RESULTS OF SEDIMENT CORE TAKEN FROM BLACK OAK LAKE, VILAS 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.

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.

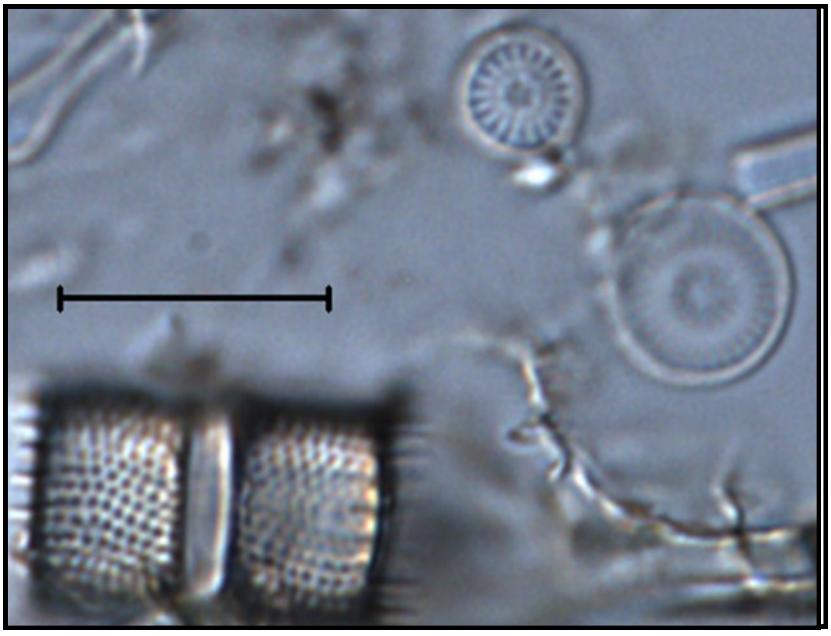

Figure 1. Photomicrograph of the diatoms commonly found in the Black Oak Lake sediment core. The diatom in the bottom left (*Aulacoseira subarctica*) it a filamentous diatom common in low nutrient waters. The circular shaped diatoms in the upper right (*Discotella stelligera*) is also common in low nutrient waters.

On 18 July 2012 a sediment core was collected near the deep area of Black Oak Lake (N46° 09.75' W89° 18.69') using a gravity corer. The water depth was 81 feet. The length of the core was 54 cm. It is assumed that the upper sample represents present day conditions while the deeper sample is indicative of water quality conditions at least 100 years ago. The upper 30 cm was dark brown in color while the portion below 30 cm was light brown in color. The diatom community was analyzed from a section representing the top 2 cm and a section from 48-50 cm .

Results

In Black Oak Lake, historically the major component of the diatom community are those species that float in the open water of the lake. The major taxa of these planktonic diatoms in the bottom sample were the chain forming diatom *Aulacoseira subarctica* and *Discotella stelligera* (Figure 2). These diatoms are common in lakes throughout the Upper Midwest with low nutrient levels.

There are similar amounts of planktonic diatoms in the top and bottom of the core indicating there has not been a significant change in the lake's ecology. There has been a subtle change in the floristic composition of the diatom community between the time the bottom sample was deposited and the present time. There has been a decline in *A. subarctica* and an increase in *Cyclotella* spp. (includes *Discotella*) (Figure 2). There was a decline in *D. stelligera* and an increase in *Cyclotella bodanica* var. *lemanica*. The first taxa is generally more common in lakes with lower phosphorus concentrations and the latter taxa is more common in waters with slightly higher phosphorus levels.

In the top sample there is an increase in *Asterionella formosa* (Figure 2). This species is one of the first diatoms to increase as a result of nutrient enrichment following human disturbances. Recent studies have shown that this diatom may respond more to an increase in nitrogen and not necessarily to an increase in phosphorus.

The percentage of planktonic diatoms was similar in the top and bottom sample (Figure 2). In many northern WI lakes with shoreline development, there is an increase in the diatom species that grow attached to substrates such as submerged aquatic vegetation (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. The diatom community indicates that in Black Oak Lake there has not be a large increase in SAV. There may be some local areas where this has changed in recent decades but it is not evident in the sediment core.

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.

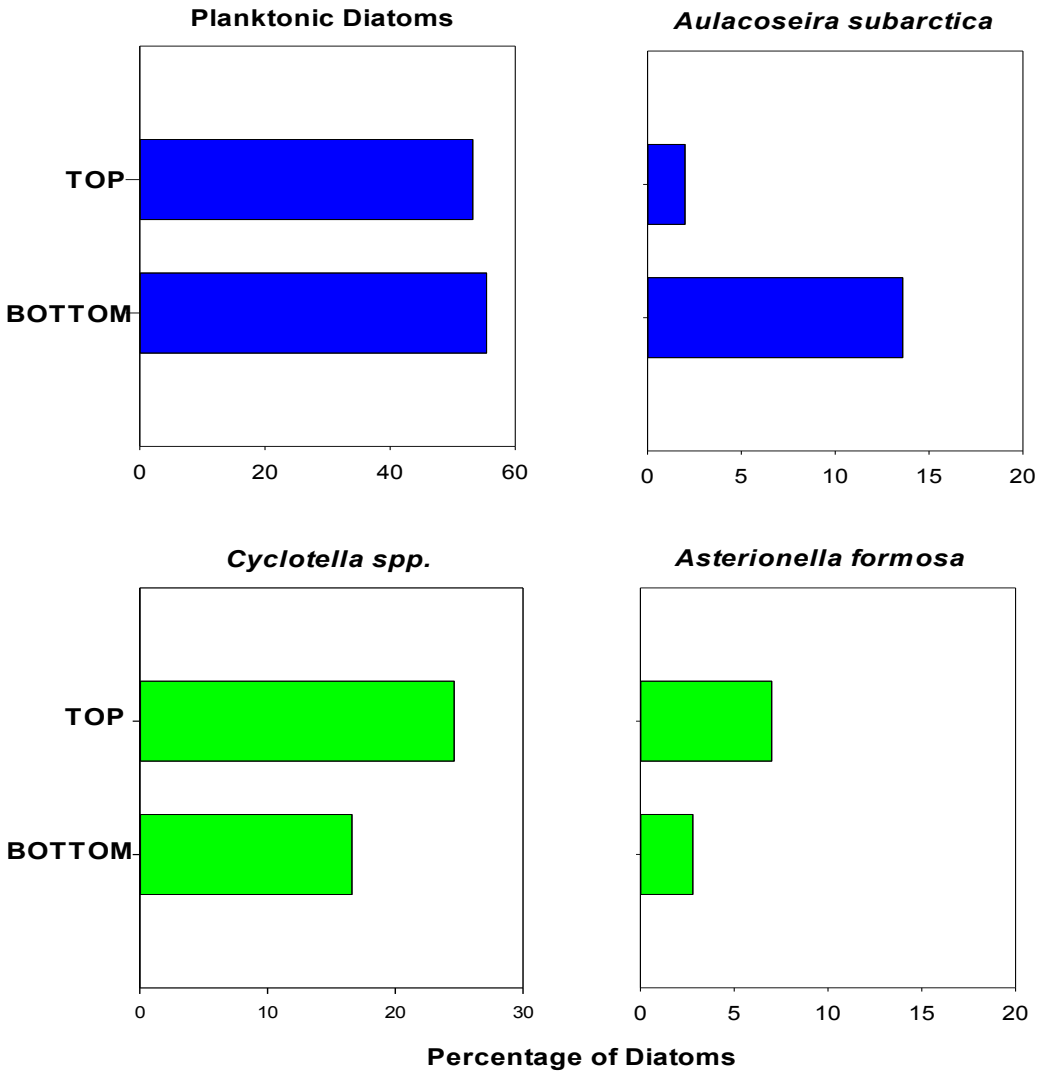

Figure 2. Changes in the abundance of important diatoms found at the top and bottom of the Black Oak Lake sediment core. The dominant diatoms were planktonic diatoms which float in the open water. The decline in *A. subarctica* and increase in *A. formosa* indicates a slight increase in nutrients.

Such a model was applied to the diatom community in the core from Black Oak Lake. The model indicates there has been a small increase in phosphorus of around 2-3 µg L^{-1}. The model predicted a present day summer mean phosphorus concentration of 9 µg L^{-1} but the measured concentration for the last 3 years is 6-7 µg L^{-1}. The model over estimates the present day concentration because most of the lakes used in the calibration dataset have phosphorus concentrations that are higher than those found in Black Oak Lake. The model predicts the pre-settlement phosphorus concentration of 6-7 µg L^{-1}. It is likely that the historical concentration is 4-5 µg L^{-1}.

In summary, the sediment core indicates that there have only been subtle changes in the lake over the last 100 years. Nutrient levels have only increased a small amount. Unlike many northern lakes with shoreline development there has not been a significant increase in

submerged aquatic vegetation. The floristic changes in the diatom community as well as the modeling indicate there has been a small increase in the nutrient concentrations. Phosphorus levels have probably increased 2-3 μg L^{-1}.

Although the increase in nutrients is relatively small, it does indicate that shoreline development is having some adverse effect on the nutrient levels in the lake. While the greatest impact of shoreline development is the alteration of habitat on the shoreline as well as in the shallow water area of the lake, some increased nutrients are added to the lake. It is easier to reduce this input now than wait until it becomes a problem and then try to fix it.

BLACK OAK LAKE
Vilas County

Top (0-2 cm)

COUNT TOTAL

TAXA	Number	Prop.
Achnanthes curtissima Carter	2	0.004
Achnanthes sp. 1	6	0.012
Achnanthidium altergracillima (Lange-Bertalot) Round et	16	0.032
Achnanthidium exiguum (Grunow) Czarnecki	1	0.002
Achnanthidium eutrophilum (Lange-Bertalot in Lange-	2	0.004
Achnanthidium minutissimum (Kützing) Czarnecki	7	0.014
Adlafia minuscula (Grunow) Lange-Bertalot	1	0.002
Asterionella formosa Hassal	35	0.070
Aulacoseira subarctica (Müller) Haworth	10	0.020
Brachysira microcephala (Grunow) Compère	2	0.004
Cavinula pseudoscutiformis	1	0.002
Cyclotella bodanica var. lemanica Müller	48	0.096
Cyclotella comensis Grunow et Van Heurck	13	0.026
Cyclotella delicatula Hustedt	1	0.002
Cyclotella michiganiana Skvortzow	2	0.004
Cyclotella sp. 1	3	0.006
Cymbopleura subcuspidata (Krammer) Krammer	2	0.004
Discotella pseudostelligera (Hustedt) Houk et Klee	9	0.018
Discotella stelligera (Hustedt) Houk et Klee	47	0.094
Encyonema mesianum (Cholnoky) Mann in Round, Craw-	1	0.002
Encyonopsis subminuta Krammer & Reichardt	4	0.008
Fragilaria (GV) 12-13/10 u central area	8	0.016
Fragilaria crotonensis Kitton	10	0.020
Fragilaria crotonensis var. oregona Sovereign	48	0.096
Gomphonema gracile Ehrenberg emend Van Heurck	1	0.002
Gomphonema pumilum (Grunow) Reichardt et Lange-Bertalot	2	0.004
Karayevia clevei (Grunow) Bukhtiyarova	5	0.010
Mayamaea permitis (Hustedt) Bruder et Medlin	2	0.004
Navicula cryptocephala Kützing	2	0.004
Navicula cryptotenella Lange-Bertalot ex Krammer et	2	0.004
Navicula harderii Hustedt	2	0.004
Navicula lanceolata (Agardh) Ehrenberg	1	0.002
Navicula minima Grunow in Van Heurck	2	0.004
Navicula radiosa Kützing	2	0.004
Navicula schmassmanni Hustedt	4	0.008
Navicula sp. 1 ?	2	0.004
Navicula spp.	4	0.008
Navicula subminuscula Manguin	5	0.010

BLACK OAK LAKE
Vilas County

Top (0-2 cm)

COUNT TOTAL

TAXA	Number	Prop.
Nitzschia acicularis (Kützing) Smith	4	0.008
Nitzschia lacuum Lange-Bertalot	1	0.002
Nitzschia palea (Kützing) Smith	2	0.004
Nitzschia palea var. debilis (Kützing) Grunow	2	0.004
Nitzschia tropica Hustedt	8	0.016
Planothidium frequentissimum (Lange-Bertalot) Lange-	2	0.004
Platessa conspicua (Mayer) Lange-Bertalot	4	0.008
Pseudostaurosira brevistriata (Grunow) Williams et Round	4	0.008
Pseudostaurosira trainorii Morales	4	0.008
Sellaphora pupula (Kützing) Meresckowsky	1	0.002
Stauroneis spp.	1	0.002
Staurosira construens Ehrenberg	9	0.018
Staurosira construens var. venter (Ehrenberg) Hamilton	8	0.016
Staurosirella pinnata (Ehrenberg) Williams et Round	13	0.026
Staurosirella pinnata var. intercedens (Grunow) Hamilton	8	0.016
Staurosirella pinnata var. lancettula (Schumann) Siver et	2	0.004
Stephanodiscus alpinus Hustedt	10	0.020
Stephanodiscus medius Håkansson	1	0.002
Stephanodiscus minutulus (Kützing) Cleve et Möller	7	0.014
Synedra acus var. angustissima (Grunow) Van Heurck	9	0.018
Synedra delicatissima Smith	26	0.052
Synedra famelica Kützing	4	0.008
Synedra rumpens var. familiaris (Kützing) Hustedt	3	0.006
Synedra sp.	1	0.002
Tabellaria flocculosa (strain III) sensu Koppen	5	0.010
Tabellaria flocculosa (strain IIIp) sensu Koppen	23	0.046
Tabellaria spp.	4	0.008
unknown pennate	19	0.038
TOTAL	500	1.000

BLACK OAK LAKE
Vilas County

Bottom (48-50 cm)

COUNT TOTAL

TAXA	Number	Prop.
Achnanthes biasolettiana (Kützing) Grunow	2	0.004
Achnanthes subatomoides (Hustedt) Lange-Bertalot et Archibald	5	0.010
Achnanthidium altergracillima (Lange-Bertalot) Round et Bukhtiyarova	3	0.006
Achnanthidium exiguum (Grunow) Czarnecki	1	0.002
Achnanthidium minutissimum (Kützing) Czarnecki	7	0.014
Achnanthidium sp. 1 ?	2	0.004
Achnanthidium spp	5	0.010
Adlafia bryophila (Petersen) Lange-Bertalot	2	0.004
Adlafia minuscula (Grunow) Lange-Bertalot	2	0.004
Amphora veneta Kützing	4	0.008
Asterionella formosa Hassal	14	0.028
Asterionella ralfsii var. americana Körner	1	0.002
Aulacoseira italica (Ehrenberg) Simonsen	3	0.006
Aulacoseira sp. 1?	2	0.004
Aulacoseira subarctica (Müller) Haworth	66	0.132
Cocconeis pseudolineata (Geitler) Lange-Bertalot	1	0.002
Cocconeis pseudothumensis Reichardt	2	0.004
Cyclotella bodanica var. lemanica Müller	5	0.010
Cyclotella michiganiana Skvortzow	2	0.004
Discotella glomerata (Hustedt) Houk et Klee	1	0.002
Discotella stelligera (Hustedt) Houk et Klee	75	0.150
Encyonema minutum (Hilse) Mann	3	0.006
Encyonema spp.	2	0.004
Encyonopsis cesatii (Rabhenhorst) Krammer	2	0.004
Encyonopsis subminuta Krammer & Reichardt	1	0.002
Eucocconeis flexella (Kützing) Cleve	1	0.002
Eunotia spp.	1	0.002
Fragilaria capucina var. mesolepta Rabenhorst	6	0.012
Fragilaria crotonensis Kitton	43	0.086
Fragilaria crotonensis var. oregona Sovereign	14	0.028
Fragilaria radians (Kützing) Williams et Round	3	0.006
Fragilaria tenera (Smith) Lange-Bertalot	1	0.002
Gomphonema auritum Braun ex Kutzing	1	0.002
Gomphonema gracile Ehrenberg emend Van Heurck	2	0.004
Gomphonema parallelistriatum Lange-Bertalot et Reichardt in Lange-Bertalot	1	0.002
Gomphonema parvulius (Lange-Bertalot et Reichardt) Lange-Bertalot et Reichardt	2	0.004
Gomphonema pumilum (Grunow) Reichardt et Lange-Bertalot	2	0.004
Gomphonema spp.	2	0.004

BLACK OAK LAKE
Vilas County

Bottom (48-50 cm)

COUNT TOTAL

TAXA	Number	Prop.
Gomphonema truncatum Ehrenberg	1	0.002
Hantzschia amphioxys (Ehrenberg) Grunow	2	0.004
Karayevia clevei (Grunow) Bukhtiyarova	3	0.006
Karayevia suchlandtii (Hustedt) Bukhtiyarova	1	0.002
Navicula cryptotenella Lange-Bertalot ex Krammer et Lange-	2	0.004
Navicula menisculus Schumann	2	0.004
Navicula pseudoventralis Hustedt	1	0.002
Navicula radiosa Kützing	3	0.006
Navicula spp.	7	0.014
Navicula vitabunda Hustedt	2	0.004
Neidium spp.	1	0.002
Nitzschia acicularis (Kützing) Smith	1	0.002
Nitzschia acidoclinata Lange-Bertalot	1	0.002
Nitzschia inconspicua Grunow	1	0.002
Nitzschia lacuum Lange-Bertalot	2	0.004
Nitzschia linearis (Agardh ex Smith) Smith	4	0.008
Nitzschia palea (Kützing) Smith	1	0.002
Nitzschia pura Hustedt	1	0.002
Psammothidium didymum (Hustedt) Bukhtiyarova et Round	4	0.008
Sellaphora pupula (Kützing) Meresckowsky	4	0.008
Sellaphora rugula (Hohn & Hellerman) Potapova & Ponader	1	0.002
Staurosira construens var. binodis (Ehrenberg) Hamilton	2	0.004
Staurosira construens var. venter (Ehrenberg) Hamilton	5	0.010
Staurosirella leptostauron var. dubia (Grunow) Edlund	2	0.004
Staurosirella pinnata (Ehrenberg) Williams et Round	27	0.054
Staurosirella pinnata var. lancettula (Schumann) Siver et	13	0.026
Synedra cyclopum Brutschy	2	0.004
Synedra delicatissima Smith	24	0.048
Synedra famelica Kützing	45	0.090
Synedra sp.	2	0.004
Tabellaria flocculosa (strain III) sensu Koppen	13	0.026
Tabellaria flocculosa (strain IIIp) sensu Koppen	12	0.024
Tabellaria flocculosa var. linearis Koppen	1	0.002
Tabellaria spp.	1	0.002
unknown pennate	14	0.028
TOTAL	500	1.000