Lake Winnipeg Phytoplankton Summary and Update

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Acknowledgements::

LWRC, DFO, MC, CEOS and EC.,

History of Limnological Research on L Winnipeg

1927 Biological Board of Canada

Lowe Phytoplankton Survey

Bajkov & Neave: Biological and Chemical survey

1969 Fisheries Research Board of Canada (Freshwater Institute)

Dr. G. Brunskill and team of Scientists limnological survey from 50 lake wide stations during 6 open water cruises

1994 Geological Survey of Canada and Manitoba Energy and Mines

Sediment cores and limnological samples from 33 stations during August

1996 Geological Survey of Canada and Energy and Mines

Repeat of the 1994 survey (August only)

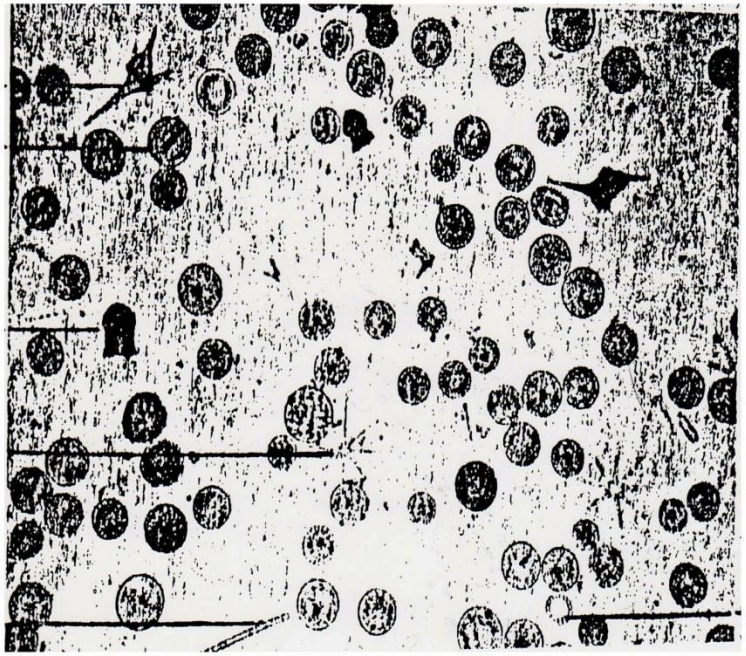
1998 International Joint Commission- International Red River Basin Task Force: Influence of the 1997 flood on contaminant transport in the south basin

1999 Lake Winnipeg Consortium _18 member agencies

August lake wide survey to collect air, water, sediments, chemisty, bacteria, plankton and benthos (August)

Lake wide surveys continuing to present facilitated by LWRC and joint Federal Provincial departments.

A microscope field of phytoplankton from August in the late 20's (Lowe 1928)

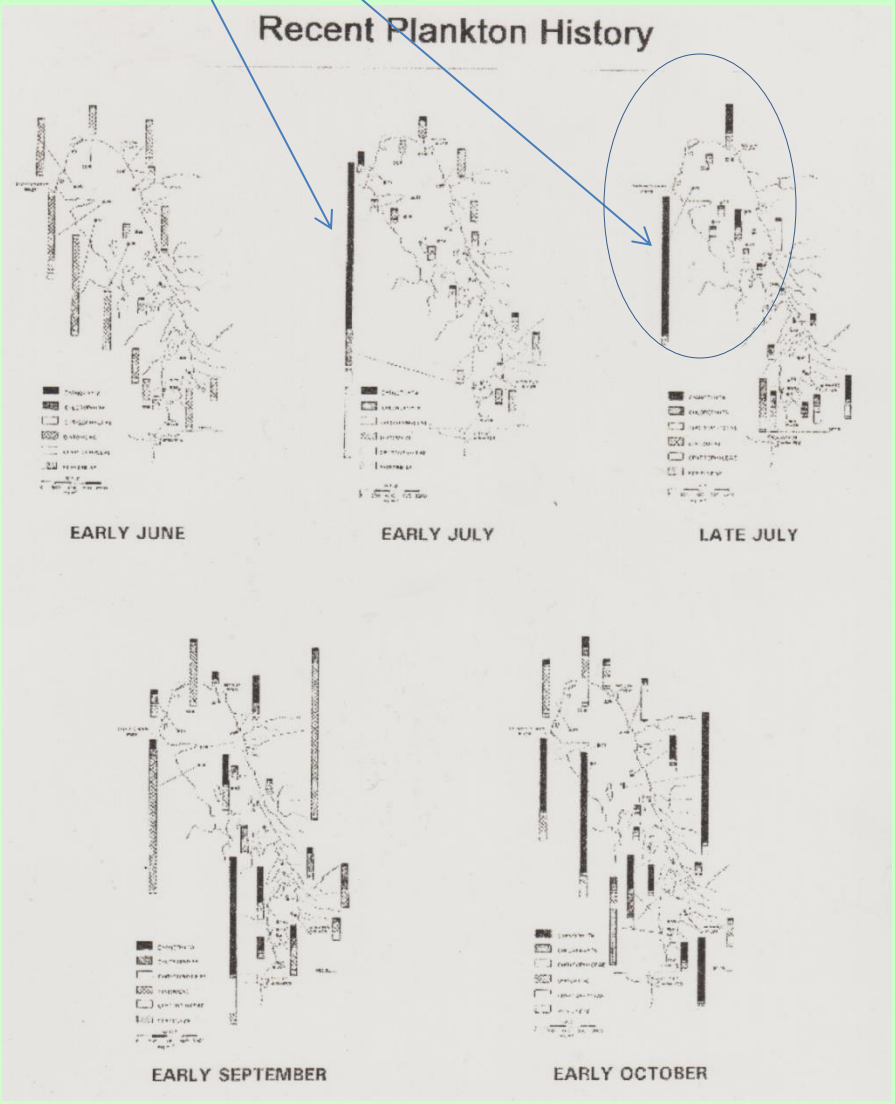


- **Phytoplankon composition in Lake Winnipeg was dominated by the centric diatom *S. niagarae* with *Ceratium hirundenella,***

  ***Asterionella formosa*, and *Aulacoseira* and *Anabaena* present.**

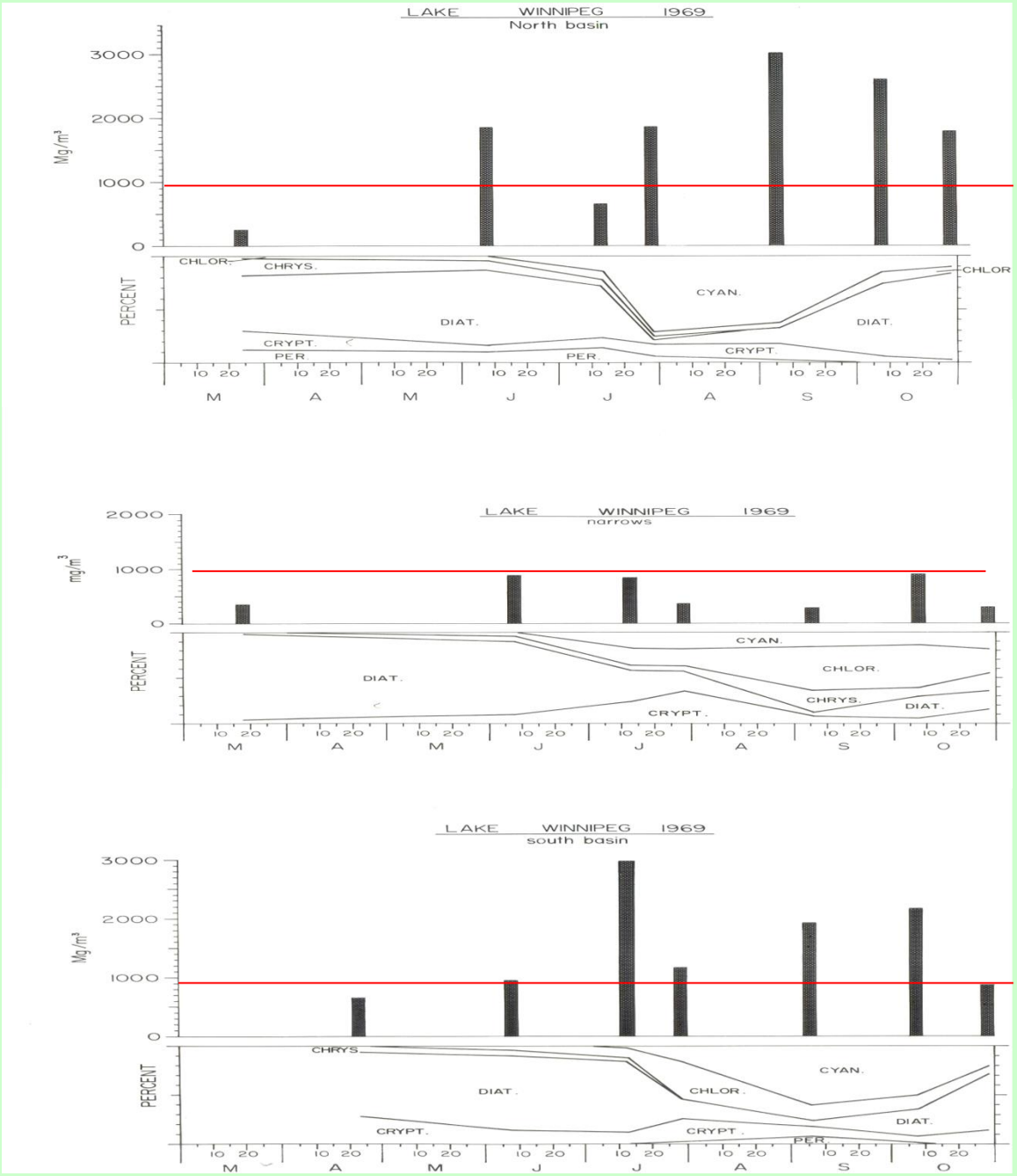
Phytoplankton whole lake surveys July _October 1969

Dark Bar = Bluegreens



- Lake Winnipeg Phytoplankton spatial surveys from 1969
- Spring plankton was dominated by diatoms mainly *Aulacoseira islandica, & A. subarctica*
- Areas of high bluegreen biomass (black shaded bars) were found in the western region of the South Basin (*Microcystis & Oscillatoria (Planktothrix suspensa*) in early July and a surface bloom (Aphanizomenon flos aquae) off the Saskatchewan River in late July 1969.
- Mixed blugreens remained into September and October together with the fall diatoms dominated by *Aulacoseira ambigua* and *A. granulata , A. subarctica other single celled centrics.*

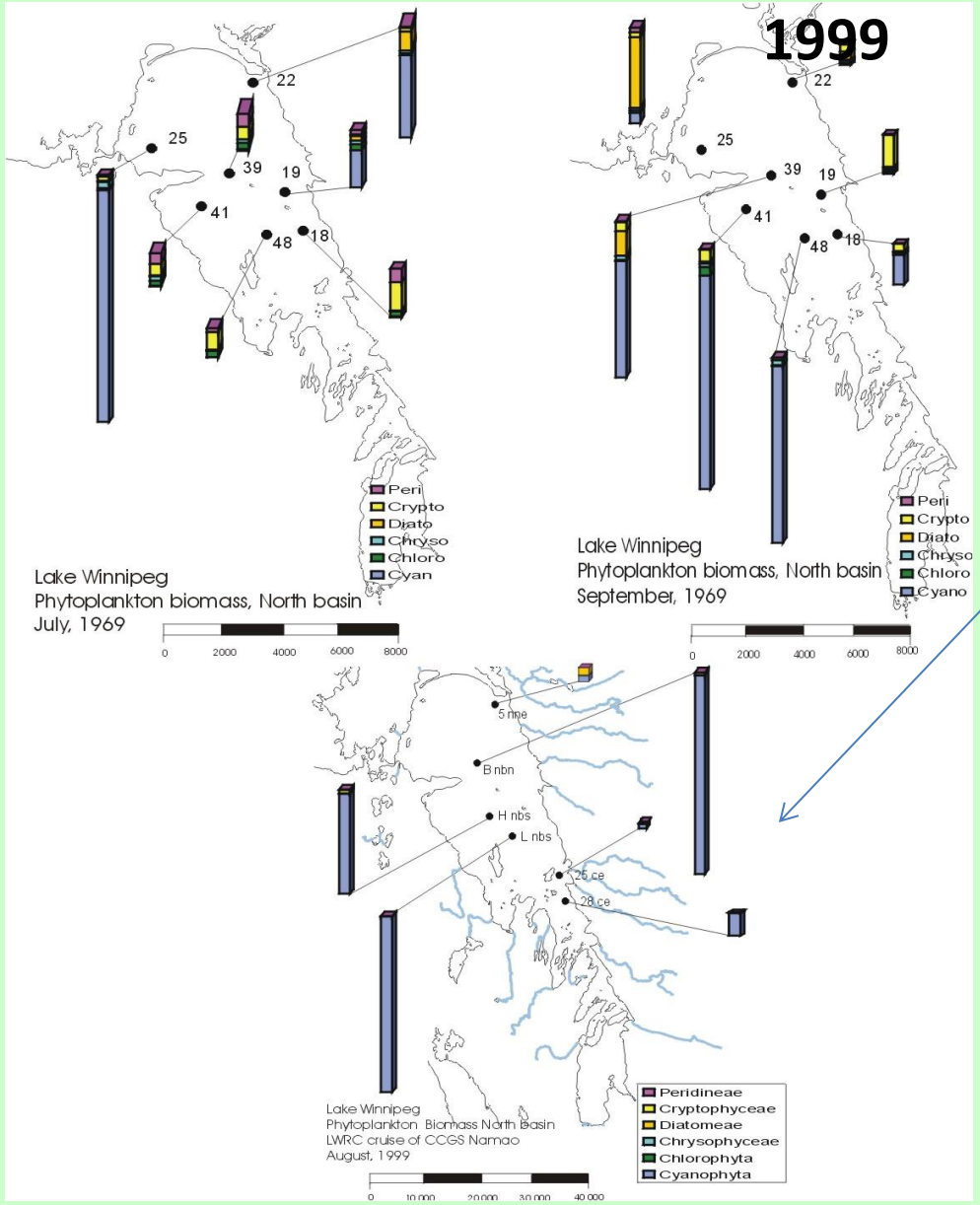
Maximum biomass was 10000ug/L 1969



mesotrophic

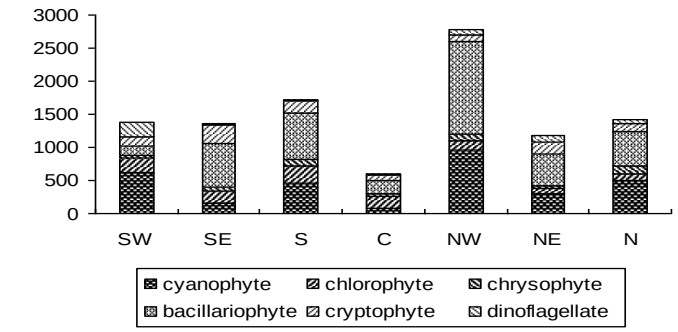
oligotrophic

Phytoplankton spatial distribution in Lake Winnipeg North Basin **August 1969, 1994 and 1999**

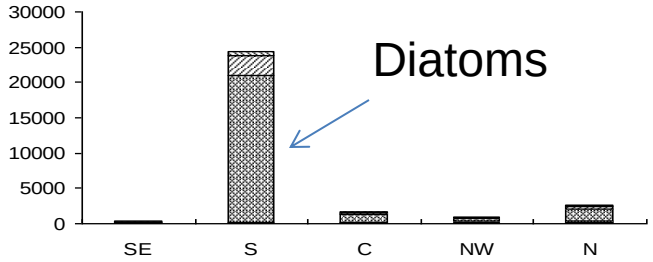


- **General decrease in algal diveristy with increased bluegreen dominance.**
- **Scale change 1969 (8000ug/L maximum biomass)**
- **1999 (40000ug/L)**
- **note scale change in bottom graph**

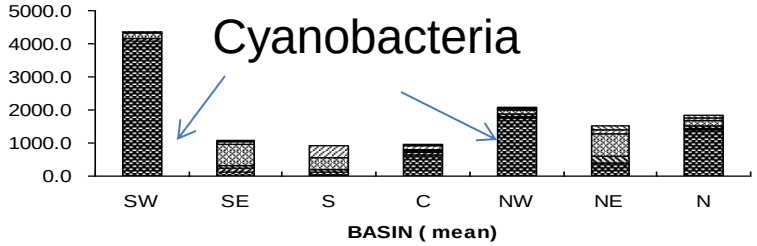
Lake Winnipeg August (basin means) 1969, 1992, 1994



L. Winnipeg 1992

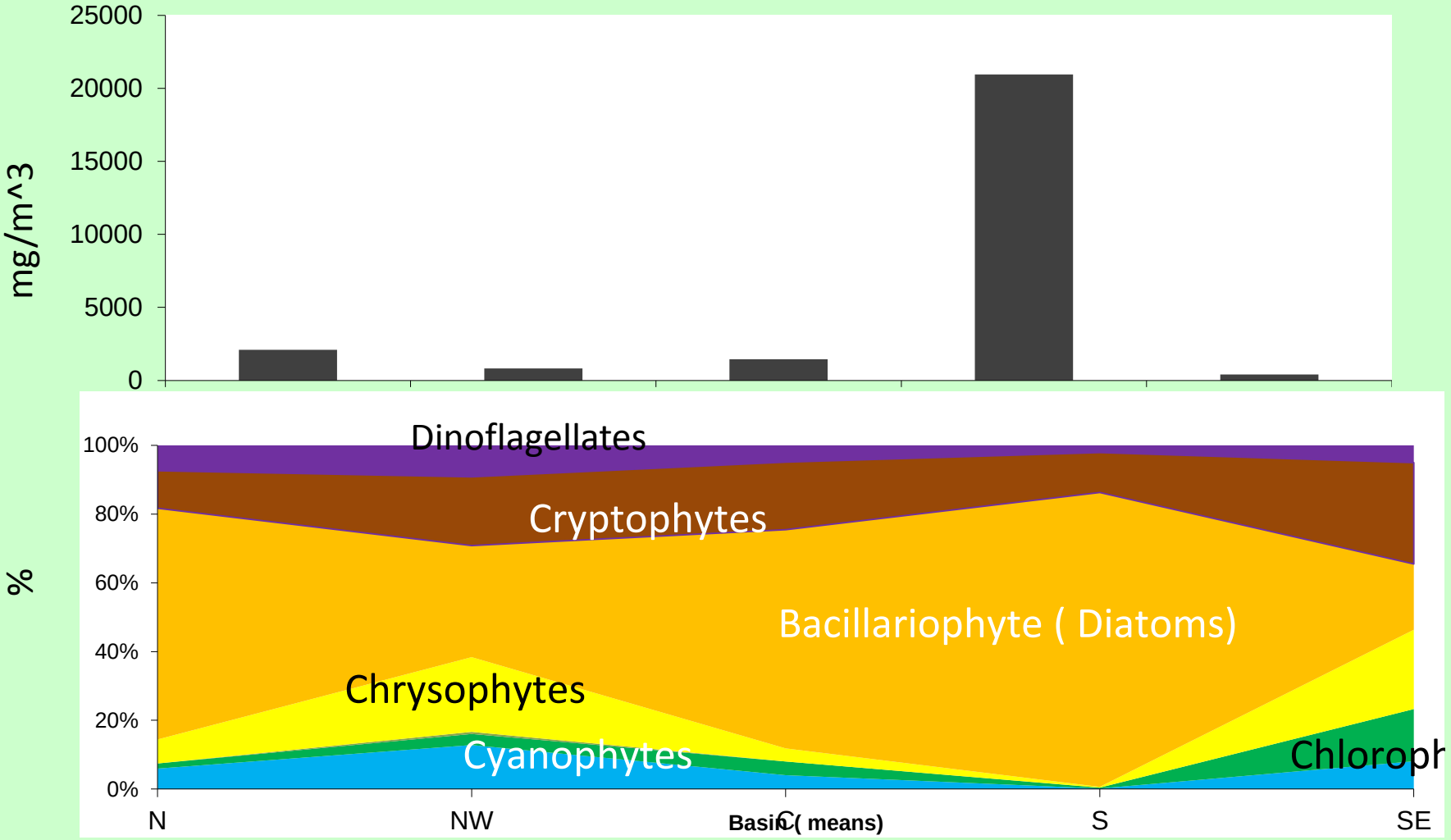


Lake Winnipeg 1994
August

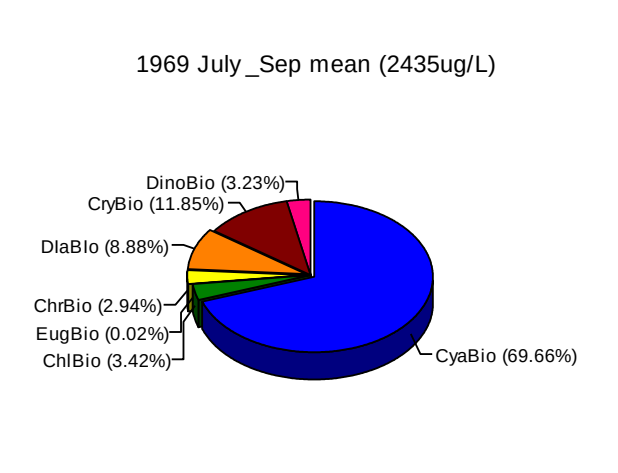


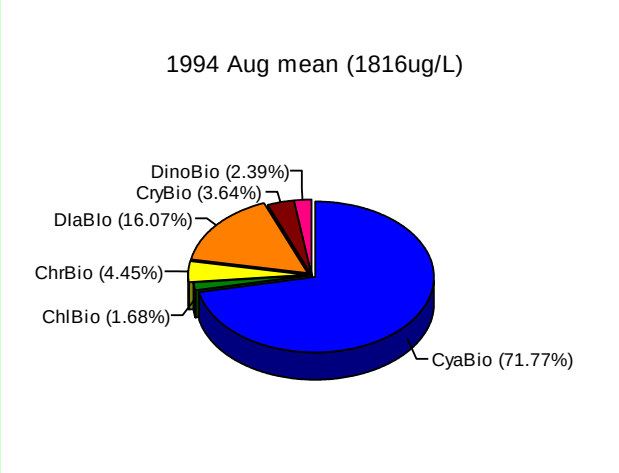
SW- south west
SE-south east
S-south
C- narrows
NW- north west
NE-north east
N –North

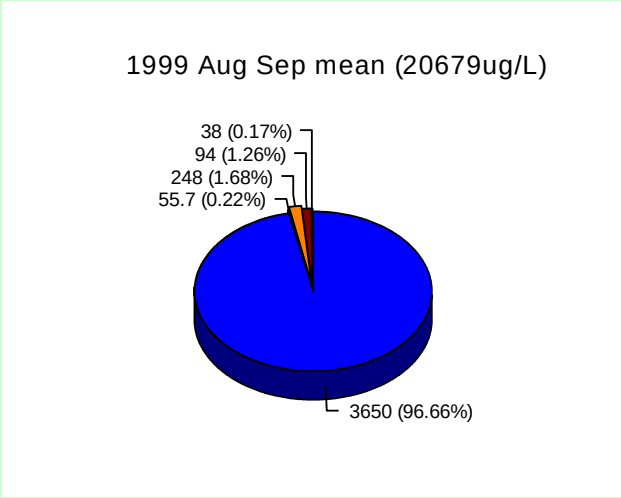
Lake Winnipeg Phytoplankton Basin Average1992



Changes in August September algal composition in the North Basin of Lake Winnipeg 1969, 1994 and 1999





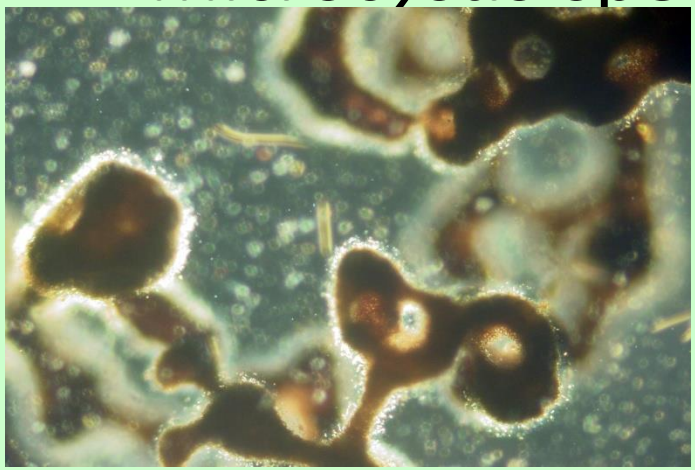


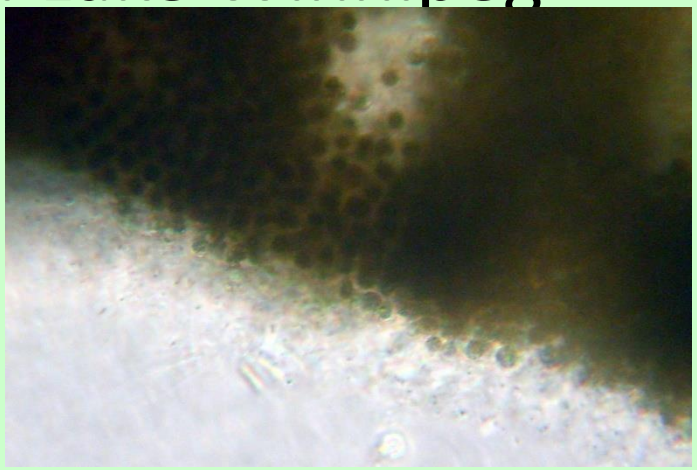
Bluegreen bloom extended ~100 mile over the North Basin of L Winnipeg in 1999

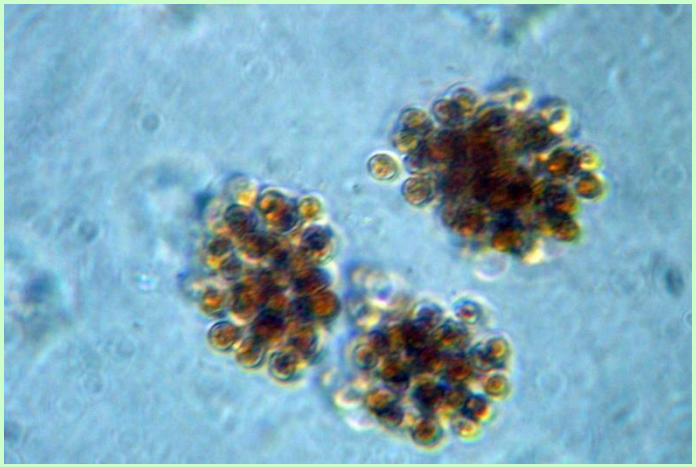
Aphanizomenon in the boat wake

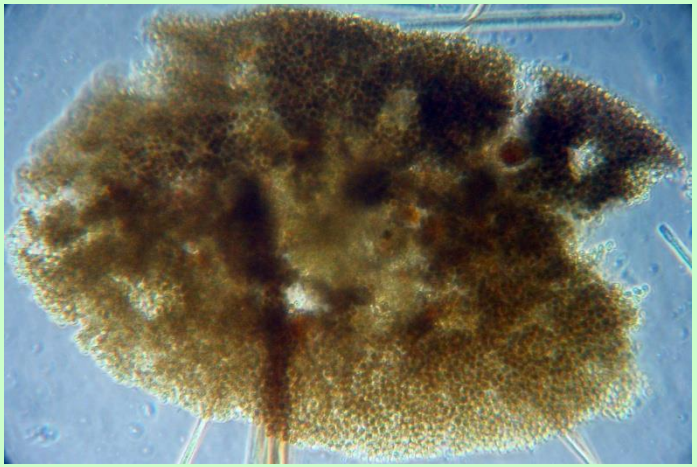
North basin Aphanizomenon bloom

Colony and cell structure of common *Microcystis* species in Lake Winnipeg



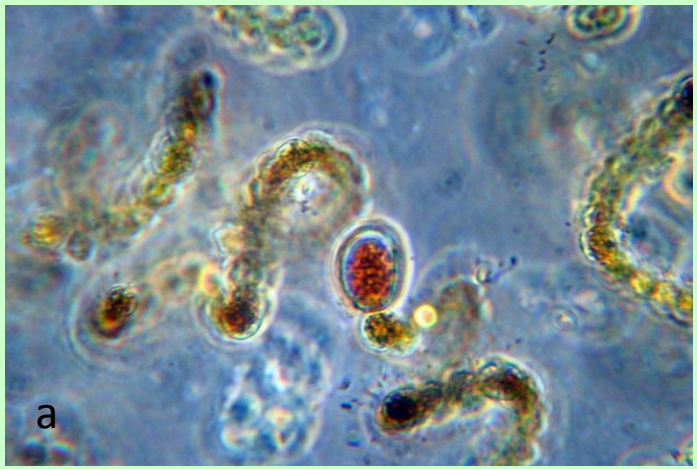


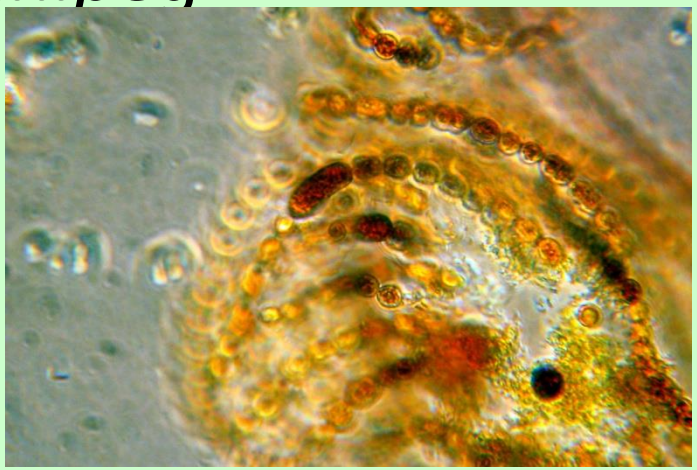


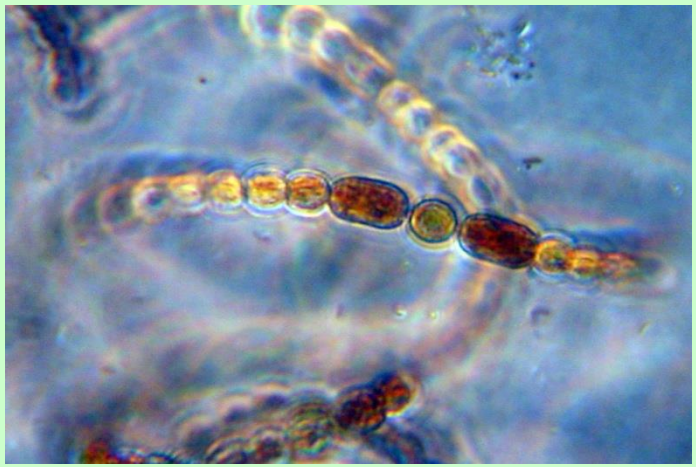


Upper left right, lower left right: *Microcystis botrys*, blowup of *M. botrys* showing the mucilage strands, *Microcystis novacecki* *Microcystis flos aquae* colony slightly squashed

Colony and cell structure of *Anabaena species in Lake Winnipeg*

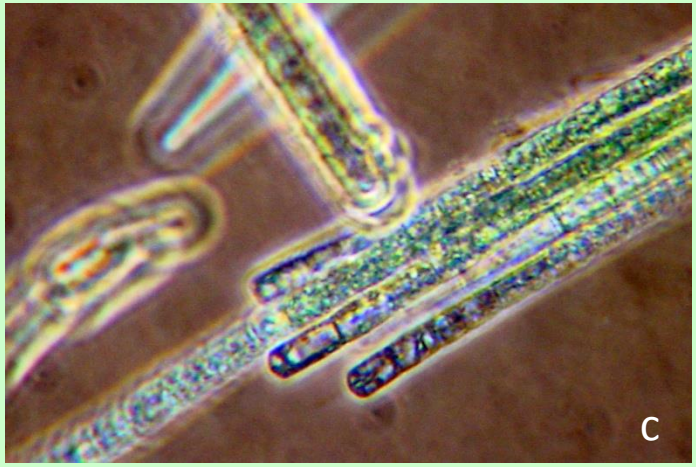


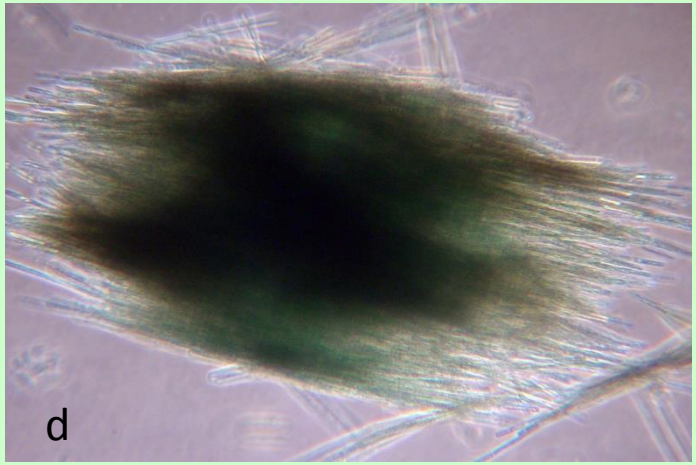




Left to right top to bottom *Anabaena spiroides, Anabaena flos aquae, Anabaena lemmermannii , Anabaena crassa*

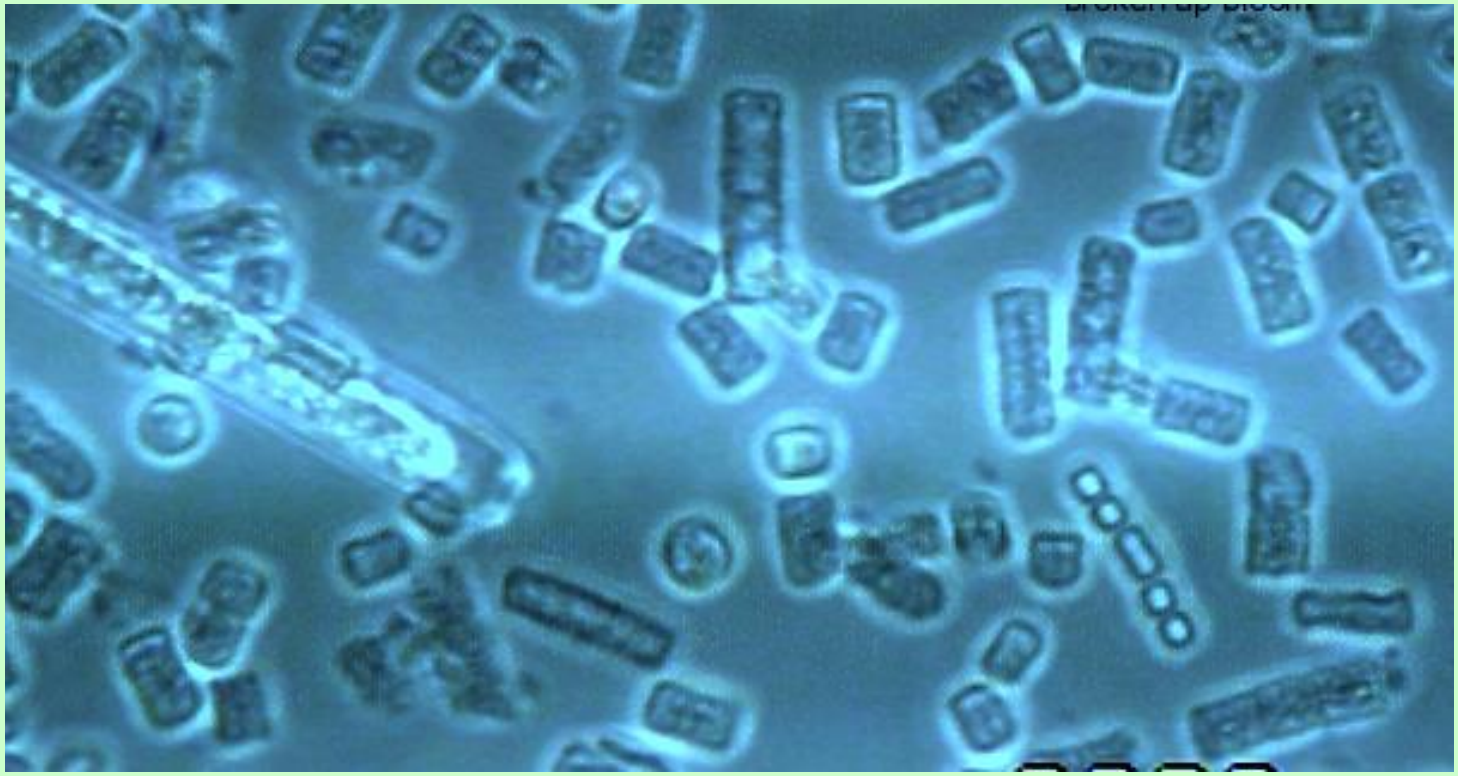
Surfaces blooms of Cyanobacteria or Bluegreen algae and colonial and cell structure of *Aphanizomenon flos aquae Complex*



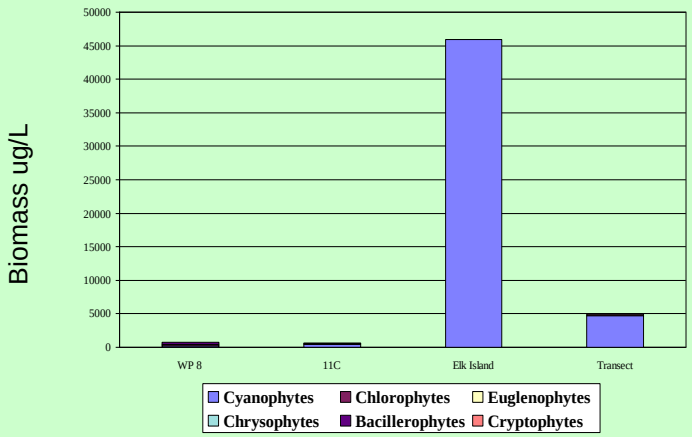


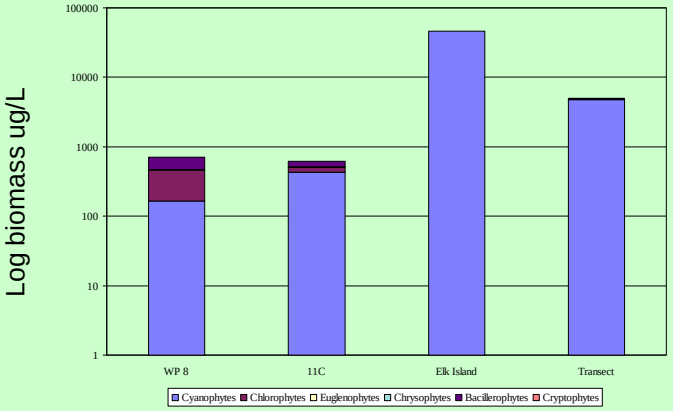
Upper left to Right: *Aphanizomenon flos aquae* b) Surface scum in the north basin,
c) End cell structure of flake of *A. klebahnii* d) Eco morph of *Aphanizomenon flos aquae* complex similar to *A. yesoense*

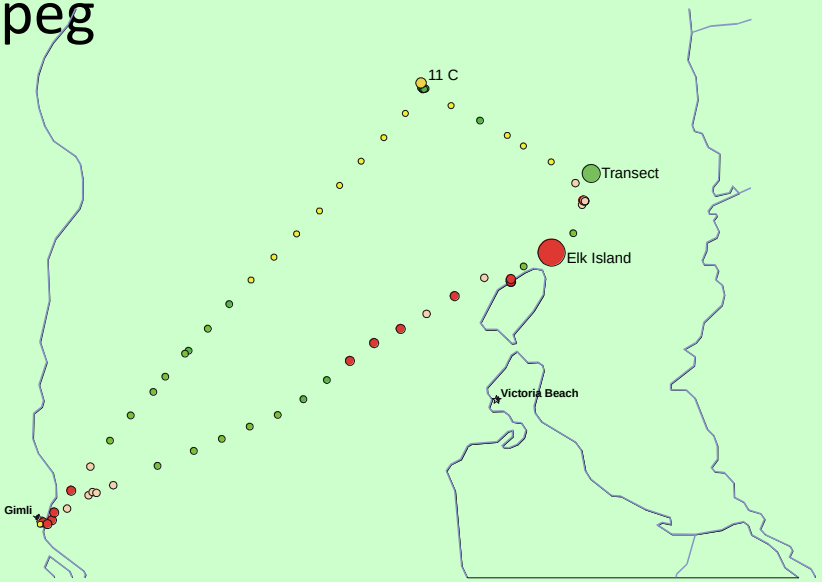
Decomposing *Aphanizomenon* bloom: fragments, single cells
and free akinetes
Microcystins measured were in excess of 1200ug/L

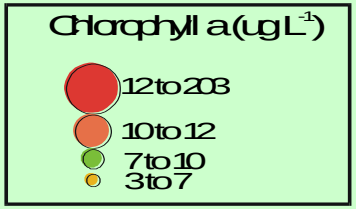


Algal Biomass and Chlorophyll a on 26 Sept 01, between Gimili & Elk Island South Basin Lake Winnipeg









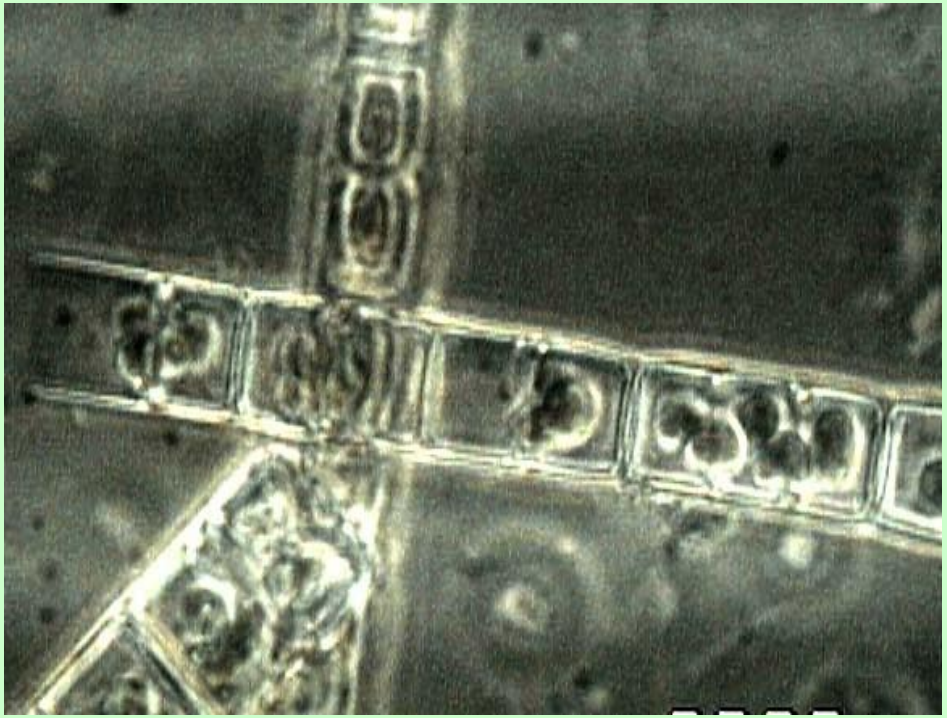
Microcystin >2000ug/L at site of maximum biomass by Boyer's Lab in Syracus New York

Winter Algal Blooms

Aulacoseira icelandica

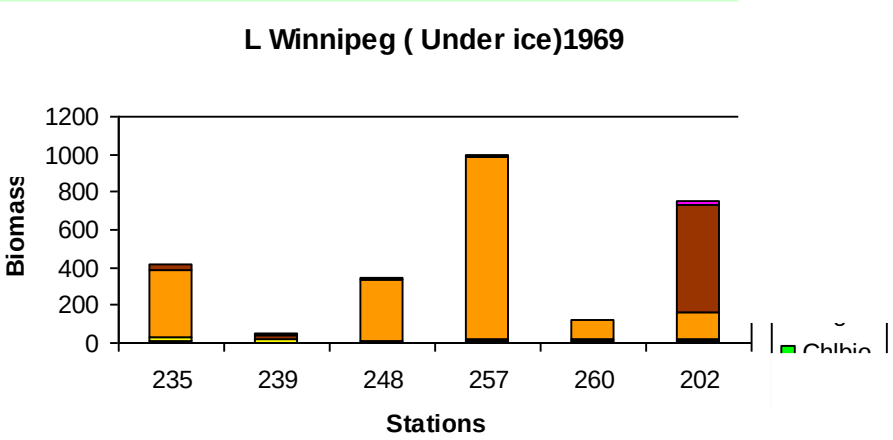
Diatom (algae) which forms blooms under ice and can coat fishing nets

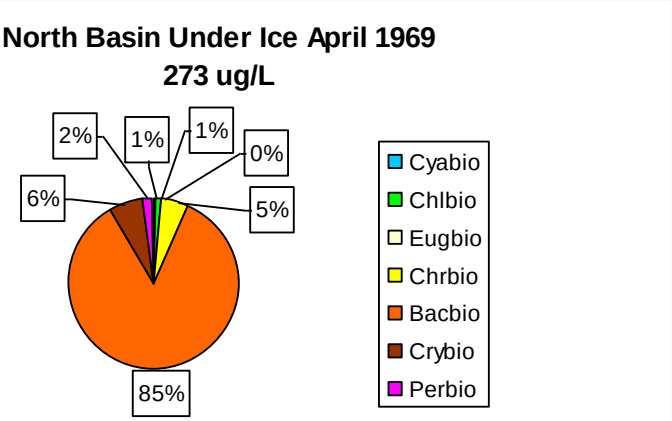
Aulacoseira coating a net

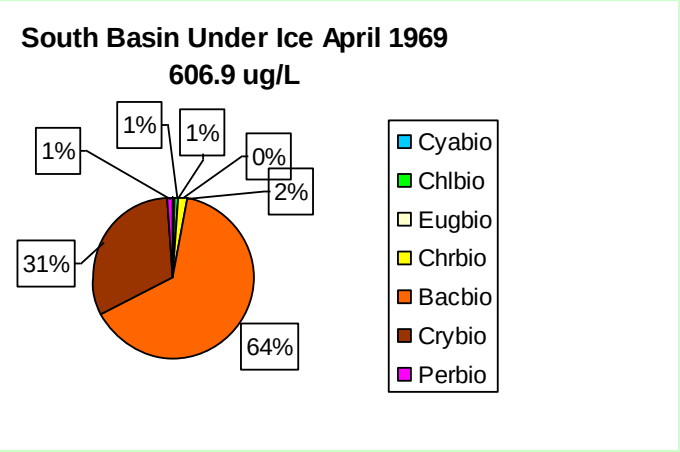


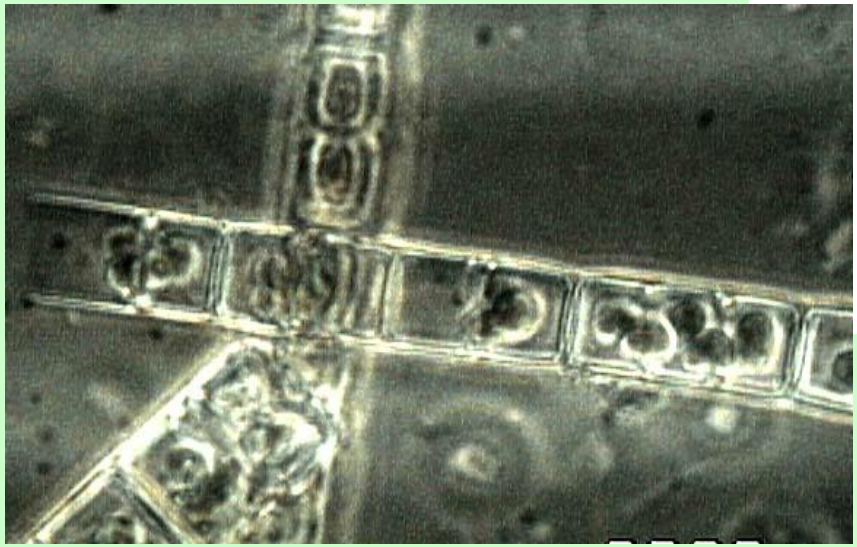
Aulacoseira under the microsco

Lake Winnipeg Under Ice

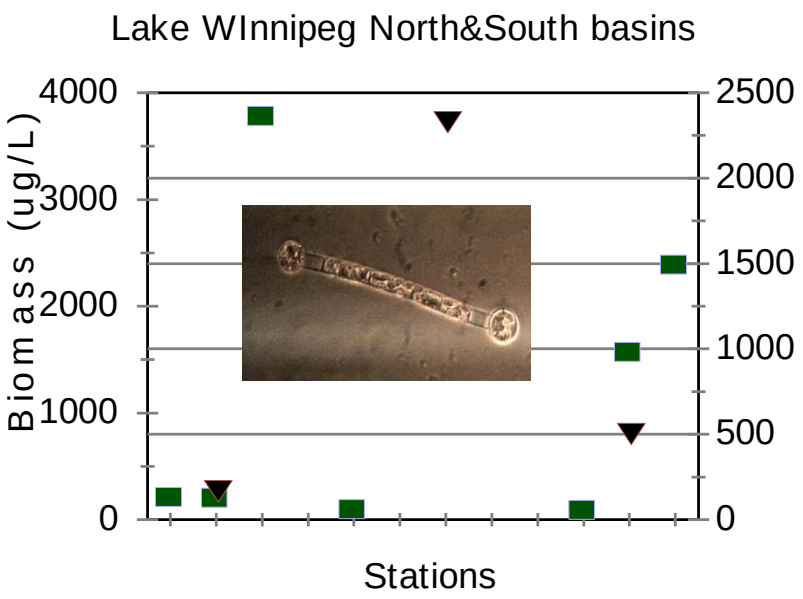


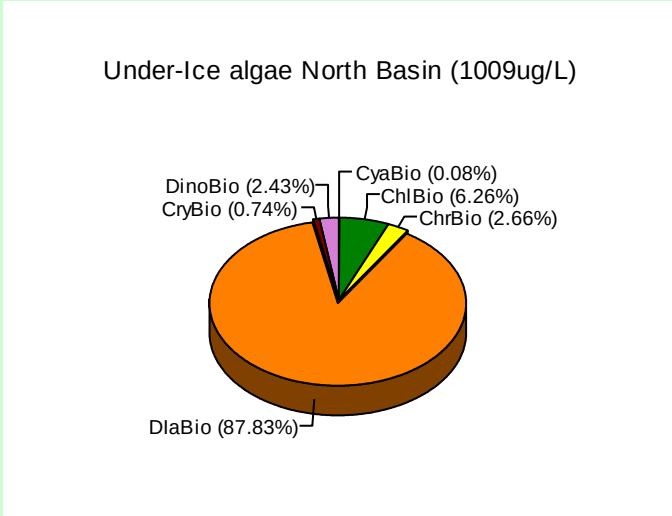


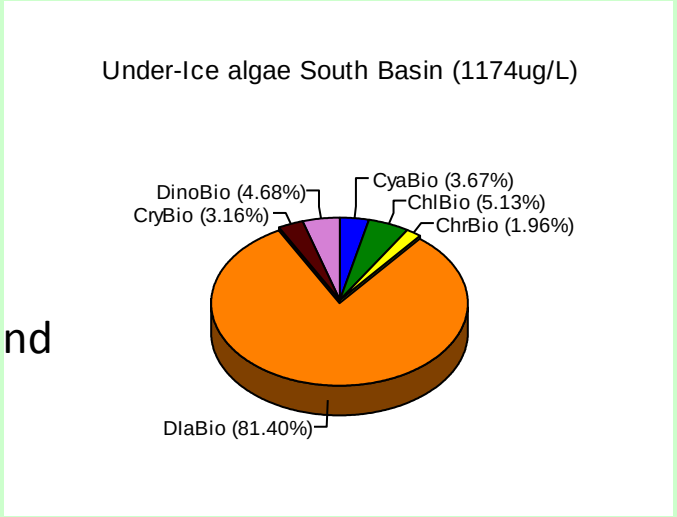




Under Ice April 2002



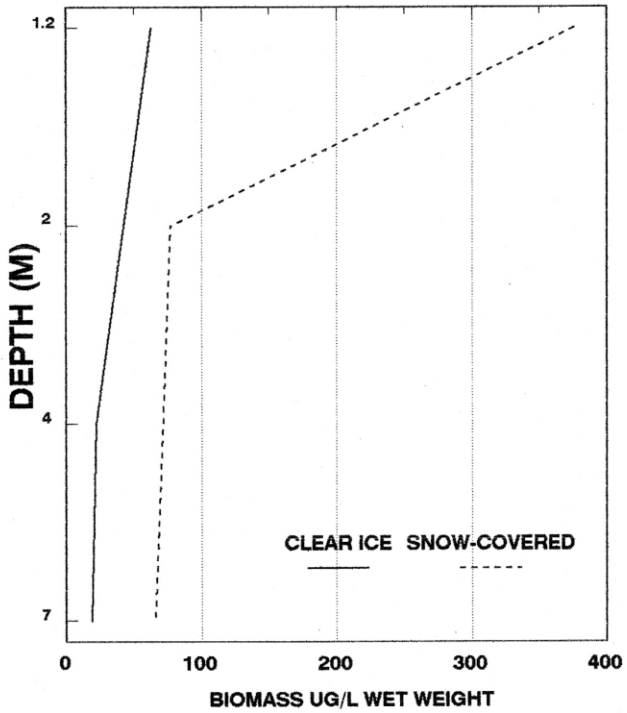




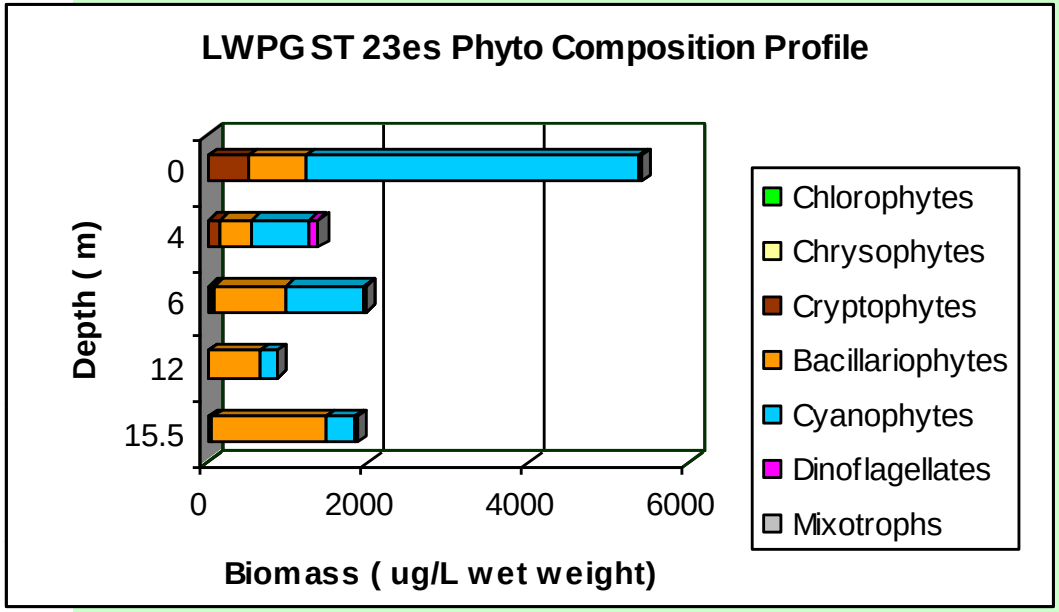
- In 2002 phytoplankton mean biomass and composition were very similar in both North and South Basin.
- Maximum higher in the south basin.
- **Blue-green fragments (bottom re-suspension) were present in samples from the south basin.**

Winter profile & Summer profile

Winter Depth profile of *A. islandica* under ice in **March 1994** off Gimli



Summer depth profile

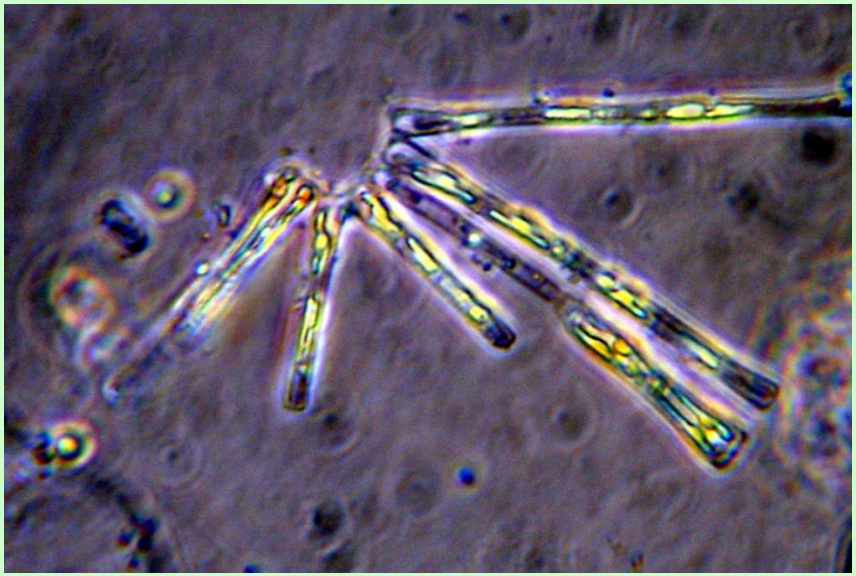


- Under cloudy ice the *Aulacoseira* concentration is very near the under surface of the ice where as under clear ice the filaments are distributed more evenly in the water column.
- Actively dividing with filaments 2mm (very long)
- Lipids present in cells
- Cell silica walls thin (1/10 the thickness of the open water season.)
- **The extreme thinness of the cell wall, lipid accumulation and water column viscosity helps them maintain their position in the water column with out a lot of turbulence.**

statification - living diatoms at the bottom and blue-greens dominating at the surface.

Chla was highest at 15 meters

Under ice algal blooms and Si limitation

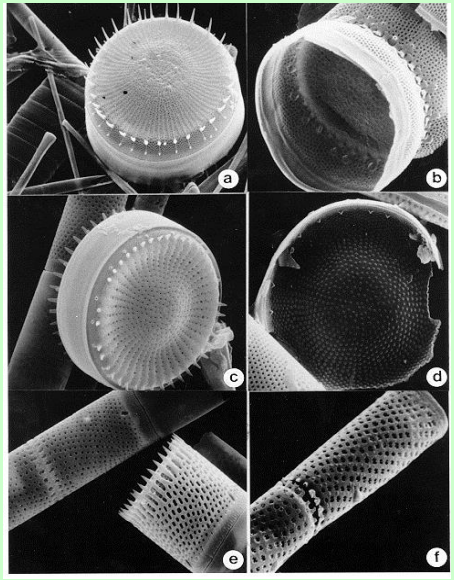


- Under ice algal blooms can lead to open water silica limitation in years with low snow and little spring precipitation. Silica limitation can be seen in species such as *Asterionella formosa*
- Rapid size reduction in *Asterionella* is an effect of Si limitation under increased phosphorus(Kling 1993, Gensemer 1996) and a good morphological indicator of this situation.
- Optimum stoicheometry was found to be 16:1:17 for N, P and Si and that lowering of SrSi in summer lead to decreased diatoms and increased Cyanobacteria in Austrian Lakes. (Treubner& Dokulil 2002)

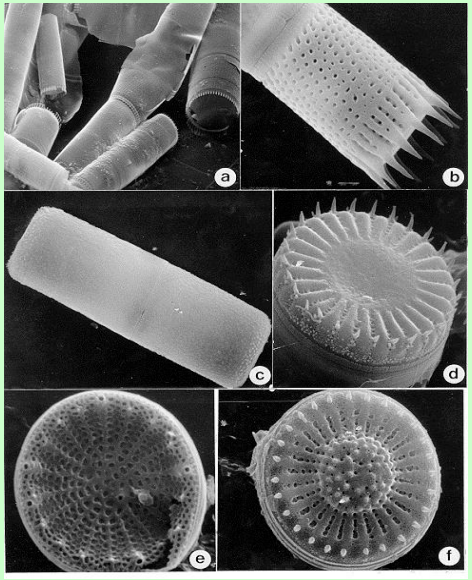
Low silica (srsi) in Summer / Fall 2003
Diatoms infected with chitrids
Si limitation?

- At several north basin stations in September 2003 the chitrid *Rhizophyduim simplex* (Dang.) Fischer were observed on ***A. ambigua*** **with up to 50% of the cells infected.**
- *Stephanodisus niagarae* **infected to a lesser extent by an species of chitrid.**

Dominant Centric Diatoms in LWPG



1



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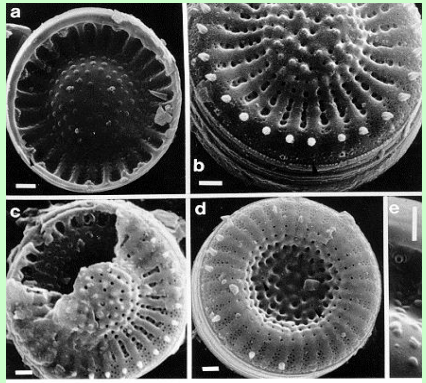


3

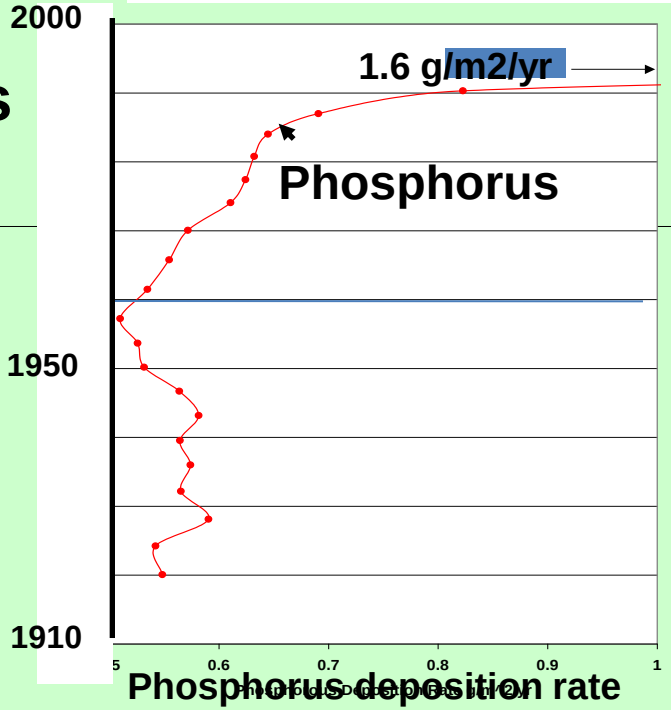
Possible invaders
S. binderanus
S. agassizensis,
C. dubius

- Centric diatoms are common in the spring, fall and under ice diatom blooms in Lake Winnipeg.
- 1a)*Stephanodiscus niagarae*, b)*S. binderanus*, c,d)*S. agassizensis*, e,f)*Aulacoseira ambigua, A. granulata*
- 2 a) *Aulacoseira islandica*(dominant under ice in late winter), *A. subarctica, Melosira varians, Cyclotella meneghiniana, Stephanodiscus parvus, Cyclostephanos dubius*.
- 3a-d) *Cyclostephanos dubius* only recently common in Lake Winnipeg but very common upstream in Lake of the Woods.

Chemical changes

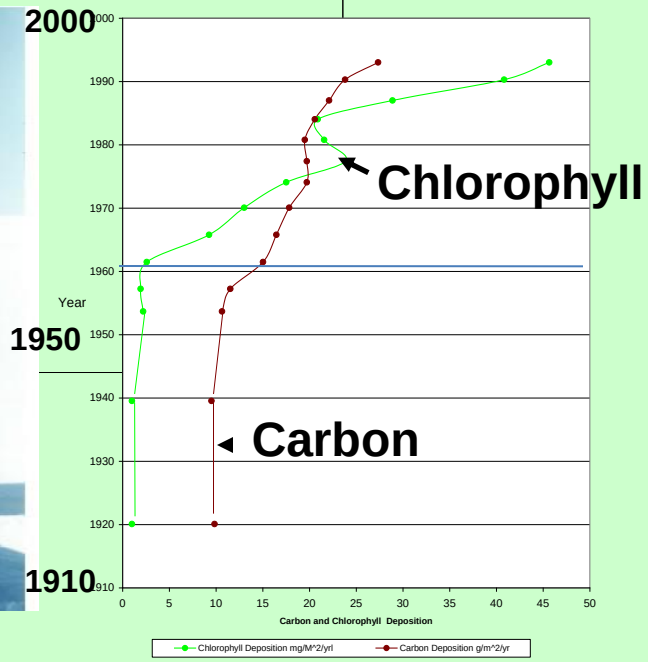
Increasing Phosphorus, Chlorophyll-a, and Carbon deposition rate in the north basin of Lake Winnipeg

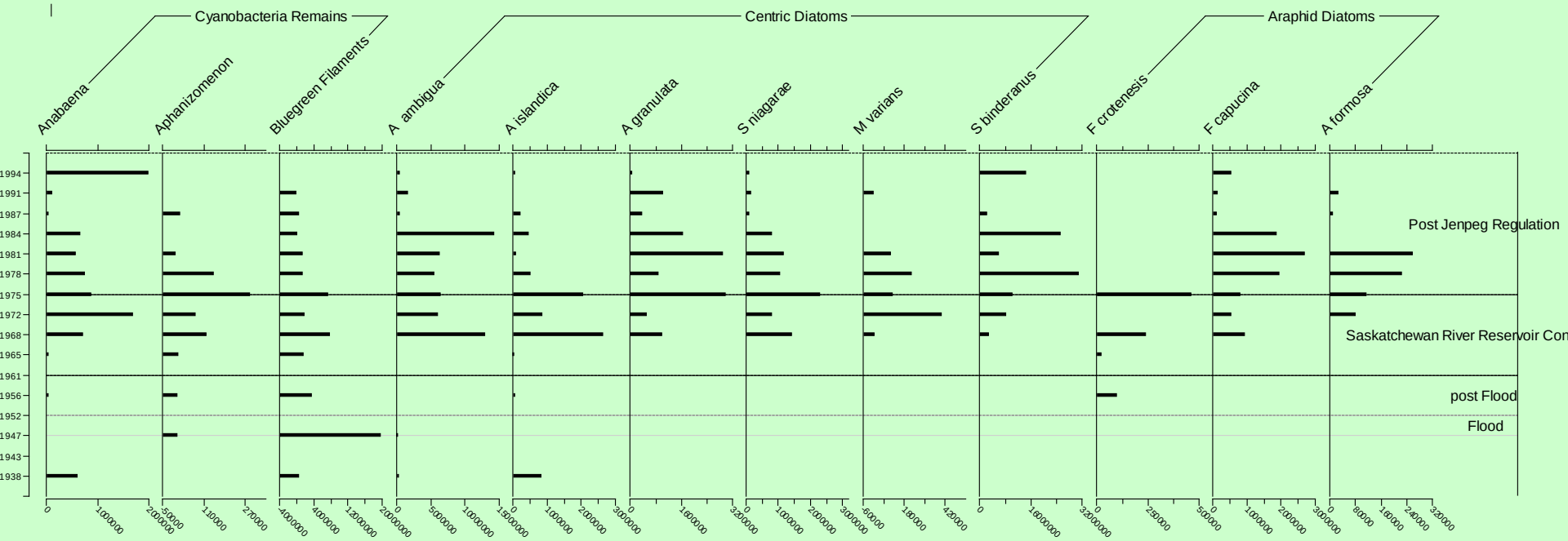
History of past 100 years recorded in sediment core



Phosphorus deposition rate

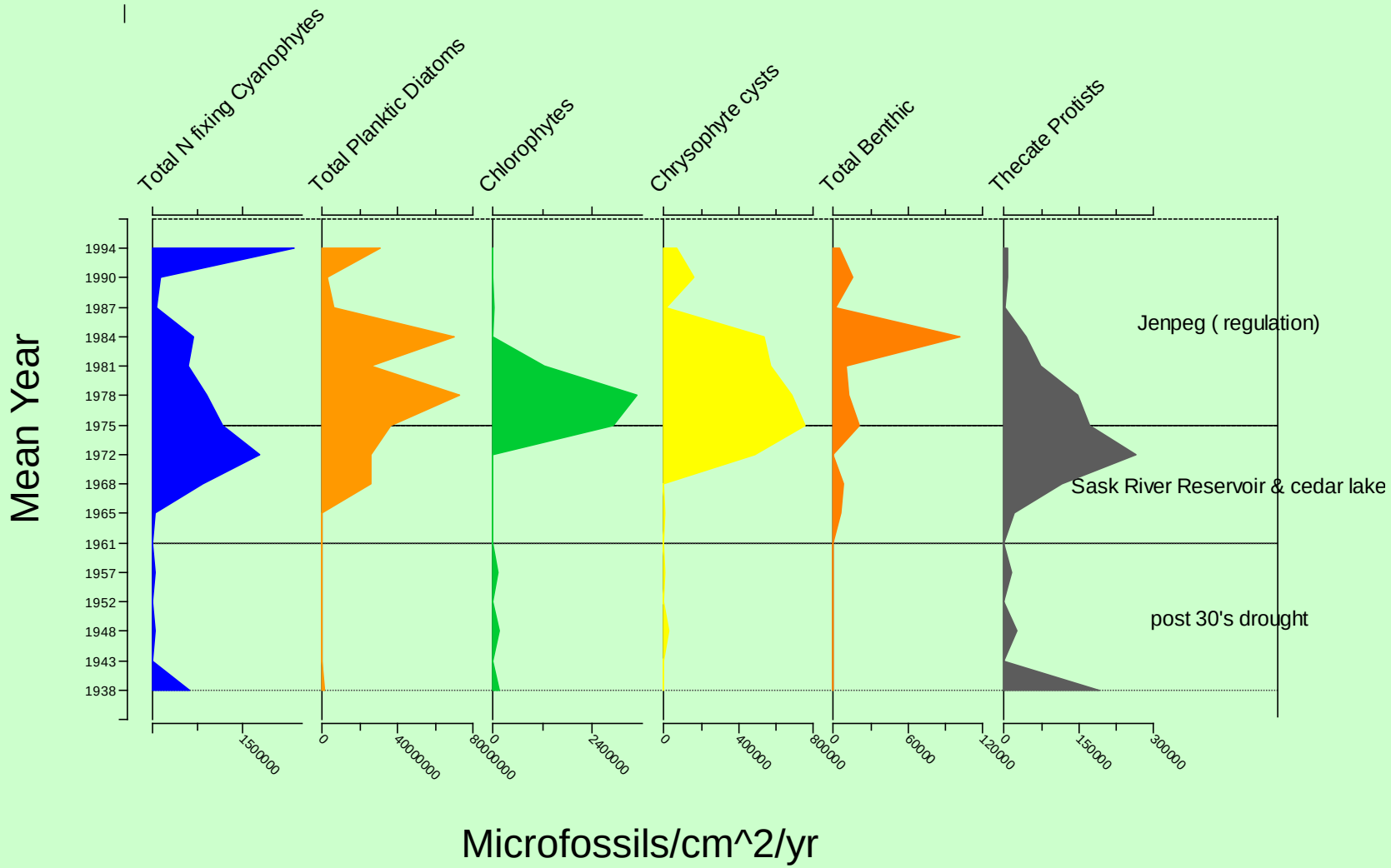
Lake Winnipeg North Basin



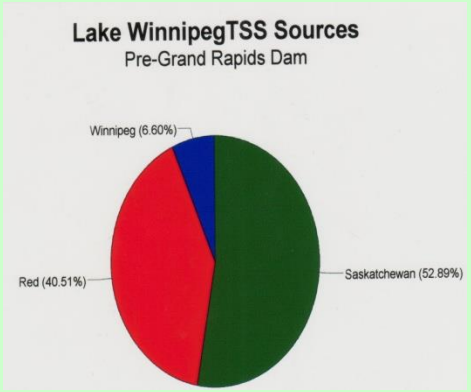

Cyanobacteria Remains
Centric Diatoms
Araphid Diatoms
Anabaena
Aphanizomenon
Bluegreen Filaments
A ambigua
A islandica
A granulata
S niagarae
M varians
S binderanus
F crotenesis
F capucina
A formosa
1994
1991
1987
1984
1981
1978
1975
1972
1968
1965
1961
1956
1952
1947
1943
1938
Post Jenpeg Regulation
Saskatchewan River Reservoir Con
post Flood
Flood
0
1000000
2000000
50000
110000
270000
400000
800000
1200000
2000000
0
5000000
10000000
15000000
0
1000000
2000000
3000000
0
1800000
3200000
0
1000000
2000000
3000000
60000
180000
420000
0
18000000
32000000
0
250000
500000
0
1000000
2000000
3000000
0
80000
160000
240000
320000

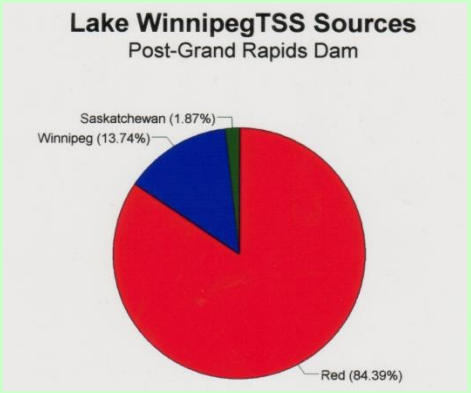
North basin 1994 core

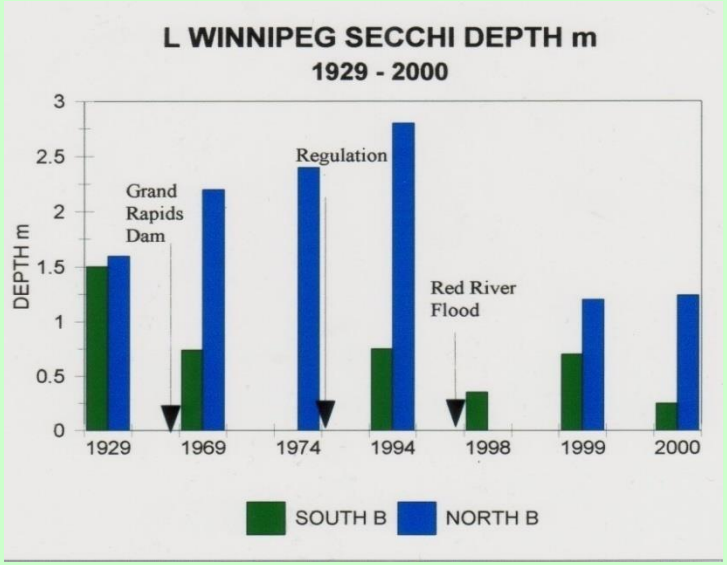
Microfossil Summary



Decrease in Suspended Solids Results in Increase Transparency in the North Basin

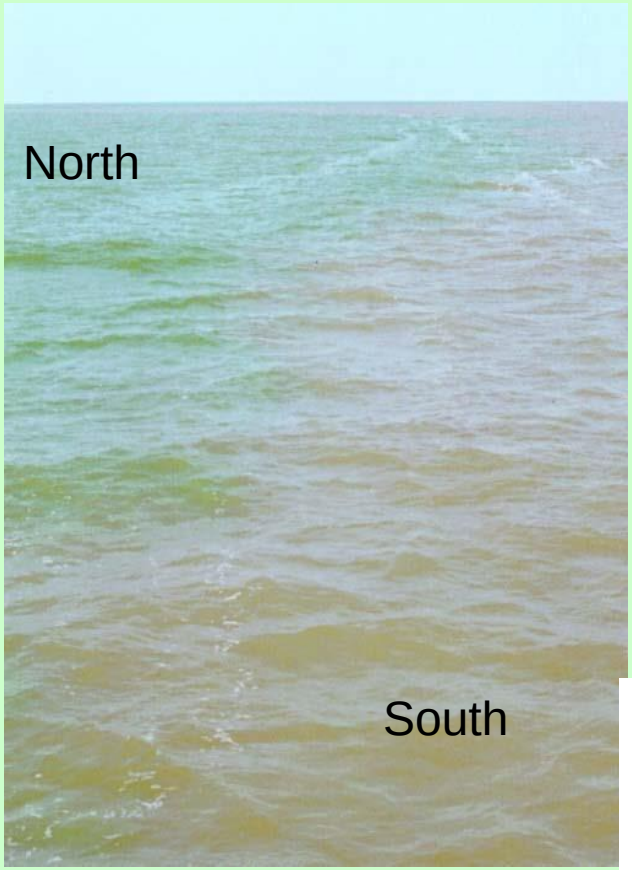






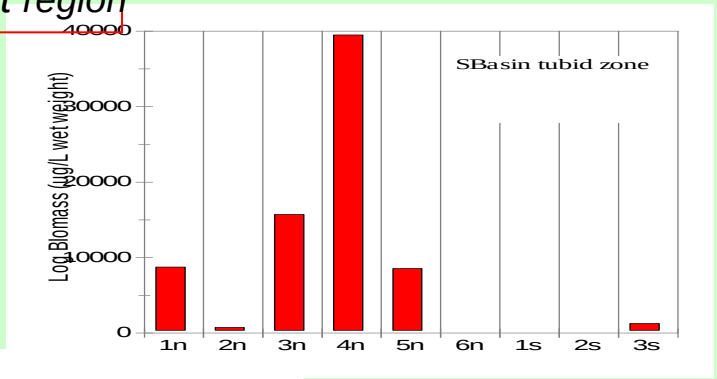
- Suspended solids entering the north basin of Lake Winnipeg decreased from 53 % to 2% of the total TSS after the installation of the Grand Rapids Dam
- A corresponding increase can be seen in the increase in transparency shown by the increase in secchi disk readings to 1996
- Secchi reading decreased in both basins following the Red River flood of 1997

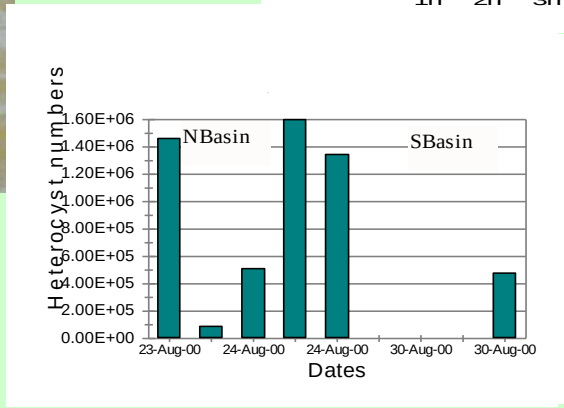
Transition Between Turbid South Basin and Clearer Water in the North Basin 2000

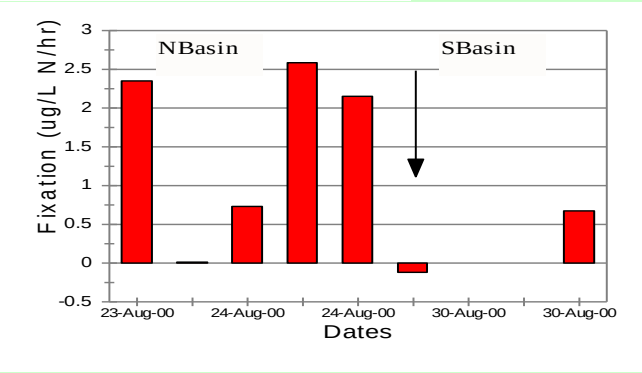


- Light limited situation in the turbid south basin inhibits phytoplankton production.
- Biomass, heterocysts, & N fixation increase in the less turbid areas

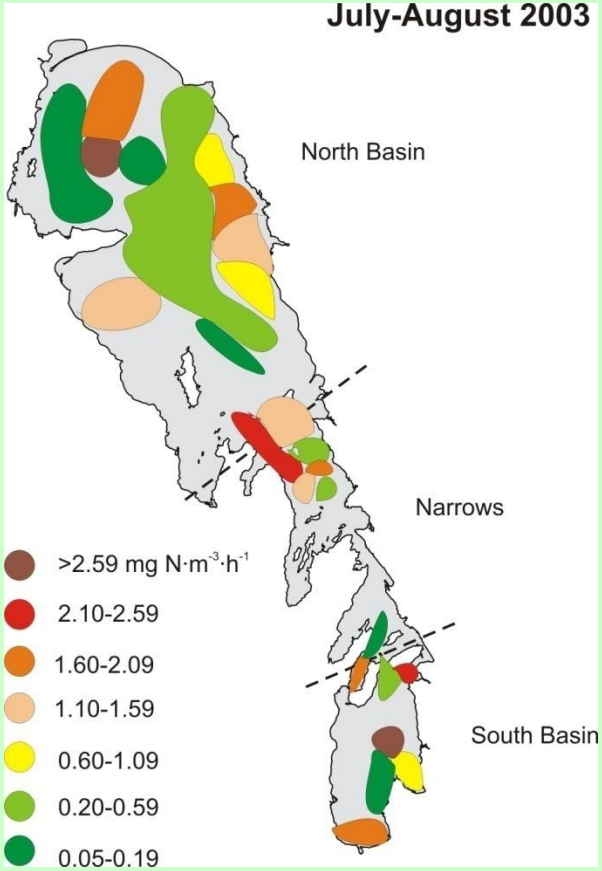
N-fixation in the transparent region

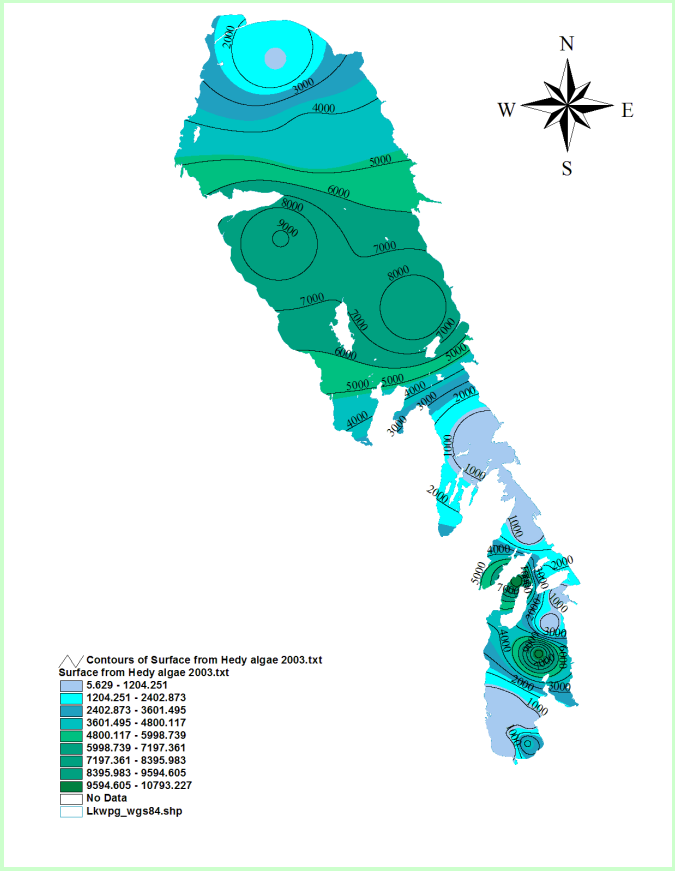




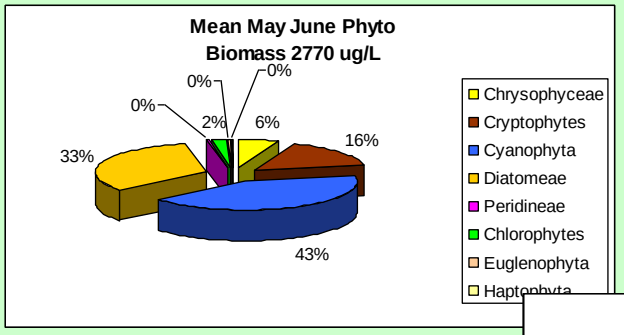


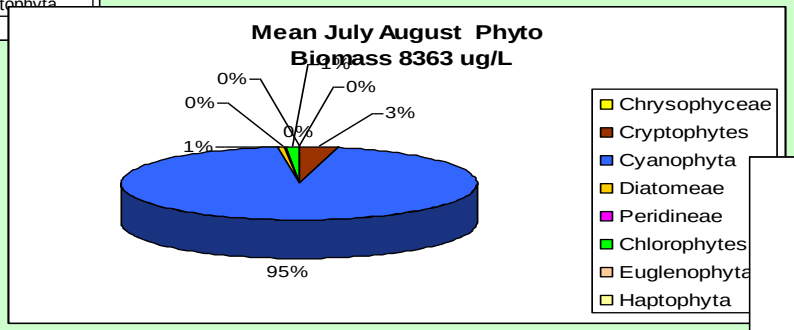
N Fixation and Cyanophyte biomass

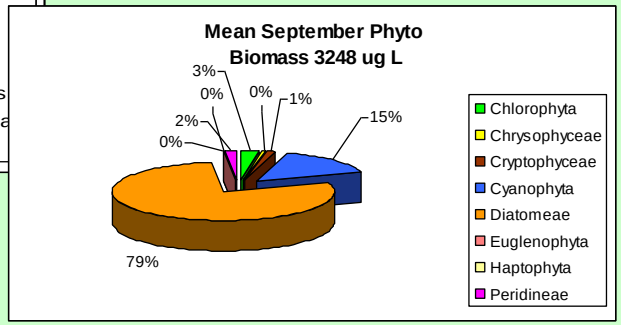




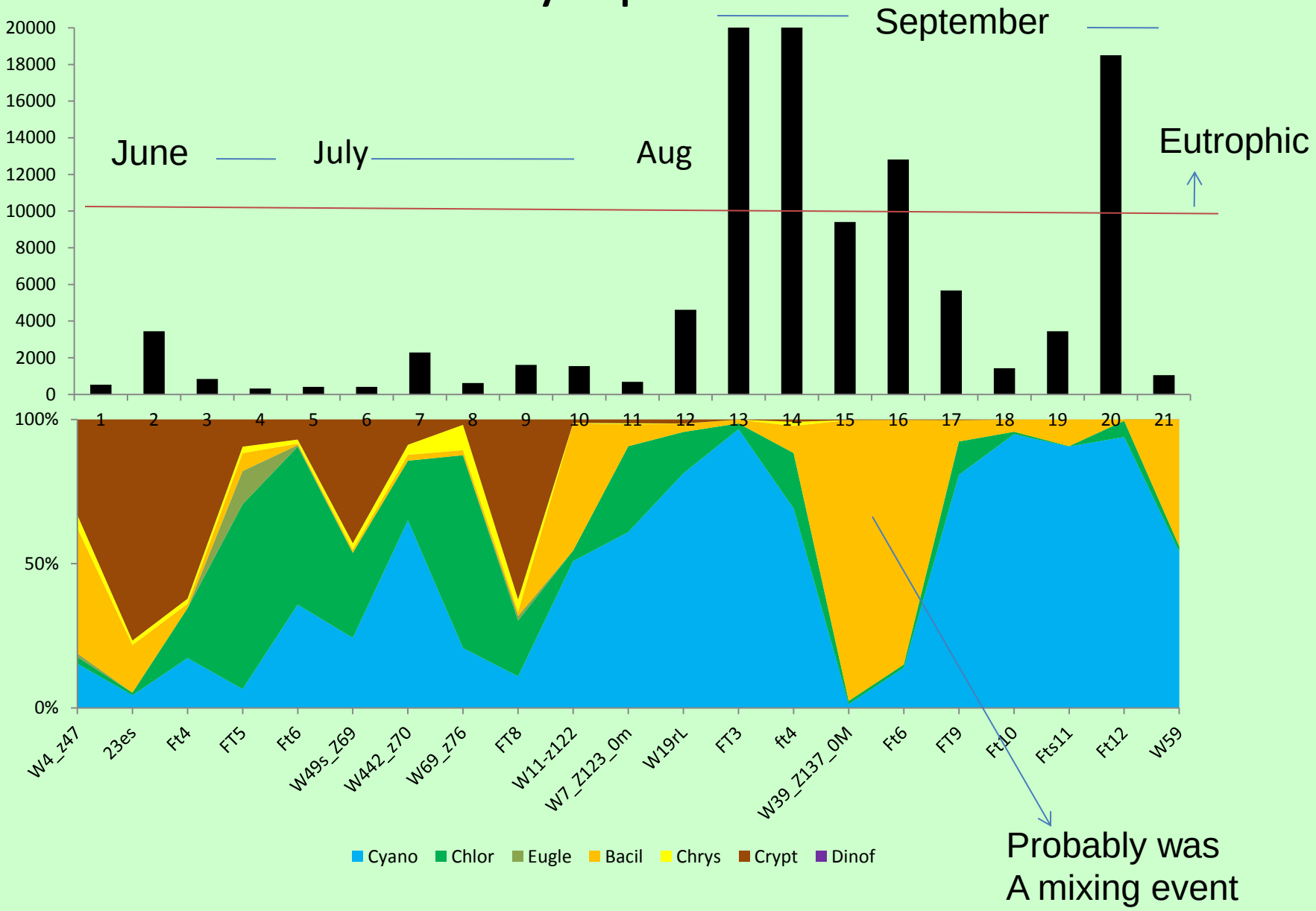
Lake Winnipeg 2003
Preliminary Summary of Spring, Summer & Fall Surveys
Average Biomass and Composition



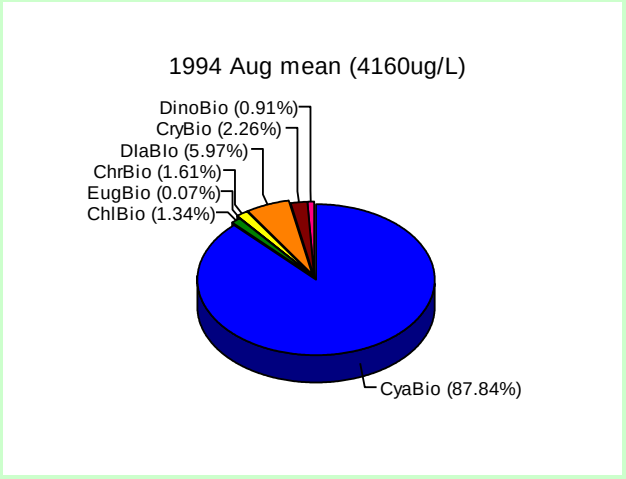


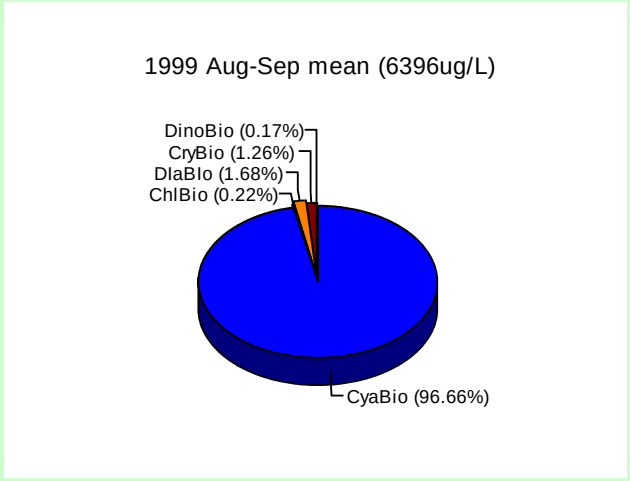


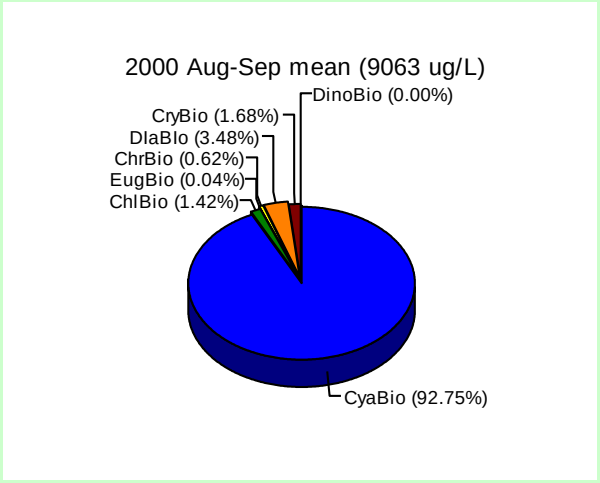
2007 Phytoplankton

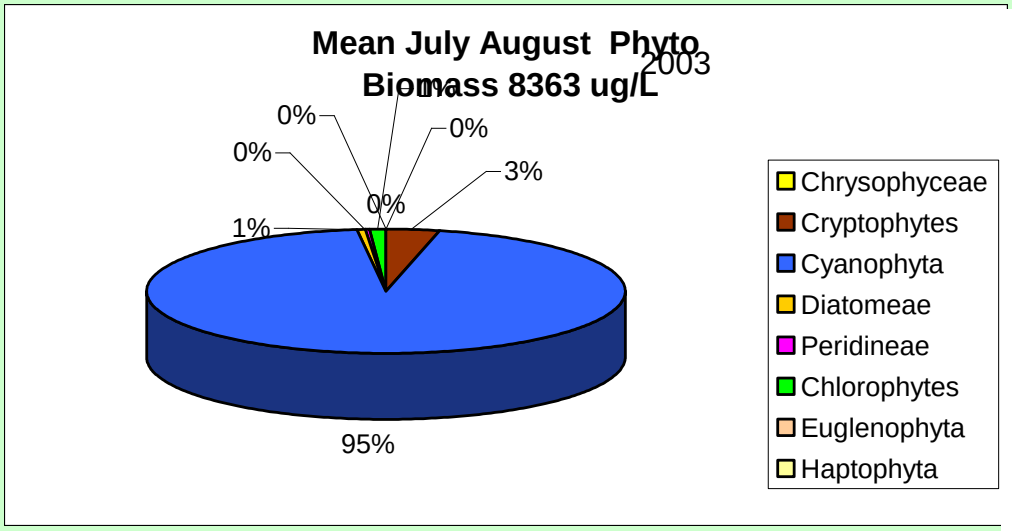


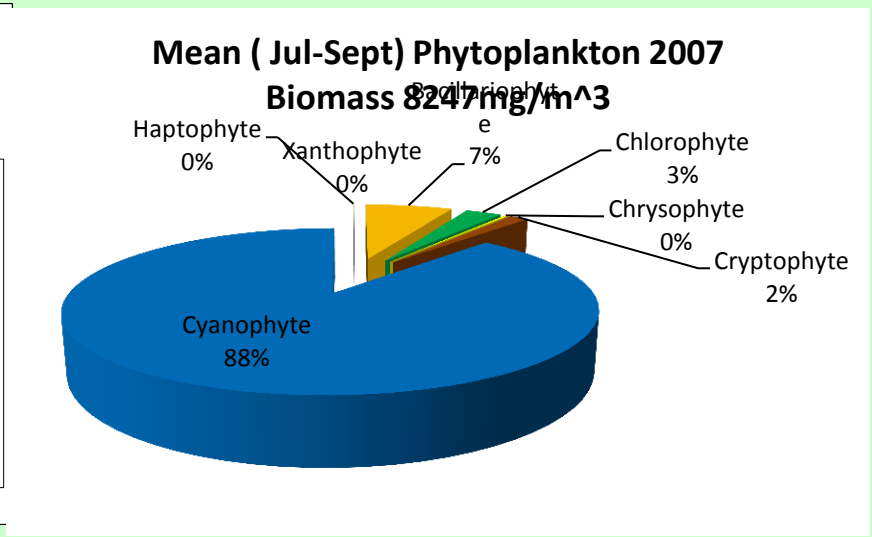
Summary of whole lake Spatial Phytoplankton Composition 1994, 1999, 2000, 2003











Observations

- Increased incidence of algal bloom formation
- Changes in algal composition
  - Species are disappearing
  - Previously rare species becoming dominant
- Shifted in dominance to increased frequency, duration and magnitude of nitrogen fixing toxin producing blue greens
- Incidents of anoxia may be increasing

(records 2003)

- Diatoms decreasing in diversity and duration