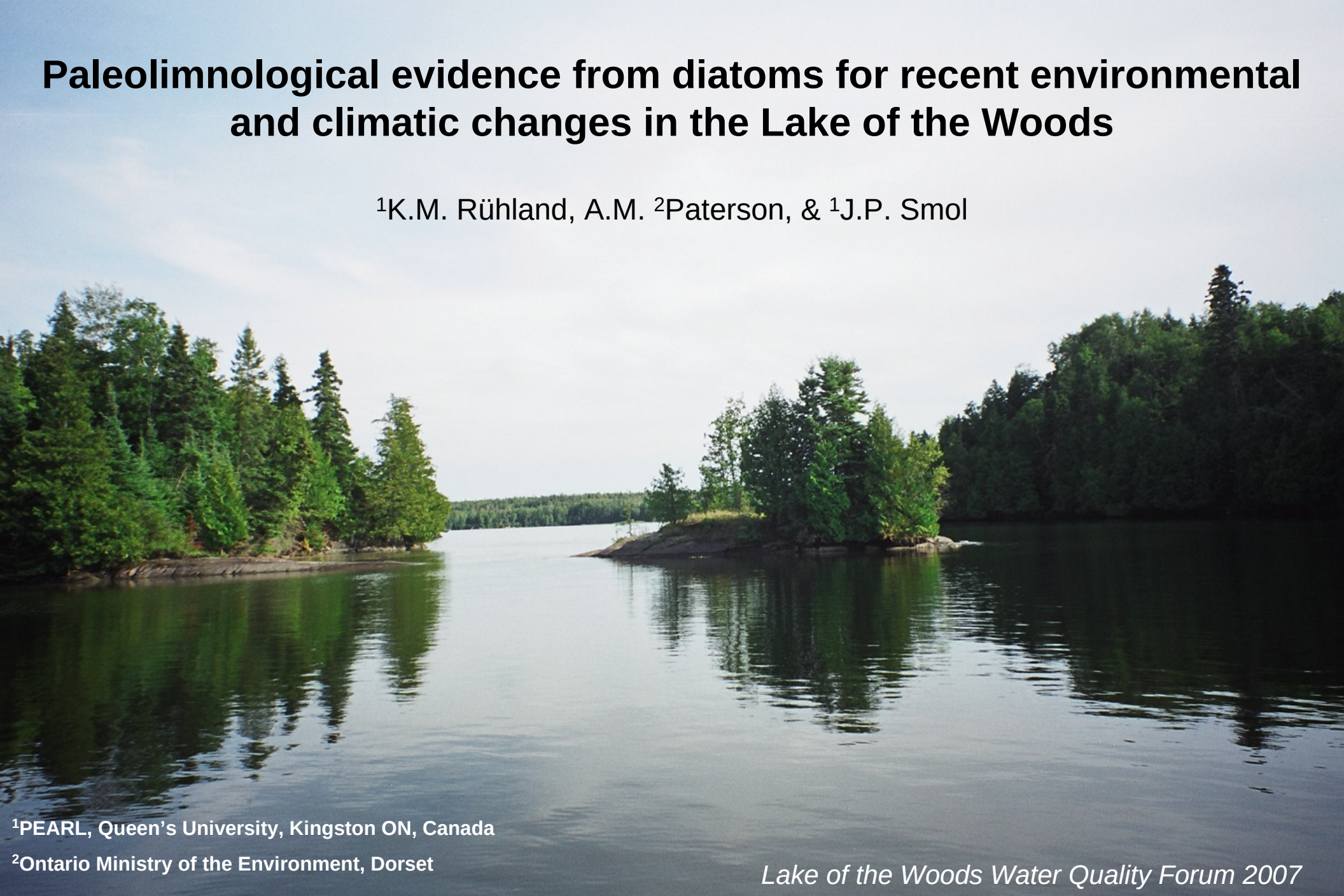
Paleolimnological evidence from diatoms for recent environmental and climatic changes in the Lake of the Woods

[1]K.M. Rühland, A.M. [2]Paterson, & [1]J.P. Smol



[1]PEARL, Queen's University, Kingston ON, Canada

[2]Ontario Ministry of the Environment, Dorset

Lake of the Woods Water Quality Forum 2007

Development of an Algal Bloom - 2003

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

“The islands were numerous and crowded, the water shoal and foul, frequently with a green scum of vegetable matter”

- **Major Joseph Delafield, July 30th, 1823**

“…the water became tinged with green, derived from a minute vegetable growth”

- **S. J. Dawson, Summer 1857**

“…deposits of green vegetable matter” in the lake’s bays during the summer.

- **objection to a proposal to use LOW to supply clean water to Winnipeg 1883**

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?

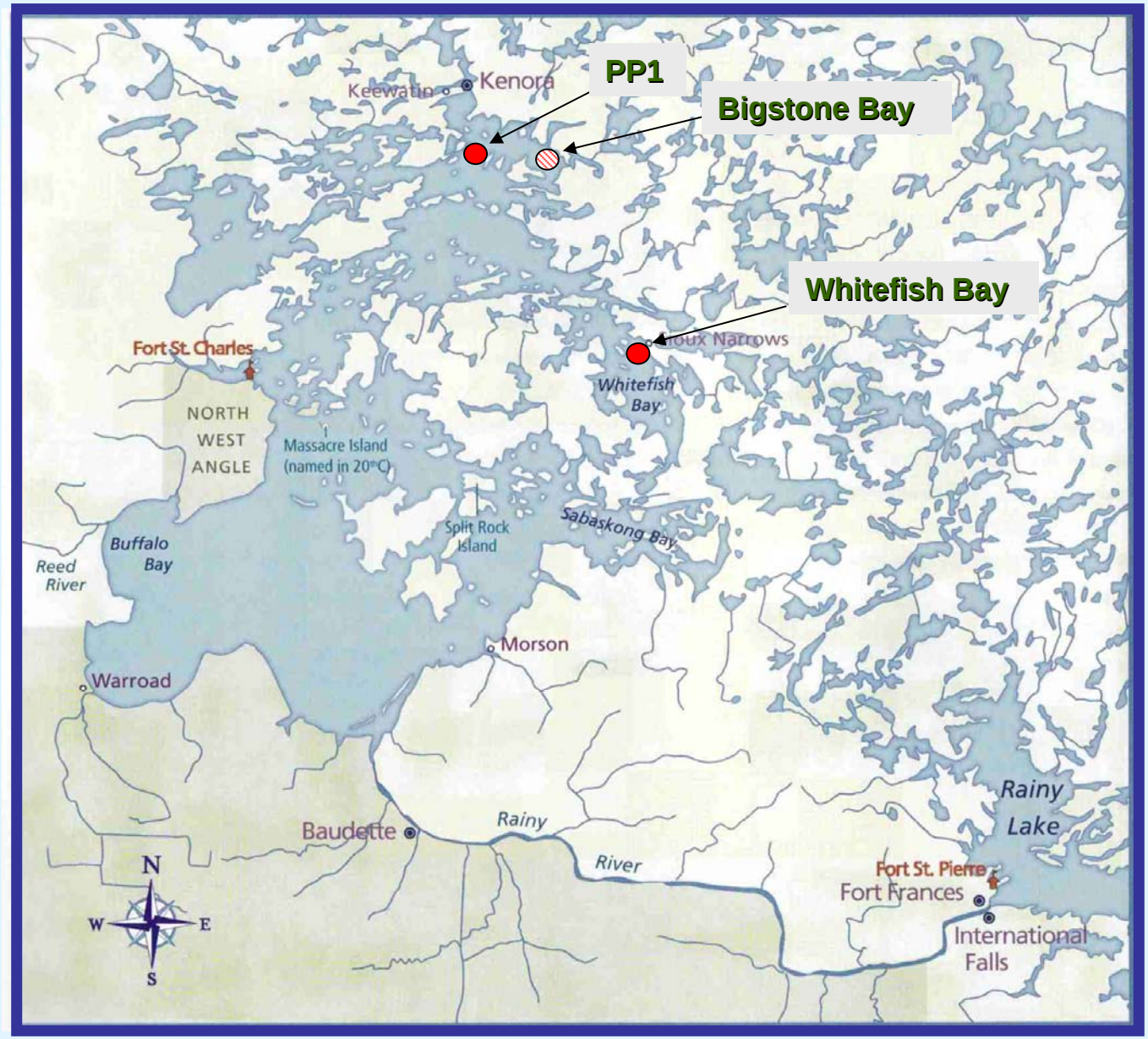
3) If so, when did these changes occur?

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

5) What are the possible reasons for this change?

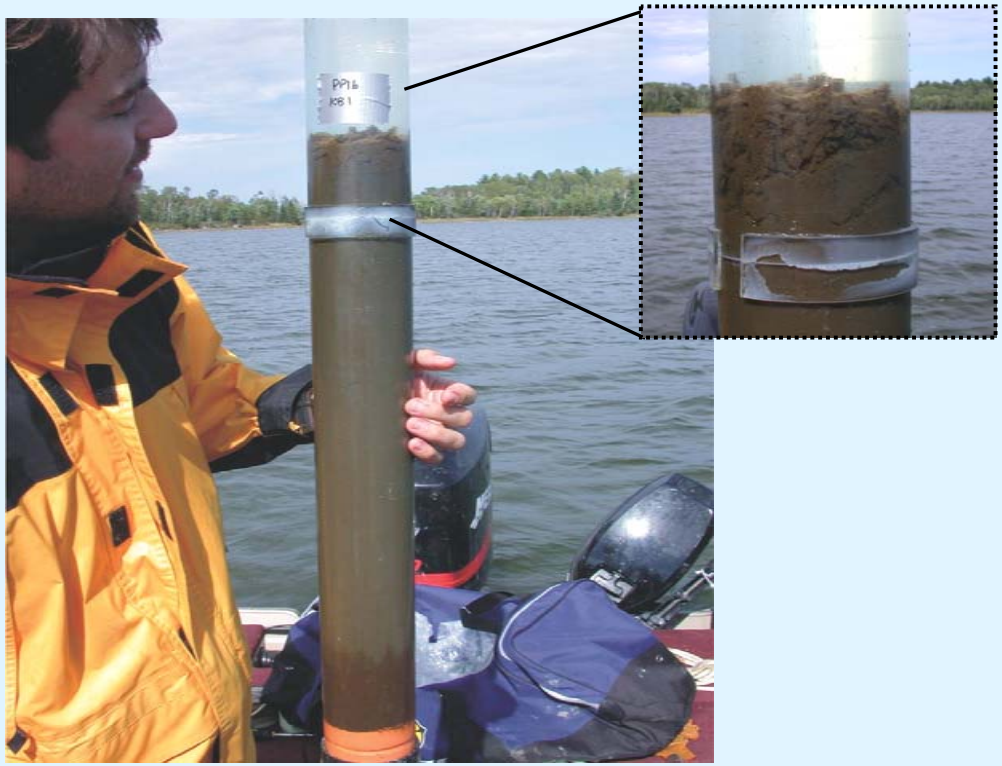
The Paleolimnological Approach

Location of sampling sites for sediment cores



Modified from Robertson & McCracken 2003

The Paleolimnological Method



Core retrieval

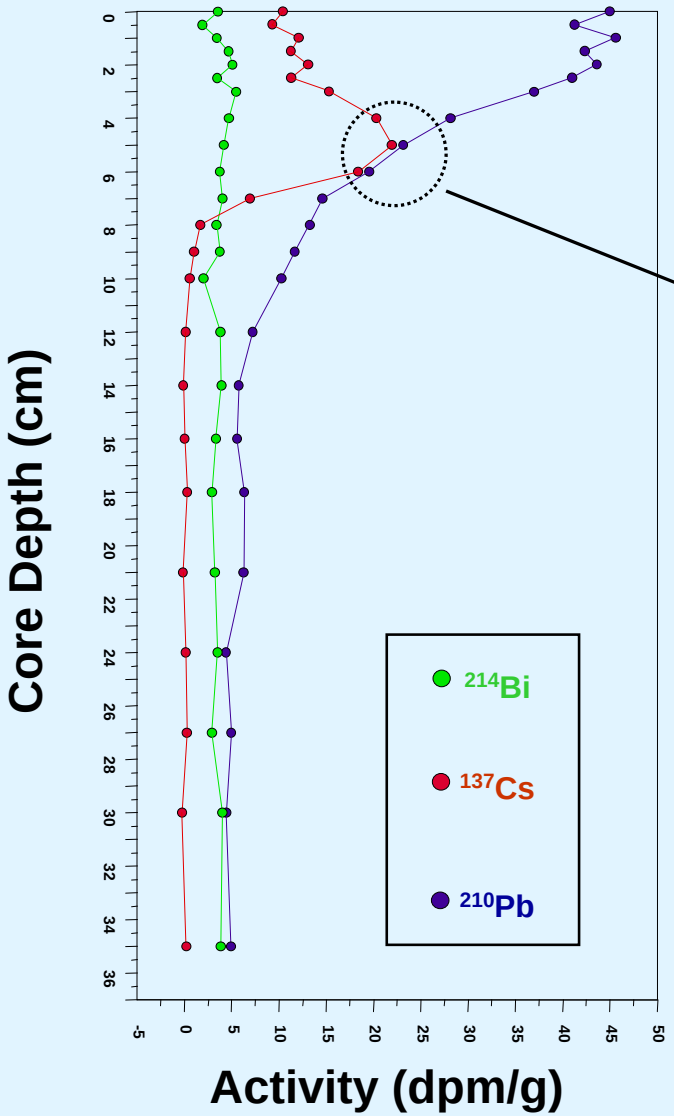
- gravity cores retrieved from deep, quiet locations
- undisturbed water-sediment interface = most recent deposits retrieved

The Paleolimnological Method

Core sectioning

- sediment is sectioned into intervals (Glew 1988 extruder)
- each 0.5 cm interval extruded into plastic sample bags

The Paleolimnological Method



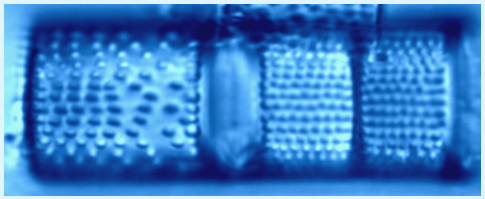
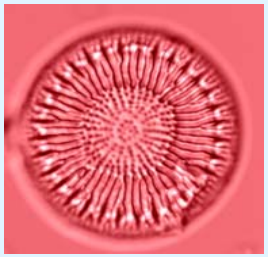
Dating the sedimentary sequences

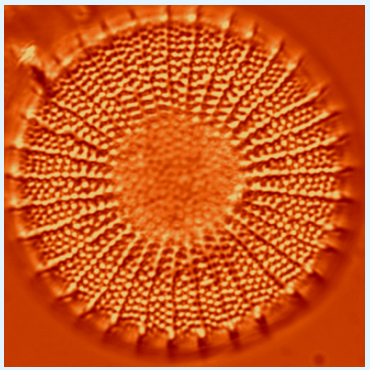
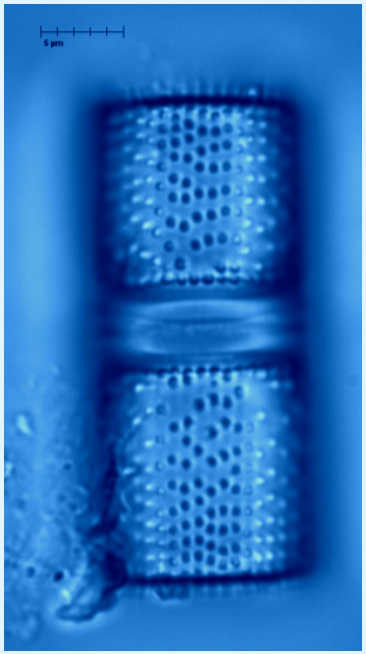
- ^{210}Pb (radioisotope)
- ^{137}Cs peak ca. 1963
  - corresponds to nuclear test ban treaty

The Paleolimnological Method

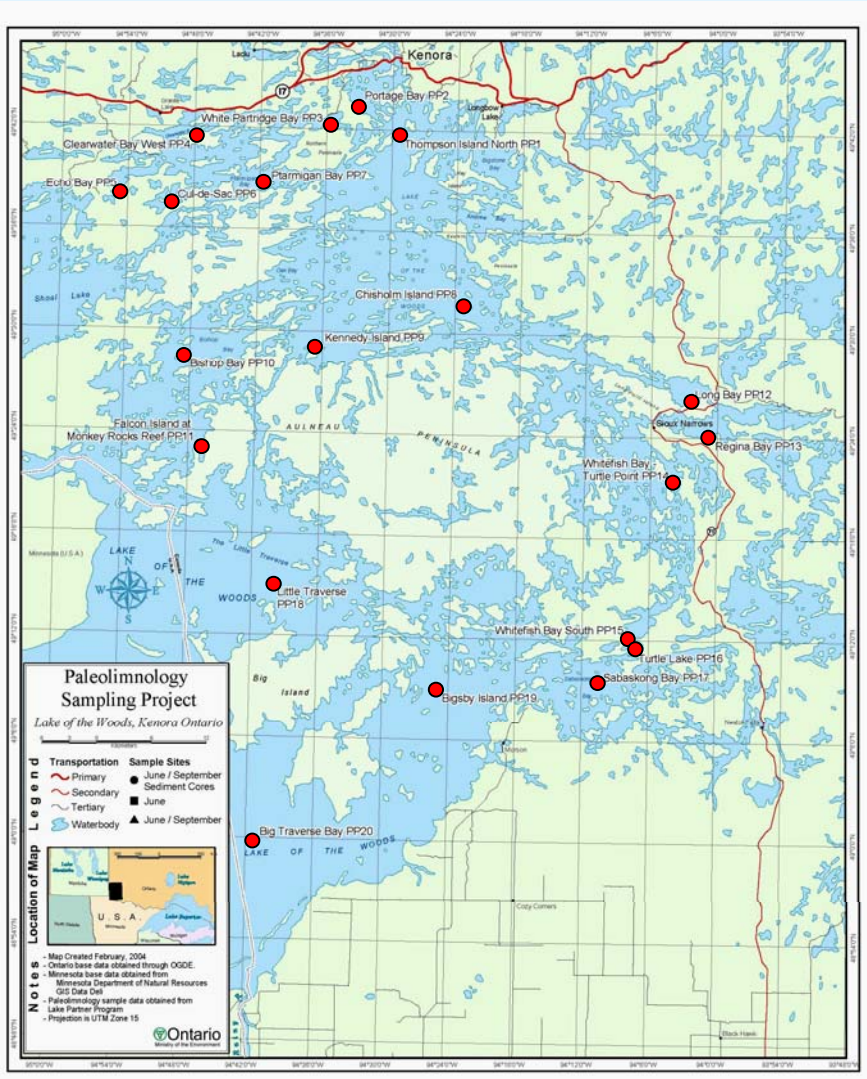
Diatoms as Indicators of Environmental Change

- well preserved in lake sediments
- remain stable in sedimentary sequences
- taxonomically specific ornamentation
- many have narrow optima and tolerances
- respond rapidly to environmental change

Developing Models for Predicting Total Phosphorus



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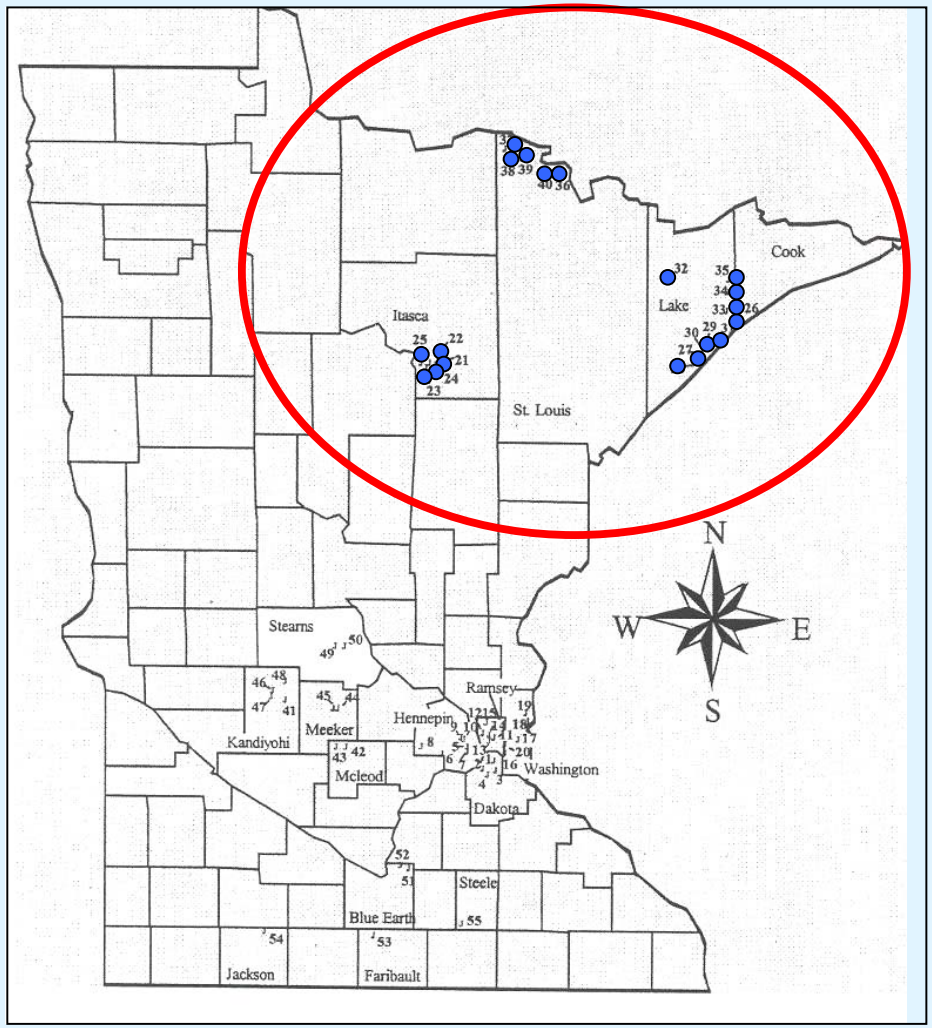
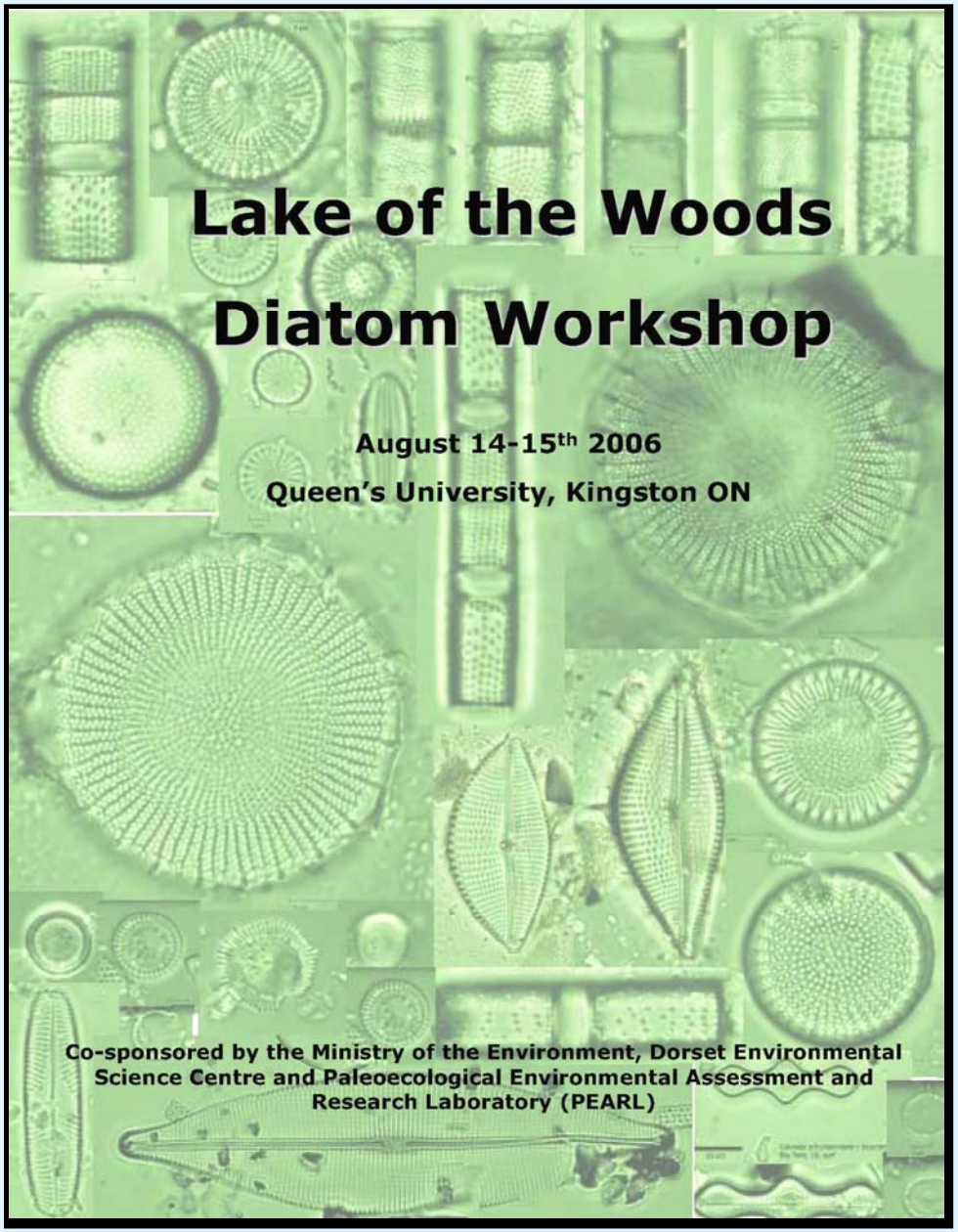


Lake of the Woods training set

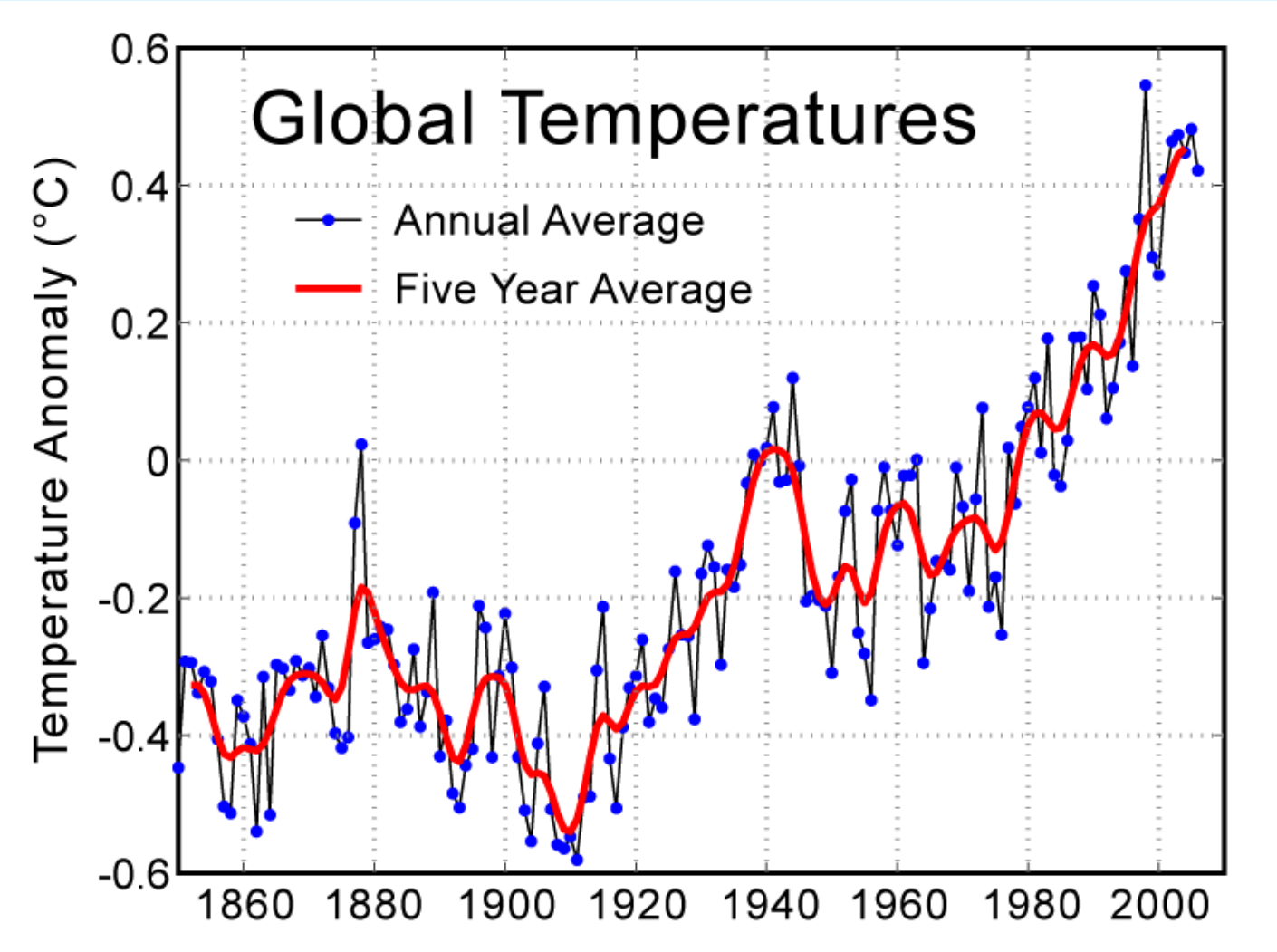
Minnesota training set



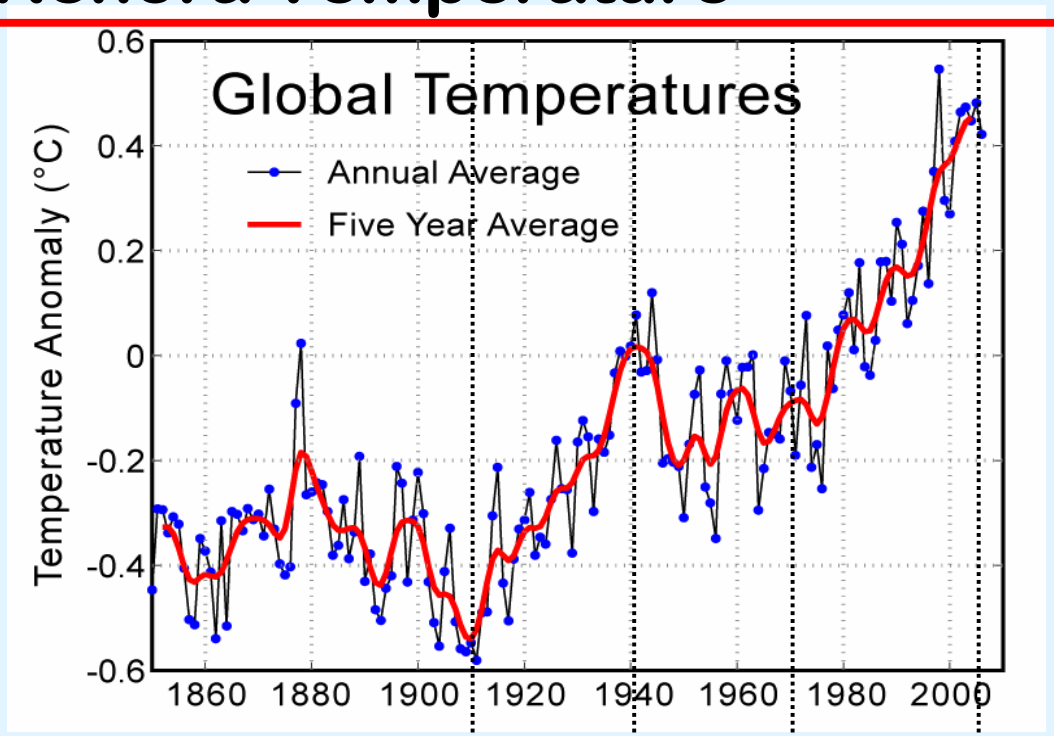
- **Exchange of diatom datasets requires taxonomic consistency**

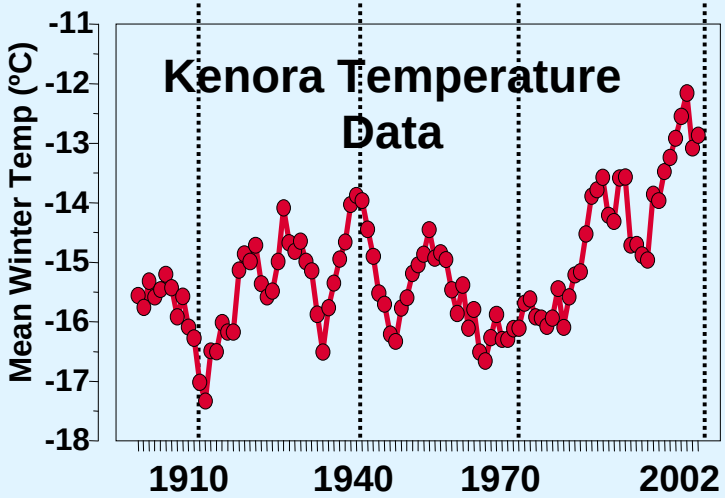
- **Diatom workshop, August 2006**

The Instrumental Record



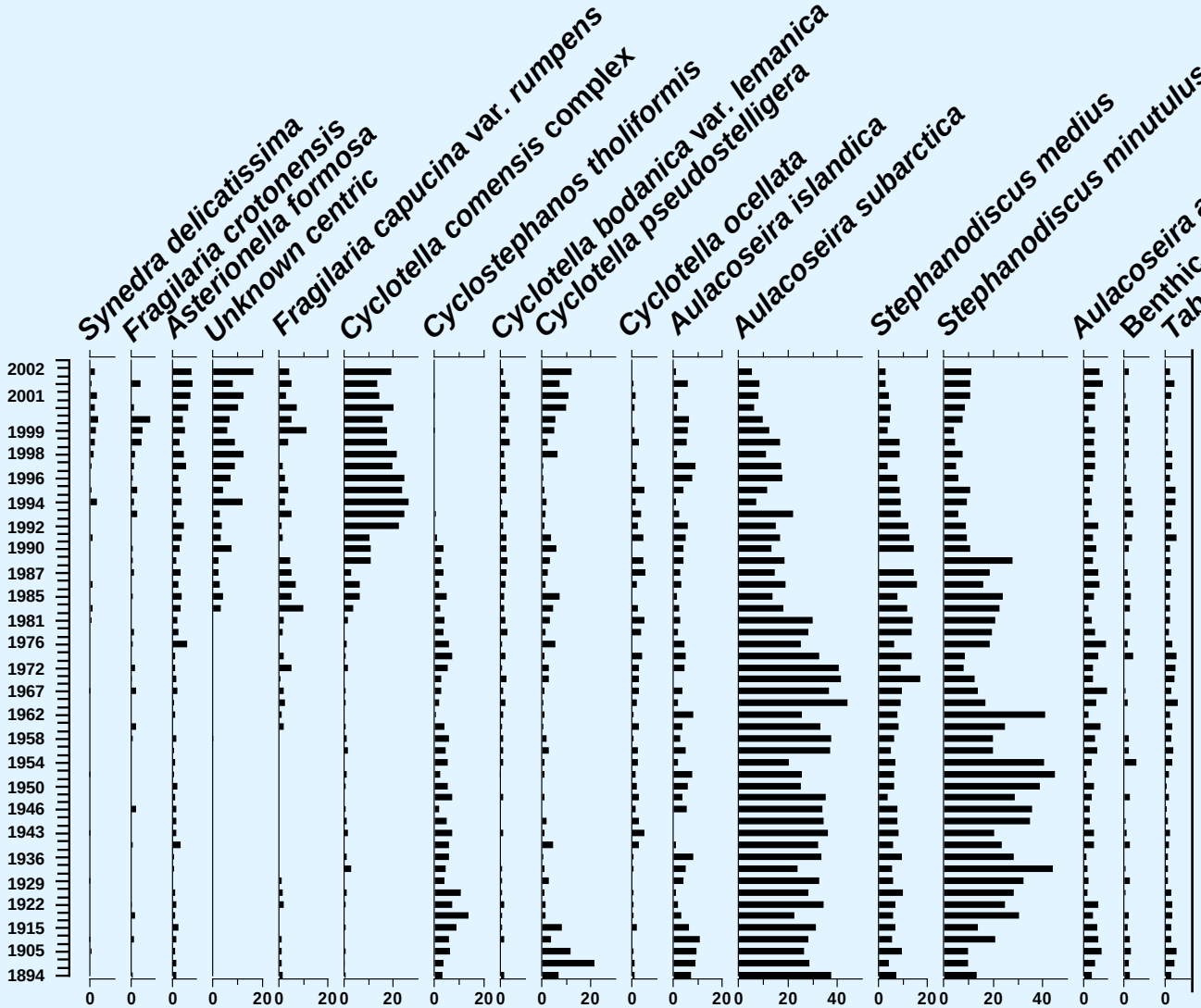
Global vs Kenora Temperature





Whitefish Bay Diatom Profile

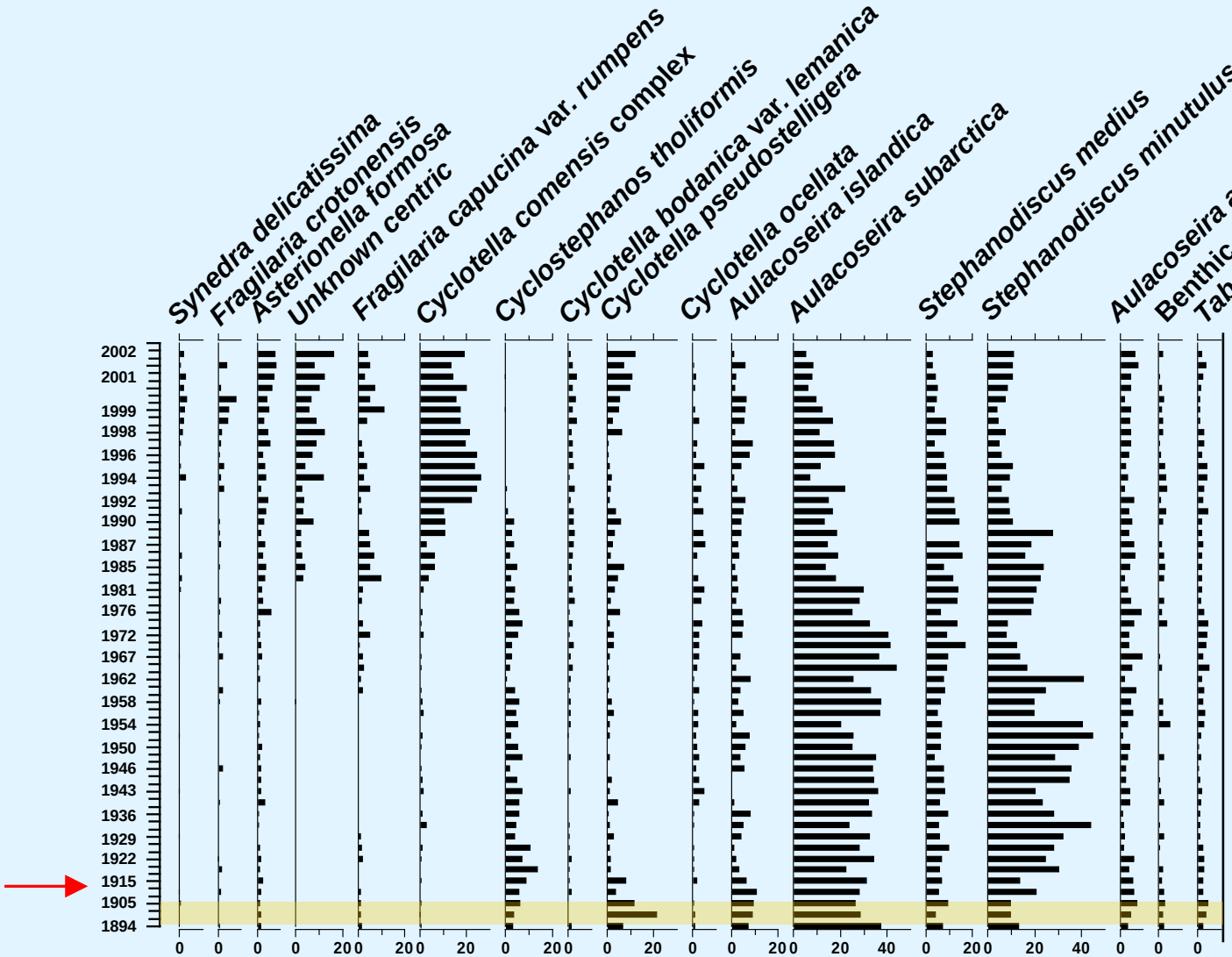
Reference site

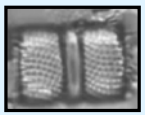


Whitefish Bay Diatom Profile

ca. 1885-1915

Reference site





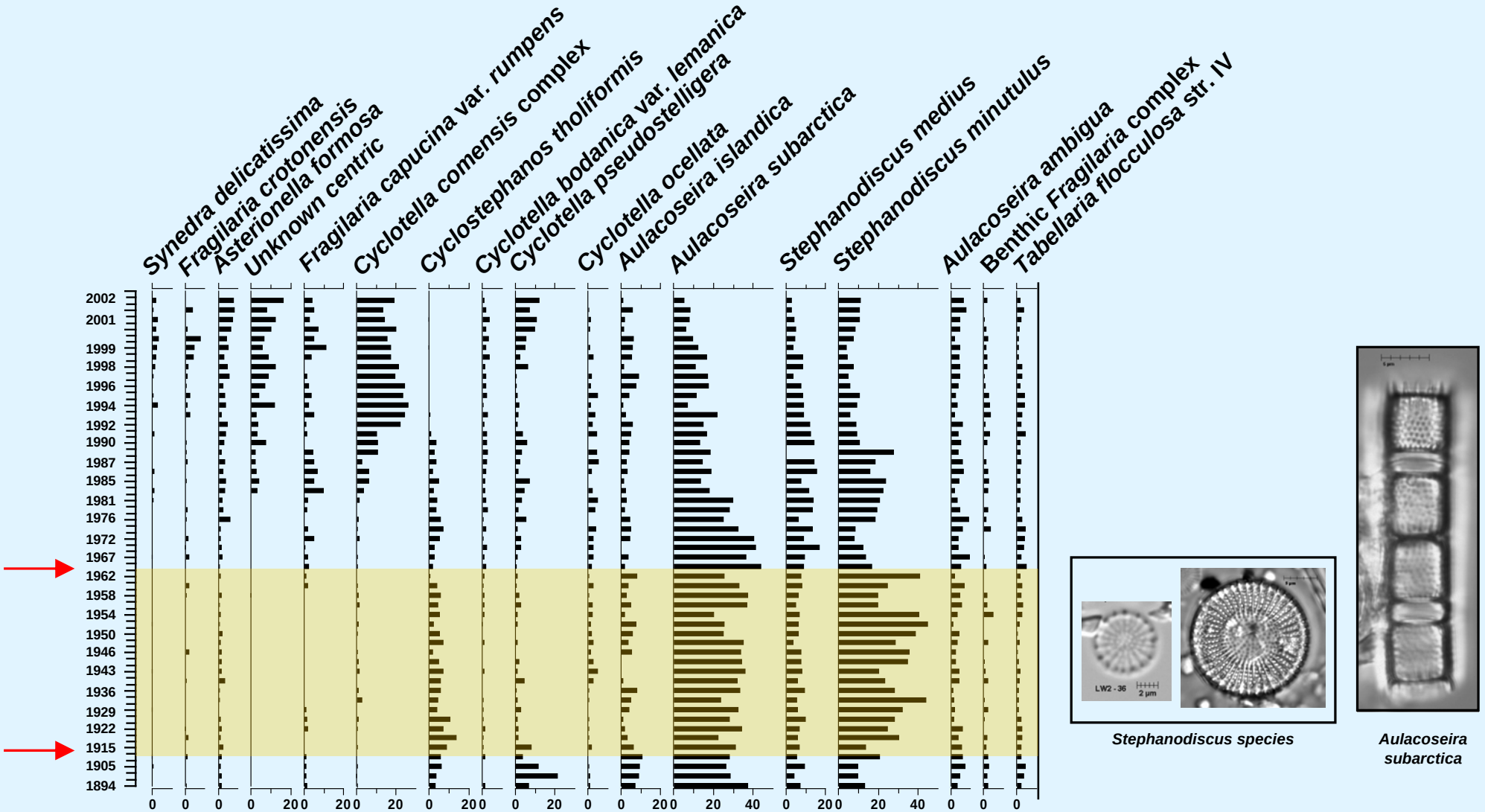
Aulacoseira subarctica

Cyclotella pseudostelligera

Whitefish Bay Diatom Profile

ca. 1905 Rise in water level

Reference site



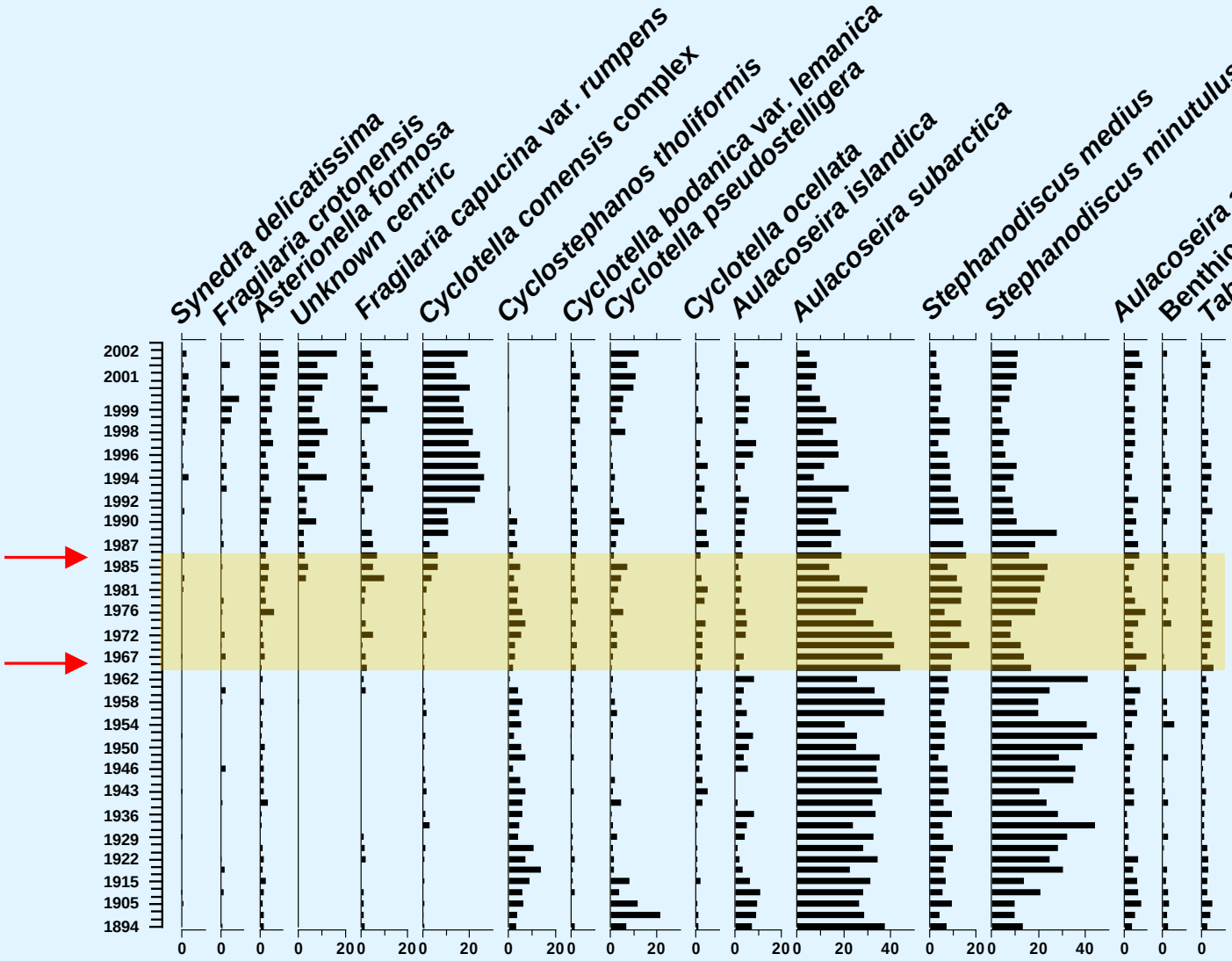
Stephanodiscus species

Aulacoseira subarctica

Whitefish Bay Diatom Profile

ca. 1966-1986 Canal

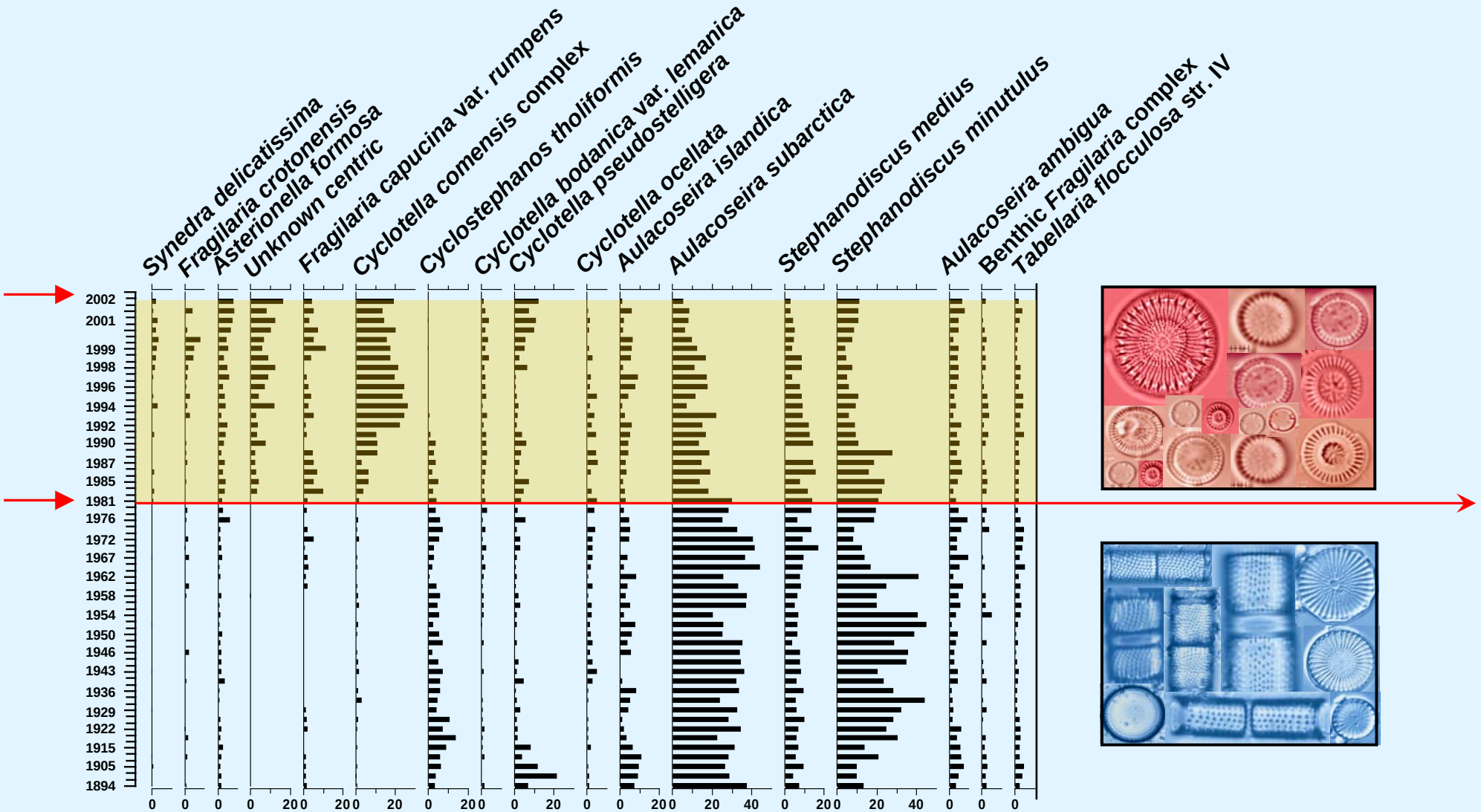
Reference site



Whitefish Bay Diatom Profile

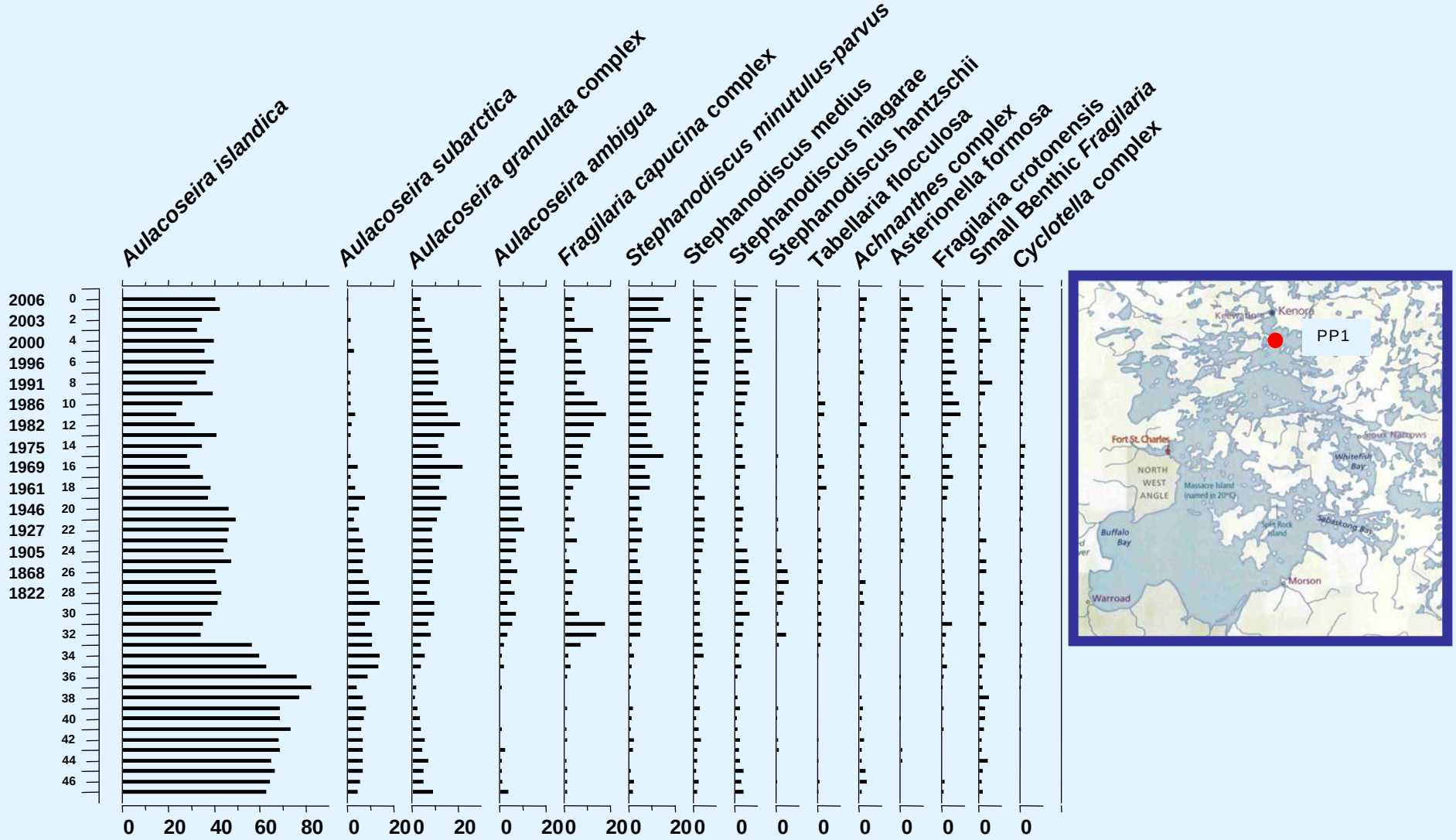
1980 – present

Reference site



PP1 Diatom Profile

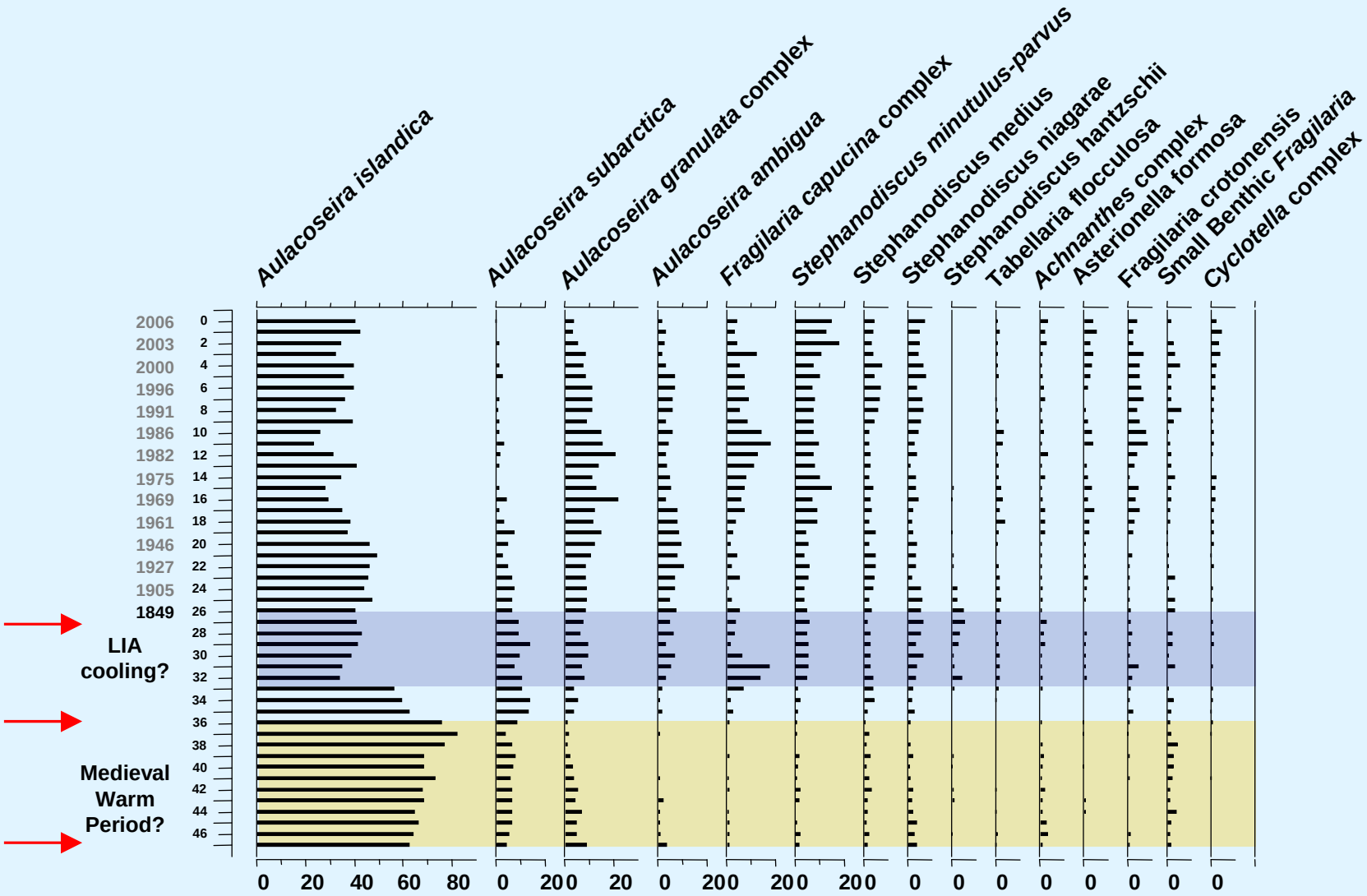
Impacted site



PP1 Diatom Profile

~ AD 1100 – AD 1850

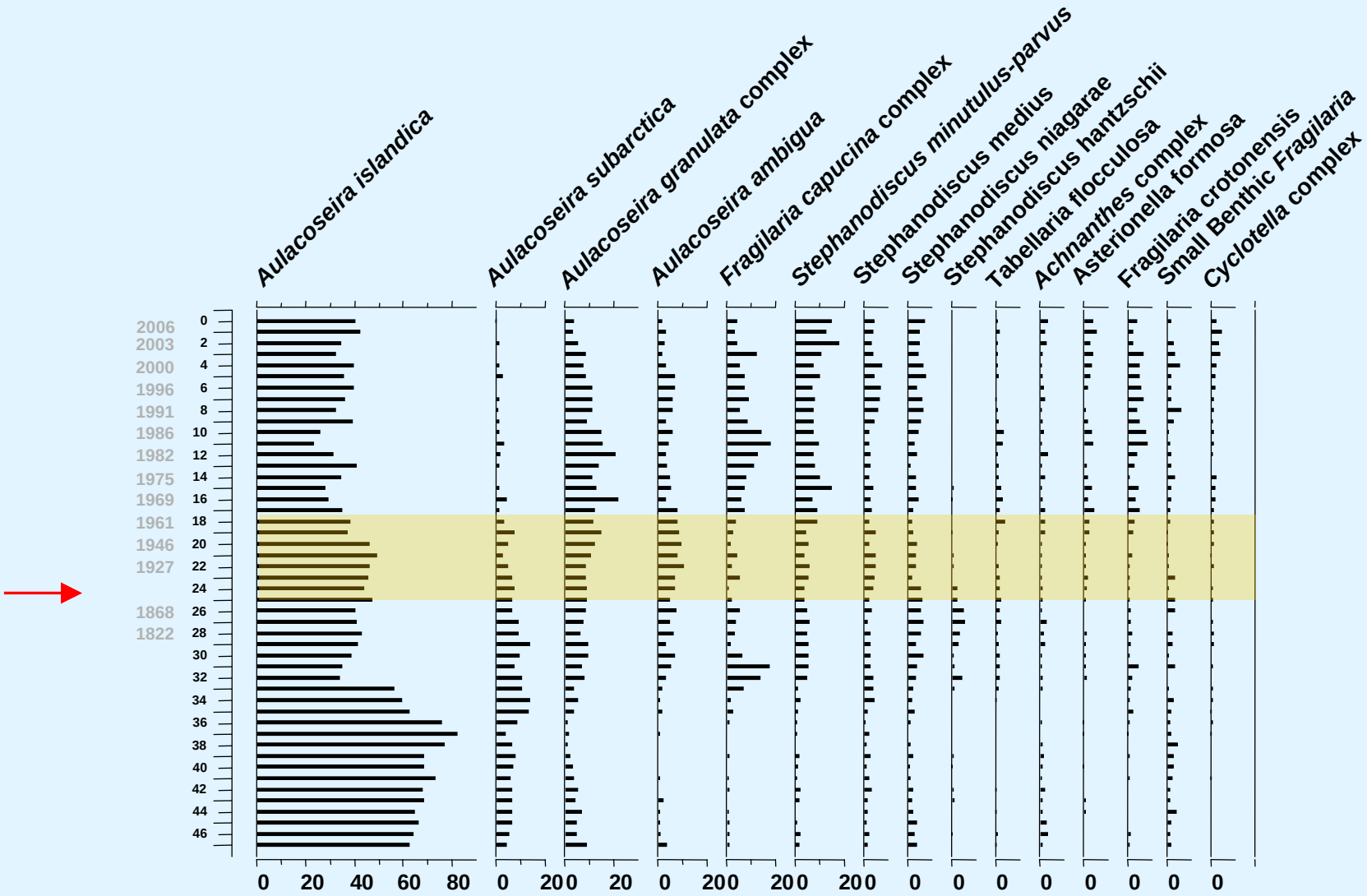
Impacted site



PP1 Diatom Profile

Impacted site

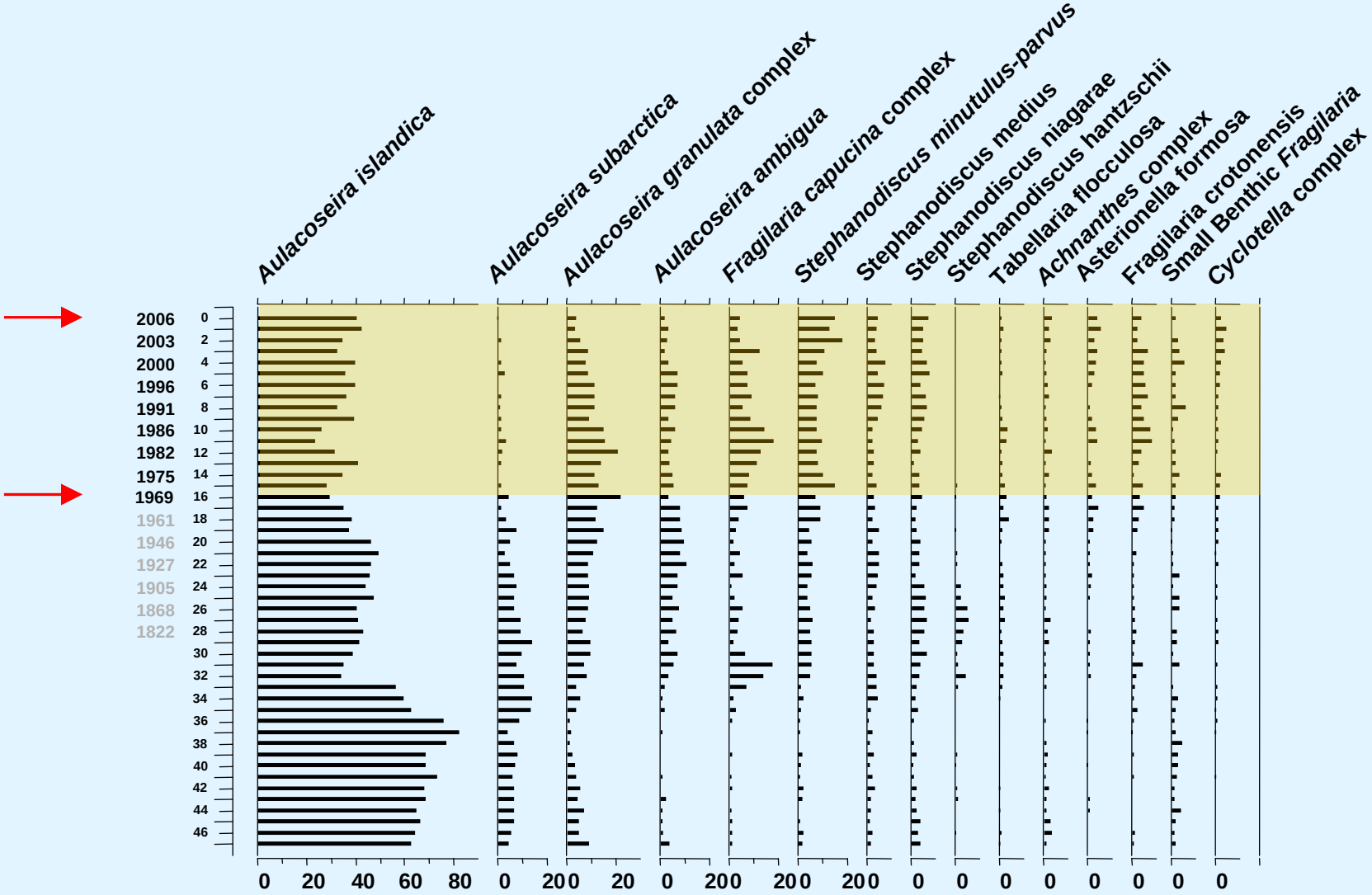
ca. 1905 Rise in water level



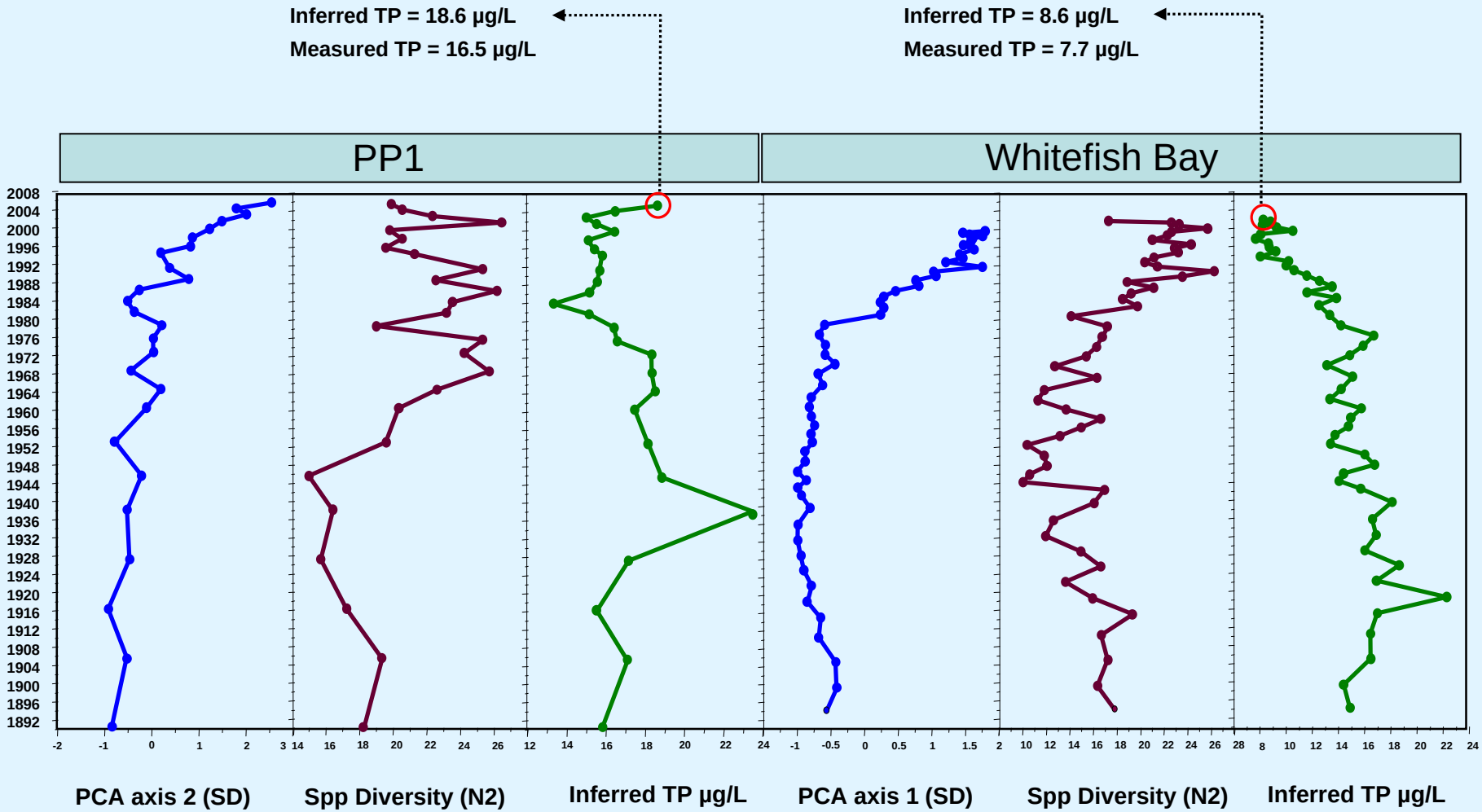
PP1 Diatom Profile

Last few decades

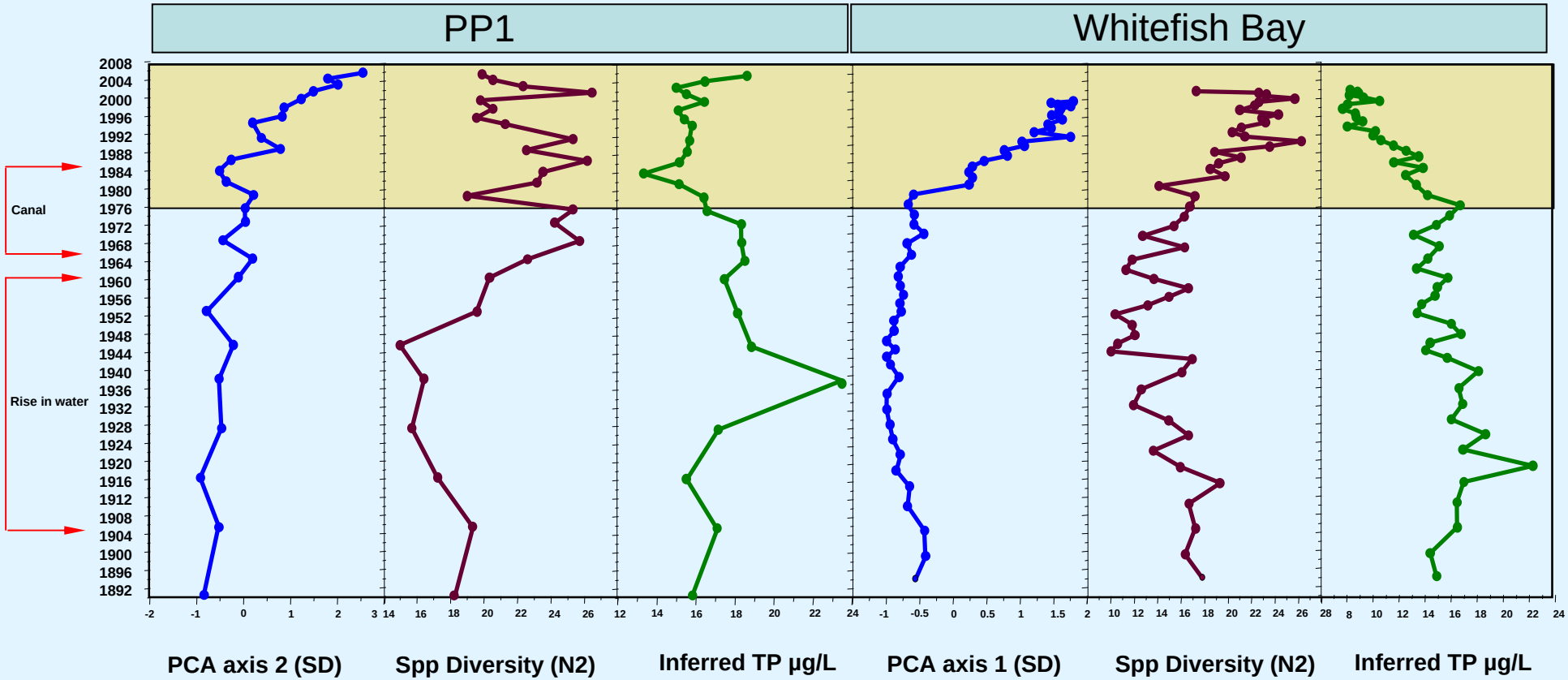
Impacted site



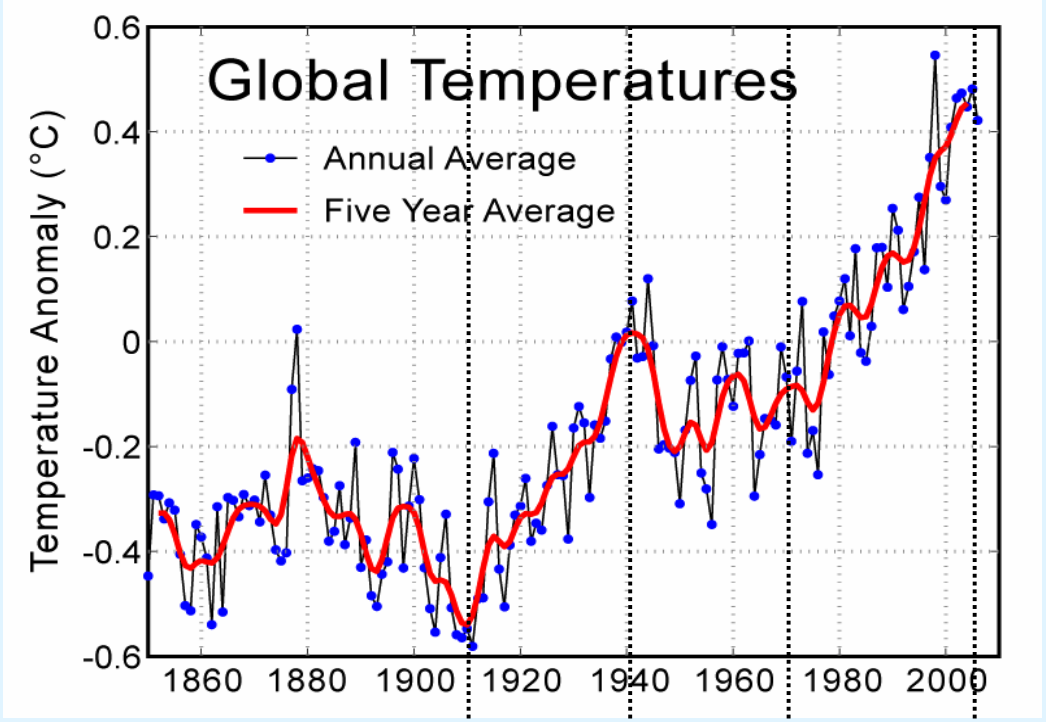
Summary of Diatom Trends

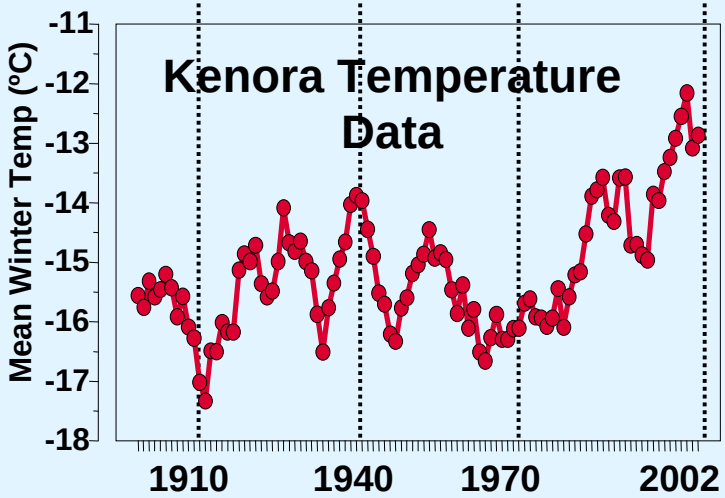


Summary of Diatom Trends

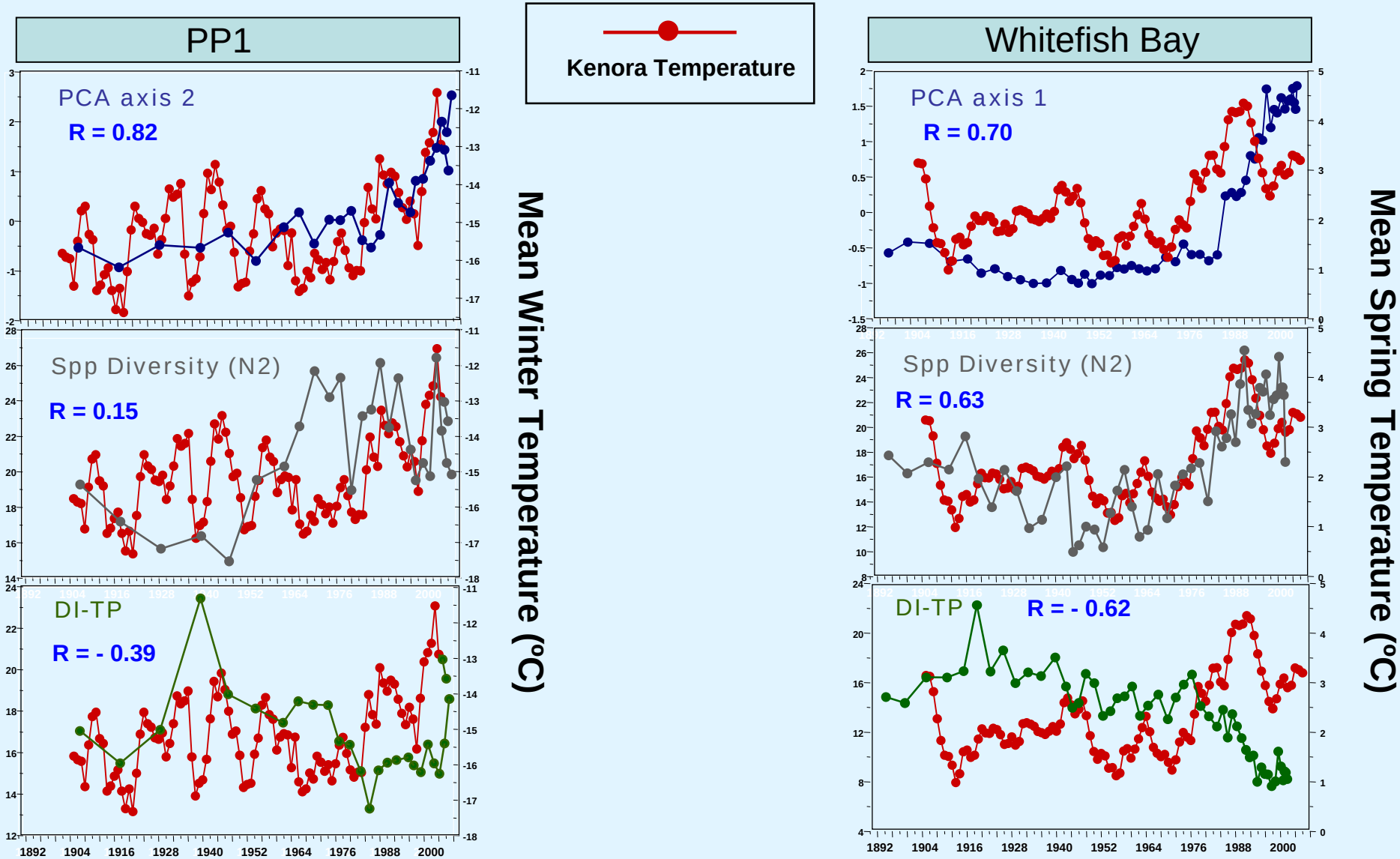


Global vs Kenora 100-year Temperature Trends

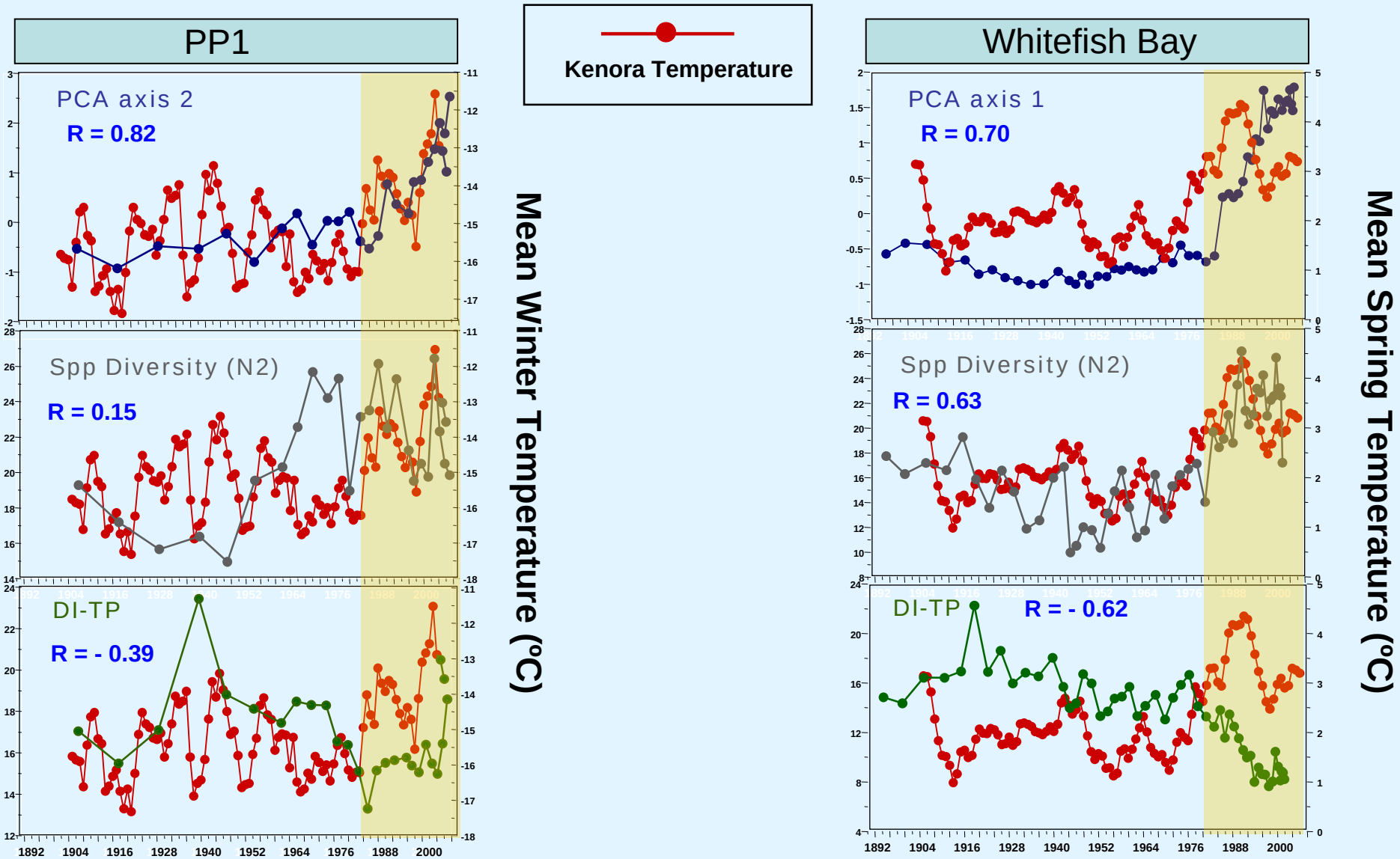




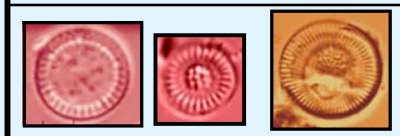
Diatom – Temperature Relationships



Diatom – Temperature Relationships

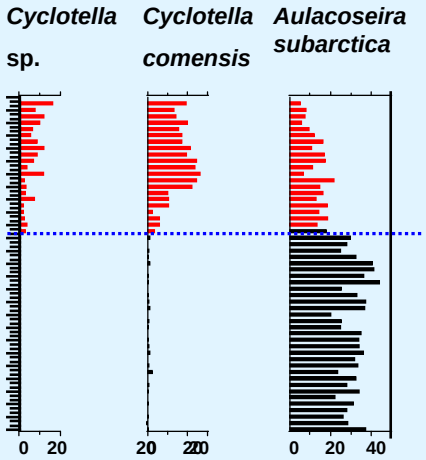


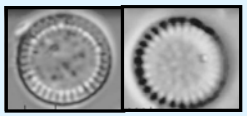
Climatic Warming and the Aquatic Environment

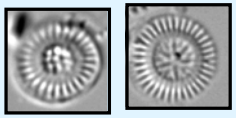
Length of ice cover	↓
Growing Season	↑
Thermal Stratification - Strength	↑
Thermal Stratification - Duration	↑
Allochthonous sources of TP	↓
 *Cyclotella* species	↑
Diversity	↑

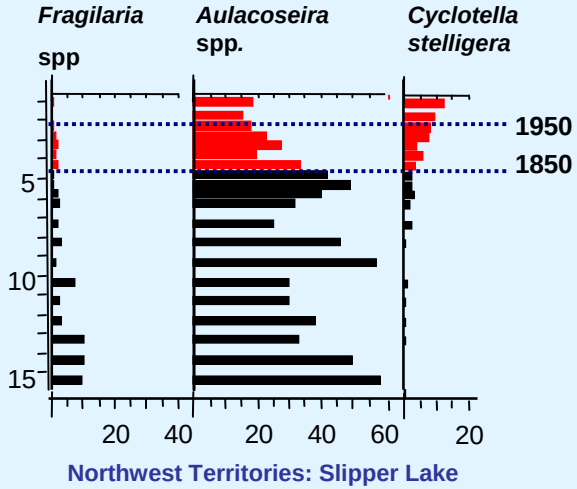
- Hemispheric-scale trend

Climatic Warming and increases in *Cyclotella* species

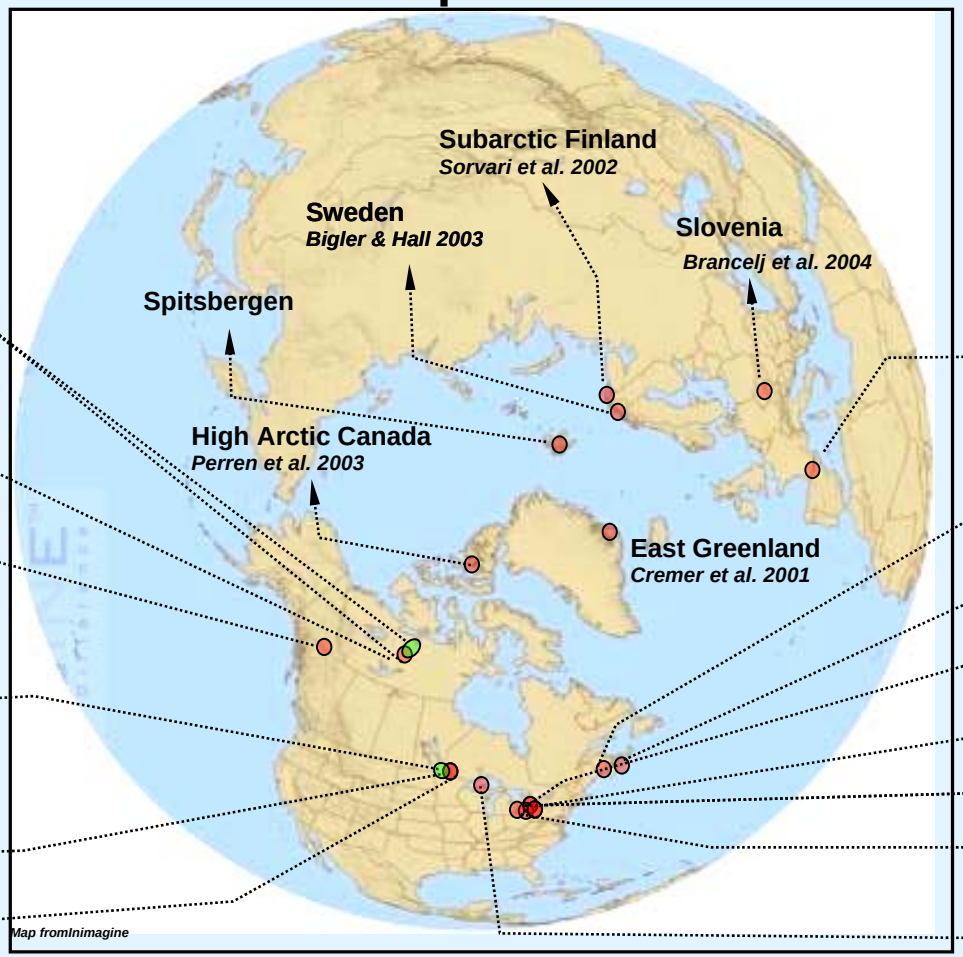








Northern Hemisphere-Scale trends



Subarctic Canada
Rühland et al. 2003

Great Slave L. NWT
Stoermer et al. 1990

Yukon Canada
Karst-Riddoch et al. 2005

ELA NW ON Canada
Enache et al. unpubl.

ELA NW ON Canada
Laird et al. unpubl.

LOW NW ON Canada
Rühland et al. this study

Spanish Pyrenees
Catalan et al. 2002

NB Canada
Harris et al. 2006

NS Canada
Ginn et al. in press

SE ON Canada
Forrest et al. 2002

S ON Canada
Clerk et al. 2000

SW ON Canada
Werner et al. 2005

Lake Erie
Stoermer et al. 1996

Lake Superior
Stoermer et al. 1993

Summary of Results

- Marked changes in diatom assemblages over last ca. 20-30 yrs
- Substantial decrease in DI-TP starting ca. 1980
- Timing of changes consistent between sites
- Changes consistent with climate warming
- Strong relationships between diatom trends & climate records

Concluding Remarks

- Phosphorus has long been an important component of the LOW
- Climate must be considered an important part of the equation
- LOW fits into an emerging global pattern of climate change and its impacts on lakes

Acknowledgements

- Bev Clark (MOE, Dorset)
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