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

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Objectives:

- Describe the plankton composition and seasonal dynamics of plankton populations in Big and Little Platte Lakes, MI during 2006.
- Compare plankton composition and seasonal dynamics in 2006 with composition and dynamics in 2002- 2005.
- Describe the planktonic food web of Big Platte Lake, MI, including major feeding pathways.
- Determine greatest source of error in phytoplankton abundance estimates.

Methods:

Phytoplankton and zooplankton samples were collected from Big Platte Lake every two weeks in 2006 (March-December) unless ice conditions made sampling unsafe. Only one set of samples was collected in March and December. Phytoplankton samples were collected from Little Platte Lake every two weeks in 2006 (March-November).

MDNR technicians sampled epilimnetic phytoplankton in Big Platte Lake 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 As the tube was withdrawn from the water, its contents were released into a clean container.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 tube samples were collected from separate locations near the deep hole and combined in a single container. MDNR personnel also collected discrete samples from 45, 60, 75 and 90 feet at one location and combined them in a single container to produce an integrated 45-90 foot sample. Three 250-mL sub-samples were collected from each container and algae were preserved with Lugol's solution. Little Platte Lake is shallow and well-mixed, so MDNR technicians sampled phytoplankton by filling three 250-mL bottles just below the surface and preserving samples with Lugol's solution.

MDNR technicians collected zooplankton samples from Big Platt 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.

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 were counted within 38 rectangular fields of view along a single transect through the middle of the counting chamber. 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 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
Formula	$L*W^{*}H*\pi/4$	$H*D^2*\pi/4$	$L*W^2*\pi/6$	$D^3*\pi/6$	$\frac{1}{2}(\frac{2}{3}L*W*T)*\pi/6 + \frac{1}{2}(\frac{1}{3}L*W*T)*\pi/6$

Algal biovolume 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 samples and applying a published geometric

formula that closely approximated the shape of each taxon (Table 2). The biovolume 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 and applying a published length- dry 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.

When estimating algal abundance on a given date, potential sources of error include one field technique (filling 250-mL bottles) and three laboratory techniques (filling settling chambers, using settling chambers of different size, counting rectangular fields of view along a transect). To evaluate the greatest source of error in algal abundance estimates, we conducted two laboratory experiments. In the first experiment, we evaluated error caused by field collection (bottles), chamber type, and transect counting. In the second experiment, we evaluated error caused by filling settling chambers (replication), chamber type, and transect counting. In both experiments, we filled a small and large diameter chamber with 5 mL of well-mixed sample. We counted algae along 3 parallel transects (top, middle, bottom of chamber) in the small (27 fields/transect) and large (38 fields/transect) chamber. Transect counts for dominant algal groups were analyzed with a Two-Factor ANOVA (Experiment 1 factors = bottle and chamber type, Experiment 2 factors = replicate and chamber type).

Results:

Phytoplankton in Big Platte Lake:

Small green algae, flagellates, and diatom species dominated the phytoplankton in the epilimnion of Big Platte Lake in 2006. The most common green algae were *Scenedesmus* and unidentified colonial and single-celled microgreens. The most common flagellates were *Dinobryon*, a colonial chrysophyte, and two cryptomonads (*Cryptomonas*, *Chroomonas*). In past years, the large *Cryptomonas* was referred to as a "Euglenoid." Common diatoms included *Asterionella* in the winter, spring and fall; *Melosira, Fragilaria,* and *Navicula* (and similar taxa) during spring and fall mixing; and centrics during the summer. Blue-green algae were represented by the colonial genera *Chroococcus* and *Merismopedium,* and in the summer *Microcystis*.

Planktonic algae were most abundant in the spring and late summer 2006 when peak cell counts were 3.7 and 4.4 million cells per liter, respectively (Fig. 1d). Spring and summer phytoplankton abundance maxima have been a consistent feature of Big Platte Lake since 2002, even though the dates of peak abundance have varied slightly from year to year. In 2002, 2003 and 2005, the spring abundance peak occurred in June; whereas in 2004 and 2006, the spring abundance peak occurred in April (Fig. 1). The summer abundance peak occurred in August during all years except 2002 when it occurred in early September.

The annual average epilimnetic cell counts were higher in 2006 than in 2005 (2.5 versus 1.6 million cells per liter) and 5 times higher than in past years (2003: 470,000 cells per liter; 2004: 550,000 cells per liter). In part, high cell counts in 2006 can be attributed to increased lake productivity. Mean chlorophyll *a* concentration increased 40% between 2004 and 2006 (Fig. 2). It is also likely that cell counts increased in 2005 and 2006 as a result of improved resolution and technical precision during the counting process. In recent years, small cells were counted at 200x rather than 100x magnification.

There was a distinct seasonal succession of algal taxa in Big Platte Lake during 2006. Small flagellates were numerically dominant under the ice in winter and during the spring (Fig. 1c). Small green algae became numerically dominant in the summer. Colonial blue-green algae and diatoms became quite abundant during the late summer. The seasonal succession in 2006 was similar to that in 2004 and 2005 except that green algae did not exhibit a spring abundance peak and blue-green algae were more prominently represented in late summer (Fig. 1).

Although flagellates and small green algae were numerically dominant in Big Platte Lake during 2006, diatoms contributed the most algal biomass (Fig. 3d). Diatom cells are much larger than the cells of most other algal taxa in Big Platte Lake. Only the dinoflagellate *Ceratium* has larger cells. Diatoms comprised greater than 50% of algal biomass in the epilimnion (0-30 ft.) during 2006 (Fig. 3d). During winter, spring, and early summer, diatoms comprised greater than 70% of algal biomass. Although flagellates and green algae were abundant in the epilimnion during most of the year, their contribution to total algal biomass was limited because of their small size. Because we disregarded the glass frustule (cell wall) when calculating diatom biomass, we underestimate the contribution of diatoms to total biomass.

In 2006, algal biomass in Big Platte Lake ranged from 0.53 to 7.38 mg/L, and mean annual algal biomass was 2.22 mg/L. Algal biomass was low (< 1.5 mg/L) during winter, spring, and fall 2006 (Fig. 3d). Centric diatom blooms were responsible for algal biomass peaks in early June and late July. In 2003-2005, mean algal biomass was much lower (0.22-1.22 mg/L, respectively) than in 2006. Diatoms also dominated algal biomass during spring, summer and fall except during August 2003 when algal biomass was dominated by blue-green algae (Fig. 3).

The distribution of algal biomass with depth reflects the mixing status and thermal properties of Big Platte Lake. In January, algal biomass was greatest near the surface indicating that the lake was not mixing (Fig. 4). A layer of ice most likely covered Big Platte Lake restricting mixing and light levels and encouraging the growth of small,

mobile flagellates. Between April and June, Big Platte Lake alternated between periods of mixing and stratification. During mixing periods, algal biomass was similar at all depths (Fig. 4, May 16). Heavy diatoms and nutrients from the bottom are brought to the surface by the moving water. During stratified periods, algae grow quickly in the well-lit, nutrient rich surface waters such that algal biomass is highest in the epilimnion (Fig. 4, June 1). Between July and September, algal biomass was greatest near the surface indicating that the lake was stratified (Fig. 4). Green algae, flagellates and blue-green algae grew well in the warm surface waters. Diatom biomass in surface water decreased as heavy species sank toward the bottom. In late July, there was a *tremendous* centric diatom bloom after which the diatoms settled toward the bottom. In late October, algal biomass was similar at all depths, indicating that Platte Lake had once again become mixed. Similar algal biomass in the epilimnion and hypolimnion continued through December (Fig. 4).

Phytoplankton in Little Platte Lake:

Small green algae and colonial blue-green species dominated the phytoplankton in the epilimnion of Little Platte Lake in 2006. The most common green algae were *Scenedesmus, Ankistrodesmus,* and unidentified colonial and single-celled microgreens. Blue-green algae were represented by the colonial genera *Chroococcus, Merismopedium,* and *Microcystis*. Nitrogen-fixing *Anabaena* was also present in moderate numbers. Common flagellates included *Dinobryon* and two cryptomonads (*Cryptomonas*, *Chroomonas*). Centric and small pennate diatoms were abundant throughout the year. *Fragilaria* was common during spring and fall mixing.

Planktonic algae were most abundant in late spring and late summer 2006 when peak cell counts were 9.7 and 6.5 million cells per liter, respectively (Fig. 5b). Average epilimnetic cell counts were higher in 2006 than in 2005 as a result of a large spring bloom of green algae in 2006. In 2005, there was no spring abundance peak (Fig. 5). The summer abundance peak was similar in 2005 and 2006.

Although there was a seasonal succession of algal taxa in Little Platte Lake during 2006, it was less distinct than that in Big Platte Lake. Small flagellates and diatoms were present in comparable numbers throughout the year (Fig. 5b). Small green algae became numerically dominant in the spring and colonial blue-green algae became abundant during the late summer. The seasonal succession in 2005 differed from that in 2006 because green algae did not exhibit a spring abundance peak (Fig. 5).

Although small green algae and colonial blue-greens were numerically dominant in Little Platte Lake during 2006, diatoms and flagellates contributed the most algal biomass (Fig. 6b). Diatom cells are much larger than the cells of most other algal taxa in Little Platte Lake. Diatoms dominated algal biomass during winter and fall 2006 and shared dominance with flagellates in spring 2006 (Fig. 6b). The large flagellates *Peridinium* and *Gymnodinium* contributed to the spring biomass peak.

In 2006, algal biomass in Little Platte Lake ranged from 1.3 to 6.4 mg/L, and mean annual algal biomass was 3.0 mg/L. Algal biomass was low (< 3.0 mg/L) during winter and summer 2006 (Fig. 6b). In 2005, diatoms and flagellates also dominated algal biomass, but mean algal biomass was much lower than in 2006.

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. Cyclopoid copepods (both naupliar and copepodid stages) and the cladoceran *Bosmina* were the most common microcrustaceans in 2006. *Polyarthra* and *Keratella* were the most common rotifers.

Planktonic crustaceans and rotifers were most abundant during spring and early summer 2006 (Fig. 7d). Rotifers exhibited two abundance peaks, one in late April (81 animals per liter) and one in early June (183 animals per liter). Crustaceans also exhibited two abundance peaks, one in mid May (64 animals per liter) and one in late June (94 animals per liter) on June 28. Crustacean abundance peaks appeared to follow rotifer abundance peaks. Rotifers were more abundant than crustaceans in the spring and fall. Large numbers of copepod nauplii were present in mid-May and late June (Fig. 7d). Cladocerans exhibited a single dominant abundance peak in June.

Zooplankton abundance and seasonal dynamics have changed during the past 3 years. Crustaceans were most abundant in 2002 (peak = 166 per liter, not shown) and 2003 (peak = 142 per liter) and least abundant in 2004 (peak = 35 per liter). Crustaceans typically exhibit 2-3 abundance peaks per year depending on the number of copepod cohorts and cladoceran blooms (Fig. 7). In 2005, there were 3 copepod cohorts and one mid-summer cladoceran bloom. In 2006, there were 2 copepod cohorts and no cladoceran bloom. Rotifers were also most abundant in 2002 (peak = 939 per liter) and 2003 (peak = 552 per liter) and least abundant in 2004 and 2005 (peak = 122 and 121 per liter). Rotifers exhibited three abundance peaks in 2002, two abundance peaks in 2004 and 2006, but only one abundance peak (June) in 2003 and 2005.

There was a distinct seasonal succession of zooplankton taxa in Platte Lake in 2006. Cyclopoid copepods (nauplii and copepodids) dominated the crustacean plankton in the winter and spring but shared dominance with the cladocerans between June and October (Fig. 7d). *Daphnia* replaced *Bosmina* as the dominant cladoceran in July, but *Bosmina* became dominant once again in August. Rotifers were numerically dominant throughout the year, but particularly in late May.

In 2006, zooplankton biomass in Big Platte Lake ranged from 4.5 to 86.0 μg/L, and mean annual zooplankton biomass was 29.8 μg/L. Zooplankton biomass was lowest (< 20 μg/L) in the winter, early spring, and fall (Fig. 8d). Although rotifers and copepod nauplii were numerically dominant during most of the year, they only comprised a small portion of total zooplankton biomass in 2006. Juvenile and adult copepods dominated zooplankton biomass in winter, spring and fall, and large-bodied cladocerans were a significant component of zooplankton biomass during the summer (Fig. 8d).

The mean abundance and seasonal pattern of biomass varied between years in Big Platte Lake. Mean zooplankton biomass was higher in 2003 (64 mg/L) than in 2004-2006 (30-34 mg/L). Zooplankton biomass exhibited two dominant peaks in 2003, 2004 and 2006, but only one dominant peak in 2005 (Fig. 8). In all years, cladocerans were responsible for summertime biomass peaks.

Algal counting variability

In experiment 1, counts for centric diatoms and green algae were significantly different between sample bottles (Table 3). There were more centric diatoms in bottle 710 than in bottle 945. There were more green algae in bottle 945 than in bottle 710 (Fig. 9). Counts for *Chroococcus* and flagellates were similar between bottles. Chamber type had a significant effect on green algae density estimates and a marginally significant effect on flagellate density estimates (Table 3). In both cases, density estimates were higher in the large-diameter chamber (Fig. 9). There was no bottle-by-chamber interaction for any taxonomic group (Table 3). Transect variability (error bars on graph) was typically small compared to bottle or chamber differences. The largest transect variability was for centric diatoms in bottle 710.

In experiment 2, there was no difference in replicate counts or replicate-by-chamber interaction for any phytoplankton group (Table 3). Chamber type had a significant effect on green algae and flagellate density estimates (Table 3). In both cases, density estimates were higher in the large-diameter chamber (Fig. 10). Transect variability (error bars on graph) was typically small compared to replicate or chamber differences. The largest transect variability was among centric diatoms.

Table 3: Two-way ANOVA results (p-values) for several phytoplankton taxa counted in samples collected from Big Platte Lake in 2006. Significant values in bold.

	Source of Error		
Algal Taxon – Experiment 1	Bottle	Chamber	Bottle * Chamber
Centric diatoms	**0.036**	0.729	0.686
Green algae	**0.022**	**0.001**	0.239
Chroococcus	0.511	0.117	0.935
Flagellates	0.431	0.055	0.779
Algal Taxon – Experiment 2	Replicate	Chamber	Bottle * Chamber
Centric diatoms	0.593	0.703	0.340
Green algae	0.262	**0.001**	0.083
Chroococcus	0.709	0.116	0.611
Flagellates	0.867	**0.007**	0.542

Discussion:

Plankton Food Web

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. 11). The Big Platte Lake food web has remained unchanged since 2002. No unique or exotic plankton species were discovered in 2006.

Algae (phytoplankton) constitute the basis for the grazing food web in Big Platte Lake (Fig. 11). 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. High diatom biomass in the epilimnion is usually indicative of mixing conditions. Peak diatom biomass occurred later in May each year between 2003 and 2006 (Fig. 3) suggesting a change in local weather conditions or regional climate warming.

Periods of strong mixing are often indicated by the presence of bottom-dwelling (benthic) diatoms in plankton samples. Large benthic diatoms such as *Cymatopleura* and *Gyrosigma* are often present in surface and mid-water samples collected during spring and fall mixing periods (May, November). Interestingly, these large benthic diatoms are also present in water samples collected in mid-summer (late July-early August). This suggests that Big Platte Lake undergoes significant mixing in mid-summer and may be considered a polymictic lake.

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 (see Fig. 4; April 19, July 8 and August 23). 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. 11). Cladocerans such as *Bosmina* and *Daphnia* are large (400-2500 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 green algae densities during each year of this study (compare Figs. 1 and 7). Peak cladoceran

abundance coincided green algae peaks in 2003 and 2005 but also with a June flagellate peak in 2004. 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, the temporary replacement of *Bosmina* by *Daphnia* in July can be explained by species-specific growth rates and feeding ability. *Bosmina* is smaller than *Daphnia* and grows more quickly in the cool epilimnion early in the summer. As water temperature increases, so do *Daphnia* populations. By July, the large herbivore is abundant and feed heavily on green algae thereby reducing its abundance. 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. A growing *Bosmina* population soon surpasses the stagnant *Daphnia* population.

Abundance of planktonic crustaceans and rotifers was lower in 2004 than in other years because the density of edible green algae was low in 2004. Abundant green algae fueled fast-growing populations of rotifers and cladocerans. Green algal counts were never more than 400,000 per ml in 2004. Cladoceran abundance was low in 2006 even though the density of flagellates was quite high. Low abundance of edible green algae during 2006 or competition from abundant rotifers may have been responsible for poor cladoceran growth. Alternatively, cladocerans may be feeding on algae, but may in turn be eaten by planktivorous fish.

Predators in Platte Lake include cyclopoid copepods and planktivorous fish (Fig. 11). 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.

Algal counting variability

The largest sources of variability in the phytoplankton collection and enumeration procedure include filling sample bottles and using settling chambers of different diameter. Significantly different density estimates for centric diatoms and green algae between sample bottles suggests that the single collection pail was not adequately mixed before sample bottles were filled. Significantly lower density estimates for green algae and flagellates in small-diameter settling chambers suggests that algae are adhering to the sides of the small chamber or clumping on the bottom of the chamber. Michigan Water Research Center personnel saw no evidence of clumping, so the adherence hypothesis seems likely. Moreover, the green algae and flagellates were dominated by small, single-celled organisms that could easily adhere to walls via electrostatic interactions.

If the Platte Fish Hatchery continues to pool algal samples in a single pail prior to filling 3 sample bottles, I recommend that the pail be stirred thoroughly before filling each bottle. Stirring could begin with a circular motion, but must conclude with a back-and-forth motion to ensure that algal cells are not separated by size as a result of

centripetal forces. The Michigan Water Research Center will eliminate variability due to chamber differences by using only large-diameter settling chambers. One or two drops of dilute soap solution will be added to each sample to decrease wall adhesion.

If the Platte Fish State Fish Hatchery Consent Agreement Team wishes to compare algal populations between lakes or years, I recommend that epilimnetic (0-30 feet) algal samples be collected from at least 3 locations within the deep basin of the lake. Comparisons between lakes or years require an estimate of variability within the lake. If samples are collected from a single pail, one can only estimate the variability within that pail. I also recommend that at least one hypolimnetic (45-90 feet) sample be collected on each date to look for heavy diatom species that indicate mixing events.