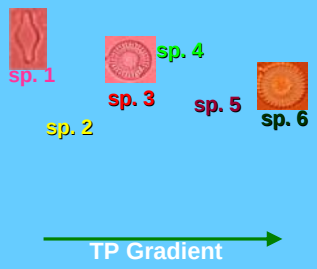
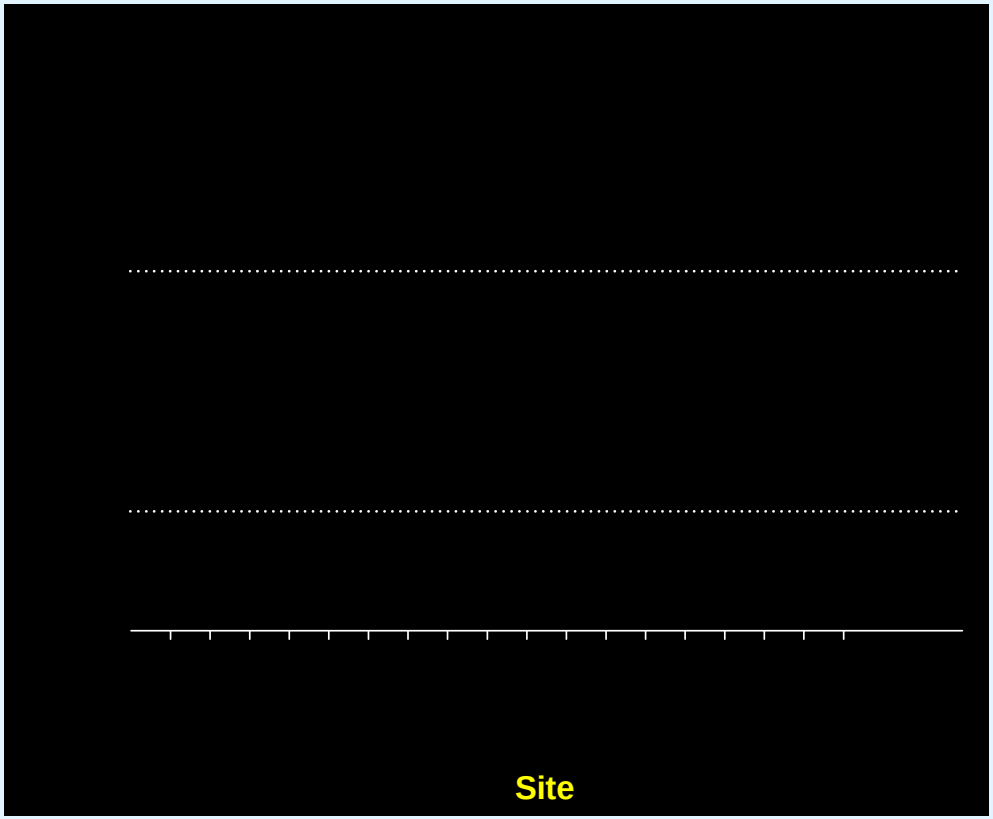
Assessing the implications of multiple stressors & recent diatom shifts in the Lake of the Woods, ON, Canada

Rühland, K.M.[1], Paterson, A.M.[2], Hargan, K.[3], Jenkin, A.[4]



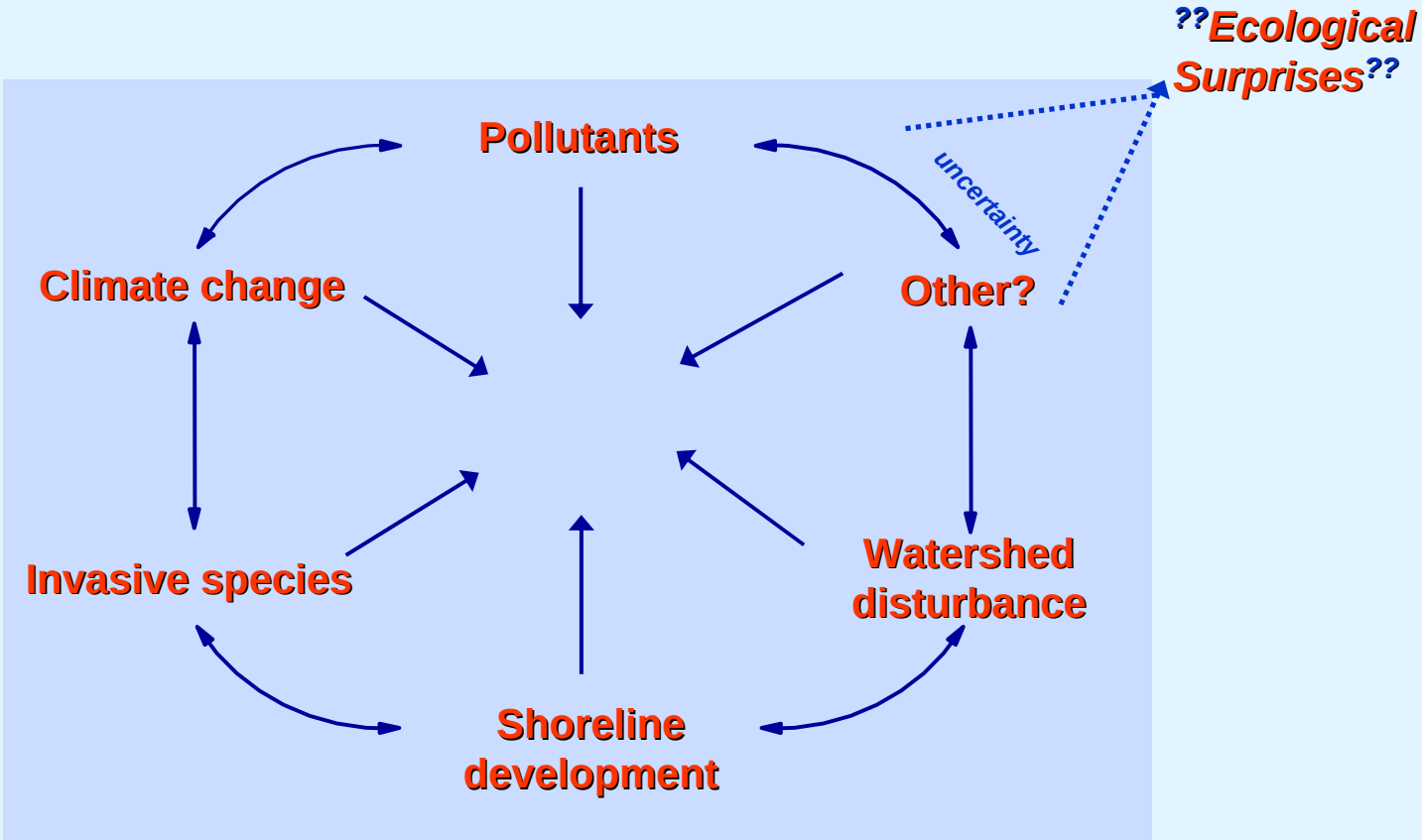
[1]PEARL, Queen's University, Kingston ON, Canada: [2]Ontario Ministry of the Environment, Dorset: [3]Trent University, Peterborough, ON, Canada: [4]Gartner Lee, BrGGG


Site

Multiple threats to water quality and ecology

"Novel combinations of ecosystem stressors may be resulting in novel community composition in aquatic systems…"

Quinlan et al. 2008 Can. J. Fish. Aquat. Sci. 65



"Climate change will affect lakes in very complex ways….future studies need to consider multiple stressor effects."

Keller 2007 Environ. Rev. 15

Development of an Algal Bloom - 2003

August 31st

July 18th

June 19th

(Terra MODIS images –
G. McCullough, U. of Winnipeg)

Some Important Lake Management Questions:

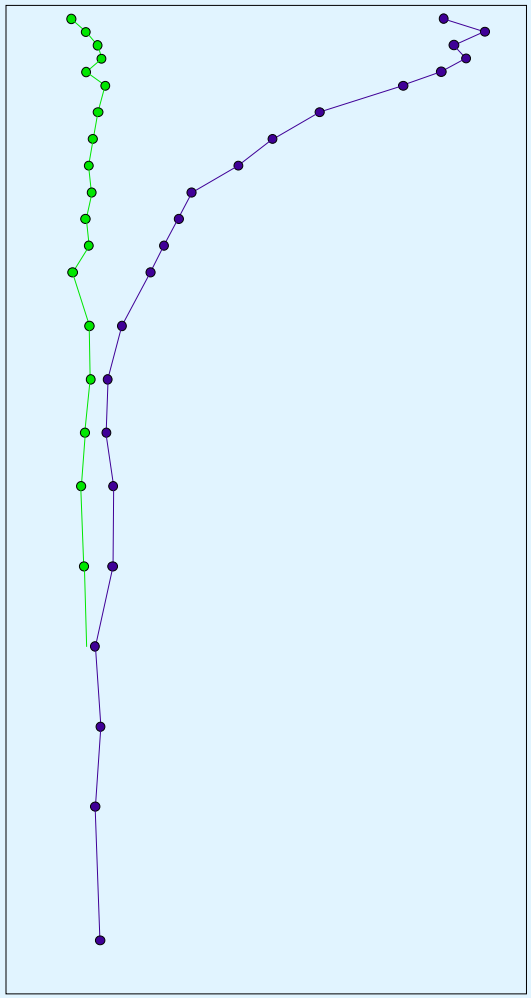
1) What is the ‘natural’ or baseline condition of the lake?

2) Has the water quality changed since pre-development (or pre-industrial) times?

3) If so, when did these changes occur?

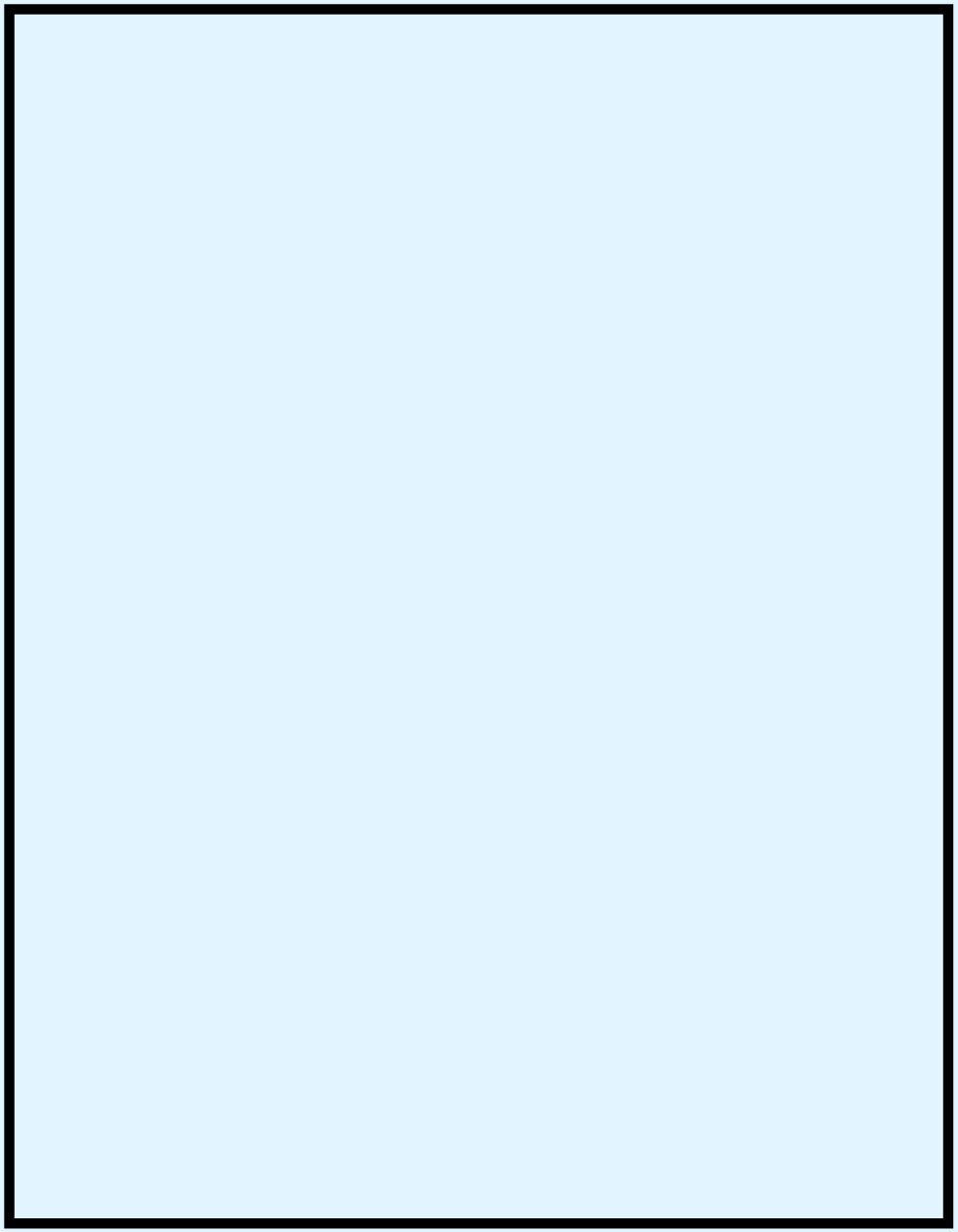
4) What is the direction and magnitude of this change?

5) What are the possible reasons for this change?



Dating the sedimentary sequences

- ^{210}Pb (radioisotope)

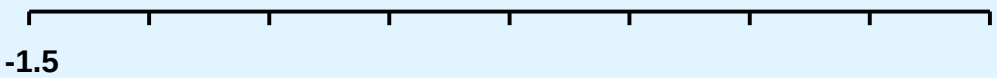


- **Exchange of diatom datasets requires taxonomic consistency**

- **Diatom workshop, August 2006**

Rühland et al. in prep.

Summary of Diatom Trends: trajectories through time



PCA axis 1 (λ_1 = 0.503) – SD units

Historical timeline

- **1887: Rollerway Dam built on western outlet to Winnipeg R.**
- **1892: Power plant constructed on eastern outlet for Kenora**

From DeSellas et al. SOBR

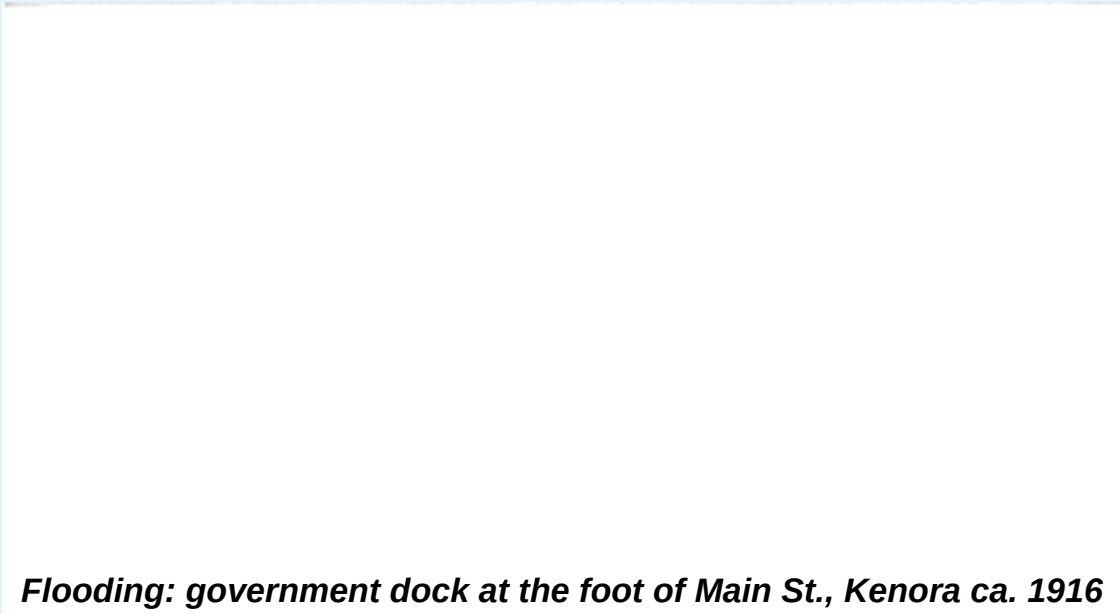
Early 1900s events: LoW water levels are highest on record

Historical timeline

- 1916: July water level of LOW highest on record
  - IJC recommended the expansion in the outflow capacity of the lake
  - benefits shown in 1950 when a flood containing 40% more water occurred but LOW was contained to a lower level

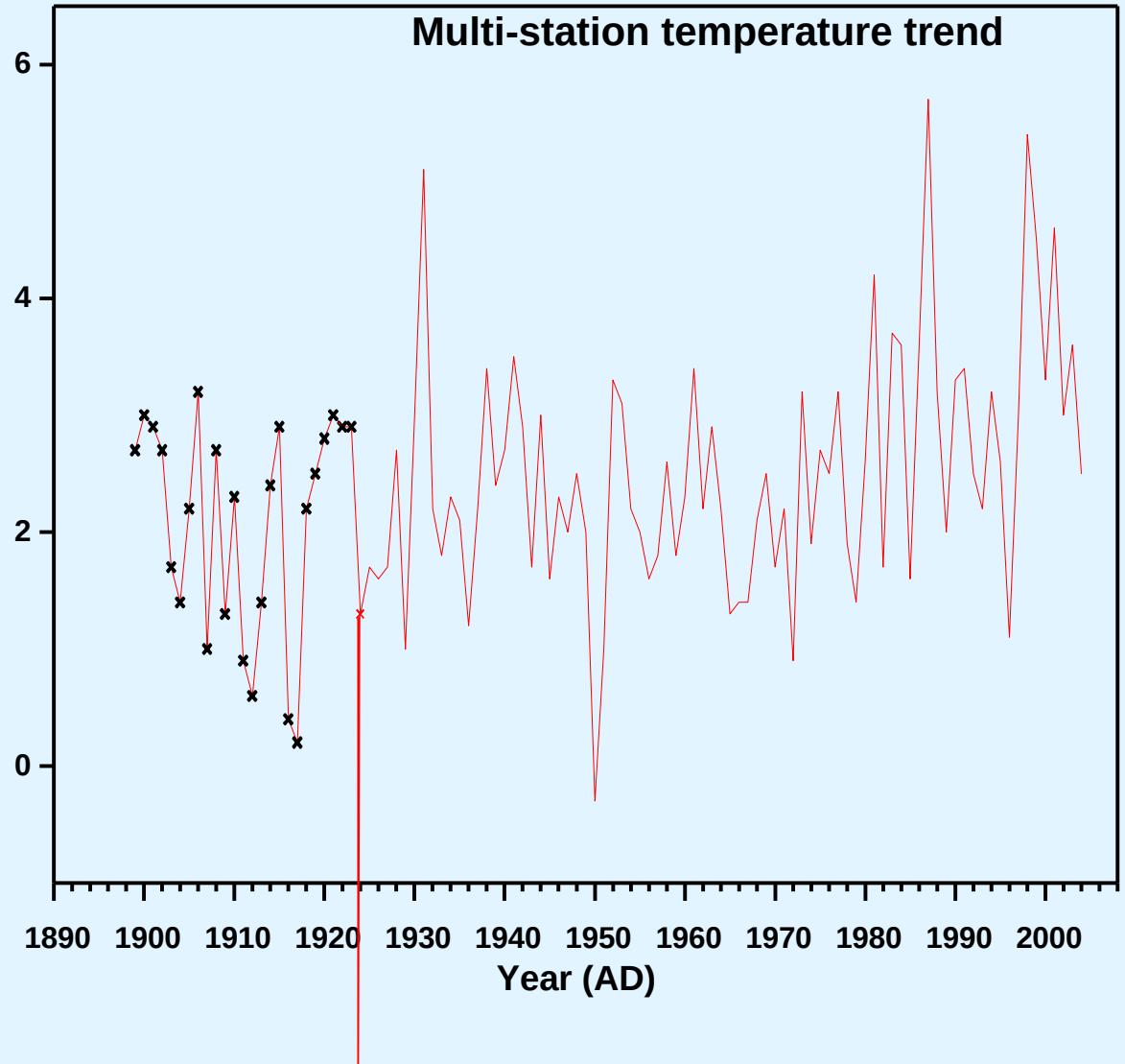
From "Managing the Water Resources of the Winnipeg River Drainage Basin". LWCB 2002.

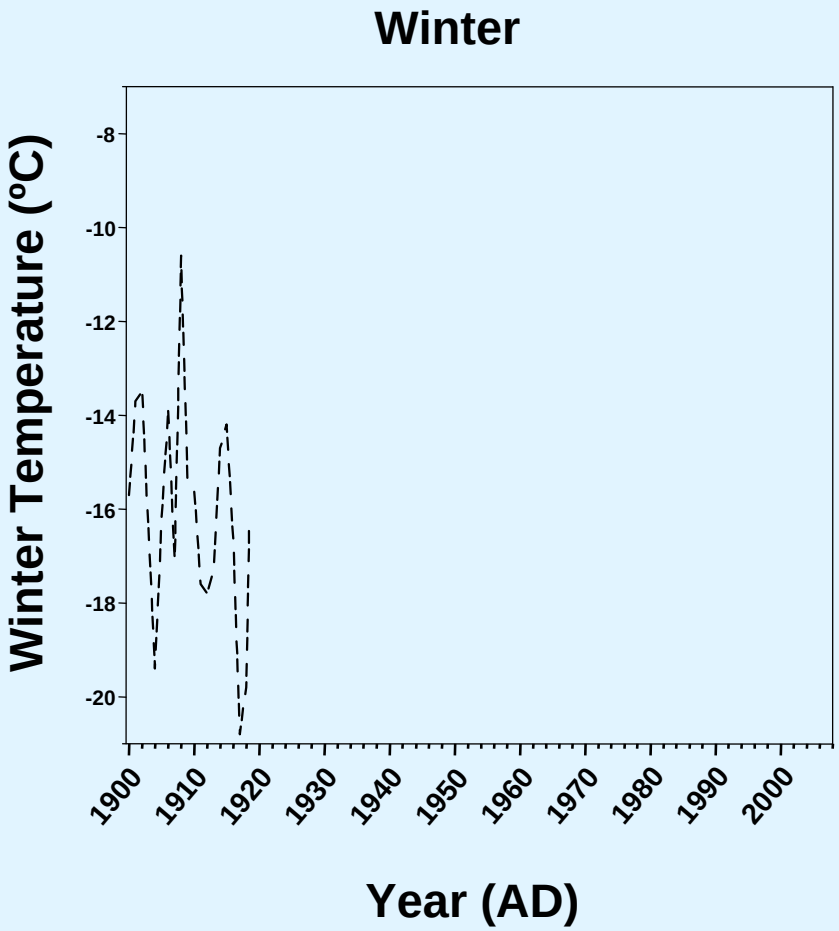
From DeSellas et al. SOBR



Flooding: government dock at the foot of Main St., Kenora ca. 1916

Photo courtesy of the Lake of the Woods Museum, Kenora


Multi-station temperature trend
6
4
2
0
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Year (AD)

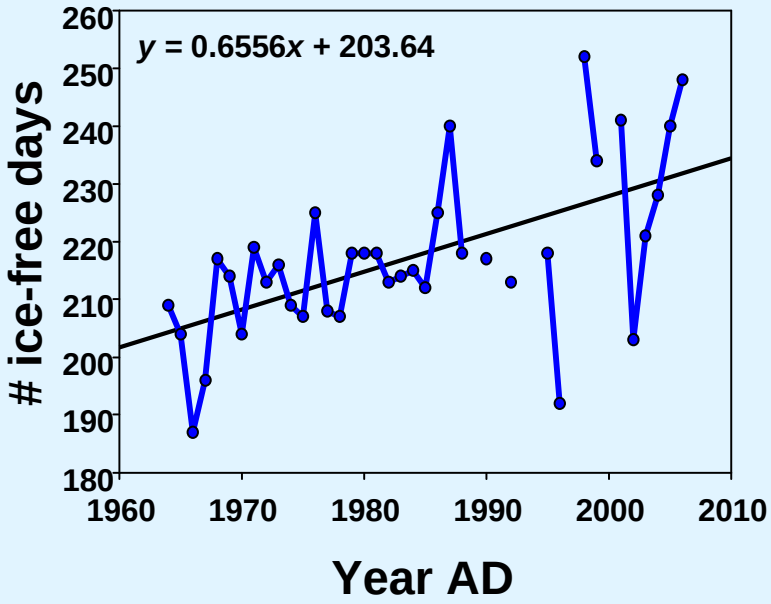


(http://www.cccma.ec.gc.ca/hccd/)

Whitefish Bay Ice Cover Record

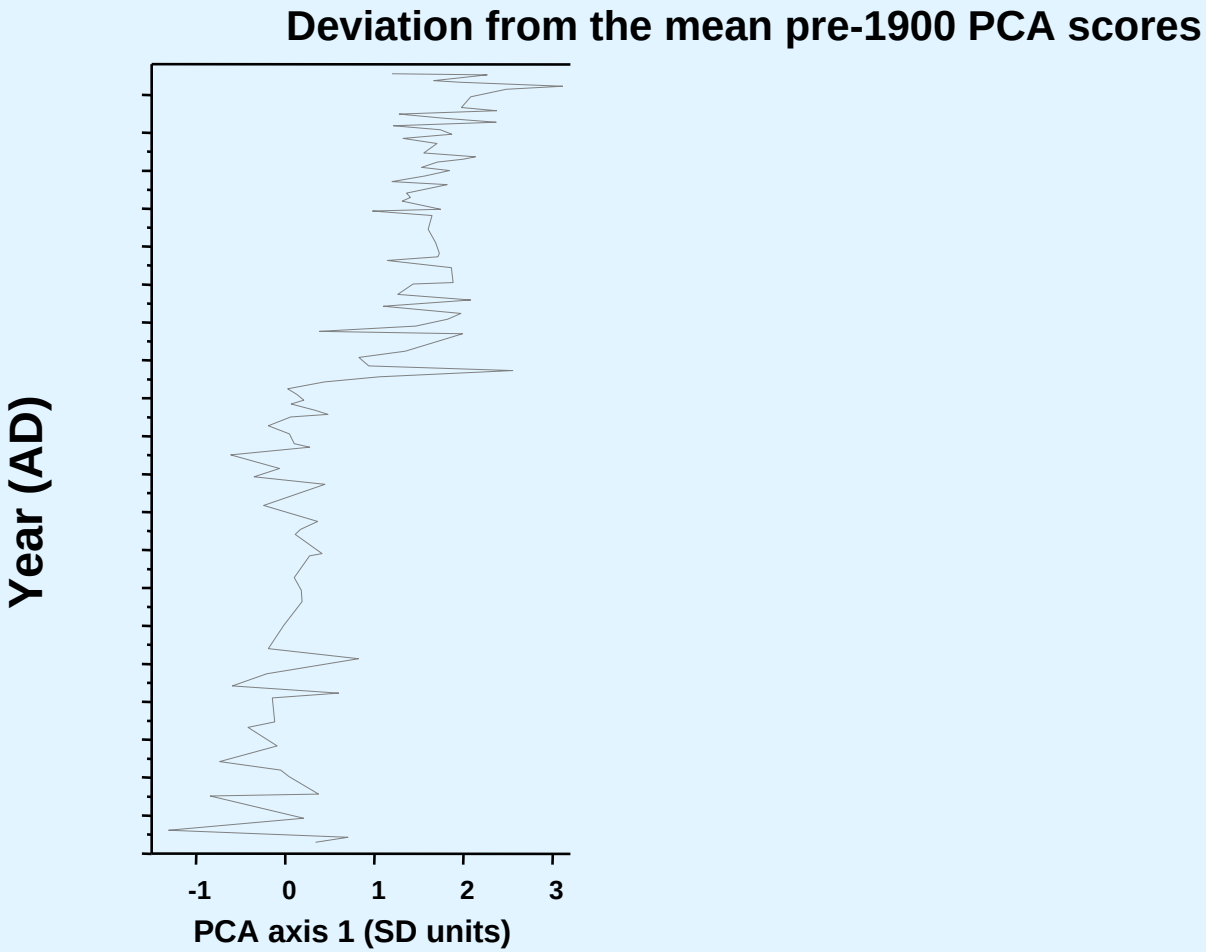
"The longer & colder a winter is, the earlier lakes freeze & the later they thaw."

David M. Livingstone 2005



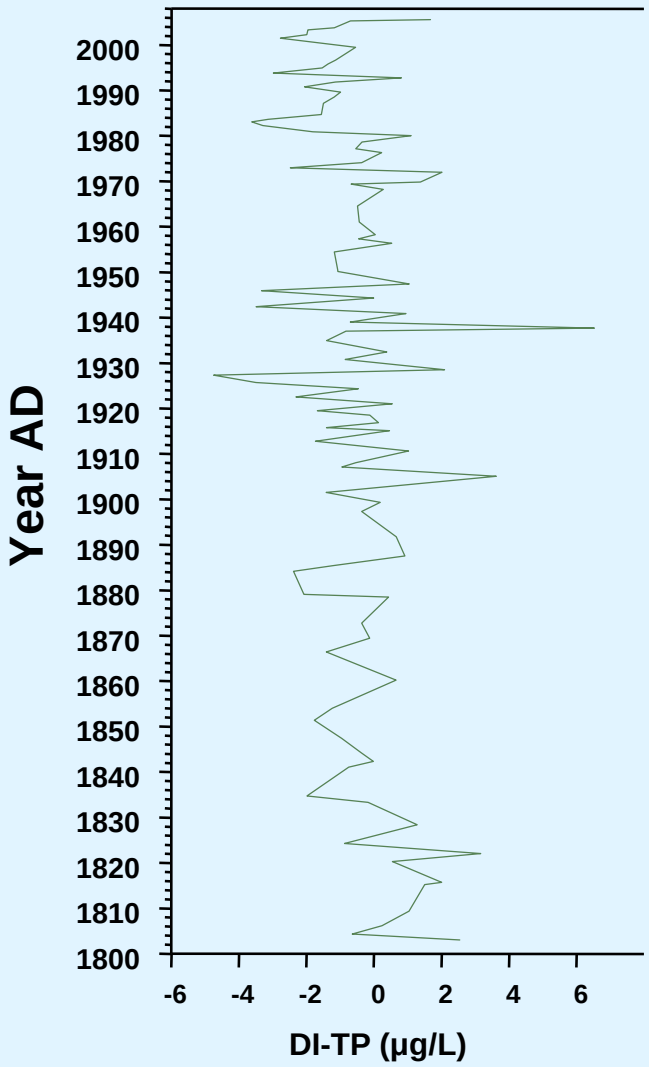
- Ice-free period increased by **27.7** days since 1964
- Corresponds to increased temperatures

Summary of Diatom Trends:



Rühland et al. in prep.

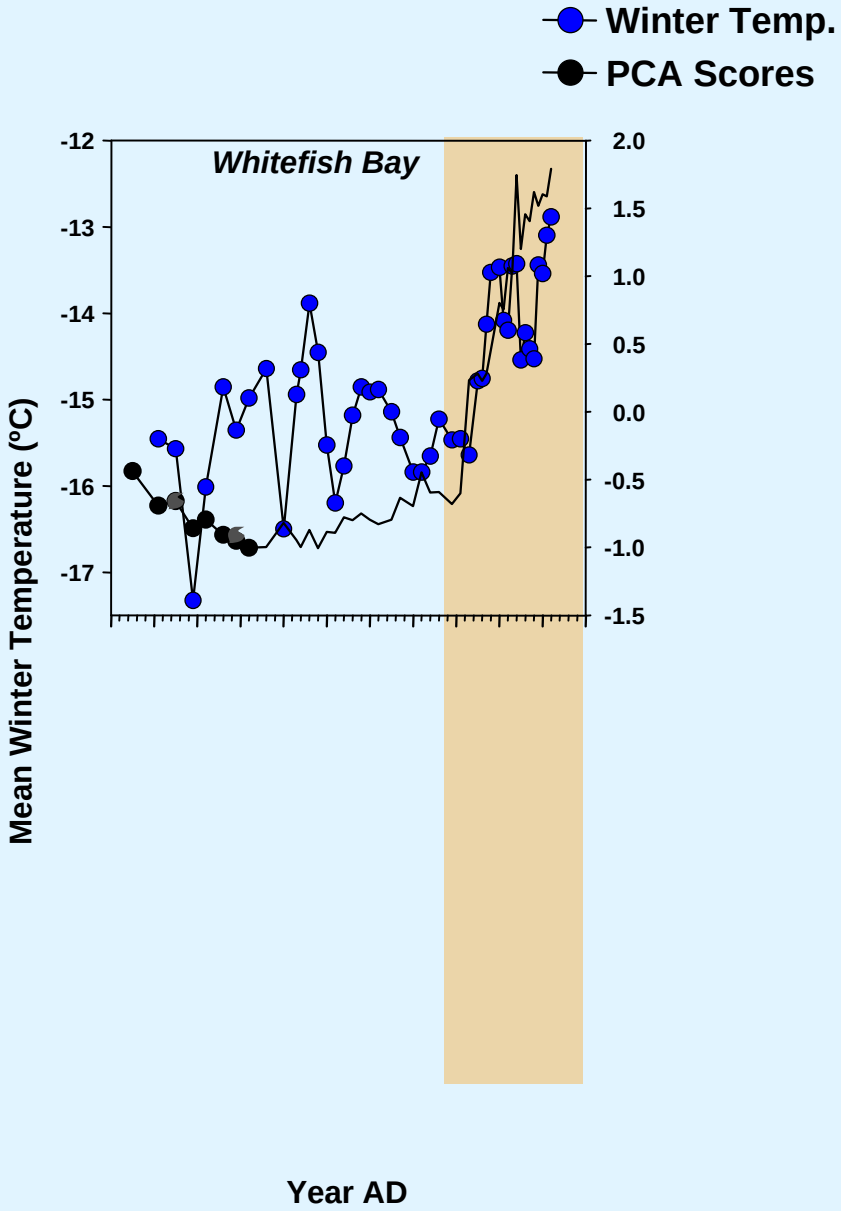
Summary of Diatom Trends: PCA & DI-TP downcore IMPACT SITES



Rühland et al. in prep.

Summary of Diatom Trends: PCA & DI-TP downcore REFERENCE SITE

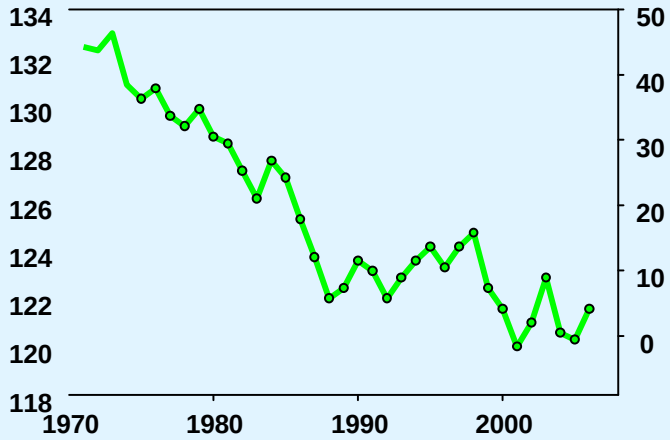
Diatom – Kenora Temperature Relationships

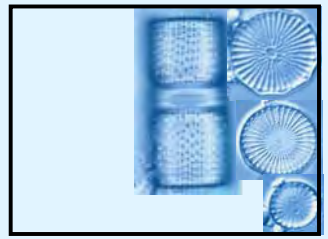


Diatom – Whitefish Bay Ice-out Relationships

Taxon-specific Relationships

Whitefish Bay – Reference site





Rühland, Paterson, Smol 2008: Global Change Biology

Warming & Hemispheric –scale shifts in *Cyclotella* Species

- Synthesis of >200 diatom-based paleo records
  - non-acidified/non-enriched lakes
- Changes in habitat structure/quality
  - hemispheric warming
- Increases in rel. abundances *Cyclotella* taxa
- Decrease in *Aulacoseira* and/or benthic *Fragilaria* taxa

- Spatially coherent picture that climate-driven taxon-specific changes are now evident across the Northern Hemisphere representing a wide spectrum of lakes.

Rühland, Paterson, Smol 2008: Global Change Biology

Summary of Results

- Diatom Assemblages
  - clearly different between impact sites & reference site
  - clearly similar among 3 impact sites
- Strong temporal coherence among all sites
  - ca. 1900s –post-dam construction & rise in water level
  - last few decades – increased temperatures & longer ice-free period
- DI-TP trends
  - minimal directional changes- 3 impact sites- main direction of diatom changes not tracking changes in [TP]
  - reference site decreasing trend post-1970s-80s
- High diatom correlations to temperature & lake-ice trends
- Taxon-specific shifts - warmer temperatures, longer ice-free period & associated changes in water column

Concluding Remarks

- Paleolimnological techniques
  - determines background ecological conditions
  - extends the environmental record
- Multiple stressors on LoW include hydro-management & recent warming
  - affect lake in complex ways
- Climatically-induced limnological changes = important mechanism
- Climate must be considered an important part of the equation