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

Scott McNaught, Ph.D.
Central Michigan University

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

April 1, 2004

Objectives:

- Describe seasonal dynamics of plankton populations in Platte Lake, MI during 2003.
- Compare plankton seasonal dynamics in 2002 and 2003.
- Describe the planktonic food web of Platte Lake, MI, including major feeding pathways.
- Discuss potential impacts of zebra mussels on planktonic food web.
- Discuss possible causes of late summer foam event.

Methods:

Phytoplankton and zooplankton samples were collected every two weeks in 2003 unless ice conditions made sampling unsafe. No samples were collected in February and only one set of samples was collected in April and December.

Between January 29 and July 2, MDNR technicians collected a single set of 250-ml phytoplankton samples at 8 discrete depths (0, 7.5, 15, 30, 45, 60, 75, and 90 feet) using a 4-L bottle sampler. After July 2, the epilimnetic phytoplankton was sampled with a 2-cm diameter silicone tube dropped vertically through the upper 30 feet of water where algae are most abundant. The tube sampler was outfitted with a one-way foot valve on the lower end to facilitate sample collection. As the tube was withdrawn from the water, its contents were released into a clean container. Three 250-mL epilimnetic samples were collected from separate locations near the deep hole. MDNR personnel also collected discrete samples from 45, 60, 75 and 90 feet at one location on each sampling date. All algal samples were preserved with Lugol's solution.

Between January 29 and May 21, MDNR technicians collected a single set of 250-ml zooplankton samples at 8 discrete depths (0, 7.5, 15, 30, 45, 60, 75, and 90 feet) using a 4-L bottle sampler. Entire contents of the bottle sampler were filtered through a 64-µm mesh and preserved with formalin. After May 21, the zooplankton was sampled with 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.

Phytoplankton samples were examined by placing a known volume of well-mixed sample into a settling chamber for 24 hours. Algal species were enumerated at 400x magnification using a Zeiss inverted compound microscope. Algal biovolume was calculated as the product of species density and average cell volume. Average cell volume was determined by measuring length, width, and depth of 20 randomly selected cells and applying a published geometric formula that closely approximated the shape of each taxon.

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 mass. The average individual mass of species in Platte Lake was estimated using published values for similar species found in Lake Michigan (Makarewicz et al. 1994).

Results and Discussion:

Phytoplankton:

Diatom species, small green algae, and chrysophytes dominated the phytoplankton of Platte Lake in 2003. The most common diatom species were large colonial or pennate diatoms (*Fragilaria, Melosira*, and *Synedra*). The most common green algae were *Scenedesmus* and an unidentified picoplankter. *Dinobryon* was the most common chrysophyte.

Planktonic algae were most abundant between April and June 2003 (Fig. 1). Springtime abundance reached 1,000,000 cells per liter. Summertime abundance was typically less than 500,000 cells per liter except in mid-August when there was a bloom of blue-green algae and metalimnetic pulse of diatoms (Fig. 1). The seasonal pattern of phytoplankton abundance in 2003 was similar to that in 2002; however, peak abundances were lower in 2003 (1,000,000 cells per liter) than in 2002 (1,800,000 cells per liter).

There was a distinct seasonal succession of algal taxa in Platte Lake. Chrysophytes dominated the phytoplankton under the ice in early March (Fig. 1). Diatoms were numerically dominant in the spring (April-June) when the lake was well mixed by the wind. Green algae dominated the plankton in June after the onset of stratification. In mid-August, blue-green algae became temporarily important in the epilimnion of Platte Lake. Diatoms once again became dominant in October after fall mixing occurred (Fig. 1).

The distribution of algal taxa with depth varied seasonally. In early March, chrysophytes occurred in the upper waters just under the ice, and diatoms were present deep in the lake (Fig. 1). Planktonic algae were evenly distributed in the water column during April, May, October and November when the water column was well mixed (Figs. 1). In June and September, green algae dominated the epilimnion and diatoms dominated the hypolimnion. During the summer (June-Sept.), planktonic algae were more abundant in the upper 30-40 feet of Platte Lake than in the deeper waters (Figs. 1). In mid-August, a temporary blue-green bloom occurred in the epilimnion and diatoms became abundant at 45 feet. High numbers of diatoms at 45 feet likely resulted from a strong and prolonged wind event that disturbed bottom sediments in shallow portions of the lake.

Patterns of algal biovolume across season and depth demonstrate the importance of diatoms in Platte Lake. Diatoms comprised > 90% of algal biovolume in March, April, May, October, and November 2003 (Fig. 2). During summer months (June-September), diatoms were less important in the epilimnion (0-30 feet) but dominated algal biovolume in the hypolimnion. Although green algae were abundant in the epilimnion during June and September, their contribution to total algal biovolume was limited because of their small size. During periods of mixing (April, May, October) high diatom biovolume was evident near the bottom of Platte Lake (Fig. 2) because large colonial diatoms such as *Melosira* had been disturbed from the sediment surface. In July and August, the colonial planktonic diatom *Fragilaria* was responsible for the high diatom biovolume in the epilimnion and at 45 feet.

Zooplankton:

The zooplankton community of Platte Lake includes 5 copepod species, 9 cladoceran species and many rotifer species. Cyclopoid copepods (both naupliar and copepodid stages) and the cladoceran *Bosmina* dominated the crustacean zooplankton in 2003. *Polyarthra* and *Keratella* were the dominant rotifers.

Planktonic animals were most abundant between May and July 2003 (Fig. 3a). Cyclopoid copepodids and nauplii reached peak abundance in mid-May, whereas cladocerans and rotifers reached peak abundance in mid-June. Rotifers were three times more abundant than crustacean plankton (Fig. 3a); however, they accounted for only a very small proportion of zooplankton biomass even when they were most abundant (Fig. 3b). The seasonal pattern of zooplankton abundance in 2003 was different from that in 2002 when rotifers and copepods exhibited an extra abundance peak in late April. Rotifer density in late April 2002 was extremely high (900 individuals per liter), but rotifer density in June 2002 2003 (420 individuals per liter) was comparable to that in June 2003 (550 individuals per liter).

There was a distinct seasonal succession of zooplankton taxa in Platte Lake in 2003. Cyclopoid copepods (nauplii and copepodids) dominated the crustacean plankton in the winter and spring but shared dominance with the cladocerans between May and November (Fig. 3). *Daphnia* replaced *Bosmina* as the dominant cladoceran in July. Rotifers were prominent numerically between May and November.

Plankton Food Web

Planktonic organisms in 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.

Algae (phytoplankton) constitute the basis for the grazing food web in 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 most abundant during the spring and fall when the lake is well mixed by the wind. Light taxa such as the green algae are abundant in the late spring and summer. Blue-green algae are abundant in the late summer when nitrogen concentrations become low in the epilimnion.

Copepod nauplii and most of the rotifer and cladoceran species in Platte Lake are grazers that feed on diatoms, chrysophytes and green algae (Fig. 4). Nauplii and rotifers are small (80-300 μm) and can only ingest single celled or small colonial algae (ex: *Scenedesmus*). Cladocerans such as *Bosmina* and *Daphnia* are large (400-2500 μm) and can ingest both small and large algal cells and colonies. If only large algae (i.e., colonial diatoms) are available, cladocerans may out-compete rotifers and nauplii for food. Rotifers and *Bosmina* became abundant in mid-June 2002 and 2003 just as edible green algae were at their peak in the epilimnion of Platte Lake. Once green algae disappeared in July, *Daphnia* became the dominant grazer. None of the grazers eat blue-green algae (ex: Microcystis), which are often toxic and difficult to ingest.

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 predations is intense, small bodied taxa (ex: rotifers, nauplii) will dominate the zooplankton.

Potential Impact of Zebra Mussels

Zebra mussels are exotic mollusks that were introduced to the Great Lakes ecosystem in 1984. Since their introduction, zebra mussels have been transported to many inland lakes in live wells and the lower units of motorboats.

Zebra mussels are bottom-dwelling organisms that prefer to be attached to hard substrates (ex: rocks, logs, piers). Zebra mussels are grazers that filter algae from large quantities of water each day. Zebra mussels ingest most algal types except blue-green algae. If filtered particles include blue-green algae or other undesirable materials, zebra mussels will package the particles and deposit the "pseudofeces" on the lake bottom. In lakes where zebra mussels have become abundant, the accumulation of pseudofeces and true feces has caused a dramatic increase in rooted aquatic plants and bottom-dwelling invertebrates.

Zebra mussels will become abundant in Platte Lake only if they can find enough hard substrate for attachment. It is unclear whether marl is an adequate substrate. If zebra mussels become abundant in Platte Lake, they could have a dramatic effect on water clarity, phytoplankton composition, and rooted aquatic vegetation. Most of Platte Lake is shallow (< 5 m). Therefore a large volume of water is in close proximity to the bottom and vulnerable to filter-feeding bottom-dwellers. Zebra mussels would be able to clear algae and other particle from much of the water. This would improve water clarity. However, blue-green algae will become more prevalent because zebra mussels will not ingest them. Finally, rooted aquatic plants will become more abundant as zebra mussels transfer nutrients from the open water to the bottom.

Late Summer Foaming Event

In late August 2003, the surface of Platte Lake near the shore became covered with dense foam. This foam persisted for several weeks. Though not analyzed chemically, the foam was most likely composed of surfactants released from dead algae. In mid-August, the diatom *Fragilaria* and the blue-green *Microcystis* were both abundant in the epilimnion of Platte Lake. Diatoms are a likely source of surfactant because they they store photosynthetic product as oil (triglycerides). It is likely that an extended wind event disturbed shallow sediments and entrained decomposing diatoms into the epilimnetic water. Diatom and/or blue-green cell membranes burst, releasing stored oils and other organic molecules. The oils and other hydrophobic surfactants were then transformed into foam by turbulent mixing.