Ecological Change in Lake Temagami Over the Last Century

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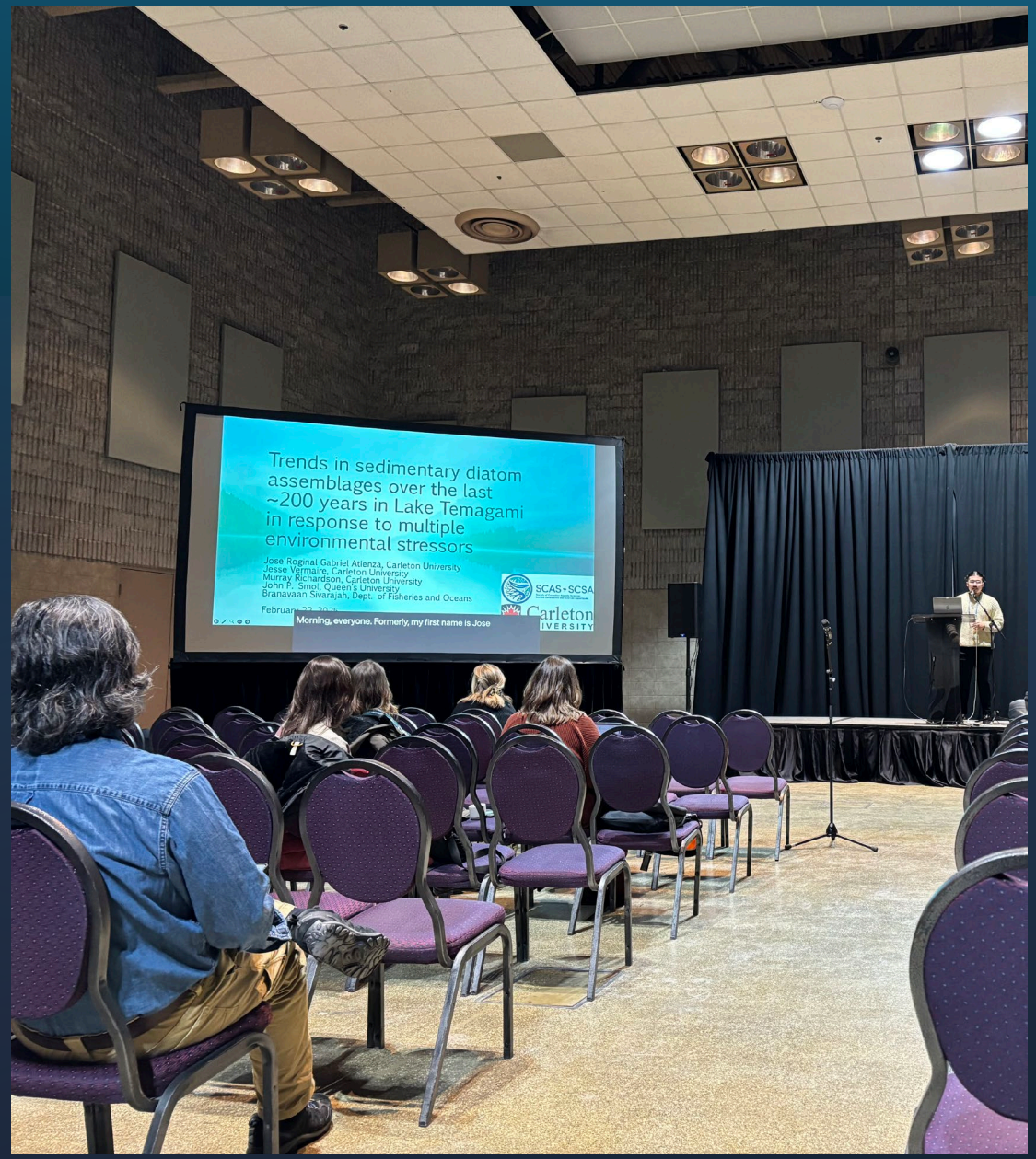
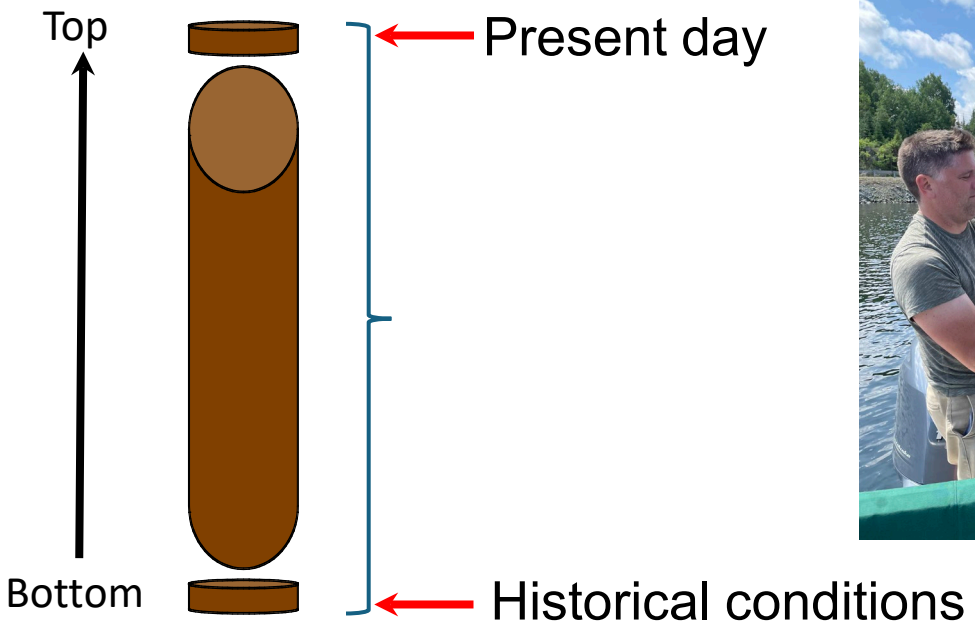
Carleton UNIVERSITY



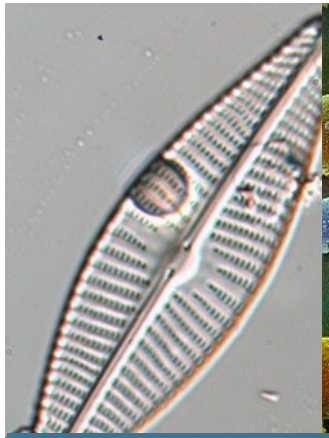
Jose Atienza
MSc student in Geography at Carleton University

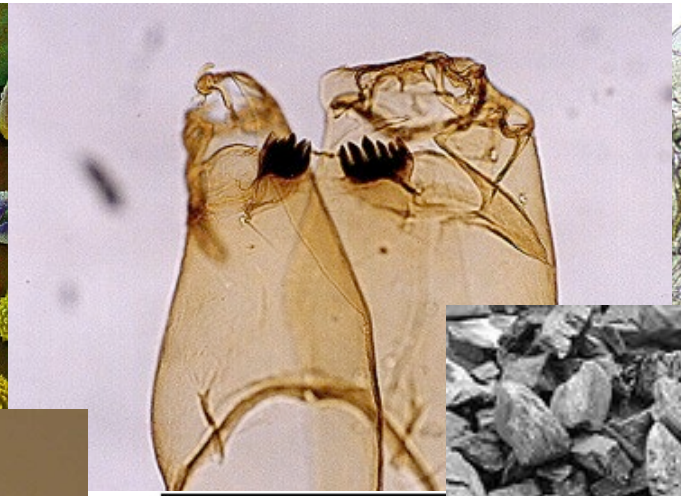
Paleolimnology

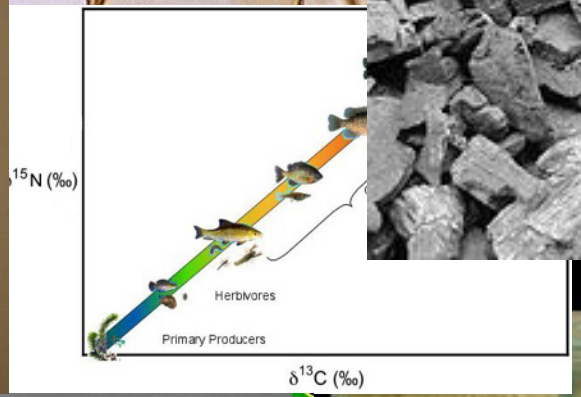
- Lakes have a memory of environmental change

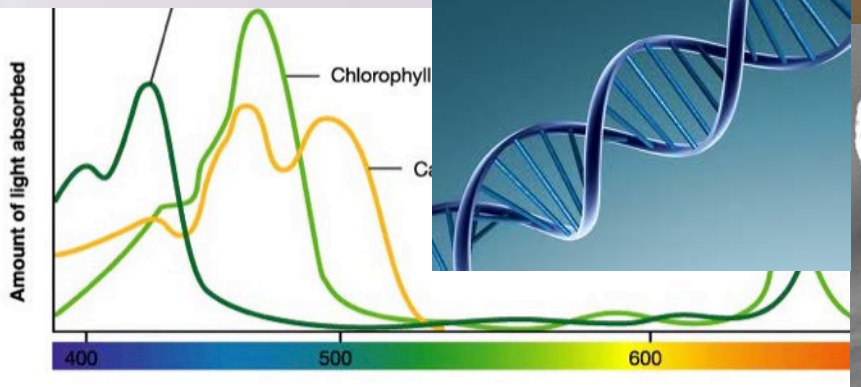


Indicators in Sediment Records

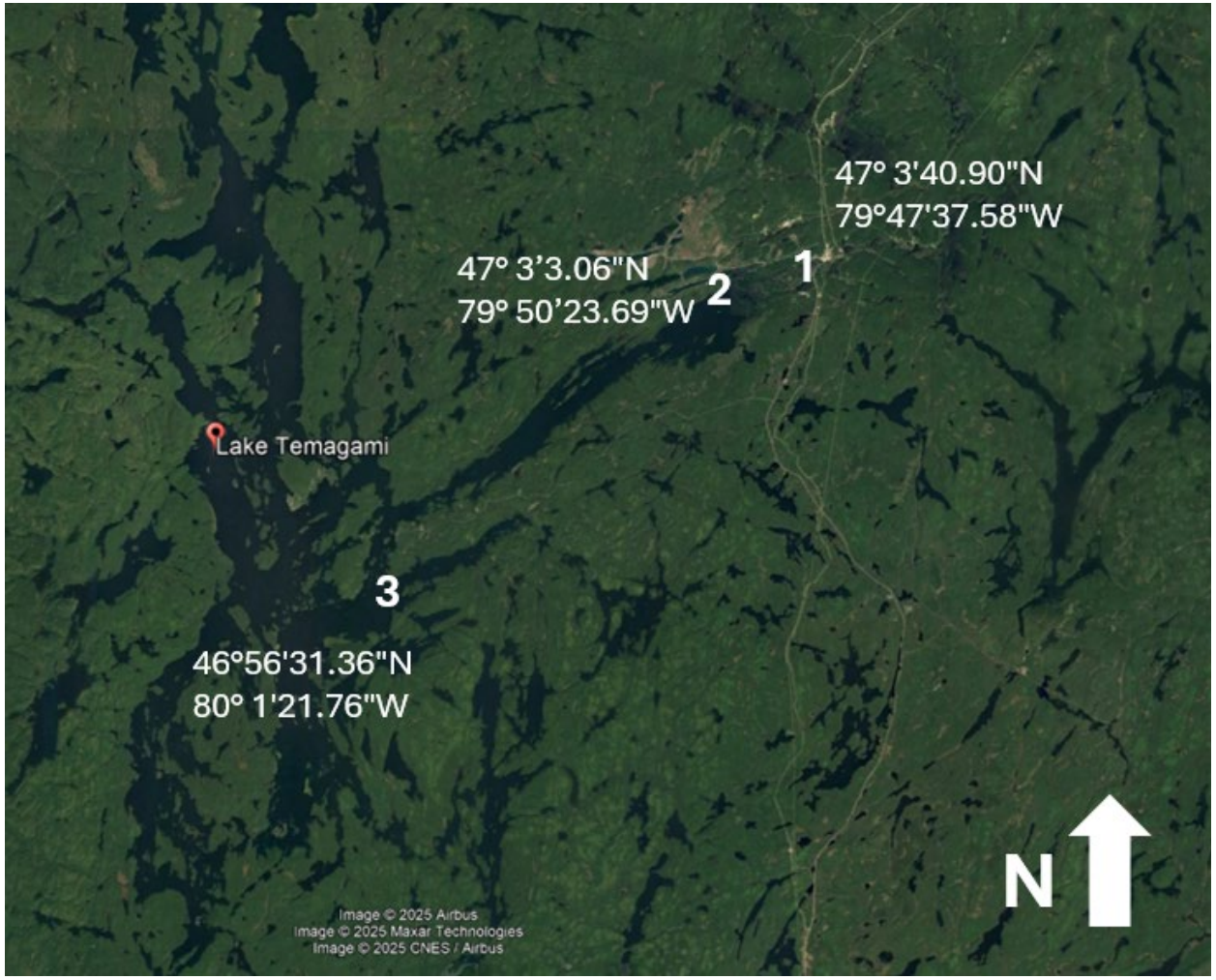








Lake Temagami



- Sediment Core collection from 3 sites:
  - Core 1: Shallow bay in Town
  - Core 2: Northeast arm
  - Core 3 Deep water/ central hub

- Dating sediment core
  - Lead-210 naturally occurring radioisotope with half life ~22 years
  - Cs-137 independent marker peaks ~1962

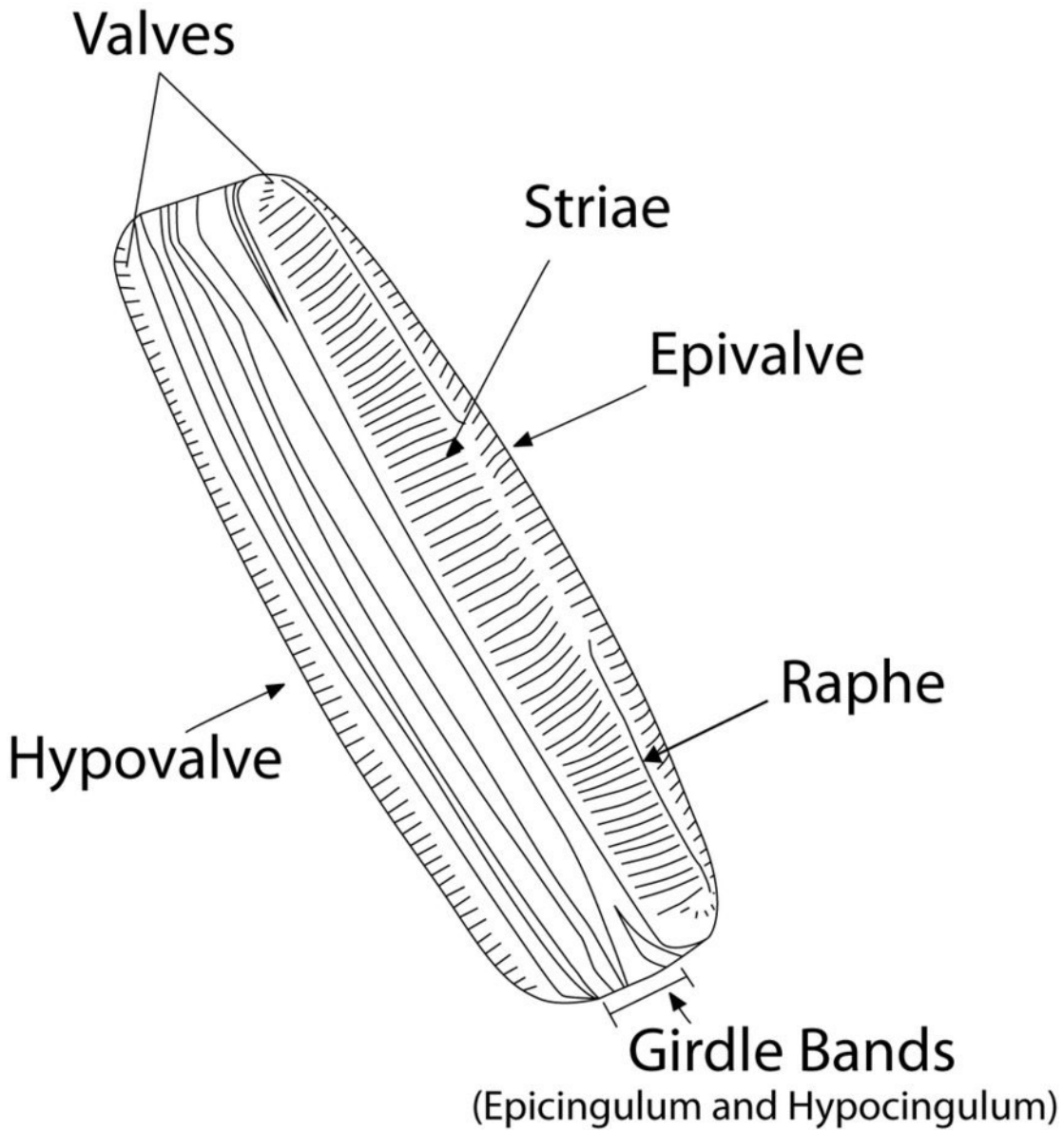
Environmental Indicators

- Chlorophyll *a*
  - Pigment involved in photosynthesis
  - Indicator of amount of primary producers in lake (algae)

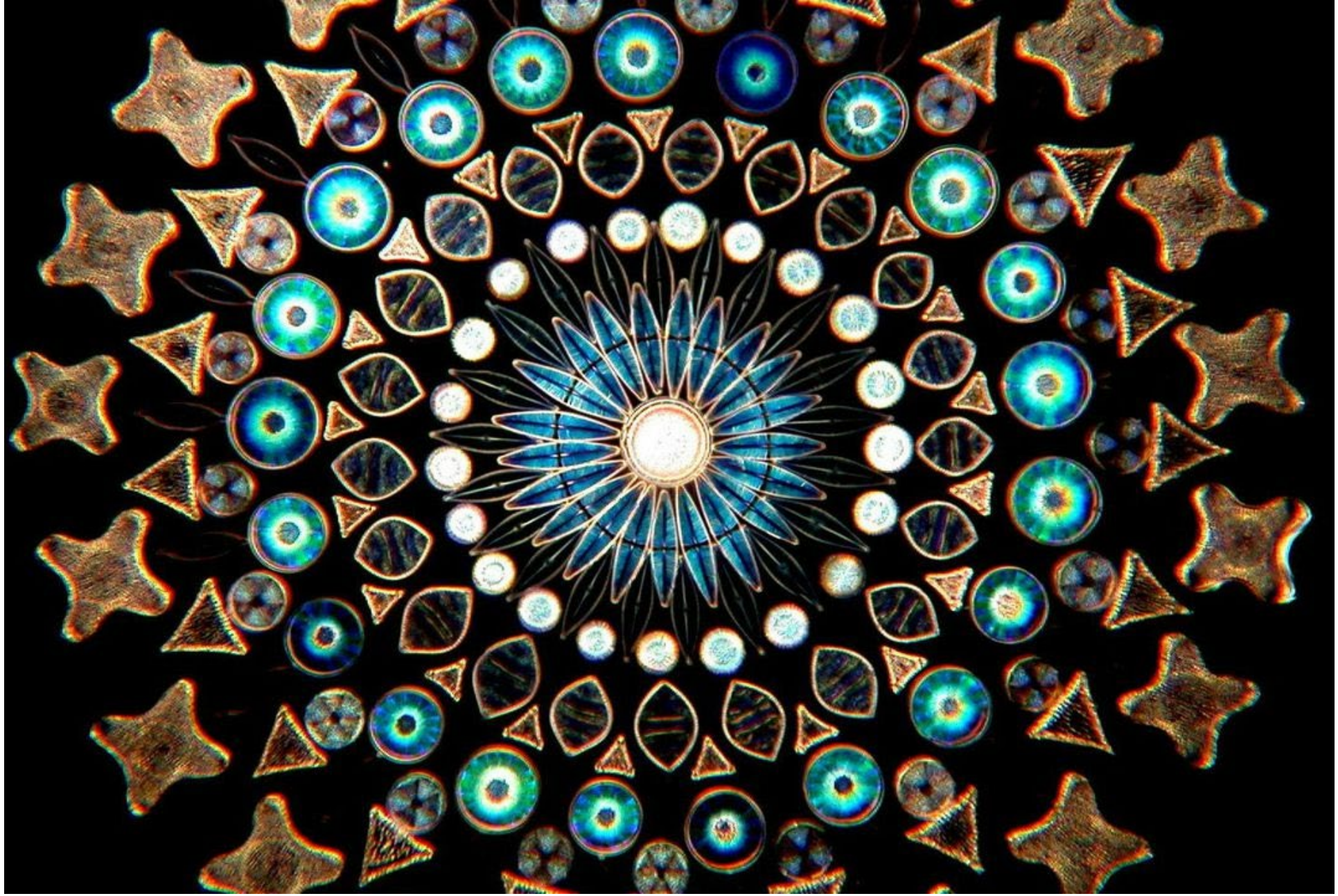
- Diatoms
  - Single celled algae, thousands of different species with differing environmental optima
  - Powerful bioindicator of environmental change

- Metal(loids)
  - Concentration of metals in sediment
  - Indicator of past industrial activity at local to global scales

Diatoms



https://www.deviantart.com/skipperthepilot/art/Diatom-Diagram-204179856



Smithsonian Magazine

Environmental changes

1. Water level regulation
2. Acid Rain
3. Global warming

Water level regulation

Cross Lake Control Dam

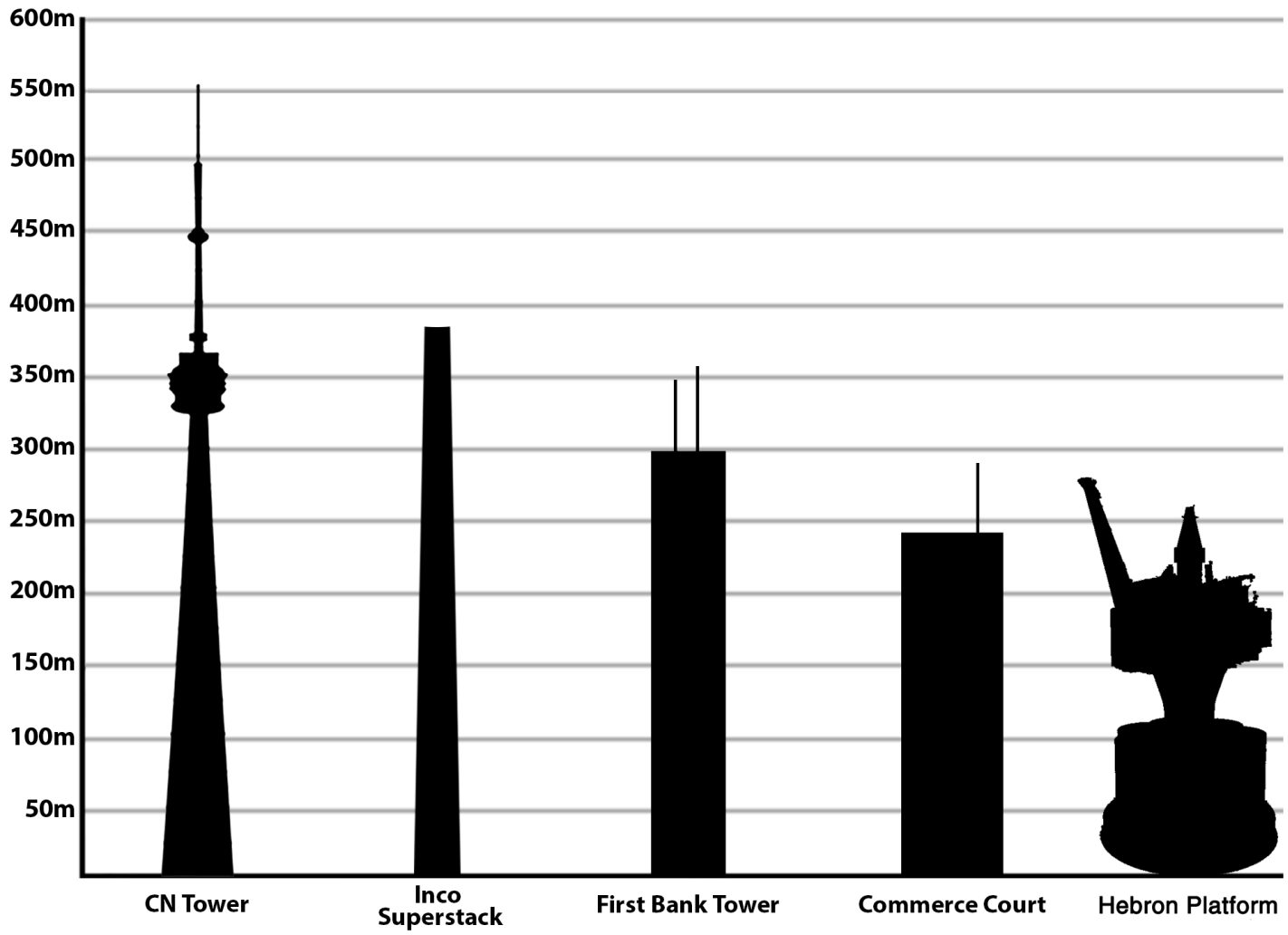
- Constructed in 1917 (OPG)

Metal(loid) deposition and acid rain

Vale-Inco superstack
Sudbury Ontario

- Became operational in 1972
- 2018 emissions greatly reduced
- Superstack to be dismantled

Tallest structures in Canada



Global warming and lake ecosystems

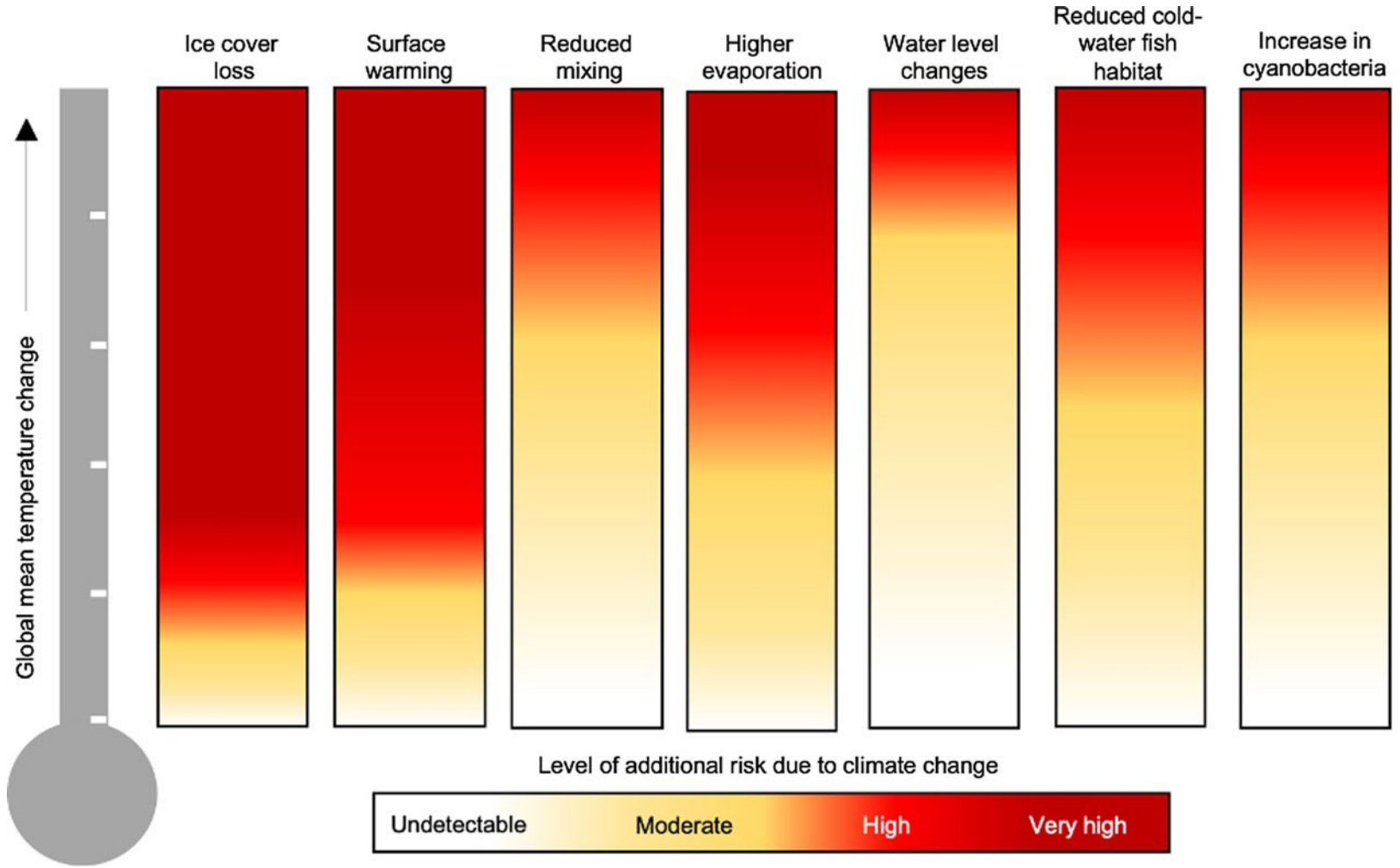


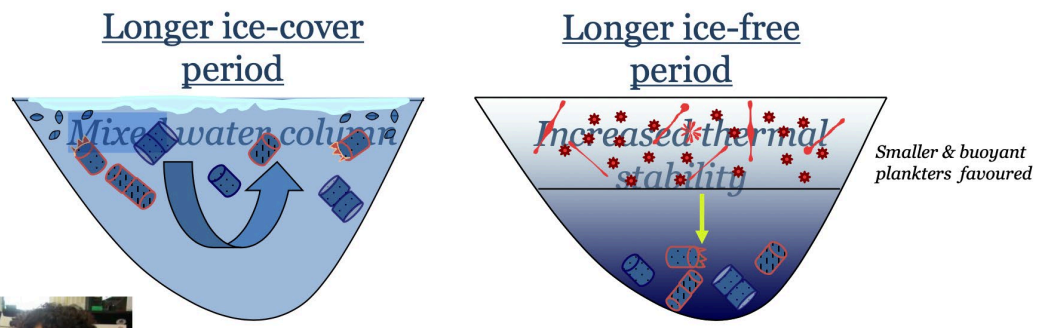
Figure 4. Expected climate change responses of key lake ecosystem processes. Shown are the level of additional risk to ...

BioScience, biac052, https://doi.org/10.1093/biosci/biac052

Longer growing season and warmer water temperatures can increase the likelihood of algae blooms.

Warming temperatures and lake water properties

Planktonic diatoms favoured



- changes in mixing strength and depth
- changes in water column light & nutrients

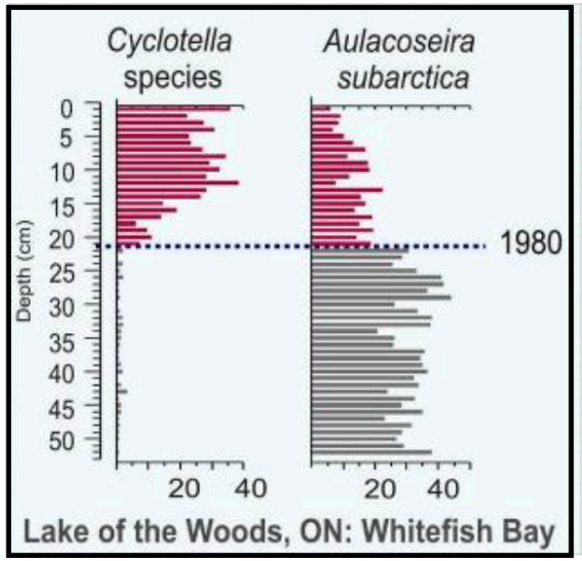
Schematic: K. Rühland

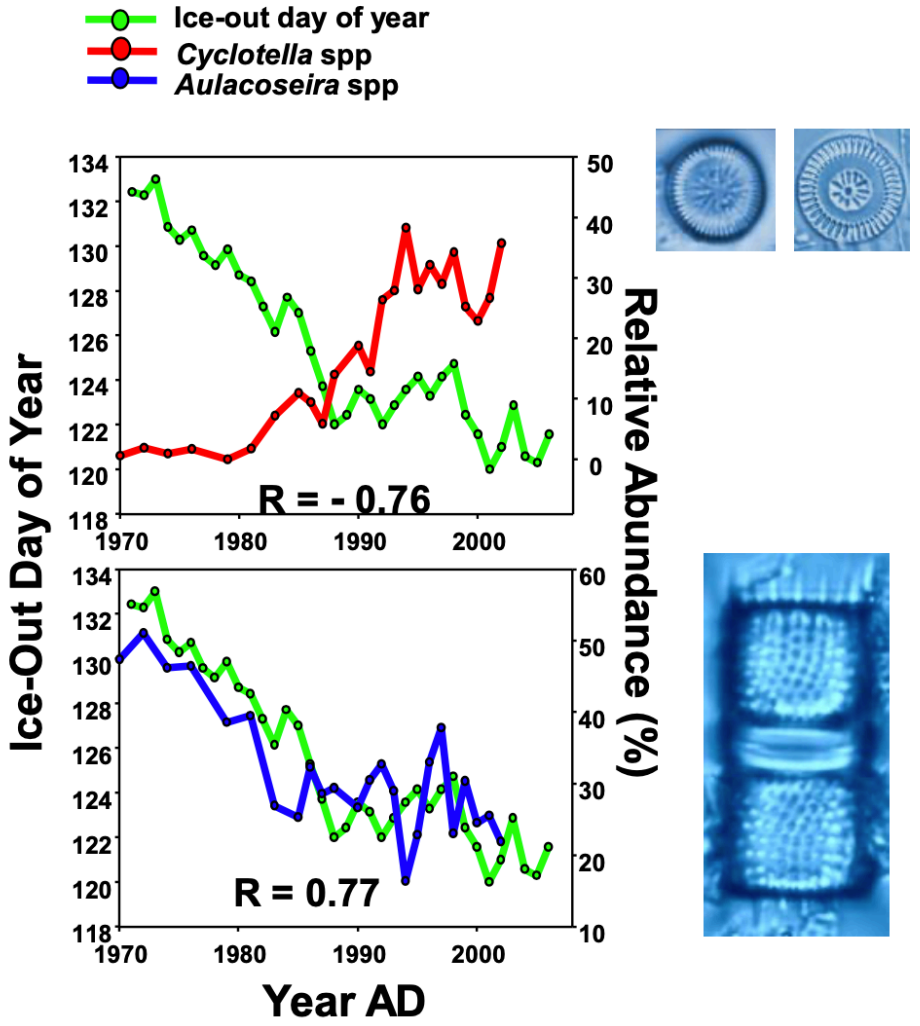
Queen's University

PEARL

Lake of the Woods, Canada and USA – lake ice data

Whitefish Bay – Reference site

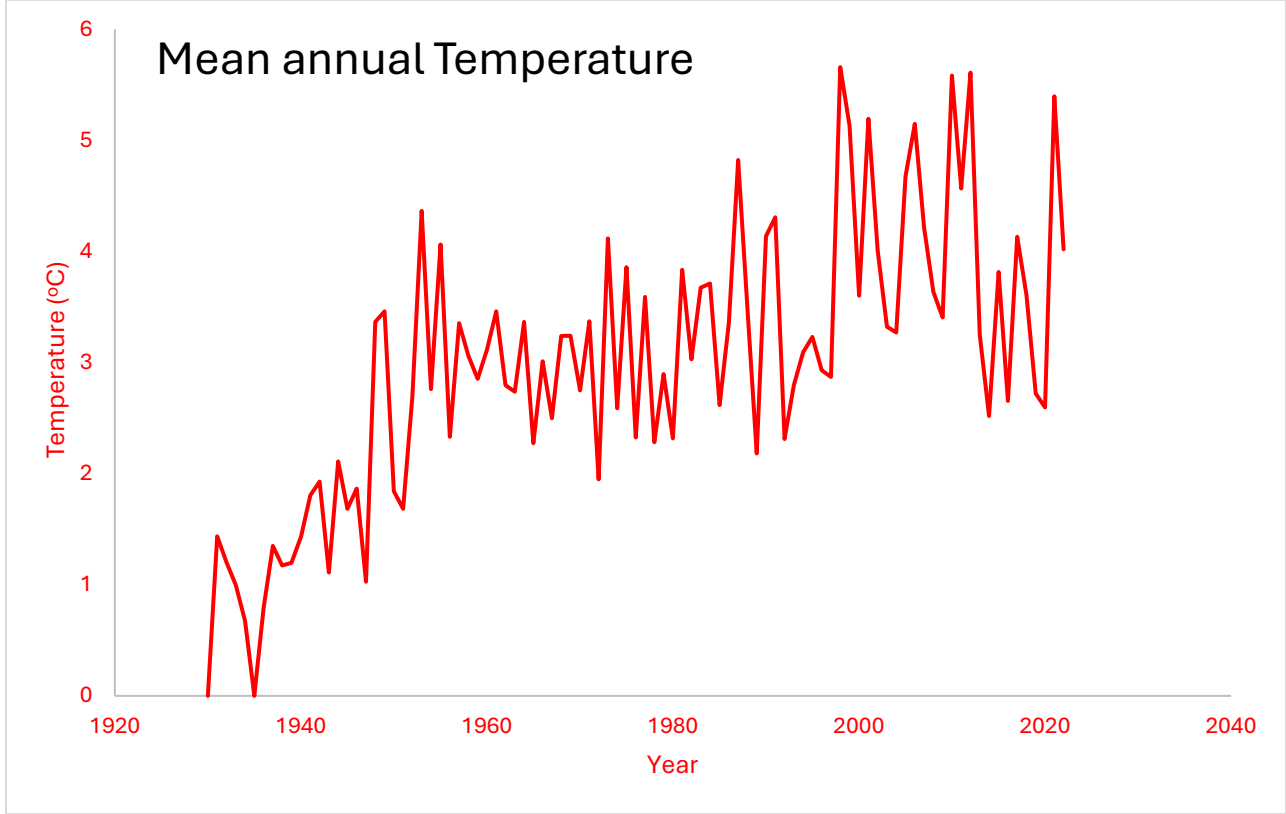


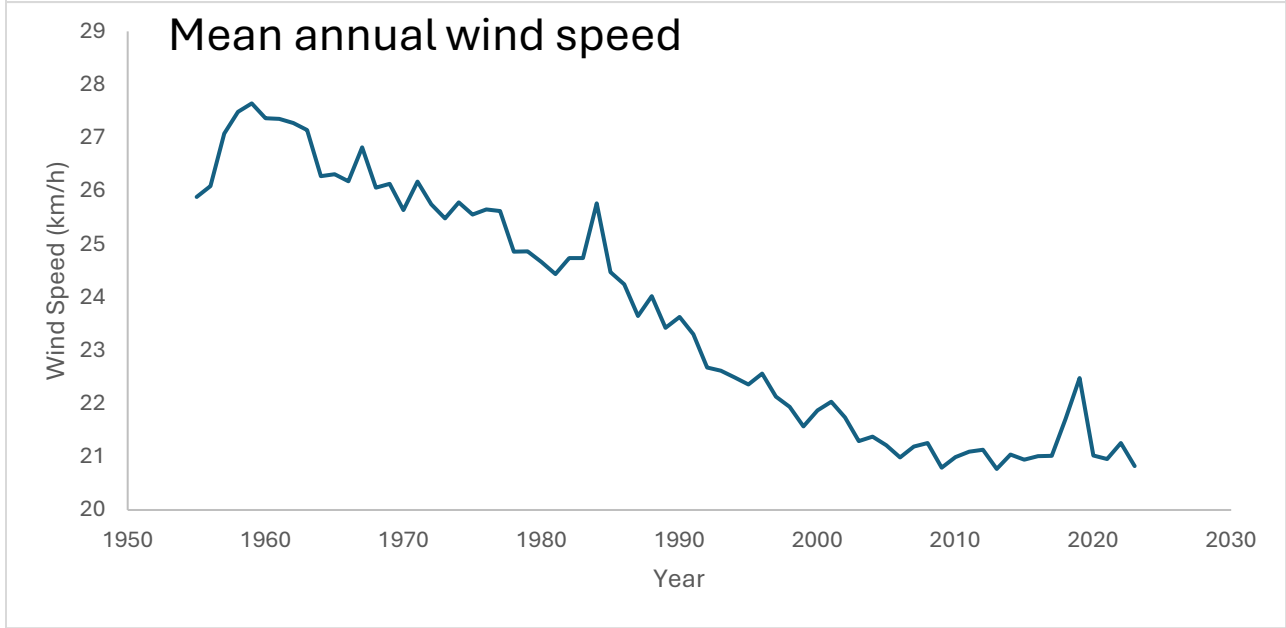


Rühland, Paterson, Smol 2008: Global Change Biology

Regional climate trends for Temagami

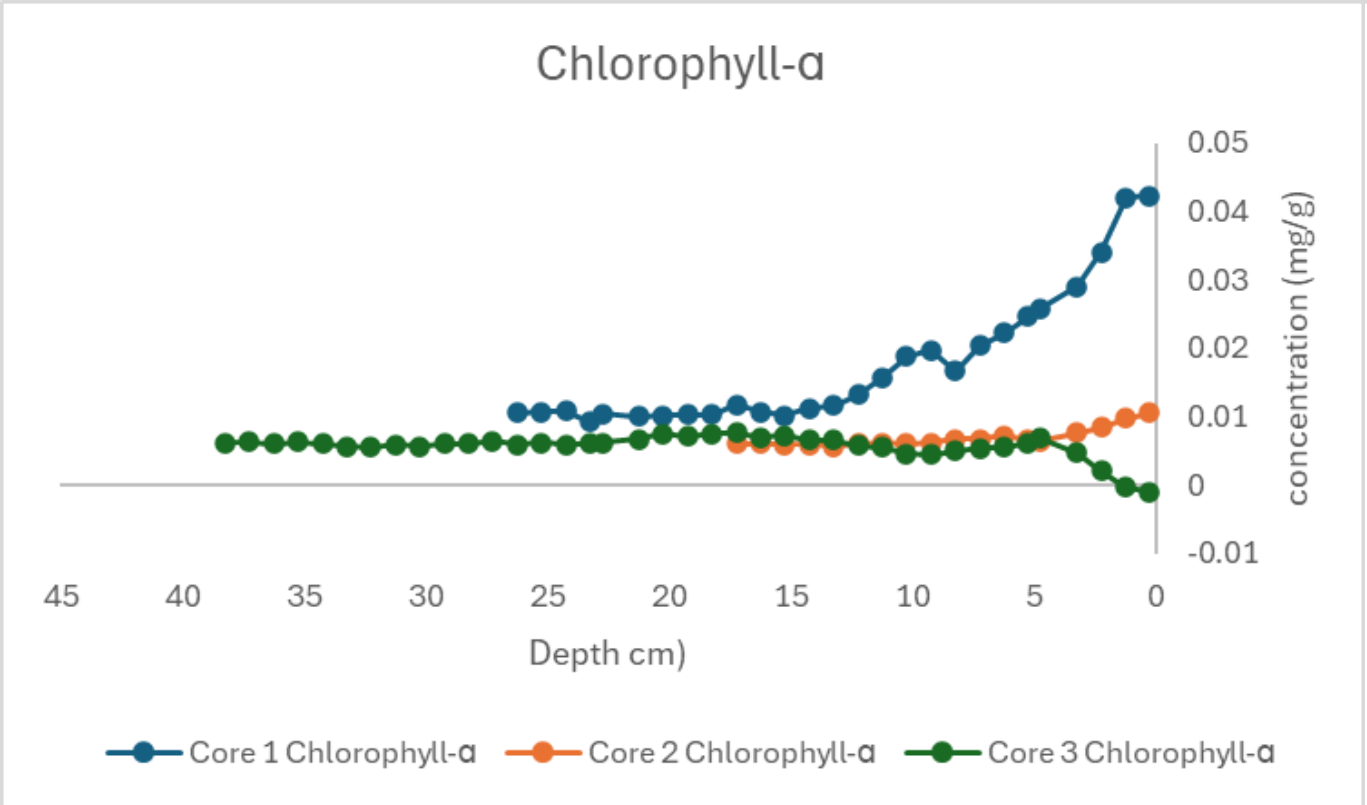
- Warming temperatures
- Reduced wind speed

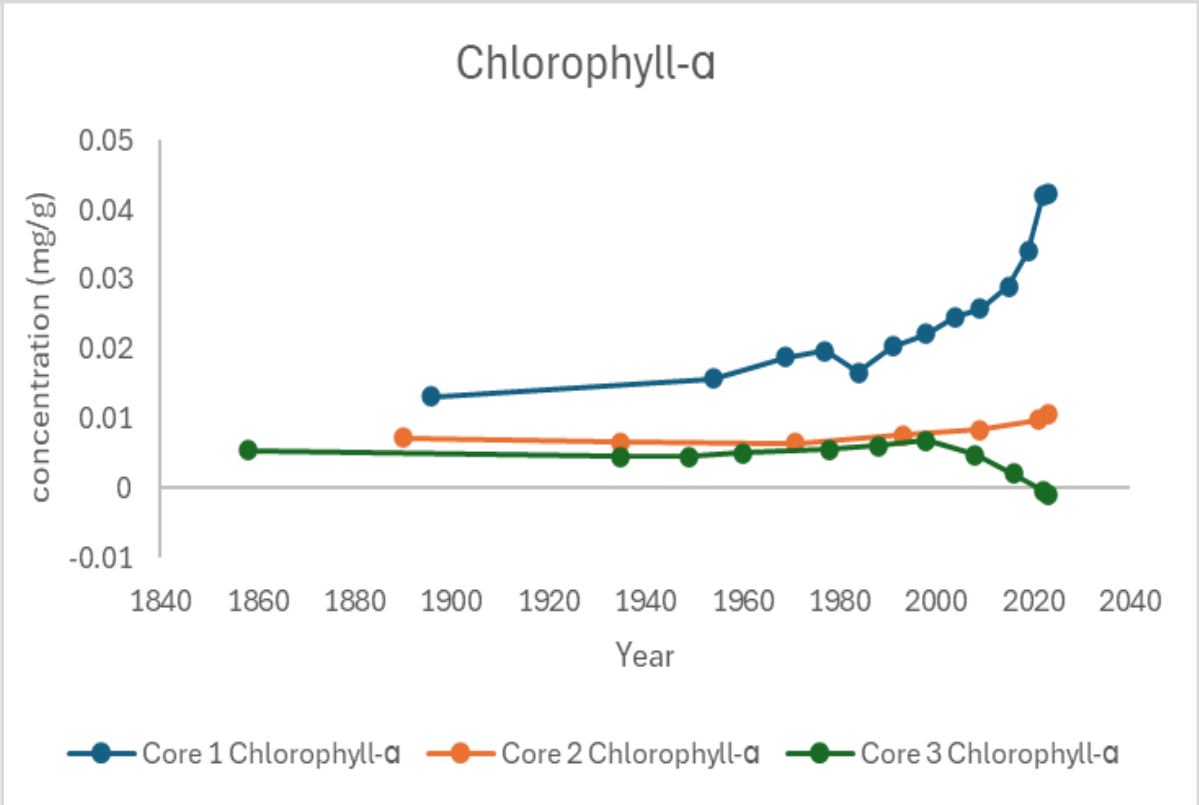




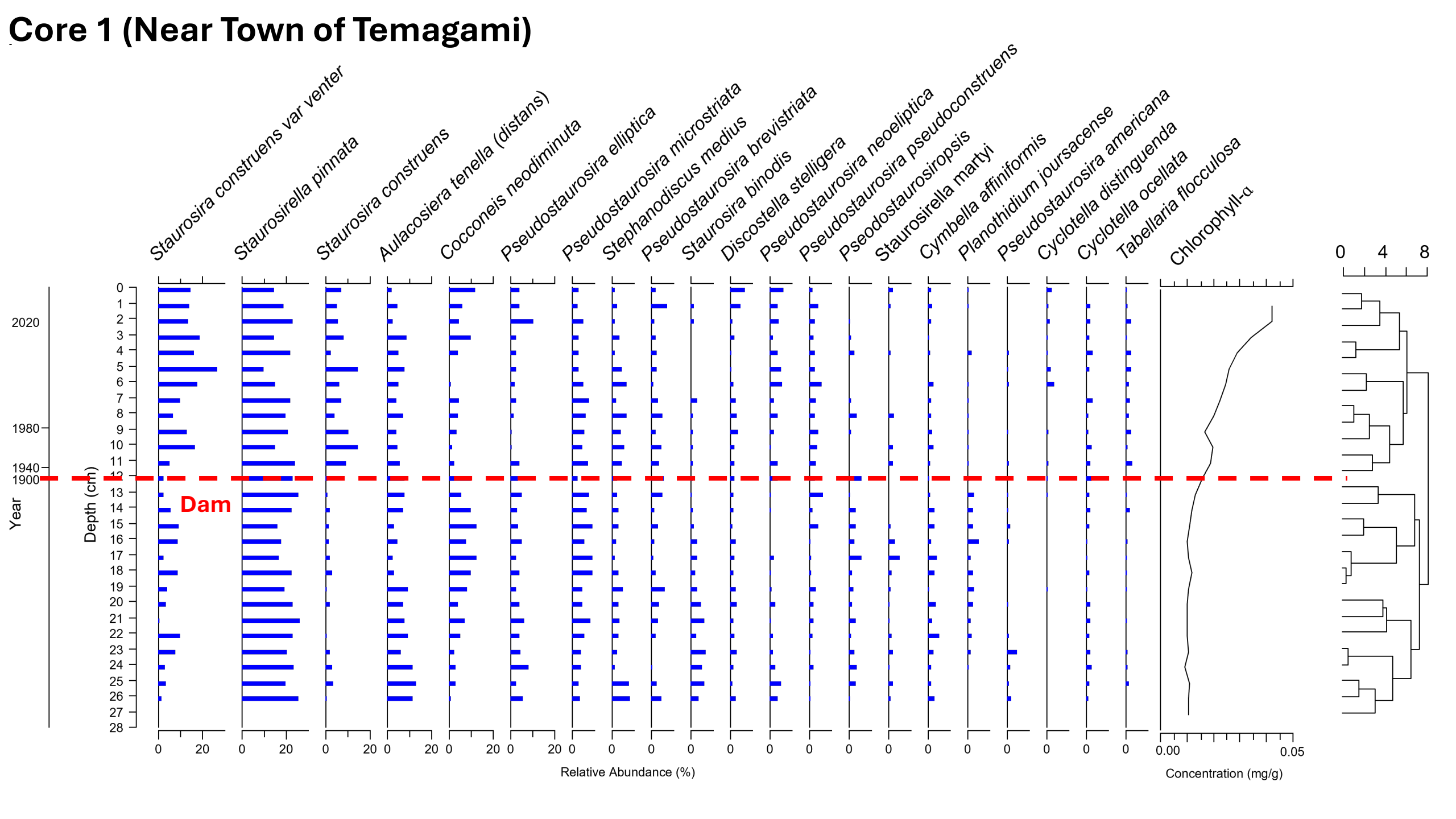
Sedimentary Chlorophyll-*a* Concentration (mg/g) over the years and depth (cm)

- Increase of primary production in Core 1 and 2

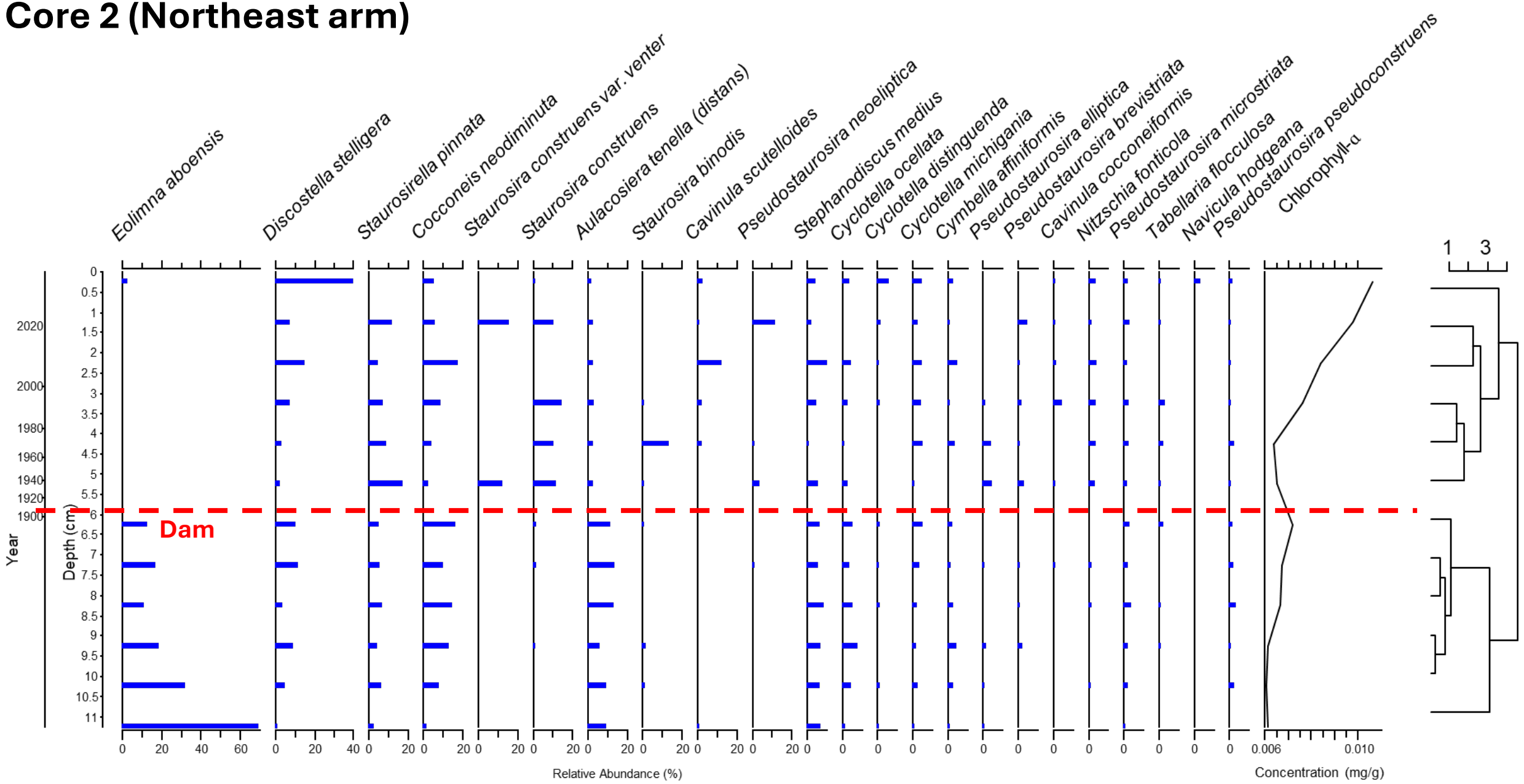




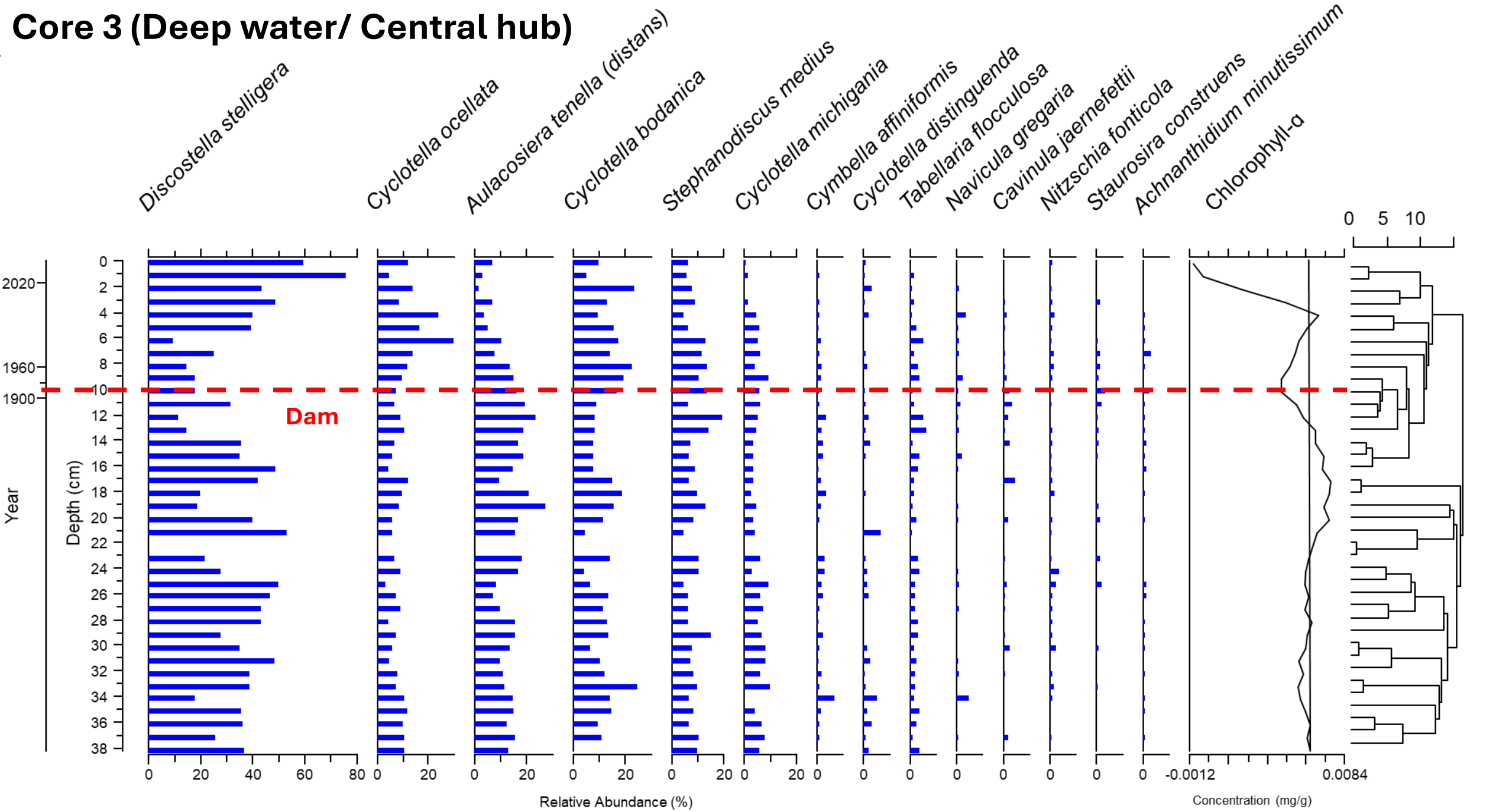
Core 1 (Near Town of Temagami)



Core 2 (Northeast arm)



Core 3 (Deep water/ Central hub)



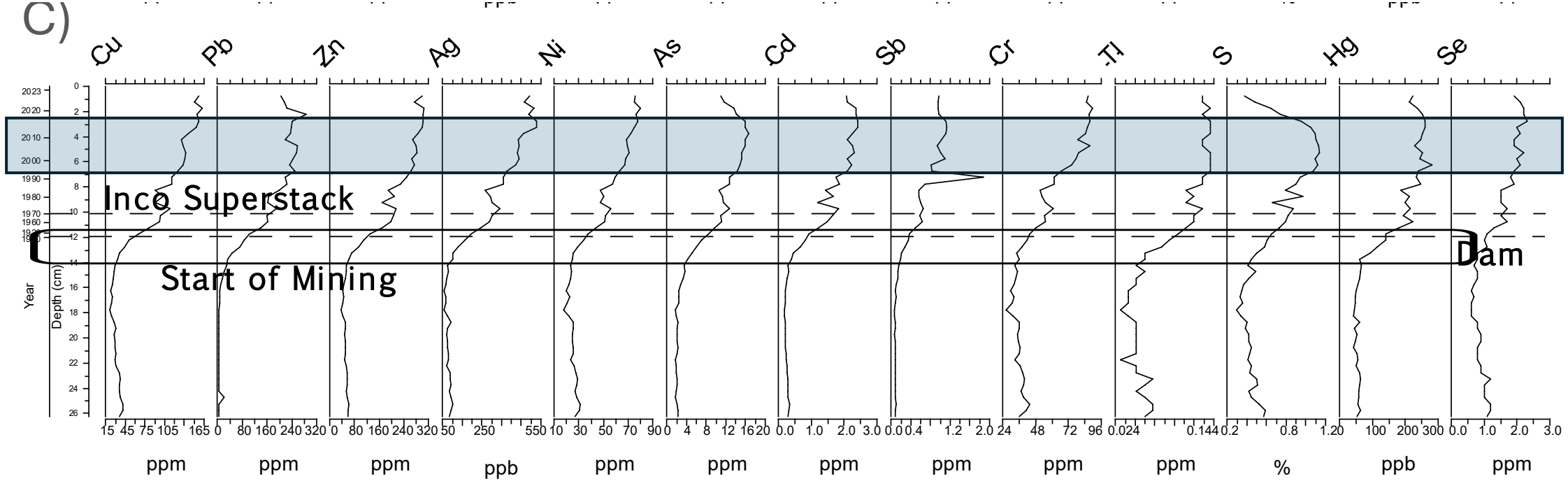
Metal(loid) deposition and acid rain

Vale-Inco superstack
Sudbury Ontario

- Became operational in 1972
- 2018 emissions greatly reduced
- Superstack to be dismantled

Core 3 (Deep water/ Central hub) Metal(loids)

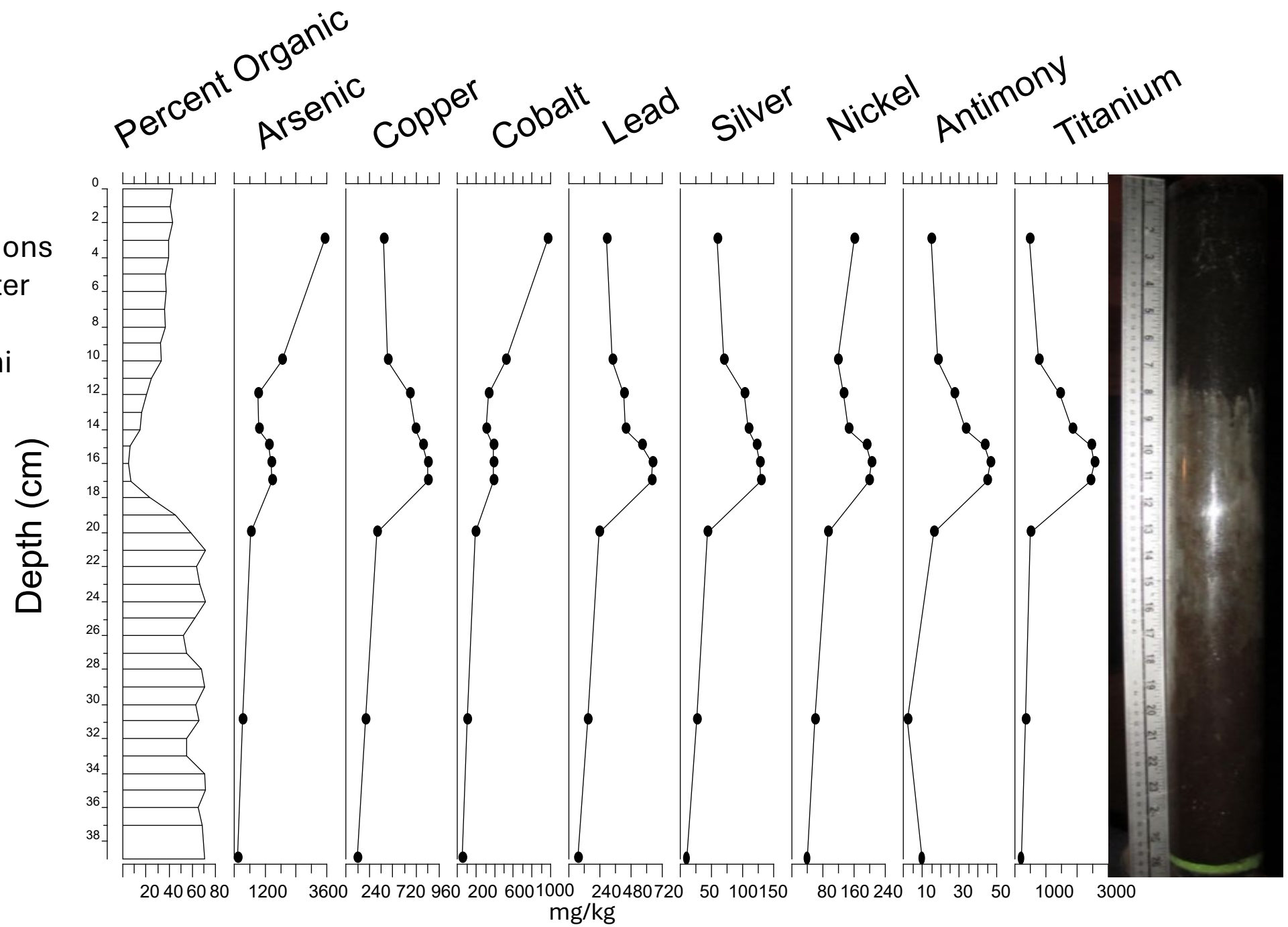
- Metal(loid) concentrations in the sediment begin increasing ~1900
- % Sulfur peaks in the early 2000s and begins declining ~2018
- Some metal(loids) remain elevated



Cobalt Ontario

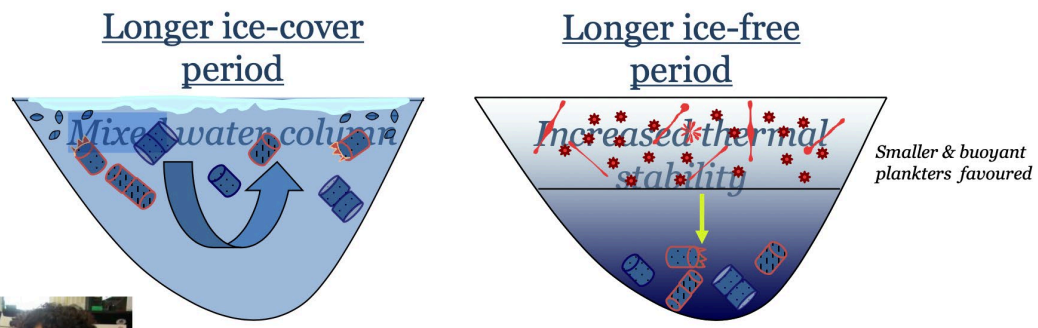

Cobalt Ontario: Direct input of mine tailings to lakes
Mayfair Rd
Mayfair Rd
Ibsen Pond
100 m

- As concentrations ~x100 greater than Temamgami



Warming temperatures and lake water properties

Planktonic diatoms favoured



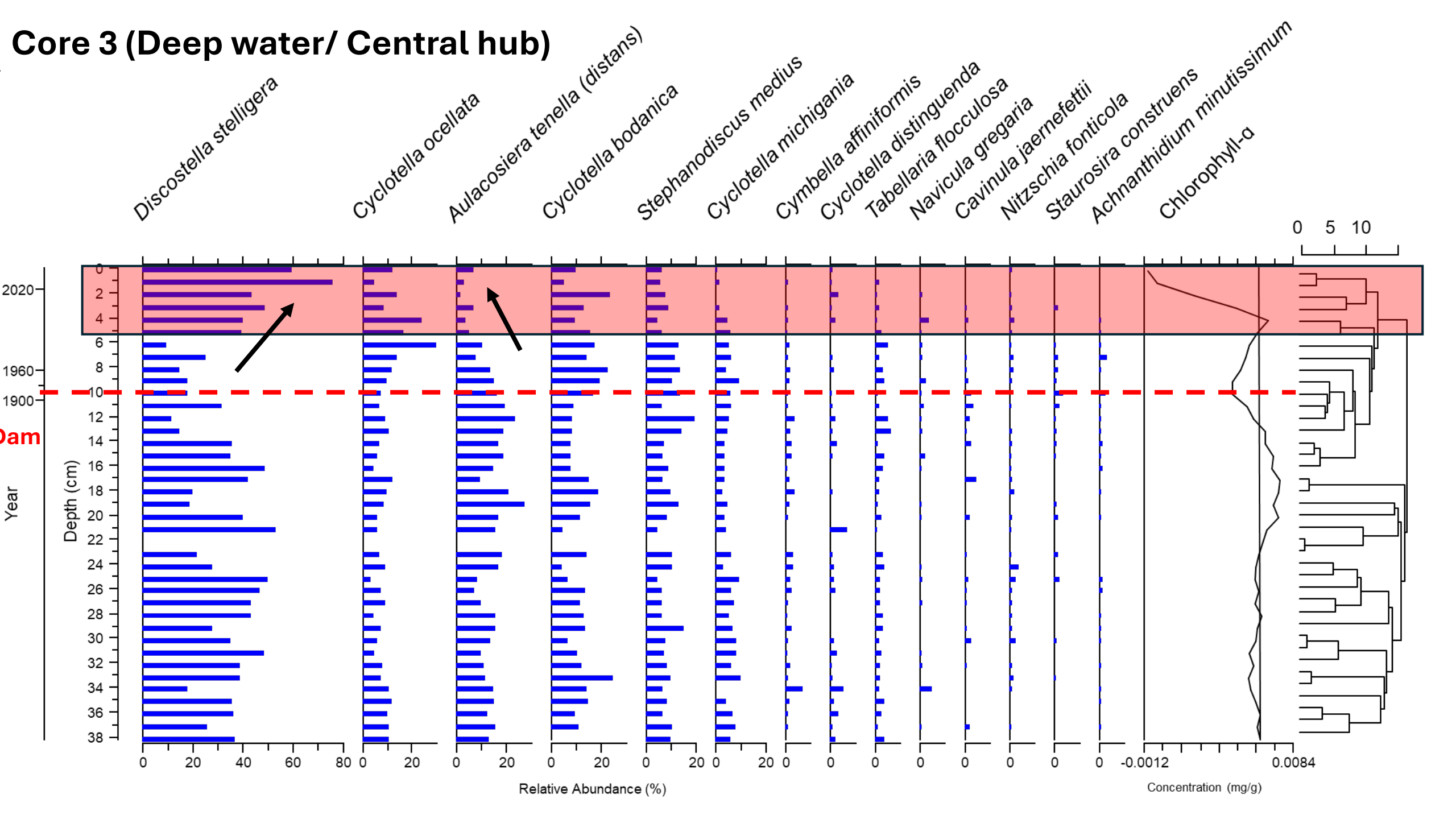
- changes in mixing strength and depth
- changes in water column light & nutrients

Schematic: K. Rühland

Queen's University

PEARL

Core 3 (Deep water/ Central hub)



Conclusions

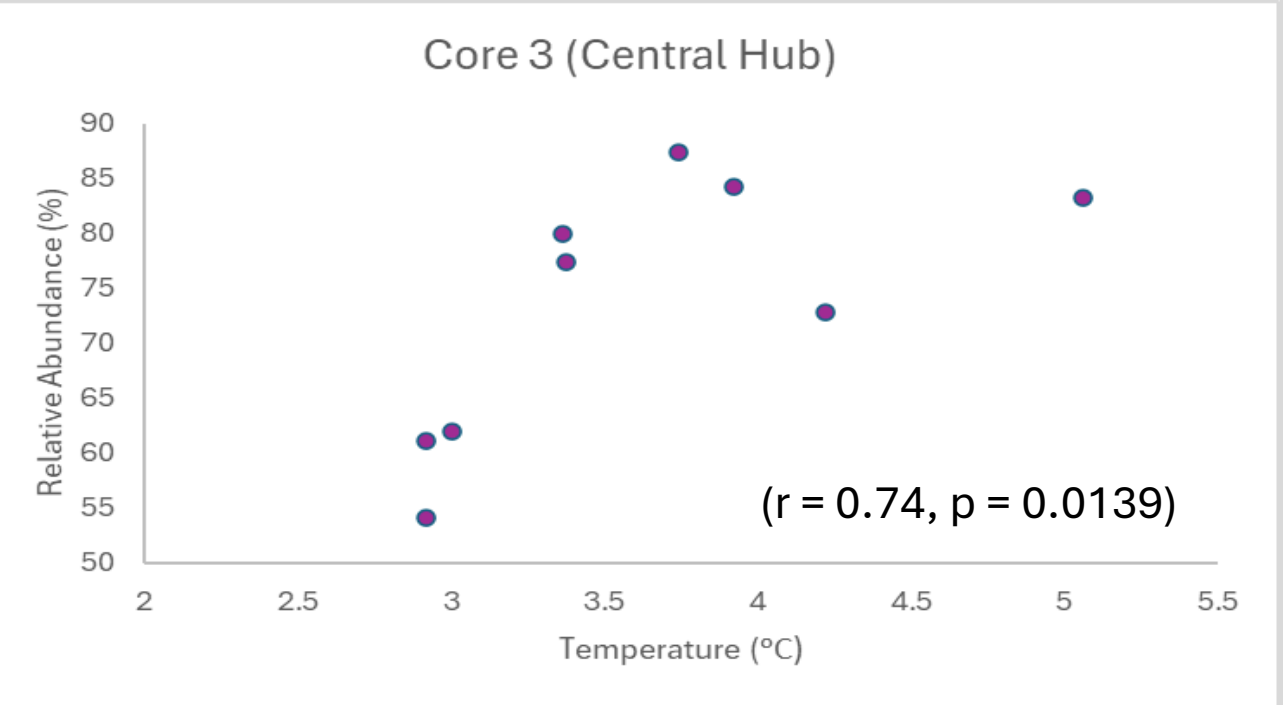
- Water regulation had the largest effect on the diatom community, particularly in the shallower cores
- Evidence of metal(loid) deposition during acid rain, however some chemical recovery is evident
- Global warming may be increasing primary production in the shallower sections of the lake and increasing the strength of thermal stritification

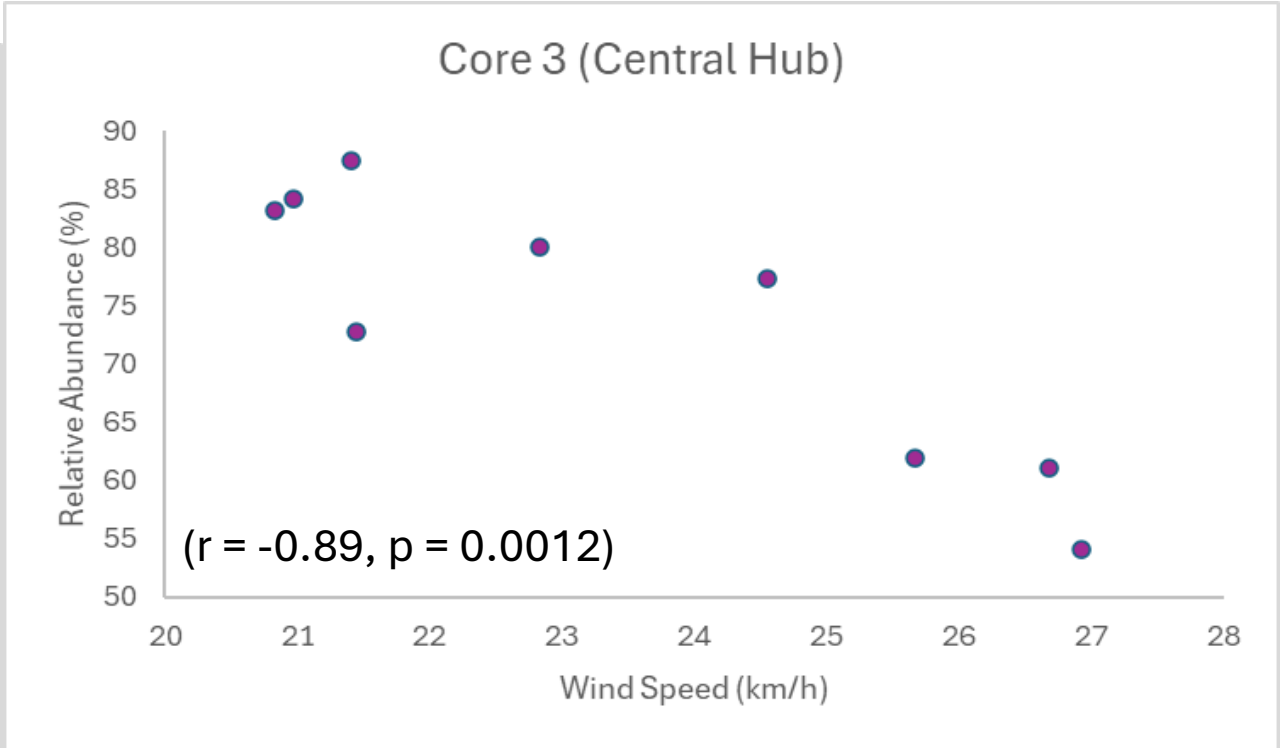
Thank you

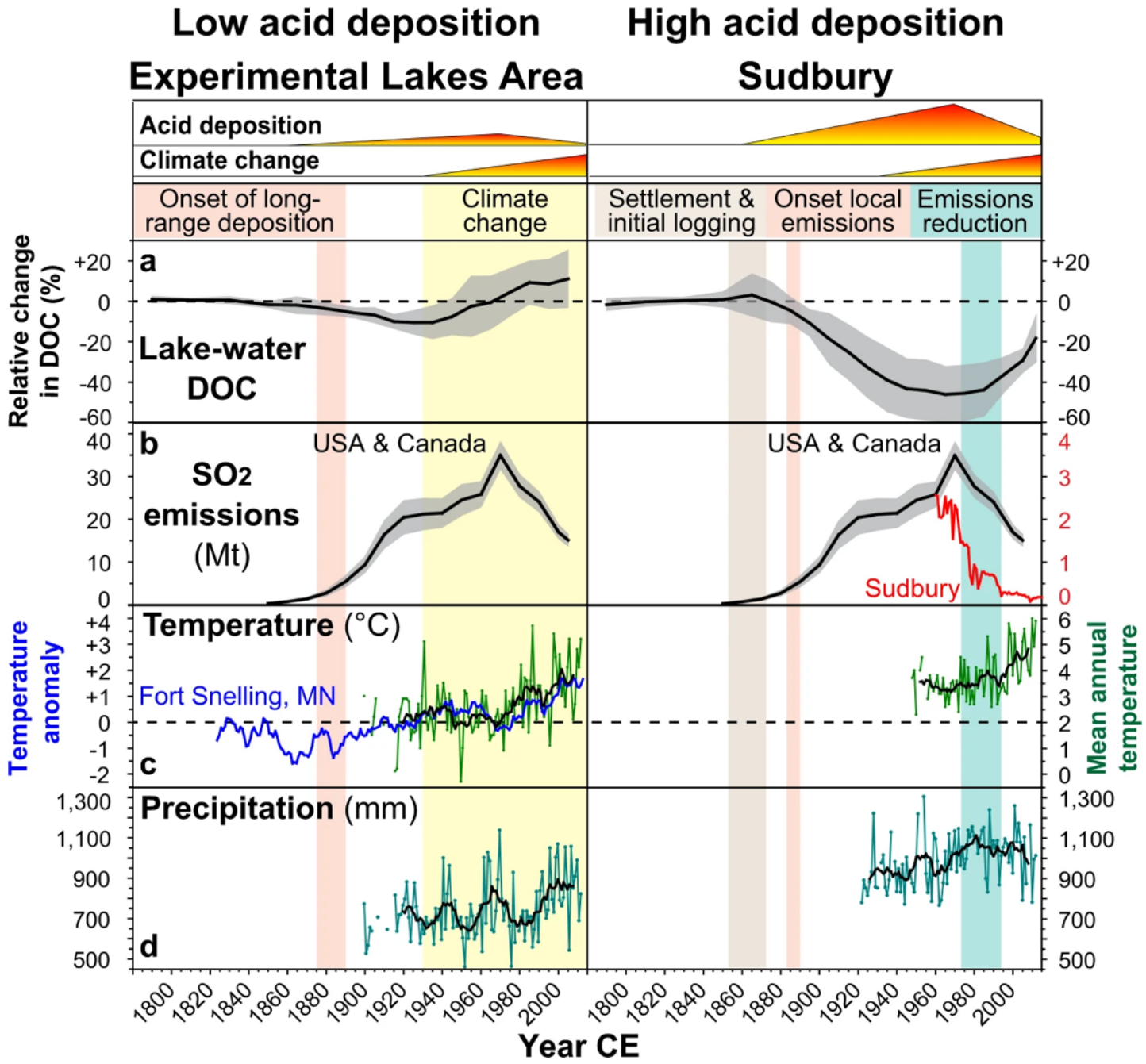
Temagami Environmental Research and Stewardship (TERAS)

Natural Science and Engineering Research Council (NSERC)

Results (Wind Speed and *Discostella stelligera/Cyclotella spp.*)

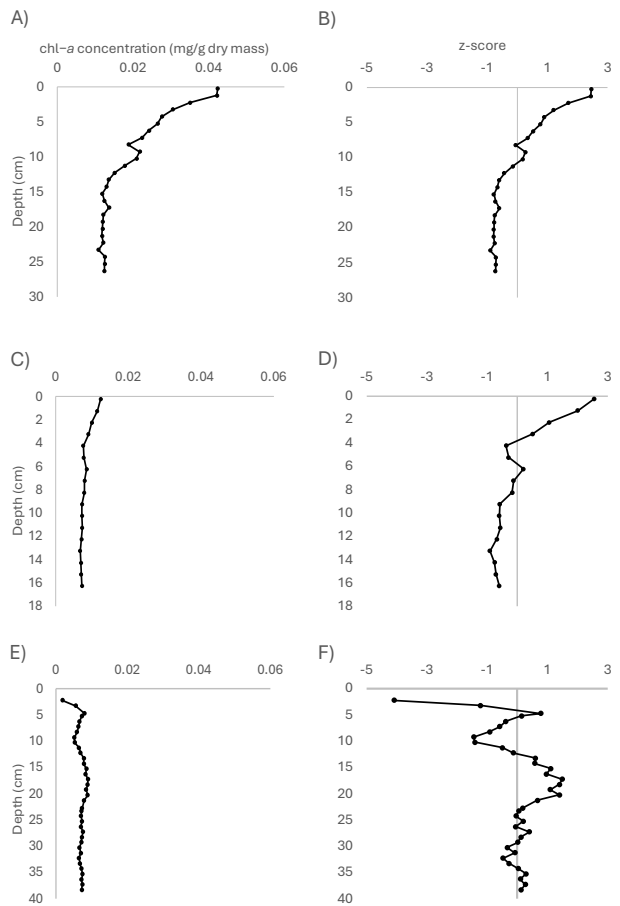


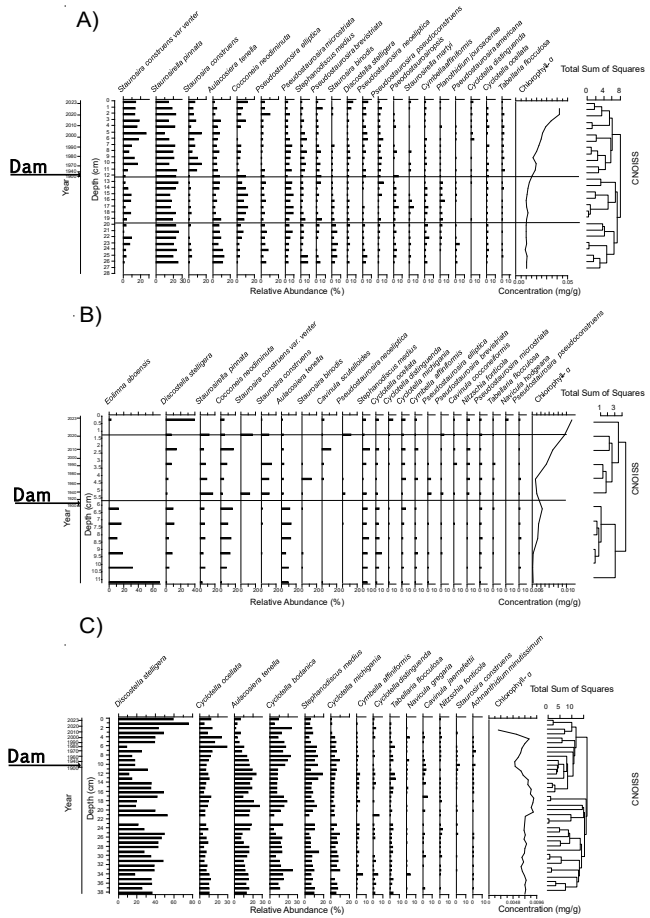


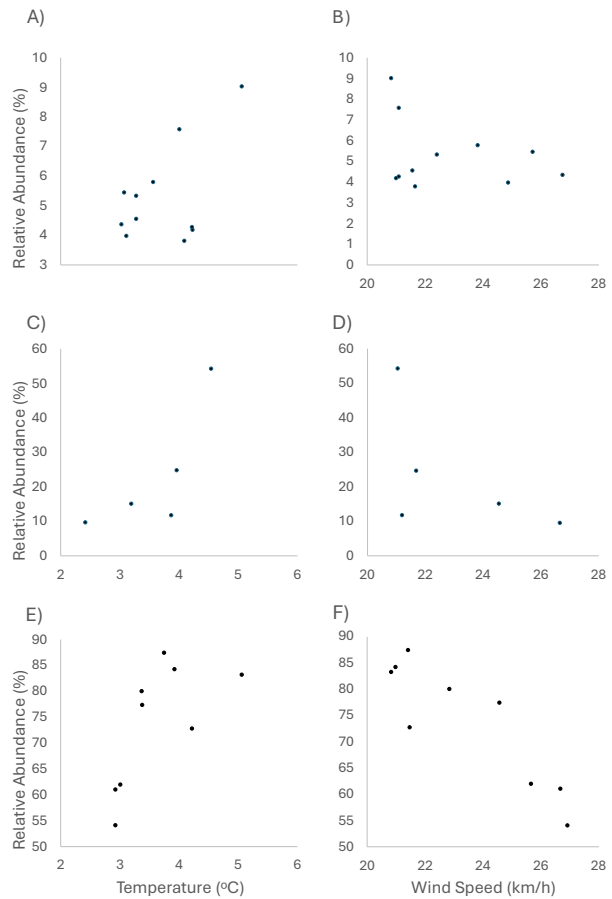


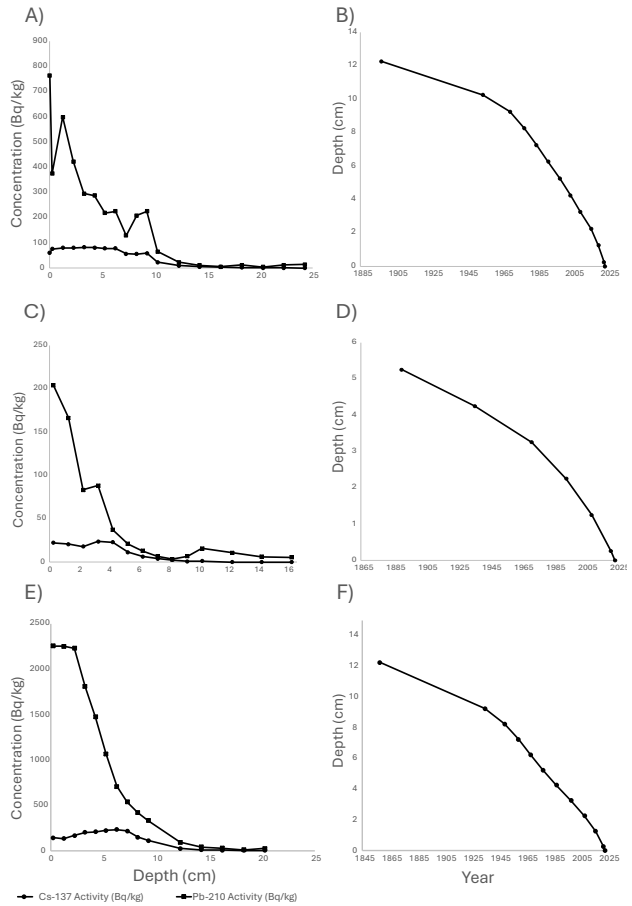
- Climate change may increase dissolved organic carbon (DOC) also known as “lake browning”
- Recovery from acid rain deposition can also lead to recovery of DOC concentrations.

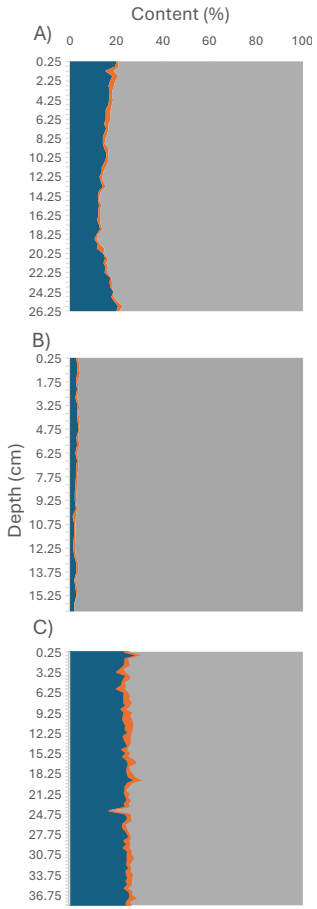
Meyer-Jacob, C., *et al. Sci Rep* **9**, 16676 (2019). https://doi.org/10.1038/s41598-019-52912-0

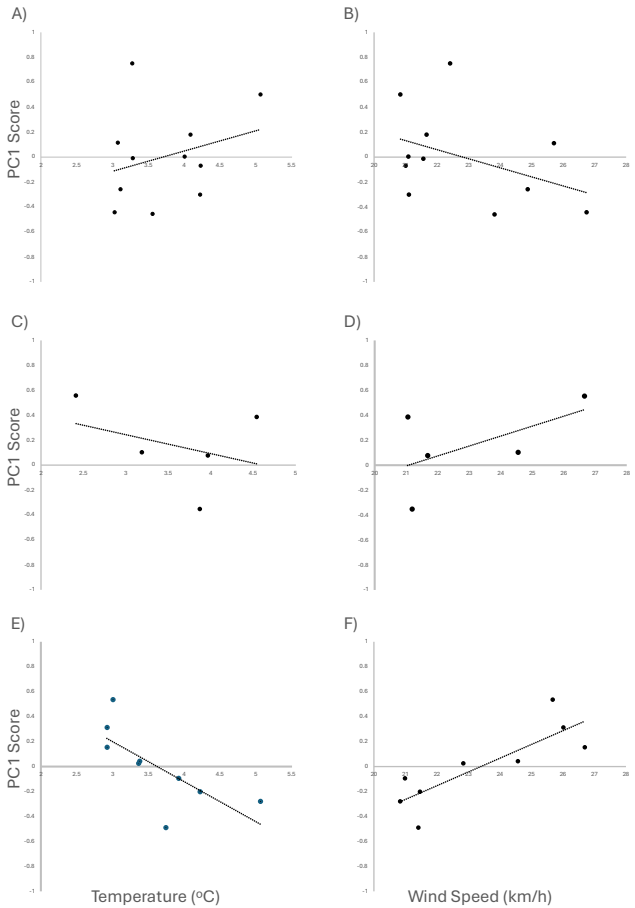

A)
chl-a concentration (mg/g dry mass)
0
0.02
0.04
0.06
Depth (cm)
0
5
10
15
20
25
30
B)
z-score
-5
-3
-1
1
3
C)
D)
E)
F)
0
2
4
6
8
10
12
14
16
18
35
40

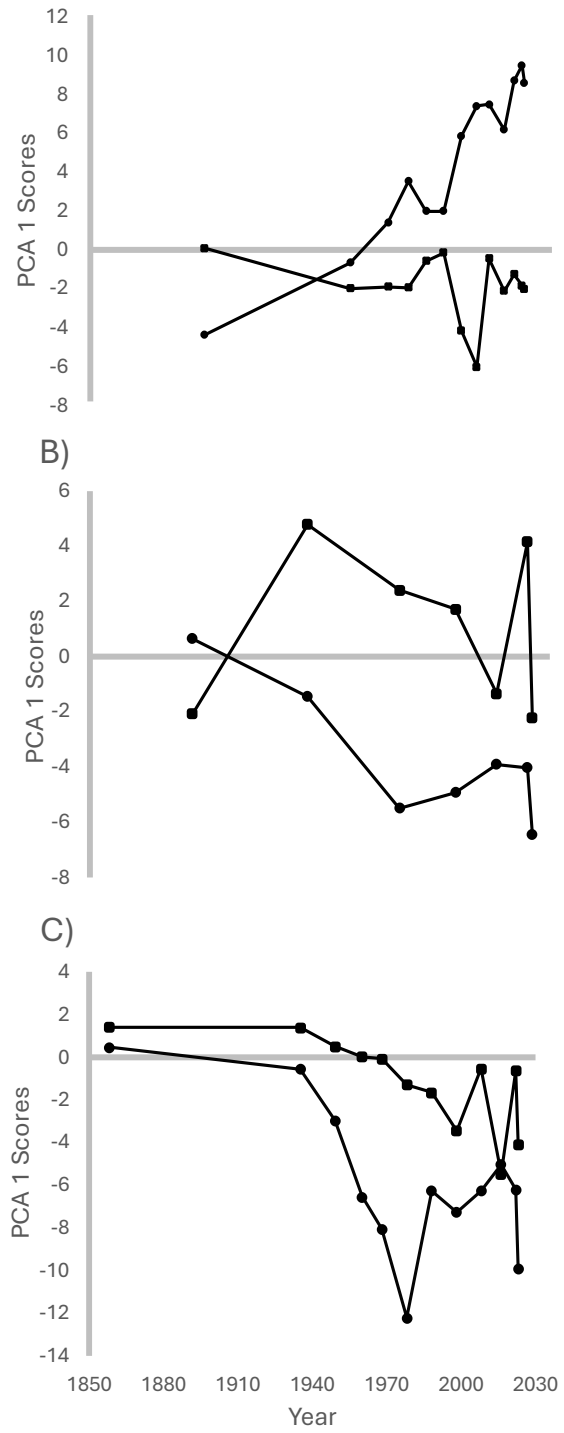

A)
Dam
Year
Depth (cm)
Total Sum of Squares
CNOISS
Relative Abundance (%)
Concentration (mg/g)
B)
Dam
Year
Depth (cm)
Total Sum of Squares
CNOISS
Relative Abundance (%)
Concentration (mg/g)
C)
Dam
Year
Depth (cm)
Total Sum of Squares
CNOISS
Relative Abundance (%)
Concentration (mg/g)

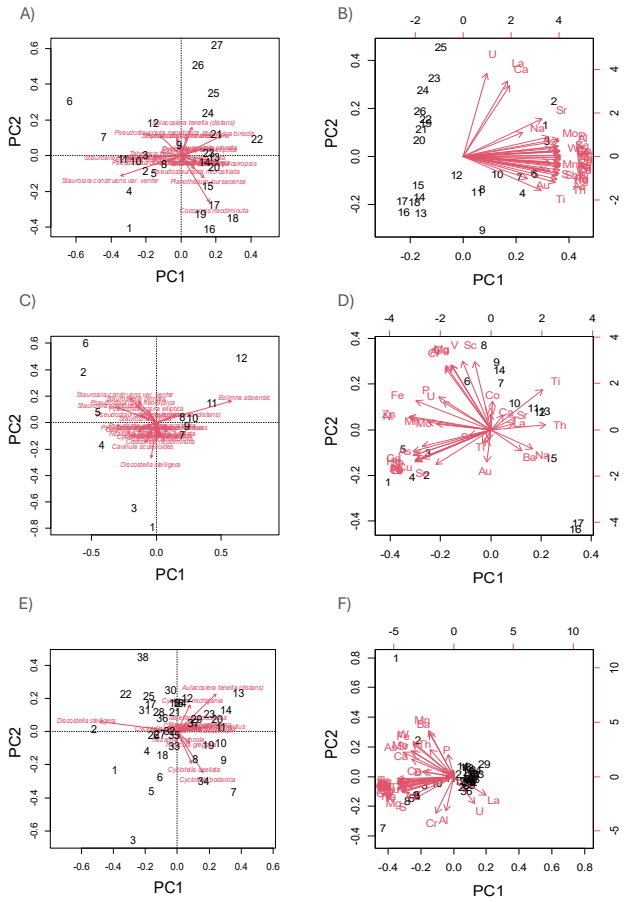

A)
B)
C)
D)
E)
F)
Relative Abundance (%)
Temperature (°C)
Wind Speed (km/h)

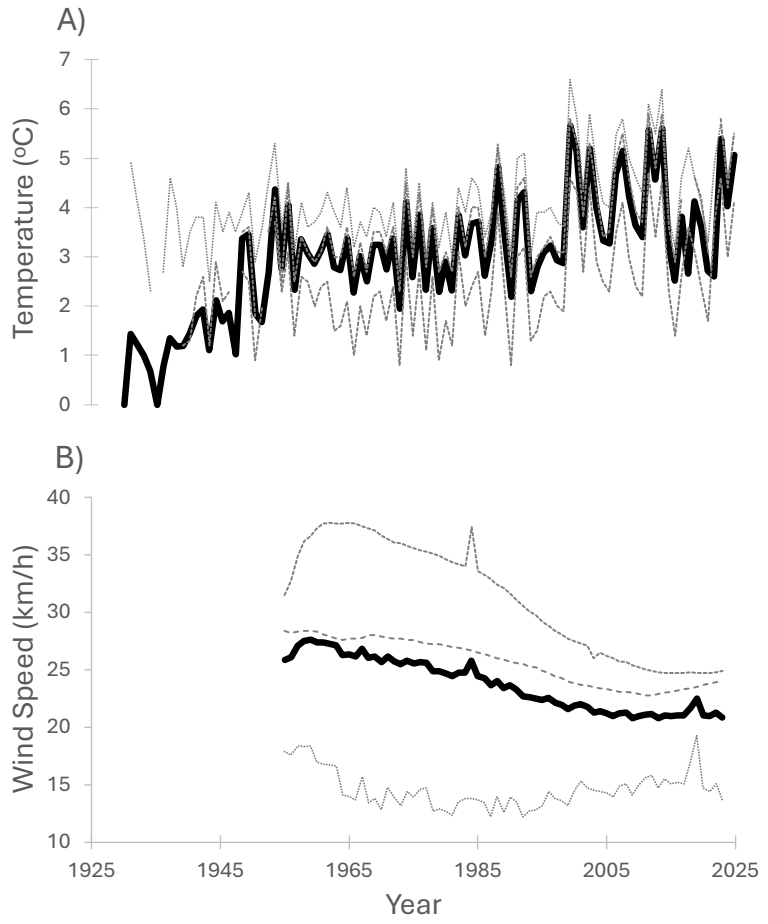

A)
B)
C)
D)
E)
F)
Concentration (Bq/kg)
Depth (cm)
Year
Cs-137 Activity (Bq/kg)
Pb-210 Activity (Bq/kg)


Content (%)
A)
0
20
40
60
80
100
0.25
2.25
4.25
6.25
8.25
10.25
12.25
14.25
16.25
18.25
20.25
22.25
24.25
26.25
B)
Depth (cm)
0.25
1.75
3.25
4.75
6.25
7.75
9.25
10.75
12.25
13.75
15.25
C)
0.25
3.25
6.25
9.25
12.25
15.25
18.25
21.25
24.75
27.75
30.75
33.75
36.75


A)
B)
C)
D)
E)
F)
PC1 Score
PC1 Score
PC1 Score
Temperature (ºC)
Wind Speed (km/h)


B)
C)
PCA 1 Scores
Year
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
1850
1880
1910
1940
1970
2000
2030


A)
B)
C)
D)
E)
F)
PC1
PC2


A)
Temperature (°C)
7
6
5
4
3
2
1
0
B)
Wind Speed (km/h)
40
35
30
25
20
15
10
1925
1945
1965
1985
2005
2025
Year

Data Collection - lab analysis

Taxonomic analysis

Species matrix

taxa
a b c d e f
lakes
1 2 3 4 5 6
Data

statistical analysis

Environmental analysis

Environment matrix

environment
TP pH O2 Temp
lakes
1 2 3 4 5 6
Data

Modern species environment relationship