RESULTS OF SEDIMENT CORE TAKEN FROM BIG DOCTOR LAKE, BURNETT COUNTY, WISCONSIN

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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.

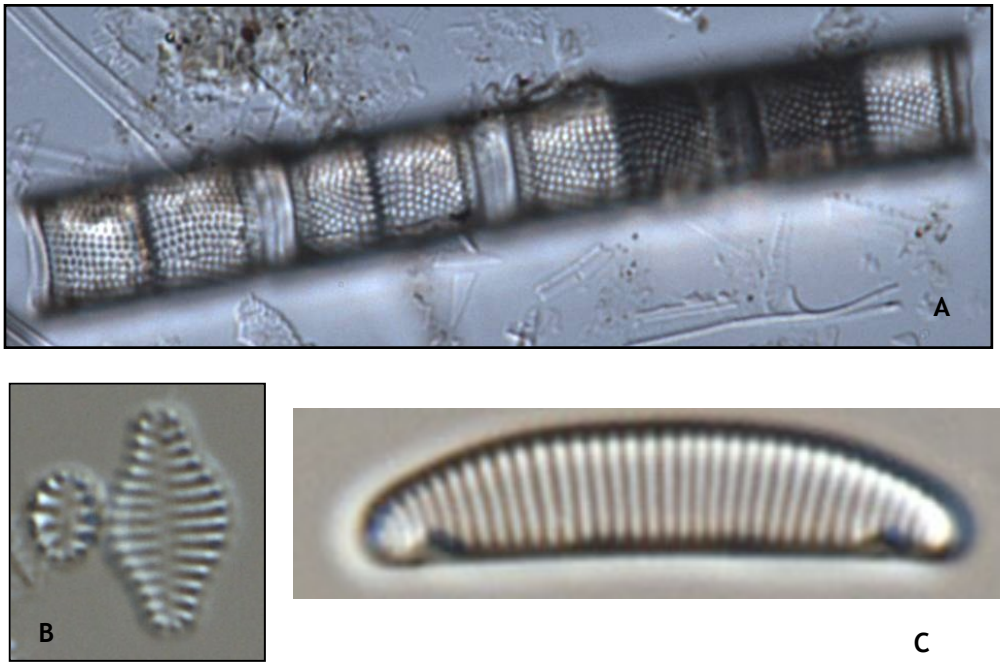

Figure 1. Photomicrographs of the diatoms commonly found in the Big Doctor Lake sediment core. The top diatom, *Aulacoseira am*bigua (A), is found in the open water environments, the bottom left diatoms are part of the benthic *Fragilaria* (B), while the bottom right diatom (*Eunotia incisa*) is found in lower pH environments. Benthic *Fragilaria* are commonly found attached to substrates such as aquatic plants.

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 concentrations, water clarity, and pH conditions as well as alterations in the aquatic plant (macrophyte) community.

On 29 August 2012 a sediment core were taken from near the deep area (N45.74348° W92.39800°) of Big Doctor Lake using a gravity corer. Samples from the top of the core (0-1 cm) and a section (35-37 cm) 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. A radiochemical analysis of the bottom sample will be conducted to determine if the sample was deposited at least 100 years ago. This analysis will not be completed until the fall of 2013.

Results

In Big Doctor Lake the presettlement diatom community was dominated by diatoms of the group *Eunotia* (Figure 2). These diatoms are typically found in pH environments that are slightly acidic and often are dominant in northern WI wetlands. In the top sample these diatoms were much less common. Instead the community was dominated by taxa that are more common at higher pH values. Common diatoms were *Aulacoseira ambigua* (Figure 1a), *Achnanthidium minutissima*, and the group benthic *Fragilaria* (Figure 2). The latter two diatoms are typically found attached to macrophytes.

The diatom community indicates that the present day pH level is higher than the historical level. This may be the result of increased sediment and nutrient inputs to the lake. A study in northcentral WI found that a consequence of shoreland development was increased delivery sediment materials which resulted in an increase in the lake's pH. This seems to have occurred in Big Doctor Lake. The increase in benthic *Fragilaria* and *A. minutissima* indicate there are more submerged aquatic plants (SAV) at the present time.

In northern WI, many lakes with shoreline development have experienced an increase in SAV. Dr. Susan Borman recently conducted a study in lakes in the northwestern part of WI where she compared the SAV community in the 1930s with the present day community. She found that lakes with cottages have more plants and the species have shifted to those that are larger and grow closer to the lake's surface. This same thing has occurred in southern and central WI but often these lakes have higher phosphorus loading rates and planktonic diatoms become more important. The change in the plant community appears to have happened in Big Doctor Lake as the top sample has more diatoms that typically are associated with aquatic plants.

Diatom assemblages historically have been used as indicators of nutrient changes in a qualitative way. In recent years, ecologically relevant statistical methods have been developed to infer environmental conditions from diatom assemblages. These methods are based on multivariate ordination and weighted averaging regression and calibration. Ecological preferences of diatom species are determined by relating modern limnological variables to surface sediment diatom assemblages. The species-environment relationships are then used to infer environmental conditions from fossil diatom assemblages found in the sediment core.

Such a model was applied to the diatom community in the core from Big Doctor Lake. The model extimates a summer phosphorus concentration of about 25 µg L^{-1} which is much lower

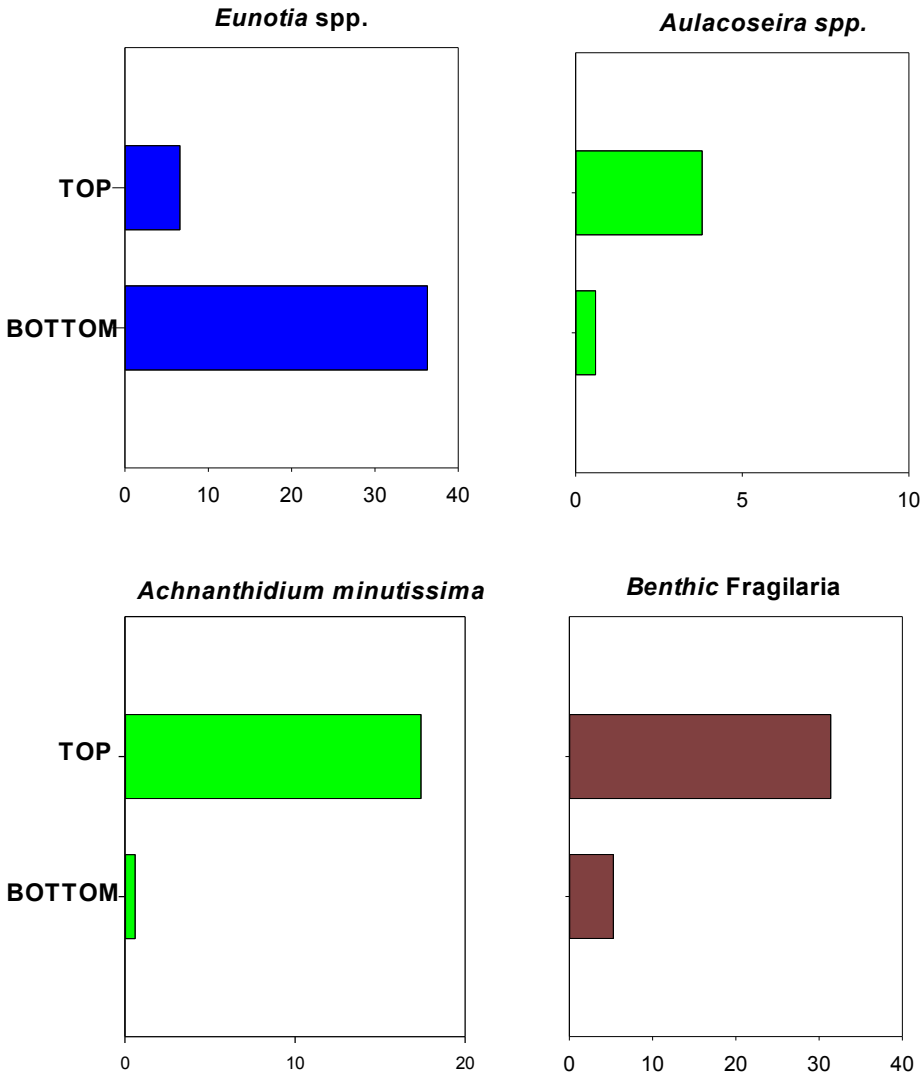

Figure 2. Changes in the abundance of important diatoms found at the top and bottom of the Big Doctor Lake sediment core. The dominant diatoms at the bottom of the core were *Eunotica* which are typically found in lower pH environments. At the top of the core the diatoms that grow attached to aquatic plants are more common. This indicates an increase in growth of submerged aquatic vegetation. *Aulacoseira* are found floating the open water and probably indicate higher nutrient levels.

than has been measured in the last few years. The concentration measured in 2012 was generally between 80-90 µg L^{-1}. The model significantly under estimates the present day phosphorus levels so the modelled estimates of historical phosphorus concentrations of 13-15 µg L^{-1} are suspect. Judging from the change in the diatom community I would speculate that present day phosphorus levels are higher than historical ones but I do not know how much higher they are.

In summary, the sediment core indicates that there has been an increase the pH level in the lake and at the present time the aquatic plant community is greater than it was historically.

Although the modeling indicates summer phosphorus levels have increased from 13 to 25 µg L^{-1} this is suspect since the present day concentration is underestimated. It is likely that phosphorus levels have increased but it is difficult to know what the historical levels were.

BIG DOCTOR LAKE

Burnett County

Top (0-2 cm)

TAXA	COUNT TOTAL Number	Prop.
Achnanthidium altergracillima (Lange-Bertalot) Round et Bukhtiyarova	2	0.004
Achnanthidium minutissimum (Kützing) Czarnecki	87	0.174
Achnanthidium rivulare Potapova et Ponader	2	0.004
Aulacoseira ambigua (Grunow in Van Heurck) Simonsen	13	0.026
Aulacoseira distans (Ehrenberg) Simonsen	1	0.002
Aulacoseira italica (Ehrenberg) Simonsen	5	0.010
Aulacoseira spp.	2	0.004
Brachysira microcephala (Kützing) Compère	5	0.010
Brachysira serians (Brébisson) Round et Mann	1	0.002
Brachysira spp.	1	0.002
Cavinula pseudoscutiformis (Hustedt in Schmidt et al.) Mann et Stickle in Round, Crawford and Mann	1	0.002
Cocconeis placentula Ehrenberg	9	0.018
Cocconeis spp.	6	0.012
Cymbella mesiana Cholnoky	2	0.004
Cymbella naviculiformis Auerswald ex Heiberg	1	0.002
Cymbella spp.	2	0.004
Discostella stelligera (Cleve et Grunow in Cleve) Houk et Klee	1	0.002
Encyonema minutum (Hilse in Rabenhorst) Mann in Round, Crawford and Mann	5	0.010
Eunotia bilunaris (Ehrenberg) Souza in Souza and Moreira-Filho	1	0.002
Eunotia circumborealis Lange-Bertalot et Nörpel in Lange-Bertalot	6	0.012
Eunotia incisa Smith ex Gregory	13	0.026
Eunotia minor (Kützing) Grunow in Van Heurck	4	0.008
Eunotia parallela Ehrenberg	2	0.004
Eunotia serra Ehrenberg	1	0.002
Eunotia spp.	6	0.012
Fragilaria radians (Kützing) Williams et Round	9	0.018
Fragilaria sepes Ehrenberg	1	0.002
Fragilaria tenera (Smith) Lange-Bertalot	4	0.008
Gomphonema anjae Lange-Bertalot & Reidhardt	1	0.002
Gomphonema exilissimum (Grunow in Van Heurck) Lange-Bertalot et Reichardt in Lange-Bertalot and Metzeltin	3	0.006
Gomphonema parvulum (Kützing) Kützing	2	0.004
Gomphonema parvulum fo. saprophilum Lange-Bertalot et Reichardt in Lange-Bertalot	1	0.002
Gomphonema spp.	3	0.006
Hantzschia amphioxys (Ehrenberg) Grunow in Cleve and Grunow	1	0.002
Navicula joubaudii Germain	4	0.008
Navicula leptostriata Jørgensen	4	0.008
Navicula minima Grunow in Van Heurck	2	0.004
Navicula spp.	7	0.014
Navicula subminuscula Manguin	7	0.014
Navicula utermoehlii Hustedt in A. Schmidt	4	0.008
Neidium bisulcatum (Lagerstedt) Cleve	2	0.004
Neidium spp.	2	0.004

BIG DOCTOR LAKE
Burnett County

Top (0-2 cm)

TAXA	COUNT TOTAL Number	Prop.
Nitzschia dissipata var. media (Hantzsch) Grunow in Van Heurck	2	0.004
Nitzschia palea var. debilis (Kützing) Grunow in Cleve and Grunow	1	0.002
Nitzschia spp.	7	0.014
Nupela fennica (Hustedt) Lange-Bertalot in Krammer and Lange-Bertalot	2	0.004
Nupela impexiformis (Lange-Bertalot in Lange-Bertalot and Krammer) Lange-Bertalot	5	0.010
Nupela sp. 1 ?	6	0.012
Nupela vitiosa (Schimanski) Siver et Hamilton	10	0.020
Nupela wellneri (Lange-Bertalot in Lange-Bertalot and Krammer) Lange-Bertalot in U. Rumrich, Lange-Bertalot and M. Rumrich	2	0.004
Pinnularia rupestris Hantzsch in Rabenhorst	1	0.002
Pinnularia spp.	7	0.014
Psammothidium subatomoides (Hustedt in Schmidt) Bukhtiyarova et Round	2	0.004
Pseudostaurosira brevistriata (Grunow in Van Heurck) Williams et Round	63	0.126
Punctastriata mimetica Morales	2	0.004
Sellaphora disjuncta (Hustedt) Mann	2	0.004
Sellaphora laevissima (Kützing) Mann	2	0.004
Sellaphora pupula (Kützing) Meresckowsky	2	0.004
Sellaphora rectangularis (Gregory) Lange-Bertalot et Metzeltin	1	0.002
Sellaphora seminulum (Grunow) Mann	9	0.018
Sellaphora sp. 1 ?	1	0.002
Stauroforma exiguiformis (Lange-Bertalot) Flower, Jones et Round	2	0.004
Stauroneis anceps fo. gracilis Rabenhorst	1	0.002
Stauroneis spp.	2	0.004
Staurosira construens var. venter (Ehrenberg) Hamilton in Hamilton, Poulin, Charles and Angell	38	0.076
Staurosirella pinnata (Ehrenberg) Williams et Round	52	0.104
Synedra delicatissima var. angustissima Grunow in Van Heurck	5	0.010
Synedra minuscula Grunow in Van Heurck	4	0.008
Synedra rumpens Kützing	4	0.008
Synedra spp.	2	0.004
Tabellaria flocculosa (strain III) sensu Koppen (Roth) Kützing	7	0.014
Tabellaria flocculosa var. linearis Koppen	1	0.002
Tabellaria spp.	2	0.004
Tabellaria ventricosa Kützing	1	0.002
Tryblionella scalaris (Ehrenberg) Siver et Hamilton	1	0.002
unknown pennate	15	0.030
TOTAL	500	1.000

BIG DOCTOR LAKE
Burnett County

Bottom (35-37 cm)

lots of diatoms fragments; sponge spicules and phytoliths

TAXA	COUNT TOTAL Number	Prop.
Achnanthidium altergracillima (Lange-Bertalot) Round et Bukhtiyarova	1	0.002
Achnanthidium minutissimum (Kützing) Czarnecki	3	0.006
Aulacoseira italica (Ehrenberg) Simonsen	2	0.004
Aulacoseira nygaardii (Camburn in Camburn and Kingston) Camburn et Charles	1	0.002
Cymbella mesiana Cholnoky	2	0.004
Cymbella spp.	3	0.006
Encyonema minutum (Hilse in Rabenhorst) Mann in Round, Crawford and Mann	7	0.014
Encyonema silesiacum (Bleisch in Rabenhorst) Mann in Round, Crawford and Mann	4	0.008
Encyonopsis sp. 1 ?	11	0.021
Eunotia bilunaris (Ehrenberg) Souza in Souza and Moreira-Filho	1	0.002
Eunotia carolina Patrick	38	0.074
Eunotia circumborealis Lange-Bertalot et Nörpel in Lange-Bertalot	1	0.002
Eunotia faba (Ehrenberg) Grunow in Van Heurck	3	0.006
Eunotia flexuosa (Brébisson ex Kutzing) Kützing	24	0.047
Eunotia formica Ehrenberg	7	0.014
Eunotia hexaglyphis Ehrenberg	4	0.008
Eunotia implicata Nörpel, Alles et Lange-Bertalot in Alles, Nörpel and Lange-Bertalot	2	0.004
Eunotia incisa Smith ex Gregory	79	0.154
Eunotia intermedia (Krasske ex Hustedt) Nörpel et Lange-Bertalot in Lange-Bertalot	6	0.012
Eunotia parallela Ehrenberg	1	0.002
Eunotia praerupta Ehrenberg	6	0.012
Eunotia rhomboidea Hustedt	3	0.006
Eunotia spp.	11	0.021
Fragilaria famelica (Kützing) Lange-Bertalot	1	0.002
Fragilaria vaucheriae (Kützing) Petersen	2	0.004
Gomphonema acuminatum Ehrenberg	7	0.014
Gomphonema auritum Braun & Kutzing	1	0.002
Gomphonema exilissimum (Grunow in Van Heurck) Lange-Bertalot et Reichardt in Lange-Bertalot and Metzeltin	3	0.006
Gomphonema gracile Ehrenberg	11	0.021
Gomphonema hebridense Gregory	1	0.002
Gomphonema maclaughlinii Reichardt	4	0.008
Gomphonema minutum (Agardh) Agardh	16	0.031
Gomphonema minutum fo. curtum (Hustedt) Lange-Bertalot et Reichardt in Krammer and Lange-Bertalot	7	0.014
Gomphonema parvulius (Lange-Bertalot et Reichardt) Lange-Bertalot et Reichardt in Lange-Bertalot and Metzeltin	9	0.018
Gomphonema parvulum (Kützing) Kützing	2	0.004
Gomphonema sp. 1 Big Doctor	3	0.006
Gomphonema sp. 26 NAWQA EAM	1	0.002
Gomphonema spp.	10	0.020
Gomphonema truncatum Ehrenberg	3	0.006
Hantzschia amphioxys (Ehrenberg) Grunow in Cleve and Grunow	1	0.002
Navicula spp.	4	0.008
Navicula vulpina Kützing	21	0.041

BIG DOCTOR LAKE
Burnett County

Bottom (35-37 cm)
lots of diatom fragments; sponge spicules and phytoliths

TAXA	COUNT TOTAL Number	Prop.
Neidium ampliatum (Ehrenberg) Krammer in Krammer and Lange-Bertalot	1	0.002
Neidium spp.	13	0.025
Neidium temperei Reimer	3	0.006
Pinnularia maior (Kützing) Rabenhorst	2	0.004
Pinnularia microstauron (Ehrenberg) Cleve	2	0.004
Pinnularia pseudogibba Krammer	4	0.008
Pinnularia spp.	7	0.014
Pinnularia subgibba Krammer	3	0.006
Pinnularia viridiformis Krammer	6	0.012
Pinnularia viridis (Nitzsch) Ehrenberg	1	0.002
Sellaphora americana (Ehrenberg) Mann	2	0.004
Sellaphora laevissima (Kützing) Mann	5	0.010
Sellaphora pupula (Kützing) Meresckowsky	3	0.006
Sellaphora rectangularis (Gregory) Lange-Bertalot et Metzeltin	9	0.018
Sellaphora rugula (Hohn & Hellerman) Potapova & Ponader	1	0.002
Sellaphora spp.	3	0.006
Stauroneis anceps Ehrenberg	3	0.006
Stauroneis gracilior (rabenhorst) Reichardt	1	0.002
Stauroneis phoenicenteron (Nitzsch) Ehrenberg	5	0.010
Stauroneis spp.	10	0.020
Staurosira construens var. venter (Ehrenberg) Hamilton in Hamilton, Poulin, Charles and Angell	27	0.053
Synedra delicatissima Smith	2	0.004
Synedra rumpens Kützing	2	0.004
Synedra spp.	1	0.002
Synedra ulna var. danica (Kützing) Grunow in Van Heurck	1	0.002
Tabellaria flocculosa (strain III) sensu Koppen (Roth) Kützing	12	0.023
Tabellaria flocculosa var. linearis Koppen	9	0.018
Tabellaria spp.	6	0.012
Undetermined Pennate	41	0.080
TOTAL	512	1.000