Phytoplankton recovery from acid and metal contamination: a comparison of limed and un-manipulated lakes

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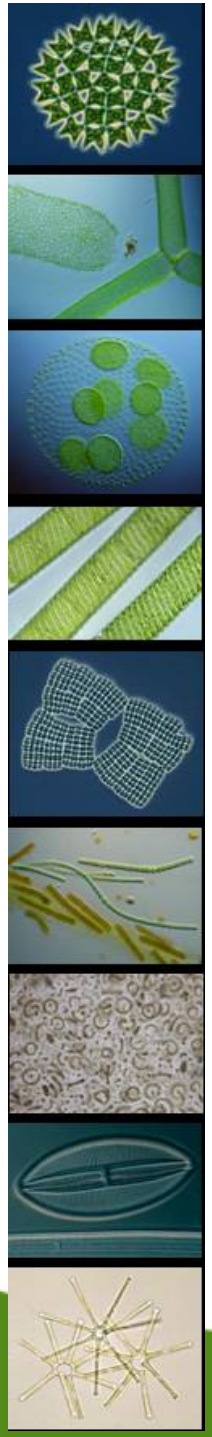
Protecting our environment.

Ontario

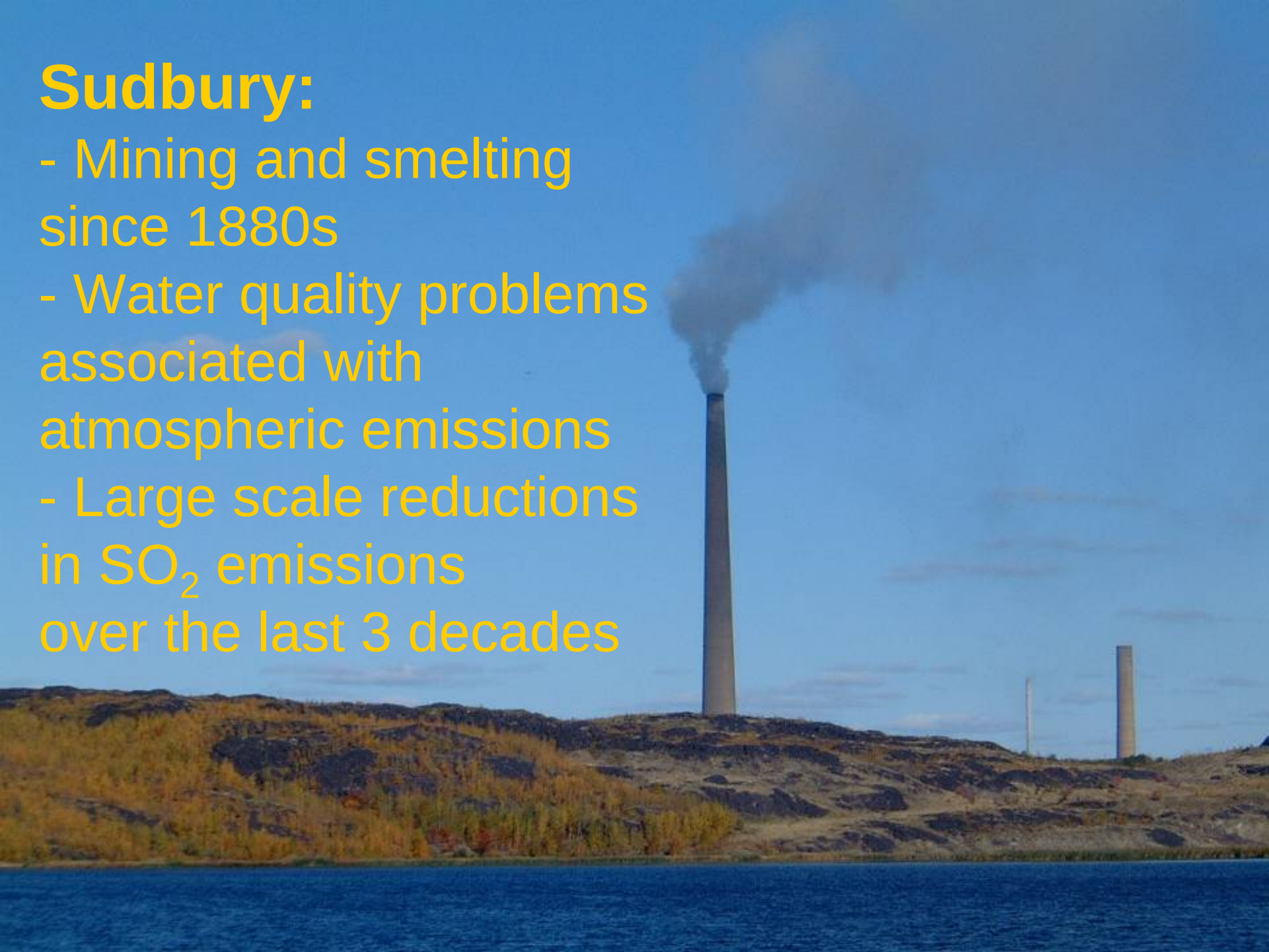


Introduction

Phytoplanktonic algae possess many attributes that make them ideal organisms to employ in lake water quality monitoring programs such as:

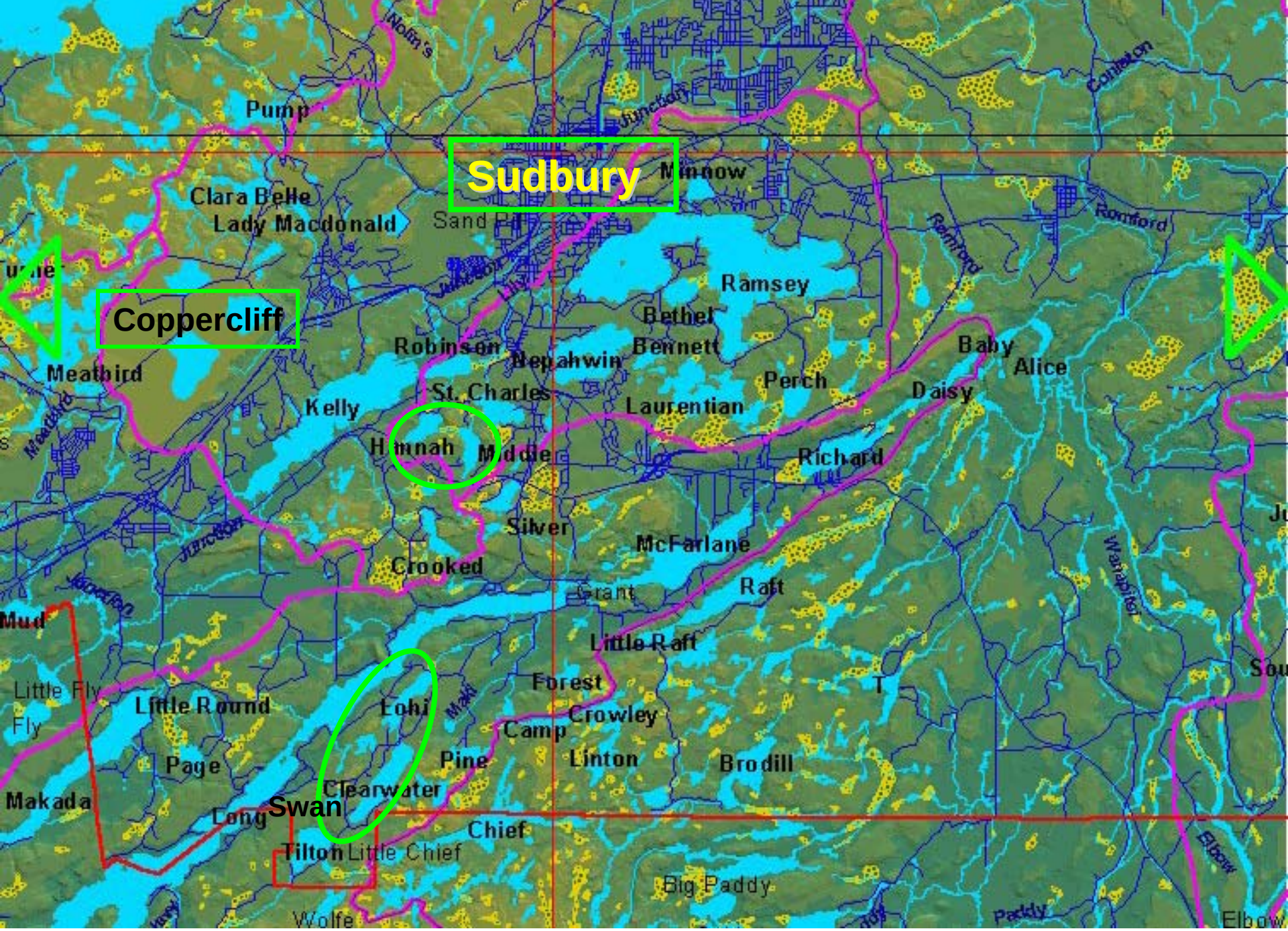
- species-specific environmental optima and tolerances
- rapid responses to shifts in environmental conditions

Changes affect higher trophic levels

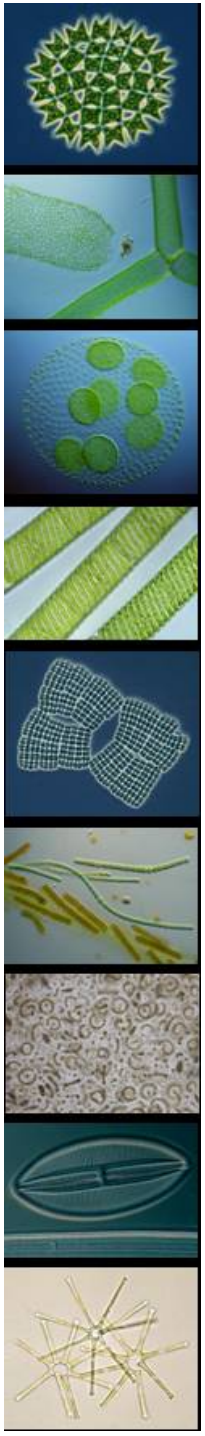


Sudbury:

- Mining and smelting since 1880s
- Water quality problems associated with atmospheric emissions
- Large scale reductions in SO_2 emissions over the last 3 decades



http://www.city.greatersudbury.on.ca/lakewaterquality/maps/lakeindex.cfm



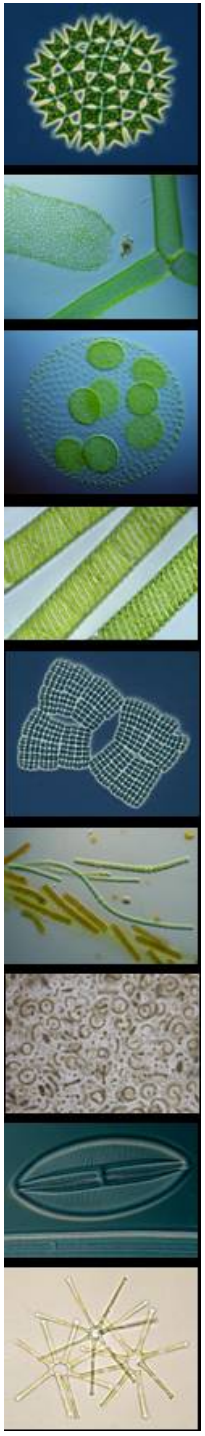
Study lakes (2) – unmanipulated

Clearwater & Swan -

***1970s*:**

- pH 4.0 - 4.3
- Metals elevated (e.g. Cu, Ni and Al)
- Fish extirpated
- Low diversity macrophytes, zooplankton, benthos; no reduction in phytoplankton biomass
- Phytoplankton dominated by dinoflagellates (e.g. *Peridinium inconspicuum*) & green algae

2000s: indications of chemical recovery; drought induced re-acidification in Swan (1988)



Study lakes – (3) manipulated

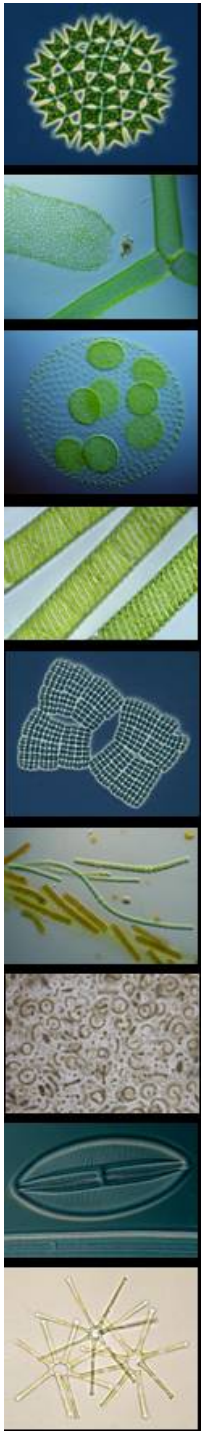
Hannah, Middle & Lohi -

1970s, pre-liming & fertilization (MD, HN):

- pH ~4, elevated metals
- No fish & low diversity phytoplankton, macrophytes, zooplankton and benthos.
- Phytoplankton dominated by dinoflagellates & greens

1970s, post-liming & fertilization (MD, HN):

- pH 6 - 7, decreases in metal concentrations
- Phytoplankton dominated by chrysophytes & diatoms; no increase in richness, increases in biomass after fertilization of Middle & Hannah
- Lohi, re-acidified late 1970s (pH 4.6 – 4.8)



Study lakes – (3) manipulated

Hannah & Middle -

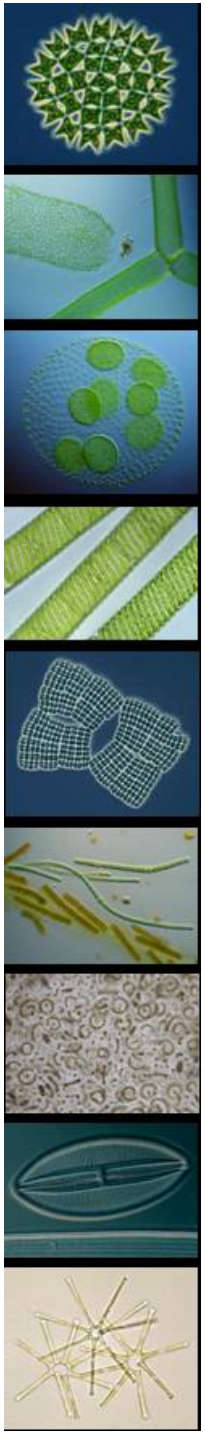
2000s:

- pH > 7 (consistent pH >6 since liming)
- lower metal concentrations

Lohi -

2000s:

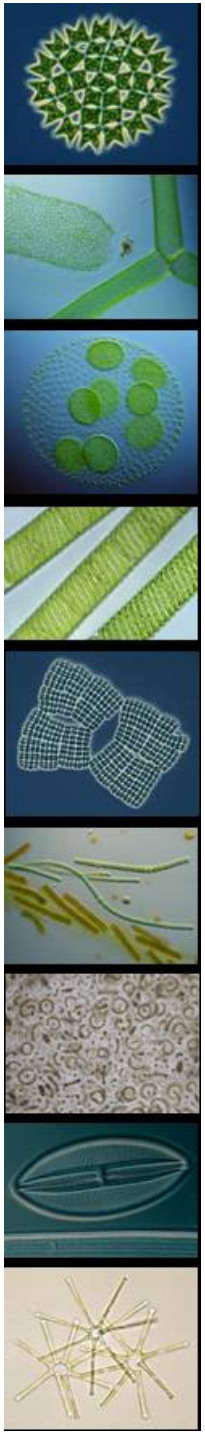
- pH > 6 (< 7; increase in pH since re-acidification)
- lower metal concentrations



Objectives

1) Examine trends in phytoplankton class- and genus/species level data from 1982 to 2006 to evaluate recovery from acidification and metal contamination

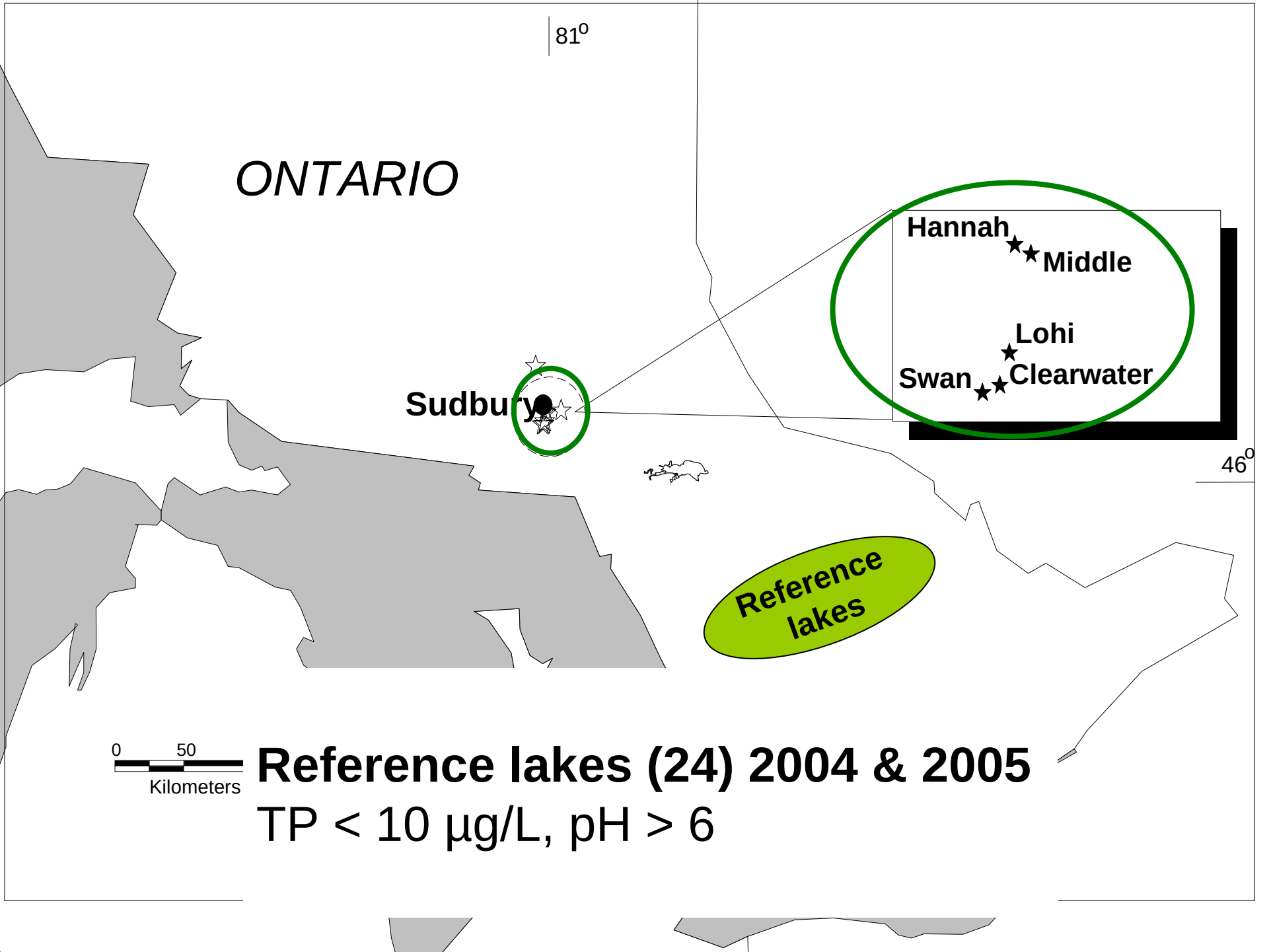
2) Compare trends over time in manipulated and unmanipulated lakes



Approach

- % relative abundance algal classes
- Number of algal taxa
- Correspondence analysis genus / species level data; comparison CA axis 1 & 2 scores

Trends assessed relative to reference lakes to evaluate recovery



Reference lakes (24) 2004 & 2005

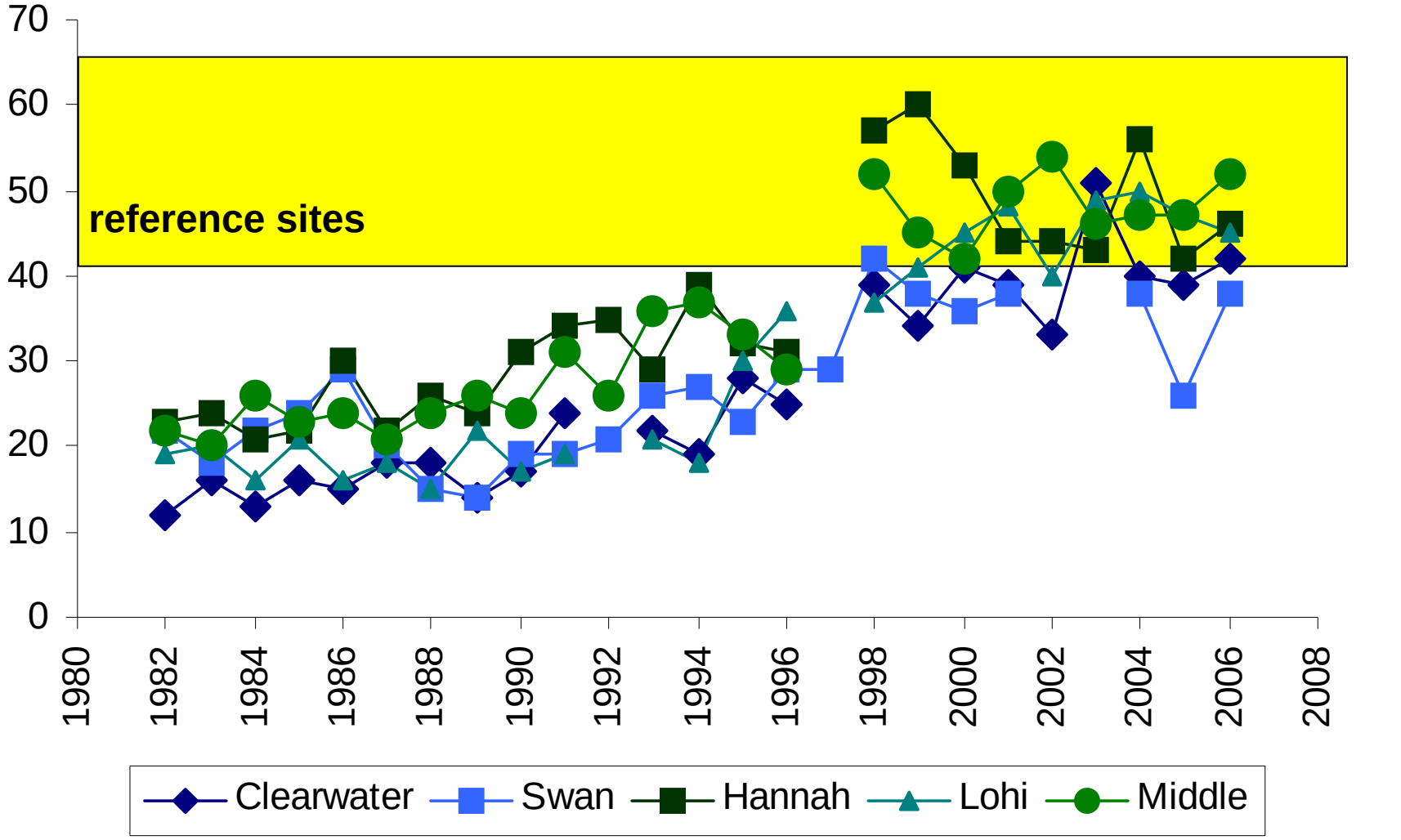
TP < 10 µg/L, pH > 6

Methods

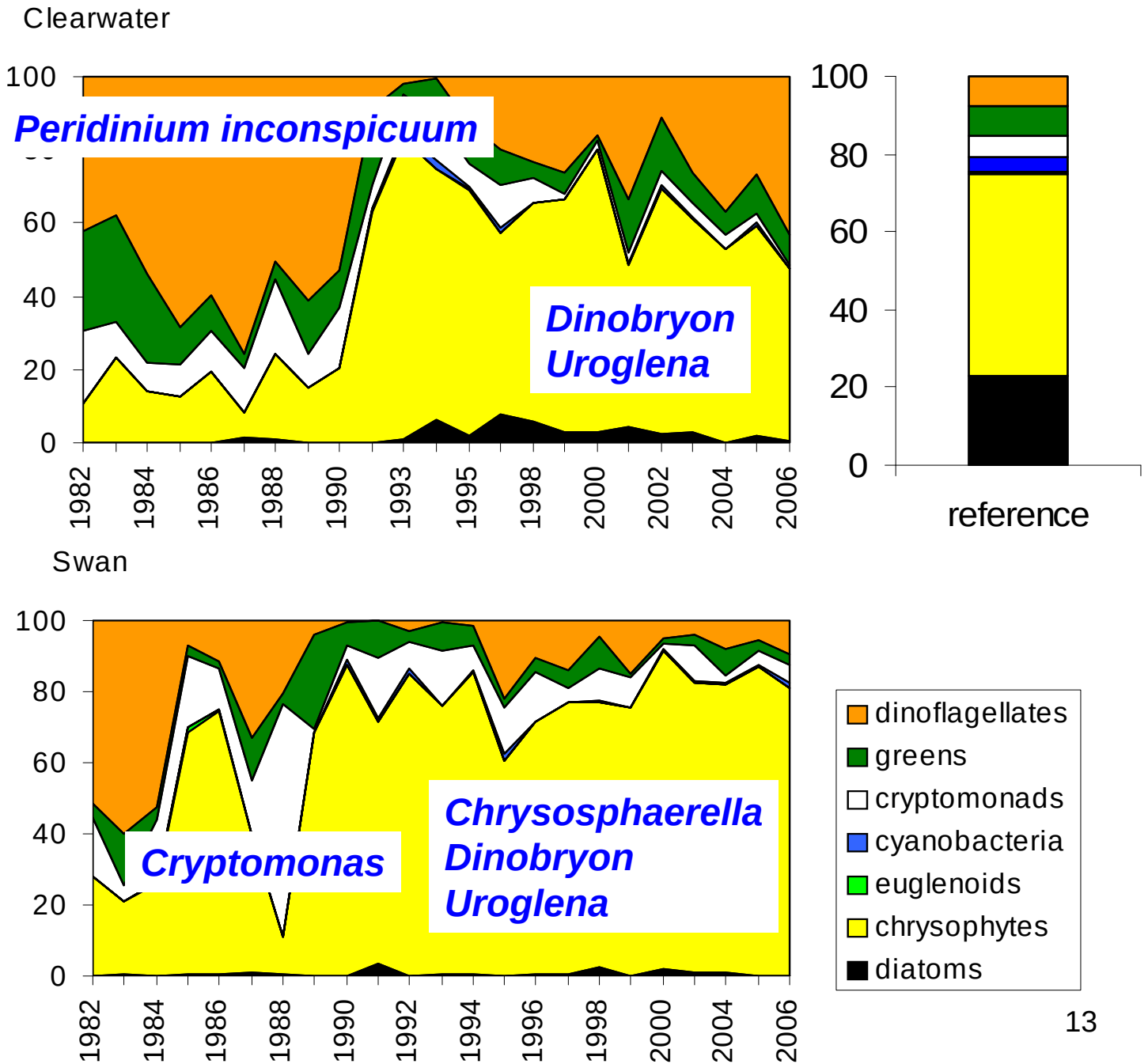
- Volume weighted euphotic zone composite phytoplankton samples were collected during the ice-free season (ca. May to November) weekly, bi-weekly or monthly.
- Preserved samples were settled to concentrate the sample.
- Sub-samples were pooled to obtain a composite sample for identification and counting.

Number of phytoplankton taxa 1982 to 2006

P < 0.001



Relative biovolume (%) algal classes



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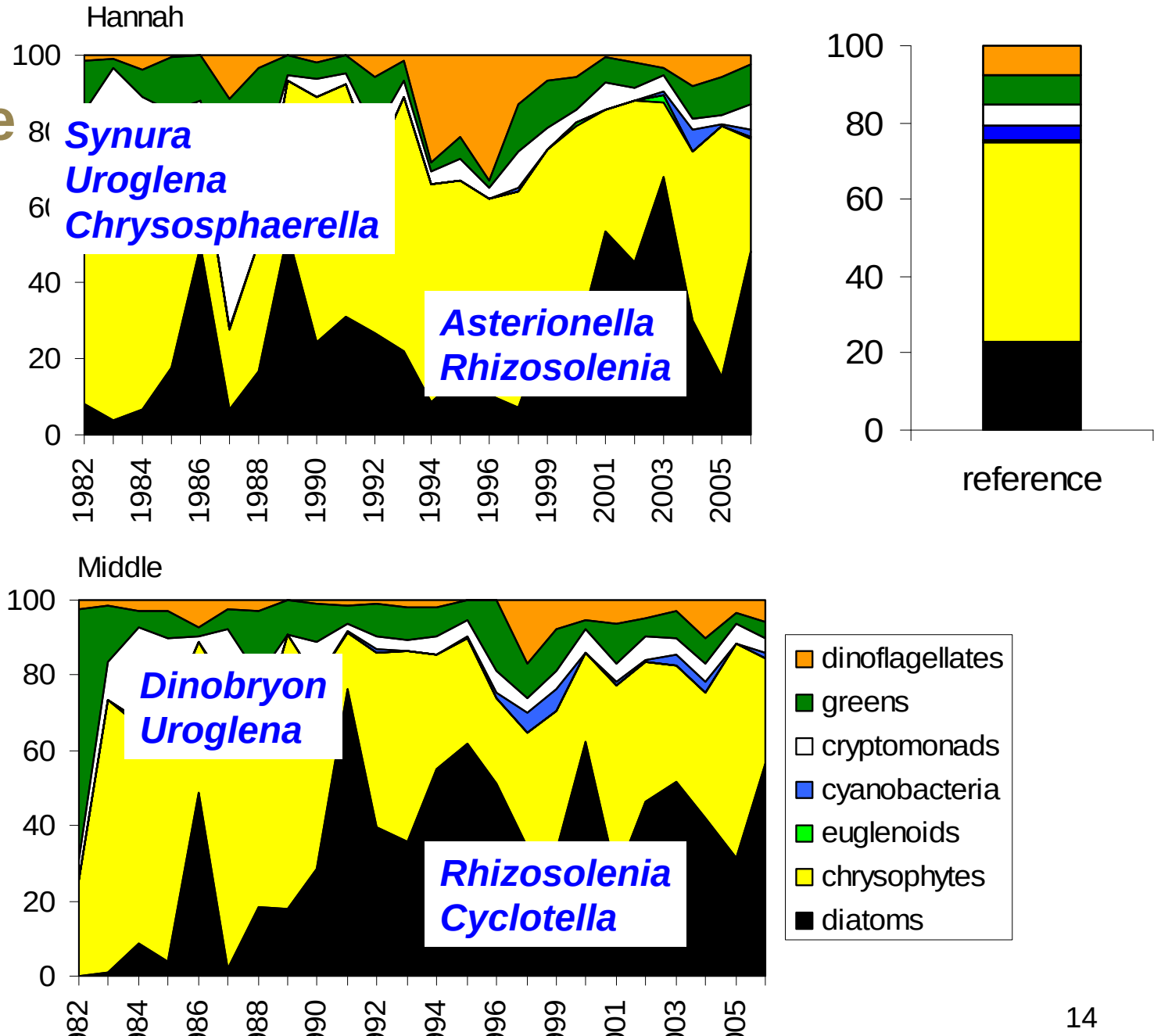
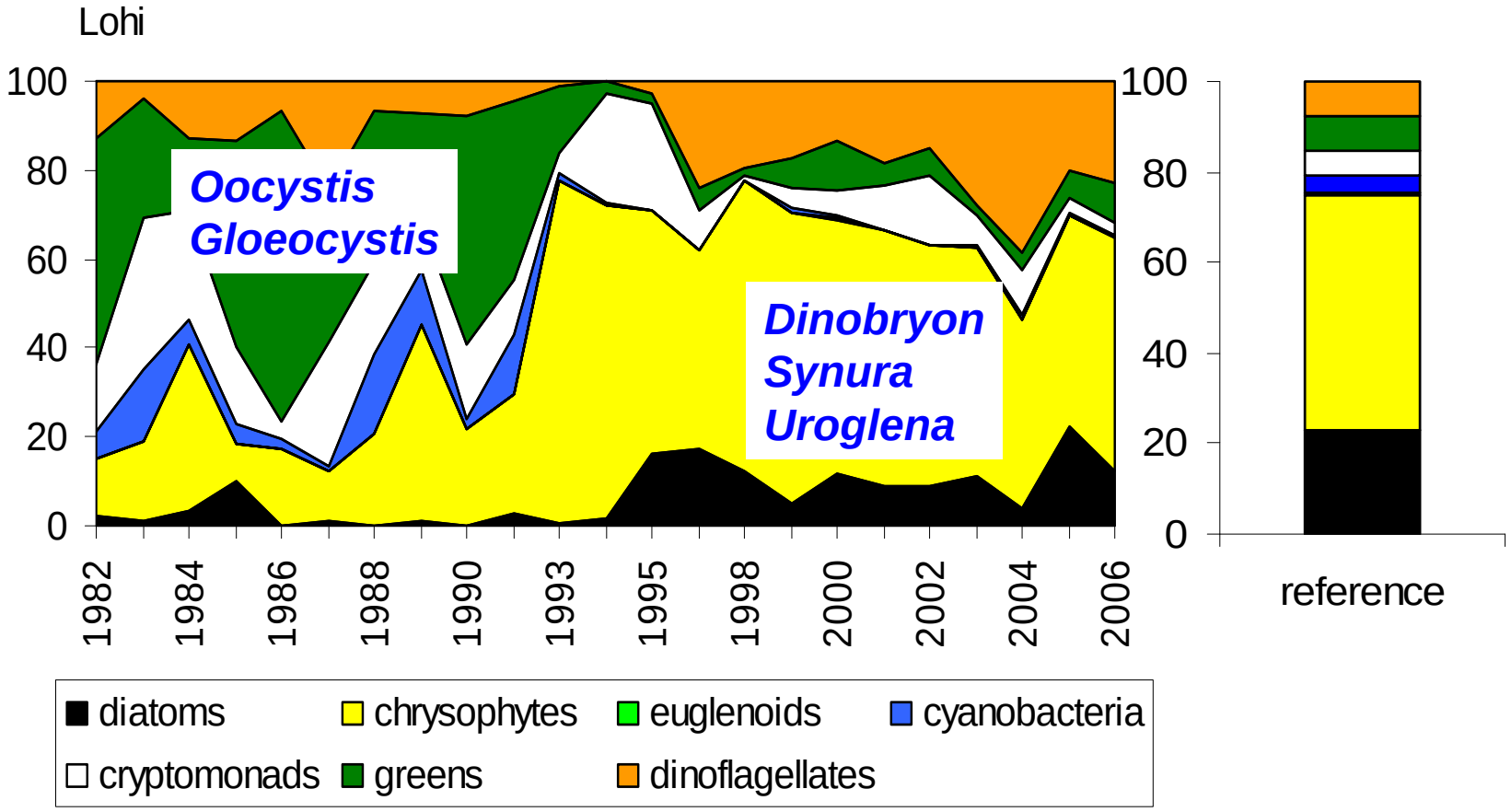
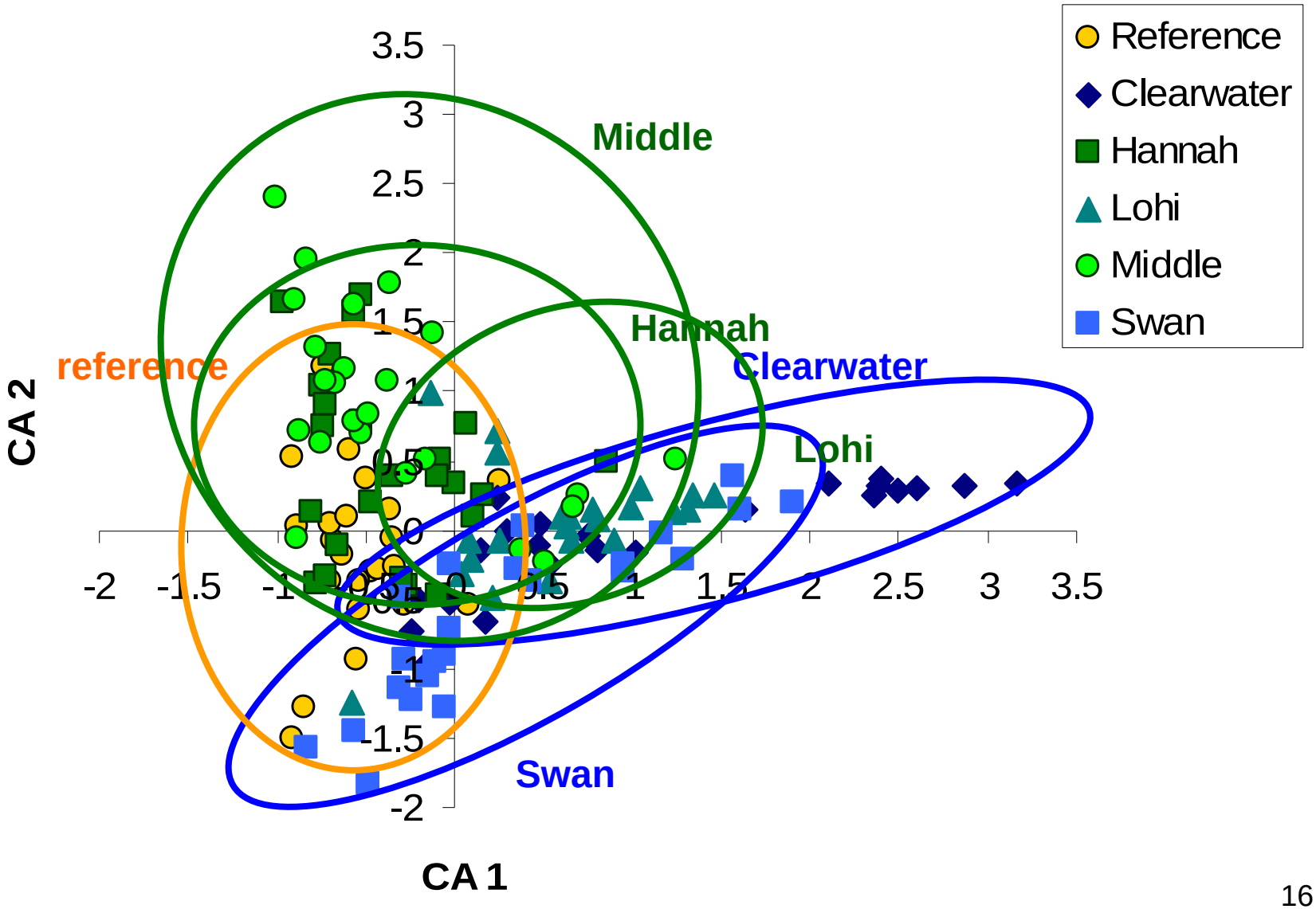


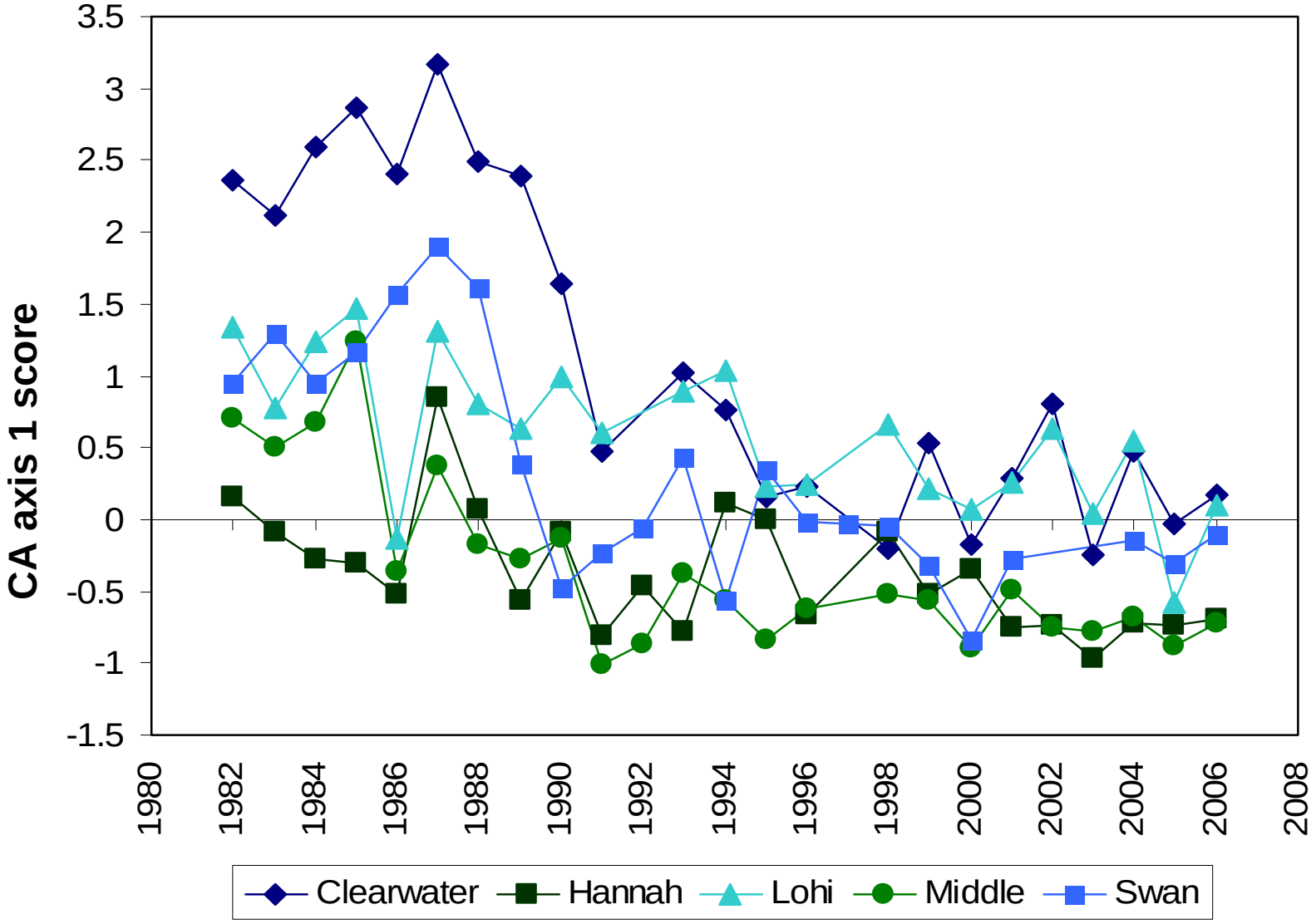
Relative biovolume (%) algal classes



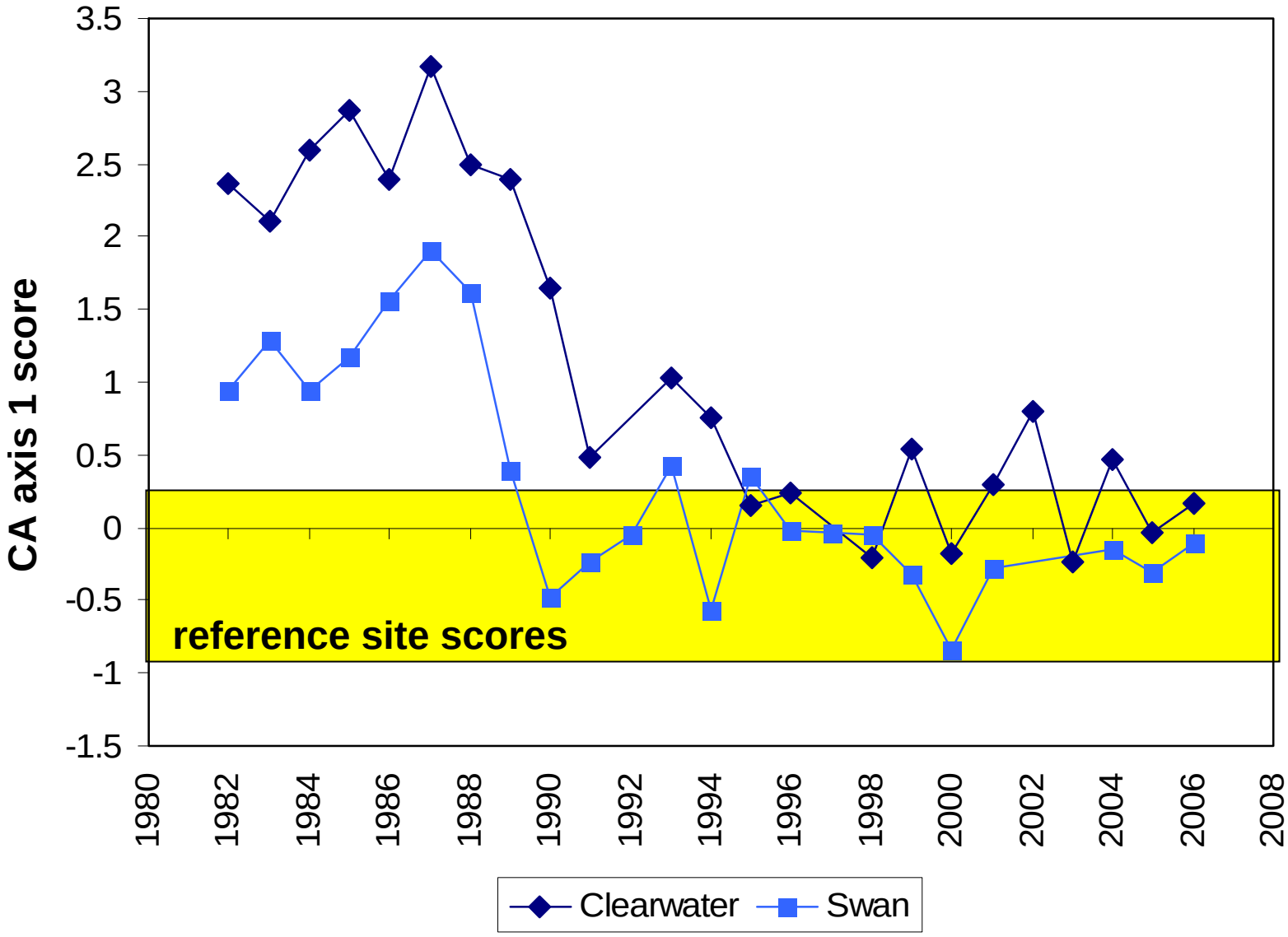
CA – genus / species level biovolumes



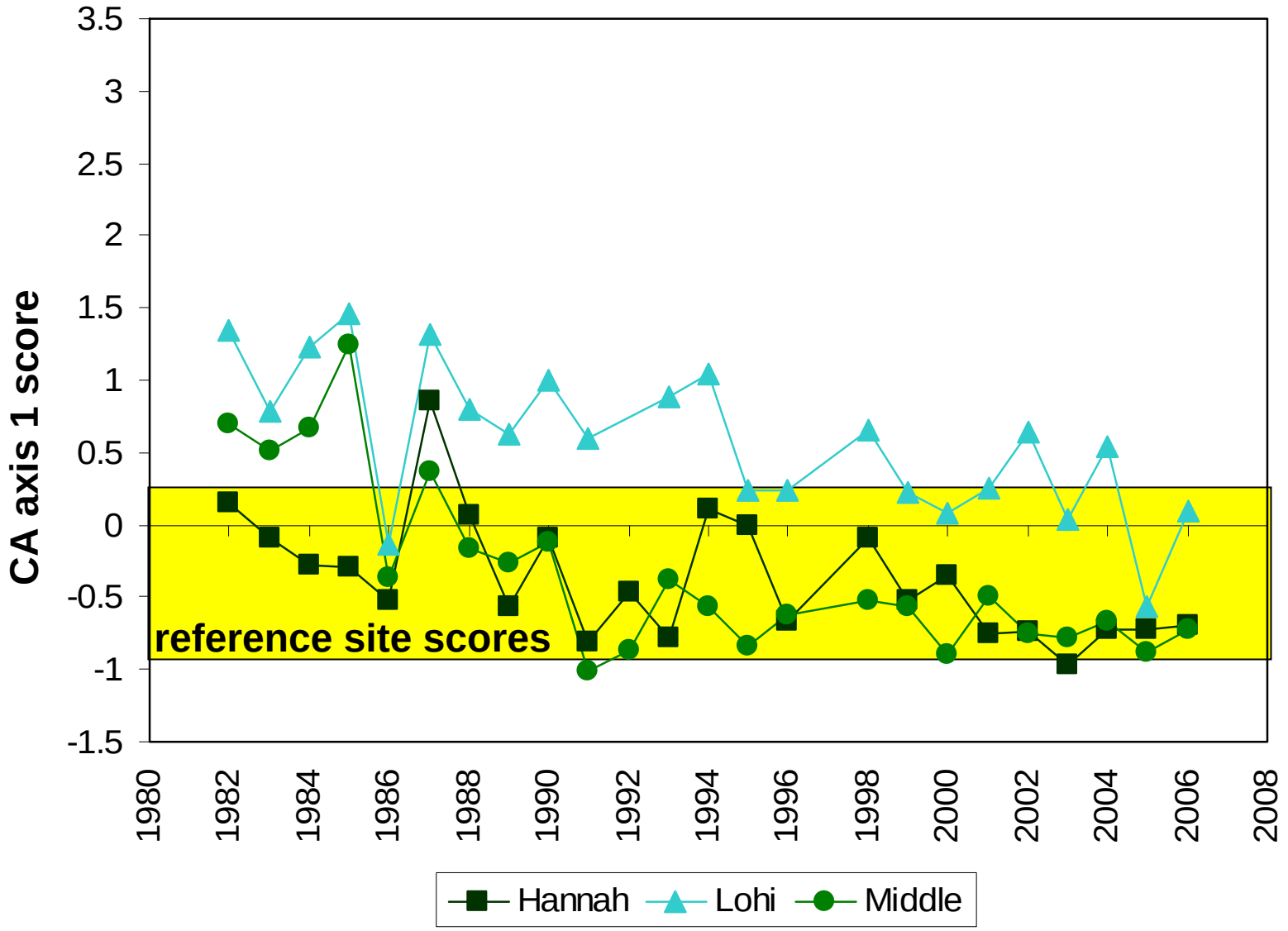
CA Axis 1 scores



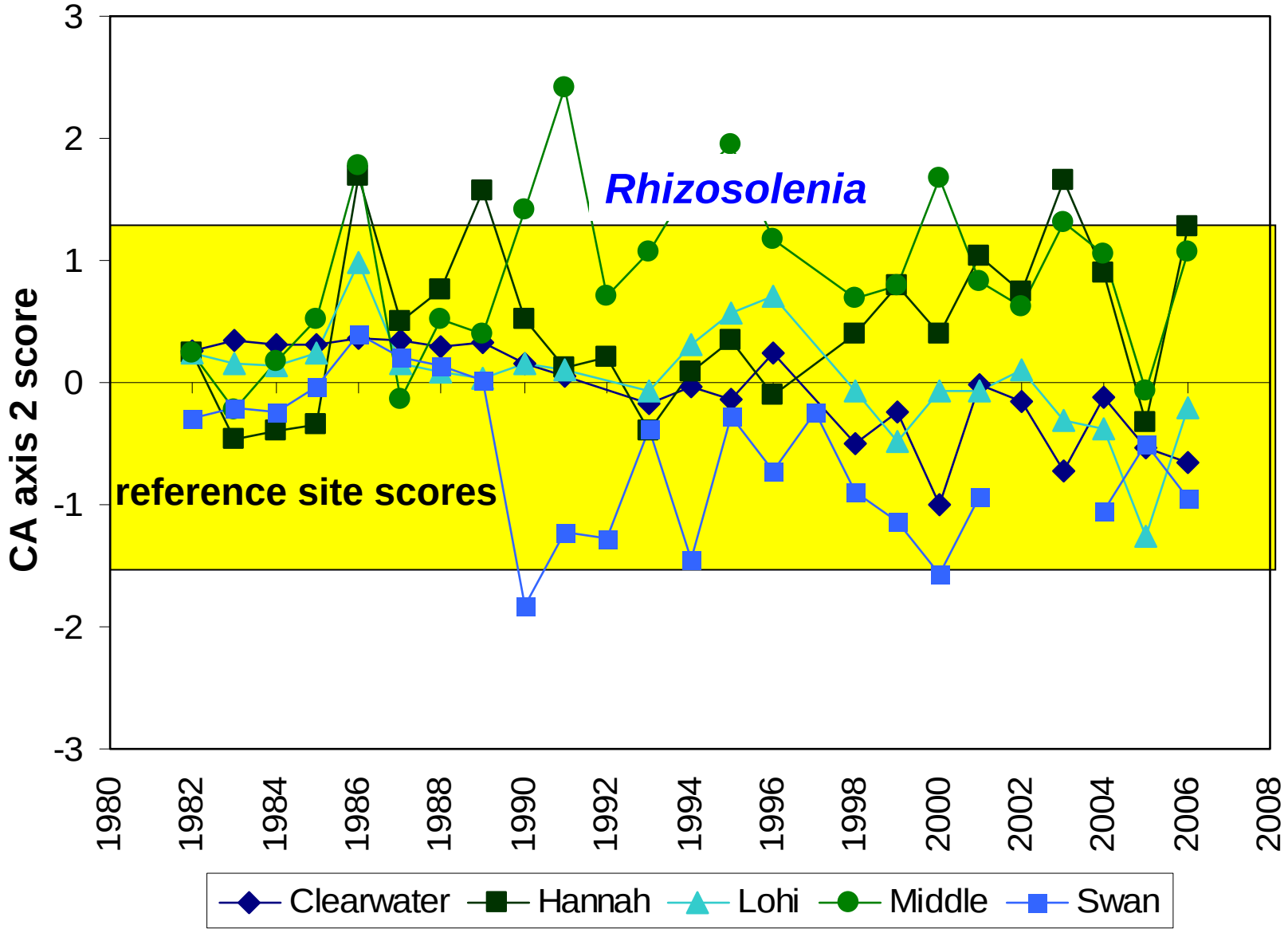
CA Axis 1 scores

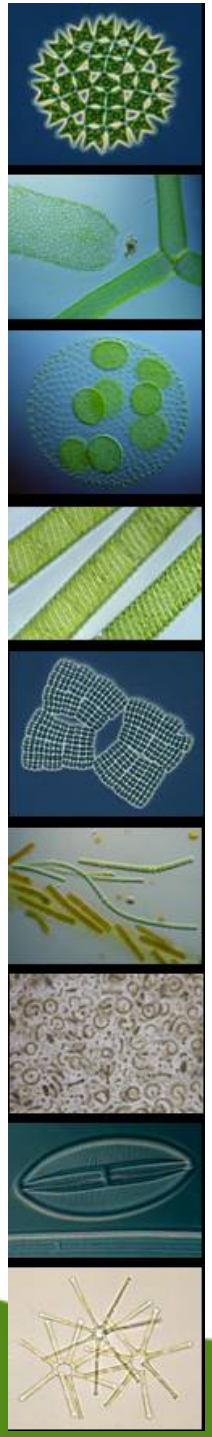


CA Axis 1 scores



CA Axis 2 scores

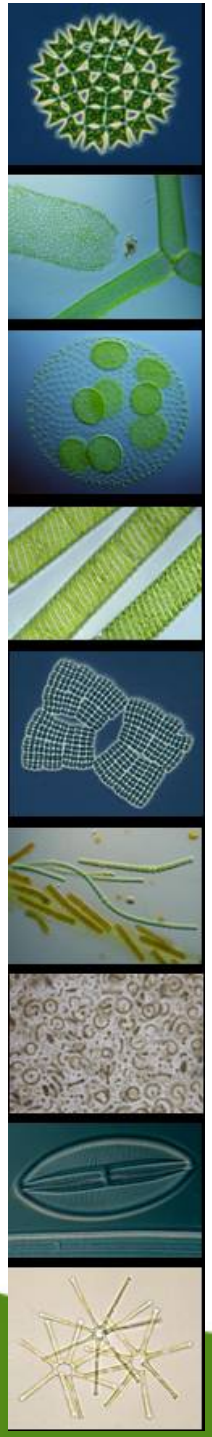




Conclusions

Unmanipulated lakes & Lohi 1982-2006:

- Increases in pH and decreases in metal concentrations
- Significant increases in the number of algal taxa recorded
- Shifts in phytoplankton community composition from dinoflagellates (cryptomonads / greens) to chrysophytes

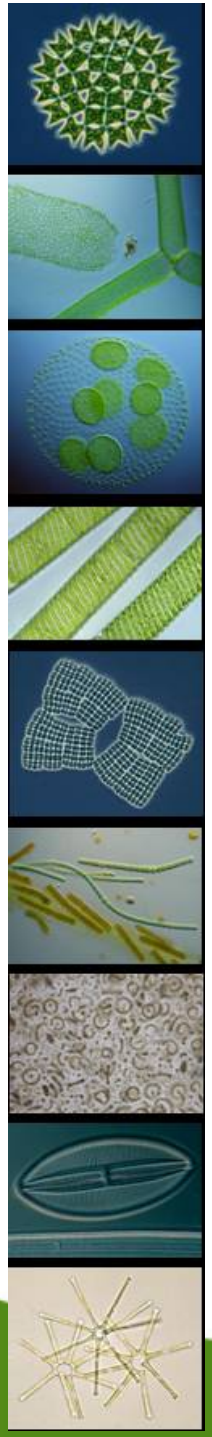


Conclusions

Unmanipulated lakes & Lohi 1982-2006 (*cont*.):

- Shifts CA axis 1 scores towards the reference lakes scores
- Samples similar to those from reference lakes after the 1990s

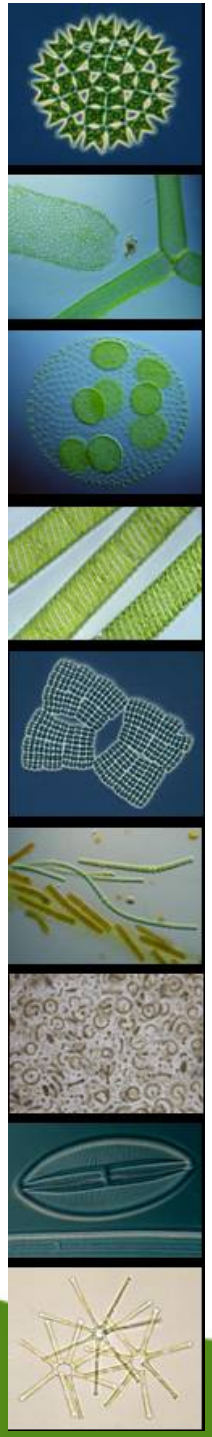
Overall, our results indicate recovery in phytoplankton of Clearwater, Swan and Lohi Lakes based on community composition and number of algal taxa (CLW, LH)



Conclusions

Manipulated lakes 1982-2006:

- Increases in pH and decreases in metal concentrations after liming in 1970s
- Significant increases in the number of algal taxa recorded
- Shifts in phytoplankton community composition from dinoflagellates to diatoms / chrysophytes

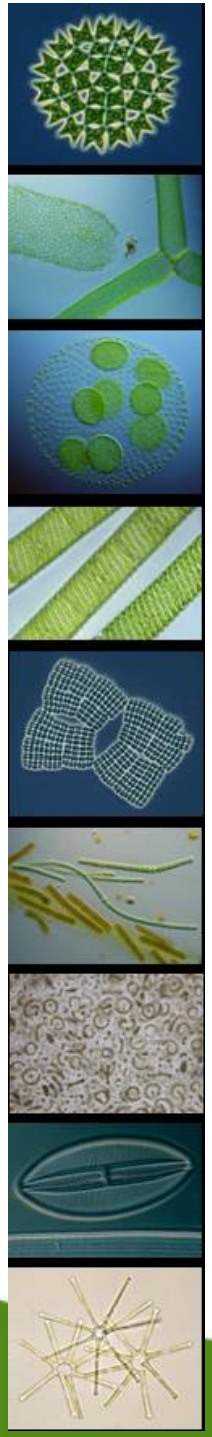


Conclusions

Manipulated lakes 1982-2006 (*cont*.):

- Shifts in CA axis 1 scores towards the reference lakes scores early to mid-1980s
- Periodic shifts away from reference lakes scores along CA axis 2; peaks in diatoms

Overall, our results indicate recovery in the phytoplankton of Hannah and Middle lakes based on number of algal taxa & community composition



Conclusions

Manipulated vs. unmanipulated lakes:

- Recovery earlier in manipulated lakes where pH >6 maintained (Hannah, Middle) based on community composition; number of taxa followed similar pattern to unmanipulated lakes
- Phytoplankton community structured differently to nearby reference lake communities in certain years

Next steps: analysis with water chemistry data

Acknowledgements (*thanks!*)

- Lucja Heintsch & Lynda Nakamoto of our phytoplankton laboratory
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