



# Lake of the Woods Diatom Workshop

August 14-15<sup>th</sup> 2006

Queen's University, Kingston ON

**Co-sponsored by:**

**Ministry of the Environment, Dorset Environmental Science Centre**

**and**

**Paleoecological Environmental Assessment and Research Laboratory (PEARL)**

Proceedings organized & compiled by Kathleen Rühland

# Lake of the Woods Diatom Workshop

August 14 – 15, 2006

PEARL, Queens' University, Kingston, Ontario, Canada

The Lake of the Woods (LOW) Diatom Workshop was organized as an important first step in bringing together researchers working in the LOW region including NW Ontario and Minnesota. As discussed in the last Lake of the Woods Water Quality Forum (Minnesota, March 8 and 9, 2006) one of the future goals for the paleolimnological aspects of the project and the main goal of this workshop was to strive for taxonomic consistency among these working groups. To successfully exchange diatom-based phosphorus (TP) models among different working groups, it is important to minimize non-analogue problems that are derived from taxonomic inconsistencies. It was suggested that there should be collaboration among the diatom researchers including the St. Croix Watershed Research Station (MN), Center for Water and the Environment (MN), Dorset Environmental Science Centre (ON), and Paleoecological Environmental Assessment and Research Laboratory (PEARL) (ON) so that all of these calibration data could be combined. The more lakes we have in the calibration set, the more likely we can choose lakes that would better fit the fossil assemblages encountered downcore, reduce the non-analogue problems and ultimately generate a more robust TP model.

For these reasons, this diatom workshop provided us with an opportunity to get together and have a short but productive exchange of taxonomic information.

The Minnesota groups (St. Croix Watershed Research Station (Joy Ramstack, Mark Edlund) and Center for Water and the Environment (Euan Reavie, Amy Kireta and Jerry Sgro)) have analyzed approximately 145 lakes. The Ministry of the Environment at Dorset Ontario together with Queen's University (Andrew Paterson, Sergi Pla, Kathleen Rühland, and John P. Smol) has collected 17 sites in the Ontario portion of LOW plus three full cores. The Experimental Lakes Area study from PEARL (Brian Cumming, Kate Laird, Melissa Moos, and Mihaela Enache), has surveyed 45 lakes. All of these lakes share the same watershed.

The main diatom genera of interest for this workshop included: *Aulacoseira*, *Cyclotella*, *Cyclostephanos*, *Stephanodiscus*, and *Gomphonema*. The workshop consisted of round-table discussions of various taxonomic problems through projected diatom images from each of the participants. Day 2 included a microscope session.

The following pages provide photomicrographs summarizing the results of this two day workshop. The notes included alongside the photos are summaries of informal discussions among the participants. Undoubtedly, there will be some mistakes and uncertainties among the taxonomic identifications but hopefully these results will be an important and helpful step in providing a guide to identifying potentially problematic diatom taxa that are an important component of the LOW study region.

## List of participants:

*Brian Cumming*: PEARL, Queen's University, Kingston ON  
[cummingb@biology.queensu.ca](mailto:cummingb@biology.queensu.ca)

*Mihaela Enache*: PEARL, Queen's University, Kingston ON  
[enachem@biology.queensu.ca](mailto:enachem@biology.queensu.ca)

*Christine Greenaway*: PEARL, Queen's University, Kingston ON  
[greenawc@biology.queensu.ca](mailto:greenawc@biology.queensu.ca)

*Bronwyn Keatley*: PEARL, Queen's University, Kingston, ON  
[keatleyb@biology.queensu.ca](mailto:keatleyb@biology.queensu.ca)

*Amy Kireta*: UMD Natural Resources Research Institute, Ely, MN  
[akireta@nrri.umn.edu](mailto:akireta@nrri.umn.edu)

*Kate Laird*: PEARL, Queen's University, Kingston, ON  
[lairdk@biology.queensu.ca](mailto:lairdk@biology.queensu.ca)

*Isla Milne*: PEARL, Queen's University, Kingston ON  
[milnei@biology.queensu.ca](mailto:milnei@biology.queensu.ca)

*Melissa Moos*: PEARL, Queen's University, Kingston, ON  
[moosm@biology.queensu.ca](mailto:moosm@biology.queensu.ca)

*Andrew Paterson*: Ontario Ministry of the Environment, Dorset, ON  
[Andrew.Paterson@ontario.ca](mailto:Andrew.Paterson@ontario.ca)

*Joy Ramstack*: St. Croix Watershed Research Station, St. Paul, MN  
[jramstack@smm.org](mailto:jramstack@smm.org)

*Euan Reavie*: Center for Water and the Environment, Natural Resources Research Institute, Ely, MN,  
[ereavie@nrri.umn.edu](mailto:ereavie@nrri.umn.edu)

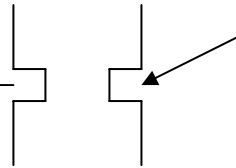
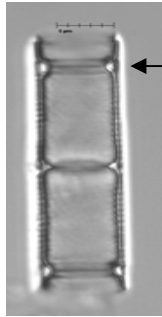
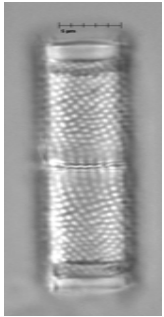
*Kathleen Rühland*: PEARL, Queen's University, Kingston, ON  
[3kmr5@biology.queensu.ca](mailto:3kmr5@biology.queensu.ca)

*Gerald Sgro*: Biology Department, John Carroll University, University Hts, OH  
[jsgro@jcu.edu](mailto:jsgro@jcu.edu)

*John Smol*: PEARL, Queen's University, Kingston, ON  
[smolj@biology.queensu.ca](mailto:smolj@biology.queensu.ca)

# **Aulacoseira: some general notes**

## *Aulacoseira ambigua*



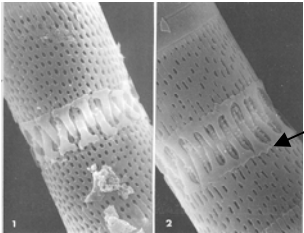
www

Look for sulcus in *A. ambigua*..they are rectangular (focus out to see clearly) and very clear.

*A. ambigua* tends to have finer striae than *A. granulata*.

Connecting spines are relatively short and pointy

## *Aulacoseira italica*

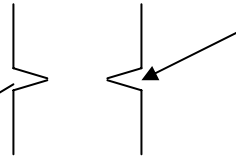
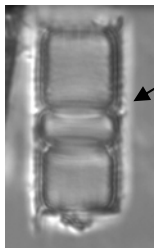
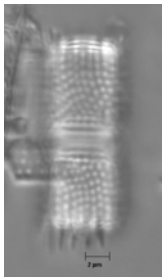


Taken from KLB p. 279



Shape of connecting spines in *A. italica* is shaped like a bone and therefore is distinguishable from *A. subarctica* whose spines are longer and pointier: *A. ambigua* has shorter, pointy spines

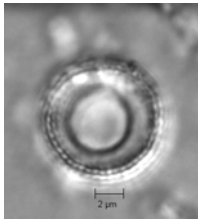
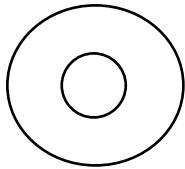
## *Aulacoseira subarctica*



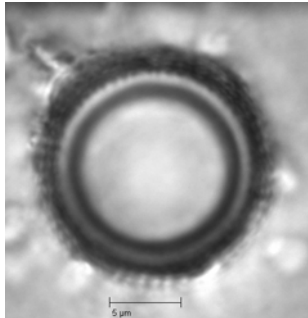
www

Sulcus in *A. subarctica* are not as clear as in *A. ambigua* and are v-shaped.

Connecting spines are usually distinctive as they are relatively long and quite pointy.



Deep ringleiste



Shallow ringleiste

## ***Aulacoseira*: some general notes - cont'd**

**Ringleiste**: also known as the annular ledge either a solid ridge or a ring-like (annulate) wall, projecting inwards from the collum and delimits the proximal position of the collum. **Collum**: areolae-free area at the distal ends of the of the mantle. The collum is separated from the areolated mantle by a small furrow, called the **sulcus**. The sulcus is quite deep in *A. ambigua*. The proximal part of the collum is the outer margin of the **ringleiste** (ring ledge), the distal part of the overlapping connection to the other theca or the girdle.

**Sulcus**: a constriction in the valve mantle just before it's distal ends in species of *Aulacoseira*. Three characteristic structures are found close to the sulcus: 1. the usually weakly developed sulcus furrow on the outer side of the mantle; 2. a pseudoseptum, the annular ridge, is on the reverse side of the sulcus, on the inside of the valve; and 3. the mostly very short, areolae-free, distal part of the mantle (collum).

**Girdle**: collective term for all structural elements between two valves. **Girdle-band**: general term for all open and closed bands (segments) of the cell-girdle, i.e. valvocopulae, intercalary bands

**Pervalvar areolae**: areolae running along the mantle

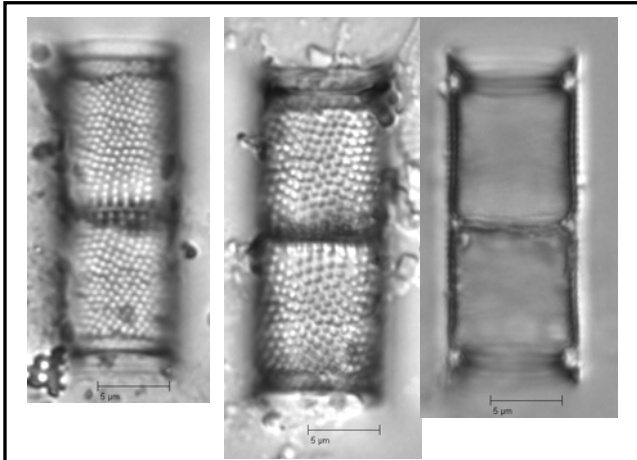
Web sites where information on this page was taken as well as some websites of potential interest:

<http://www.calacademy.org/RESEARCH/diatoms/overview/glossary.html>

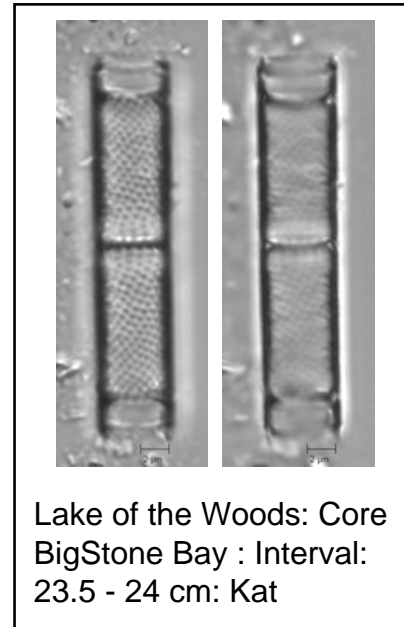
<http://www.lancs.ac.uk/staff/kingl/telford/index.htm>

<http://www.lancs.ac.uk/staff/kingl/telford/flashglossary.html>

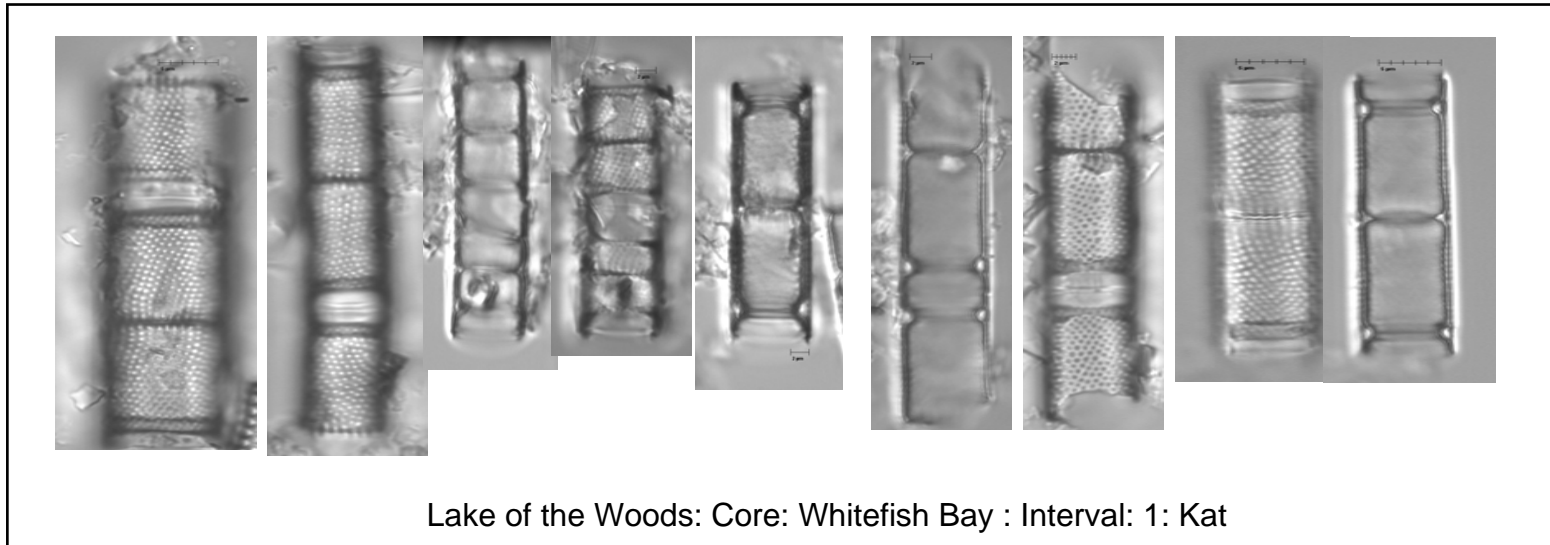
**Aulacoseira ambigua**



Lake of the Woods: Core PP1-A :  
Interval: 23.5 - 24 cm: Kat

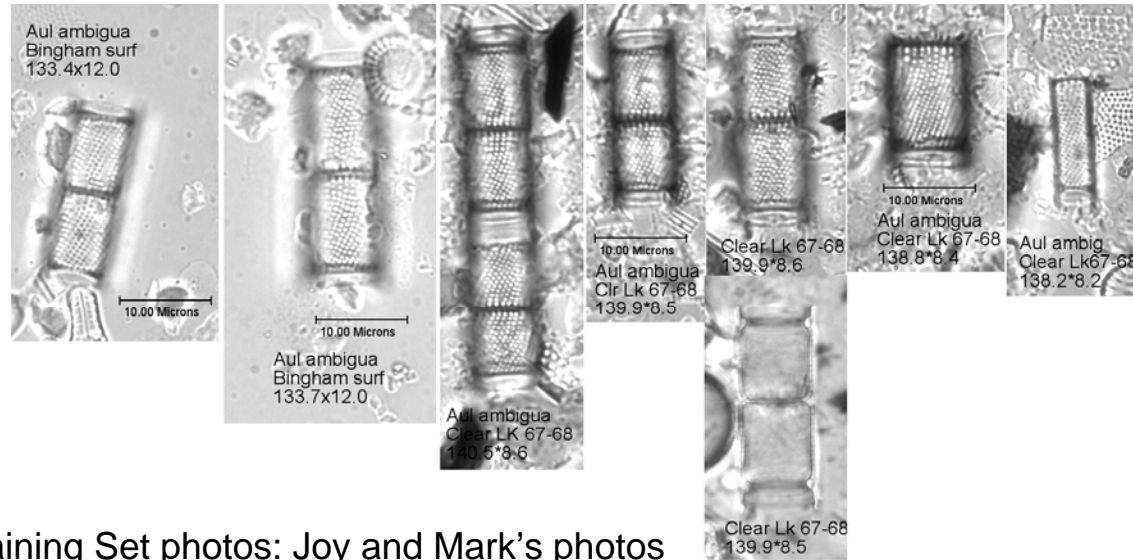


Lake of the Woods: Core  
BigStone Bay : Interval:  
23.5 - 24 cm: Kat

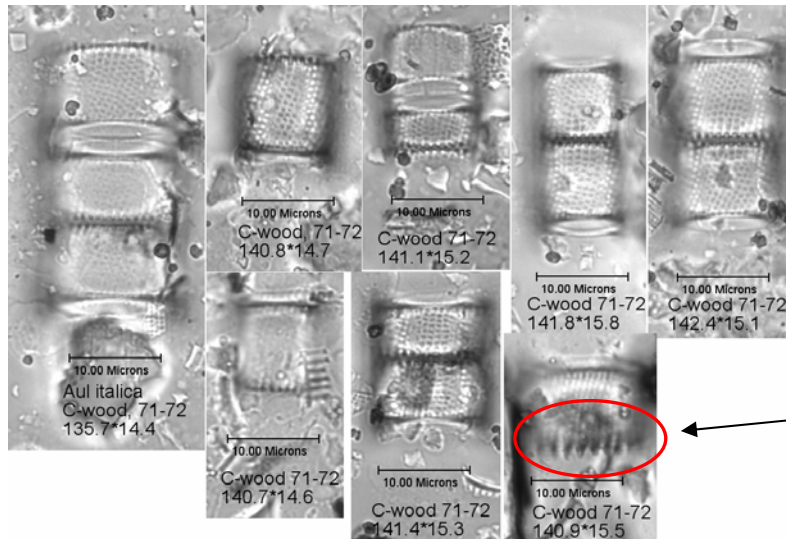


Lake of the Woods: Core: Whitefish Bay : Interval: 1: Kat

**Aulacoseira ambigua (cont'd)**



NW Minnesota Training Set photos: Joy and Mark's photos

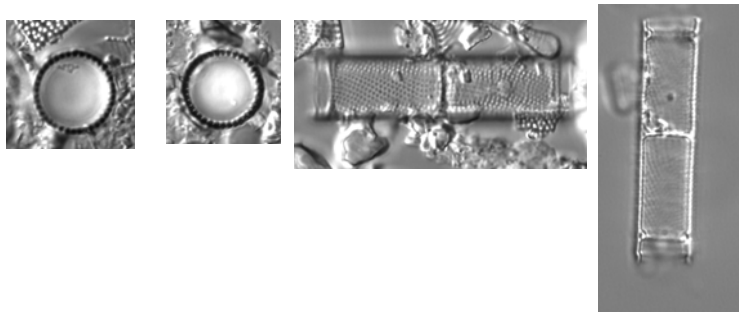


Perhaps more like *A. subarctica*

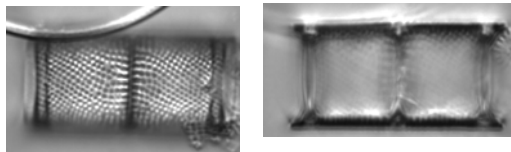
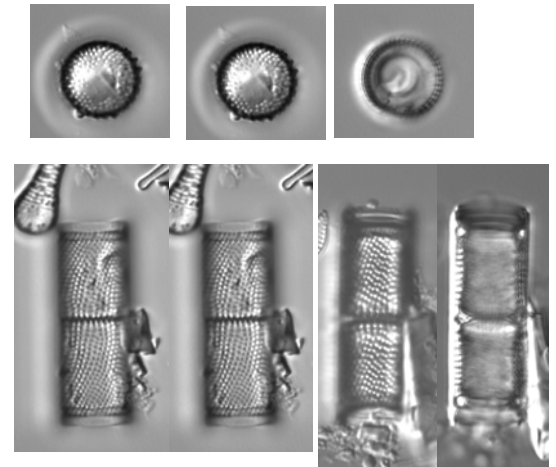


**Aulacoseira ambigua** (cont'd)

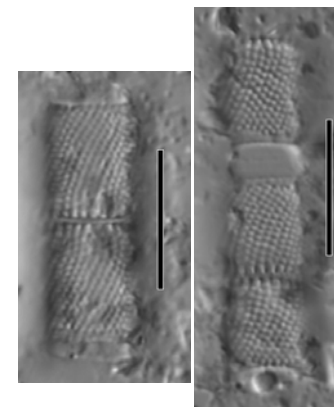
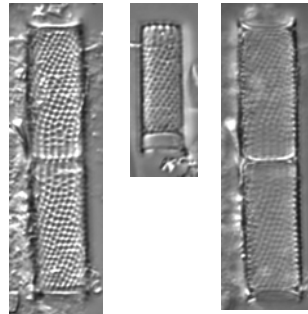
Eaglet Lake: Mihaela



Sturgeon Bay, ELA: Mihaela

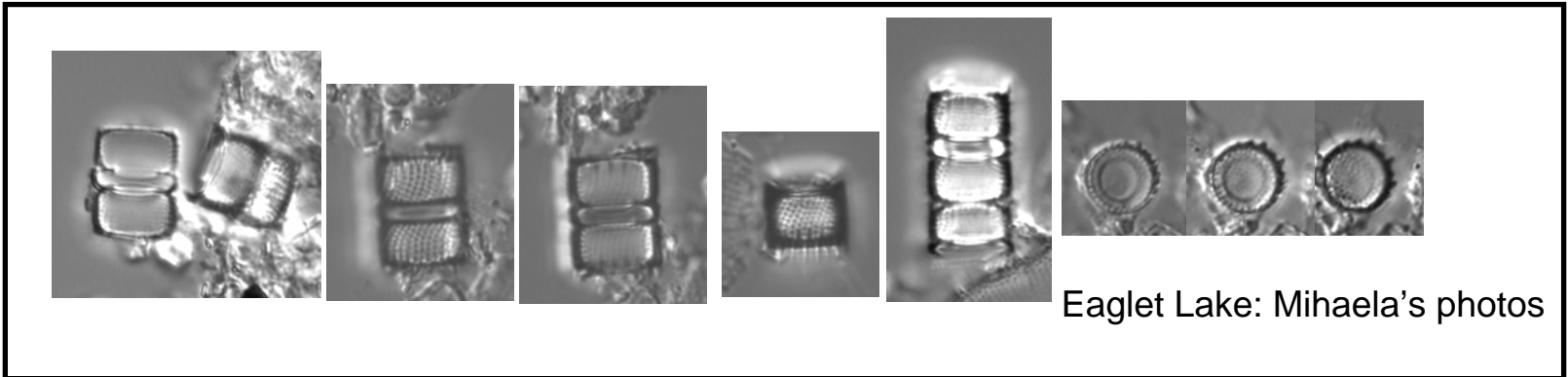
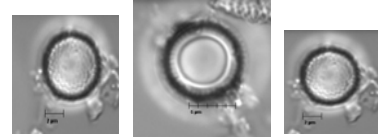
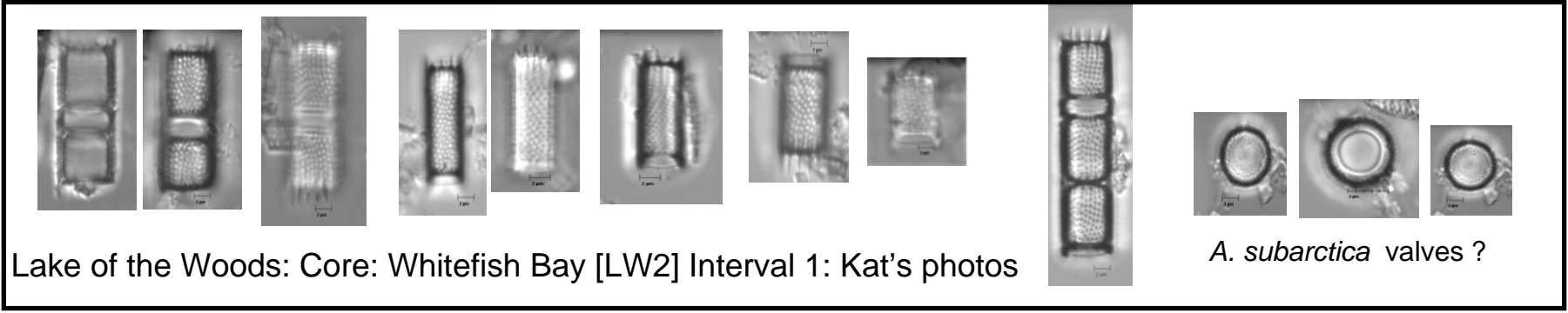
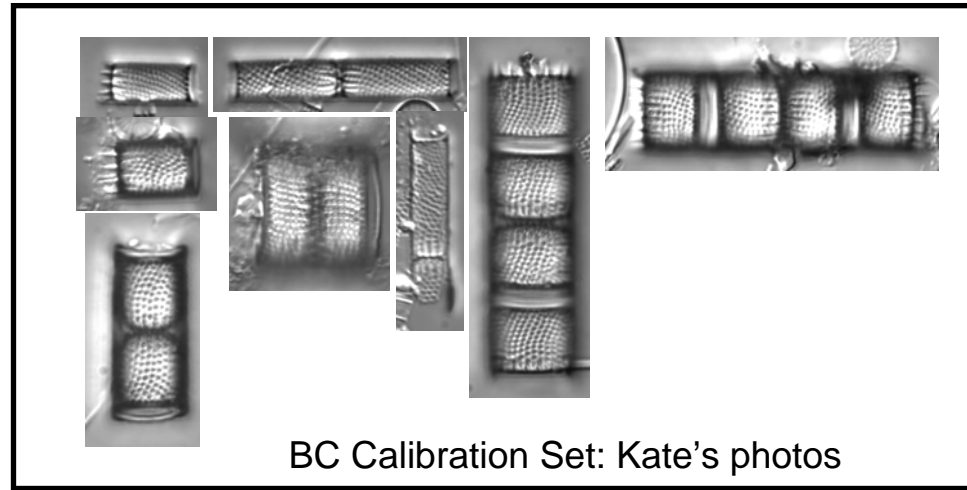


Kate's BC calibration photos



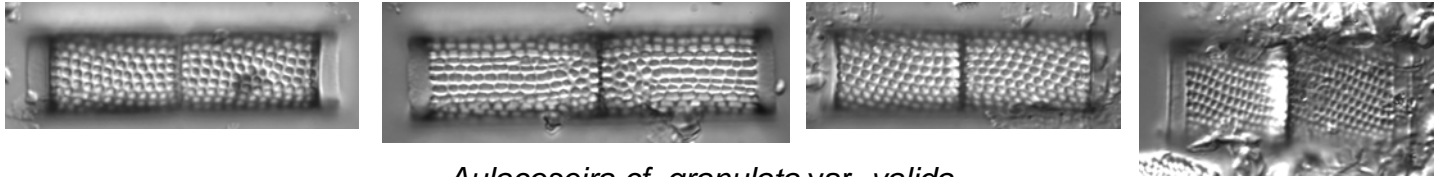
Jerry's photos

*Aulacoseira subarctica*

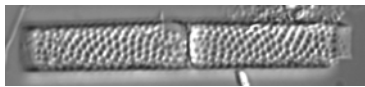


# *Aulacoseira granulata*

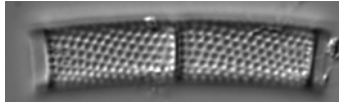
*Aulacoseira granulata* vs. *A. granulata* v. *angustissima*: striae on *A. granulata* is spiral (Stoermer); others have ignored this...possibly straighter looking on valves with spines? Not all valves have spines but should find some with spines. *A. granulata* var. *angustissima* is long and skinny, and the punctae are slightly finer. The Minnesota training set groups the *A. granulata* into the nominate variety.



*Aulacoseira* cf. *granulata* var. *valida*

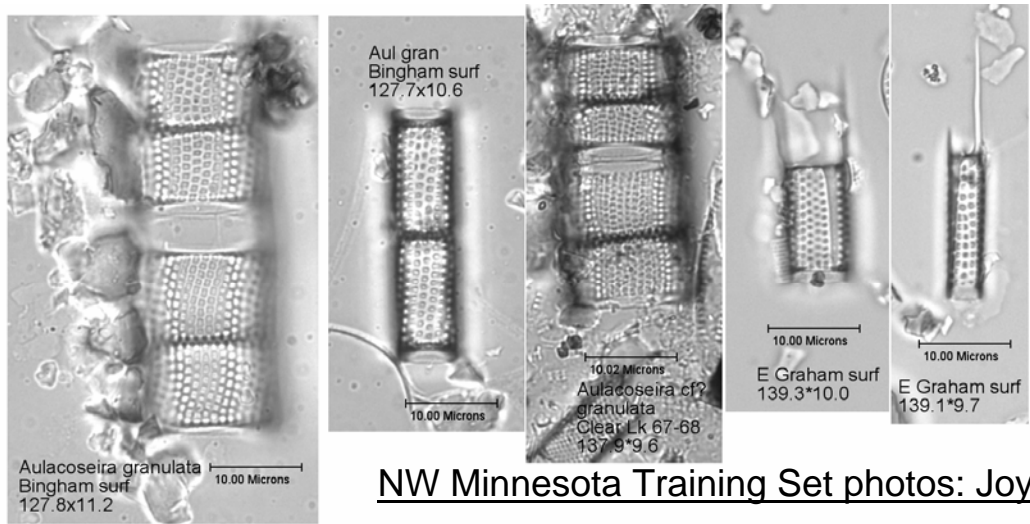


*Aulacoseira* cf. *granulata* var. *angustissima*



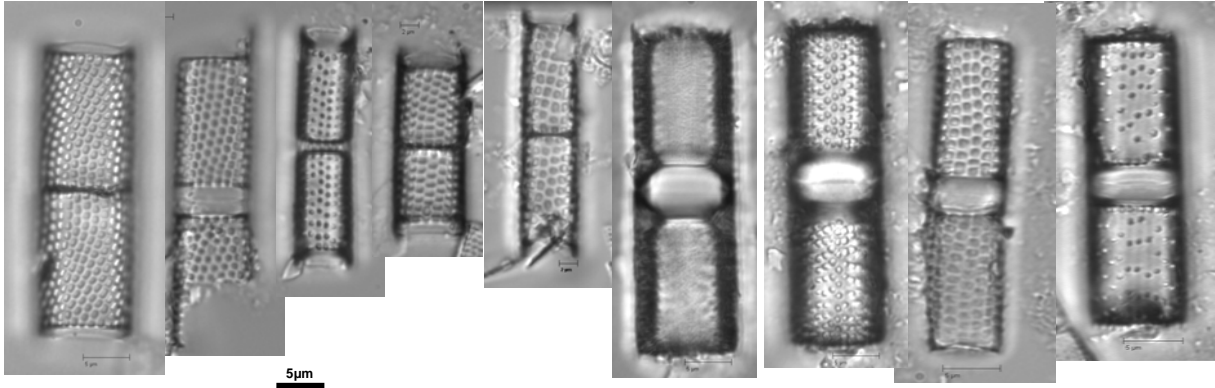
*Aulacoseira granulata*

## BC calibration set: Kate's photos

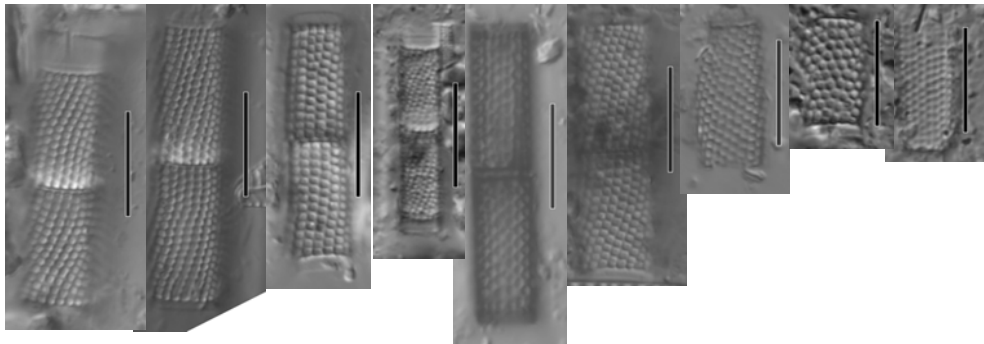


## NW Minnesota Training Set photos: Joy and Mark's photos

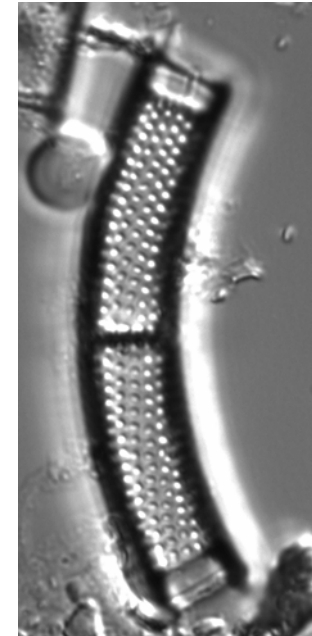
**Aulacoseira granulata cont'd**



Lake of the Woods: Whitefish Bay, PP1, Bigstone Bay: Kat's photos



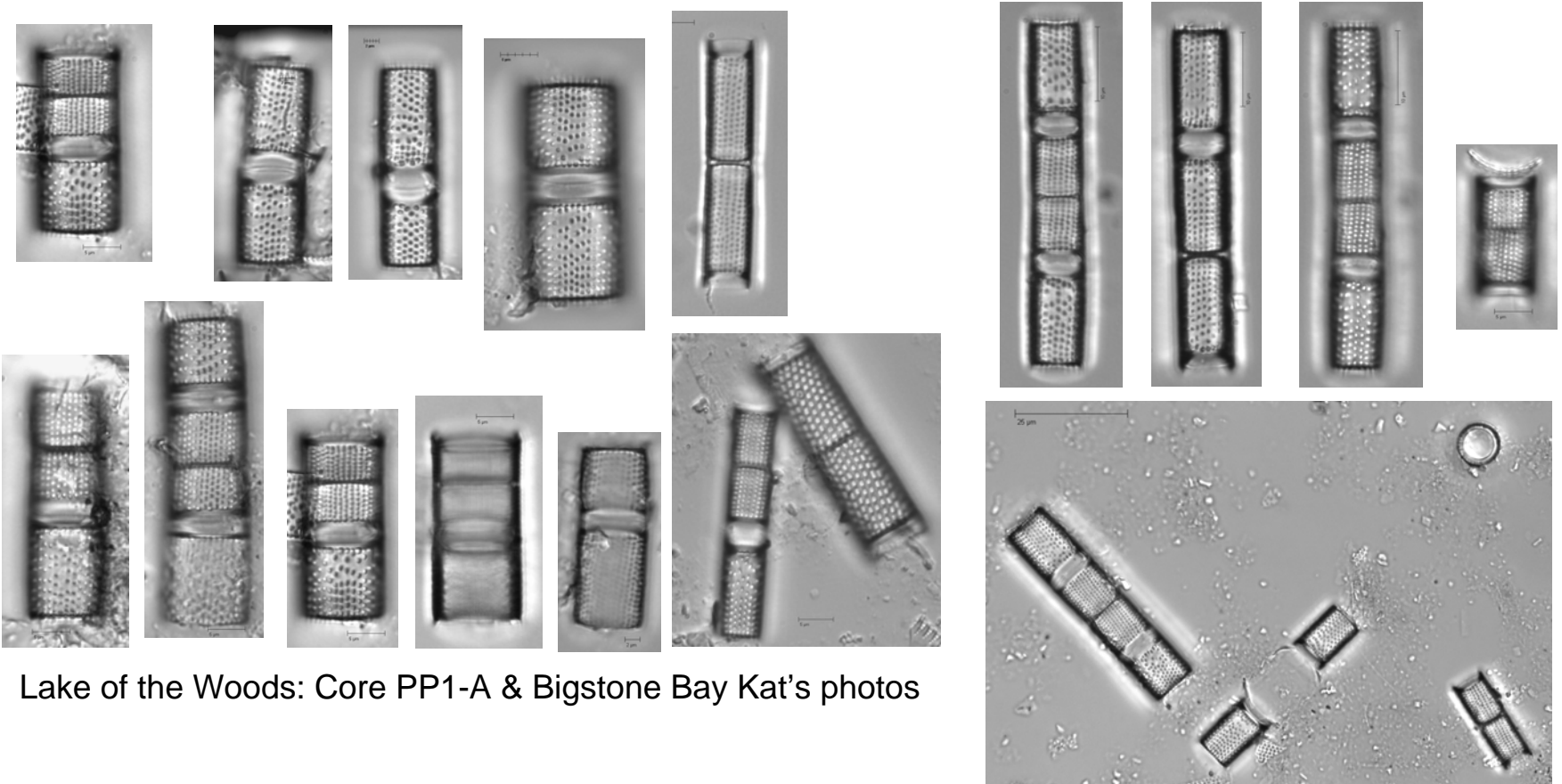
Jerry's photos



Eaglet Lake: Mihaela's photo

**Aulacoseira islandica** These hetero-valves seem to be consistent with what has been written on this taxon by Stoermer et al. 1985. *Limnol. Oceanogr.* 30: 414-418.

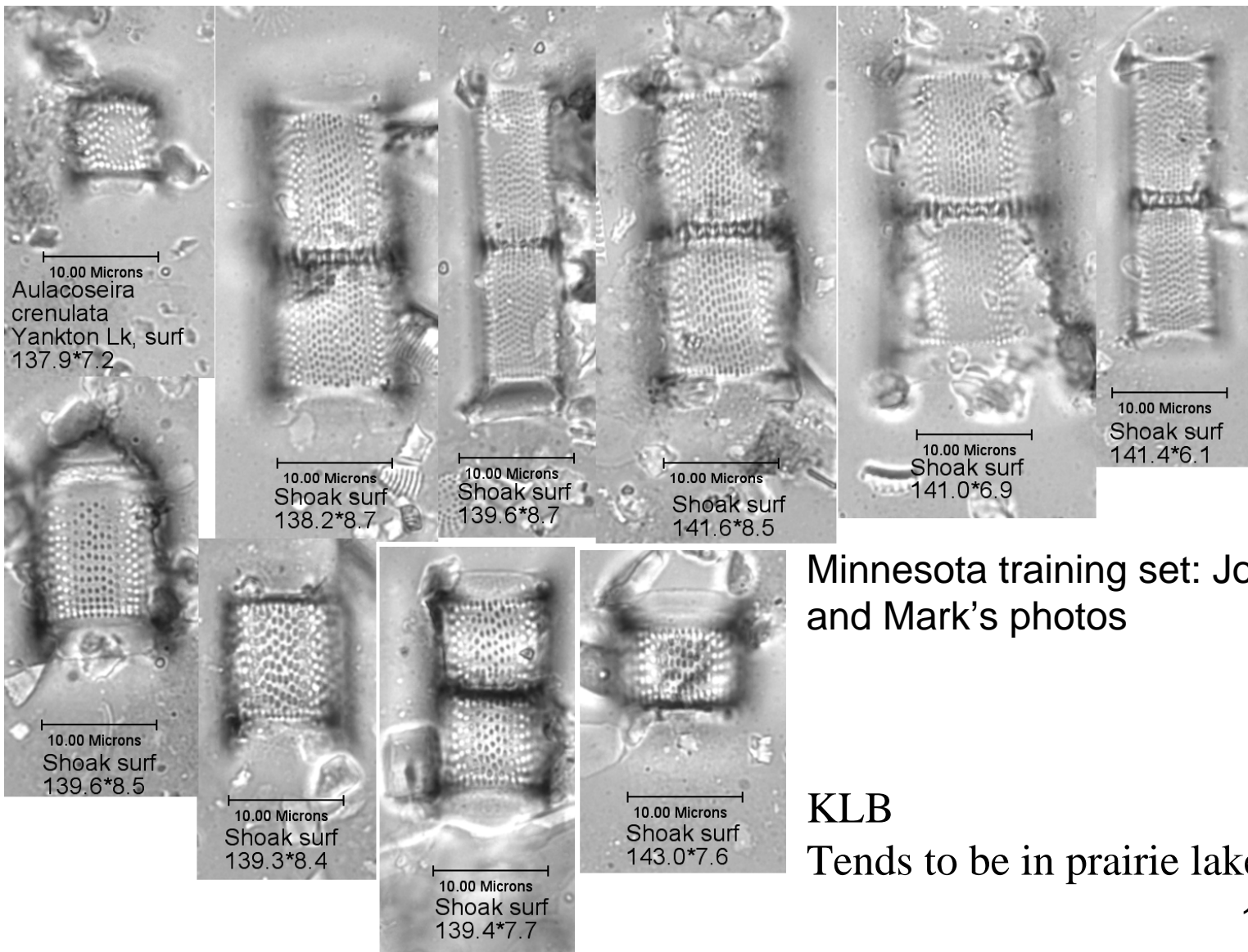
These are the Lake of the Woods heterovalves (poly-morphs). Differs with *A. granulata* in that *A. granulata* has little visible separation between valves but there may be a possible overlap with *A. crenulata*. Distinct collum area in separating cells. *A. islandica* has been found as a dominant in most of the Laurentian Great Lakes by Stoermer and his group. He has divided them according to the differences in the heterovalves (not taxonomically but as a response to changes in nutrients and silica. These samples fit in nicely with Siver and Kling 1997. *Can J Bot* 75: 1807-1835



Lake of the Woods: Core PP1-A & Bigstone Bay Kat's photos

Aulacoseira weird heterovalves Slide has been sent to Mark for verification. These valves are somewhat different than what the Minnesota group are calling *A. crenulata*, particularly the connecting spines. These are *A. islandica*

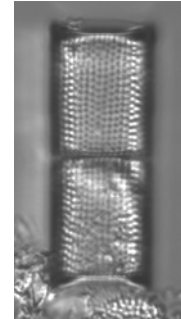
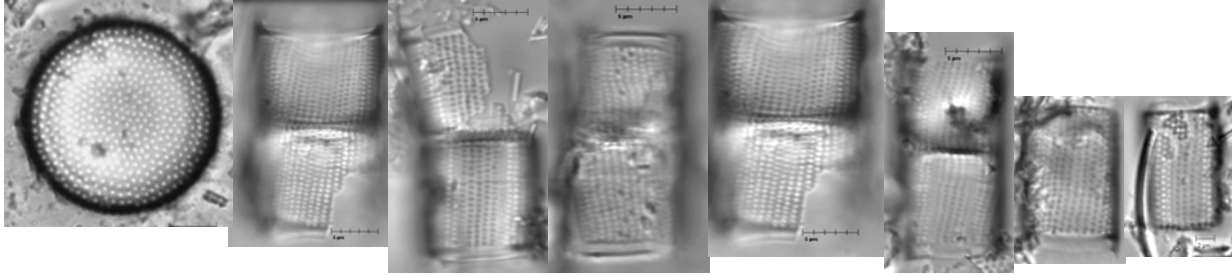
**Aulacoseira crenulata** *A. crenulata* has oval punctae, straight striae, spatula-shaped linking spines (tooth-like).



Minnesota training set: Joy and Mark's photos

KLB  
Tends to be in prairie lakes

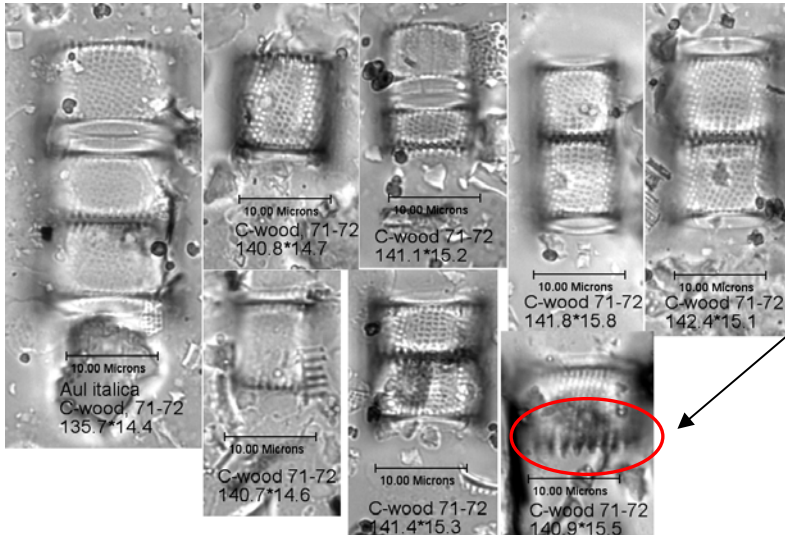
# *Aulacoseira islandica*



Lake of the Woods: Whitefish Bay, PP1, and Bigstone Bay: Kat's photos

Sturgeon Bay: Mihaela

# *Aulacoseira italica*



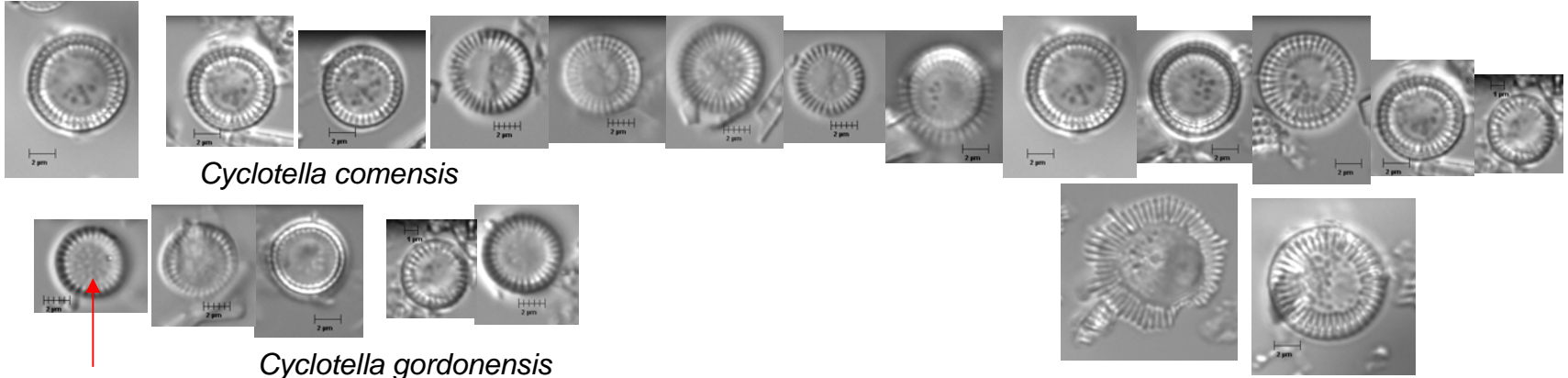
Perhaps more like *A. subarctica*

*A. italica*: some overlap with *A. ambigua* → general impression is that it is rare, and overlaps with *A. ambigua* and *A. subarctica* → shape and length of lines are important (*A. italica* with bone-like spine; *A. subarctica* is longer, pointy spine; and *A. ambigua* is short, pointy).

# *Cyclotella comensis/gordonensis*

*C. comensis* can be confused with *C. michiganiana*. Possible sources for *C. comensis* = John Kingston taxonomic cards. This species appears to be increasing in all kinds of lakes over the last decade to several decades. Mark Edlund's photo – very common in Itasca County. See also Werner and Smol 2006 (Nova Hedwigia 130: 373-392) paper on *C. comensis* that indicates similar ecologies across all ecotypes in Ontario lakes.

## Whitefish Bay [LW2] Lake of the Woods Kat's photos

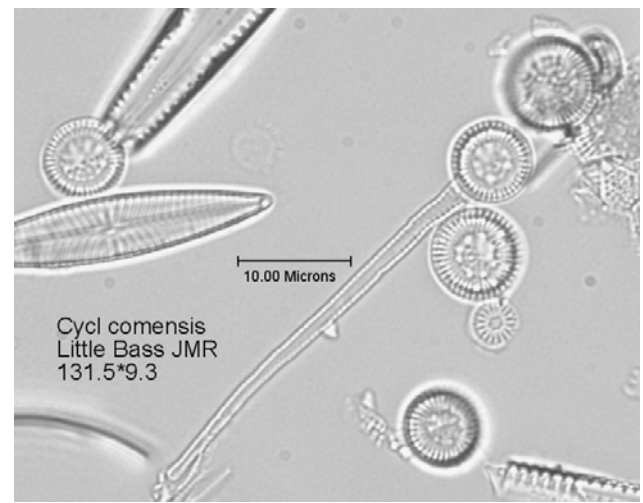
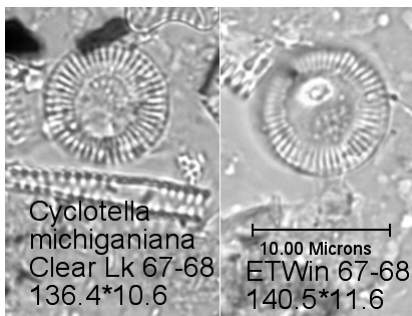


*C. gordonensis* has flat valve, short striae, and a granular central area with not much ornamentation.

*C. comensis* has a more distinct central ornamentation, is more undulated in the central area and the striae are somewhat longer.

However, these features are not always intact and the two forms seem to grade into each other in this core, particularly in the lower sections of the Whitefish Bay core.

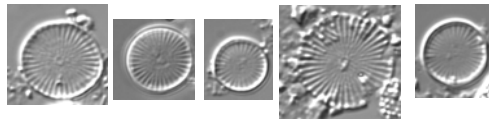
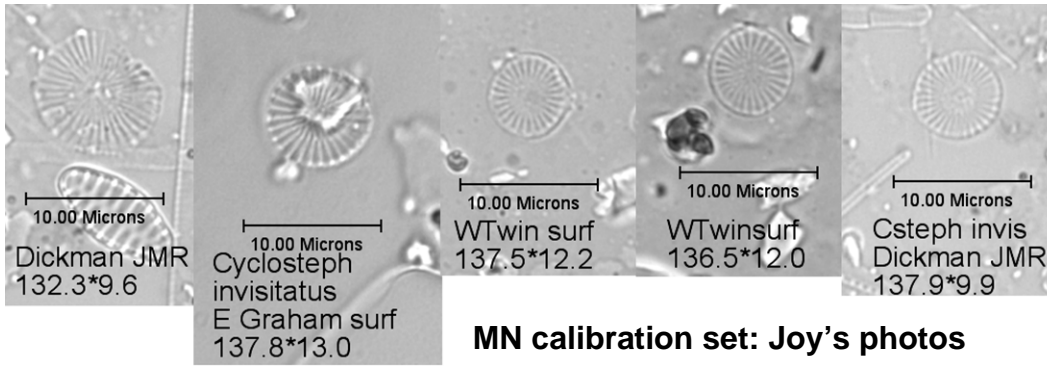
## *Cyclotella michiganiana*



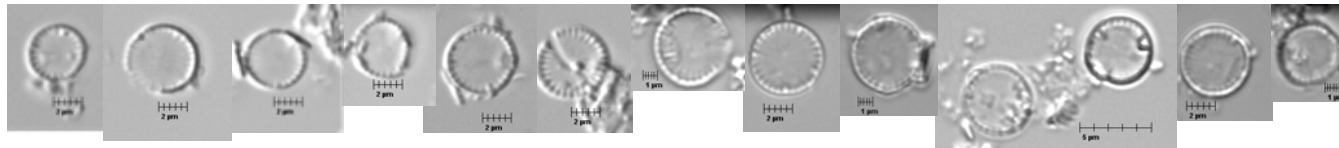
MN calibration set: Joy's photos



## Cyclostephanos invisitatus



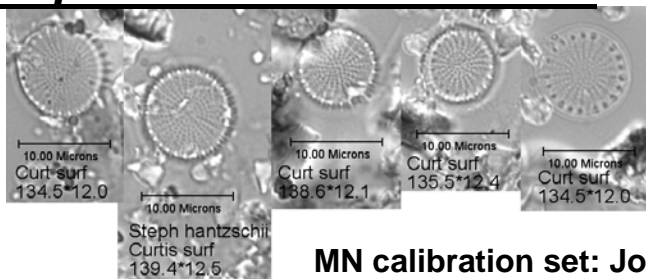
B.C. calibration set: Kate's photos



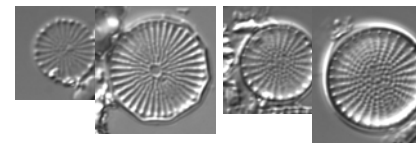
## Whitefish Bay [LW2] Lake of the Woods: Kat's photos

These are an important component of the assemblage at the top of this core. They are very consistent throughout the core in terms of their size, lack of ornamentation and the shadow lines in the very fine and very short striae. This is likely not *Cyclostephanos invisitatus* and are currently labelled as *Cyclotella* unknown. Requires SEM work perhaps.

## Stephanodiscus hantzschii



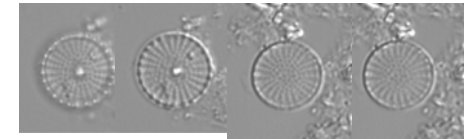
MN calibration set: Joy's photos



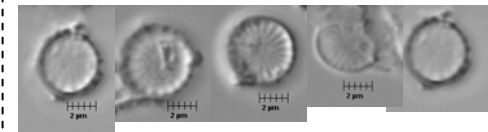
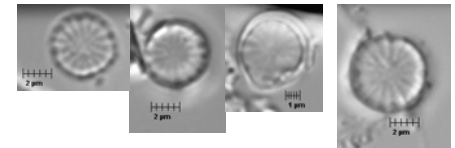
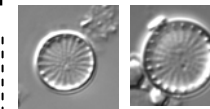
B.C. calibration set: Kate's photos

## Stephanodiscus

### parvus

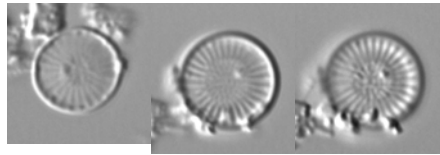


### Eaglet Lake: Mihaela

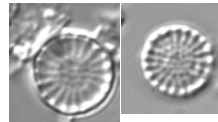


*S. parvus* is similar to *S. minutulus* but not as undulate. *S. parvus* is commonly finer and has a central punctum.

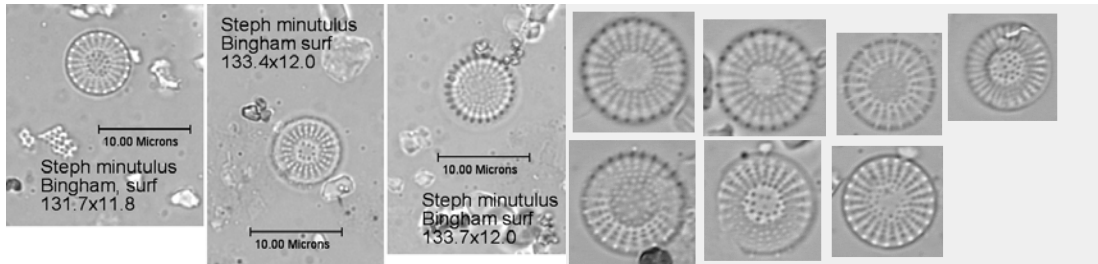
# Stephanodiscus minutulus



Sturgeon Bay: Mihaela's photos

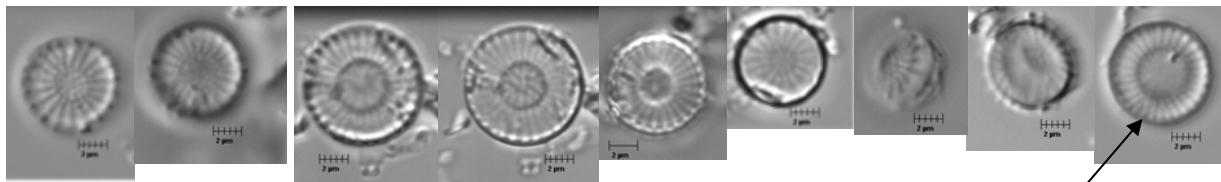


B.C. calibration set: Kate's photos



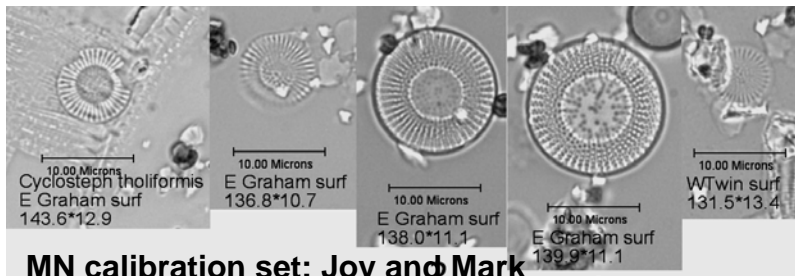
MN calibration set: Joy and Mark

Bingham LK, surf, St minutulus, JCK scope

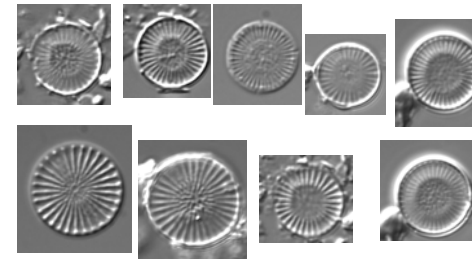


Whitefish Bay LOW: Kat's photos

# Cyclostephanos tholiformis

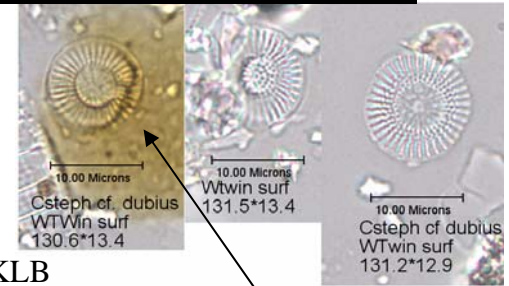


MN calibration set: Joy and Mark



B.C. calibration set: Kate's photos

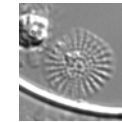
# Cyclostephanos dubius



KLB

First image may be *C. tholiformis*

MN calibration set: Joy and Mark



Eaglet Lake: Mihaela's photo

*Cyclostephanos tholiformis* has a central process and is distinguished from *Cyclostephanos invisitatus* in that *C. invisitatus* is much finer and very flat.

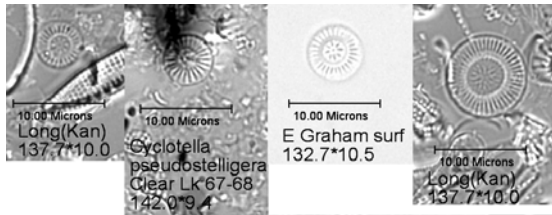
Last image may be *C. tholiformis*?

# Cyclotella pseudostelligera

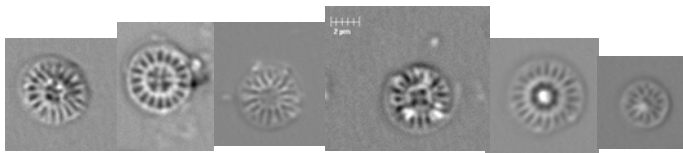
What Kat has labelled as *Cyclotella* unknown



## Whitefish Bay LOW: Kat's photos

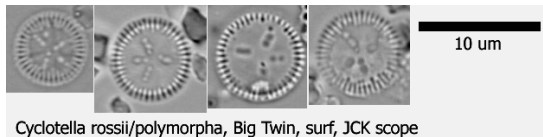


## MN calibration set: Joy and Mark



## FG04-PC2: Mihaela's photo

# Cyclotella rossii/polymorpha

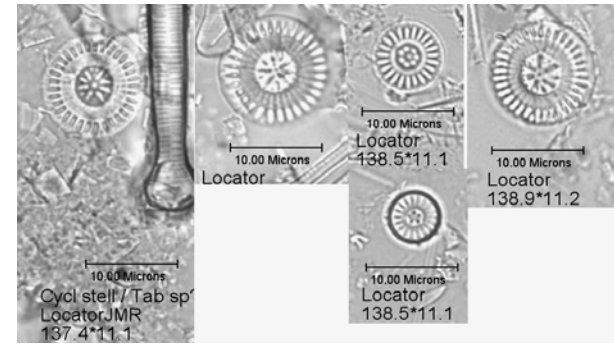


## MN calibration set: Joy and Mark

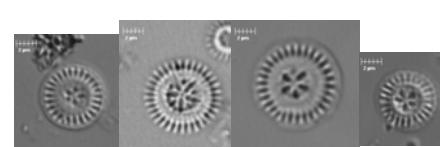
*C. rossii* in MN dataset

Polymorpha - Meyer and Håkansson, 1996, *Phycologia* 35:64-69

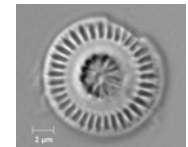
# Cyclotella stelligera



## MN calibration set: Joy

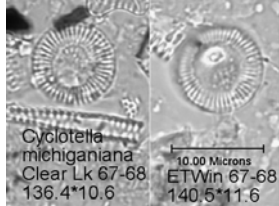


## FG04-PC2: Mihaela's photo

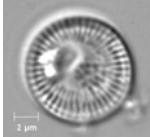


## ELA: Melissa's photo

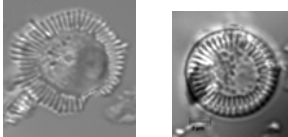
## *Cyclotella michiganiana*



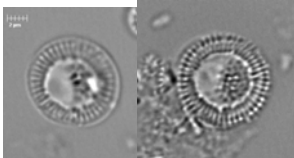
MN calibration set: Joy and Mark



ELA: Melissa's photo

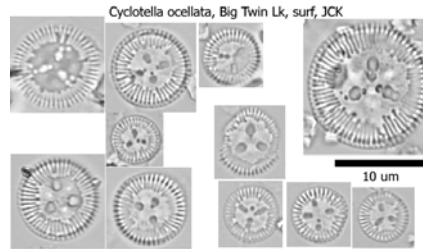


Whitefish Bay LOW: Kat's photos

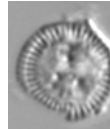


FG04-PC2: Mihaela's photo

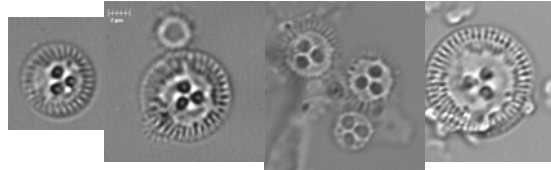
## *Cyclotella ocellata*



MN calibration set: Joy and Mark

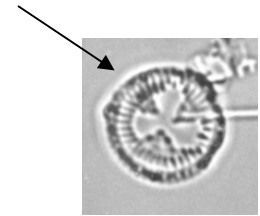


ELA: Melissa's photo



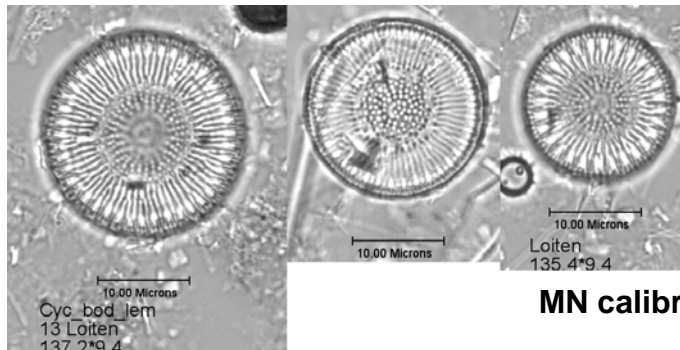
FG04-PC2: Mihaela's photo

*C. ocellata* has three or more large, distinct punctae in centre. *C. tripartita* has a "punctae field" within each of the three triangles making up the central area.



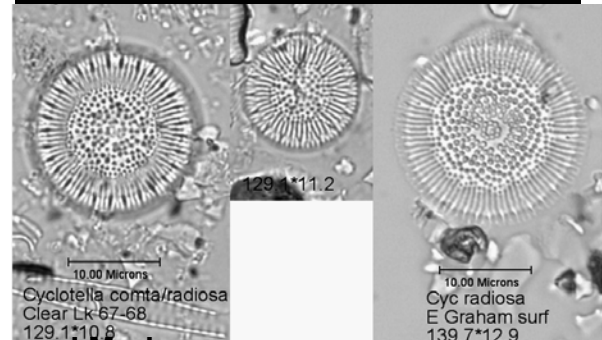
*C. tripartita*

## *Cyclotella bodanica* var. *lemanica*



MN calibration set: Joy and Mark

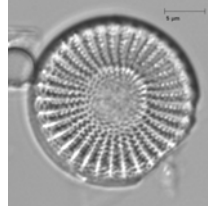
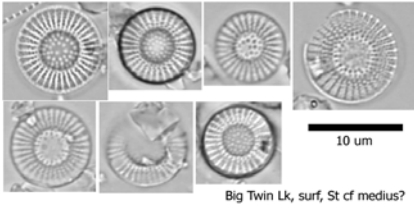
## *Cyclotella radiosa/comta*



# Stephanodiscus medius

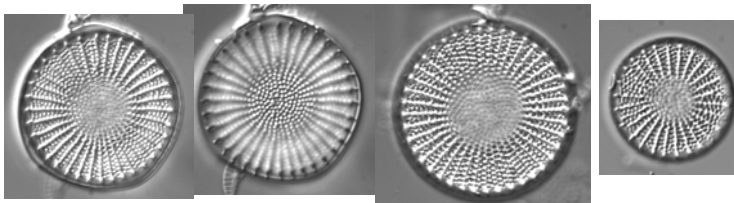
*Stephanodiscus alpinus* may possibly overlap with *S. medius*. *S. medius* is coarser. *S. medius* may also overlap with *S. oregonicus*. *S. medius* has 2-3 striae between each spine (KLB definition) whereas *S. alpinus* has two striae. *S. medius* has the appearance of “fanning out” at mantle edge. If there are three rows of punctae towards the edge of the valve, then it is *S. medius*.

*S. minutulus* (a dominant in the Minnesota set) has finer striae than *S. medius*.

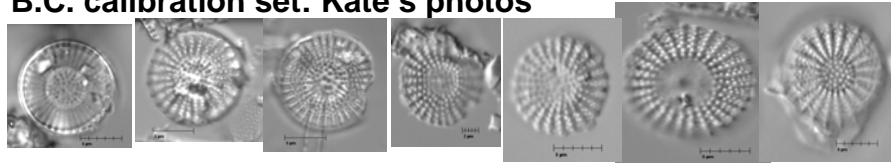


MN calibration set: Joy and Mark

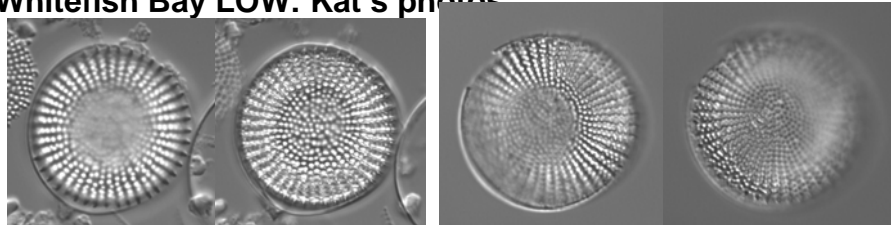
ELA: Melissa’s photo



B.C. calibration set: Kate’s photos



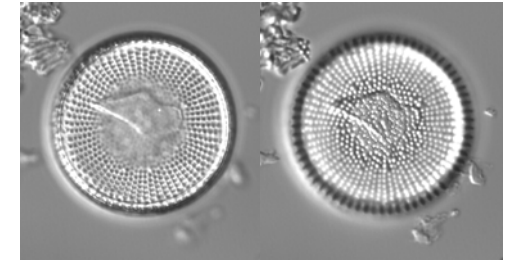
Whitefish Bay LOW: Kat’s photos



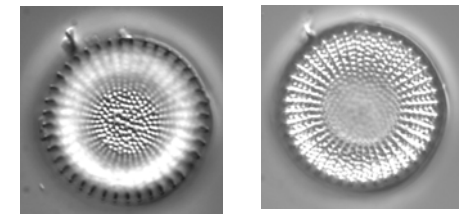
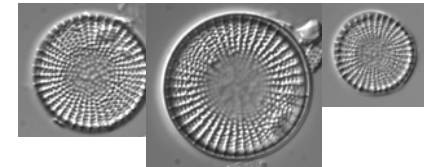
PL-04: Mihaela’s photo

*Stephanodiscus medius/alpinus*

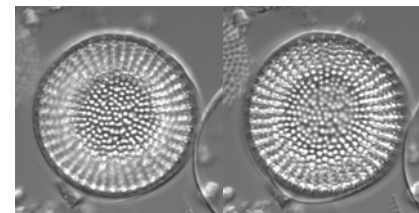
# Stephanodiscus alpinus



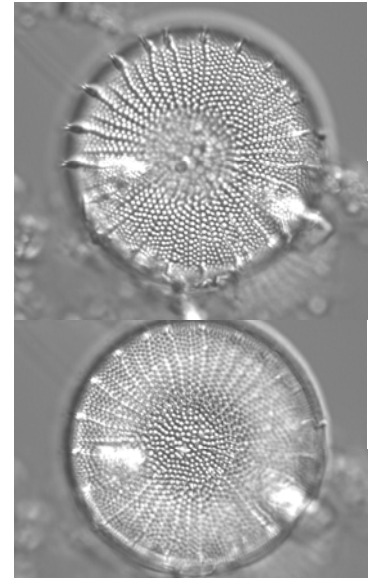
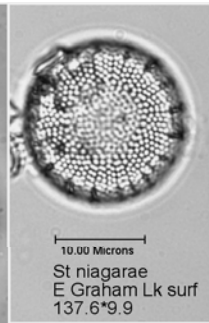
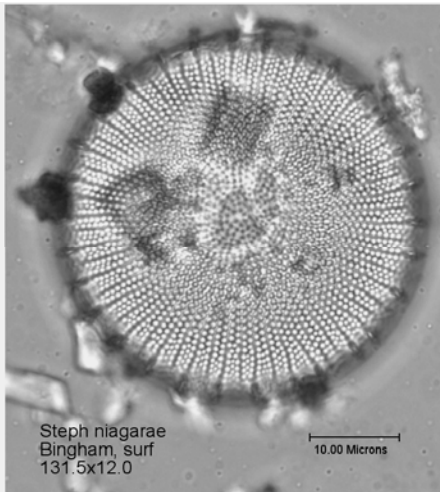
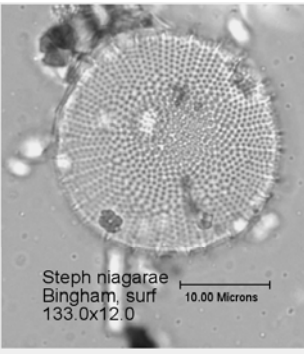
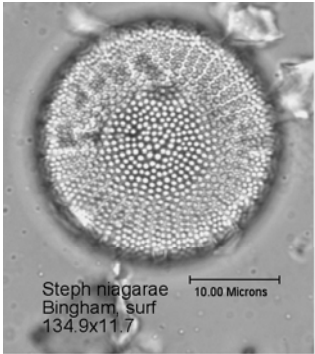
PL-04: Mihaela’s photo



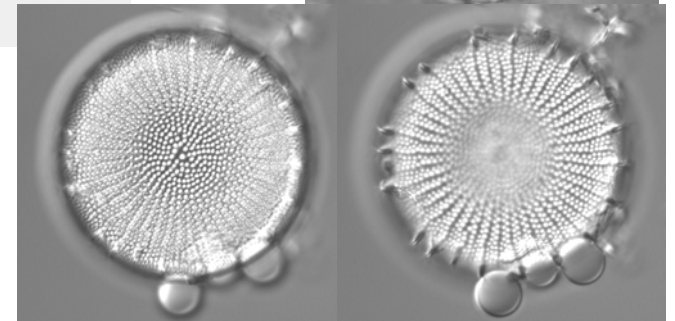
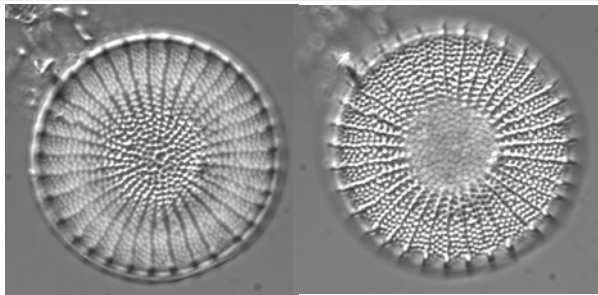
B.C. calibration set: Kate’s photos



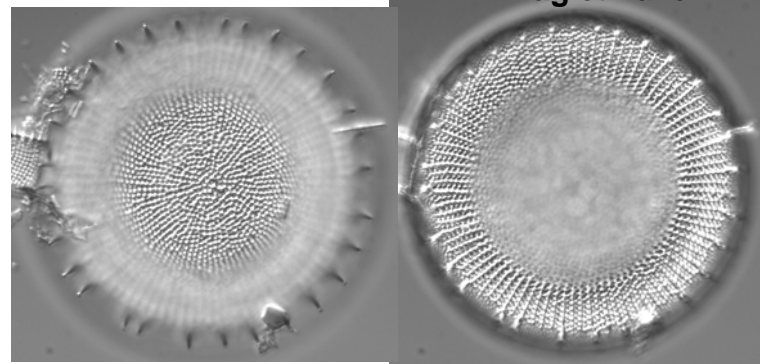
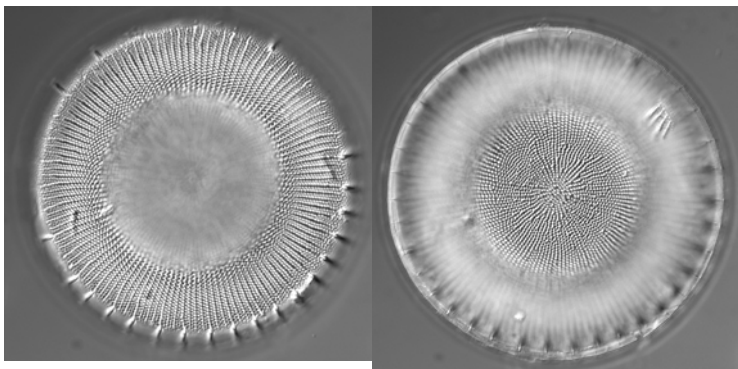
# *Stephanodiscus niagarae*



MN calibration set: Joy and Mark

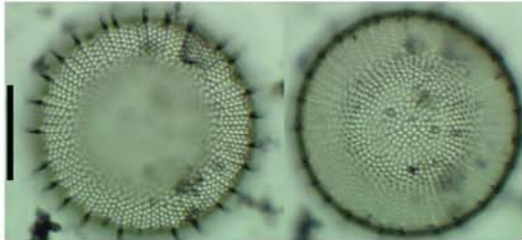


Eaglet Lake: Mihaela's photos

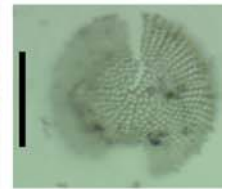
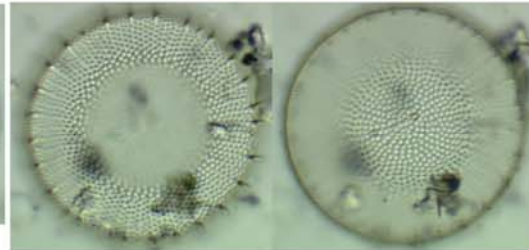
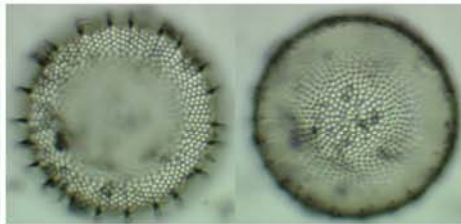


B.C. calibration set: Kate's photos

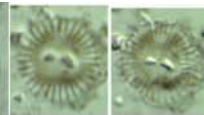
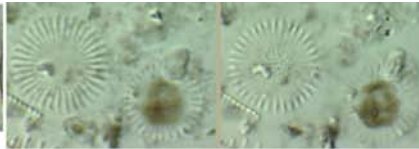
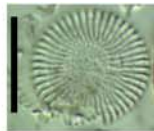
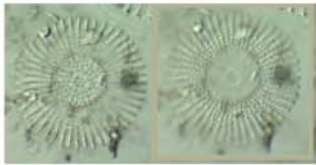
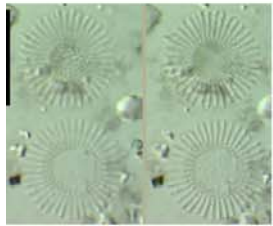
# Amy's photos of Stephs and Cyclostephs



STE niagare/rotula smallUMD

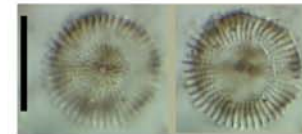


STE agassizensis

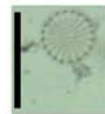
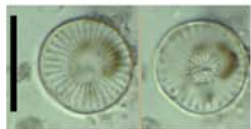


Cyclostephanos dubius var. 1 UMD

STE medius1



CSP dubius

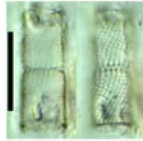


STE medius/minut

STE parvus/hantz1UMD

# UMD Aulacoseira

## Amy's *Aulacoseira* photos



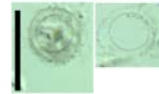
AUL ambigua



AUL ambigua1



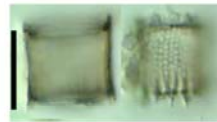
AUL tenuior1



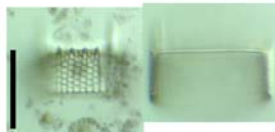
AUL tenuior 2



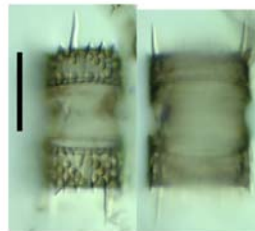
AUL islandical



AUL italical



AUL muzza



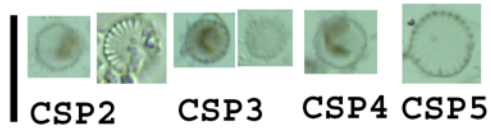
AUL muzza1



AUL lirata biseriata1

*Aulacoseira tenuior*. In Minnesota river plankton (Amy) samples, almost always found in valve view. Also found in acidic lakes in Québec (Mihaela).

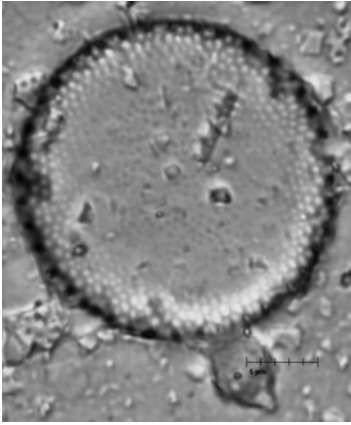




*Cyclotella meneghaniana*: decided that these smaller forms should be part of an *C. meneghaniana* complex. This may include *Cyclotella atomus*. If obviously chambered then they have been splitting them in the Minnesota set. This could be a size split or an ecotype split. Unchambered forms are *C. atomus* (including heterovalves). In the Minnesota lake dataset, *C. atomus* was not found to be important (only about one valve in one lake). *C. meneghaniana* is common in shallow, eutrophic Minnesota lakes (SW part of the state).

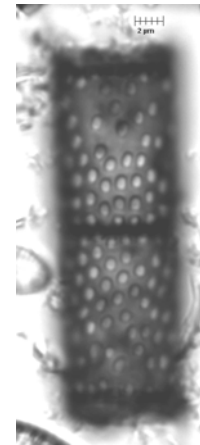
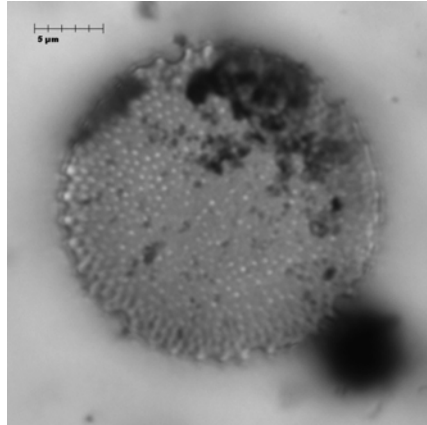
## Amy's *Cyclotella* species

# Microscope session pictures



*Aulacoseira muzzanensis*

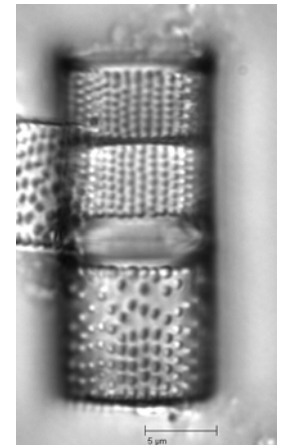
– Joy's sample



*Aulacoseira canadensis*

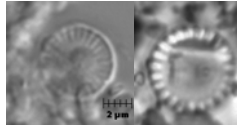
– Jerry's sample

*A. Canadensis* is similar to *A. granulata* var. *valida* but with spaces between punctae and it has very coarse punctae



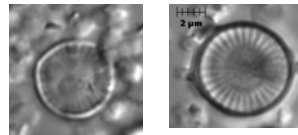
*Aulacoseira islandica*

– Kat's sample



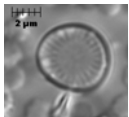
*Cyclotella mehnigiana*

– Amy's sample



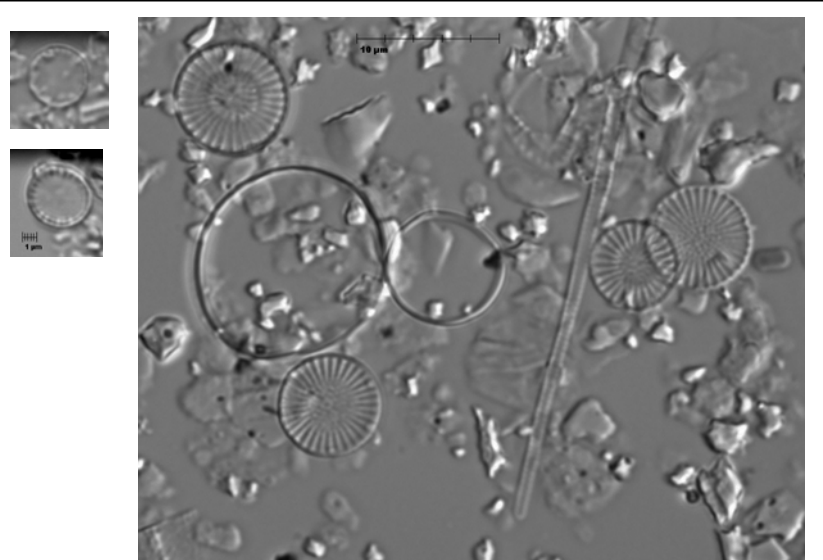
*Cyclostephanos tholiformis*

– Amy's sample



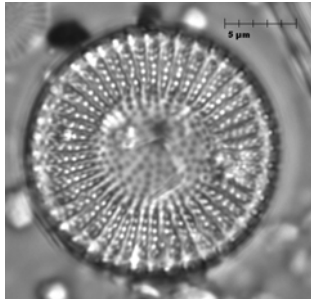
*Cyclotella stelligera*

– Amy's sample

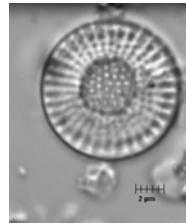


*Cyclostephanos tholiformis-dubius* – Kat's Whitefish Bay

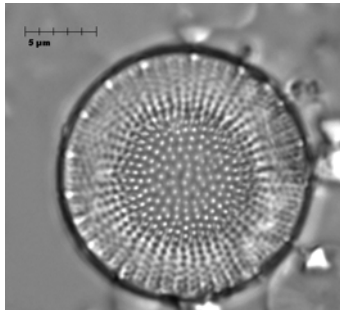
## Microscope session pictures



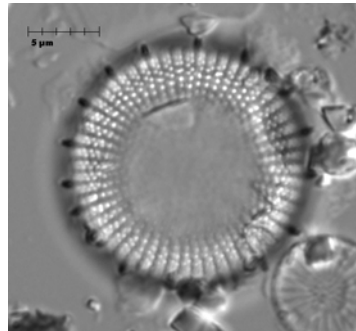
*Stephanodiscus alpinus* LOW



*Stephanodiscus minutulus*



*Stephanodiscus niagarae*



*Stephanodiscus niagarae* –  
Mark- *Steph. agassizensis*