Seasonal Dynamics and Food Web Interactions of Planktonic Organisms in Big Platte Lake, Benzie Co., Michigan in 2012.

Scott McNaught, Ph.D.
Central Michigan University

Report to the Michigan Department of Natural Resources and the Platte Lake Improvement Association

16 August 2013

Objectives:

- Describe the plankton composition and seasonal dynamics of plankton populations in Big Platte Lake, MI during 2012.
- Compare plankton composition and seasonal dynamics in 2012 with composition and dynamics in 2010 and 2011.
- Describe the planktonic food web of Big Platte Lake, MI, including major feeding pathways.

Methods:

Phytoplankton and zooplankton samples were collected from Big Platte Lake seasonally in 2012 (April, August, and October). MDNR personnel sampled epilimnetic phytoplankton at 3 locations near the deep hole in Big Platte Lake by dropping a 2-cm diameter silicone tube sampler vertically through the water column (0-30 ft.). The tube sampler was outfitted with a one-way foot valve on the lower end to facilitate sample collection. As the tube sampler was withdrawn from the water, its contents were released into a clean container. One 250-mL bottle was filled with well-mixed tube sampler water from each sample location. MDNR personnel also collected discrete samples from 45, 60, 75 and 90 feet at one location using a Van Dorn bottle sampler. Samples from individual depths were combined in a single container to produce an integrated 45-90 foot sample. One 250-mL sample bottle was filled with well-mixed hypolimnetic water. All algal samples were preserved with Lugol's solution.

MDNR personnel collected zooplankton samples from Big Platte Lake using a 30-cm diameter, 64-μm mesh net. Three vertical net tows were collected from 1 m above the sediments to the surface at separate locations near the deep hole. The net was hauled no faster than 1 m/sec. The contents of each net tow was washed into separate, labeled 250-mL bottles and preserved with formalin (37% formaldehyde).

Phytoplankton samples were examined by placing 5 ml of well-mixed sample into a settling chamber for 24 hours. Algal species were enumerated at 200-400x magnification using a Zeiss inverted compound microscope. All colonial and large solitary algal species in the sampling chamber were enumerated at 200x magnification (Table 1). Cell counts for large algal species were multiplied by 200 to get cells/liter. Small algal species in the sampling chamber were enumerated at 400x magnification using a sub-sampling technique (Table 1). All algae along a single transect through the middle of the counting chamber (38 rectangular fields of view) were counted. Cell counts for small algal species were divided by the proportion of rectangular field examined in the chamber (38/1663) and multiplied by 200 to get cells/liter. For some colonial and filamentous species (Table 1), it was easier to measure colony length or area and apply a correction formula to estimate the number of cells.

Table 1: Counting procedures used for algal types and genera found in Big Platte Lake, Benzie Co., Michigan.

Algae type	Counting Procedure	Algal Genera
Large/Colonial	magnification = 200 count entire chamber cells/L = counts * 200	*Stephanodiscus, Cyclotella, Cocsinodiscus, Cymatopleura, Amphipora, Asterionella, Diploneis, Pleuro/Gyrosigma, Rhizosolenia, Cymbella, Tabellaria, Pediastrum, Coelastrum, Mugeotia, Zygnema, Spirogyra, Gymnodinium, Peridinium, Chrysophaerella, Ceratium*
Small	magnification = 400 count fields cells/L = counts ÷ prop. chamber * 200	*Synedra, Achnanthes, Navicula Hantschia, Nitschia, Pinnularia, Mastigloia, Scenedesmus, microgreens, Golenkinia, Closterium, Mallamonas, Cryptomonas, Dinobryon, Epipyxis*
Filament	magnification = 200 count entire chamber counts = length * 5.5 cells/L = counts * 200	*Fragilaria*
Filament	magnification = 200 count entire chamber counts = length * 1.0 cells/L = counts * 200	*Melosira*
Colony	magnification = 200 count entire chamber counts = area * cells/area cells/L = counts * 200	*Microcystis*

Table 2: Shapes and geometric formulas for the volume of select algal taxa found in Big Platte Lake, Benzie Co., Michigan. Symbols: D = diameter, L = length, W = width, H = height.

	Fragilaria	*Melosira*	*Scenedesmus*	*Microcystis*	*Dinobryon*
Cell shape	elliptic prism	cylinder	prolate spheroid	sphere	ellipsoid
Volume	$L*W^{*}H*\pi/4$	$H*D^2*\pi/4$	$L*W^2*\pi/6$	$D^3*\pi/6$	$\frac{1}{2}(\frac{2}{3}L*W*T)*\pi/6 + \frac{1}{2}(\frac{1}{3}L*W*T)*\pi/6$

Algal biomass was calculated as the product of cell density and average cell volume. Average cell volume was determined by measuring length, width, and depth of 20 randomly selected cells from 2003 Big Platte Lake samples and applying a published geometric formula that closely approximated the shape of each taxon (Table 2). The volume of colonial green algae was calculated as the product of colony density and average colony volume. Cell volumes (μm^3) were multiplied by 10^{-9} to give biovolume (µl). If one assumes that algal cell density is approximately 1.0 g/ml, biovolume (µl) is equivalent to dry biomass (mg). This assumption is good for green algae and cyanobacteria. It severely underestimates diatom biomass.

Zooplankton species were enumerated by counting 5-ml sub-samples in a Bogorov tray at 25x magnification using a Leica stereomicroscope. Zooplankton biomass was calculated as the product of species density and average individual dry weight. Average individual dry weights of copepod (calanoid, cyclopoid) and cladoceran (*Bosmina*, *Daphnia*, and *Holopedium*) species was determined by measuring 30 individuals of each taxon from 2004 Big Platte Lake samples and applying a published length-weight regression to the average length (Culver et al. 1985). Average individual dry weights of rotifer species (*Polyarthra*, *Keratella*) found in Lake Michigan (Makarewicz et al. 1994) were used to estimate average individual dry weights in Big Platte Lake. Average individual dry weights of *Alona* and *Chydorus* in Lake Michigan (M. Edwards, unpublished data) were used estimate dry weight of animals found in Big Platte Lake. Average individual dry weight of *Leptodora* in Big Platte Lake was estimated by applying a published length-weight regression (Manca et al. 2000) to a 6 mm animal.

Results:

Phytoplankton in Big Platte Lake:

Planktonic algae were most abundant in August 2012 when peak cell counts were 4.1 million cells per liter (Fig. 1). In Big Platte Lake, phytoplankton have exhibited spring and summer abundance maxima since 2003, even though the dates of peak abundance have varied slightly from year to year. The spring abundance peak occurs between late April and early May and the summer abundance peak occurs between late July and August.

Flagellates and blue-green bacteria were dominant in the epilimnion of Big Platte Lake in 2012 (Fig. 1). The most common flagellates were *Dinobryon* and the cryptomonads *Cryptomonas* and *Chroomonas*. Blue-green bacteria were dominated by the colonial genera *Merismopedium,* and *Microcystis*; and *Chroococcus* was abundant in August. Green algae were abundant in April and August. The most common green algae were *Scenedesmus* and single-celled micro-greens, though *Coelastrum* was abundant in April. Diatoms were less abundant than other phytoplankton groups in 2012 (Fig. 1). Common diatoms included *Fragilaria* and small pennates such as *Navicula, Cymbella* and *Synedra*. *Asterionella* was abundant in April.

The phytoplankton composition of the deep waters (45-90 ft.) of Big Platte Lake mimicked that of the epilimnion except that diatoms were relatively more abundant in April and October. The heavy, filamentous diatom *Melosira* was common in deep water during April and October 2012.

There was a seasonal shift in phytoplankton composition in Big Platte Lake during 2012. Green algae and flagellates were consistently abundant throughout the year. Blue-green bacteria though numerically dominant throughout the year became even more abundant in August (Fig. 1). The species composition in 2012 was similar to that in 2010 and 2011, except that the August peak in blue-green bacteria was higher in 2012 than in previous years. Blue-green bacteria have been a prominent feature of Big Platte Lake during the past 5 years (2008-2012) compared to earlier years (2006-2007).

Although flagellates and blue-green bacteria were numerically dominant in Big Platte Lake, diatoms represented a substantial portion of algal biomass particularly in the deep water (Fig. 2). Diatom cells are much larger than the cells of most other algal taxa in Big Platte Lake. Only the dinoflagellate *Ceratium* has larger cells. Diatom biomass may be underestimated because mass of the glass frustule (cell wall) is not included in the biomass calculation. Diatoms comprised the majority of algal biomass (≥50%) in the epilimnion (0-30 ft.) of Big Platte Lake during April 2012 when the lake was mixing (Fig. 2). Mixing events are required to keep heavy diatoms suspended in the water column.

In 2012, epilimnetic algal biomass in Big Platte Lake ranged from 0.7 to 1.1 mg/L. Algal biomass was low (< 1.0 mg/L) during December 2012 (Fig. 2). A bloom of blue-green bacteria was responsible for the large biomass peak in August. Mean algal biomass in 2012 (0.87 mg/L) was similar to than that in 2010 (0.75 mg/L) and 2011 (1.1 mg/L). In 2010 and 2012, diatoms dominated algal biomass in Big Platte Lake. Strong dominance by diatoms in deep water during August, however, has decreased since 2010 (Fig. 2).

The distribution of algal biomass with depth reflects the mixing status of Big Platte Lake in 2012. In April, algal biomass was similar in the epilimnion and deep waters of Big Platte Lake suggesting that the lake was mixing (Fig. 2). In August, algal biomass was greatest in the epilimnion indicating that the lake was stratified.

Zooplankton in Big Platte Lake:

The zooplankton community of Big Platte Lake includes 5 copepod taxa (*Diacyclops thomasi*, *Mesocyclops edax*, *Diaptomus* spp., *Epischura lacustris*, and harpacticoids), 9 cladoceran taxa (*Bosmina*, *Eubosmina*, *Ceriodaphnia*, *Diaphanosoma*, *Daphnia*, *Holopedium*, *Sida*, *Chydorus*, *Leptodora*) and many rotifer species. The copepods *Diacyclops* and *Diaptomus* (both naupliar and copepodid stages) and the cladocerans *Bosmina* and *Daphnia* were the most common microcrustaceans in 2012. *Polyarthra* and *Keratella* were the most common rotifers.

Planktonic crustaceans were most abundant (13 per L) during April 2012 (Fig. 3). Rotifers were similarly abundant in April (47 per L) and August (53 per L). Larval and adult copepods dominated the crustacean plankton in 2012 (Fig. 3).

Zooplankton abundance has remained low during the past 3 years. Crustacean abundance has been less than 25 per liter. Rotifer abundance has increased from 20 per liter to 53 per liter, yet these values are only 1/3 those observed in 2003-2008. There has been a slight change in seasonal abundance patterns since 2011. In 2010 and 2011, crustaceans and rotifers were most abundant during August, but in 2012 they were most abundant in April.

In 2012, zooplankton biomass in Big Platte Lake ranged from 5.6 μg/L in October to 11.9 μg/L in April (Fig. 3). Although rotifers were numerically dominant during most of the year, they exhibited a minor portion of total zooplankton biomass during April and

August 2012. Adult copepods dominated zooplankton biomass in April and August. Rotifers and cladocerans were co-dominant in October (Fig. 3).

Mean zooplankton biomass in Big Platte Lake decreased from 15 µg/L in 2010 to 8.3 µg/L in 2010. Cladocerans were responsible for summertime biomass peaks in 2010 and 2011, but in 2012 there was no peak in cladoceran biomass. Low cladoceran biomass in recent years may be caused by increased fish predation or zebra mussel filtering.

Discussion:

Planktonic organisms in Big Platte Lake include bacteria, protozoans, algae, rotifers, and crustaceans. Bacteria and protozoans interact closely in a “microbial food web”. Bacteria ingest organic molecules dissolved in lake water and protozoans eat the bacteria. Algae, rotifers, and crustacean plankton interact with one another, and with larger invertebrates and fish, in a traditional grazing food web (Fig. 4). The Big Platte Lake food web has remained unchanged since 2002. No unique or exotic plankton species were discovered in 2012. However, the filtering effect of exotic zebra mussels may be responsible for reduced abundance of phytoplankton and zooplankton, which could translate to lower fish abundance higher in the food web.

Algae (phytoplankton) constitute the basis for the grazing food web in Big Platte Lake (Fig. 4). Algae use photosynthetic pigments to acquire energy from the sun. They use this energy to create sugars, which are eventually stored as starch or oil. Heavy algal taxa such as the diatoms are abundant during spring and fall overturn when the lake is mixed, top to bottom, by the wind. Diatom biomass can also be high in the epilimnion following strong wind events during the summer. Strong winds can re-suspend diatoms that have settled to the bottom in shallow water.

When Big Platte Lake is not mixed, it stratifies into warm surface and cool deep-water layers. Heavy diatoms sink into the hypolimnion and lighter phytoplankton taxa such as green algae and flagellates become abundant. Small green algae and flagellates thrive during the spring and early summer when epilimnetic nutrients (nitrogen and phosphorus) are plentiful. During calm periods in late summer, epilimnetic nitrogen concentrations become low. Colonial blue-green algae become abundant because they can tolerate low nitrogen concentrations and have gas vacuoles that allow them to float near the surface. Added phosphorus during the late summer can enhance the growth of blue-green algae.

When diatoms, flagellates and green algae are abundant in Big Platte Lake, populations of herbivorous zooplankton (rotifers, copepod nauplii, and cladocerans) increase. Nauplii and rotifers are small (80-300 µm) and can only ingest single celled or small colonial green algae and flagellates (Fig. 4). Cladocerans such as *Bosmina* and *Daphnia* are large (300-2500 µm) and can ingest diatoms as well as small green algae and flagellates. Because they can eat a wider range of food sizes, cladocerans may out-compete rotifers and nauplii for food in June when all algal types are abundant.

Planktonic herbivores in Big Platte Lake are most abundant when densities of green algae and flagellates are high. Peak rotifer abundance coincided with abundant flagellates and green algae during each year of this study (compare Figs. 1 and 3). Rotifers and cladocerans reproduce asexually and their populations can increase quickly when food is abundant. Copepods reproduce sexually and rarely produce more than three sets of nauplii in a year. The copepods in Big Platte Lake produced nauplii in late May and August when edible algae were most abundant.

Among the cladocerans, *Daphnia* replaces *Bosmina* in mid-summer because it grows quickly in warm water and out-competes *Bosmina* for flagellates and green algae. In August, the blue-green alga *Microcystis* becomes abundant. *Microcystis* can be toxic to *Daphnia* and is difficult to ingest. *Bosmina*, however, can avoid the blue-green colonies and feed on green algae and flagellates. Therefore, late in the summer *Bosmina* once again becomes the dominant cladoceran.

Abundance of planktonic crustaceans may have been lower in the past three years than in earlier years because the density of edible green algae was low during the summer. Abundant green algae fuel fast-growing populations of nauplii and cladocerans. Without abundant green algae, crustacean plankton cannot be abundant. Cladoceran abundance was low in 2012 possibly as a result of increased fish predation or competition from zebra mussels that filter algae from the water (Fig. 4).

Predators in Platte Lake include cyclopoid copepods and planktivorous fish (Fig. 4). Cyclopoid copepods feed on protozoans and rotifers during all juvenile and adult (copepodid) life stages. Larval and juvenile fish are visual predators that actively select large prey such as adult copepods and cladocerans. Some fish species such as alewife, yellow perch, and sunfish also feed on plankton as adults. If fish predation is intense, small-bodied taxa (ex: rotifers, nauplii) will dominate the zooplankton.