Ward Lake
Polk County, Wisconsin
Water Quality & Biological Assessment, LPL –1229-08

Ward Lake 1853

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Introduction

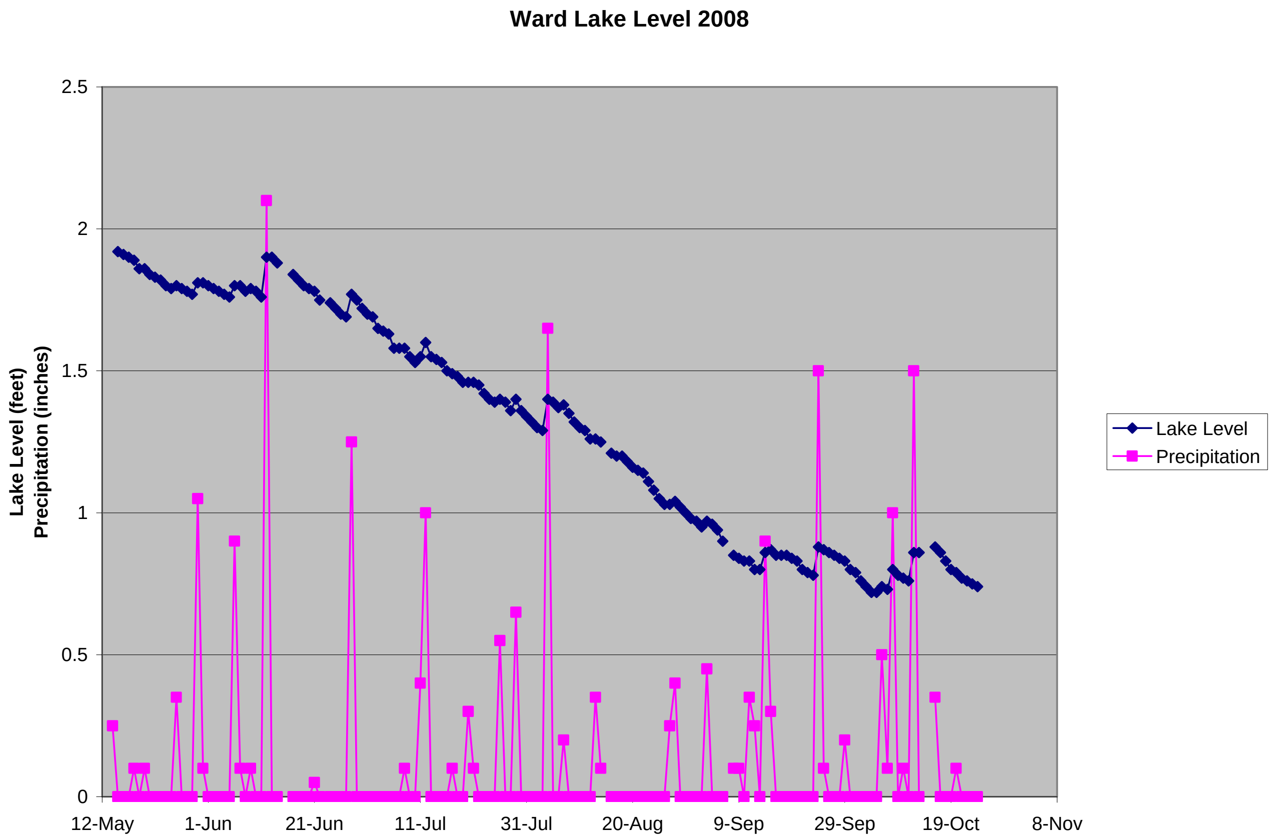
The study Ward Lake was performed by the Polk County Land and Water Resources Department with assistance from the Ward Lake Association and financial assistance from a Department of Natural Resources Lake Planning Grant (LPL-1229-08). The samples were collected during the growing season of 2008. This report characterizes the current physical, biological, and chemical status of Ward Lake.

Physical Setting and Properties

Ward Lake is a landlocked lake, fed by seepage from groundwater. The 95.6-acre lake is located in north central Polk County, nine miles northeast of Luck, Wisconsin, and a particularly vital natural area that is home to some of Wisconsin's most beautiful natural resources. The lake has a maximum depth of 45 feet and is surrounded by 2.1 miles of shoreline. Unfortunately, Ward Lake is 303D listed by the DNR meaning it has degraded water quality in the area of mercury.

The Ward Lake watershed consists of 448 acres, most of which lie to the west of the lake. The lake and its watershed are in the southwestern section of the watershed of the Clam River, a St. Croix River tributary that has been classified as an outstanding water resource by the Wisconsin Department of Natural Resources (WDNR).

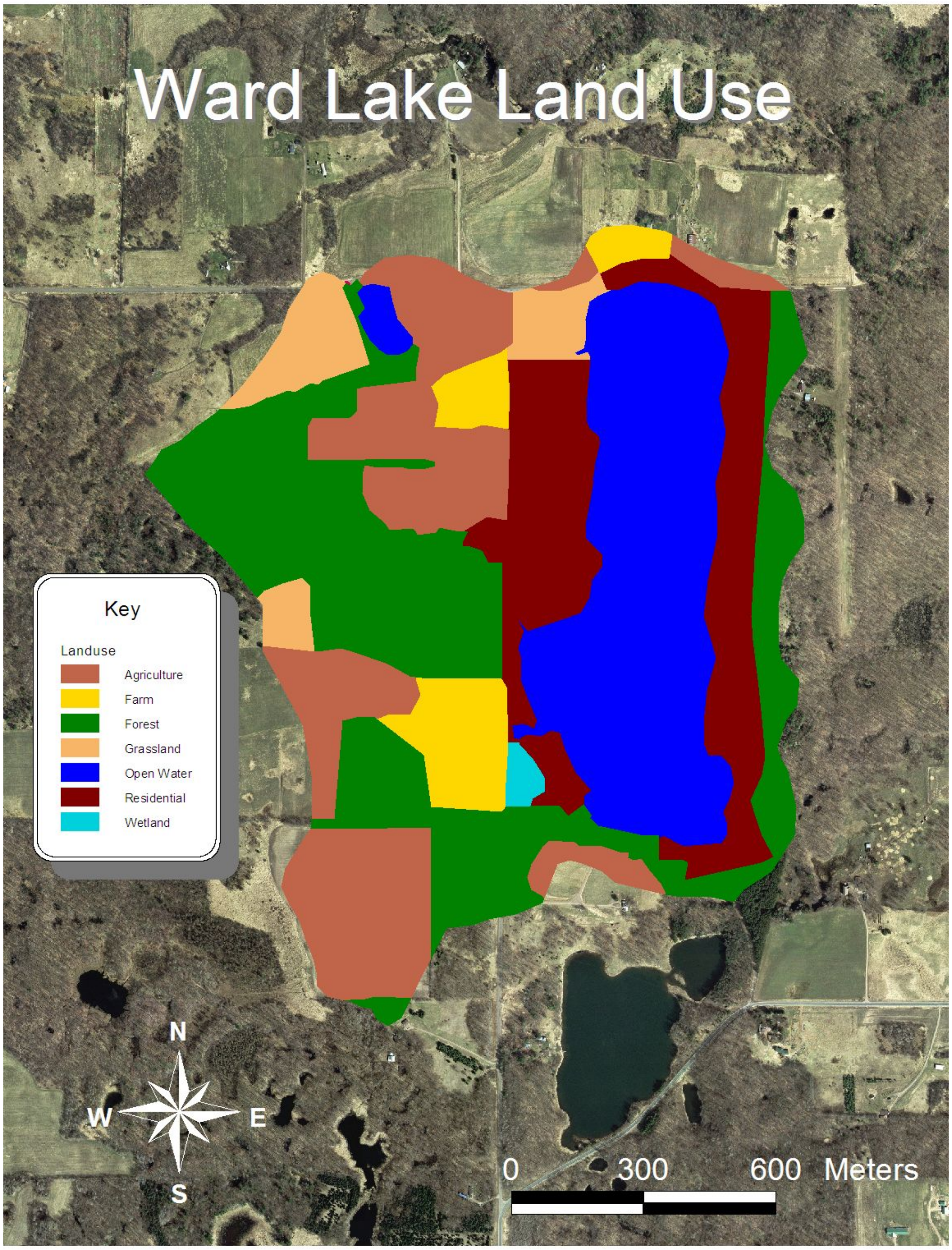
Precipitation in the area has an average annual rate of 31 inches. The lake level was recorded almost daily by volunteers during the summer and fall of 2008. Ward Lake received 20.5 inches of rain fall from May 13 to October 24th. The lake responded very little to precipitation events, indicating groundwater may be a larger source than surface water input. The seemed lake showed a response to rain events over 0.2 inches. From the highest level recorded to the lowest level, Ward Lake dropped 1.18 feet in 2008. With just over 20 inches of rainfall, evaporation obviously exceeded precipitation.



Ward Lake Level 2008
Lake Level (feet)
Precipitation (inches)
2.5
2
1.5
1
0.5
0
12-May
1-Jun
21-Jun
11-Jul
31-Jul
20-Aug
9-Sep
29-Sep
19-Oct
8-Nov
Lake Level
Precipitation

Watershed modeling

The Wisconsin Lake Modeling Suite (WiLMS) was used to model current conditions for Ward Lake and verify monitoring and in lake nutrient loading. Phosphorous is the key parameter in the modeling scenarios because it is the limiting nutrient for algal growth in most lakes.



Based on average evaporation and precipitation and runoff coefficients for Polk County soils the watershed load was calculated to be 200.1 pounds of phosphorous annually.   Septic systems accounted for about 14.2% according to the model. Because the land use that is considered agriculture is not actively cropped and additional model was run and the former crop fields were converted to grass/pasture. This dropped the loading rate to 144.3 pounds of total loading, with residential development being the biggest contributor (especially when the septic systems are also taken into account.

To model the internal load of the lake was estimated using in situ data quantifying the increases in phosphorous concentrations in the fall. The in situ data is used to do a phosphorous back calculation using the equation

$P_{\inf low} = P_{in-lake} \div \frac{FR}{\delta + FR}$ ($\delta = \sqrt{FR}$) where $P_{\text{in-lake}}$ = the mean annual total phosphorous concentrations and FR = the reciprocal of the retention time. This provides some indication of the applicability of models to Wisconsin lakes. Using this method it was predicted that Ward Lake loses 27 pounds of phosphorous through the thermo-cline where it is deposited to the sediment. This is to be expected in a deeply stratified lake. Continuous nutrient data should be taken in order to continue a trend and update the lake's nutrient budget as needed (especially as land-use changes, as residential development is the biggest contributor).

This data was used to select the 1979 Reckhow Natural Lake Model:

$P = \frac{1000L}{11.6 + 1.2q_s}$ where P is the predicted mixed lake total phosphorous concentration in mg/m^3, L is the areal total phosphorous load in mg/m^2 of lake area/year and q_s is the areal water loading or surface overflow rate in m/year. This model was a great fit for Ward Lake as it predicted the total phosphorous water column concentration to be 19 mg/m^3 and the observed was 20 mg/m^3.

This is good news as this model can be run over and over with in situ data and will be able to predict the effectiveness of management and/or land use change.

Runoff Samples

The 2000 study identified seven inflow culverts around Ward Lake where seasonal runoff enters. In order to assess watershed influence and areas contributing non-point loading, stormwater runoff events were sampled. Starting in May, rain events during the growing season were sampled by lake volunteers at road side culverts and analyzed for nitrate plus nitrite, ammonium, TKN, TP, SRP, Cl and TSS. This will help identify any areas in the watershed where additional BMPs may be necessary.

Starting from the south the sample sites were as follows: A, B, B2, and C. The results are in the following table, with the averages in bold.

SITE A	Cl	NO 2+3	NH4	TKN	TP	SRP	TSS
5/25/08	3.2	0.17	0.08	2.93	2.09	0.061	212
6/11/2008	2.1	0.1	0.08	1.49	0.722	0.053	123
6/27/2008	4.5	0.8	0.28	12.5	8.73	0.318	988
8/3/2008	5.8	0.9	0.31	0.77	0.267	0.077	19
	3.9	**0.4925**	**0.1875**	**4.4225**	**2.95225**	**0.12725**	**335.5**

SITE C	Cl	NO 2+3	NH4	TKN	TP	SRP	TSS
5/25/2008	0.5	0.12	<.01	0.7	0.087	0.031	5
6/11/2008	3.5	0.5	0.13	1.97	0.346	0.193	28
6/27/2008	4.7	0.3	0.07	1.92	0.463	0.216	42
8/3/2008	1.3	0.9	0.04	2.39	0.621	0.088	175
	2.5	**0.455**	**0.08**	**1.745**	**0.37925**	**0.132**	**62.5**

SITE B1	Cl	NO 2+3	NH4	TKN	TP	SRP	TSS
6/11/2008	6.4	<.1	0.03	1.17	0.372	0.075	132
6/27/2008	5.2	0.9	0.95	5.51	0.992	0.331	171
	5.8	**0.9**	**0.49**	**3.34**	**0.682**	**0.203**	**151.5**

SITE B2	Cl	NO 2+3	NH4	TKN	TP	SRP	TSS
6/11/2008	1	1.4	0.24	3.5	1.19	0.484	39

Site A has the highest levels of nutrients. This could be due to the farming practices, or simply because this culvert drains a much larger area. Regardless, outside of small residential practices, such as riparian buffers, raingardens, and other infiltration practices; this area has the highest potential to control phosphorous. I detailed survey should be done in order to accurately delineate the subwatershed, so appropriate Best Management Practices (BMPs) could be installed.

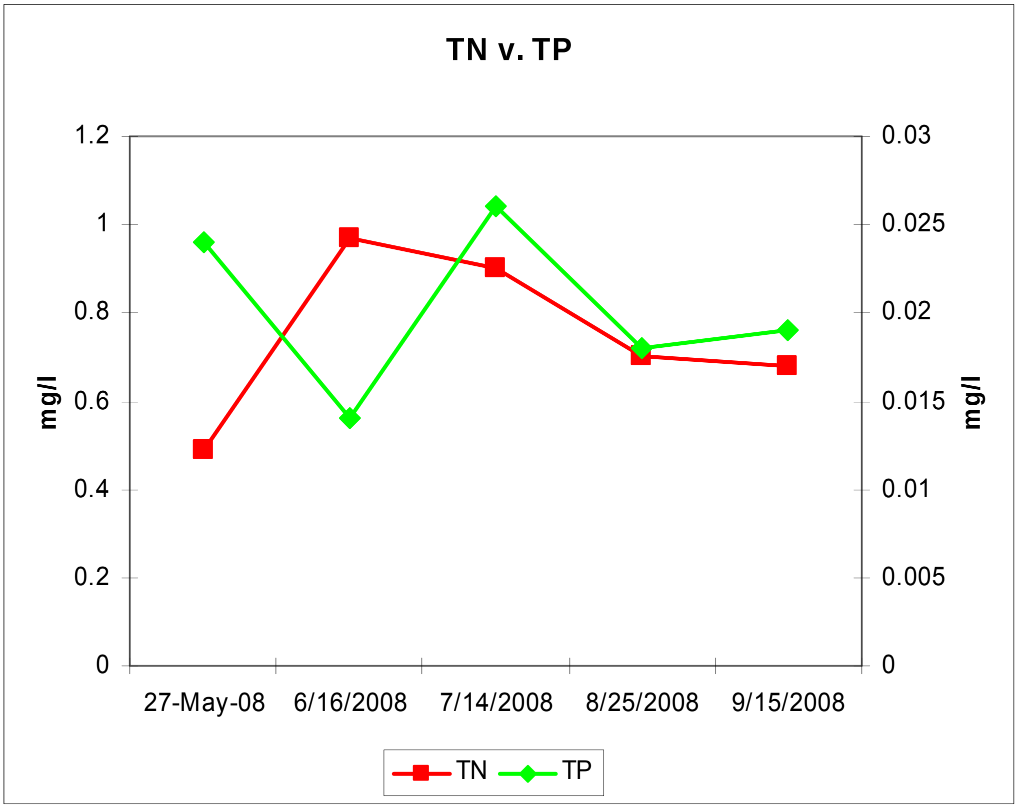
In-Lake Water Quality

Water quality samples were collected five times on Ward Lake at the deep hole in 2008. All samples were analyzed for two types of phosphorus, three types of nitrogen, chlorophyll a, and total suspended solids.

Total phosphorus concentrations in Ward Lake averaged 0.020 mg/L, ranging from 0.018 to 0.024 mg/L. Total phosphorus includes phosphorus bound in plant and algae matter, suspended in the water column attached to fine particles, and dissolved in the water column. It is an indicator of how much phosphorus is in the system. This total phosphorus concentration is quite low for Polk County; however, Ward lake is quite deep for a lake of its size. Shallow systems do tend to have higher phosphorous levels due to the land area : water volume ratio, such is typical in the glaciated part of Wisconsin. The soluble reactive phosphorus (SRP) is only the dissolved portion of phosphorus that is readily available to plants and algae. Ward Lake averaged 0.0095 mg/L SRP with a range from <0.002 to 0.024 mg/L. The highest reading was in mid-September and could be a blip from macrophytes and algae senescing, the other four readings were very stable and almost constant.

Nitrogen was also analyzed. The most abundant form of nitrogen found in Ward Lake was Total Kjeldahl nitrogen (TKN) at 0.602 mg/L. Kjeldahl nitrogen is organic nitrogen plus ammonium. Subtracting the ammonium concentration from TKN gives the organic nitrogen found in plant and algae material in Ward Lake (0.426 mg/L). The two forms of nitrogen (nitrite-nitrate and ammonium) that are readily available were also abundant at 0.23 mg/L and 0.176 mg/L respectively and an average total nitrogen value of 0.748.

Generally lake managers look fro a TN:TP ratio of 20:1. The ratio in Ward Lake is closer to 40:1. Elevated TN:TP ratios were also seen in other Polk County lakes over the last several years, likely due to drought conditions, promoting blue-green algae to fix nitrogen form the atmosphere. There is not a algae bloom problem in Ward Lake, so this should not be an issue in the future if/when climactic variables return to normal.

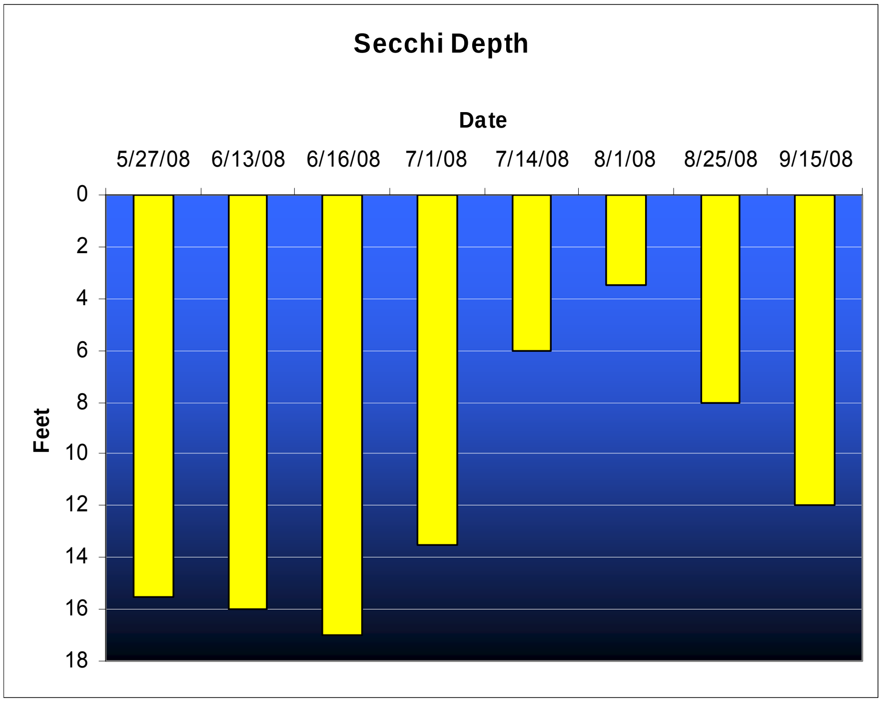


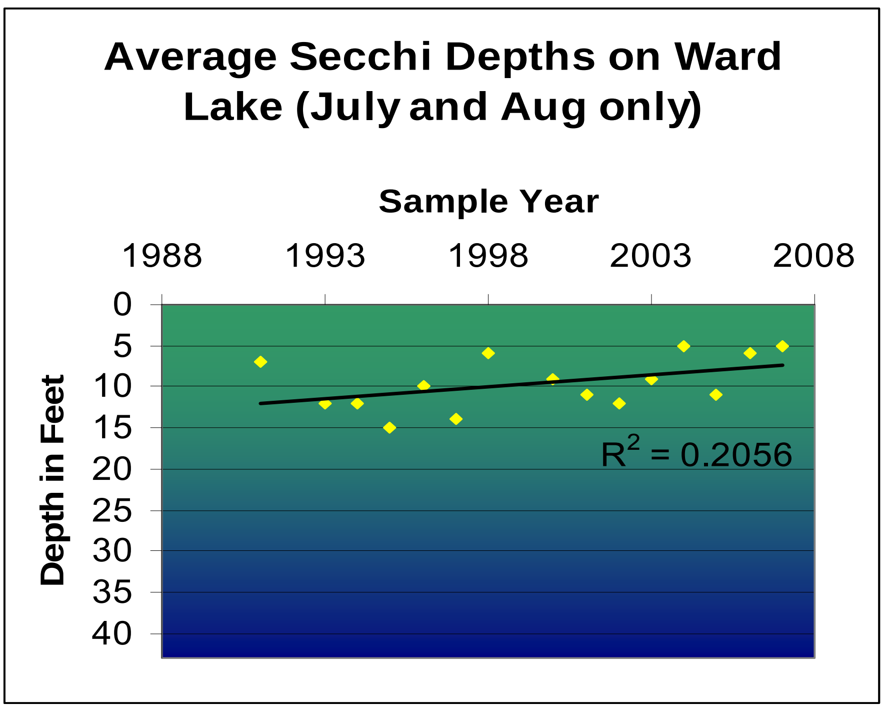
The total suspended solids were negligible, but did increase slightly with the algal "blooms".

The average chlorophyll a concentration in Ward Lake was only 7.8 mg/l. However the concentration was only 7 mg/l in May and June, and spiked to 18 mg/l by Mid-July, then back down to 7 mg/L in August. While chlorophyll *a* gives a general indication of the amount of algae growth in the water column, but cannot be directly correlated with biomass. Mildly eutrophic lakes can have chlorophyll *a* concentrations of 15 µg/L. Chlorophyll a is a good estimation of the amount of algae growth in the lake and should also be monitored with the nutrient suite.

This is all very encouraging for Ward Lake. However, Ward Lake has a very low alkalinity (levels of calcium as bicarbonate). Calcium is a positively charged cation that binds with negatively charged compounds. Phosphorus often takes the form of PO_4^- and binds with calcium, magnesium, iron, or aluminum. Since phosphorus is the driving factor behind algae blooms and there is not much calcium or other cations to bind with phosphorus in the lake, any additions of phosphorus will likely see immediate results in the water clarity. The cations buffer the water from nutrient additions. Ward Lake has a minimal ambient buffer. Much care should be taken to limit watershed nutrient additions to protect the water quality of Ward Lake.

The average Secchi depth in Ward Lake was 11.4 feet. Secchi depth is a measure of the amount of light that can penetrate the water column. The Secchi depth is affected by dissolved and suspended materials in the water column, as well as phytoplankton. The Secchi Depth has remained pretty constant since 1988.



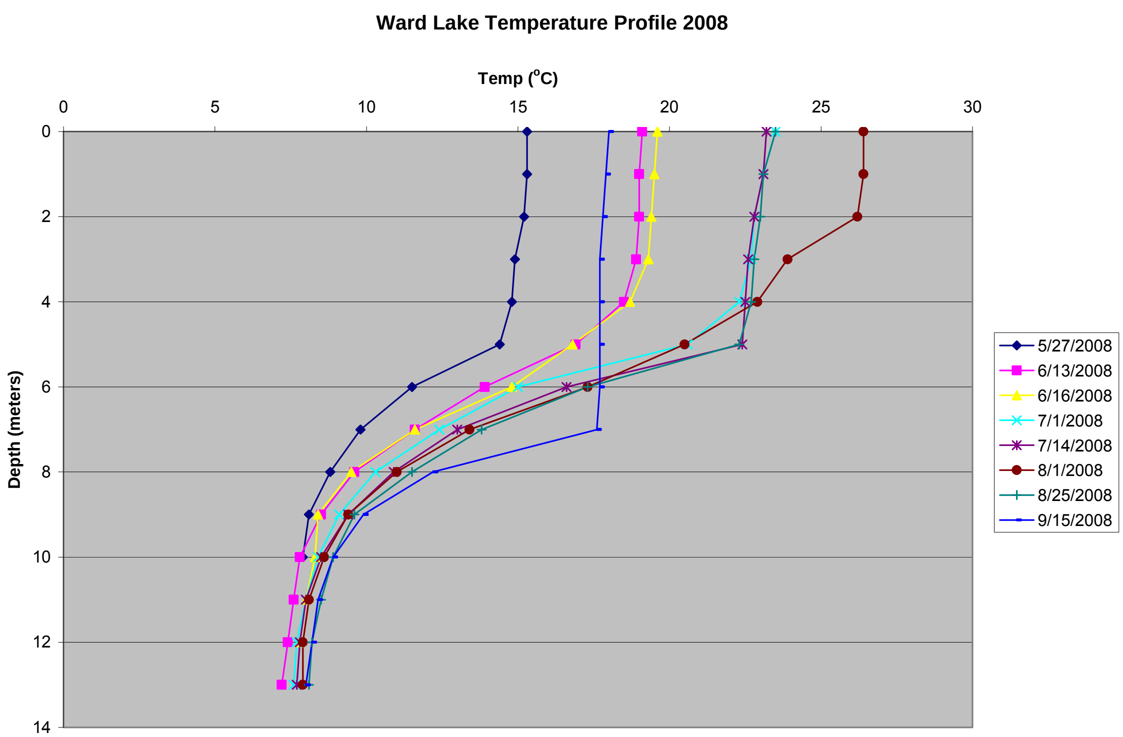


Water column profiles

Lake ecosystems are reliant on oxygen, carbon dioxide, and nitrogen that they obtain from the atmosphere to perform basic ecosystem functions. Oxygen is the most important element as it is required by all aquatic organisms in order to survive. The solubility of oxygen and other gases depends on the water temperature, the amount of wind mixing that brings water into contact with the atmosphere, the biological activity that consumes or produces gas within a lake, and gas composition of groundwater and surface water entering a lake.

The profile of Ward Lake was taken at the deepest point approximately every two weeks May through September. Using a YSI 85 multi-parameter probe; temperature, dissolved oxygen, conductivity, and salinity readings were recorded at each meter of water depth. The temperature and oxygen profiles of a lake are important to understand the mixing of oxygen and nutrients in the water column.

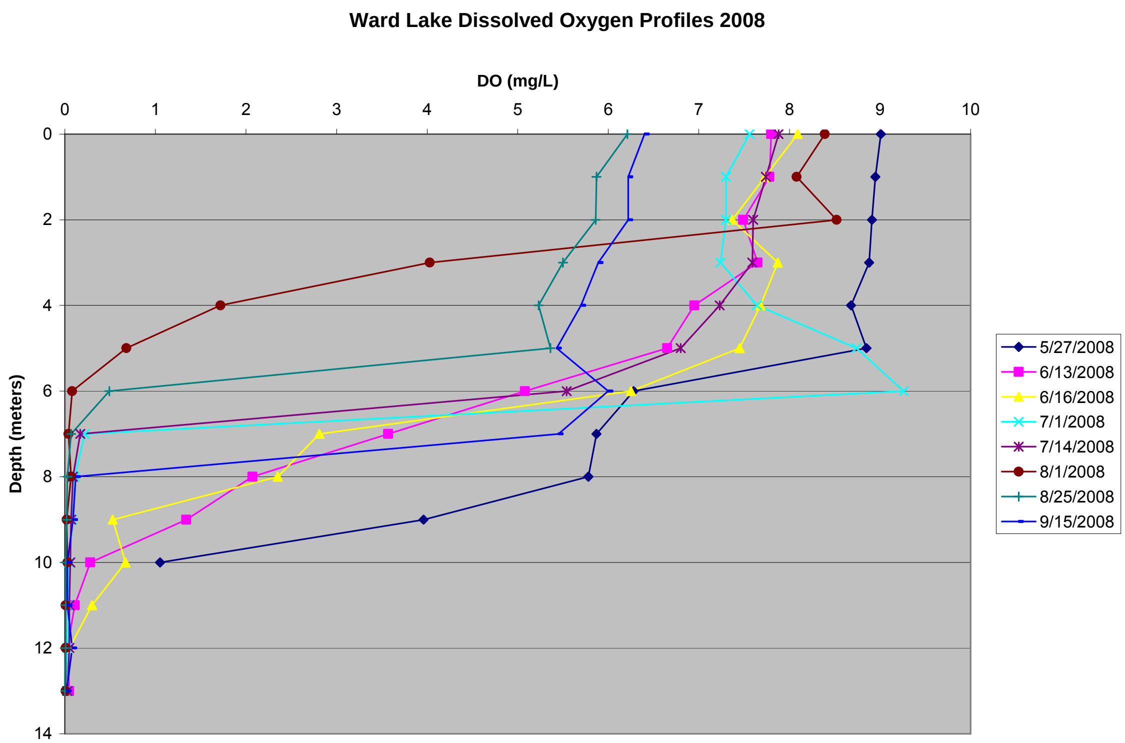
The warmest water temperature on the surface of Ward Lake was 26.4 ^{o}C on August 1, 2008. The coldest, measured lake water at the surface was 15.3 ^{o}C on May 27, 2008. The water temperature on any given day was 7-19 degrees different at the bottom of the lake than at the top, with the bottom staying very stable at 7 to 8 degrees Celsius.



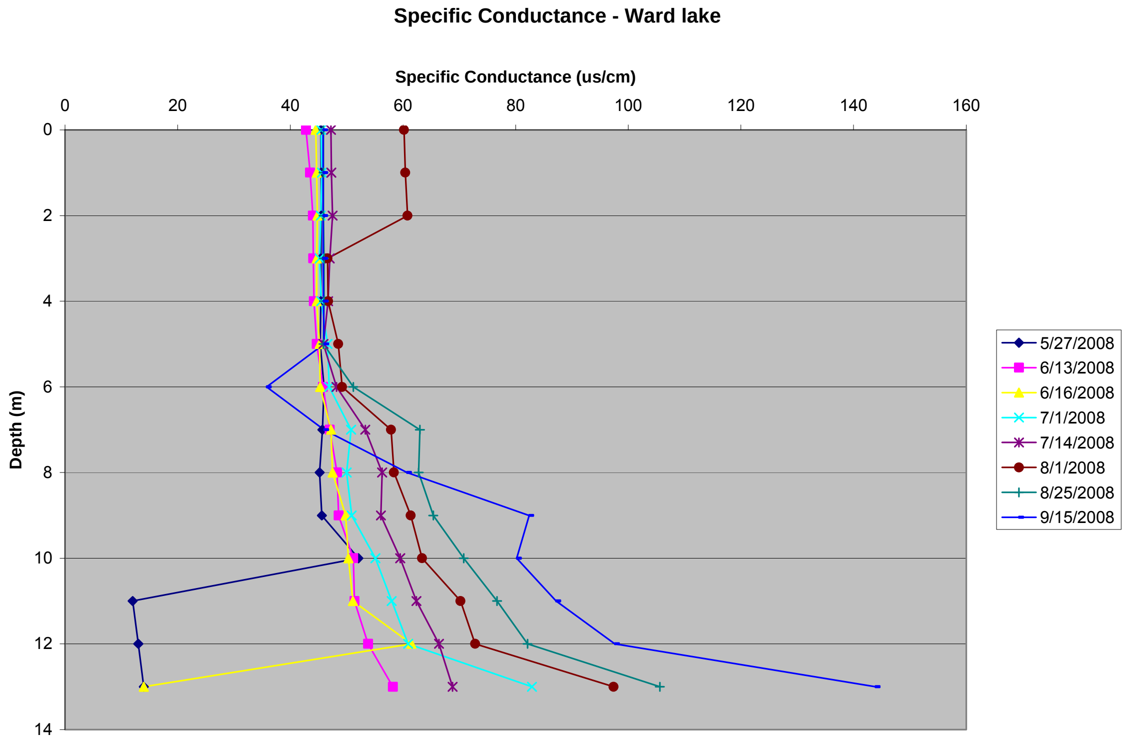
Ward Lake has a very stable thermo-cline that creates a density difference in the water that creates distinct layers in the water column; wind and wave action are not able to mix the water of the lake. These distinct layers allows for nutrient loss during the course of the growing season. As particles (and attached nutrients) fall through the thermo-cline to the hypolimnion (lower-layer), they are not able to be reincorporated into the epilimnion (the upper layer), thus helping to maintain water clarity.

The oxygen profile of Wild Goose Lake throughout the 2008 growing season is graphed below. The oxygen concentration ranged from 8.58 to 7.13 mg/L at the surface. The oxygen concentrations at the bottom of the lake (at 3 meters depth) ranged from 5.01 to 7.51 mg/L.

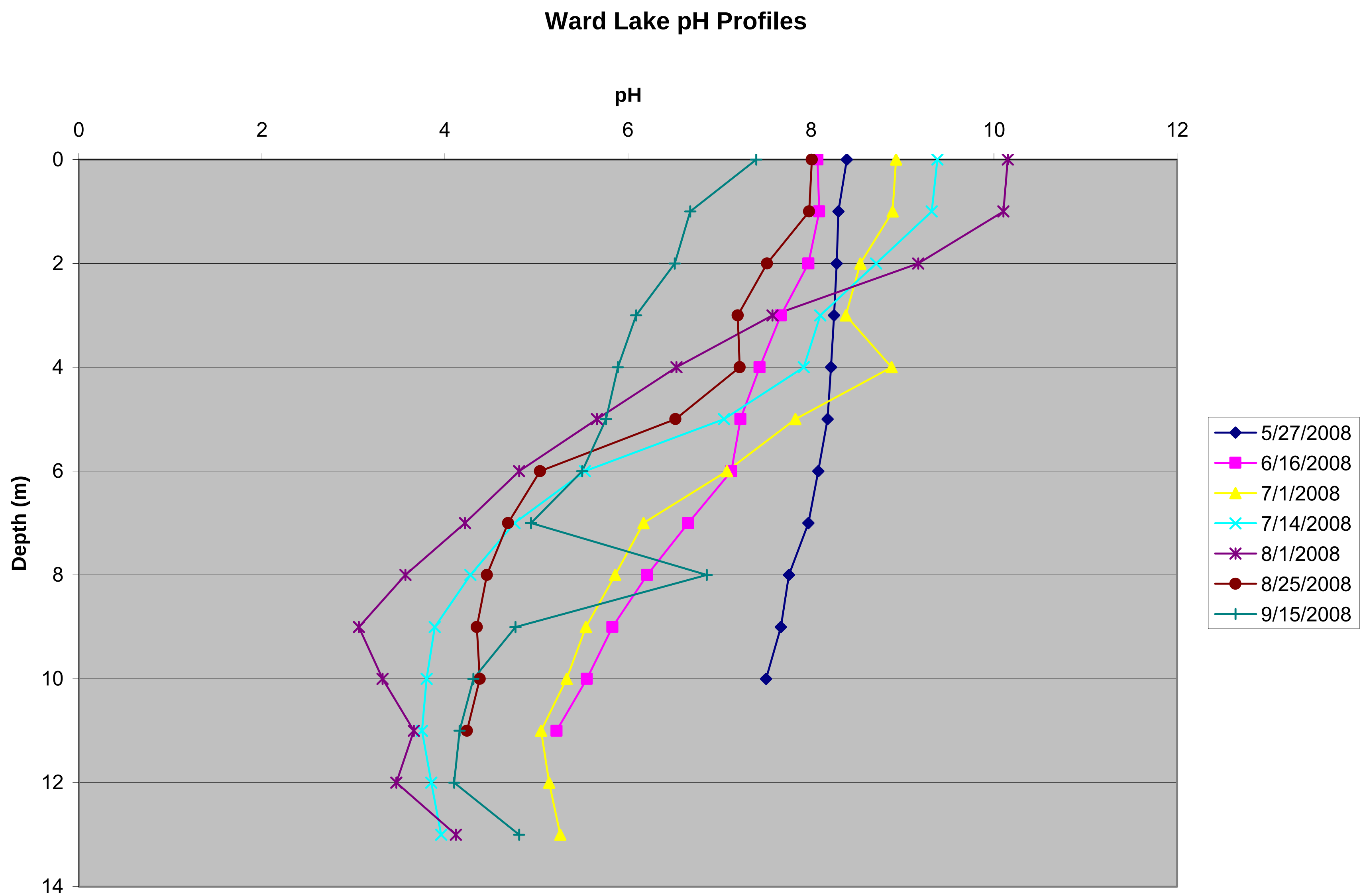
The oxygen profile of Ward Lake throughout the 2008 growing season is graphed below. The oxygen concentration ranged from 9.01 to 6.21 mg/L at the surface. The oxygen concentrations at the bottom of the lake (at 13 meters depth) ranged from 1.05 to 0.00 mg/L. Bacteria at the bottom of the lake consume the particles that continuously sink to the bottom. As the bacteria decay the organic matter they consume oxygen, often making the bottom of strongly stratified lake anoxic. This again shows how well mixed that Ward Lake is.



The specific conductance on Ward Lake is an indicator of the low alkalinity that was tested with the water samples. Specific conductance is simply conductivity (µS/second) normalized at 25°C. The specific conductance on Ward is one of the lowest in the county at the surface and indicates the Ward Lake may be more susceptible to change than some other lakes in the area.



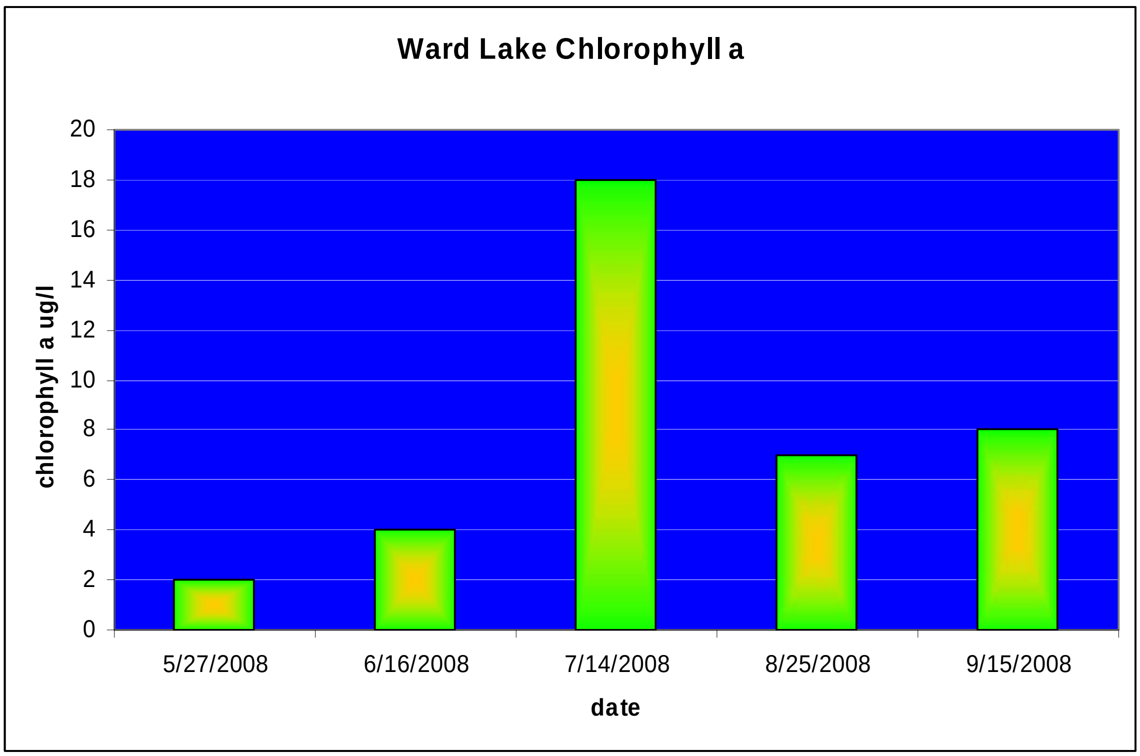
pH profiles were also taken on Ward Lake using a YSI 60 pH meter. Algae can cause the pH of a system to increase as it depletes the bicarbonate in the lake (of which Ward has very little). As can be seen on the chart below, July and August have surface pH 1.5 to two orders of magnitude higher than May, June, and September. This can be seen in the algae composition.


Ward Lake pH Profiles
pH
0
2
4
6
8
10
12
Depth (m)
0
2
4
6
8
10
12
14
5/27/2008
6/16/2008
7/1/2008
7/14/2008
8/1/2008
8/25/2008
9/15/2008

Chlorophyll *a* and Algae

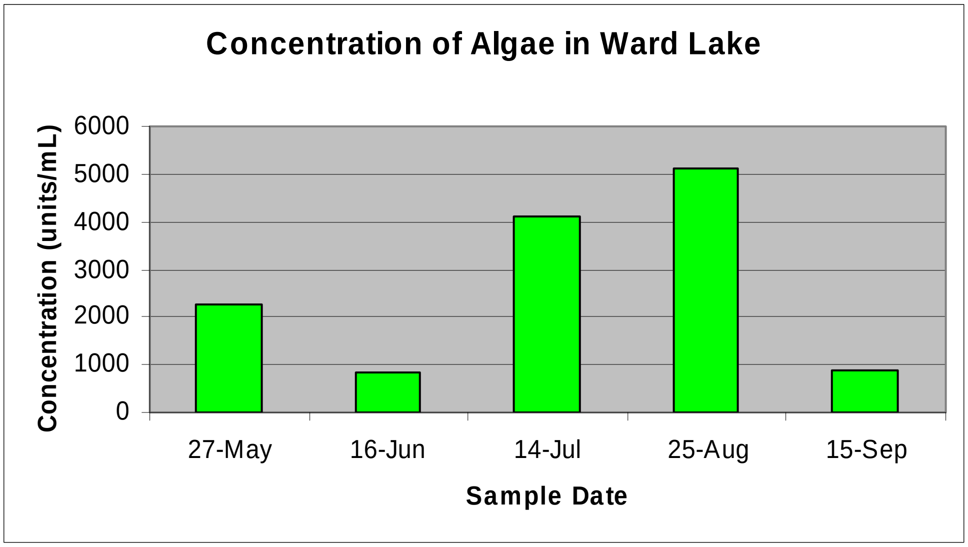
Each month algae samples were collected on Ward Lake to classify the type or division of algae in the water column. The samples were taken with a 6-foot composite sampler at the deep hole of the lake.

While algae are natural and essential to the food web, too much of the wrong class can cause problems. It is critical to know how much and what types of algae are present. All green plants and algae use chlorophyll to convert sunlight to useable energy during photosynthesis. All plants and algae contain chlorophyll *a*, but some also contain other types. Chlorophyll *a* is used as an indirect measure of algae in the water column. Ward Lake had an average chlorophyll *a* concentration of 7.8 ug/L. The values ranged from 2 ug/L in early May to 18 ug/L in mid-July. Ideally, chlorophyll *a* concentrations should be below 20 ug/L to maintain water clarity, so Ward Lake is in good shape.



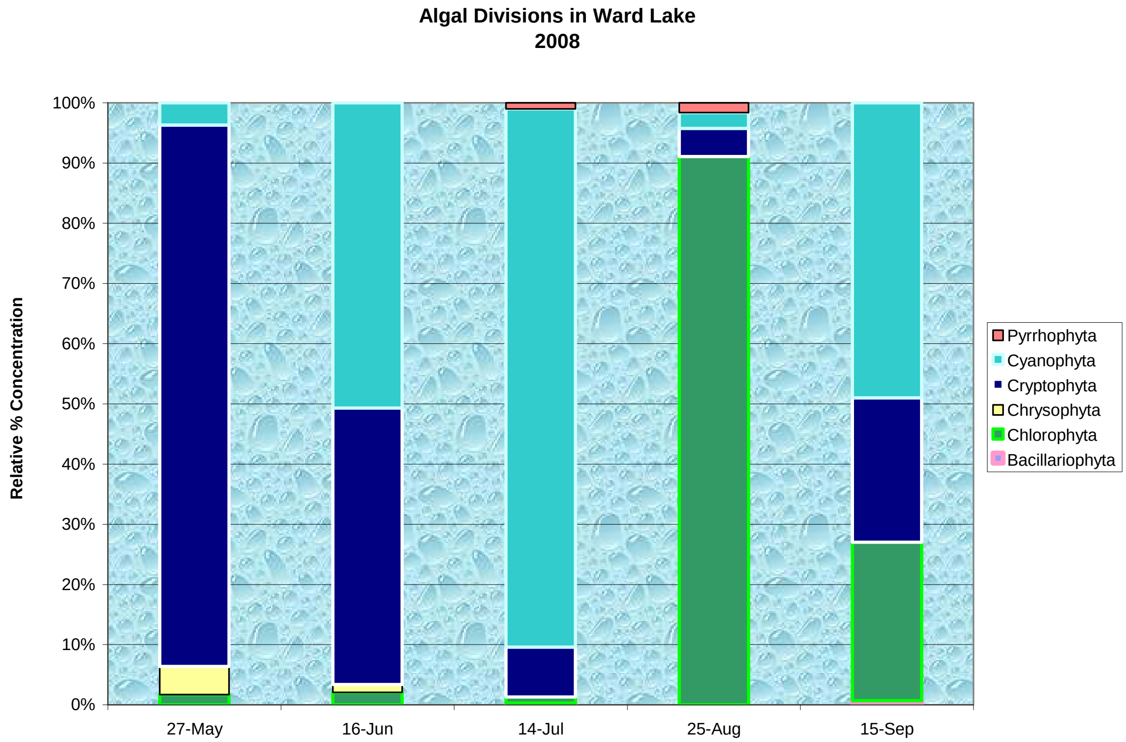
The types of algae in Ward Lake were also quantified. Plants and algae are the first link in the food web, but not all types of algae are as easily consumed by zooplankton in the lake. Six classes of algae were quantified in Ward Lake. These classes are Basillariophyta, Chlorophyta, Cryptophyta, Cyanophyta, and to a lesser extent Chrysophyta, and Pyrrhophyta.

The species composition of algal communities change seasonally in response to light, temperature, nutrients, grazing of zooplankton, and rain events. In Ward Lake, these factors changed the water conditions.   The August and September samples had a decreased chlorophyll a concentration , as well as, TP concentration, a slight decrease in overall algae concentration, but a moderate increase in algae counts.



As mentioned previously, phosphorus is often the limiting nutrient in a lake's water column; however increases in nitrogen can also have an effect on algal ystems. Some types of algae are able to capitalize on this. Cyanobacteria (blue-green algae) can acquire nitrogen from the atmosphere as a gas (N_2) instead of through the water column with a structure called heterocysts. They have a competitive advantage in Ward Lake where nutrients are low. In fact, blue green algae were the dominant algae type from mid-June through September.

While it appears as though the green algae take over and dominates the blue-greens in August, this is not the case. The dominant species of green algae in the month of August were *Chloromonas. sp*. and *Selenastrum sp.* both of which have a very small cell size and can appear to dominate in simple phytoplankton counts. The blue-green algae went from being dominated in July by *Microsystin sp.* to being dominated by *Annabaena sp*. and *Aphanizomenon flos-aquae* in August and September. In order to get an accurate picture of the algal community in Ward Lake a biovolume sample should be taken.

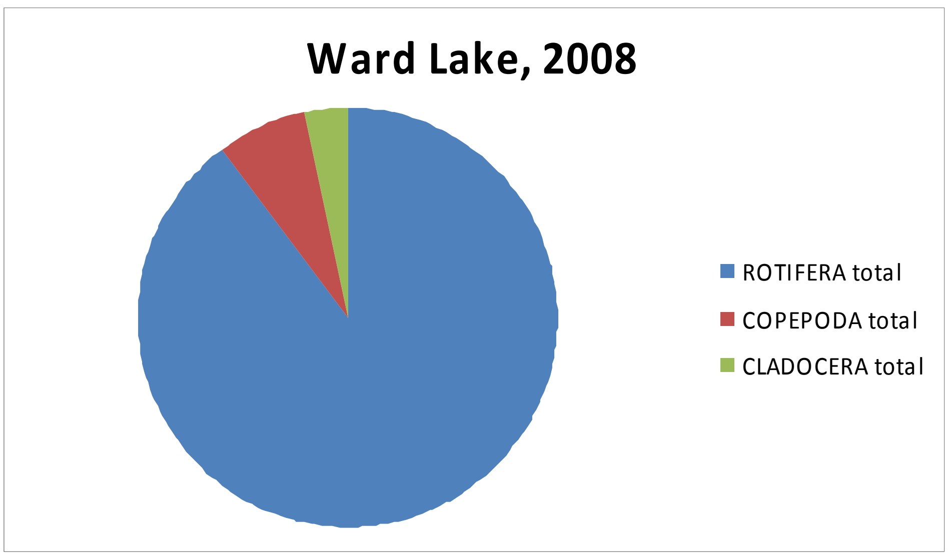


Ward Lake had an overall low concentration of algae in the lake. The concentration ranged from 840-5,125 units/ml of water. (Blue-green algae begin to produce toxins at 100,000 natural units/mL.) However, the relative concentration of blue-green algae in Ward Lake reached 90% of the population on one sampling date and to 50% on two other occasions.

Zooplankton

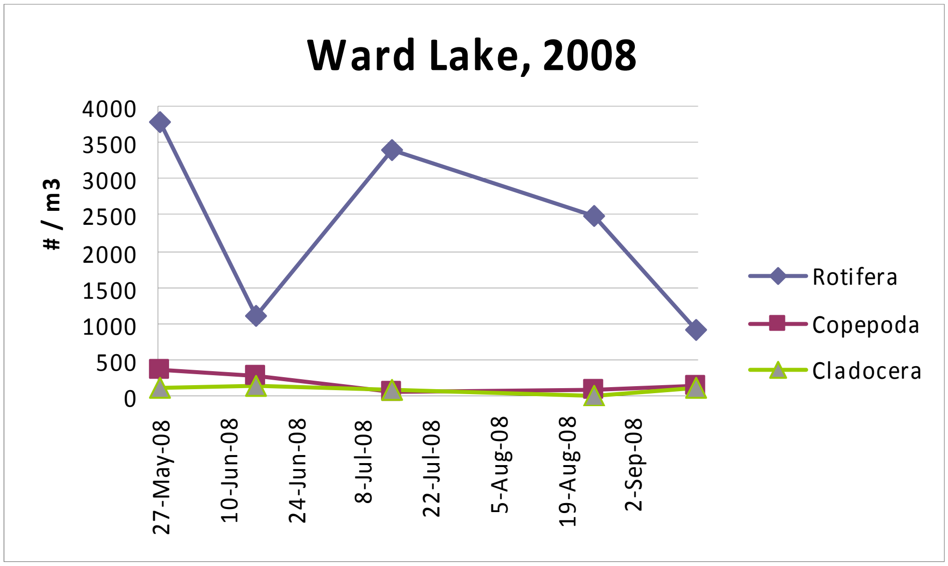
Zooplankton are small aquatic animals. They are one of the primary links between the processes of the lake ecosystems. For instance, zooplankton can mediate noxious algal blooms by heavy grazing *per se*. Selective, species-specific or size-specific grazing causes selective mortality among the phytoplankton, which in turn will affect the competitive balance between different phytoplankton species (Andersson 1988). A shift in algal species composition can change the zooplankton community, exacerbating the algal blooms and stressing the fish community, including the development of game-fish fry. Fish predation from planktivorous fish (pan fish) can drastically reduce zooplankton populations and also lead to algae blooms. In some lakes biomanipulation is used to manage this effect; using picivorous fish to reduce the planktivors, increasing zooplankton to reduce algae. This in turn improves the water clarity. With the healthy bass population in Ward Lake this could be an issue. With bass population rising and the increased size limit on large mouth bass many Northern Wisconsin lakes are seeing a shift in their fish communities affecting the zooplankton and algae. The DNR fish manager should be contacted to see where Ward Lake is at, with the bass control/walleye project.

Zooplankton also respond to changes to lakeshore and littoral zone community. Changes in aquatic plants, and shoreland habitat impact plankton either directly or indirectly (Lafrancois 2009).

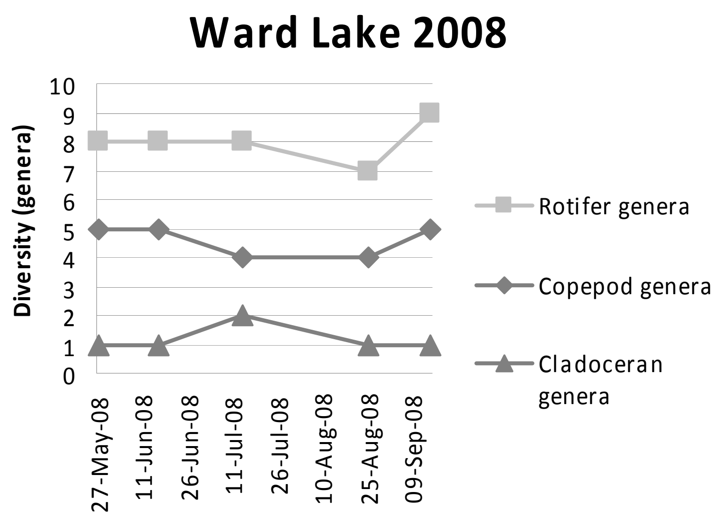


The three primary components of the zooplankton community are rotifers, copepods and cladocerans. Rotifers are size selective omnivores that eat algae, zooplankton and sometimes each other; they are not capable of reducing algal biomass. Copepods are also size selective omnivores, and are heavily preyed upon by fish. Some have specific feeding habits, and they are highly variable in size. Cladocerans are filter feeders that are an important part of the food web.

Species of cladocerans (particularly Daphnia) are well known in reducing algal biomass and helping to maintain a clear water regime in lake ecosystems. Below are the relative concentrations of the three major groups of zooplankton for Ward Lake in 2008.



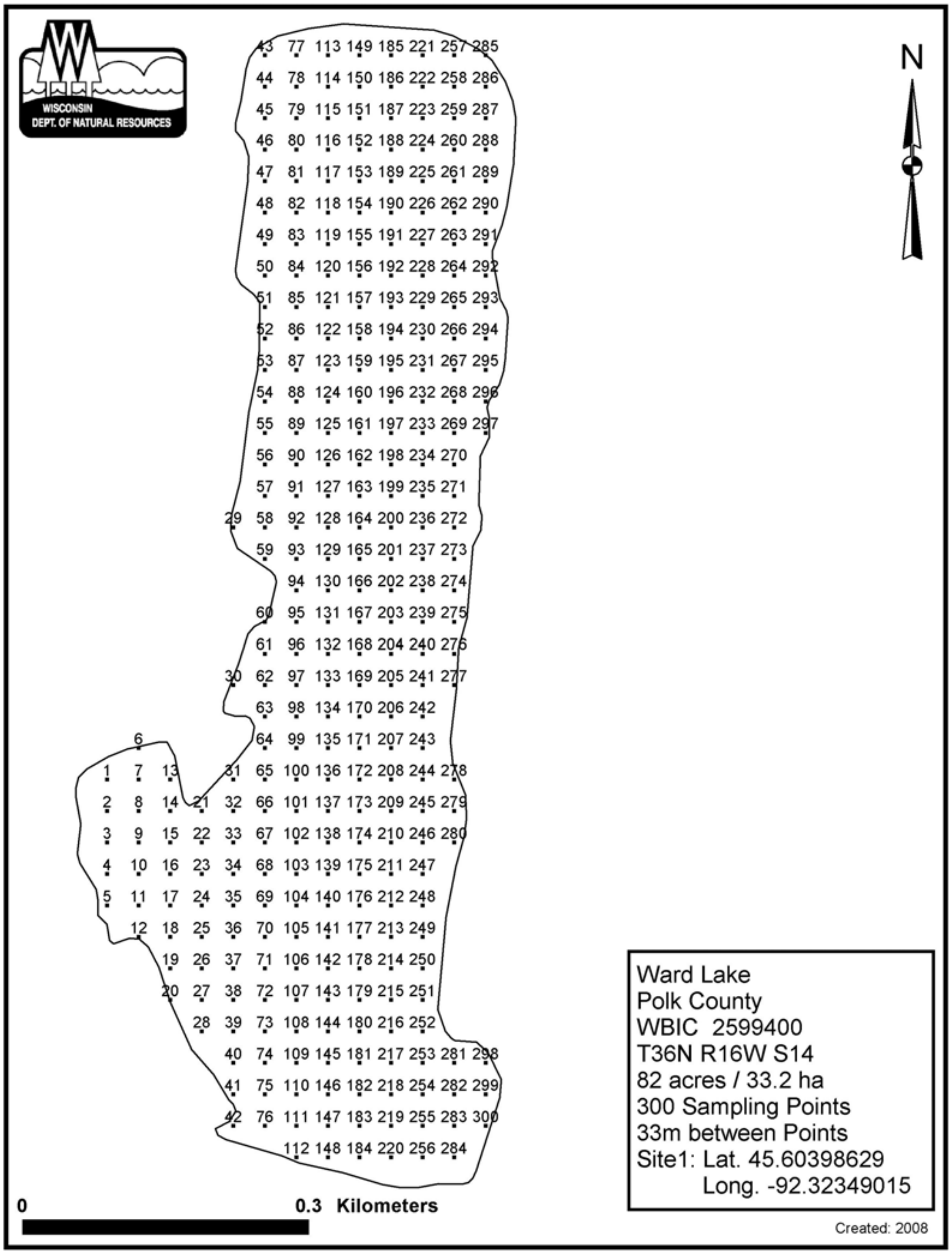
This analysis showed that the zooplankton population in the lake is characteristic of eutrophic (however Ward is not eutrophic) lakes with high predation by planktivorous fish. As seen the charts above the lake is dominated by rotifers; these are the smallest zooplankton and are tolerant of fish predation. However, the presence of some larger species in low numbers indicates good potential for a more robust zooplankton community that could be capable of mitigating an algae bloom, if one were to occur. There is a possibility that calcium limitation rather than fish predation is the cause of the zooplankton community structure. If that is the case, it is imperative that the in-lake plant community remain intact in order to mitigate nutrients that could cause an algae bloom in the future.



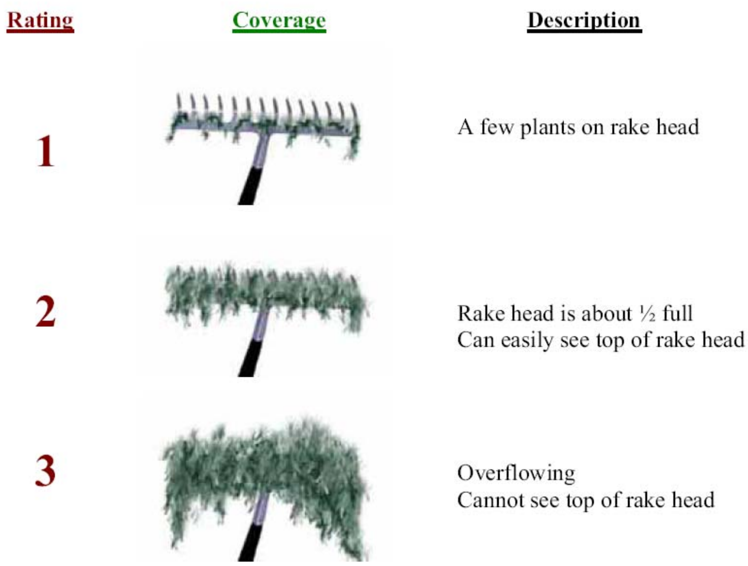
Monitoring zooplankton could be an indirect measure of the fisheries management in Ward Lake. As the bass population is reduced and the walleye and other beneficial picivores expand their dominance, this should be seen in the zooplankton population. Also, because of the low nutrient status of the lake the zooplankton and algae may respond faster to disturbance than the nutrient status. In my opinion word lake is a good candidate for biomontoring to assess lake health. Unfortunately, the benthic macroinvertebrate samples did not preserve well and were not useful for this report. However, monitoring the benthic chironomids in the lake may also provide some valuable information.

Aquatic Vegetation

The aquatic macrophyte survey was carried out on Ward Lake on August 7th, 2008. 300 sampling points were established in and around the lake using a standard formula that takes into account the shoreline shape and distance, islands, water clarity, depth and total lake acres. Points were generated in ArcView (a GIS program) and downloaded to a GPS unit. These points were then sampled in field.



All plants found were identified to species. During the point intercept survey, we located each survey point using a handheld mapping GPS unit, and each point, depth was recorded. Every point that was not too shallow or terrestrial was sampled (shallow communities were characterized visually). At each of these points, we used a rake (either on a pole or a throw line depending on depth) to sample an approximately 1 meter section of the benthos. All plants on the rake, as well as any that were dislodged by the rake were identified, and assigned a rake fullness value of 1 to 3 as an estimation of abundance (figure below). We also recorded visual sightings of plants within six feet of the sample point. Substrate (lake-bottom) type was assigned at each site where the bottom was visible or it could be reliably determined using the rake.



Rake fullness rating (UW Extension 2007)

Data collected was entered into a spreadsheet for analysis. The following statistics were generated from the spreadsheet:

- Frequency of occurrence for all sample points in lake
- Relative frequency
- Total sample points
- Sample points with vegetation
- Simpson's diversity index
- Maximum plant depth
- Species richness
- Floristic Quality Index

The following are explanations of the various analysis values:

<u>Frequency of occurrence for each species</u>- Frequency of occurrence is expressed as a percentage and there are two values for this. The first is the percentage of all sample points that this plant was sampled. The second is the percentage of littoral sample points that the plant was sampled. The first value shows how often the plant would be encountered everywhere in the lake, while the second value shows if only within the depths plants potentially grow. In either case, the greater this value, the more frequent the plant is in the lake. If one wants to compare to the whole lake, we look at the frequency of all points and if one wants to focus only where plants are more probable, then one would look at frequency in the littoral zone.

Frequency of occurrence example:
Plant A sampled at 35 of 150 total points = 35/150 = 0.23 = 23%
Plant A's frequency of occurrence = 23% considering whole lake sample.
This frequency can tell us how common the plant was sampled in the entire lake.

Relative frequency-This value shows, as a percentage, the frequency of a particular plant relative to other plants. This is not dependent on the number of points sampled. The relative frequency of all plants will add to 100%. This means that if plant A had a relative frequency of 30%, it occurred 30% of the time compared to all plants sampled or makes up 30% of all plants sampled. This value allows us to see which plants are the dominant species in the lake. The higher the relative frequency the more common the plant is compared to the other plants.

Sample sites with vegetation- The number of sites where plants were actually collected. This gives a good idea of the plant coverage of the lake. If 10% of all sample points had vegetation, it implies that about 10% of the lake is covered with plants.

Relative frequency example:
Suppose we were sampling 10 points in a very small lake and got the following results:
Frequency sampled
Plant A present at 3 sites 3 of 10 sites
Plant B present at 5 sites 5 of 10 sites
Plant C present at 2 sites 2 of 10 sites
Plant D present at 6 sites 6 of 10 sites
One can see that Plant D is the most frequent sampled at all points with 60% (6/10) of the sites having plant D. However, the relative frequency allows us to see what the frequency is compared the other plants, without taking into account the number of sites. It is calculated by dividing the number of times a plant is sampled by the total of all plants sampled. If we add all frequencies (3+5+2+6), we get a sum of 16. We can calculate the relative frequency by dividing by the individual frequency.
Plant A = 3/16 = 0.1875 or 18.75%
Plant B = 5/16 = 0.3125 or 31.25%
Plant C = 2/16 = 0.125 or 12.5%
Plant D = 6/16 = 0.375 or 37.5%
Now we can compare the plants to one another. Plant D is still the most frequent, but the relative frequency tells us that of all plants sampled at those 10 sites, 37.5% of them are Plant D. This is much lower than the frequency of occurrence (60%) because although we sampled Plant D at 6 of 10 sites, we were sampling many other plants too, thereby giving a lower frequency when compared to those other plants. This then gives a true measure of the dominant plants present.

Species	Common Name	Rlative Frequency (%)	Frequency of Occurance (%)
Elatine triandra	Matted waterwort	3.3	3.64
Juncus palocarpus f. submersus	Brown-fruited rush	4.9	5.45
Nitella	Nitella	1.6	1.82
Polygonum amphibium	Water smartweed	visual	visual
Potamogeton diversifolius	Common snail-seed pondweed	1.6	1.82
Potamogeton gramineus	Variable pondweed	visual	visual
Potamogeton natans	Floating-leaf	visual	visual
Potamogeton robbinsii	Robbins pondweed	85.2	94.55
Sagittaria graminea	Grass-leaved	1.6	1.82
Schoenoplectus tabernaemontani	Softstem bulrush	visual	visual

Species list and frequency values

Species richness-The number of different individual species found in the lake. There is a number for the species richness of plants sampled, and another number that takes into account plants viewed but not actually sampled during the survey. Ward is not a highly diverse lake with only 10 species being sampled, and 16 total when visual observations are counted.

Simpson's diversity index- Simpson's Index **(**D**)** measures the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species).

$$D = \frac{\sum n(n-1)}{N(N-1)}$$

Where D = Simpson's Diversity, n= the total number of organisms of a particular species, N=the total number of organisms of all species.
To measure how diverse the plant community is, Simpson's index is calculated. This value can range from 0 to 1.0. The greater the value, the more diverse the plant community is in a particular lake. In theory, the value is the chance that two species sampled are different. An index of "1" means that the two will always be different (very diverse) and a "0" would indicate that they will never be different (only one species found). The more diverse the plant community, the better the lake ecosystem.

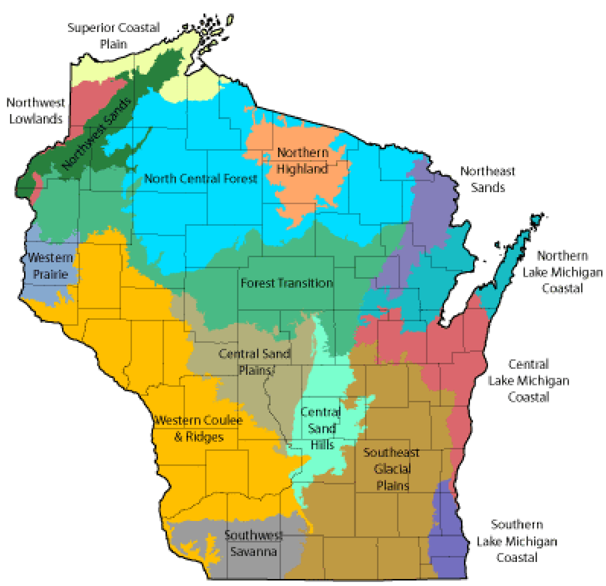
Simpson's diversity example:
If one went into a lake and found just one plant, the Simpson's diversity would be "0." This is because if we went and sampled randomly two plants, there would be a 0% chance of them being different, since there is only one plant.
If every plant sampled were different, then the Simpson's diversity would be "1." This is because if two plants were sampled randomly, there would be a 100% chance they would be different since every plant is different.

These are extreme and theoretical scenarios, but they do make the point. The greater the Simpson's index is for a lake, the greater the diversity since it represents a greater chance of two randomly sampled plants being different.

The Simpson's diversity index on Ward Lake was calculated to be 0.27.

<u>Maximum depth of plants</u>-This depth indicates the deepest that plants were sampled. Generally more clear lakes have a greater depth of plants while lower water clarity limits light penetration and reduces the depth at which plants are found. The maxium rooting depth on Ward Lake was fifteen feet (4.59 meters).

<u>Floristic Quality Index</u>- The Floristic Quality Index is designed to evaluate the closeness of the flora in an area to that of an undisturbed condition. It can be used to identify natural areas, compare the quality of different sites or locations within a single lake, monitor long-term floristic trends, and monitor habitat restoration efforts. This is an important assessment in Wisconsin because of the demand by the Department of Natural Resources (DNR), local governments, and riparian landowners to consider the integrity of lake plant communities for planning, zoning, sensitive area designation, and aquatic plant management decisions.
It takes into account the species of aquatic plants found and their tolerance for changing water quality and habitat modification using the equation $I = \overline{C}\sqrt{N}$ (where *I* is the floristic quality, $\overline{C}$ is the average coefficient of conservation (obtainable from http://www.botany.wisc.edu/wisflora/FloristicR.asp) and $\sqrt{N}$ is the square root of the number of species). The index uses a conservatism value assigned to various plants ranging from 1 to 10. A high conservatism value indicates that a plant is intolerant of change while a lower value indicates tolerance. Those plants with higher values are more apt to respond adversely to water quality and habitat changes. The FQI is calculated using the number of species and the average conservatism value of all species used in the index. Therefore, a higher FQI, indicates a healthier lake plant community. It should be noted that invasive species of a value of 0.



Wisconsin Eco-region Map (WDNR)

Summary of North Central Harwood Forest Values for Floristic Quality Index:
Mean species richness = 14
Mean average conservatism = 5.6
Mean Floristic Quality = 20.9*
*Floristic Quality has a significant correlation with area of lake (+), alkalinity(-), conductivity(-), pH(-) and Secchi depth (+). In a positive correlation, as that value rises so will FQI, while with a negative correlation, as a value rises, the FQI will decrease and vice versa.

Species observed for FQI = 10 (14)
Average conservatism = 7 (5.6)
Floristic Quality = 22.14 (20.9)

Based on the data collected the aquatic macrophyte community of Ward Lake is sensitive and is likely a barometer of the lakes health (particularly *Potamogeton diversifolius*). Ward Lake has a very low alkalinity and almost all of the plant observed have a very narrow range of alkalinity and pH where they are found. Additionally the isoetid part of the plant community (small near shore plants) is extremely sensitive to sedimentation as well. The aquatic plant community should constantly be monitored to assess the lakes health as traditional water chemistry measurements may not be sufficient to truly assess the health of Ward Lake, and monitor for invasive species.

Seed of *Potamogeton diversifolius* (Photo by Peg Wiggins)

Discussion

Ward Lake is very interesting system for Polk County. It is low nutrient, deep, and low alkalinity (calcium concentration).   Low calcium concentrations has several effects for Ward Lake. First of all, low populations of snails will be found where there is not much calcium. Snails need calcium for the development of their shells. Since snails are host to the parasite that causes swimmer's itch, swimmer's itch should not be a problem.

Secondly, calcium is a positively charged cation that binds with negatively charged compounds. Phosphorus often takes the form of PO_4^- and binds with calcium, magnesium, iron, or aluminum. Since phosphorus is the driving factor behind algae blooms and there is not much calcium or other cations to bind with phosphorus in the lake, any additions of phosphorus will likely see immediate results in the water clarity. The cations buffer the water from nutrient additions. Ward Lake has a minimal ambient buffer. Much care should be taken to limit watershed nutrient additions to protect the water quality of Ward Lake.

We have seen lakes with a higher Floristic Quality Index, however, the *Potamogeton diversifolius* (which is relatively rare) and *Elatine triandra* (which is extremely rare) make the aquatic plant community special. There were not any invasive species sampled, but the introduction of Eurasian Water Milfoil, or Curly-leaf Pondweed would be catastrophic for the sensitive species in Ward Lake

The algae community seems to be fairly balanced and what one would expect during the course of a field season. Nonetheless, it may be worth the resources to do some bio-volume sampling to get an accurate portrayal of the actual ratios of the different algae classes.

The zooplankton appears as though it is subject to high fish predation. Continued monitoring of the zooplankton could be an indirect way of monitoring the fish community.

Because there is no longer row cropping within the boundaries of the watershed, special attention should be paid to the residential areas of the watershed. This is the best possibility of controlling anthropogenic nutrients and sediment within the watershed.

Erosion near the Ward Lake shoreline

Recommendations

Monitor the biological populations of the lake. The composition of algae, zooplankton, benthic invertebrates, fish, and aquatic macrophytes need to be continuously monitored along with traditional water quality parameters in order to assess the success of fisheries and watershed management.

Any new construction in the watershed shall have proper erosion control measures in place, especially with the extreme sensitivity of the aquatic plant community, and that residential development is the main anthropogenic land-use in the watershed. Sediment loading from construction sites is a major polluter to our waterways. ***Properly installed*** silt fences, erosion control blankets and other BMPs are required under the Uniform Dwelling Code and Stormwater and Erosion Control Ordinance.

Watershed residents should limit the amount of impervious surfaces on their property to allow for water infiltration and reduce runoff. Rain gardens and native vegetation are also beneficial to reduce stormwater runoff and for wildlife habitat.

New residents should be alerted of local Zoning laws to prevent misunderstandings and violations.

No phosphorus fertilizers shall be applied in shoreland areas of Polk County.

Septic systems should regularly be maintained and checked on to prevent pollution from entering the lake.

Riparian vegetation, aquatic plants, and coarse woody habitat (fallen trees and logs) should be left where it stands, or intalled to preserve the water quality of Wild Goose Lake and provide habitat for young game fish and zooplankton.

Because there is a long record of ecological change in the lakes sediment, a sediment core sample should be considered. Knowing the historical conditions prior to European settlement and the subsequent drivers of change could help with management techniques and set benchmarks for other shallow systems in Polk County, the state and throughout the mid-west, especially those with low alkalinity.

Recreational boating should be moderated on small lakes. Non-motorized sports will have less impact on water quality and turbidity than personal water craft (PWC) and motorized boats. At a minimum, slow-no-wake speeds should be implemented and the 100-foot from shore law upheld to ensure that shoreline is not eroding.

Residents should begin a relationship with the Polk County Association of Lakes and Rivers, Wisconsin Association of Lakes, and the Lakes Partnership. An informed citizenry will be the best advocate for the lake. Newsletters and conferences will be valuable educational material for Wild Goose Lake residents.

Area residents and fisherman should inspect boating and fishing equipment to prevent the introduction of invasive species into Wild Goose Lake. Unused fishing bait should be disposed of in the trash. Tackle and sinkers should be lead free. Aquatic plants should be removed from the trailer and axles before and after launching.

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Appendix A

Education

Two pontoon cruises were offered to the Ward Lake Association to learn about facets of Ward Lake's health. On June 13, 2008, ten members came to learn about water sampling, lake chemistry, macrophytes, and macroinvertebrates and interconnectedness of chemistry and biology and biology and chemistry. The members had a lot of interest in the subjects and asked many good questions. This prompted us to discuss groundwater, shoreline habitat, and imperviousness at our next pontoon cruise.

The second pontoon cruise was held on August 8, 2008. Two members attended. Instead of cruising the lake as planned, we reviewed water chemistry data and information gathered thus far, talked about aquatic macrophytes, shoreline habitat, course woody debris, stormwater runoff, and management practices for the lake.

Appendix B

Date: 10/15/2009   Ward Lake

Lake Id: Ward Lake
Watershed Id: 2

Hydrologic and Morphometric Data

Tributary Drainage Area: 338.7 acre
Total Unit Runoff: 8 in.
Annual Runoff Volume: 225.8 acre-ft
Lake Surface Area <As>: 94.6 acre
Lake Volume <V>: 1886.4 acre-ft
Lake Mean Depth <z>: 19.9 ft
Precipitation - Evaporation: 3.3 in.
Hydraulic Loading: 251.8 acre-ft/year
Areal Water Load <qs>: 2.7 ft/year
Lake Flushing Rate <p>: 0.13 1/year
Water Residence Time: 7.49 year
Observed spring overturn total phosphorus (SPO): 24 mg/m^3
Observed growing season mean phosphorus (GSM): 20 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre	Low	Most Likely	High	Loading %	Low	Most Likely	High
	(ac)	**|---- Loading (kg/ha-year) ----|**				**|----- Loading (kg/year) ----|**		
Row Crop AG	89.27	0.50	1.00	3.00	39.8	18	36	108
Mixed AG	24.48	0.30	0.80	1.40	8.7	3	8	14
Pasture/Grass	22.74	0.10	0.30	0.50	3.0	1	3	5
HD Urban (1/8 Ac)	0.0	1.00	1.50	2.00	0.0	0	0	0
MD Urban (1/4 Ac)	73.47	0.30	0.50	0.80	16.4	9	15	24
Rural Res (>1 Ac)	0.0	0.05	0.10	0.25	0.0	0	0	0
Wetlands	0.965	0.10	0.10	0.10	0.0	0	0	0
Forest	127.78	0.05	0.09	0.18	5.1	3	5	9
Lake Surface	94.6	0.10	0.30	1.00	12.7	4	11	38

POINT SOURCE DATA

Point Sources	Water Load	Low	Most Likely	High	Loading %
	(m^3/year)	**(kg/year)**	**(kg/year)**	**(kg/year)**	

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SEPTIC TANK DATA

Description	Low	Most Likely	High	Loading %
Septic Tank Output (kg/capita-year)	0.3	0.5	0.8	
# capita-years	258			

% Phosphorus Retained by Soil	98	90	80	
Septic Tank Loading (kg/year)	1.55	12.90	41.28	14.2

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	85.7	200.1	528.1	100.0
Total Loading (kg)	38.9	90.8	239.6	100.0
Areal Loading (lb/ac-year)	0.91	2.12	5.58	0.0
Areal Loading (mg/m^2-year)	101.55	237.07	625.74	0.0
Total PS Loading (lb)	0.0	0.0	0.0	0.0
Total PS Loading (kg)	0.0	0.0	0.0	0.0
Total NPS Loading (lb)	73.9	146.3	352.7	85.8
Total NPS Loading (kg)	33.5	66.4	160.0	85.8

Date: 10/15/2009 Scenario: Ward Lake, No Row Crop

Lake Id: Ward Lake
Watershed Id: 2

Hydrologic and Morphometric Data

Tributary Drainage Area: 338.7 acre
Total Unit Runoff: 8.00 in.
Annual Runoff Volume: 225.8 acre-ft
Lake Surface Area <As>: 94.6 acre
Lake Volume <V>: 1886.4 acre-ft
Lake Mean Depth <z>: 19.9 ft
Precipitation - Evaporation: 3.3 in.
Hydraulic Loading: 251.8 acre-ft/year
Areal Water Load <qs>: 2.7 ft/year
Lake Flushing Rate <p>: 0.13 1/year
Water Residence Time: 7.49 year
Observed spring overturn total phosphorus (SPO): 24.0 mg/m^3
Observed growing season mean phosphorus (GSM): 20.0 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre (ac)	Low	Most Likely	High	Loading %	Low	Most Likely	High
		|---- Loading (kg/ha-year) ----|				|----- Loading (kg/year) ----|		
Row Crop AG	0.0	0.50	1.00	3.00	0.0	0	0	0
Mixed AG	24.5	0.30	0.80	1.40	12.1	3	8	14
Pasture/Grass	112.0	0.10	0.30	0.50	20.8	5	14	23
HD Urban (1/8 Ac)	0.0	1.00	1.50	2.00	0.0	0	0	0
MD Urban (1/4 Ac)	73.5	0.30	0.50	0.80	22.7	9	15	24
Rural Res (>1 Ac)	0.0	0.05	0.10	0.25	0.0	0	0	0
Wetlands	1.0	0.10	0.10	0.10	0.1	0	0	0
Forest	127.8	0.05	0.09	0.18	7.1			

3 5 9
Lake Surface 94.6 0.10 0.30 1.00 17.5
4 11 38

POINT SOURCE DATA

Point Sources	Water Load (m^3/year)	Low (kg/year)	Most Likely (kg/year)	High (kg/year)	Loading %

=

SEPTIC TANK DATA

Description		Low	Most Likely	High	Loading %
Septic Tank Output (kg/capita-year)		0.30	0.50	0.80	
# capita-years	258.0				
% Phosphorus Retained by Soil		98.0	90.0	80.0	
Septic Tank Loading (kg/year)		1.55	12.90	41.28	19.7

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	53.8	144.3	329.0	100.0
Total Loading (kg)	24.4	65.5	149.2	100.0
Areal Loading (lb/ac-year)	0.57	1.53	3.48	
Areal Loading (mg/m^2-year)	63.80	171.01	389.81	
Total PS Loading (lb)	0.0	0.0	0.0	0.0
Total PS Loading (kg)	0.0	0.0	0.0	0.0
Total NPS Loading (lb)	42.0	90.6	153.6	80.3
Total NPS Loading (kg)	19.0	41.1	69.7	80.3

Wisconsin Internal Load Estimator

Date: 10/15/2010 Scenario: 20

Method 1 - A Complete Total Phosphorus Mass Budget

Method 1 - A Complete Total Phosphorus Mass Budget 20.2 mg/m^3
Phosphorus Inflow Concentration: 292.2 mg/m^3
Areal External Loading: 237.1 mg/m^2-year
Predicted Phosphorus Retention Coefficient: 0.80
Observed Phosphorus Retention Coefficient: 0.93
Internal Load: -27 Lb -12 kg

Method 2 - From Growing Season In Situ Phososphorus Increases

Start of Anoxia

Average Hypolimnetic Phosphorus Concentration: 24 mg/m^3
Hypolimnetic Volume: 290.9 acre-ft
Anoxia Sediment Area: 29.09 acres

Just Prior To The End of Stratification

Average Hypolimnetic Phosphorus Concentration: 0 mg/m^3
Hypolimnetic Volume: 290.9 acre-ft
Anoxia Sediment Area: 29.09 acres
Time Period of Stratification: 30 days
Sediment Phosphorus Release Rate: -2.4 mg/m^2-day -6.63E-003

lb/acre-day
Internal Load: -19 Lb   -9 kg

<u>Method 3 - From In Situ Phososphorus Increases In The Fall</u>
Start of Anoxia
Average Hypolimnetic Phosphorus Concentration: 24 mg/m^3
Hypolimnetic Volume: 290.9 acre-ft
Anoxia Sediment Area: 29.09 acres
Just Prior To The End of Stratification
Average Water Column Phosphorus Concentration: 24 mg/m^3
Lake Volume: 1886.4 acre-ft
Anoxia Sediment Area Just Before Turnover: 29.09 acres
Time Period Between Observations: 30 days
Sediment Phosphorus Release Rate: 13.4 mg/m^2-day   3.64E-002 lb/acre-day
Internal Load: 104 Lb   47 kg

<u>Method 4 - From Phososphorus Release Rate and Anoxic Area</u>
Start of Anoxia Anoxic Sediment Area: 29.09 acre
End of Anoxia Anoxic Sediment Area: 29.09 acre
Phosphorus Release Rate As Calculated In Method 2: -2.4 mg/m^2-day
Phosphorus Release Rate As Calculated In Method 3: -2.4 mg/m^2-day
Average of Methods 2 and 3 Release Rates: -1.2 mg/m^2-day
Period of Anoxia: 120 days
Default Areal Sediment Phosphorus Release Rates:

	Low	Most Likely	High
	6	14	24
Internal Load: (Lb)	0	0	0
Internal Load: (kg)	0	0	0

<u>Internal Load Comparison (Percentanges are of the Total Estimate Load)</u>
Total External Load: 200 Lb   91 kg

	Lb	kg	%
From A Complete Mass Budget:	-27	-12	-15.4
From Growing Season In Situ Phosphorus Increases:	-19	-9	-10.5
From In Situ Phososphorus Increases In The Fall:	104	47	34.2
From Phososphorus Release Rate and Anoxic Area:	0	0	0.0

<u>Predicted Water Column Total Phosphorus Concentration (ug/l)</u>

	Low	Most Likely	High
Nurnberg+ 1984 Total Phosphorus Model:	-14	135	156

Osgood, 1988 Lake Mixing Index: 9.8
Phosphorus Loading Summary:

	Low	Most Likely	High
Internal Load (Lb):	-27	52.1	0
Internal Load (kg):	-12	23.6	0
External Load (Lb):	86	200	528
External Load (kg):	39	91	240
Total Load (Lb):	59	252	528
Total Load (kg):	27	114	240

Phosphorus Prediction and Uncertainty Analysis Module

Date: 10/15/2010 Scenario: 15
Observed spring overturn total phosphorus (SPO): 24.0 mg/m^3
Observed growing season mean phosphorus (GSM): 20.0 mg/m^3
Back calculation for SPO total phosphorus: 113.74 mg/m^3
Back calculation GSM phosphorus: 94.79 mg/m^3
% Confidence Range: 70%
Nurenberg Model Input - Est. Gross Int. Loading: 135 kg

Lake Phosphorus Model	**Low** Total P (mg/m^3)	**Most Likely** Total P (mg/m^3)	**High** Total P (mg/m^3)	**Predicted** -Observed (mg/m^3)	**% Dif.**
Walker, 1987 Reservoir	24	57	150	37	185
Canfield-Bachmann, 1981 Natural Lake	23	39	69	19	95
Canfield-Bachmann, 1981 Artificial Lake	23	35	55	15	75
Rechow, 1979 General	8	19	50	-1	-5
Rechow, 1977 Anoxic	52	122	321	102	510
Rechow, 1977 water load<50m/year	13	31	82	11	55
Rechow, 1977 water load>50m/year	N/A	N/A	N/A	N/A	N/A
Walker, 1977 General	41	96	252	72	300
Vollenweider, 1982 Combined OECD	28	55	123	33	150
Dillon-Rigler-Kirchner	30	69	182	45	188
Vollenweider, 1982 Shallow Lake/Res.	22	47	111	25	114
Larsen-Mercier, 1976	33	78	206	54	225
Nurnberg, 1984 Oxic	460	494	591	474	2370

Lake Phosphorus Model	**Confidence** Lower Bound	**Confidence** Upper Bound	Fit?	**Parameter** Calculation (kg/year)	**Back** Type	**Model**
Walker, 1987 Reservoir	31	117	Tw	152	GSM	
Canfield-Bachmann, 1981 Natural Lake	12	112	FIT	406	GSM	
Canfield-Bachmann, 1981 Artificial Lake	11	101	FIT	813	GSM	
Rechow, 1979 General	10	39	FIT	456	GSM	
Rechow, 1977 Anoxic	69	250	FIT	71	GSM	

Rechow, 1977 water load<50m/year	17	64	FIT	278	GSM
Rechow, 1977 water load>50m/year	N/A	N/A	N/A	N/A	N/A
Walker, 1977 General	45	206	FIT	108	SPO
Vollenweider, 1982 Combined OECD	26	111	FIT	197	ANN
Dillon-Rigler-Kirchner	39	142	P qs p	150	SPO
Vollenweider, 1982 Shallow Lake/Res.	22	96	FIT	227	ANN
Larsen-Mercier, 1976	45	159	P Pin	132	SPO
Nurnberg, 1984 Oxic	313	758	P	-521	ANN

Water and Nutrient Outflow Module
Date: 10/15/2010 Scenario: 11
Average Annual Surface Total Phosphorus: 20mg/m^3
Annual Discharge: 2.52E+002 AF => 3.11E+005 m^3
Annual Outflow Loading: 13.0 LB => 5.9 kg

Expanded Trophic Response Module
Date: 10/15/2010 Scenario: 19
Total Phosphorus: 20 mg/m^3
Growing Season
Chorophyll a: 7.8 mg/m^3
Secchi Disk Depth: 3.44 m
Carlson TSI Equations:
TSI (Total Phosphorus): 47 TSI (Chlorphyll a): 51 TSI (Secchi Disk Depth): 42

Expanded Trophic Response Module
Date: 10/15/2010 Scenario: 20
Total Phosphorus: 20 mg/m^3
Growing Season
Chorophyll a: 7.8 mg/m^3
Secchi Disk Depth: 3.44 m
Cholorphyll a Nuisance Frequency
Chla Mean Min: 5
Chla Mean Max: 100
Chla Mean Increment: 5
Chla Temporal CV: 0.62
Chla Nuisance Criterion: 20

Mean	Freq %
5	0.5
10	7.7
15	21.9
20	37.8
25	52.0
30	63.5
35	72.3
40	79.0
45	84.1

50	87.9
55	90.7
60	92.8
65	94.4
70	95.6
75	96.6
80	97.3
85	97.8
90	98.3
95	98.6
100	98.9

Expanded Trophic Response Module

Date: 10/15/2010 Scenario: 21
Total Phosphorus: 20 mg/m^3
Growing Season
Chorophyll a: 7.8 mg/m^3
Secchi Disk Depth: 3.44 m

Wisconsin Regional Prediction Equations:

		Stratified		Mixed	
	Region	Seepage	Drainage	Seepage	Drainage
Use Chlorophyll_a To Predict	South	1.8	1.9	1.0	1.1
Secchi Disk Depth (m)	Central	2.5	2.2	1.8	No Data
	North	2.5	2.1	2.0	1.4
Use Total Phosphorus To	South	2.0	1.7	0.9	0.9
Predict Secchi Disk Depth (m)	Central	2.9	1.3	1.5	No Data
	North	2.4	2.2	1.8	1.4
Use Total Phosphorus To	South	6.7	10.0	8.4	9.8
Predict Chlorophyll_a (mg/m^3))	Central	6.4	18.8	9.6	No Data
	North	6.6	7.3	8.4	10.2

Expanded Trophic Response Module

Date: 10/15/2010 Scenario: 22
Total Phosphorus: 20 mg/m^3
Growing Season
Chorophyll a: 7.8 mg/m^3
Secchi Disk Depth: 3.44 m

Wisconsin Statewide Prediction Equations:

	Natural Lakes		Impoundments	
	Stratified	Mixed	Stratified	Mixed
Secchi Disk Depth using Chlorophyll_a:	2.2	1.8	1.9	1.4
Secchi Disk Depth using Total Phosphorus:	2.2	1.6		

1.7 1.3
Chlorphyll_a using Total Phosphorus: 7.4 9.2
10.3 9.4

Appendix C

ZOOPLANKTON OF WILD GOOSE AND WARD LAKES, POLK CO. WI, 2008.

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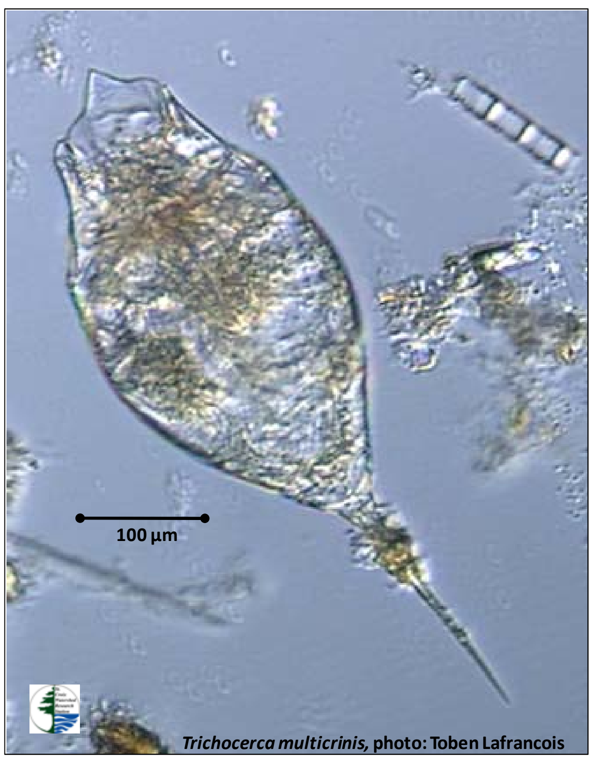
March 2009



Trichocerca multicrinis, photo: Toben Lafrancois

Suggested reference: Lafrancois, T. 2009. Zooplankton of Wild Goose and Ward Lakes, Polk Co. WI, 2008. Final report to Polk County Land and Water Resources Dept., March 2009.

EXECUTIVE SUMMARY

Zooplankton form a critical link between bottom-up and top-down processes in lakes. They are voracious consumers of algae and bacteria, and are also a favorite fish food of planktivorous panfish, minnows and fry of larger fish. In this way, zooplankton connect two of the most important features of lake management- water clarity and fishing. Examining zooplankton community composition, abundances, and presence of sensitive or tolerant organisms is like looking under the hood of a car because it shows how important lake processes are mechanically connected.

Zooplankton were sampled monthly from May to September of 2008 from Ward and Wild Goose Lakes, Polk County, Wisconsin. Vertical tows were taken at the deepest point of each lake. Organisms were counted and enumerated at the St. Croix Watershed Research Station, Marine on St. Croix, Minnesota.

Basic analysis shows that the zooplankton in both lakes are characteristic of eutrophic lakes with high predation by planktivorous fish. Zooplankton diversity and abundance in Ward and Wild Goose Lakes were both dominated by rotifers (the smallest zooplankton, tolerant of fish predation). Several species present are tolerant of eutrophication. The lakes had similar communities in spring, but diverged over the season. Wild Goose had significantly more cladoceran (water flea) genera ($p = 0.011$), but significantly lower overall zooplankton density ($p = 0.036$). Larger copepods and cladocerans were present but rare. Presence of some larger species in low numbers indicates good potential for a more robust zooplankton community (more capable of mitigating algal blooms).

It is difficult to infer more about zooplankton based on a single tow per lake per sample because zooplankton are notoriously patchy. Stability of taxa found over time indicate that these data are suitable for cluster analysis along environmental gradients to determine driving factors in these two lakes. Interpreting the current state of these lakes requires reference conditions from historical data like diatom and zooplankton analysis in sediment cores to determine lake states pre-settlement.

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INTRODUCTION AND METHODS

ZOOPLANKTON BACKGROUND INFORMATION

Zooplankton are small aquatic animals (specimens from this study range from 0.03 mm long to 3 mm long). Three primary components of the zooplankton community are rotifers, copepods, and cladocerans. Single celled organisms were not found in this survey, most likely due to over-dessication in sample preservative. Organisms of the phylum Rotifera are either soft-bodied or have a hard lorica (shell). All rotifers have mouthparts with bristles that undulate like two little wheels, giving this group their name. Rotifers are small, ranging from 0.03 mm to 1.00 mm long, depending on the species. They are size-selective omnivores that eat algae, protozoa, and sometimes each other. Rotifers are preyed on by other plankton but only incidentally by fish. Some have long spines or gelatinous sheaths to deter predators.

Copepods are crustaceans (phylum Arthropoda, subphylum Crustacea) of two orders (Calanoida and Cyclopoida). Other orders of copepods are benthic (live in the sediments) or parasitic on fish and are not usually included in studies of plankton. Copepods are multi-segmented animals that are size selective omnivores, eating algae and other plankton. Some have more specific feeding habits. Copepods are highly variable in size, depending on the species, ranging from 0.3 mm to 3.0 mm long (and even larger in some cases). They can be eaten by larger plankton and are a favorite fish food (either planktivores like pan fish and minnows or fry of larger fish).

Cladocerans are also crustaceans (phylum Arthropoda, subphylum Crustacea) of similar size range than copepods but very distinct morphologically. Cladocerans filter-feed by creating a current with fan-like legs protected by a hard but un-segmented carapace. Most cladocerans are parthogenetic, females producing clonal eggs. Males are produced in times of environmental stress and sexual reproduction occurs for one or two generations. Cladocerans are voracious consumers of algae and are also a favorite food of fish.

Zooplankton are often an overlooked component of aquatic systems, but their role in ecosystem function is extremely important. Lake systems are valued primarily for water clarity and fishing or other recreation. Both of these values are strongly linked to water quality and ecosystem health. Zooplankton are the primary link between the 'bottom up' processes and 'top down' processes of the ecosystem. Bottom up processes, like increased nutrients, can cause noxious algal blooms. Zooplankton can mediate these blooms by heavy grazing. On the other hand, shifts in algal composition caused by increased nutrients can change zooplankton community composition, exacerbating algal blooms and stressing planktivorous fish and / or the development of fry. Top down processes include fish predation, where increased planktivorous fishes (e.g. pan fish) can drastically reduce zooplankton populations and lead to algal blooms. In some lakes a trophic cascade is used to manage this effect, using piscivorous fish to reduce planktivorous fish populations, increasing plankton to reduce algae— and consequently improving water clarity.

Zooplankton also respond to changes in watershed and lakeshore management. Changes in aquatic plants, landscape use in the watershed, and buffer zones around a lake impact plankton directly or indirectly. Understanding the plankton in a lake (both algae and zooplankton) is like looking under the hood of a car, showing the mechanisms that connect lake management, ecosystem effects, water clarity, and fishing.

METHODS, FIELD SAMPLING

Zooplankton were sampled from Ward Lake and Wild Goose Lake in 2008 by Polk County personnel. Samples were taken monthly from May to September. At the deepest point of each lake, a zooplankton tow net (54um mesh[1]) was lowered nearly to the bottom and drawn vertically to the surface at a constant rate. Samples were rinsed from the net into a collection jar and preserved in 80% ETOH for counting. The area of the net's mouth and the depth of the tow were recorded, allowing calculation of the volume of water each sample represents.

METHODS, LABORATORY

Zooplankton were identified at the St. Croix Watershed Research Station, Marine on St. Croix MN (a non-profit research branch of the Science Museum of Minnesota). Samples were rinsed in a 54um net and placed in Falcon centrifuge tubes with 30 to 35 ml of 80% ETOH (depending on the density of sample). The Falcon tube was vigorously agitated and sub-sampled with a 1ml Hempsten-Stempel pipette. This subsample was placed in a Sedgwick rafter cell for counting. Two samples (one from each lake) were sub-sampled six times and counted to assess the number of subsamples needed to get a) maximum taxa richness and b) numbers within 1 STD of the mean on a subsequent count. Ten out of twenty rows were counted (starting at row 1, skipping every other row). Three such sub-samples were counted for each lake sample except two from Wild Goose Lake (August and September) because only two were required to achieve reliable counts. Numbers were then converted to n/m^3 based on the Falcon tube volume and tow volume. The methods listed here reflect the particular conditions of these lakes and sampling design. They were tested for sufficiency but should not be reproduced in other systems without re-testing adequacy.

An Olympus BX50F4 Microscope was used for counting and digital pictures of whole organisms. The most widely accepted taxonomic keys were used (Balcer et al., 1984; Thorp et al., 1997; Smith et al., 2001) as well as online resources (U. New Hampshire, 2003). It should be noted that available keys are not always in agreement, and some contain errors. Complete taxonomic certainty requires further research including examination of live animals and several different preservation techniques not suitable for population assessment as performed here. Results from the present analysis will be consistent with other studies of zooplankton because these keys represent the best available taxonomy to date. A list of taxonomic certainty and related issues is shown in Table 1. Online images and keys are extremely useful but were taken with caution because not all taxa are represented in these keys and not all branches in the decision trees are taxonomically definitive. The online resources were used primarily as confirmation for particular species or genera that were considered represented with confidence by the source.

DATA ORGANIZATION AND COMMUNITY INDICES

Zooplankton abundances were converted to numbers per cubic meter (n/m^3), equivalent to 1,000 liters or 1.31 cubic yards (the SI name for this volume is the stère). Care should be taken when inferring total zooplankton population in a lake at any given time because the density is based on a single tow at one point and zooplankton are notoriously patchy in distribution. The numbers are robust for general comparisons over time, however. Stability of plankton community composition over sampling dates supports the inference that zooplankton abundances reported are representative of the larger community.

Zooplankton communities change naturally over the season (community phenology), so data were analyzed over time (a total of 5 monthly samples in 2008) and as a whole year mean for gross comparison with other lakes.

[1] Assuming a standard two net; this value could be 80 µm depending on what Polk Co. staff used.

Densities are tabulated by species if available, by genus, and by major group (Rotifera, Copepoda, and Cladocera). The latter is the most coarse distinction but is ecologically meaningful due to the major differences between these groups compared to similarities between genera within a group. Some species with known environmental tolerances are noted in Table 1.

Several basic community measures were calculated. Over-all generic richness is simply the raw number of genera. Taxa richness (lowest detectable taxonomic resolution) was also tabulated. All other metrics used incorporate density and diversity in various ways. Shannon diversity (Shannon-Weiner Index) is a measure of information, treating taxa as types and abundance as frequency. The advantage of using information theory applied to diversity is that it measures both abundance and evenness at once. The disadvantage is that the index is difficult to interpret ecologically. Values in aquatic systems generally range from 1 to 5, with 5 being the highest diversity with maximum evenness. Shannon evenness is a related measure that converts Shannon diversity to expresses evenness directly. Values range from 0 (minimum evenness) to 1 (maximum evenness, or each taxa equally abundant).

Simpson diversity (Ds) is a difficult number to interpret, and is included in the analyses below for use in further analysis if desired. Simpson's reciprocal index (1/Ds) is sometimes used to exaggerate the scale, but again it is difficult to interpret and not used below. Simpson's index (1-Ds) is used below because it represents a more intuitive scale and has direct ecological interpretation. Simpson diversity (1-Ds) is the probability that from two randomly selected members of the community, the second organism encountered is a different type than the first. This is a useful measure relating diversity to evenness. Berger-Parker dominance is simply the per-cent of the total number of organisms composed by the most common organism. Communities with higher dominance (above 50%) tend to be impaired in one way or another, such that even with high diversity, only one type of organism is found. Jaccard's similarity is 100·(c/A+B-c), where c is the number of genera in common, A and B are the numbers of genera in samples A and B, respectively. This measures the per cent similarity between two communities (irrespective of abundance), with 100% equivalent to total similarity. The lake similarity index for the whole year is NOT a mean of monthly similarity, but pools all taxa for the year in each lake for an overall comparison.

ZOOPLANKTON COMMUNITY ANALYSIS, WARD LAKE

Zooplankton abundances for Ward Lake are sorted by date in Table 2 and summarized with basic community analysis in Table 4. Mean generic richness was 13.8 genera, and mean species richness was 16.8 taxa (not all taxa could be identified at species level). Most of both the generic and species diversity is rotifer diversity. Rotifers dominated the zooplankton community of Ward Lake, both over time (Figure 1) and as a whole (Figure 2). Dominance (% composition) of rotifers averaged at 89.98% (mean over the whole year, Table 5). Looking at the dominant genera, the rotifer *Keratella* spp. was dominant throughout all sampling periods (Table 4) but the relative dominance changed over sampling periods. *Keratella* is a genera that is very tolerant of fish presence due to its small size and hard lorica. The most common non-rotifer overall was the small cyclopoid copepod *Microcyclops* sp.

ZOOPLANKTON COMMUNITY ANALYSIS, WILD GOOSE LAKE

Zooplankton abundances for Wild Goose Lake are sorted by date in Table 3 and summarized with basic community analysis in Table 4. Mean generic richness was 15.4 genera and mean species richness was 18 taxa (not all taxa could be identified at the species level). Most of both generic and species richness is due to rotifer diversity. Rotifers dominated the zooplankton community of Wild Goose lake over time (Figure 3) and as a whole (Figure 4).

Dominance (% composition) of rotifers averaged at 75.65% (mean over the whole year, Figure 6). The rotifer *Keratella* spp. was dominant throughout all sampling periods but one, where the cladoceran *Bosmina* was dominant (Table 4). The relative dominance changed over sampling period. The most common non-rotifers overall were the small cyclopoid copepod *Microcyclops* sp. and the cladoceran *Bosmina longirostrus*, with the caveat that not all samples were preserved well enough to distinguish the genera *Bosmina* from *Eubosmina*. Both genera are found in the area. In this survey *B. longirostrus* was positively identified, but many individuals did not retain the sensory bristle or other characters required to distinguish the genera so the two genera are lumped together for analysis. *Eubosmina* spp. were not positively identified, however. Live samples would help differentiate the two.

Comparison of Ward and Wild Goose Lake zooplankton communities, 2008

Community measures for Ward and Wild Goose lakes are compared in Table 4 and shown graphically in Figures 7-10. Both Ward and Wild Goose Lakes are rotifer dominated communities, indicating heavy fish predation on the cladocerans and copepods with corresponding reduction of the capacity for zooplankton to be a controlling factor of algal blooms. A few features are of note. For both lakes, Simpson's Diversity Index (1-Ds) looks fairly good (Figure 9). However, given the dominance of rotifers as a group, the Simpson's Diversity of genera is misleading, and diversity of the major groups is low (Figure 10). This should be interpreted not in terms of 'diversity' alone (since the maximum diversity of the three groups is three), but as a measure of evenness. The score is a composite of number of groups (taxa diversity) and evennes (the relative abundance of different groups). A low diversity score tested against the 3 main groups is really another measurement expressing the dominance of rotifers.

The basic community measures were compared with a simple T-test as a preliminary comparative measure. Means for the entire year were compared against the monthly variance. The results are informative but should be taken with caution because variance over the year represents community phenology and is not necessarily random. Wild Goose Lake showed significantly greater diversity of cladoceran genera ($p = 0.011$) but had significantly lower total zooplankton density (#/m^3, $p = 0.036$). Differences in zooplankton density are shown in Figure 7.

Jaccard's similarity of the two zooplankton communities, expressed as a % of shared genera, are listed in Table 6 and shown in Figure 11. The two lakes are most similar in spring, then diverge. This could be the result of several factors, including differences in temperature, depth, fish species present (top-down effects, and algal species present (bottom-up effects). Further analysis using ecological gradients could help tease out the key processes.

Future analyses and recommendations

The zooplankton counts here are as robust as possible given a single sample per lake per date. These data allow decent comparisons between lakes and can track major changes in community phenology. The very basic abundances and indices presented in this report can detect large scale impacts over time if the survey is repeated.

Three major limitations to these data can be addressed by future work. First, zooplankton community phenology can be obscured by patchy spatial distribution. In order to make inferences about populations in a given lake and to avoid both type I and II errors in lake to lake comparisons, at least 3 samples are needed per lake (scaled up to lake size).

Secondly, it is difficult to assess the meaning of the indices reported here without an ecological context. This can be addressed using the data reported here by cluster analysis across environmental gradients to identify factors associated with changes in the zooplankton community. Finally, some zooplankton are preserved in sediment cores, particularly cladocerans, allowing a pre-settlement state to be inferred. Paleobiology offers a context for determining the nature and extent of impacts currently impacting a lake. Zooplankton presence in sediment cores can characterize both background state of the lake as well as year to year variation pre-settlement (i.e., pre-fish stocking) and over recent history (i.e., eutrophication). These additional analyses are highly recommended to make the most use of the biological data presented here.

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TABLES

TABLE 1. SPECIES PRESENT AND TAXONOMIC NOTES, POLK COUNTY 2008.

Polk Co, WI: 2008			
Ward Lake and Wild Goose Lake	**% Certain**	**Taxonomic notes**	**Ecological notes**
ROTIFERA			
Anuraeopsis sp.	100		
Ascomorpha saltans	90		
Asplanchna spp.	100		
Asplanchna herricki	100		
Asplanchna priodonta	90	Organs not always preserved	
Collotheca mutabilis	90		
Conochiloides natans	90		
Conochilus unicornis	80	Cannot always see antennae, could be other species (but certain of genus)	
Filinia terminalis	70	Very close to 10 micrometers on the terminal setae, but almost always 8 to 9; strange, since terminalis is cold stenotherm and longiseta is warm stenotherm, so based on ecology should be F. longiseta (and could be, keys can be very off),	(Cold or warm stenotherm?)
Harringia sp.	100		Benthic species
Kellicottia spp.	100		
Kellicottia bostoniensis	100		Indicates high P
Kellicottia longiseta	100		Indicates high P
Kerratella spp.	100		
Keratella cochlearis cochlearis/robustus	100	The two subspecies can be separated by size but many were on the border; very similar ecology.	
Keratella hiemalis	100		
Lecane sp.	80		
Monostyla spp.	90	Some keys uncertain, lump with *Lecane* spp.	
Monostyla bulla	90		
Monostyla lunaris	90		
Polyarthra spp.	100		
Polyarthra euryptera	80	Fins sometimes shrivelled, made species call based on size (see taxonomic refs)	

Polyarthra major	80	Fins sometimes shrivelled, made species call based on size (see taxonomic refs)	
Polyarthra remata	90	Fins sometimes shrivelled, made species call based on size (see taxonomic refs)	
Pompholyx (prob. *sulcata*)	70	Not all characters very clear	
Synchaeta sp.			
Trichocerca spp.	100		
Trichocerca cylindrica	90	Some mashed enough to possibley be something else	
Trichocerca multicrinis	100		Associated with eutrophication
Trichocerca similis			
Trichotria sp.	100		
Nauplii (not counted in richness)	100		
Calanoid nauplius	100		
Cyclopoid nauplius	80	Counted ambiguous specimens as cyclopoid	
COPEPODA			
Cryptocyclops sp.	90	Have 5th leg pictures	
Cyclops sp.	90	Have 5th leg pictures; keys do not all match	
Diacyclops sp.	100		
Diaptomus sp.	100		Very large, tend to be easy fish prey.
Epischura lacustris	80	Keys to Epischura in both major keys, but body not bent.	
Microcyclops sp.	100		
Paracyclops sp.	90	Have 5th leg pics; keys don't all match	
Thermocyclops sp.	90	Have 5th leg pics; keys don't all match	
CLADOCERA total			
Bosmina/Eubosmina spp.	100	Sensory bristle location highly variable, sometimes absent. Both genera are known from the area.	Live samples or samples in 50% ETOH would allow positive ID.
Ceriodaphnia sp.	100		Fish tolerant
Daphnia spp.	100		
Daphnia ambigua			
Daphnia galeata mendotae	100		
Daphnia laevis	100		
Daphnia lumholtzi	100		Invasive

Daphnia pulex	90	Rostrum pattern not always apparent	
Daphnia rosea	80	Keys to D. rosea, but could easily be galeata without helmet; some also keyed to dubia.	
Diaphanosoma spp.	70	All available keys do not necessarily jive. Several pictures of *Diaphanosoma* have 3 segmented antennal rami, which is a character for *Sida.*	
Diaphanosoma bergei	70		
Diaphanosoma brachyurum	70		
Holopedium gibberum	100		
Sida crystalina	70	All available keys do not necessarily agree on generic characters.	
HEXAPODA			
Chaoborus sp.	100	With better preserved samples could put a species on these.	The 'ghost midge', voracious planktivore. Kairomones can induce helmets in Daphnia spp.

TABLE 2. WARD LAKE ZOOPLANKTON ABUNDANCE, POLK CO. (WI) 2008..

Polk Co, WI: 2008	Ward	Ward	Ward	Ward	Ward	**Ward**
Abundance summary	27-May-08	16-Jun-08	14-Jul-08	25-Aug-08	15-Sep-08	**MEAN**
	#/m^3	**#/m^3**	**#/m^3**	**#/m^3**	**#/m^3**	**#/m^3**
ROTIFERA total	3784.65	1114.35	3391.35	2470.2	917.7	**2335.65**
Anuraeopsis sp.	0	0	0	0	0	**0**
Ascomorpha saltans	0	65.55	17.25	0	24.15	**21.39**
Asplanchna spp.	13.8	34.5	3.45	0	6.9	**11.73**
Asplanchna herricki	13.8	0	0	0	6.9	4.14
Asplanchna priodonta	0	34.5	3.45	0	0	7.59
Collotheca mutabilis	0	0	0	6.9	0	**1.38**
Conochiloides natans	34.5	0	0	0	0	**6.9**
Conochilus unicornis	10.35	13.8	282.9	462.3	3.45	**154.56**
Filinia terminalis	0	0	0	13.8	0	**2.76**
Harringia sp.	0	0	0	0	0	**0**
Kellicottia spp.	72.45	24.15	37.95	0	31.05	**33.12**
Kellicottia bostoniensis	72.45	24.15	10.35	0	31.05	27.6
Kellicottia longiseta	0	0	27.6	0	0	5.52
Kerratella spp.	3201.6	531.3	1914.75	1562.85	558.9	**1553.88**
Keratella cochlearis cochlearis/robustus	3105	531.3	1914.75	1562.85	555.45	1533.87
Keratella hiemalis	96.6	0	0	0	3.45	20.01
Lecane sp.	0	0	0	0	3.45	**0.69**
Monostyla spp.	0	3.45	0	0	0	**0.69**
Monostyla bulla	0	3.45	0	0	0	0.69
Monostyla lunaris	0	0	0	0	0	0
Polyarthra spp.	293.25	362.25	203.55	44.85	34.5	**187.68**
Polyarthra euryptera	0	134.55	48.3	0	0	36.57
Polyarthra major	0	0	0	0	0	0
Polyarthra remata	293.25	227.7	155.25	44.85	34.5	151.11
Pompholyx sulcata	120.75	79.35	917.7	262.2	203.55	**316.71**
Synchaeta sp.						
Trichocerca spp.	37.95	0	13.8	117.3	51.75	**44.16**
Trichocerca cylindrica	27.6	0	13.8	10.35	27.6	15.87
Trichocerca multicrinis	10.35	0	0	106.95	24.15	28.29
Trichocerca similis	0	0	0	0	0	0
Trichotria sp.	0	0	0	0	0	**0**
Nauplii (not counted in richness)	520.95	341.55	51.75	155.25	0	**213.9**
Calanoid nauplius	34.5	27.6	6.9	24.15	0	18.63
Cyclopoid nauplius	486.45	313.95	44.85	131.1	0	195.27
COPEPODA total	345	279.45	58.65	79.35	127.65	**178.02**
Calanoid total	44.85	24.15	10.35	6.9	20.7	**21.39**
Cyclopoid total	300.15	255.3	48.3	72.45	106.95	**156.63**
Cryptocyclops sp.	0	10.35	0	0	0	**2.07**
Cyclops sp.	0	6.9	0	3.45	17.25	**5.52**
Diacyclops sp.	48.3	3.45	24.15	24.15	10.35	**22.08**

Diaptomus sp.	31.05	24.15	10.35	6.9	10.35	**16.56**
Epischura lacustris	13.8	0	0	0	10.35	**4.83**
Microcyclops sp.	248.4	234.6	20.7	44.85	79.35	**125.58**
Paracyclops sp.	3.45	0	3.45	0	0	**1.38**
Thermocyclops sp.	0	0	0	0	0	**0**
CLADOCERA total	106.95	124.2	75.9	10.35	120.75	**87.63**
Bosmina/Eubosmina spp.	0	0	0	0	0	**0**
Ceriodaphnia sp.	0	0	0	0	0	**0**
Daphnia spp.	106.95	124.2	72.45	10.35	120.75	**86.94**
Daphnia ambigua	0	24.15	0	0	0	4.83
Daphnia galeata mendotae	96.6	48.3	65.55	6.9	93.15	62.1
Daphnia laevis	0	0	0	0	0	0
Daphnia lumholtzi	0	3.45	0	0	0	0.69
Daphnia pulex	10.35	24.15	6.9	3.45	27.6	14.49
Daphnia rosea	0	24.15	0	0	0	4.83
Diaphanosoma spp.	0	0	0	0	0	**0**
Diaphanosoma bergei	0	0	0	0	0	**0**
Diaphanosoma brachyurum	0	0	0	0	0	**0**
Holopedium gibberum	0	0	0	0	0	**0**
Sida crystalina	0	0	3.45	0	0	**0.69**
HEXAPODA	0	0	13.8	13.8	0	5.52
Chaoborus sp.	0	0	13.8	13.8	0	**5.52**

TABLE 3. WILD GOOSE LAKE ZOOPLANKTON ABUNDANCE, POLK CO. (WI) 2008.

Polk Co, WI: 2008	Wild Goose	Wild Goose	Wild Goose	Wild Goose	Wild Goose	**Wild Goose**
WILD GOOSE LAKE 2008	27-May-08	16-Jun-08	14-Jul-08	25-Aug-08	15-Sep-08	**MEAN**
	#/m3	#/m3	#/m3	#/m3	#/m3	**#/m3**
ROTIFERA total	434.616	195.02	121.191	419.293	1067.585	**447.541**
Anuraeopsis sp.	0	0	8.358	66.864	0	**15.0444**
Ascomorpha saltans	70.844	10.348	4.179	4.179	0	**17.91**
Asplanchna spp.	1.592	0	0	0	1.433	**0.605**
Asplanchna herricki	0	0	0	0	0	**0**
Asplanchna priodonta	1.592	0	0	0	1.433	**0.605**
Collotheca mutabilis	0	0	1.393	0	0	**0.2786**
Conochiloides natans	0	0	0	0	25.794	**5.1588**
Conochilus unicornis	7.164	0	5.572	5.572	0	**3.6616**
Filinia terminalis	0	1.592	16.716	11.144	70.217	**19.9338**
Harringia sp.	0	0	2.786	2.786	0	**1.1144**
Kellicottia spp.	19.9	3.98	0	57.113	18.629	**19.9244**
Kellicottia bostoniensis	19.9	3.98	0	57.113	18.629	**19.9244**
Kellicottia longiseta	0	0	0	0	0	**0**
Kerratella spp.	179.896	150.444	39.004	221.487	379.745	**194.1152**
Keratella cochlearis cochlearis/robustus	179.896	148.852	39.004	221.487	379.745	**193.7968**
Keratella hiemalis	0	1.592	0	0	0	**0.3184**
Lecane sp.	0	0	0	0	0	**0**
Monostyla spp.	0	1.592	0	32.039	0	**6.7262**
Monostyla bulla	0	0	0	0	0	**0**
Monostyla lunaris	0	1.592	0	32.039	0	**6.7262**
Polyarthra spp.	141.688	11.144	2.786	9.751	199.187	**72.9112**
Polyarthra euryptera	0	0.796	1.393	0	47.289	**9.8956**
Polyarthra major	0	0	1.393	0	2.866	**0.8518**
Polyarthra remata	141.688	10.348	0	9.751	149.032	**62.1638**
Pompholyx sulcata	0	0	0	0	0	**0**
Synchaeta sp.	0	0	0	0	4.299	**0.8598**
Trichocerca spp.	11.144	15.92	40.397	8.358	368.281	**88.82**
Trichocerca cylindrica	7.96	15.92	40.397	8.358	329.59	**80.445**
Trichocerca multicrinis	3.184	0	0	0	34.392	**7.5152**
Trichocerca similis	0	0	0	0	4.299	**0.8598**
Trichotria sp.	2.388	0	0	0	0	**0.4776**
Nauplii (not counted in richness)	164.772	37.412	16.716	40.397	22.928	**56.445**
Calanoid nauplius	12.736	13.532	0	4.179	0	**6.0894**
Cyclopoid nauplius	152.036	23.88	16.716	36.218	22.928	**50.3556**
COPEPODA total	133.728	44.576	9.751	25.074	44.423	**51.5104**
Calanoid total	13.532	7.164	6.965	2.786	2.866	**6.6626**
Cyclopoid total	120.196	37.412	2.786	22.288	41.557	**44.8478**
Cryptocyclops sp.	0	7.164	0	0	0	**1.4328**
Cyclops sp.	0	0	0	0	0	**0**

Diacyclops sp.	19.9	2.388	0	0	15.763	**7.6102**
Diaptomus sp.	11.144	7.164	6.965	2.786	1.433	**5.8984**
Epischura lacustris	2.388	0	0	0	1.433	**0.7642**
Microcyclops sp.	96.316	12.736	2.786	19.502	25.794	**31.4268**
Paracyclops sp.	3.98	15.124	0	0	0	**3.8208**
Thermocyclops sp.	0	0	0	2.786	0	**0.5572**
CLADOCERA total	278.6	70.048	52.934	18.109	42.99	**92.5362**
Bosmina/Eubosmina spp.	236.412	2.388	1.393	0	0	**48.0386**
Ceriodaphnia sp.	0	1.592	0	1.393	0	**0.597**
Daphnia spp.	39.004	57.312	15.323	8.358	31.526	**30.3046**
Daphnia ambigua	31.044	7.96	0	0	0	**7.8008**
Daphnia galeata mendotae	0	1.592	0	0	0	**0.3184**
Daphnia laevis	6.368	47.76	15.323	6.965	31.526	**21.5884**
Daphnia lumholtzi	1.592	0	0	0	0	**0.3184**
Daphnia pulex	0	0	0	0	0	**0**
Daphnia rosea	0	0	0	1.393	0	**0.2786**
Diaphanosoma spp.	0	8.756	0	0	0	**1.7512**
Diaphanosoma bergei	0	6.368	0	0	0	**1.2736**
Diaphanosoma brachyurum	0	2.388	0	0	0	**0.4776**
Holopedium gibberum	0.796	0	0	0	0	**0.1592**
Sida crystalina	2.388	0	36.218	8.358	11.464	**11.6856**
HEXAPODA	0	0	0	0	0	**0**
Chaoborus sp.	0	0	0	0	0	**0**

TABLE 4. ZOOPLANKTON COMMUNITY INDICES, WARD AND WILD GOOSE LAKES OF POLK CO. (WI) 2008.

Polk Co, WI: 2008	Ward	Ward	Ward	Ward	Ward	**Ward**	Wild	Wild	Wild	Wild	Wild	**Wild**
	39595	39615	39643	39685	39706	**MEAN**	39595	39615	39643	39685	39706	**MEAN**
Generic richness	14	14	14	12	15	**13.8**	17	16	14	16	14	**15.4**
Rotifer richness	8	8	8	7	9	**8**	8	7	9	10	8	**8.4**
Copepod richness	5	5	4	4	5	**4.6**	5	5	2	3	4	**3.8**
Cladoceran richness	1	1	2	1	1	**1.2**	4	4	3	3	2	**3.2**
Taxa richness (species)	17	18	17	14	18	**16.8**	19	21	15	17	18	**18**
Rotifera	10	9	10	8	11	**9.6**	9	9	10	10	12	**10**
Copepoda	5	5	4	4	5	**4.6**	5	5	2	3	4	**3.8**
Cladocera	2	4	3	2	2	**2.6**	5	7	3	4	2	**4.2**
TOTAL N/m3	4236.6	1518	3539.7	2573.7	1166.1	**2606.82**	**846.944**	**309.644**	**183.876**	**462.476**	**1154.998**	***591.5876***
Shannon diversity (H')	1.0529343	1.8393967	1.34738	1.2885721	1.7470611	**1.5226832**	2.004712	1.8148846	2.1277987	1.8033162	1.6883097	**2.2777206**
Shannon Evenness (J)	0.3989812	0.69699	0.5105535	0.5185596	0.6451362	**0.580143**	0.7075754	0.6545813	0.8062723	0.6504088	0.6397397	**0.8329973**
Reciprocal Simpson's Index (1-Ds)	0.4186868	0.7847112	0.6299767	0.5859826	0.7205857	**0.61736**	0.826333	0.7206414	0.8516242	0.7271311	0.7551409	**0.8391768**
Berger-Parker Dominance (d)	0.7557003	0.35	0.5409357	0.6072386	0.4792899	**0.5960826**	0.2791353	0.4858612	0.2121212	0.4789157	0.3287841	**0.3281259**
Dominant genus	Keratella	Keratella	Keratella	Keratella	Keratella	**Keratella**	Bosmina/Eu	Keratella	Keratella	Keratella	Keratella	**Keratella**
Simpson's Index (Ds)	0.5813132	0.2152888	0.3700233	0.4140174	0.2794143	**0.38264**	0.173667	0.2793586	0.1483758	0.2728689	0.2448591	**0.1608232**

TABLE 5. COMPARISON OF MAJOR ZOOPLANKTON GROUPS, WARD AND WILD GOOSE LAKES OF POLK CO. (WI) 2008. CARE SHOULD BE TAKEN INTERPRETING THE INDICES, SEE TEXT.

Polk Co, WI: 2008	Ward	Ward	Ward	Ward	Ward	**Ward**	Wild Goose	Wild Goose	Wild Goose	Wild Goose	Wild Goose	**Wild Goose**
Major group diversity	27-May-08	16-Jun-08	14-Jul-08	25-Aug-08	15-Sep-08	**MEAN**	27-May-08	16-Jun-08	14-Jul-08	25-Aug-08	15-Sep-08	**MEAN**
	#/m3	#/m3	#/m3	#/m3	#/m3	**#/m3**	#/m3	#/m3	#/m3	#/m3	#/m3	**#/m3**
ROTIFERA total	3784.65	1114.35	3391.35	2470.2	917.7	**2335.65**	434.616	195.02	121.191	419.293	1067.585	**447.541**
COPEPODA total	345	279.45	58.65	79.35	127.65	**178.02**	133.728	44.576	9.751	25.074	44.423	**51.5104**
CLADOCERA total	106.95	124.2	75.9	10.35	120.75	**87.63**	278.6	70.048	52.934	18.109	42.99	**92.5362**
TOTAL N	4236.6	1518	3525.9	2559.9	1166.1	**2601.3**	846.944	309.644	183.876	462.476	1154.998	**591.5876**
Shannon diversity (H')	0.3978835	0.7432775	0.1881896	0.16438	0.6654981	**0.3944749**	0.9995533	0.9064236	0.7889864	0.3737759	0.3205443	**0.7138332**
Shannon Evenness (J)	0.3621692	0.6765604	0.1712976	0.1496251	0.6057625	**0.3590665**	0.9098327	0.8250623	0.7181664	0.3402255	0.291772	**0.649759**
Simpson's Index (1-Ds)	0.1947523	0.4208041	0.0741457	0.0679024	0.3582604	**0.1880693**	0.6042453	0.5331484	0.482537	0.1739318	0.142896	**0.3963162**
Berger-Parker Dominance (d)	0.8933225	0.7340909	0.9618395	0.9649596	0.7869822	**0.897878**	0.5131579	0.6298201	0.6590909	0.9066265	0.9243176	**0.7565084**
Dominant group	Rotifera	Rotifera	Rotifera	Rotifera	Rotifera	**Rotifera**	Rotifera	Rotifera	Rotifera	Rotifera	Rotifera	**Rotifera**

TABLE 6. JACCARD'S SIMILARITY OF ZOOPLANKTON COMMUNITIES, WARD AND WILD GOOSE LAKES, POLK CO. (WI) 2008. THE VALUE FOR THE WHOLE YEAR IS OVERALL SIMILARITY, NOT A MEAN OF MONTHLY SIMILARITIES.

Date	# Genera Ward	# Genera Wild	# Common	Jaccard's similarity
27-May-08	14	17	12	63.2
16-Jun-08	14	16	11	57.9
14-Jul-08	14	14	9	47.4
25-Aug-08	12	16	8	40.0
15-Sep-08	15	14	10	52.6
whole year	**28**	**24**	**19**	**57.6**

FIGURES

FIGURE 1. DENSITY OF THREE MAIN ZOOPLANKTON GROUPS IN WARD LAKE, POLK CO. (WI) OVER TIME IN 2008.

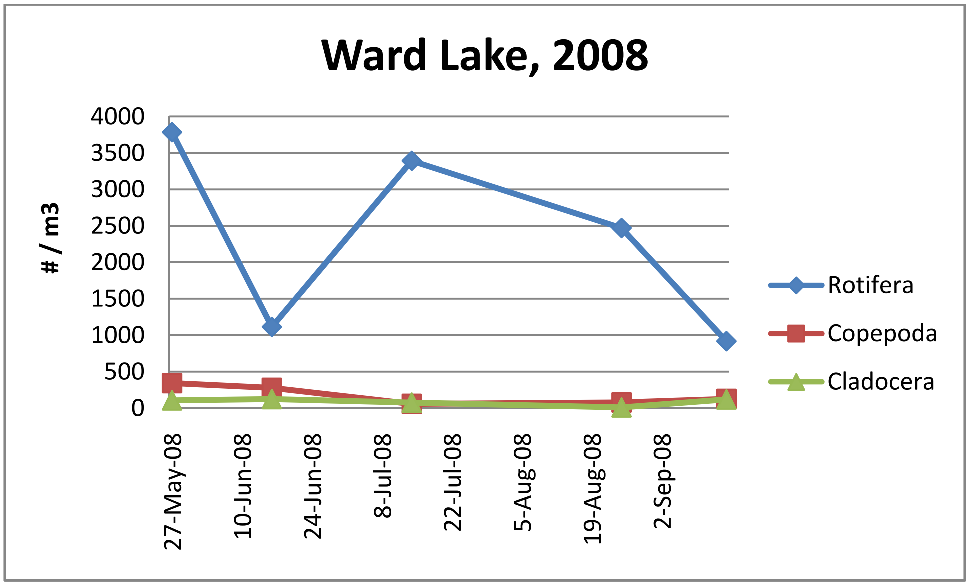


FIGURE 2. MEAN PROPORTION OF THREE MAIN ZOOPLANKTON GROUPS IN WARD LAKE, POLK CO. (WI) 2008 OVER 5 SAMPLING PERIODS.

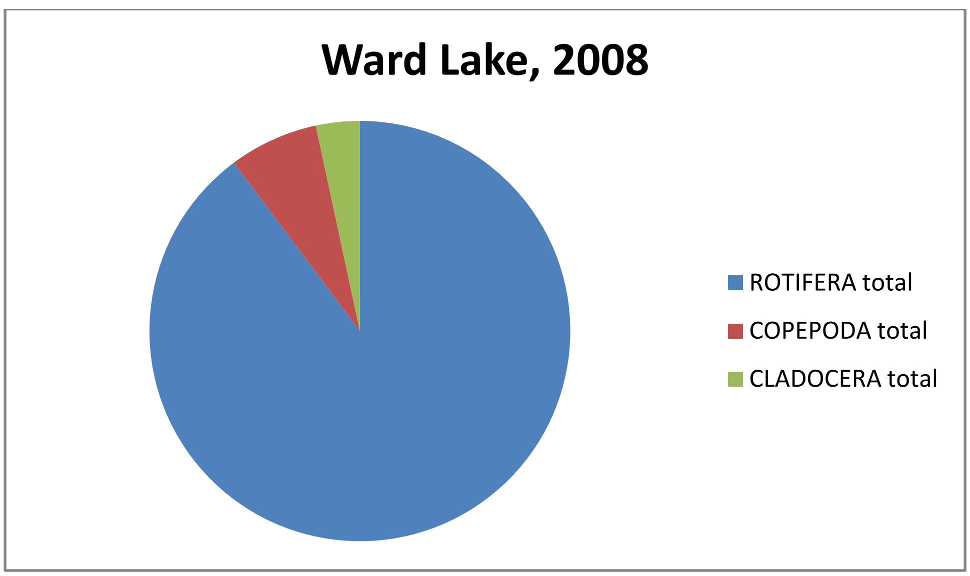


FIGURE 3. DENSITY OF THREE MAIN ZOOPLANKTON GROUPS IN WILD GOOSE LAKE, POLK CO. (WI) 2008 OVER FIVE SAMPLING PERIODS.

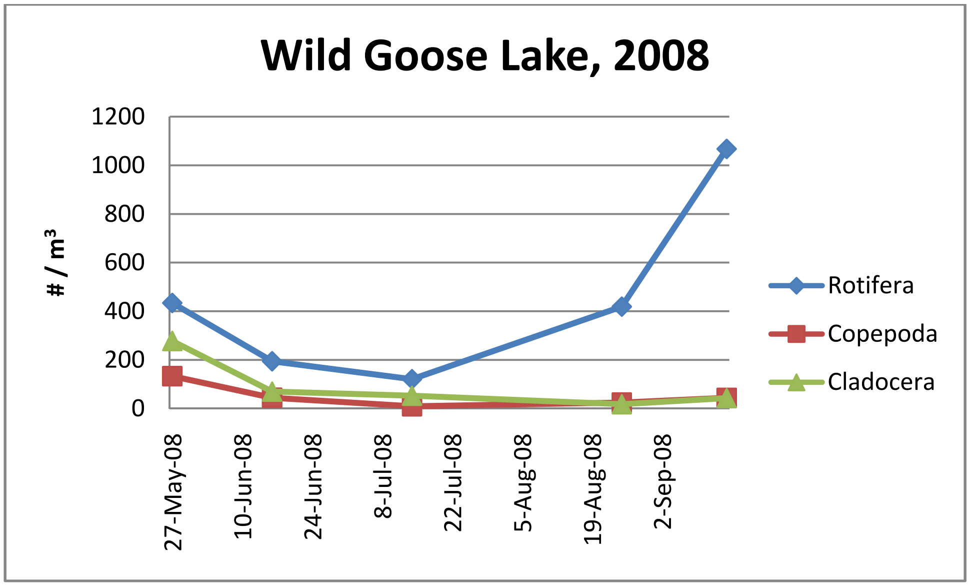


FIGURE 4. MEAN PROPORTION OF THE THREE MAIN ZOOPLANKTON GROUPS IN WILD GOOSE LAKE, POLK CO. (WI) 2008.

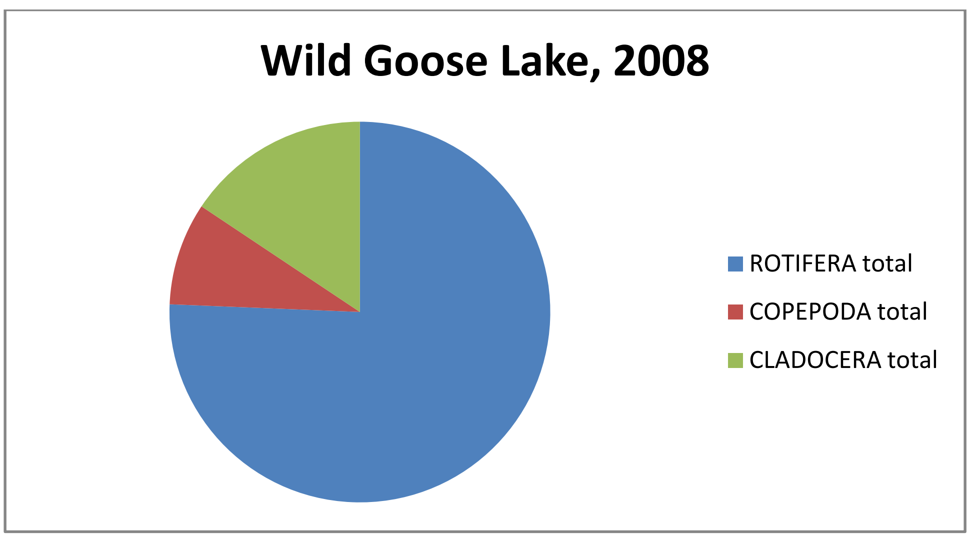


FIGURE 5. DIVERSITY OF GENERA OF THREE MAIN ZOOPLANKTON GROUPS IN WARD LAKE, POLK CO. (WI) OVER FIVE SAMPLING PERIODS.

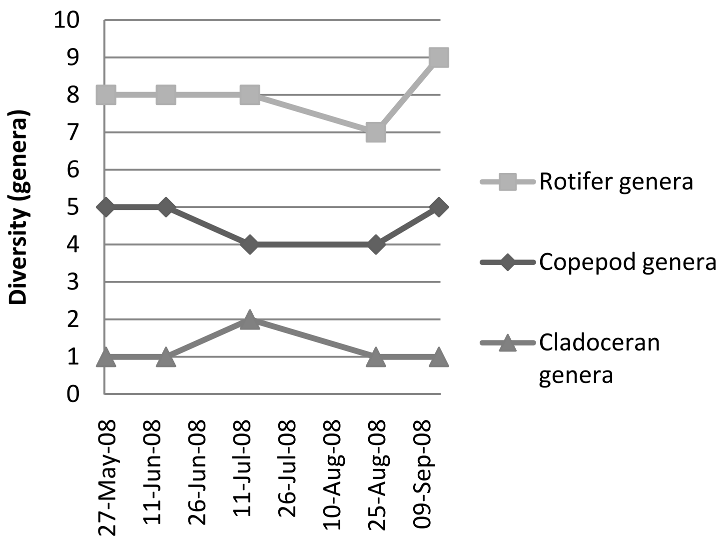


FIGURE 6. DIVERSITY OF GENERA OF THREE MAIN ZOOPLANKTON GROUPS IN WILD GOOSE LAKE, POLK CO. (WI) OVER FIVE SAMPLING PERIODS.

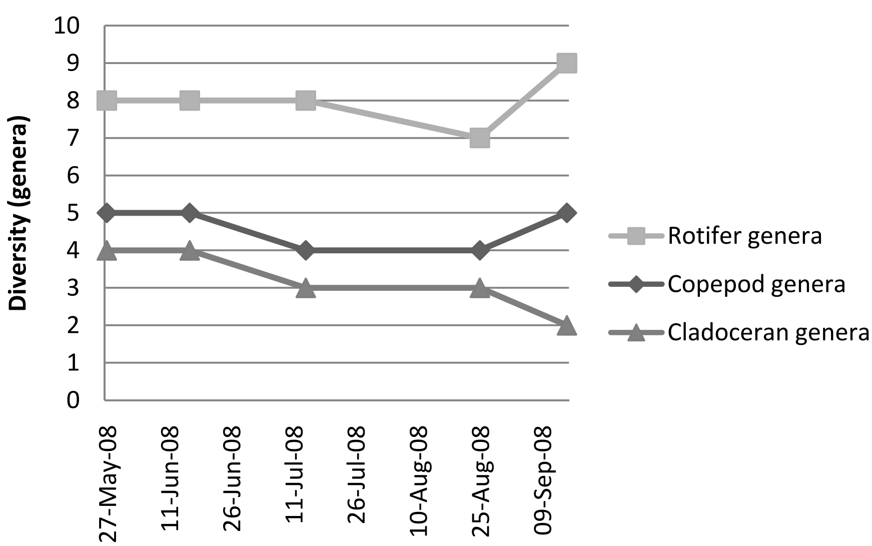


FIGURE 7. COMPARISON OF TOTAL ZOOPLANKTON DENSITY BETWEEN WARD AND WILD GOOSE LAKES IN POLK CO. (WI), 2008, OVER FIVE SAMPLING PERIODS.

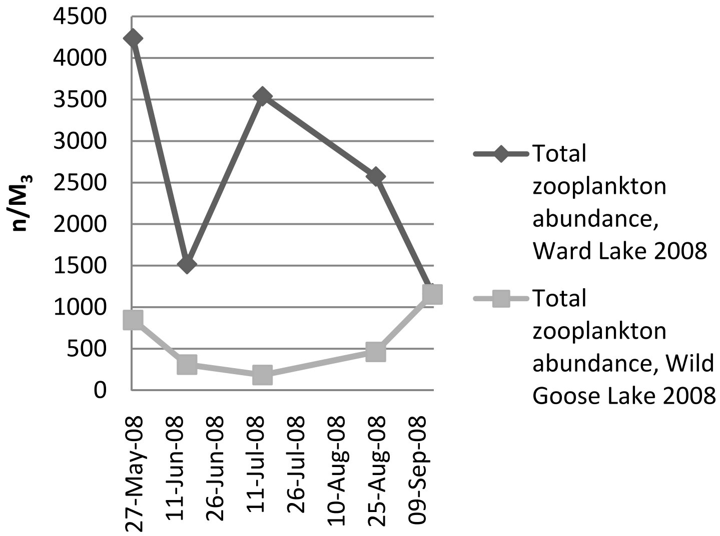


FIGURE 8. COMPARISON OF DOMINANCE (BERGER-PARKER, OR % OF TOTAL COMMUNITY COMPOSED BY MOST COMMON ORGANISM) BETWEEN WARD AND WILD GOOSE LAKES, POLK CO. (WI) 2008. IN BOTH CASES THE DOMINANT GENUS WAS *KERATELLA* SPP., PRIMARILY *K. COCHLEARIS COCHLEARIS* BUT INCLUDING *K. COCHLEARIS ROBUSTUS* AND *K. HIEMALIS.*

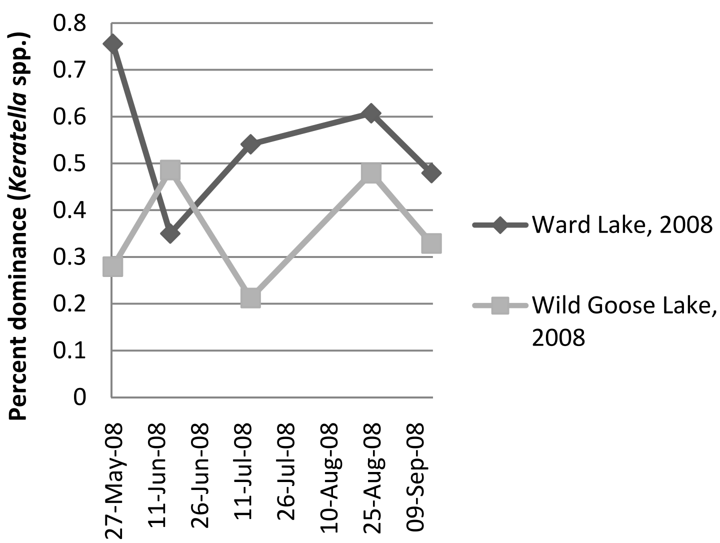


FIGURE 9. SIMPSON'S INDEX OF DIVERSITY (1 - DS OR 1 – SIMPSON'S DIVERSITY MEASURE) FOR GENERA IN WARD AND WILD GOOSE LAKES, POLK CO. (WI) 2008. THE SCALE FROM 0 TO 1 INDICATES THE PROBABILITY THAT GIVEN TWO RANDOM SAMPLES FROM THE TOTAL POPULATION, THE SECOND ORGANISM IS A DIFFERENT GENUS THAN THE FIRST.

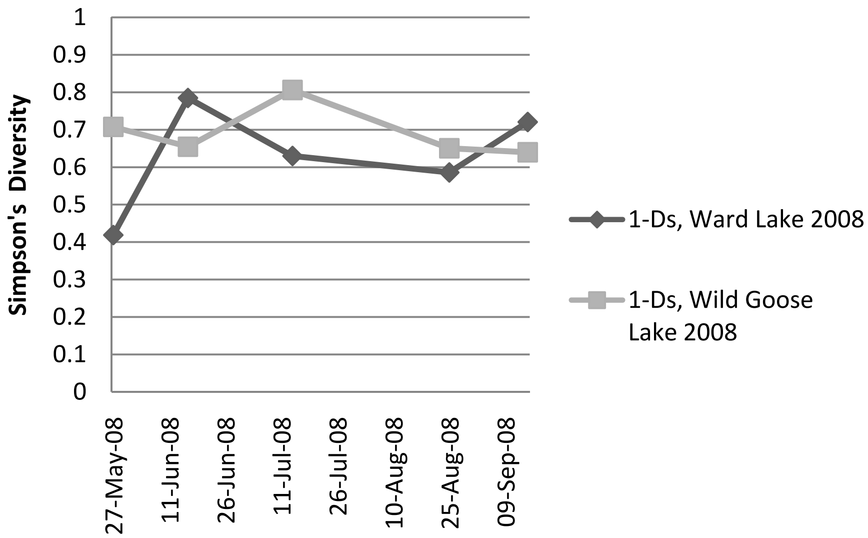


FIGURE 10. SIMPSON'S INDEX OF DIVERSITY FOR ROTIFERA, COPEPODA, AND CLADOCERA IN WARD AND WILD GOOSE LAKES, POLK CO. (WI) 2008. THE SCALE FROM 0 TO 1 INDICATES THE PROBABILITY GIVEN TWO RANDOM INDIVIDUALS THAT THE SECOND IS A DIFFERENT MAJOR GROUP THAN THE FIRST.

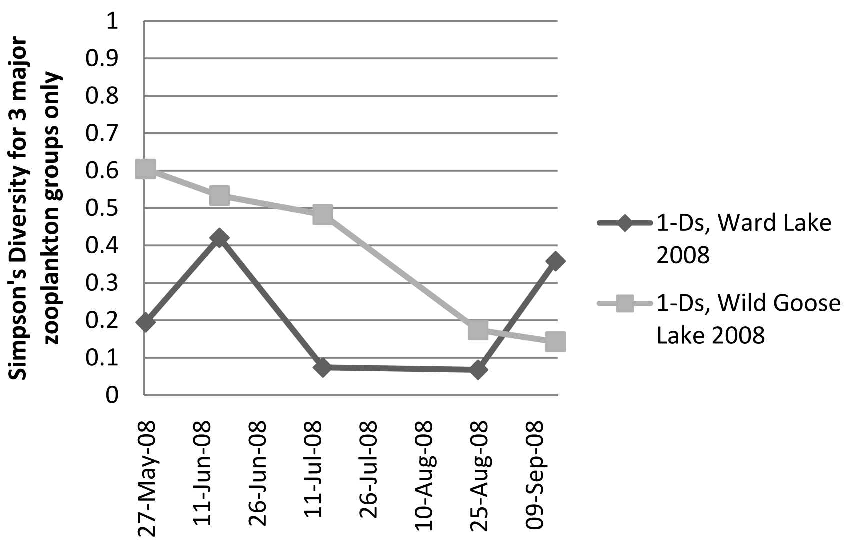
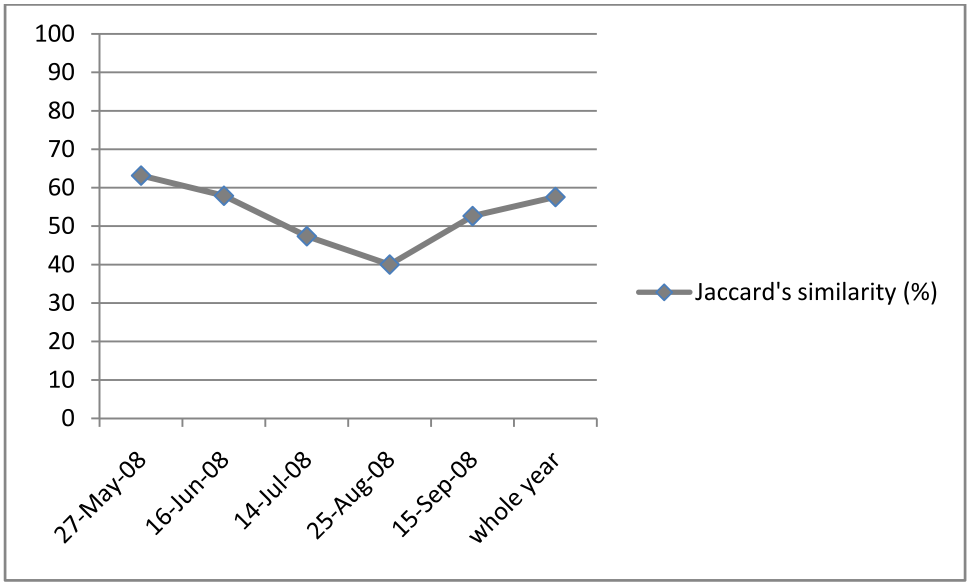


FIGURE 11. JACCARD'S SIMILARITY OF ZOOPLANKTON COMMUNITIES BETWEEN WARD AND WILD GOOSE LAKES, POLK CO. (WI) 2008. WHOLE YEAR IS THE OVERALL SIMILARITY, NOT A MEAN.



Appendix D

WISCONSIN STATE LABORATORY OF HYGIENE

Environmental Health Division
2601 Agriculture Dr.
P.O. Box 7996
Madison, WI 53707-7996
Phone: (608) 224-6202 • (800) 442-4618
FAX: (608) 224-6213

University of Wisconsin

Algae Identification Report

Site: Ward Lake
Station/Location: Mid-Lake
Depth: 6 feet
Laboratory Number: FT000237

Collection Date: May 27, 2008
Identification Date: October 23, 2008
Identified By: Dawn Perkins

Taxa	Division	# Counted	Concentration (Units/mL)[a,b]	Relative % Concentration
Ankistrodesmus sp.	Chlorophyta	5	**38**	**1.7%**
Dinobryon sp.	Chrysophyta	14	**106**	**4.7%**
Cryptomonas sp.	Cryptophyta	26	**197**	**8.7%**
Komma caudata	Cryptophyta	244	**1,847**	**81.3%**
Aphanizomenon flos-aquae	Cyanophyta	11	**83**	**3.7%**
		TOTAL	**2,271**	**100%**

Notes/Comments: Sample analyzed by the Utermohl settling chamber technique.

Signature and Date: Dawn Perkins 11/3/2008

a Natural Unit Count = unicell, colony or filament equals 1 Unit
b Method Reference = American Public Health Association et al. 1998. Standard Methods for the Examination of Water and Wastewater, 20th ed, Method 10200 F2c1

WSLH WISCONSIN STATE LABORATORY OF HYGIENE

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University of Wisconsin

Algae Identification Report

Site: Ward Lake
Station/Location: Mid-Lake
Depth: 6 feet
Laboratory Number: FT000238

Collection Date: June 16, 2008
Identification Date: October 23, 2008
Identified By: Dawn Perkins

Taxa	Division	# Counted	Concentration (Units/mL)[a,b]	Relative % Concentration
Ankistrodesmus sp.	Chlorophyta	3	**8**	**1.0%**
Gloeocystis sp.	Chlorophyta	2	**6**	**0.7%**
Oocystis sp.	Chlorophyta	1	**3**	**0.4%**
Dinobryon sp.	Chrysophyta	4	**11**	**1.3%**
Cryptomonas sp.	Cryptophyta	39	**108**	**12.9%**
Komma caudata	Cryptophyta	100	**278**	**33.1%**
Aphanizomenon flos-aquae	Cyanophyta	151	**420**	**50.0%**
Microcystis sp.	Cyanophyta	1	**3**	**0.4%**
Woronichinia naegeliana	Cyanophyta	1	**3**	**0.4%**
		TOTAL	**840**	**100%**

Notes/Comments: **Sample analyzed by the Utermohl settling chamber technique.**

Signature and Date: Dawn Perkins 11/3/2008

a Natural Unit Count = unicell, colony or filament equals 1 Unit
b Method Reference = American Public Health Association et al. 1998. Standard Methods for the Examination of Water and Wastewater, 20th ed, Method 10200 F2c1

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University of Wisconsin

Algae Identification Report

Site:	**Ward Lake**	**Collection Date:**	**July 14, 2008**
Station/Location:	**Mid-Lake**	**Identification Date:**	**October 29, 2008**
Depth:	**6 feet**	**Identified By:**	**Dawn Perkins**
Laboratory Number:	**FT000239**		

Taxa	Division	# Counted	Concentration (Units/mL)[a,b]	Relative % Concentration
Aulacoseira sp.	Bacillariophyta	1	**14**	**0.3%**
Oocystis sp.	Chlorophyta	3	**41**	**1.0%**
Cryptomonas sp.	Cryptophyta	7	**95**	**2.3%**
Komma caudata	Cryptophyta	18	**245**	**6.0%**
Anabaena sp.	Cyanophyta	22	**300**	**7.3%**
Anabaena sp. 2	Cyanophyta	6	**82**	**2.0%**
Aphanizomenon flos-aquae	Cyanophyta	241	**3,284**	**80.1%**
Ceratium hirundinella	Pyrrhophyta	3	**41**	**1.0%**
		TOTAL	**4,102**	**100%**

Notes/Comments: Sample analyzed by the Utermohl settling chamber technique.

Signature and Date: Dawn Perkins 11/3/2008

a Natural Unit Count = unicell, colony or filament equals 1 Unit

b Method Reference = American Public Health Association et al. 1998. Standard Methods for the Examination of Water and Wastewater, 20th ed, Method 10200 F2c1

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University of Wisconsin

Algae Identification Report

Site: Ward Lake
Station/Location: Mid-Lake
Depth: 6 feet
Laboratory Number: FT000240

Collection Date: August 25, 2008
Identification Date: October 29, 2008
Identified By: Dawn Perkins

Taxa	Division	# Counted	Concentration (Units/mL)[a,b]	Relative % Concentration
Ankistrodesmus sp.	Chlorophyta	2	**34**	**0.7%**
Chloromonas sp.	Chlorophyta	136	**2,316**	**45.2%**
Oocystis sp.	Chlorophyta	1	**17**	**0.3%**
Scenedesmus sp.	Chlorophyta	5	**85**	**1.7%**
Selenastrum sp.	Chlorophyta	113	**1,925**	**37.6%**
Tetraëdron sp.	Chlorophyta	14	**238**	**4.6%**
Cryptomonas sp.	Cryptophyta	7	**119**	**2.3%**
Komma caudata	Cryptophyta	7	**119**	**2.3%**
Anabaena sp.	Cyanophyta	4	**68**	**1.3%**
Aphanizomenon flos-aquae	Cyanophyta	4	**68**	**1.3%**
Microcystis sp.	Cyanophyta	3	**51**	**1.0%**
Ceratium hirundinella	Pyrrhophyta	1	**17**	**0.3%**
Peridinium sp.	Pyrrhophyta	4	**68**	**1.3%**
		TOTAL	**5,125**	**100%**

Notes/Comments: **Sample analyzed by the Utermohl settling chamber technique.**

Signature and Date: Dawn Perkins 11/3/2008

a Natural Unit Count = unicell, colony or filament equals 1 Unit
b Method Reference = American Public Health Association et al. 1998. Standard Methods for the Examination of Water and Wastewater, 20th ed, Method 10200 F2c1

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University of Wisconsin

Algae Identification Report

Site: Ward Lake
Station/Location: Mid-Lake
Depth: 6 feet
Laboratory Number: FT000241

Collection Date: September 15, 2008
Identification Date: October 30, 2008
Identified By: Dawn Perkins

Taxa	Division	# Counted	Concentration (Units/mL)[a,b]	Relative % Concentration
Aulacoseira sp.	Bacillariophyta	2	**6**	**0.7%**
Chloromonas sp.	Chlorophyta	70	**203**	**23.3%**
Scenedesmus sp.	Chlorophyta	3	**9**	**1.0%**
Tetraëdron sp.	Chlorophyta	3	**9**	**1.0%**
Ulothrix sp.	Chlorophyta	3	**9**	**1.0%**
Cryptomonas sp.	Cryptophyta	21	**61**	**7.0%**
Komma caudata	Cryptophyta	51	**148**	**17.0%**
Anabaena sp.	Cyanophyta	11	**32**	**3.7%**
Anabaena sp. 2	Cyanophyta	13	**38**	**4.4%**
Aphanizomenon flos-aquae	Cyanophyta	120	**348**	**39.9%**
Microcystis sp.	Cyanophyta	1	**3**	**0.3%**
Woronichinia naegeliana	Cyanophyta	2	**6**	**0.7%**
		TOTAL	**872**	**100%**

Notes/Comments: Sample analyzed by the Utermohl settling chamber technique.

Signature and Date: Dawn Perkins 11/3/2008

a Natural Unit Count = unicell, colony or filament equals 1 Unit
b Method Reference = American Public Health Association et al. 1998. Standard Methods for the Examination of Water and Wastewater, 20th ed, Method 10200 F2c1

WISCONSIN STATE LABORATORY OF HYGIENE

Environmental Health Division
Biomonitoring Unit – Dawn Karner
2601 Agriculture Drive
Madison, WI 53718
Phone: (608) 224-6230 • (800) 442-4618
Fax: (608) 224-6267

ALGAE IDENTIFICATION TEST REQUEST

Sample Location – Waterbody Name	Sample Location – City, State
Ward Lake	Luck, WI

Sample Point Description: mid-lake

Preservative Added: ☒ Lugol's ☐ Glutaraldehyde ☐ None

Identification Requested: ☒ Algae Count & ID to Genus ☐ Cyanobacteria Count & ID to Genus

Additional Test Instructions:

Sample Information:

Sample Type: composite	Sample Reason: lake study
Depth of Sample: 6 ft	Comments:
Collected By: AK, JW	Collector Telephone Number: 715.485.8637
Sample Date: 5/27/08	Sample Time: ____:____ (hh:mm) ☒ a.m. ☐ p.m.

For Lab Use Only:

Date Received at Lab: ___/___/___

Laboratory Number: ____________

Sample Preserved: ☐ In Field ☐ At Lab

Preservative: ____________

Date Analyzed: 10 / 23 / 08

Analyst: DKP

Field Conditions:

Lake Surface Temperature – (°C): 15.3	Wind Direction:
Ambient Air Temperature - (°C): 60's – °F	Approximate Wind Velocity (MPH): windy

Cloud Cover (Check Most Appropriate):

- ☒ **Clear Skies**
- ☐ **Partly Cloudy (Mostly Sun)**
- ☐ **Overcast**
- ☐ **Partly Sunny (Mostly Clouds)**
- ☐ **Raining**

Comments:

Send Report & Bill To:

Name (First, Last): Amy Kelsey

Company: POLK LWRD	Telephone Number: 715.485.8637

Address: 100 Polk County Plaza Ste120

City	State	Zip
Balsam Lake	WI	54810

Email Address: amyk@co.polk.wi.us

10/01/08
10:32
FT000237

Created: 9/13/2004 DK
Revised: 5/23/2005 DK

Environmental Health Division
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Fax: (608) 224-6267

WISCONSIN STATE LABORATORY OF HYGIENE

ALGAE IDENTIFICATION TEST REQUEST

Sample Location – Waterbody Name: Ward Lake	Sample Location – City, State: LUCK, WI
Sample Point Description: mid-lake	Preservative Added: ☒ Lugol's ☐ Glutaraldehyde ☐ None
Identification Requested: ☒ Algae Count & ID to Genus ☐ Cyanobacteria Count & ID to Genus	Additional Test Instructions:

Sample Information:

Sample Type: composite	Sample Reason: lake study
Depth of Sample: 6 ft	Comments:
Collected By: AK, JW	Collector Telephone Number: 715, 485-8637
Sample Date: 6 / 16 / 08	Sample Time: ___ : ___ (hh:mm) ☒ a.m. ☐ p.m.

For Lab Use Only:

Date Received at Lab: ___ / ___ / ___

Laboratory Number: ___

Sample Preserved: ☐ In Field ☐ At Lab

Preservative: ___

Date Analyzed: 10 / 23 / 08

Analyst: RKP

Field Conditions:

Lake Surface Temperature – (°C): 19.6	Wind Direction:
Ambient Air Temperature - (°C): low 60's °F	Approximate Wind Velocity (MPH): windy!

Cloud Cover (Check Most Appropriate):

☐ **Clear Skies** ☐ **Partly Cloudy (Mostly Sun)**
☐ **Overcast** ☒ **Partly Sunny (Mostly Clouds)**
☐ **Raining**

Comments:

Send Report & Bill To:

Name (First, Last): Amy Kelsey		
Company: POLK LWRD	Telephone Number: ( ) -	
Address: 100 Polk County Plaza Ste120		
City: Balsam Lake	State: WI	Zip: 54810
Email Address: amyk@co.polk.wi.us		

10/01/08
10:32
FT000238

Created: 9/13/2004 DK
Revised: 5/23/2005 DK

WSLH WISCONSIN STATE LABORATORY OF HYGIENE

Environmental Health Division
Biomonitoring Unit – Dawn Karner
2601 Agriculture Drive
Madison, WI 53718
Phone: (608) 224-6230 • (800) 442-4618
Fax: (608) 224-6267

ALGAE IDENTIFICATION TEST REQUEST

Sample Location – Waterbody Name: Ward Lake	Sample Location – City, State: Luck, WI
Sample Point Description: mid-lake	Preservative Added: ☒ Lugol's ☐ Glutaraldehyde ☐ None
Identification Requested: ☒ Algae Count & ID to Genus ☐ Cyanobacteria Count & ID to Genus	Additional Test Instructions:

Sample Information:

Sample Type: composite	Sample Reason: lake study
Depth of Sample: 6ft	Comments: green bloom
Collected By: AK, JW	Collector Telephone Number: (715) 485-8637
Sample Date: 7 / 14 / 08	Sample Time: ___ : ___ (hh:mm) ☒ a.m. ☐ p.m.

For Lab Use Only:

Date Received at Lab: ___/___/___

Laboratory Number: ____________

Sample Preserved: ☐ In Field ☐ At Lab

Preservative: ____________

Date Analyzed: 10 / 29 / 08

Analyst: DK

Field Conditions:

Lake Surface Temperature – (°C): ~~[illegible]~~ 23.2	Wind Direction:
Ambient Air Temperature - (°C):	Approximate Wind Velocity (MPH): breezy

Cloud Cover (Check Most Appropriate):

- ☐ Clear Skies
- ☒ Partly Cloudy (Mostly Sun)
- ☐ Overcast
- ~~☒ Partly Sunny~~ (Mostly Clouds)
- ☐ Raining

Comments:

Send Report & Bill To:

Name (First, Last): Amy Kelsey	
Company: Polk LWRD	Telephone Number: (715) 485-8637
Address: 100 Polk County Plaza Ste 120	
City: Balsam Lake	State: WI Zip: 54810
Email Address: amyk@co.polk.wi.us	

10/01/08
10:32
FT000239

Created: 9/13/2004 DK
Revised: 5/23/2005 DK

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2601 Agriculture Drive
Madison, WI 53718
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Fax: (608) 224-6267

WSLH WISCONSIN STATE LABORATORY OF HYGIENE

ALGAE IDENTIFICATION TEST REQUEST

Sample Location – Waterbody Name	Sample Location – City, State
Ward Lake	Luck, WI

Sample Point Description: mid-lake

Preservative Added: ☒ Lugol's ☐ Glutaraldehyde ☐ None

Identification Requested: ☒ Algae Count & ID to Genus ☐ Cyanobacteria Count & ID to Genus

Additional Test Instructions:

Sample Information:

Sample Type: composite	Sample Reason: lake study
Depth of Sample: 6 ft	Comments: not green anymore
Collected By: AK, JW	Collector Telephone Number: 715, 485-8637
Sample Date: 8 / 25 / 08	Sample Time: ___ : ___ (hh:mm) ☒ a.m. ☐ p.m.

For Lab Use Only:

Date Received at Lab: ___/___/___

Laboratory Number: ______

Sample Preserved: ☐ In Field ☐ At Lab

Preservative: ______

Date Analyzed: 10 / 29 / 08

Analyst: TCP

Field Conditions:

Lake Surface Temperature – (°C): 23.5	Wind Direction:
Ambient Air Temperature - (°C):	Approximate Wind Velocity (MPH): breezy

Cloud Cover (Check Most Appropriate):

☐ **Clear Skies** ☒ **Partly Cloudy (Mostly Sun)**

☐ **Overcast** ☐ **Partly Sunny (Mostly Clouds)**

☐ **Raining**

Comments:

Send Report & Bill To:

Name (First, Last): Amy Kelsey

Company: Polk LWRD	Telephone Number: 715, 485-8637

Address: 100 Polk County Plaza Ste 120

City	State	Zip
Balsam Lake	WI	54810

Email Address: amyk@co.polk.wi.us

10/01/08
10:32
FT000240

Created: 9/13/2004 DK
Revised: 5/23/2005 DK

WSLH

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Madison, WI 53718
Phone: (608) 224-6230 • (800) 442-4618
Fax: (608) 224-6267

ALGAE IDENTIFICATION TEST REQUEST

Sample Location – Waterbody Name: Ward Lake

Sample Location – City, State: Luck, WI

Sample Point Description: mid-lake

Preservative Added: ☒ Lugol's ☐ Glutaraldehyde ☐ None

Identification Requested: ☒ Algae Count & ID to Genus ☐ Cyanobacteria Count & ID to Genus

Additional Test Instructions:

Sample Information:

Sample Type: composite	Sample Reason: lake study
Depth of Sample: 6 ft	Comments:
Collected By: AK, JW	Collector Telephone Number: 715,485-8637
Sample Date: 9/15/08	Sample Time: ___:___ (hh:mm) ☒ a.m. ☐ p.m.

For Lab Use Only:

Date Received at Lab: ___/___/___

Laboratory Number: ______

Sample Preserved: ☐ In Field ☐ At Lab

Preservative: ______

Date Analyzed: 10/30/08

Analyst: DK

Field Conditions:

Lake Surface Temperature – (°C): 18.0	Wind Direction:
Ambient Air Temperature - (°C):	Approximate Wind Velocity (MPH): breezy

Cloud Cover (Check Most Appropriate):

☐ **Clear Skies** ☒ **Partly Cloudy (Mostly Sun)**

☐ **Overcast** ☒ ~~**Partly Sunny**~~ **(Mostly Clouds)**

☐ **Raining**

Comments:

Send Report & Bill To:

Name (First, Last): Amy Kelsey

Company: POLK LWRD

Telephone Number: 715,485-8637

Address: 100 Polk County Plaza Ste120

City: Balsam Lake State: WI Zip: 54810

Email Address: amyk@co.polk.wi.us

10/01/08
10:32
FT000241

Created: 9/13/2004 DK
Revised: 5/23/2005 DK