Diatoms as indicators of biological recovery from acidification and metal-contamination in urban lakes in Sudbury, Canada

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Outline

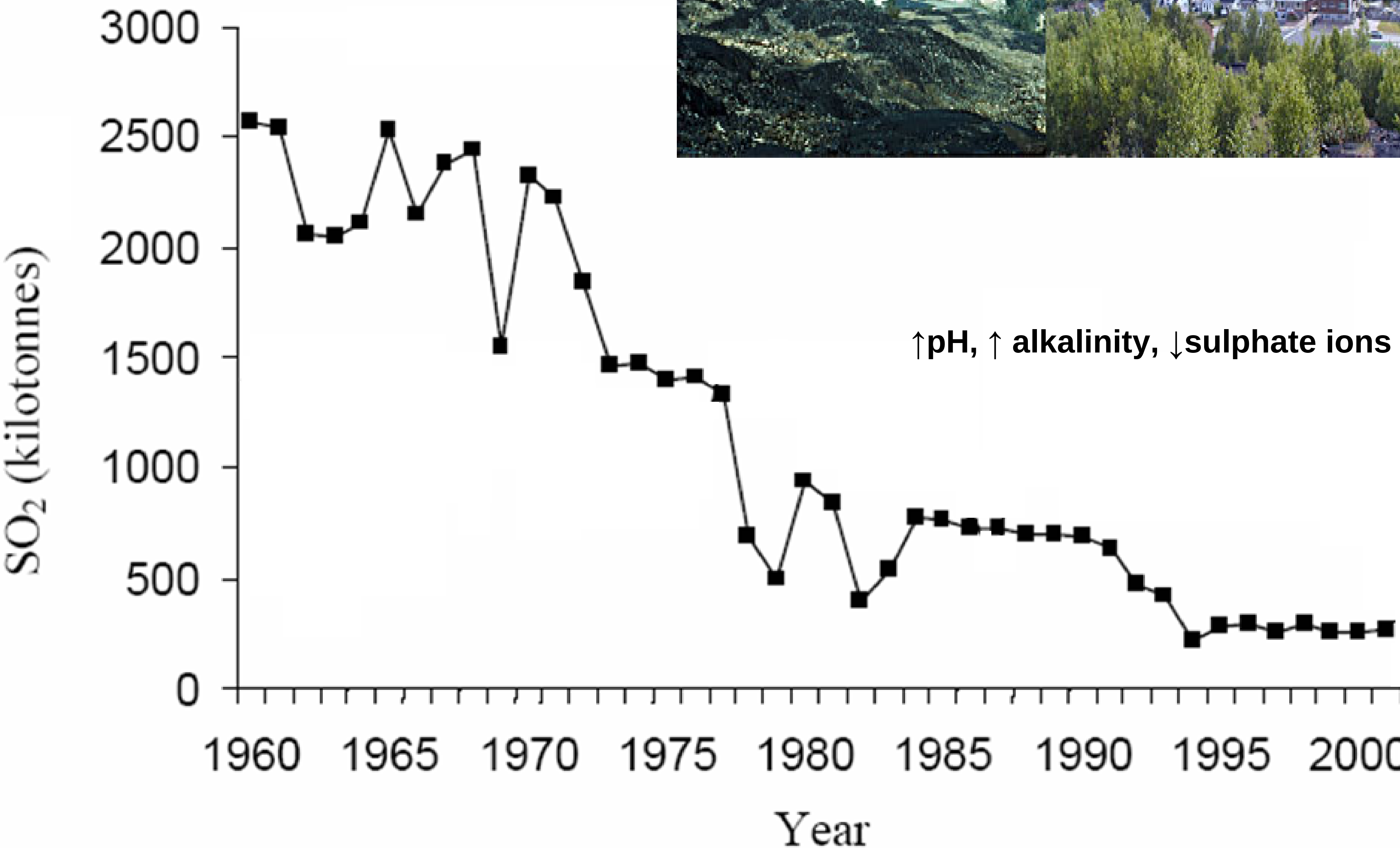
- History smelting operations in Sudbury
- Biological implications
- Assessing environmental change
- Research objectives
- Results
- Future directions

History of Sudbury

- Metal mining commenced in 1883
- Open pit roasting began at Copper Cliff in 1888
- Inco opened in 1902 and Falconbridge in 1928
- During peak emissions Sudbury was one of the largest point source of SO_2 in the world

Biological Implications

- Heavy metals and acidic deposition negatively impacted biological systems
- Reproductive failures, declines and loss of entire fish populations
- Phytoplankton, zooplankton, invertebrates and aquatic macrophytes were also impacted



↑pH, ↑ alkalinity, ↓sulphate ions

Adapted from Keller et al., 2004

Biological Recovery

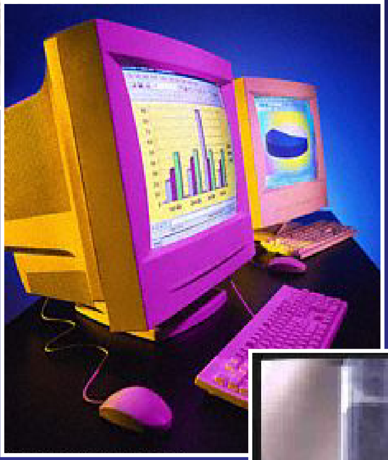
- Evidence of biological recovery
- Little known about recovery processes (e.g. role of metals)
- Recovery may be affected by multiple stressors
  - watershed disturbances, cultural eutrophication, climatic change

Assessing Biological Recovery

- Long-term data required
  - what were pre-impact conditions
  - range of natural variability
  - response of system to anthropogenic inputs
  - response of system to mitigation efforts

- Required to set realistic mitigation targets

Techniques to Assess Environmental Change



historical measurements

modeling

paleolimnology

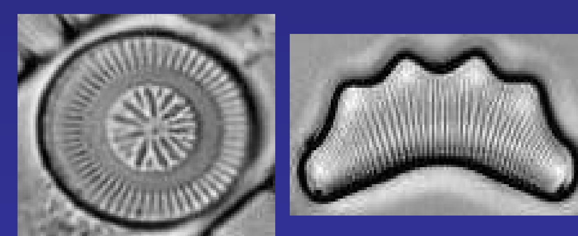
The Paleolimnological Approach

Select Study Lake

Select Coring Site & Retrieve Sediment Core

^{210}Pb

Section & Date Sediment Core

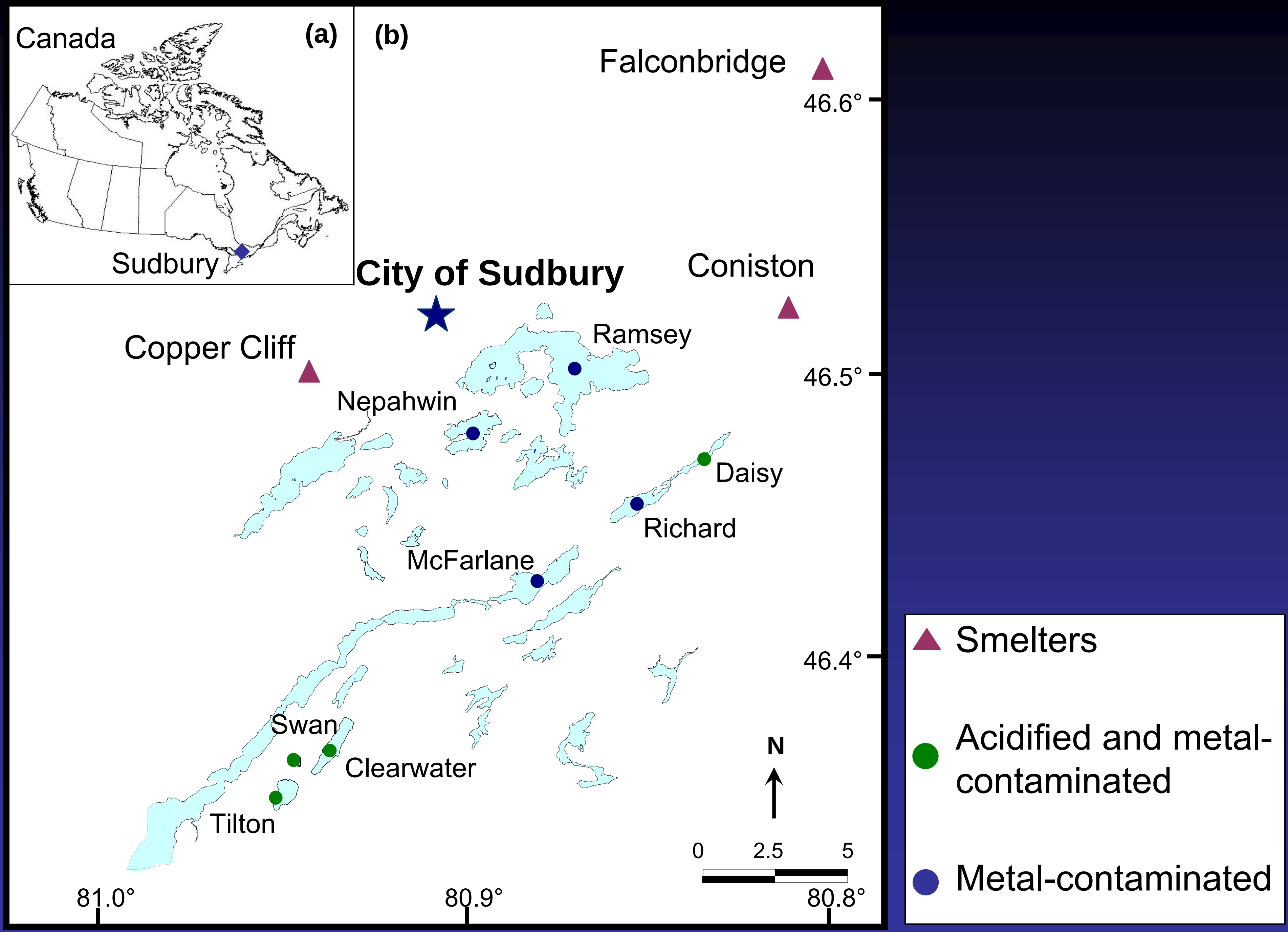


Sub-sample Sediments & Isolate Indicator of Interest

Collect Indicator Data

Analyze Data

Photos courtesy of B. Cumming, I. Walker, Dell & Leica



Canada
(a)
Sudbury
(b)
Falconbridge
46.6°
City of Sudbury
Coniston
Copper Cliff
Ramsey
46.5°
Nepahwin
Daisy
Richard
McFarlane
46.4°
Swan
Clearwater
Tilton
N
0
2.5
5
81.0°
80.9°
80.8°
Smelters
Acidified and metal-contaminated
Metal-contaminated

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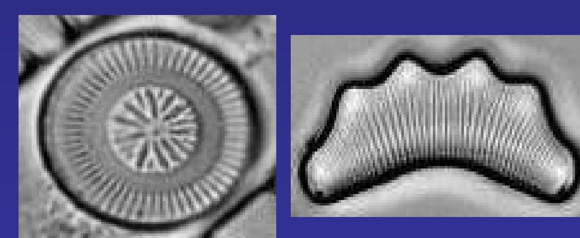

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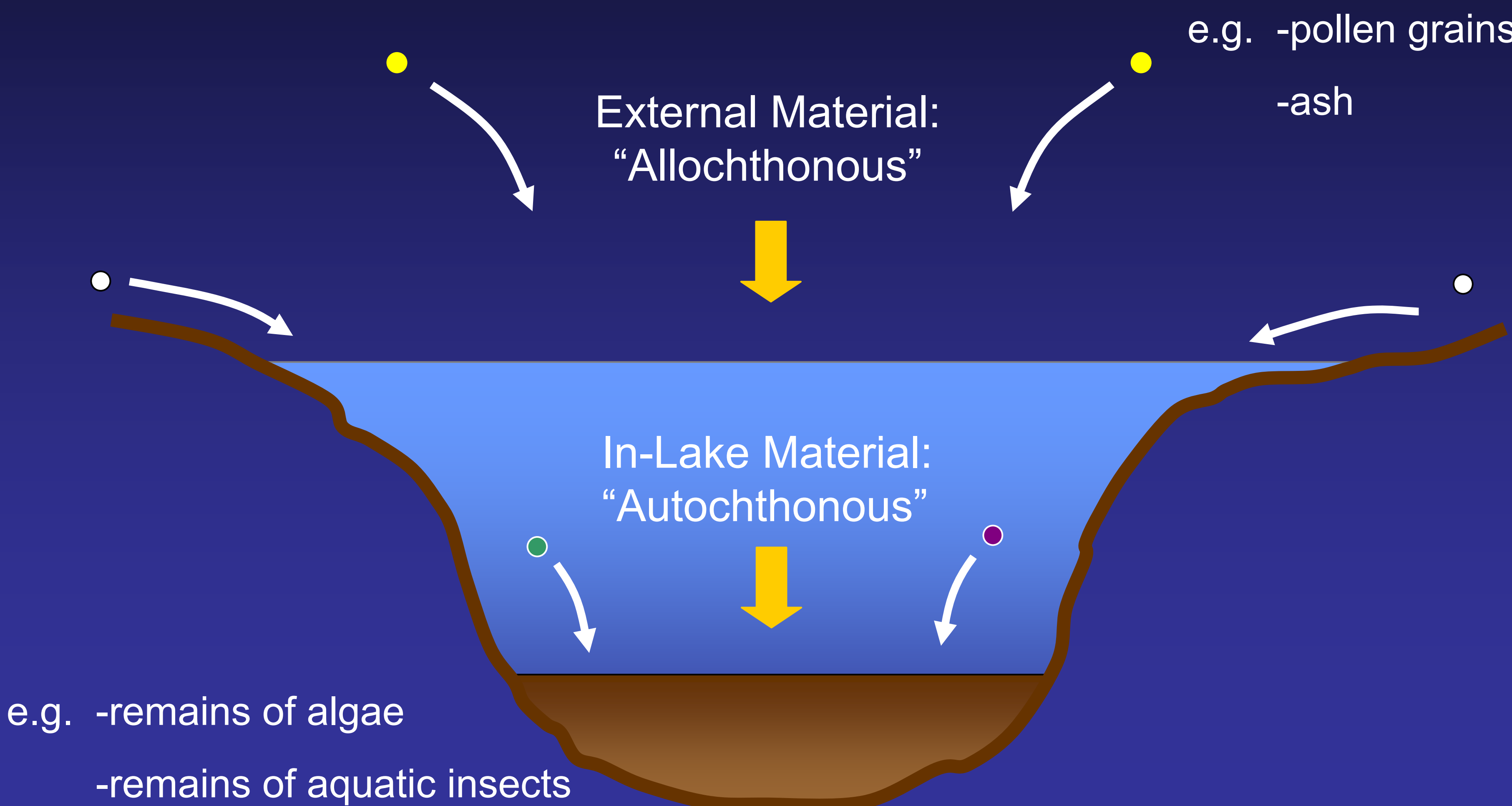
What contributes to the sediment record?



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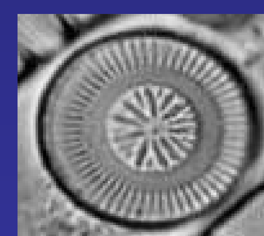

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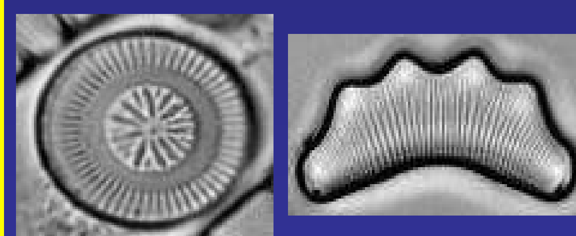

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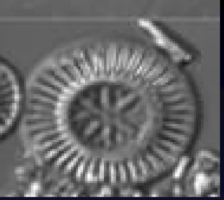
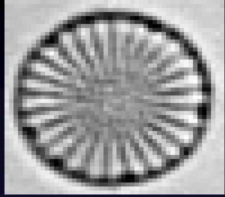


Diatoms as paleoecological indicators



- Preserve well in sediment
- Abundant and ecologically diverse
- Fast migration rate and rapid life cycle
- Definable optima and tolerances

The Paleolimnological Approach

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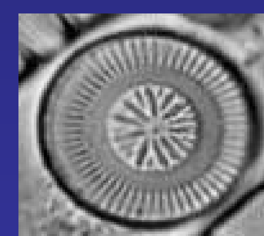
^{210}Pb

Section & Date Sediment Core



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Previous Paleolimnological Studies

- Used extensively to assess the timing, extent and rate of acidification and metal-contamination
- Tracks chemical recovery in Sudbury
- Adirondack Park (New York) and Nova Scotia (Canada) have not shown signs of chemical or biological recovery

Research Objectives

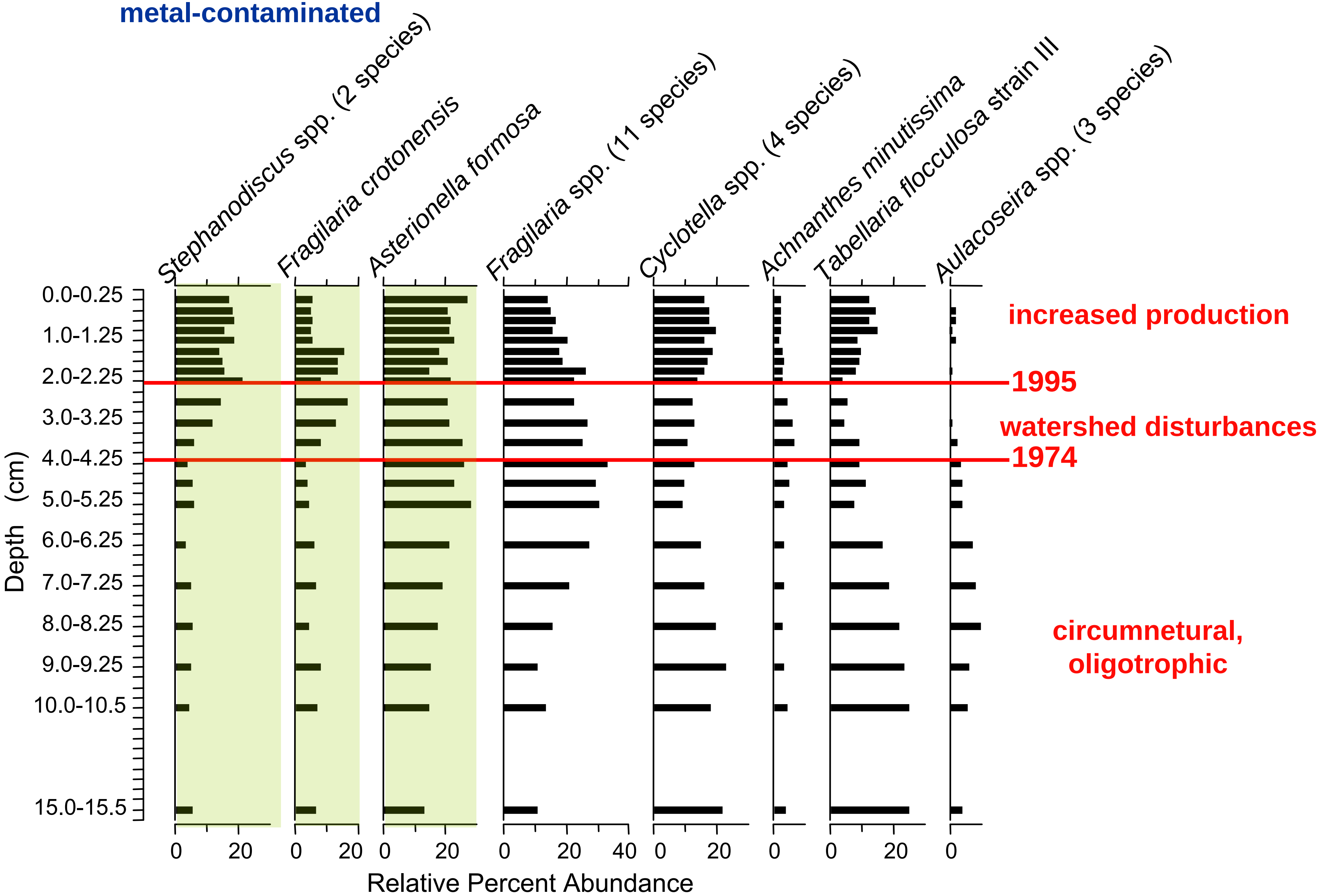
1) Do diatom assemblages track recent chemical recovery in Sudbury lakes?

2) Does chemical recovery equate to biological recovery in diatom communities?

Metal contaminated	Acidified and metal contaminated
McFarlane	Tilton
Ramsey	Daisy
Nepahwin	Swan
Richard	Clearwater

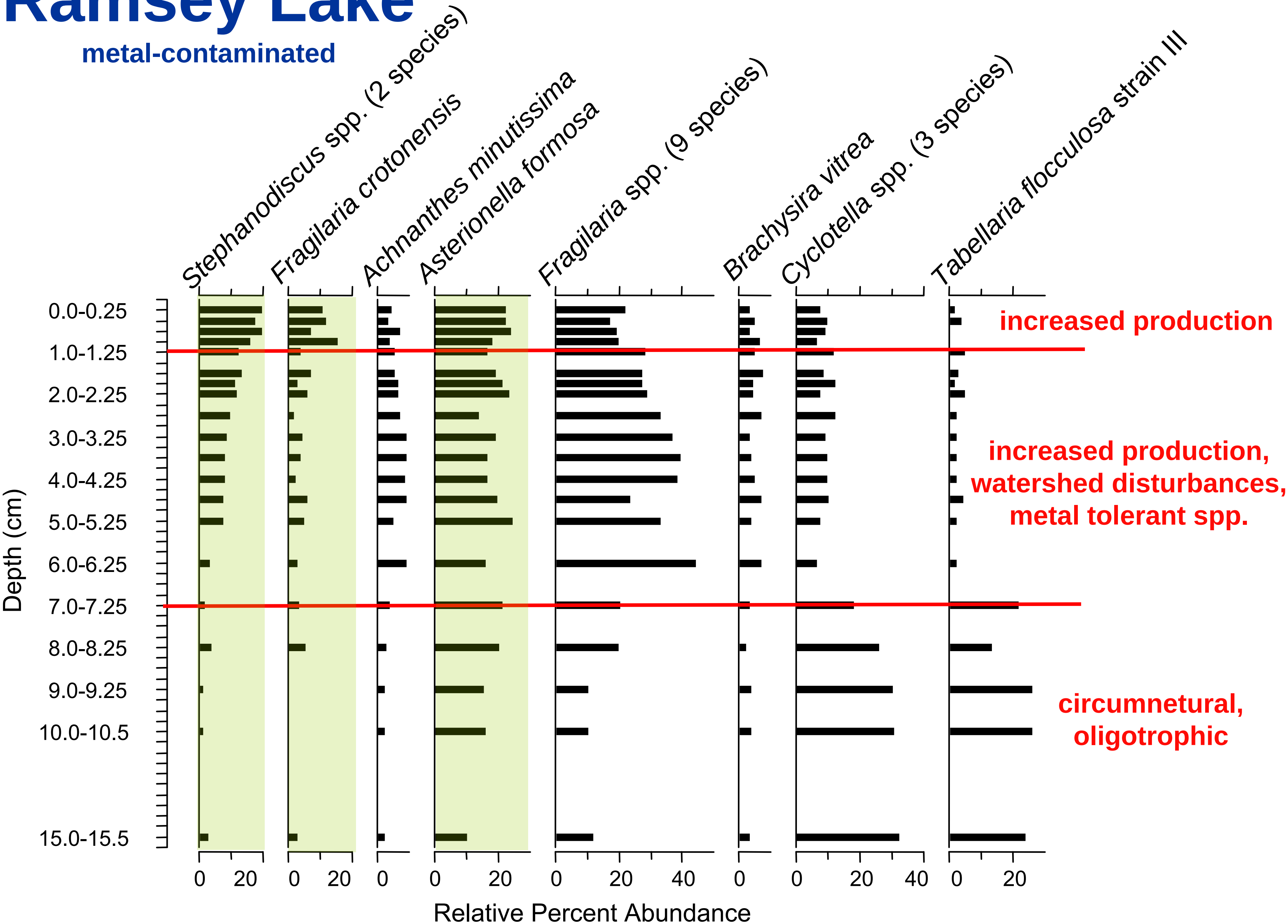
McFarlane Lake

metal-contaminated



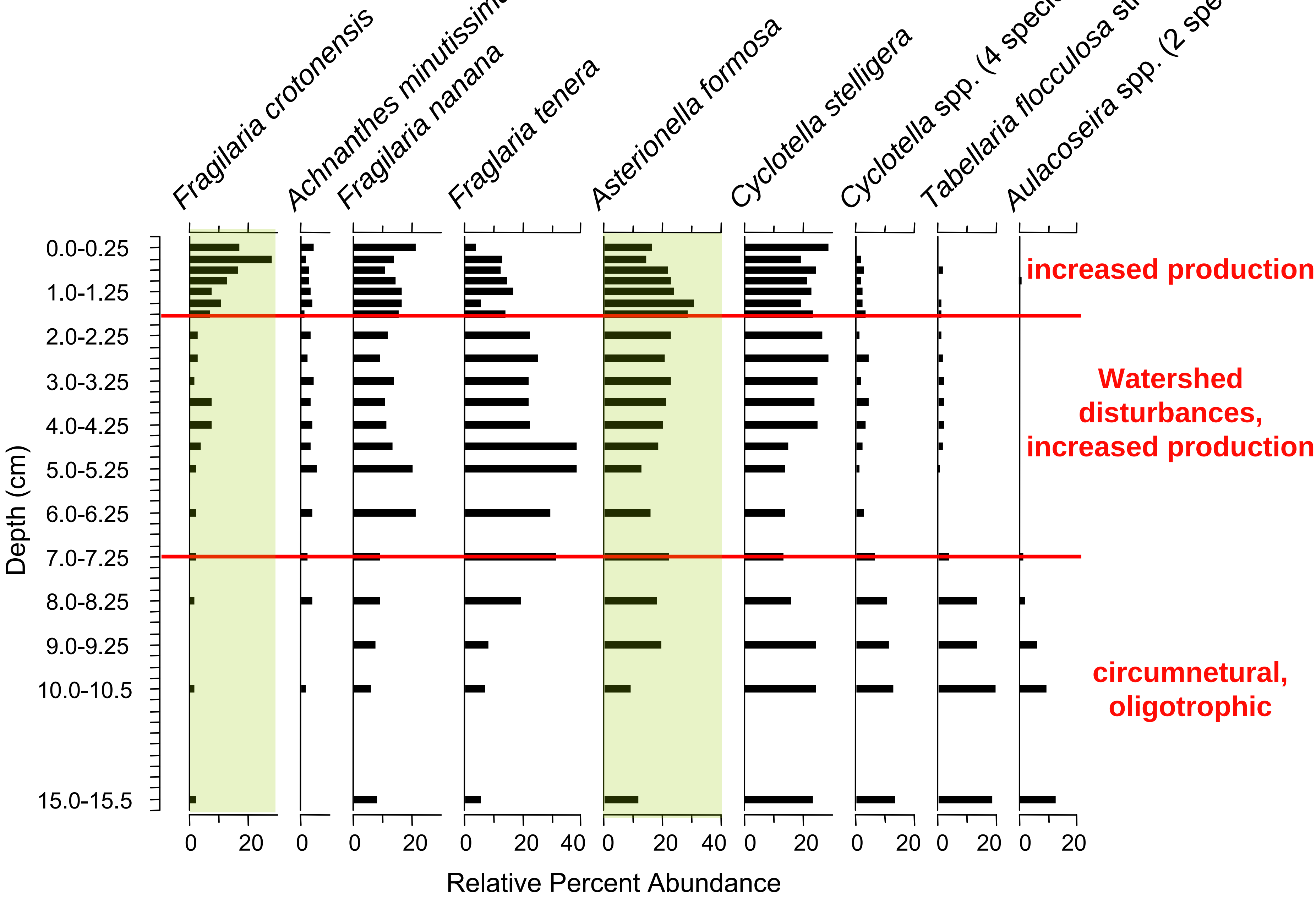
Ramsey Lake

metal-contaminated



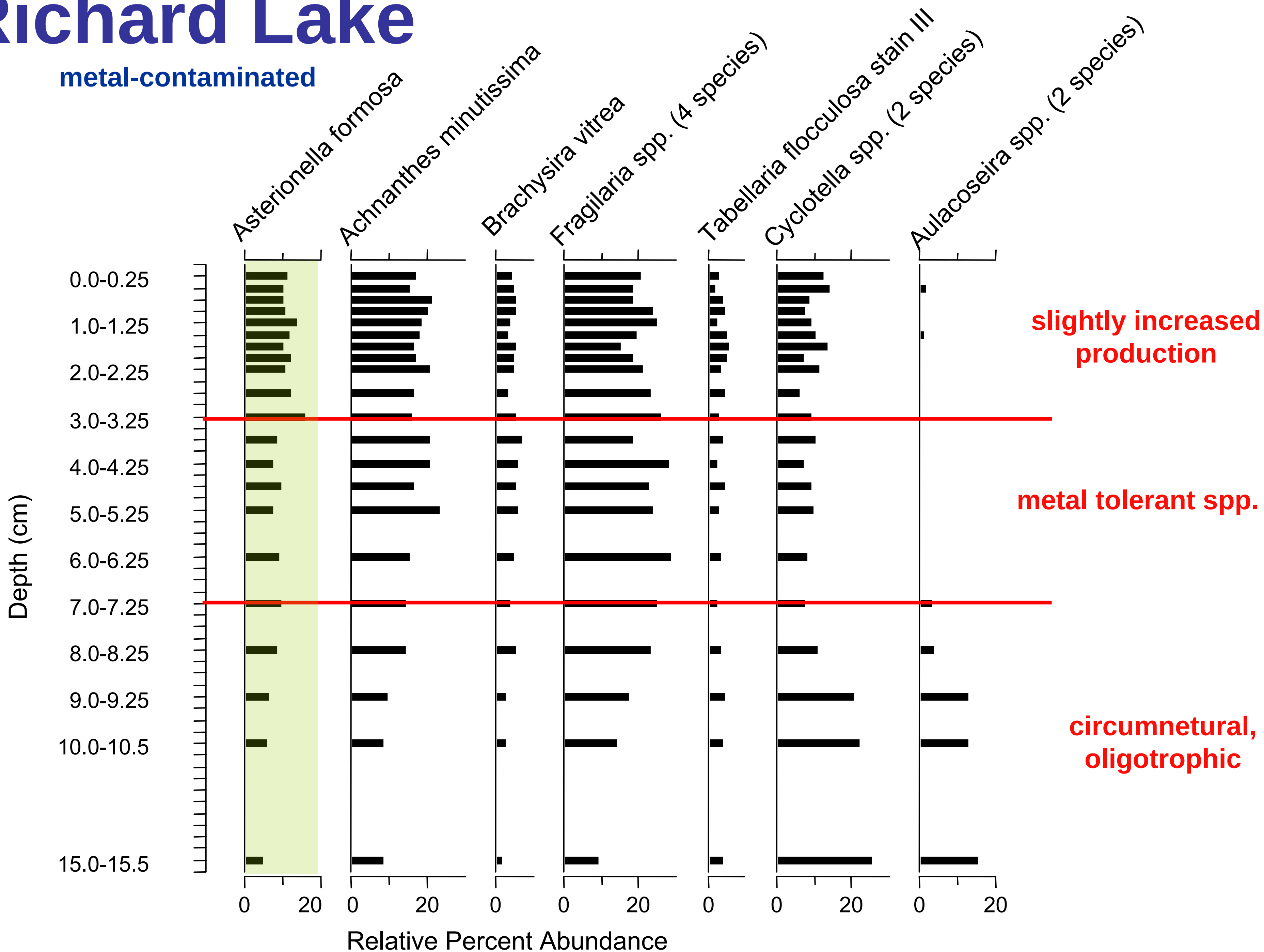
Nepahwin Lake

metal-contaminated



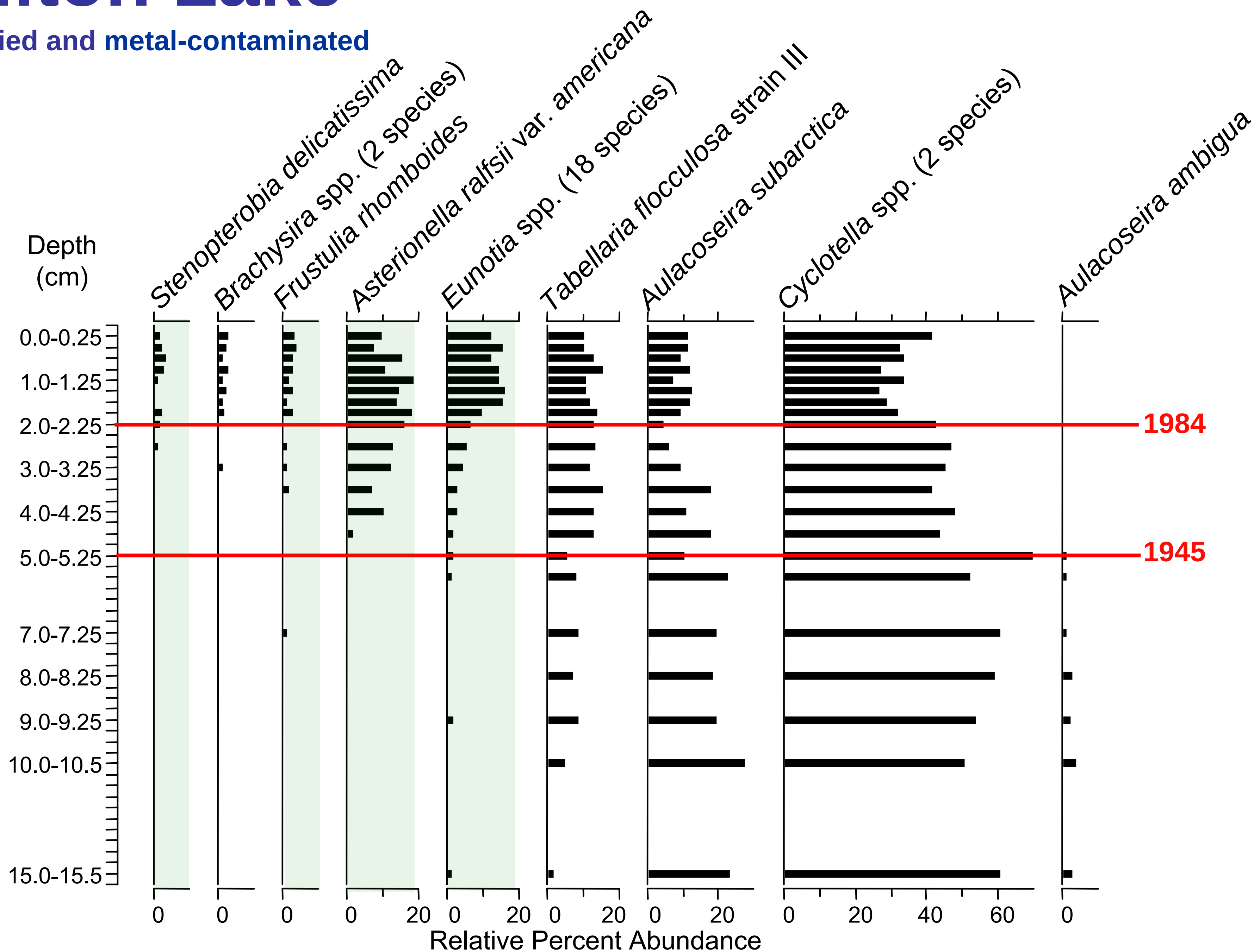
Richard Lake

metal-contaminated



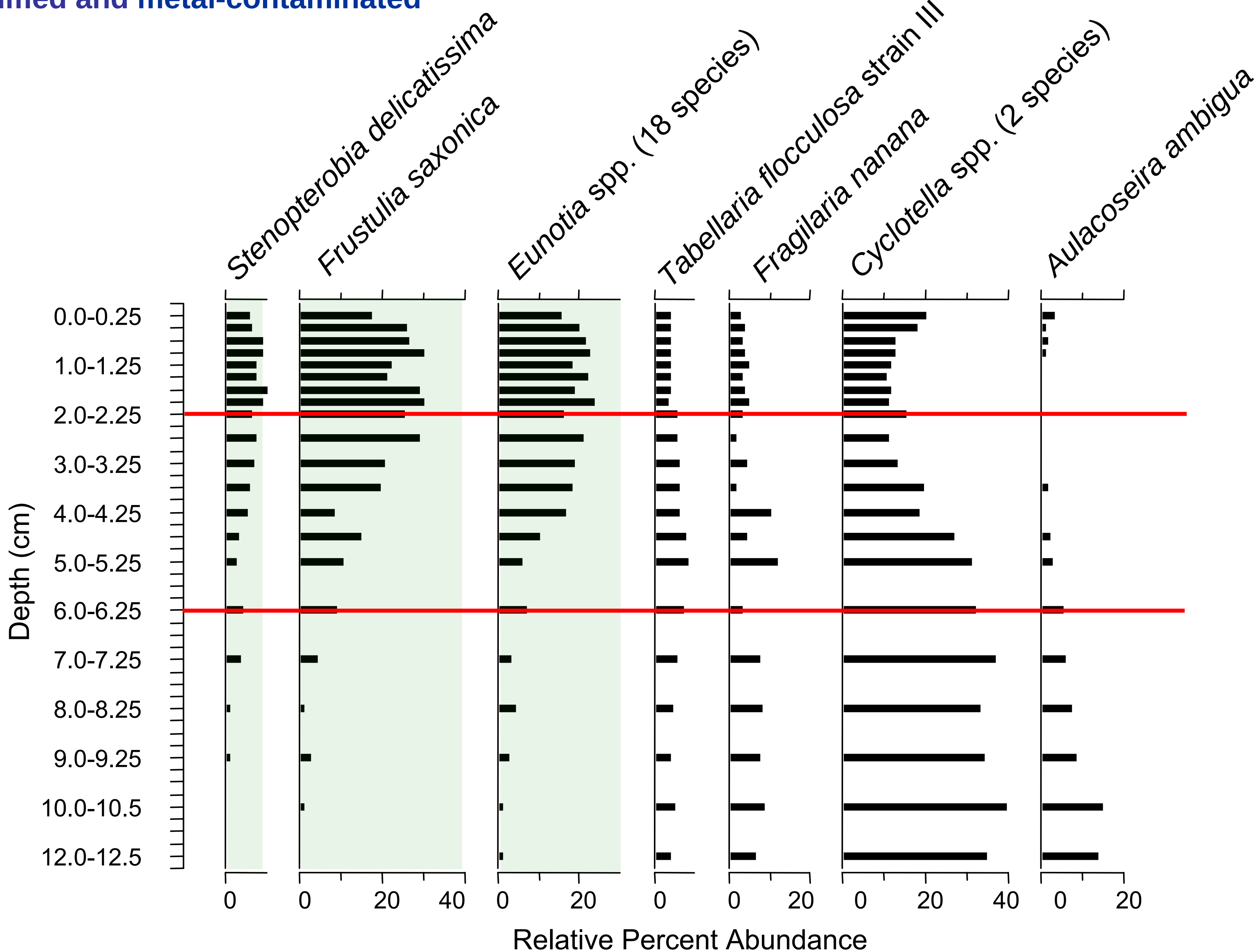
Tilton Lake

Acidified and metal-contaminated



Daisy Lake

Acidified and metal-contaminated



Conclusions

- Metal contaminated lakes
  - Increased production
  - No evidence of biological recovery

- Acidified and metal contaminated
  - Evidence of biological recovery

Future Objectives

- Complete identification and enumeration of diatoms and scaled-chrysophytes
- Complete ^{210}Pb dating
- Sediment geochemistry
- Water chemistry

Acknowledgements

- Colleagues at PEARL
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