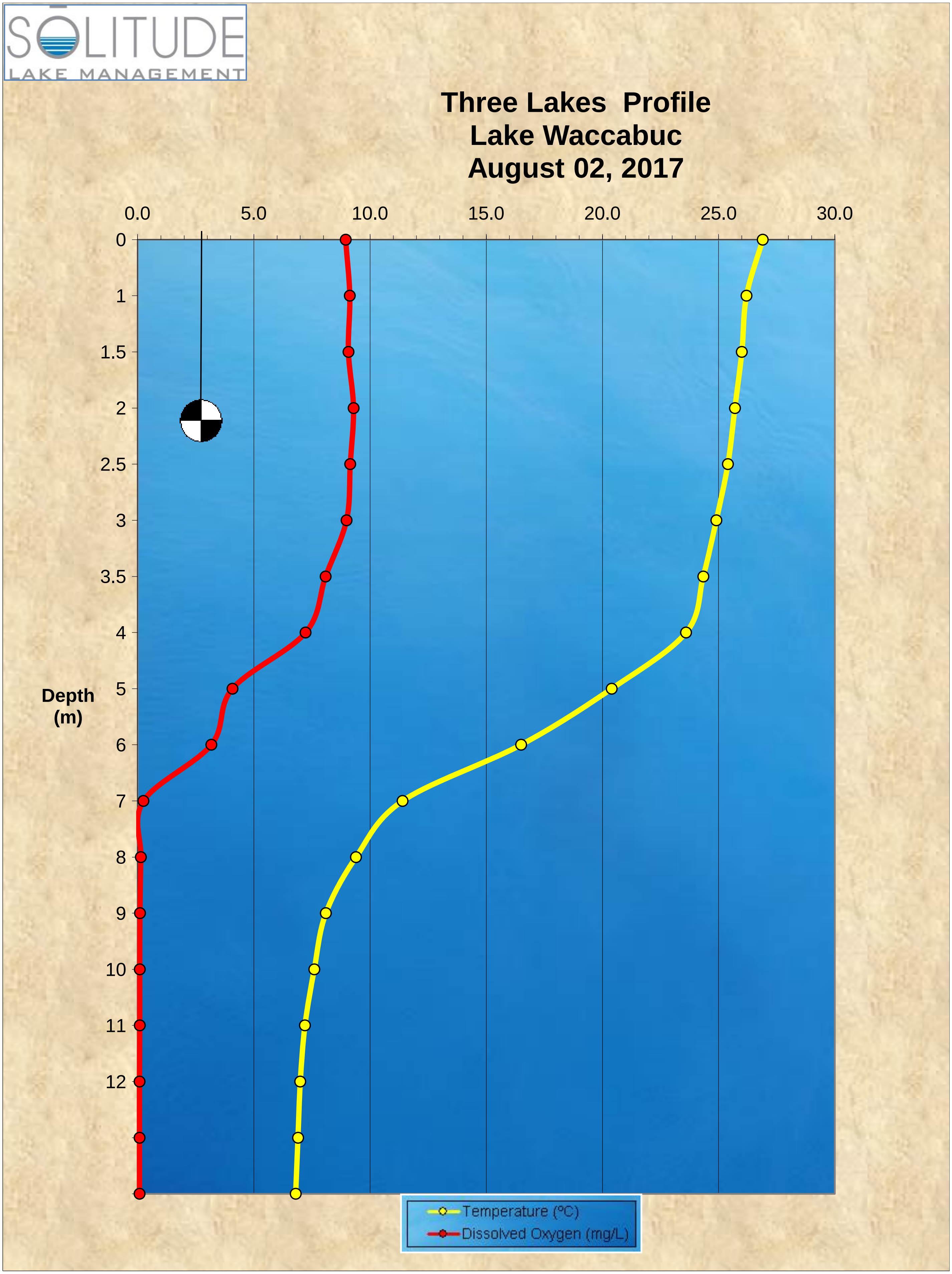
Total Depth (ft):	NA
Secchi (ft):	2.95

Notes:

Three Lakes Profile
Lake Oscaleta
August 02, 2017




Three Lakes Profile
Lake Rippowam
August 02, 2017
0.0
5.0
10.0
15.0
20.0
25.0
30.0
0
1
1.5
2
2.5
3
4
5
Depth
(m)
Temperature (°C)
Dissolved Oxygen (mg/L)


SOLITUDE
LAKE MANAGEMENT
Three Lakes Profile
Lake Waccabuc
August 02, 2017
0.0
5.0
10.0
15.0
20.0
25.0
30.0
0
1
1.5
2
2.5
3
3.5
4
5
6
7
8
9
10
11
12
Depth
(m)
Temperature (ºC)
Dissolved Oxygen (mg/L)