WHITE LAKE PROPERTY OWNERS ASSOCIATION ENVIRONMENT VOLUNTEERS

Special Report

THE PHYTOPLANKTON OF WHITE LAKE 2022

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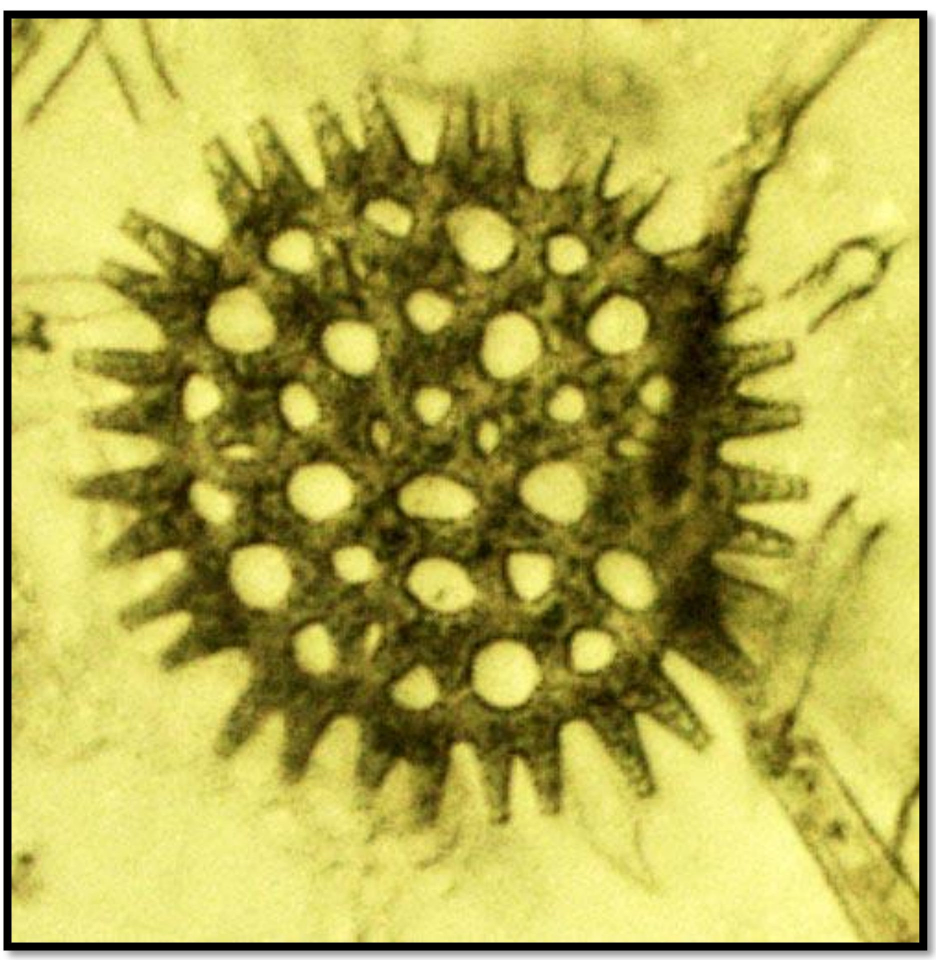
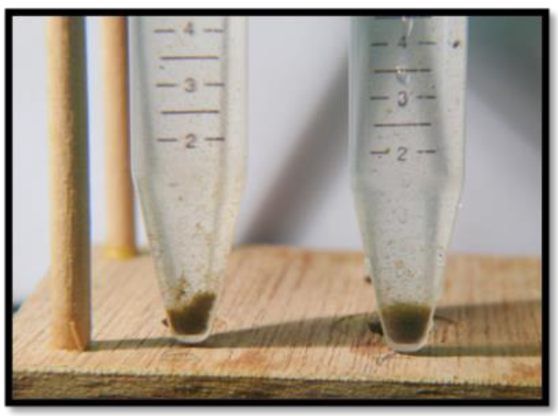


The quality of freshwater in lake systems has an influence on the microscopic organisms living in suspension in lake water.

During the summer of 2022 we sampled phytoplankton and zooplankton to get an idea of what this major component of the food web may look like in White Lake. We generated relative occurrence values for each organism that we could identify based on its proportional contribution to the plankton community.

Our sampling locations were four deep water sites used by our lake chemistry studies. Three Mile Bay, North Hardwood, Pickerel Bay and Middle Narrows have depths greater than 5 meters. These sites have no rooted aquatic plants and they are deep enough to prevent sediment from contaminating our plankton net near the bottom. The net sweep was a 4-metre vertical column representing 125 litres of lake water filtering through the net.

The content from the net was concentrated in a 15 ml. collection tube where suspended material settled to the bottom. The photo below shows two samples of plankton settling to the bottom after a period of 30 minutes.



A graduated well glass slide and a low power microscope were used to count various plankton types. As magnification increases so will the count of small organisms. Counts will increase exponentially with the magnification used, as will the time it takes to process a sample. We used a stratified counting method to compensate for this. The table below illustrates our counting method using four different examinations on each sample.

magnification	**grid squares examined**	**focusing depth on slide**	**target organisms**
40x	1000	at bottom	zebra mussel larvae
40x	1000	at bottom	large zooplankton
40x	250	at top	blue green algae
100x	50	at bottom	micro-plankton

Each grid-square represents $1mm^2$ and contained a volume of 1 mm^3. The Individual type counts were averaged to the lowest number of grid-squares used which was 50 grid-units at 100x magnification. When all four counts were combined, a value of relative occurrence could be made for each organism. This is not a statement of biomass nor biovolume but an estimate of the occurrence of a particular type based on a limited number of grid squares. This should allow us to detect types of dominant phytoplankton and zooplankton and we should be able to see shifts in dominance during the course of the summer.

Phytoplankton utilize available nutrients in the presence of sunlight for growth and reproduction by which they become food for zooplankton, fish and other organisms. This forms the base of an aquatic food web. When the word "algae" is heard the impression given is something green, filamentous and slimy. Our pelagic (free-swimming) phytoplankton are very different from this definition. This photo essay illustrates varieties of shape, structure and function of phytoplankton using photos taken from our 2022 samples unless otherwise indicated.

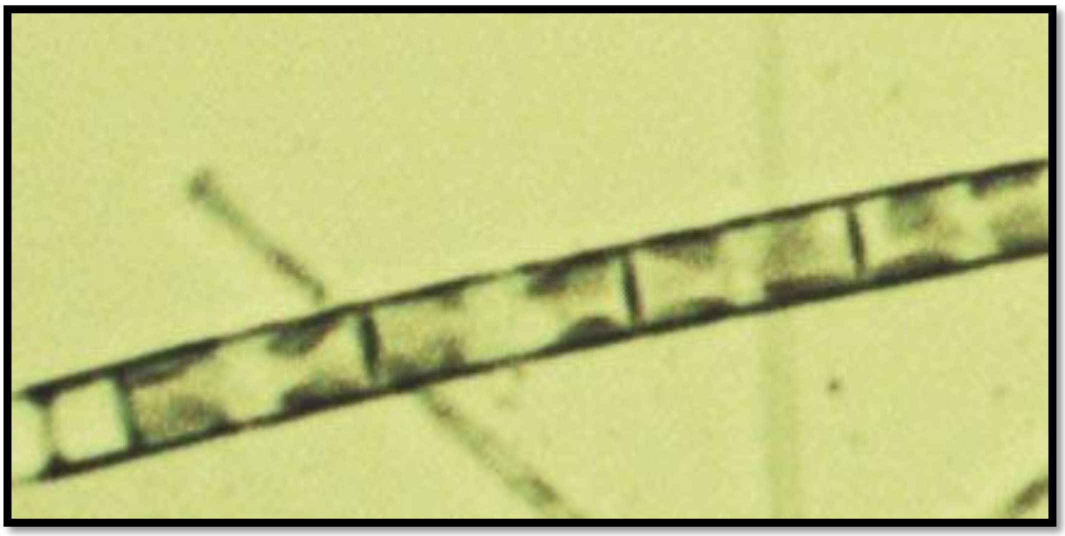
See Appendix for named sample site locations on White Lake.

A PHOTO RECORD OF PHYTOPLANKTON TYPES IN WHITE LAKE: 2022
The coloured boxes denote colours used on the dominance graphs, pages 25 and 26.

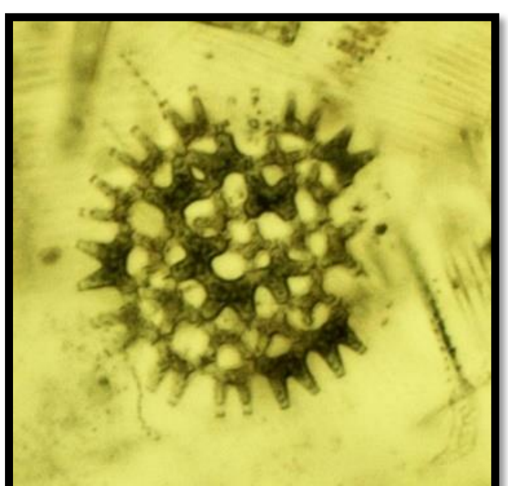
GREEN ALGAE: *CHLOROPHYTES*

Green colonial: *Astrephomene*
A large colonial alga with up to 128 cells forming on the periphery of a gelatinous spherical matrix. Each cell has two long flagella propelling the colony through the water. A cluster of smaller cells are thought to act as a kind of steering rudder.

Green filamentous: *Klebsormidium*
This alga is found in a variety of environments. It has characteristics shared with terrestrial plants using similar mechanisms for protection from harmful UV radiation. This suggests an early ancestral form of this type was an ancient colonizer of terrestrial earth. Klebsormidium was common in White Lake throughout the summer growing three-fold in occurrence by the end of summer.

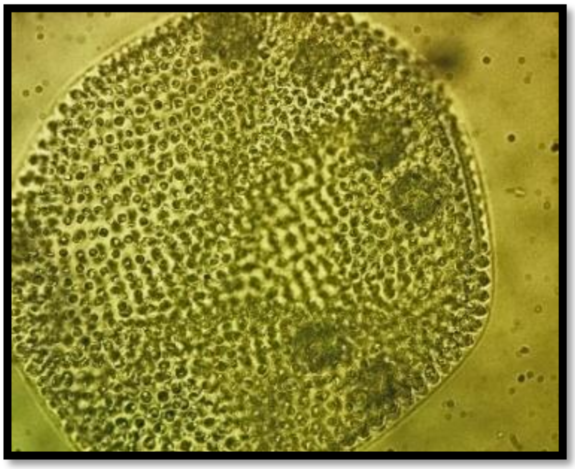


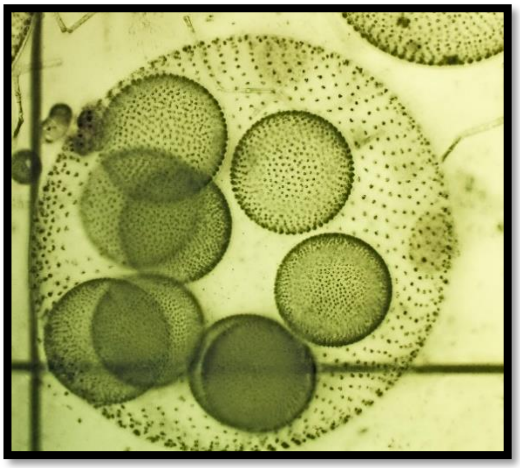
Green colonial: *Pediastrum* “the Flat Star”
A colony with 4 to 128 single cells forming a series of flat rings. The horned appendages are thought to reduce the sink rate in the water column and add protection from predators. Pediastrum prefers nutrient rich waters with a high nitrogen concentration.



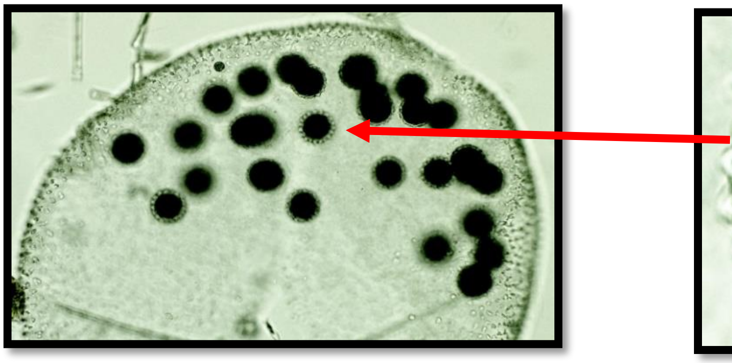
Green colonial: *Volvox,* “the Fierce Roller”

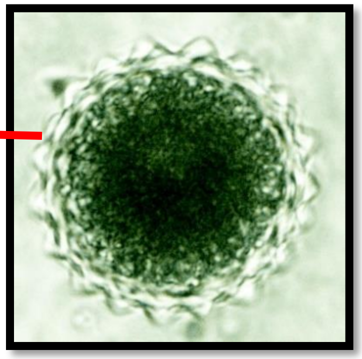
A hollow sphere composed of peripheral cells, each cell having 2 flagella moving in a coordinated motion propelling the colony forward with a rapid rotation. The internal dark spheres are growing daughter cells. Reproduction is either asexual or sexual depending on environmental conditions. During the summer vegetative daughter cells are reproduced inside the parental colony.





At the end of the season parental colonies produce distinctive resting spores with thick spiny cell walls. These spores overwinter in the sediment and will form new colonies the following season.

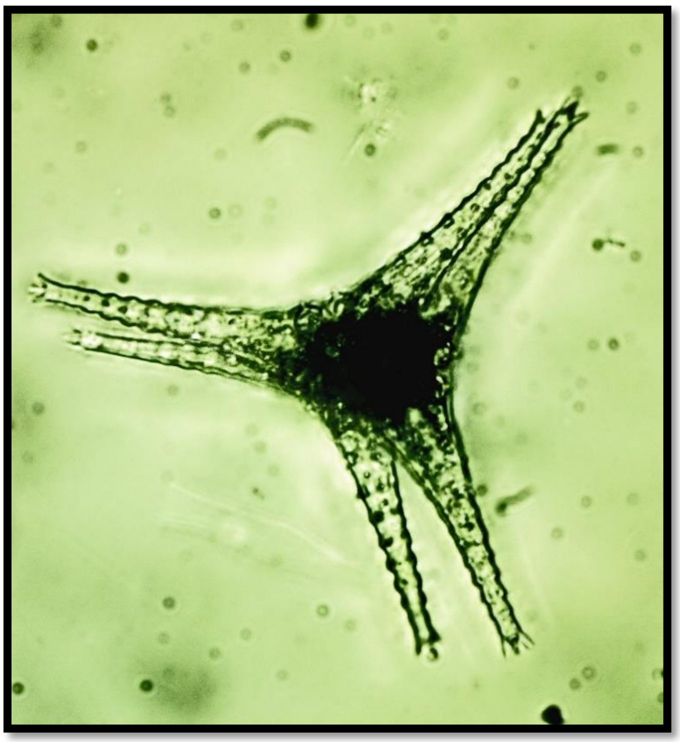




DESMIDS: *Charophyte*

Desmid*: Staurastrum*

800 of these single celled species are known globally and over 300 are found in North America. This particular cell is divided into two halves each with three appendages which give the cell its buoyancy. Each half cell contains a chloroplast, the dark area seen here at the centre. The 'mirror image' is in fact the lower half of the cell joined to the upper half by a narrow isthmus that cannot be seen in this plan view. Reproduction occurs by division of the nucleus located at the centre of the isthmus.



Staurastrum: Three Mile Bay 2018

Desmid: *Closterium*

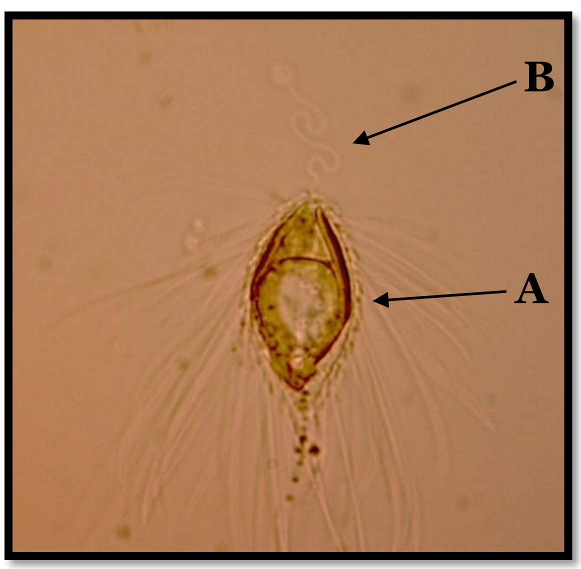
The cell surface has many pores which secrete mucilage. This enables *Closterium* to move in response to light. Sexual reproduction forms dormant reproductive spores during periods of environmental stress or during the winter. Closterium was rare in our samples.

GOLD BROWN ALGAE: *CHRYSOPHYTES*

Many within this group bear scales composed of silica. These can be preserved in lake sediment and used to study historic regime shifts in water quality. All chrysophytes produce cysts as a resting stage for survival under harsh conditions.

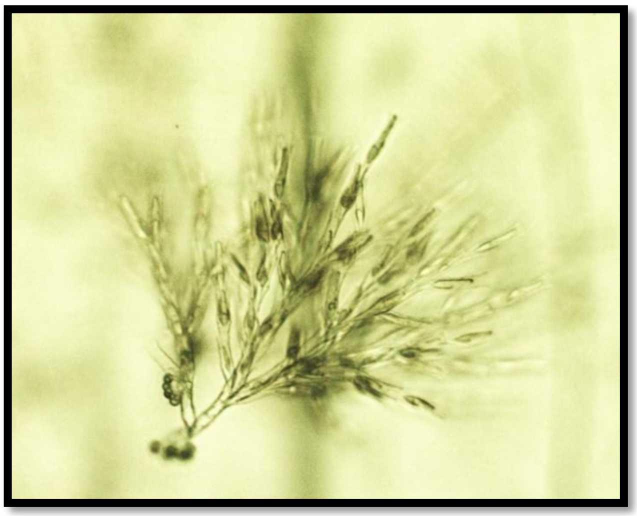
Golden Brown: *Mallamonas*

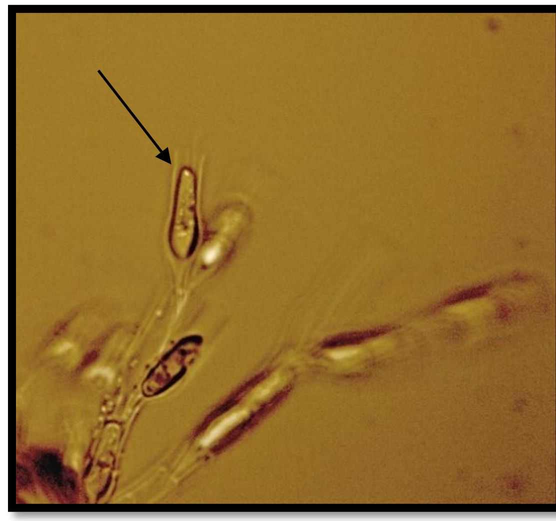
This chrysophyte has a silicate armour covering its body. We see the overlapping scales as a transparent jagged fringe in this profile view below (A). Forward motion is driven by a long whip-like flagella barely seen in this photo (B). Mallamonas are present in Three Mile Bay but they were not encountered in our 2022 samples.



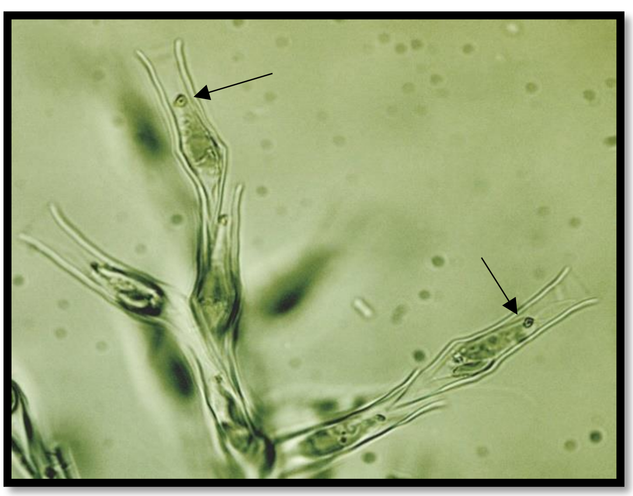
Golden Brown Colonial: *Dinobryon*

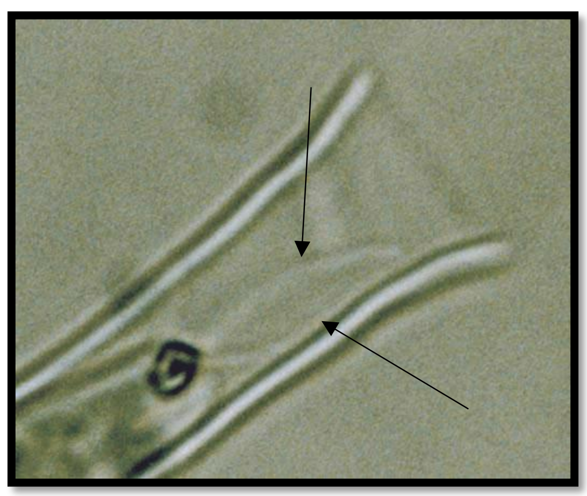
Dinobryon is common in temperate lakes. In the spring when waters are mixing it can form blooms. It photosynthesizes sunlight to fix carbon as do other algae, but it also has the ability to consume bacteria and picoplankton when sunlight becomes reduced by depth or by self-shading. In a Quebec Lake it was estimated three bacteria were consumed every 5 minutes by each dinobryon cell. This is aided by the motion of two flagella. Flagella trap bacteria that the cell then absorbs. Arrows indicate these flagella in the photos below.





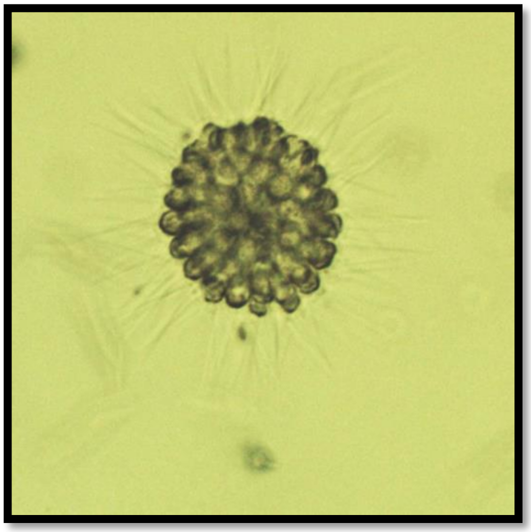
Each dinobryon cell also has an eye spot allowing it to orientate to light.

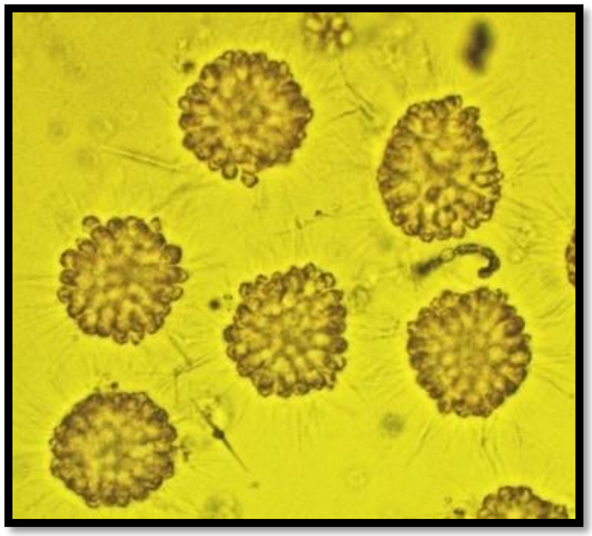




Golden Brown Colonial: *Synura*

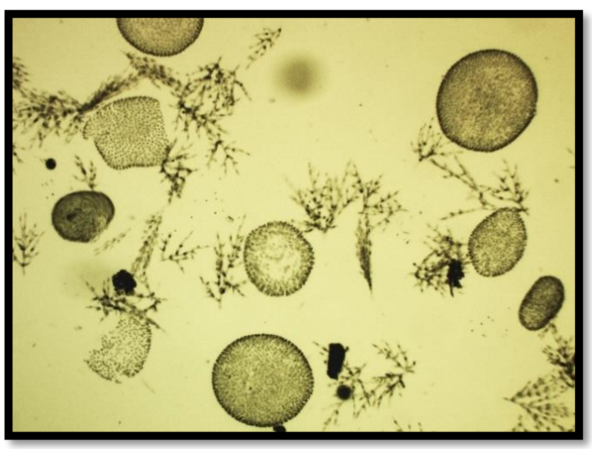
This is our most dominant type of chrysophyte in White Lake during the summer. Limnological studies of preserved scales in Ontario lakes found synura colonies increasing in relative abundance since early historic times. When synurian blooms are large they can affect the odour and taste of water.





Golden colonial: (*Uroglenopsis)*

This chrysophyte colony forms a distinctive layer of cells on the periphery of a hollow globular structure[1]. We found these in the spring shortly after ice out.

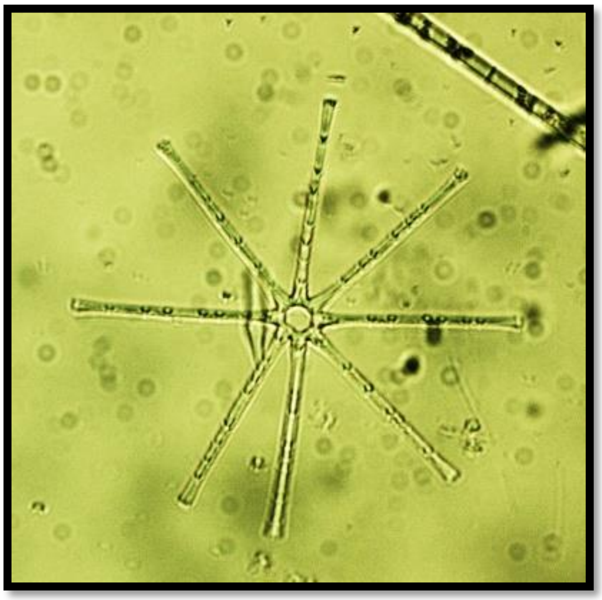


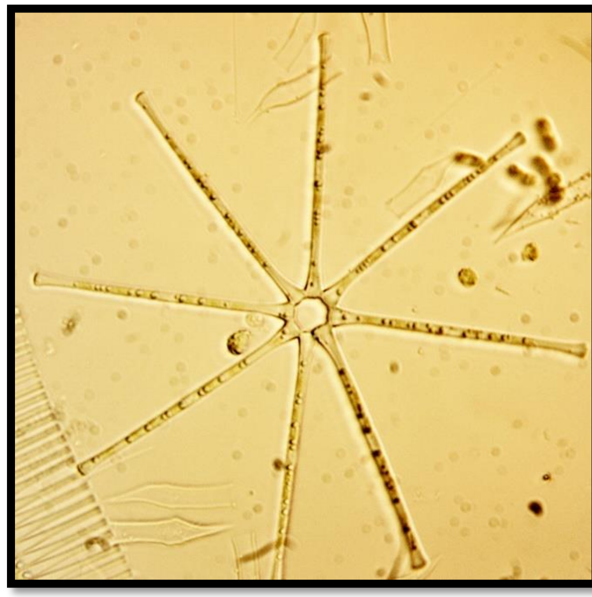
[1]M. Pusztai, P. Skaloud 2021 Species delimitation within the colonial flagellates Uroglena, Uroglenopsis and Urostipulosphaera (Chrysophyceae)
European Journal of Phycology 2022 Vol57 No 1.79-95

DIATOMS: *Bacillariophytes*

Like the chrysophytes single celled diatoms are also composed of silica. The silica content can represent 40 to 70 percent of each cell by weight. The silica structures when preserved in sediment can be recovered for use in paleolimnological work. Just such a study was done on White Lake in 2017.[1] Diatoms are especially useful as their many different species have varying sensitivity to physical and chemical changes in a lake and these can be infer such changes through time.

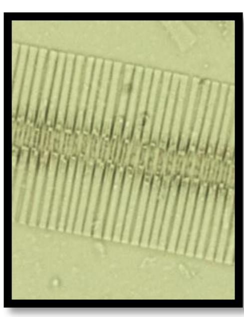
Colonial diatom: *Asterionella*





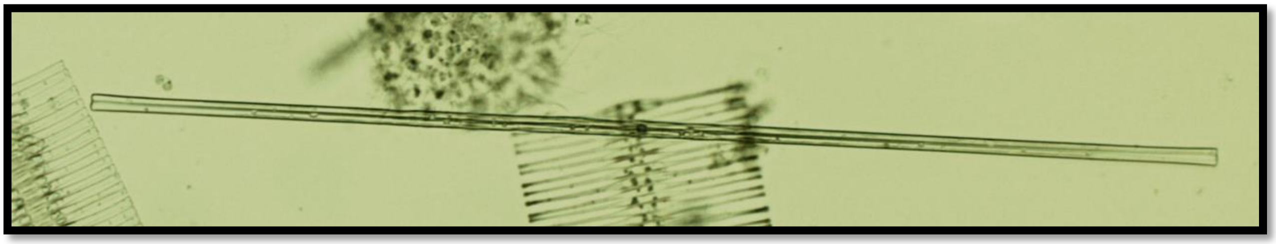
colonial diatom: *Fragilaria*

Individual cells join together at their centres to form long ribbons that can be several millimeters in length.

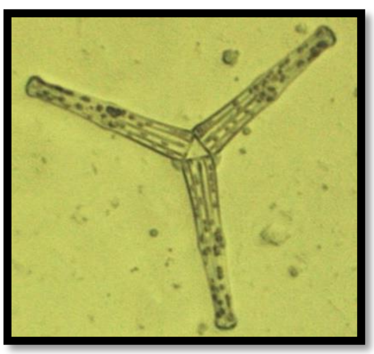


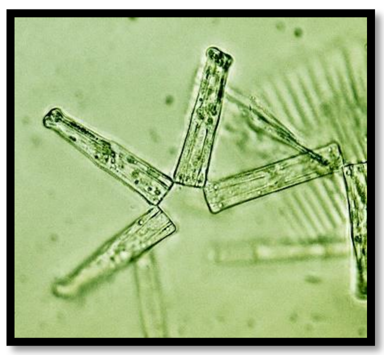
[1]: Michael J Murphy, Branaavan Sivarajah, D. Conrad Grégoire, Jesse C. Vermaire:2022. Assessing the ecological responses of a shallow mesotrophic lake to multiple environmental stressors using paleolimnological techniques. Lake and Reservoir Management. V. 38:1, p 67-79.

colonial diatom: *Synedra*
Synedra forms needle-like single cells that are much longer than those of Fragilaria as seen below.



colonial diatom: *Tabellaria*
Tabellaria also forms chains linkage occurring at the tips of each cell.





DINOFLAGELLATES

Dinoflagellates arrive in the water column after overwintering as cysts in in the bottom sediment. Cyst formation occurs when nutrients, oxygen or temperature conditions change. These single celled algae can form non toxic algal blooms during the summer. The two types shown here have distinctive patterns of armour plates composed of cellulose.

dinoflagellate: *Ceratium*

Ceratium is covered in plates

The arrow points to one of two flagella that propel ceratium using whip like motions. Ingestion of algae and bacteria occurs at the sulcus, the lateral groove by the action of a flagella.

dinoflagellate: *Peridinium*

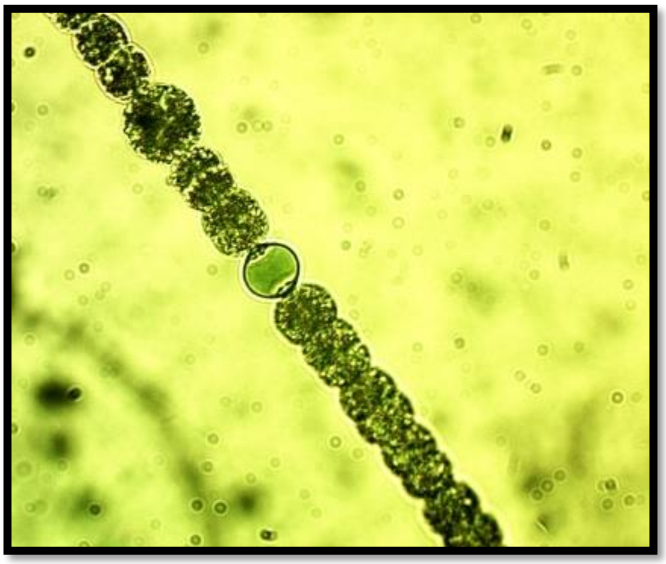
Faintly visible (arrow) is one of two flagella propelling this alga through the water. We did not log peridinium in White Lake in 2022 and like lingbya (see below) appears to have declined significantly since 2016 after the arrival of zebra mussels in White Lake.

Peridinium, White Lake August 2015

BLUE GREENS: Cyanobacteria

Cyanobacteria are one of two major groups of organisms that can fix nitrogen directly from the atmosphere. The other group is bacteria.

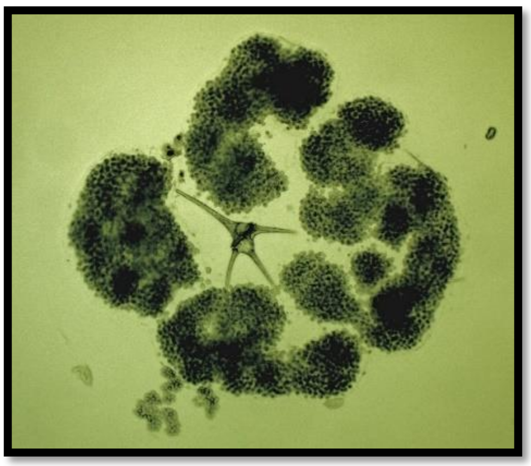
Blue green colonial: Dolichospermum (formerly *Anabaena)*
Nitrogen fixation occurs in heterocysts which appear like whitish pearls separated by green vegetative cells.

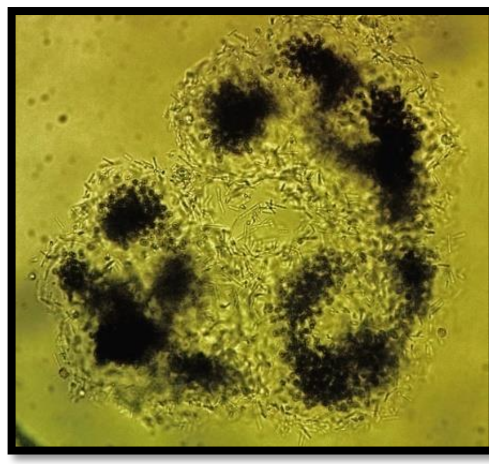


Blue Green: *Aphanizomenon*
This alga forms rafts of filaments (trichomes) composed of individual cells regulating their buoyancy in a manner similar to anabaena. Indeed, both types are regarded as genetically similar in spite of their morphological differences. Like anabaena it has the capacity to fix nitrogen from the atmosphere. Like anabaena it can produce the toxin cylindrospermopsin. It was the second most dominant cyanobacteria reported in Ontario Lake blooms as of 2009[1].

Blue-green colonial: *Microcystis*

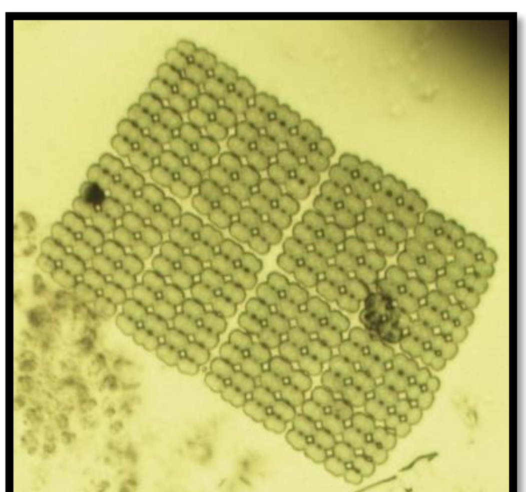
Each colony is composed of thousands of individual small cells imbedded in a clear polysaccharide matrix. The colony can move vertically through the water column controlled by thousands of buoyant chambers imbedded within each cell. Unlike anabaena they do not harvest nitrogen directly from the atmosphere. They respond to nutrient availability in particular to ammonium when it is released into the water by the senescence of aquatic plants at the end of the growing season. It has been shown they respond more quickly to utilize this than do other phytoplankton. This is especially so when phosphorus is in limited supply. Just such conditions are found in White Lake during September and October when we are most likely to see Microcystis blooms on the surface of the lake. The photo to the right illuminates the polysaccharide gel in which the cells are imbedded. Other organisms make use of this gel as well and it becomes colonized by bacteria.





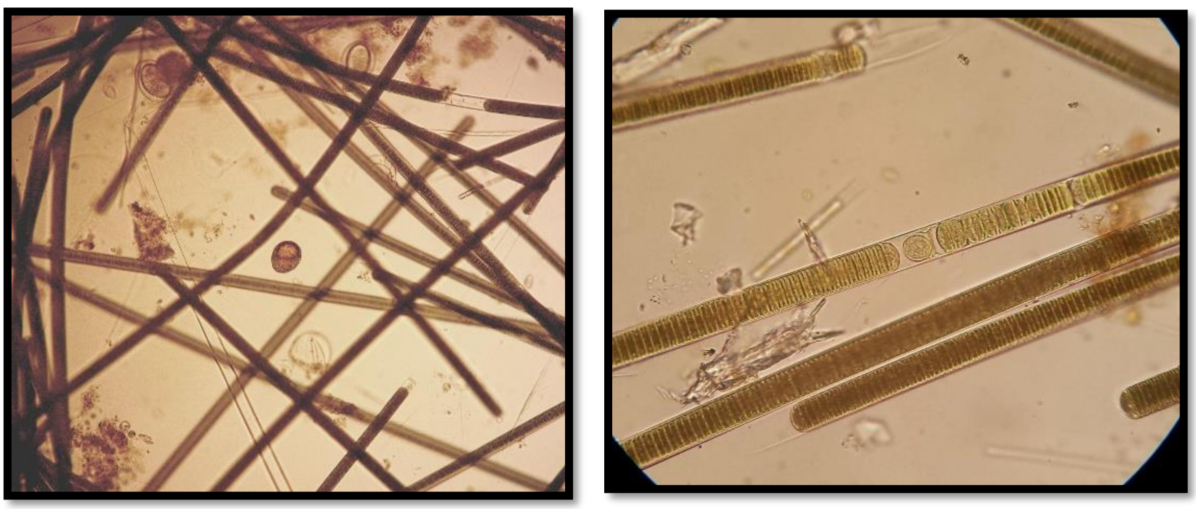
Blue Green colonial: *Merismopedia*

This large plate-like alga was encountered only in one of our samples during the 2022 season.



Blue Green Filamentous: *Lyngbya*

In previous years this large filamentous alga was very common in White Lake having been observed in large numbers as far back as 1964. Since 2016 extending to 2020 we did not see lyngbya in our lake samples. It began a return in 2020 and by 2022 it was seen regularly in our samples. This cycling of lyngbya coincides with the arrival, rise and decline in the zebra mussel population in White Lake. The Ontario Ministry of the Environment has monitored phytoplankton in Ontario lakes for several decades. Their 2011 report[1] shows trends in dominance for a variety of species of cyanobacteria based on reported algae blooms. Save for the Ocillatoriales, a group which includes lyngbya, all cyanobacteria show an increasing trend in dominance over the decades. However, Lyngbya shows a significant decline in dominance in Ontario's lakes. We propose dominance of some cyanobacteria is influenced by the presence of zebra mussels and the possibility for the reduction in dominance in lyngbya is in part a reflection of the spread of zebra mussel through Ontario's inland lakes during the time covered by this OME survey[1]. Photos below show lyngbya filaments occurring in White Lake in 2015.

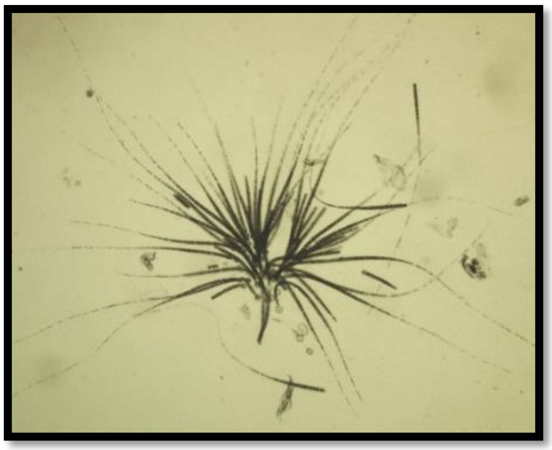


***Lyngbya* in Three Mile Bay August 29, 2015**

[1] Jennifer G. Winter, Anna M. DeSellas, Rachael Fletcher, Lucja Heintech, Andrew Morley, Lynda Nakamoto, Kaoru Utsumi:
Algal Blooms in Ontario, Canada: Increases in Reports Since 1994. Lake & Reservoir Management. 27:107-114, 2011

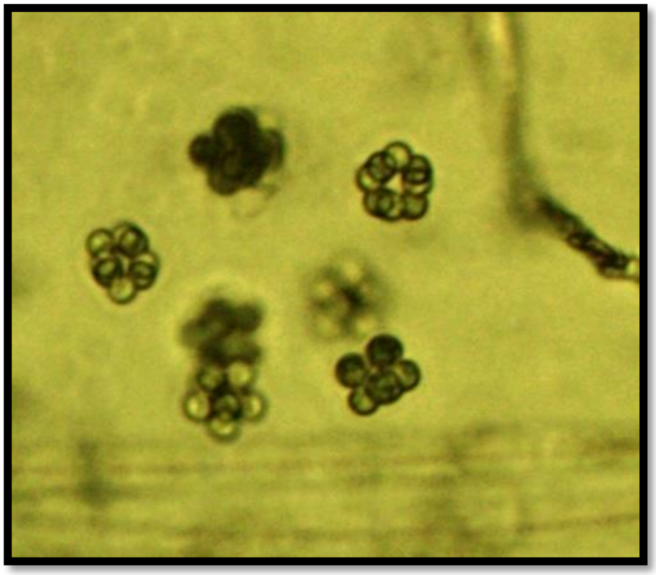
Blue Green Colonial: *Gloeotrichia*

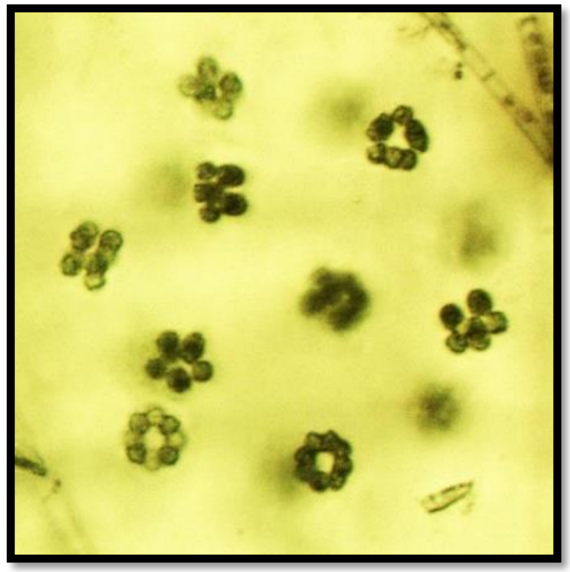
Gloeotrichia has the potential to form algal blooms. It is known to produce toxins. The colony is composed of tapering hair-like strands imbedded in a clear sphere of mucilage. At the inner end of each filament is a large buoyant cell similar to what is seen in anabaena.

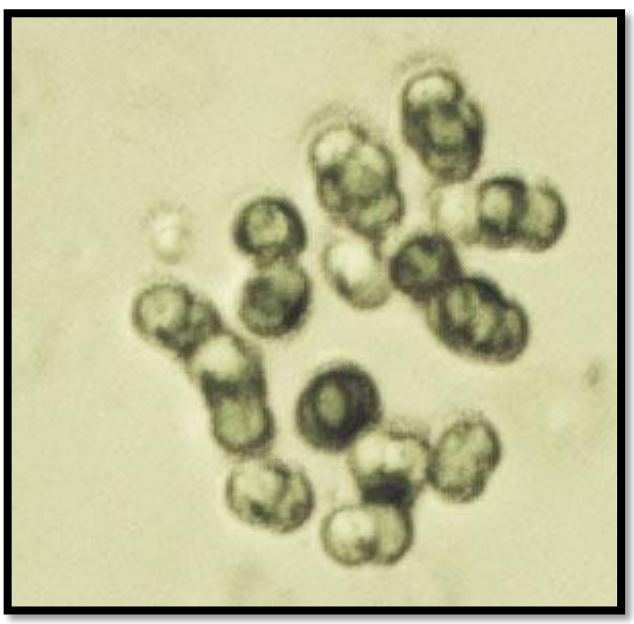


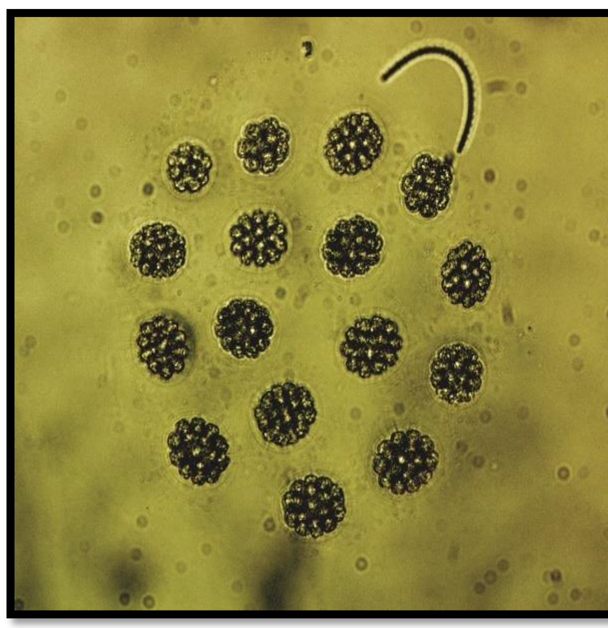
COLONIAL ALGAE: Unidentified

These examples of unidentified colonial algae were grouped into a single category for purposes of graphing. Their geometric ordering arises by cellular division. Each cluster of cells shares with other clusters a clear spherical gel containing the colony.









MYSTERIES YET TO BE INDENTIFIED

These strange items that were seen in our samples were included in our counts but remain unidentified.

THE OCCURRENCE OF PHYTOPLANKTON BY TYPE: Three Mile Bay 2022

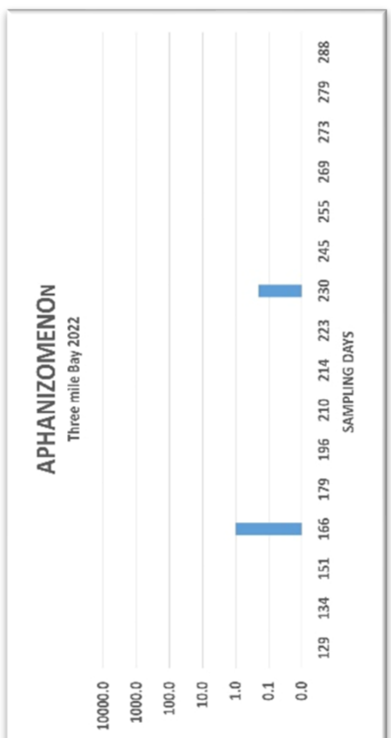
May 9th (Day 129) to October 15th (Day 288)

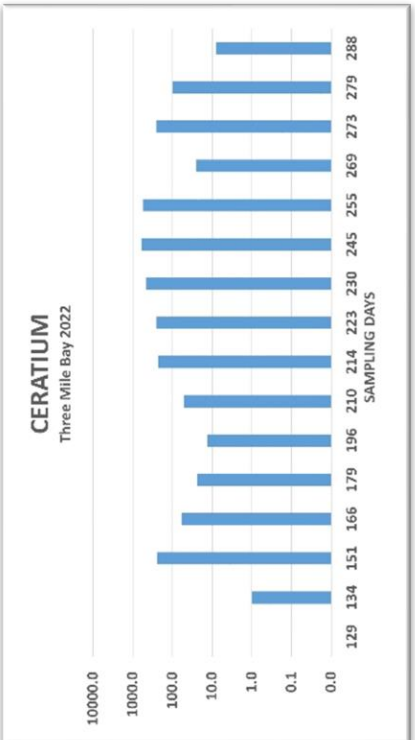
The graphs that follow show the occurrence of individual plankton types expressed as the log of raw counts on the Y axis. This allows us to see co-occurrences of various types when their counts vary by orders of magnitude. It is in the nature of phytoplankton to continually have temporary dominance of one or a few types with the diversity for all other types expressed by low numbers.

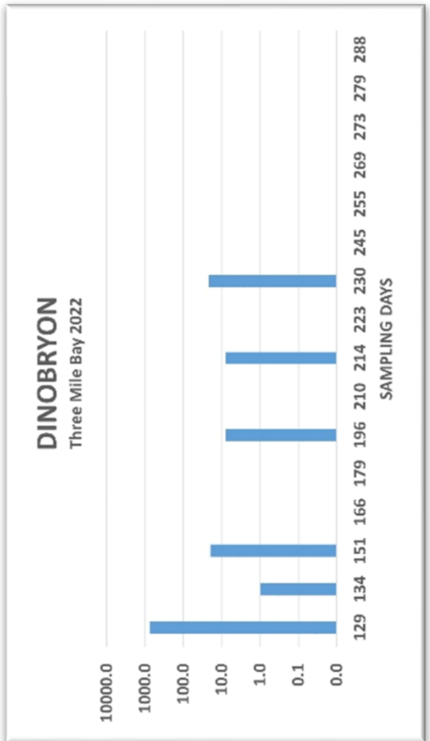

ANABAENA
Three Mile Bay 2022
10000.0
1000.0
100.0
10.0
1.0
0.1
0.0
129 134 151 166 179 196 210 214 223 230 245 255 269 273 279 288
SAMPLING DAYS

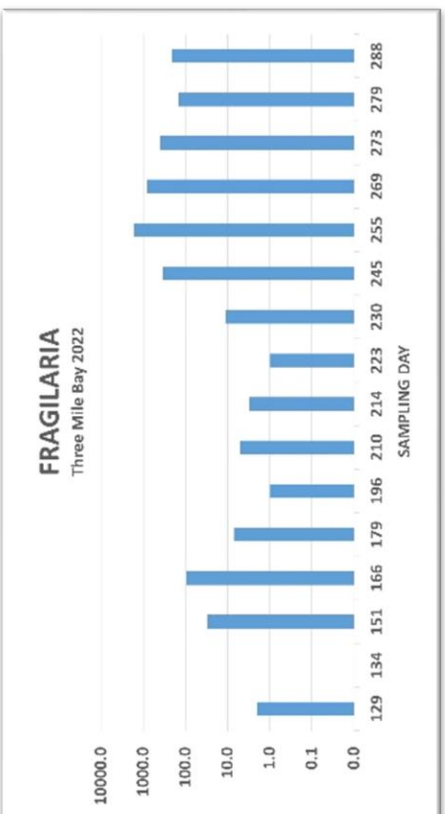

ASTERIONELLA
Three Mile bay 2022
1000.0
100.0
10.0
1.0
0.1
0.0
129 134 151 166 179 196 210 214 223 230 230 245 255 269 273 279 288
SAMPLING DAYS

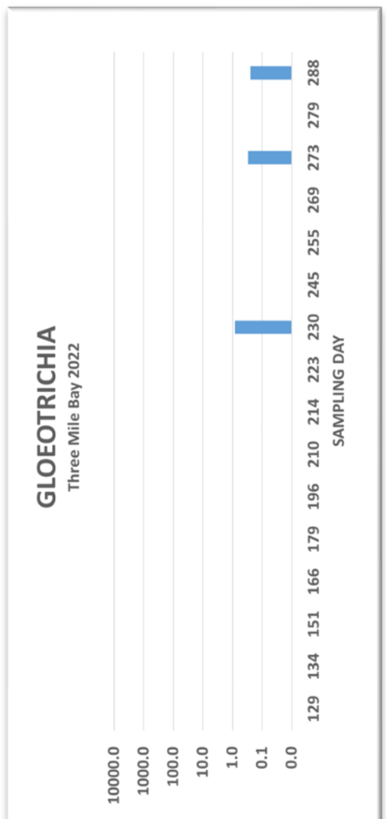

ASTREPHOMENE
Three Mile Bay 2022
10000.0
1000.0
100.0
10.0
1.0
0.1
0.0
129 134 151 166 179 196 210 214 223 230 245 255 269 273 279 288
SAMPLING DAYS

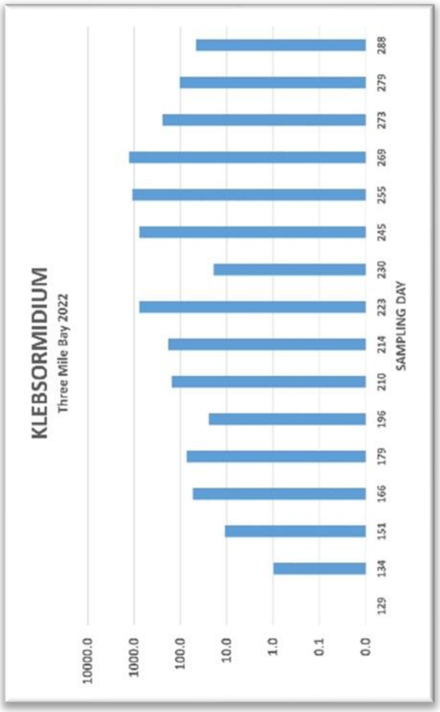

APHANIZOMENON
Three mile Bay 2022
10000.0
1000.0
100.0
10.0
1.0
0.1
0.0
129 134 151 166 179 196 210 214 223 230 245 255 269 273 279 288
SAMPLING DAYS

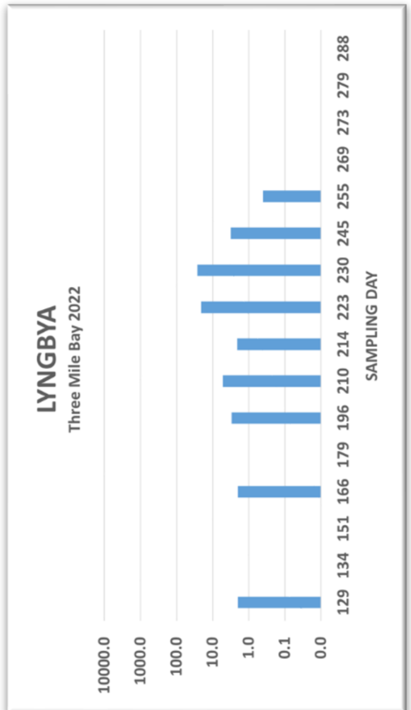

CERATIUM
Three Mile Bay 2022
10000.0
1000.0
100.0
10.0
1.0
0.1
0.0
129 134 151 166 179 196 210 214 223 230 245 255 269 273 279 288
SAMPLING DAYS


DINOBRYON
Three Mile Bay 2022
10000.0
1000.0
100.0
10.0
1.0
0.1
0.0
129 134 151 166 179 196 210 214 223 230 245 255 269 273 279 288
SAMPLING DAYS


FRAGILARIA
Three Mile Bay 2022
10000.0
1000.0
100.0
10.0
1.0
0.1
0.0
129 134 151 166 179 196 210 214 223 230 245 255 269 273 279 288
SAMPLING DAY


GLOEOTRICHIA
Three Mile Bay 2022
10000.0
1000.0
100.0
10.0
1.0
0.1
0.0
129 134 151 166 179 196 210 214 223 230 245 255 269 273 279 288
SAMPLING DAY


KLEBSORMIDIUM
Three Mile Bay 2022
10000.0
1000.0
100.0
10.0
1.0
0.1
0.0
129 134 151 166 179 196 210 214 223 230 245 255 269 273 279 288
SAMPLING DAY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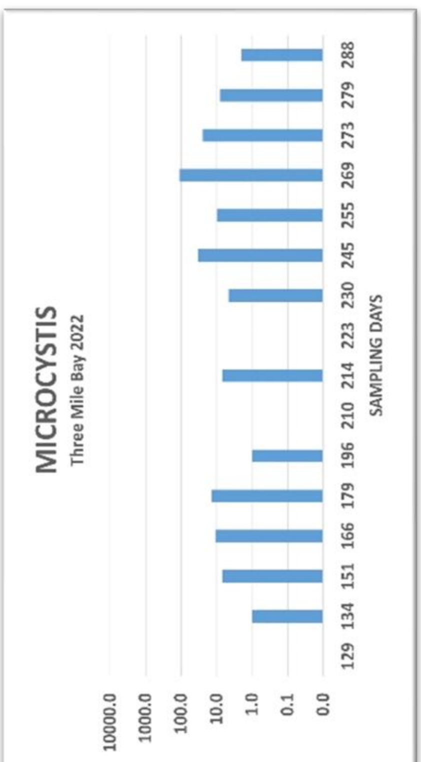
SAMPLING DAY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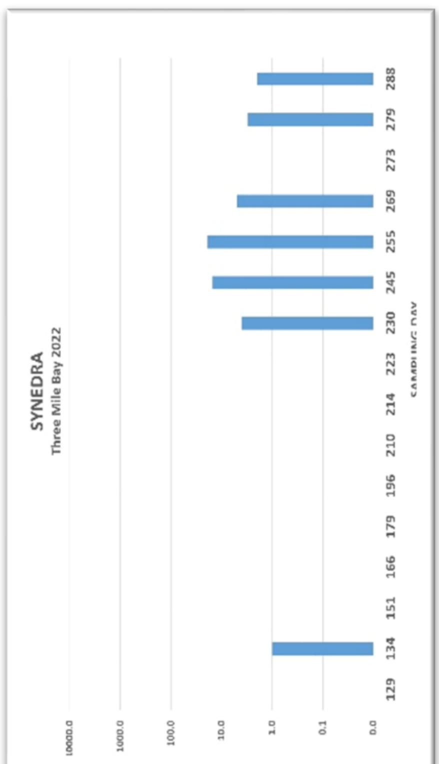
SAMPLING DAYS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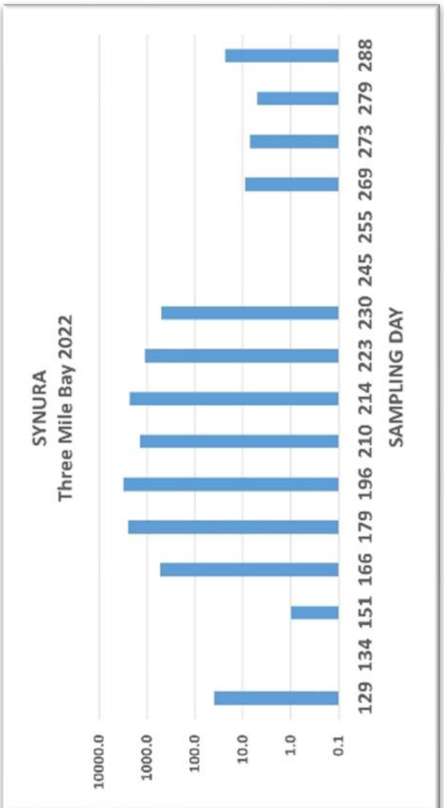
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129 134 151 166 179 196 210 214 223 230 245 255 269 273 279 288


TABELLARIA
Three Mile Bay 2022
SAMPLING DAY
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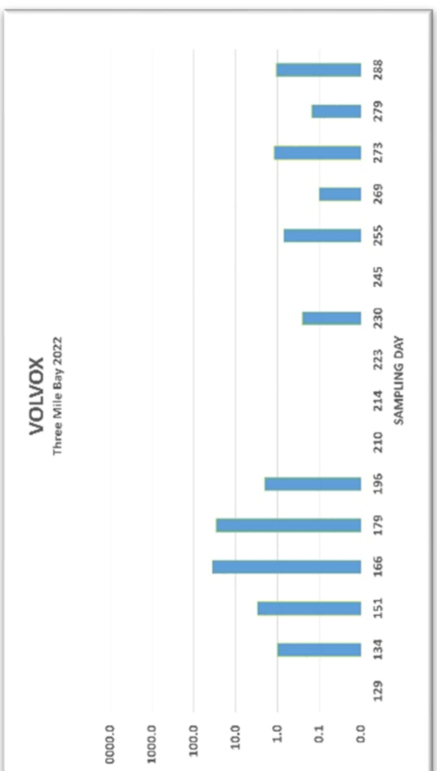
129 134 151 166 179 196 210 214 223 230 245 255 269 273 279 288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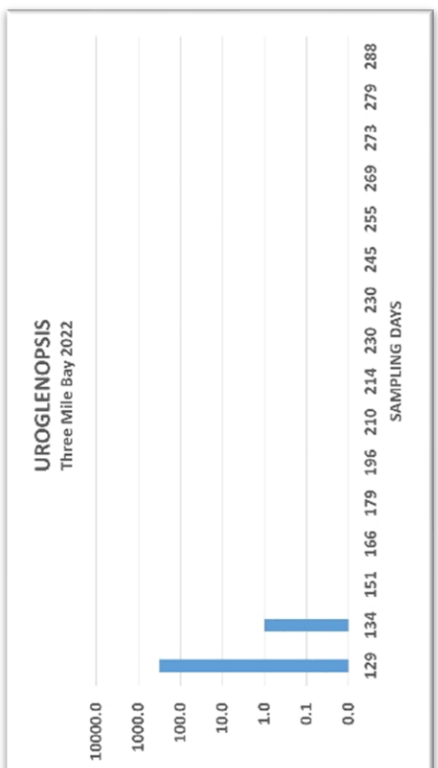
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SAMPLING DAYS
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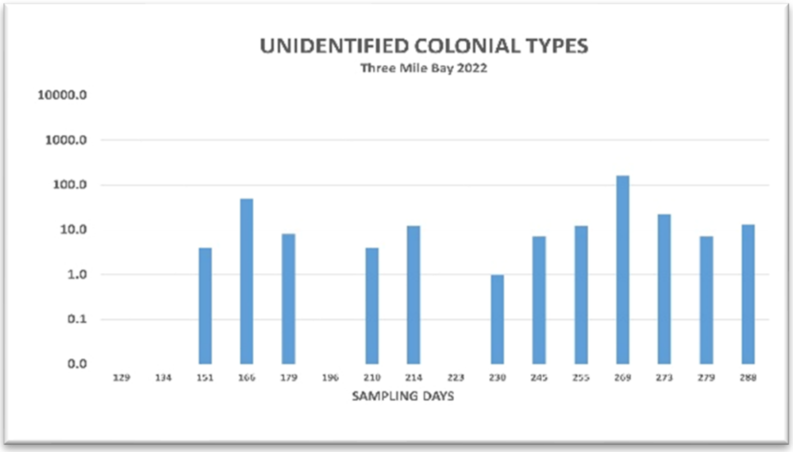
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134
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179
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245
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269
273
279
288
SAMPLING DAYS

THE DOMINANCE OF PHYTOPLANKTON TYPES IN WHITE LAKE 2022

The following graph shows relative dominance occurring on each sampling day as a cumulative percentage where each type is shown relative to the entire phytoplankton count. Type has been assigned a colour tint corresponding to the colour representing the group to which it belongs as indicated in the chart below:

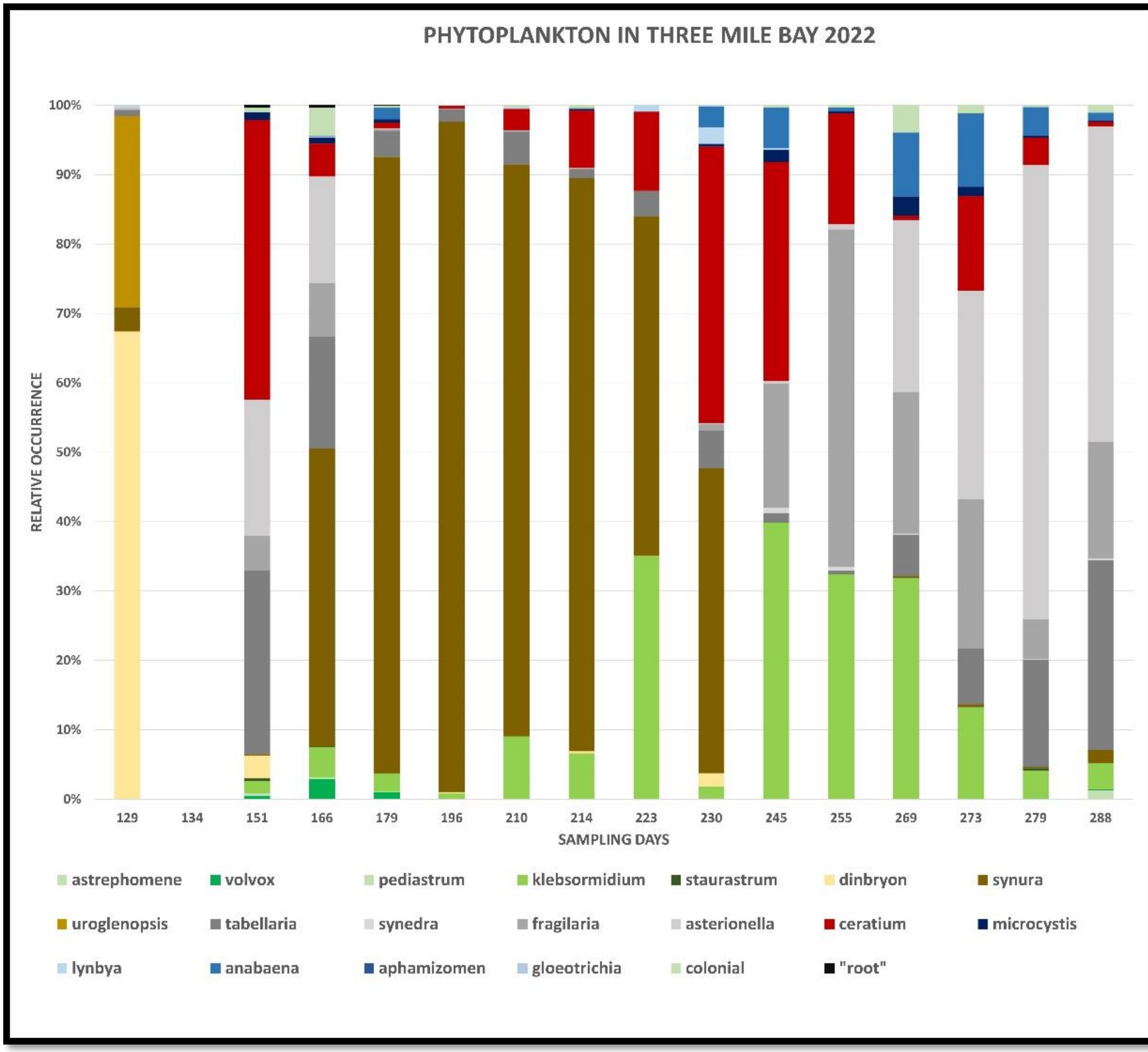
Common Names	Group	Assigned Colour
green algae	chlorophyte	greens
desmids	charophyte	deep green
golden brown algae	chrysophyte	yellows & browns
diatoms	bacillariophyte	greys
blue green algae	cyanobacteria	blues
	dinoflagellate	reds
unidentified colonies	?	pale green
unknown	?	black

The Three Mile Bay Sequence

This our most complete record, shows the dominance of spring chrysophytes- brownish to yellow tones, in particular dinobryon, seen on day 129 (May 9th). This includes the chrysophyte *uroglenopsis* which can live under ice during winter. Diatoms (grey tones) mark the internal mixing of waters prior to the rise of *synura,* a different chrysophyte (dark brown) which must prefer warmer waters. During the summer months *synura* dominates the water column. Green tones represent chlorophyte algae becoming more dominant as the water warms during the summer. With the beginning of fall dominance transitions once again to assemblages of diatoms. Diatoms will persist throughout the winter months (not shown).

Cyanobacteria shown here in blue tones increase in occurrence in the fall. In 2022 dominance of blue green algae peaked during a short-lived surface bloom which was visible on day 269 (September 26th). In spite of their large numbers forming observable scum on the surface it was the concentration of diatom types that dominated the water column on that day.

RELATIVE DOMINANCE OF PHYTOPLANKTON: Three Mile Bay



RELATIVE DOMINANCE OF PHYTOPLANKTON: OTHER SITES

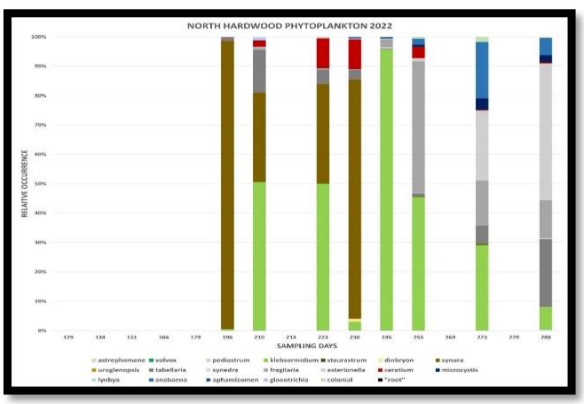
<u>North Hardwood Island, Pickerel Bay and Middle Narrows</u>

These sequences are incomplete. However, they show similar patterns in phytoplankton dominance with what was seen in Three Mile Bay.

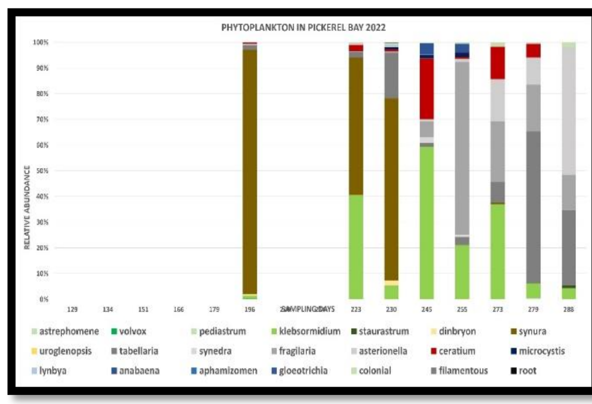
Synura dominates these waters during the summer with a comparable maximum dominance at all four sites on day 196 (July 16th), when the dominance by synura was great enough to suppress the registration of most other algal types on these graphs. Perhaps this kind of dominance could be described as a plankton bloom, only one that cannot be seen from the surface.

At North Hardwood Island on day 245 (Sept. 2nd), a unique dominance of the green filamentous alga klebsormidium was observed, more than what was found at the other sites.

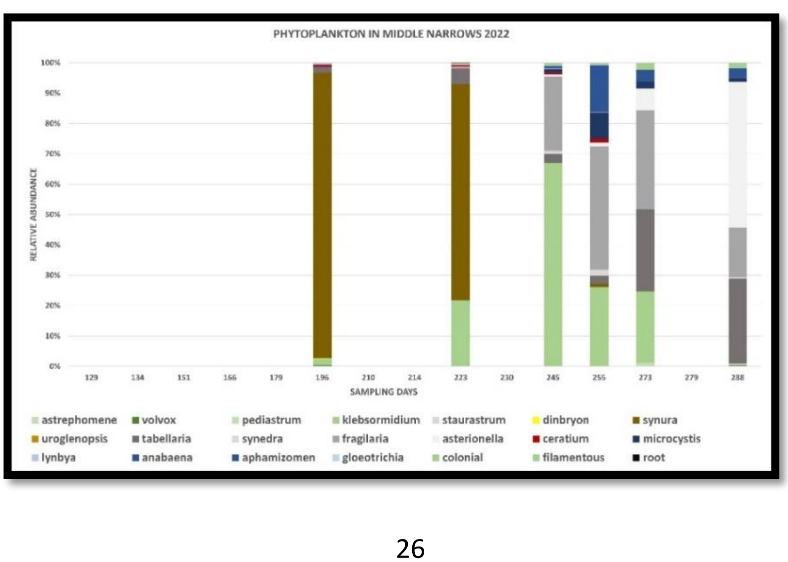
North Hardwood Island



Pickerel Bay



Middle Narrows



Appendix

Named Sampling Sites on White Lake