LAKE CORE STUDY: HISTORIC WATER QUALITY OF THE LAKE

Many historical aspects of a lake are recorded in the sediments deposited on the lake bottom. Year after year plant, animal and shoreland materials that enter a lake accumulate on its bottom to form layers, or a stratigraphic record, of components in the lake. Diatoms (a type of alga with a silicified wall), fish, plant parts and other materials of interest are preserved in these sediments. A core length represents an historic profile of lake history with the top layers being the present period, and the lower samples (sediments of different colors) representing a period 120 and more years ago. To gain such an historical perspective of Kangaroo Lake, Dr. Paul Garrison (WDNR) performed a core analysis of the lake bottom in 2007 with the help of Dr. Paul Mahlberg.

Procedure. We loaded the core sampler into the boat early one morning and transported it onto a placid Kangaroo Lake to a chosen site about ten feet deep, and gently anchored the boat. To make a core sample Dr. Garrison used a 4-foot long clear plastic tube 2 5/8-inches in diameter and with a 1/8-inch thick wall. The tube was open at both ends. Several heavy lead weights, totaling about 24 lbs., were mounted on the upper end. Three metal fins were mounted vertically at this end to help guide the tube downward when dropped into the water. Also, a 20-foot long rope was attached to this upper end so as to retrieve the core sampler from the lake bottom.

The heavy coring tube was hoisted over the side of the boat, positioned vertically in the lake, and then released. The tube plunged straight down and into the lake bottom. After about 5 minutes, we began to slowly pull it upward. When the top was near the surface, Dr. Garrison reached over the side of the boat and capped the top of the tube to prevent disturbance of the upper zone. We pulled it up further, but still in the water, until he could reach under the water to cap the lower end to prevent any core material from sliding out of the tube. We then pulled the unit into the boat holding the tube in a vertical position where we removed the detachable lead weights, fins and rope, and then returned to shore. The sediment core was 16 7/8-inches long and looked like a good sample. We carefully removed the water still remaining in the tube above the sample.

Dr. Garrison packed the core in a vertical container in his vehicle and returned to his laboratory to analyze the strata. The core will be frozen and subsequently slid out of the tube as an undisturbed column of sediment, and stored as a frozen column for a period of time. Various measurements of column length and strata thickness will be made for comparison with similar columns derived from other lakes in Wisconsin. For our study he analyzed two strata, one very close to the top and another one about 120 years old or about the time that settlers began to occupy the area around the lake. To do so he sliced and removed a segment from each of these regions along the frozen core, and examined the contents microscopically to identify their biological content. He noted in particular the different diatom species and their relative abundance in the two samples.

Results. Color differences were quite evident along the column of sediments as we looked at it upon returning to shore. A distinctly darker band represented the time of local settlement and when timber cutting occurred around Kangaroo Lake in that it included those soil sediment that washed into the lake during the timbering period between 1870 and 1900. Dr. Garrison observed similar bands in cores from other lakes, noting their relationship to settler development around those lakes.

In this study Dr. Garrison provided an analysis of two layers: a very recent one, and a second one representing about 120 or so years ago. Most diatom types in the bottom sample, called benthic diatoms, grew among and attached to aquatic plants, and indicated a relatively low nutrient supply in the lake as reported from other studies. In the recent upper stratum the dominant diatoms lived in more open water (planktonic diatoms) in a lake with fewer aquatic plants, and indicated a loss of vascular plants from the lake along with a moderate rise in nutrient enrichment of the lake. This plant loss could have occurred any time throughout the period, even very recently, or at some other pace. Currently, we observe such a plant loss possibly from human activity as mentioned elsewhere in other reports.

Summary. We are interested in expanding this study of lake cores in greater detail to profile when significant changes in density and species began to occur in the vascular plant community. Such a study would compare many strata each representing 20-year increments in time, or other time increments, that Dr. Garrison can use to expand the analyses and increase our understanding of the loss of native plants. Other features that are preserved over time--fish bones, particular plant remains--also can be incorporated into such a study to trace the loss of native aquatic plants and changes in fish species including appearance of invasive species.

The full text of Dr. Garrison's report on the analyses of the top and bottom strata of the core from Kangaroo Lake is included below.

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RESULTS OF SEDIMENT CORE TAKEN FROM KANGEROO LAKE, DOOR COUNTY, WISCONSIN

Paul Garrison, Wisconsin Department of Natural Resources
April 2008

Aquatic organisms are good indicators of a lake's water quality because they are in direct contact with the water and are strongly affected by the chemical composition of their surroundings. Most indicator groups grow rapidly and are short lived so the community composition responds rapidly to changing environmental conditions. One of the most useful organisms for paleolimnological analysis are diatoms. These are a type of algae which possess siliceous cell walls, which enables them to be highly resistant to degradation and are usually abundant, diverse, and well-preserved in sediments. They are especially useful, as they are ecologically diverse. Diatom species have unique features as shown in Figure 1, which enable them to be readily identified. Certain taxa are usually found under nutrient poor conditions while others are more common under elevated nutrient levels. Some species float in the open water areas while others grow attached to objects such as aquatic plants or the lake bottom.

By determining changes in the diatom community it is possible to determine water quality changes that have occurred in the lake. The diatom community provides information about changes in nutrient, water color, and pH conditions as well as alterations in the aquatic plant (macrophyte) community.

On 2 May 2007 a sediment core were taken from near the deep area of Kangeroo Lake. Samples from the top of the core and a section deeper in the core were kept for analysis. It is assumed that the upper sample represents present conditions while the deeper sample is indicative of water quality conditions at least 100 years ago.

Water Quality Changes

Most of the diatoms in the bottom sample were partially degraded and generally in poor shape. The diatoms remaining tended to be large varieties and heavily silicified. This raises the possibility that some smaller diatoms were dissolved over time and their absence in the bottom core sample does not reflect actual conditions when this sediment was deposited. Some of the diatoms most likely to be lost are small benthic *Fragilaria* or some planktonic species. There is no way to know for sure how many diatoms have been lost. The dominant planktonic diatom, *Cyclotella distinguenda*, usually possesses more silica than many other planktonic taxa and those found in the bottom sample were not highly degraded. This likely indicates that the large increase in this species in the top of the core compared with the bottom is probably accurate.

If we assume only a small amount of the diatoms in the bottom samples were lost over time, there has been a large change in the diatom community from the bottom to the top of the core. The diatom community at the bottom of the core is largely composed of taxa that grow amongst aquatic plants. In contrast, the diatom community in the

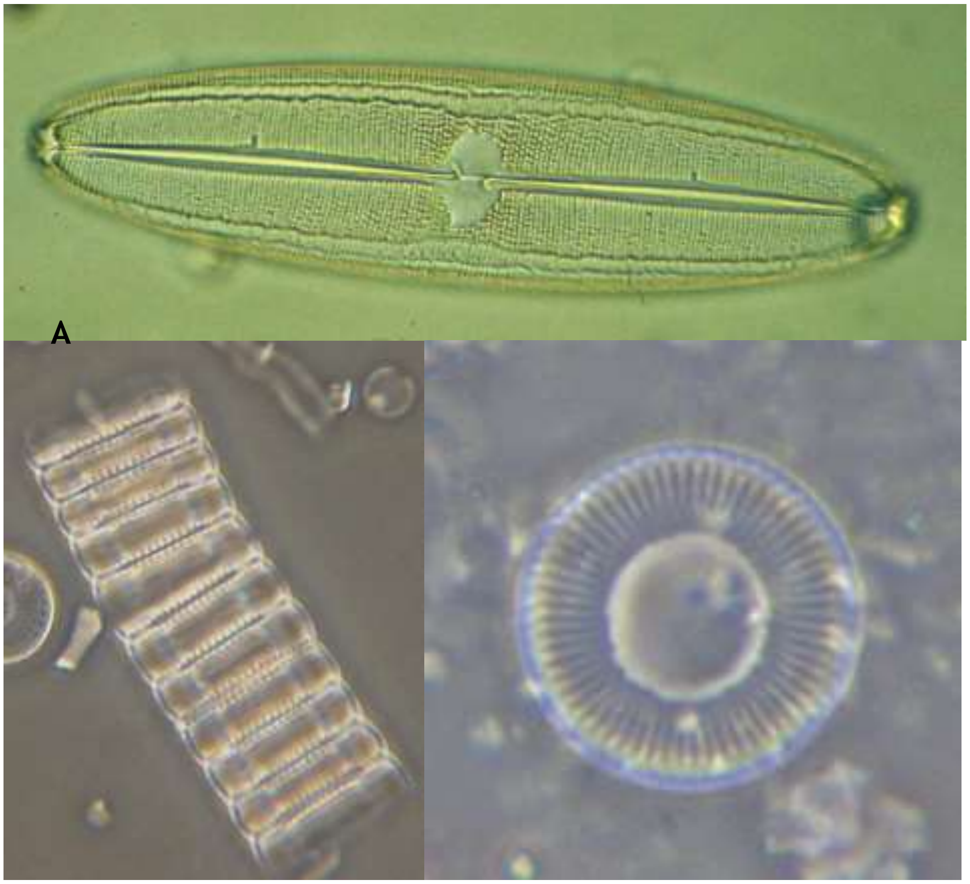

Figure 1. Micrographs of diatoms *Neidium* (top), a representative of benthic *Fragilaria* (left,) and *Cyclotella distinguenda* (right). *C. distinguenda* is often found floating in the open water while the other diatoms are found attached to substrates such as aquatic plants or on the sediment surface.

top of the core was dominated taxa that grow in the water column of the lake, referred to as planktonic diatoms.

The historical diatom community was dominated by large benthic dwelling diatoms such as *Neidium, Cymbella*, and *Pinnularia*. Other studies have found these to be dominant in shallow lakes that healthy plant communities and relatively low nutrient levels.

In contrast to the bottom sample, the diatom community in the top sample is dominated by planktonic diatoms (Figure 2). These are diatom that float in the open water of the lake and are not associated with vascular plants. The most common diatom was *Cyclotella distinguenda* (Figure 1c). There were also more benthic *Fragilaria* in the top sample compared with the bottom sample. These diatoms grow in chains (Figure 1b) within plant beds. Their increase probably indicates a moderate increase in nutrients in the top sample compared with the bottom sample. The dominant benthic *Fragilaria, Pseudostaurosira brevistrata*, tends to favor lower nutrients than other benthic *Fragilaria*.

In summary, the diatom community indicates that Kangeroo Lake historically had a healthy vascular plant community with low to moderate nutrient levels. It is likely that most of the lake at that time was more similar to the part of the lake north of County E. The diatom community in the surface sample contained very few diatoms associated with attached plants and instead was dominated by planktonic diatoms. This indicates a moderate increase in nutrients but more significantly, a loss of much of the vascular plant community.

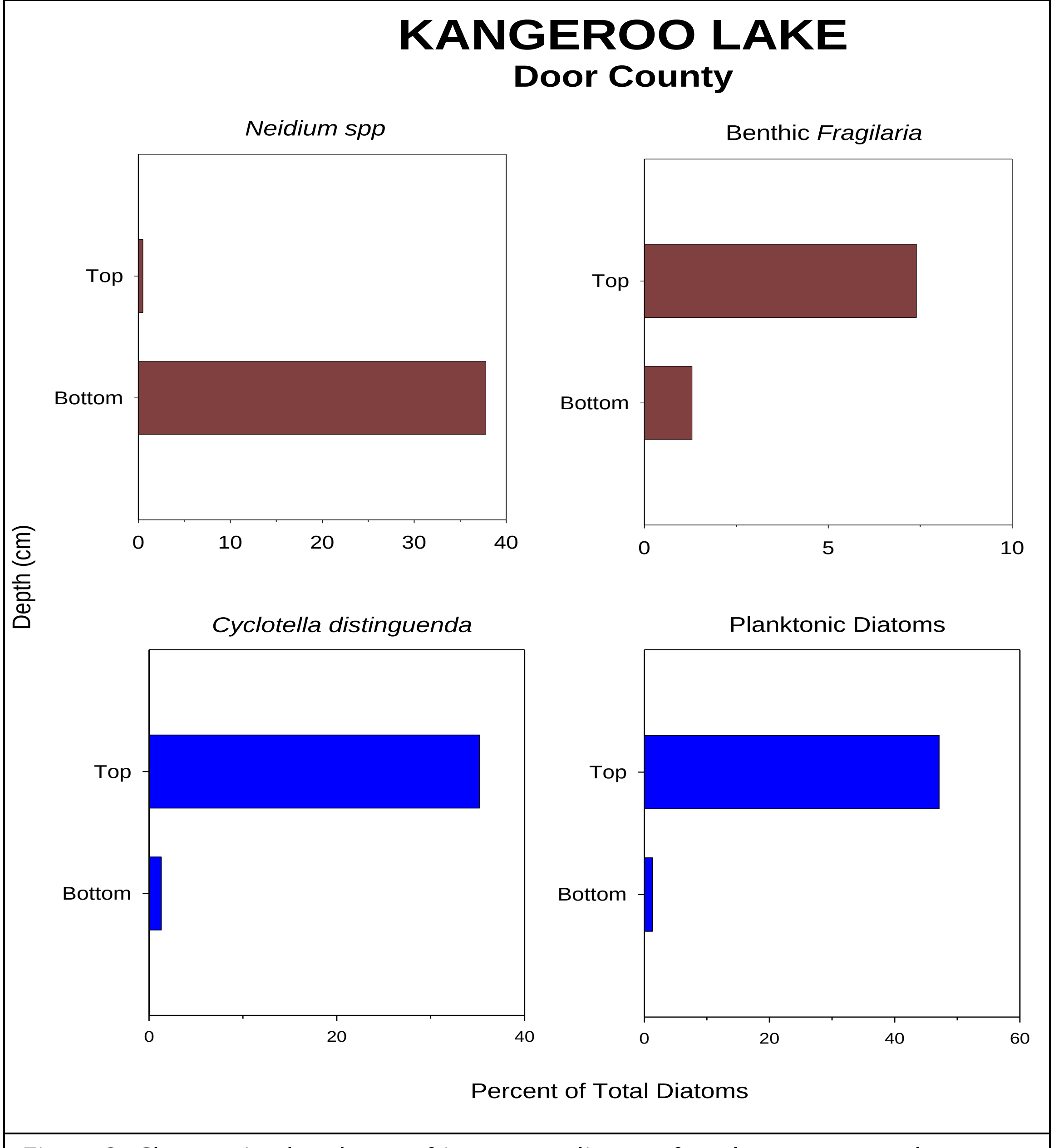

Figure 2. Changes in abundance of important diatoms found at present and pre-settlement times. Neidium grow among aquatic plants and their decline in the top sample indicates there are fewer plants now. C. distinguenda grows in the open water of the lake. Its dominance in the surface sample indicates that the diatom assemblage is largely a planktonic community at the present time.

Kangeroo Lake		
Door County		
0-1 cm		
	COUNT TOTAL	
	Number	Prop.
TAXA		
Achnanthes biasolettiana var. subatomus	17	0.042
Achnanthes rosenstockii	13	0.032
Achnanthidium minutissima	3	0.007
Achnanthidium minutissima var. gracillima	4	0.010
Achnanthidium sp.	14	0.035
Amphipleura pellucida	0.5	0.001
Amphora libyca	4	0.010
Amphora pediculus	1	0.002
Brachysira vitrea	10	0.025
Cocconeis placentula	1	0.002
Cyclotella distinguenda	131	0.325
Cyclotella michiganiana	4	0.010
Cyclotella ocellata	1	0.002
Cyclotella sp. 1 RL	6	0.015
Cymbella sp.	2	0.005
Diploneis elliptica	1	0.002
Encyonopsis angustata	5	0.012
Eucocconeis flexella	2	0.005
Fragilaria crotonensis	14	0.035
Fragilaria delicatissima	3	0.007
Fragilaria radians	31	0.077
Gomphonema gracile	2	0.005
Gomphonema sp.	4	0.010
Mastogloia smithii var. lacustris	3	0.007
Navicula aurora	3	0.007
Navicula cryptotenella	4	0.010
Navicula diluviana	3	0.007
Navicula lanceolata	4	0.010
Navicula radiofallax	2	0.005
Navicula viridula	4	0.010
Navicula (GV) (short)	4	0.010
Navicula sp.	8	0.020
Neidium sp.	2	0.005
Nitzschia angustata	0.5	0.001
Nitzschia denticula	26	0.064
Nitzschia gracilis	3.5	0.009
Nitzschia palea	13.5	0.033
Nitzschia sp.	9	0.022
Pinnularia sp.	3	0.007
Pseudostaurosira brevistrata	24	0.059
Pseudostaurosira brevistrata var. inflata	1	0.002
Rhopalodia gibba	0.5	0.001
Sellaphora rectangularis	2	0.005
Staurosirella leptostauron var. dubia	1	0.002
Staurosirella pinnata	4	0.010
Unknown	5	0.012
TOTAL	403.5	1.000
Planktonic diatoms		0.471
Nonplanktonic diatoms		0.517
Chrysophyte scales	3	
Chrysophyte cysts	9	
Zooplankton parts	2	
Phytolith	2	

Kangeroo Lake		
Door County		
Bottom		
	COUNT TOTAL	
	Number	Prop.
TAXA		
Achnanthidium minutissima	3	0.008
Achnanthidium sp.	1	0.003
Amphora libyca	18	0.045
Aneumastus tusculus	4	0.010
Caloneis silicula	4	0.010
Cyclotella distinguenda	5	0.013
Cymbella ehrenbergii	34	0.085
Cymbella sp.	11	0.028
Gomphonema affine	3	0.008
Gomphonema gracile	1	0.003
Mastogloia smithii var. lacustris	28	0.070
Navicula difficullima	2	0.005
Navicula diluviana	5	0.013
Navicula sp. 21 PIRLA	4	0.010
Navicula sp.	15	0.038
Neidium ampliatum	28	0.070
Neidium iridis	33	0.083
Neidium iridis var. amphigomphus	1	0.003
Neidium sp.	89	0.223
Nitzschia amphibia	1	0.003
Nitzschia sp.	1	0.003
Pinnularia biceps	4	0.010
Pinnularia viridis	1	0.003
Pinnularia sp.	18	0.045
Pseudostaurosira brevistrata	4	0.010
Sellaphora pupula	2	0.005
Stauroneis sp.	6	0.015
Staurosirella lapponica	1	0.003
Unknown (raphid)	73	0.183
TOTAL	400	1.000
Planktonic diatoms		0.013
Nonplanktonic diatoms		0.805
Chrysophyte scales	3	
Chrysophyte cysts	2	
Zooplankton parts	2	
Phytolith	2	