Assessing the roles of climate change and nutrients on deepwater oxygen depletion in Ontario Lake Trout lakes: A PALEOLIMNOLOGICAL PERSPECTIVE

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Outline

- Background
- Project Outline
- Study Design
- Research Questions
- Results
- Conclusion
- Next Steps

Lake Trout in Ontario

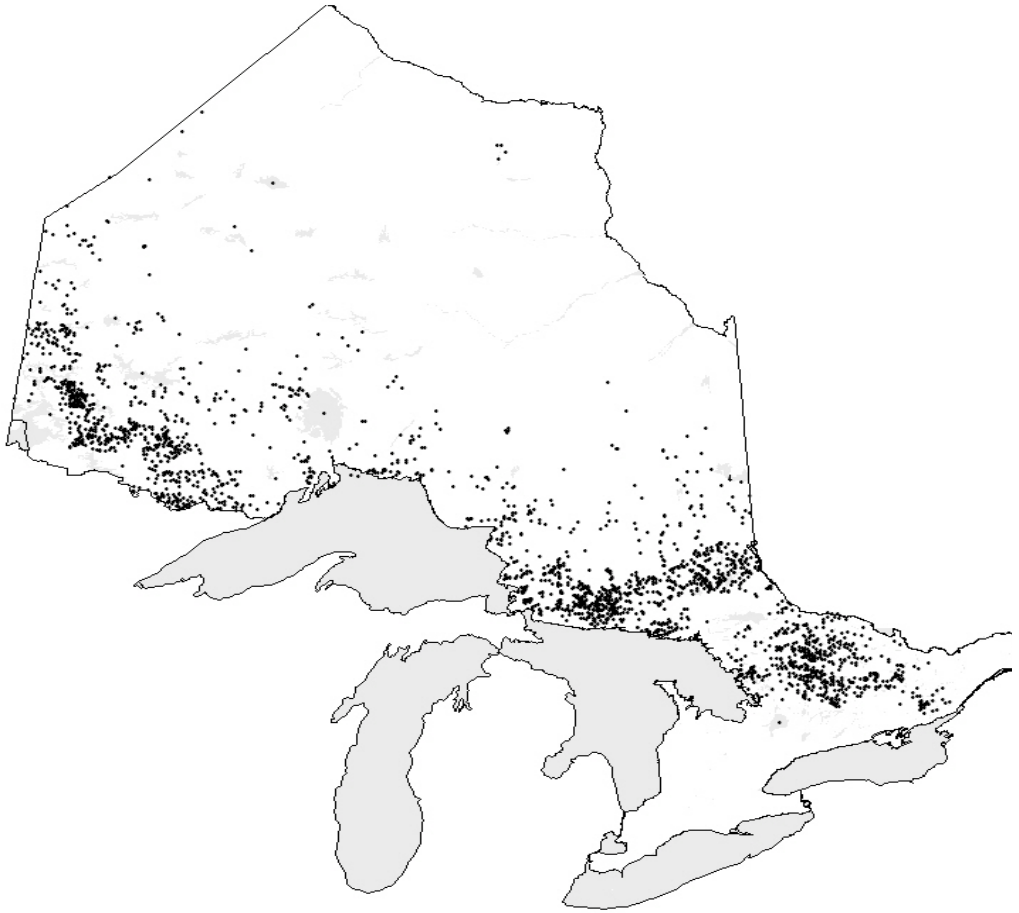
Rare & valuable resource

- 1% of Ontario lakes contain Lake Trout (20-25% of the world's Lake Trout lakes)

Good ecological indicator

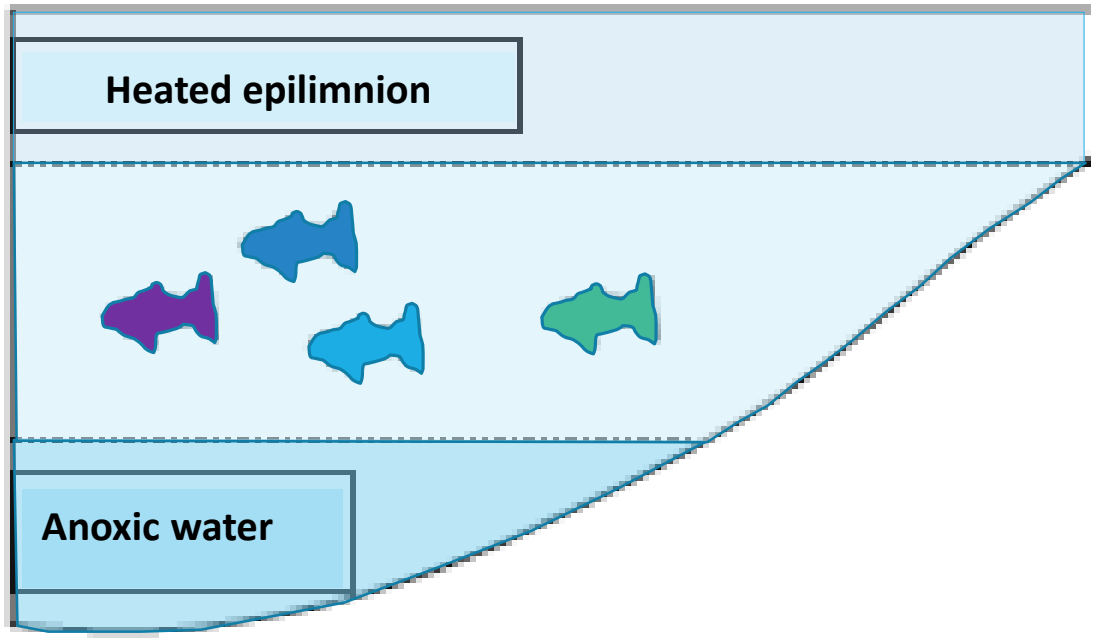
- Narrow physiological thresholds for temperature and oxygen

Important to recreational fisheries



Lake Trout lakes across Ontario (OMNR 2007)

Habitat Requirements



Modified from Ficke et al. (2007).

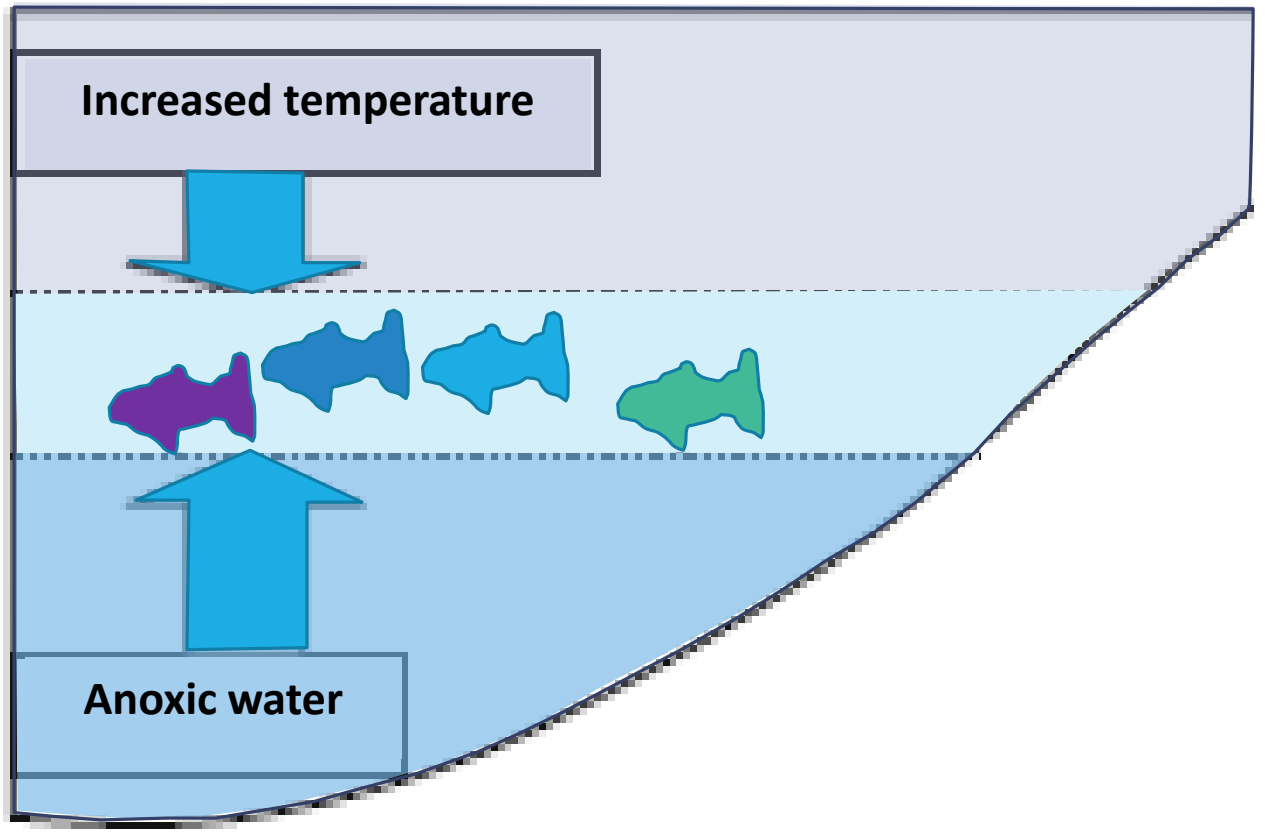
Lake Trout have narrow temperature and dissolved oxygen (DO) tolerances

- Temperature: 6-15°C
  (commonly below 8°C)
- DO: 9-12 mg/L
  (provincial standard: 7mg/L, mortality below 3 mg/L)

(Plumb and Blanchfield 2009)

Issue

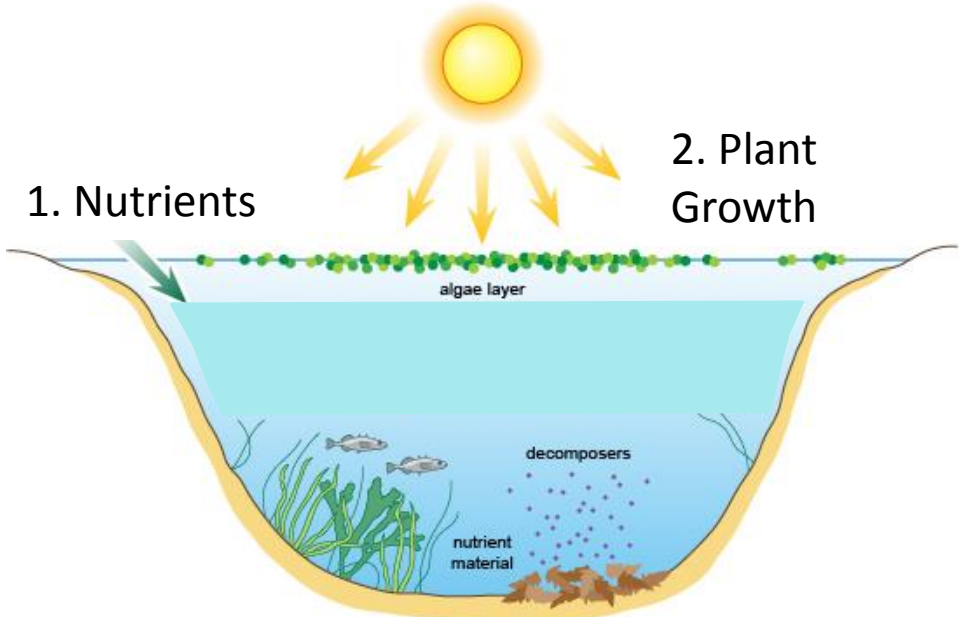
Lake Trout habitat degradation due to dissolved oxygen depletion



Modified from Ficke et al. (2007).

Role of TP in DO Depletion

Eutrophication can deplete DO in the hypolimnion during algal decomposition



3. Decomposition depletes O_2

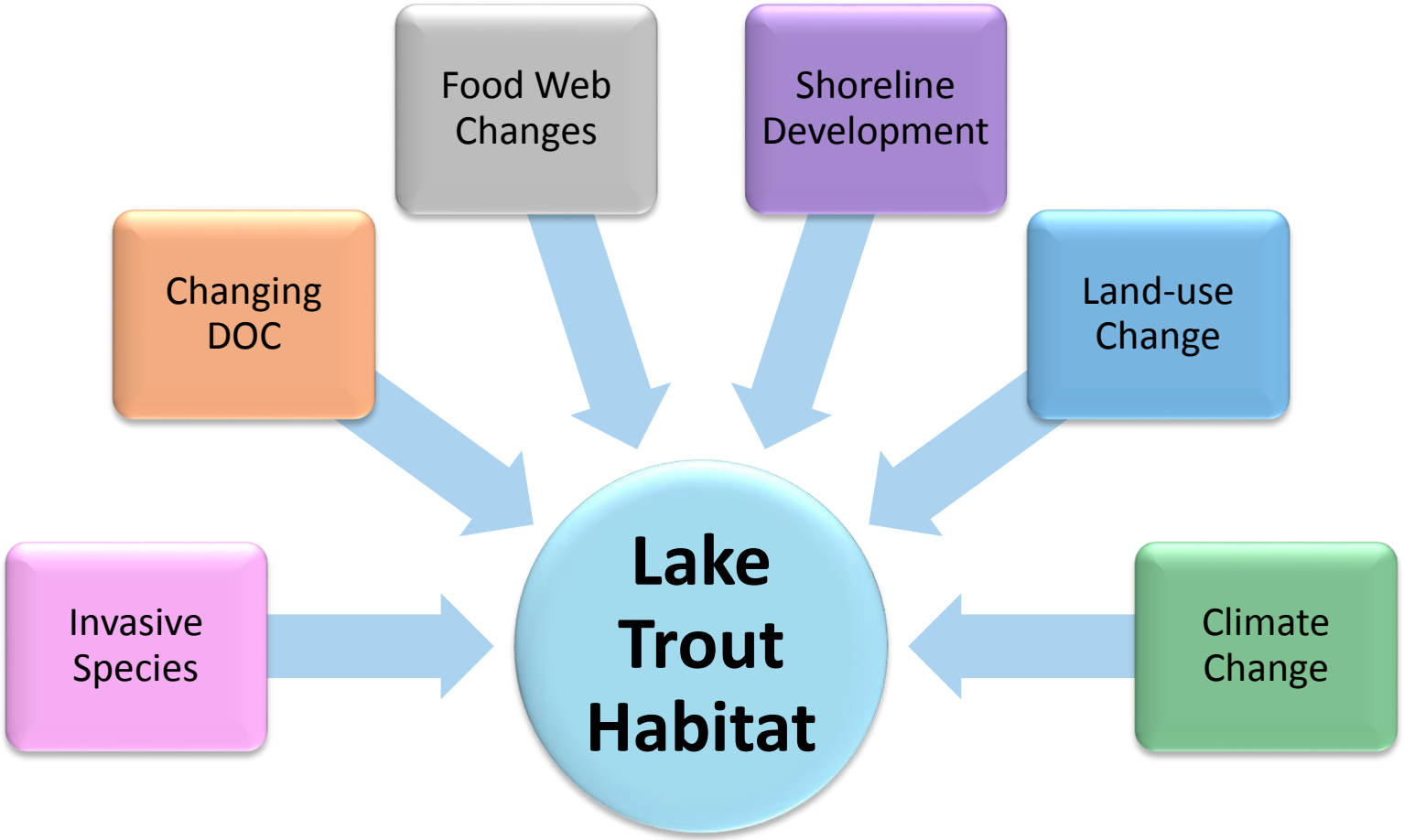
http://www.bbc.co.uk/schools/gcsebitesize/science/edexcel/problems_in_environment/pollutionrev4.shtml

Management efforts centered on controlling TP inputs

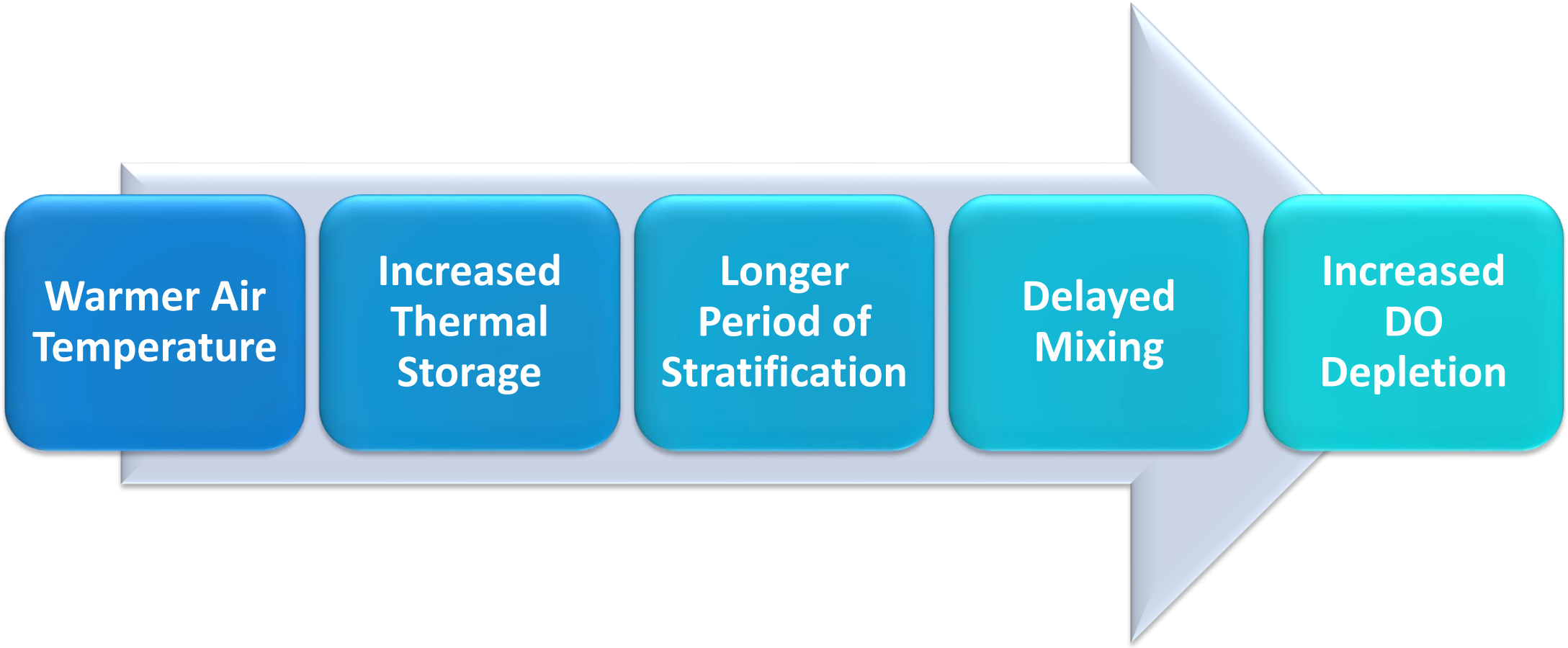
Complicated by:

- Internal loading
- Declining TP export from catchments (Eimers et al. 2009)
- DO depletion in lakes with steady or declining TP (Summers et al. 2012)

Multiple Stressors



Climate Change

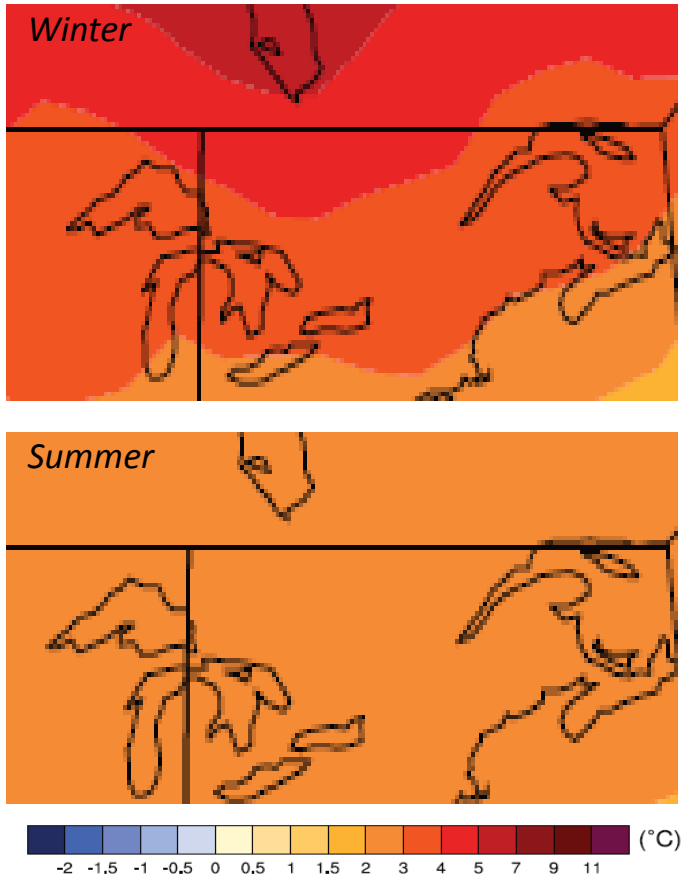


Climate Change

Climate change may complicate DO-TP dynamics

- Regional impacts across Ontario lakes

It is important to understand how the relationship between TP & DO is changing



Predicted Ontario temperature change for 2100 (IPCC 2014)

Project

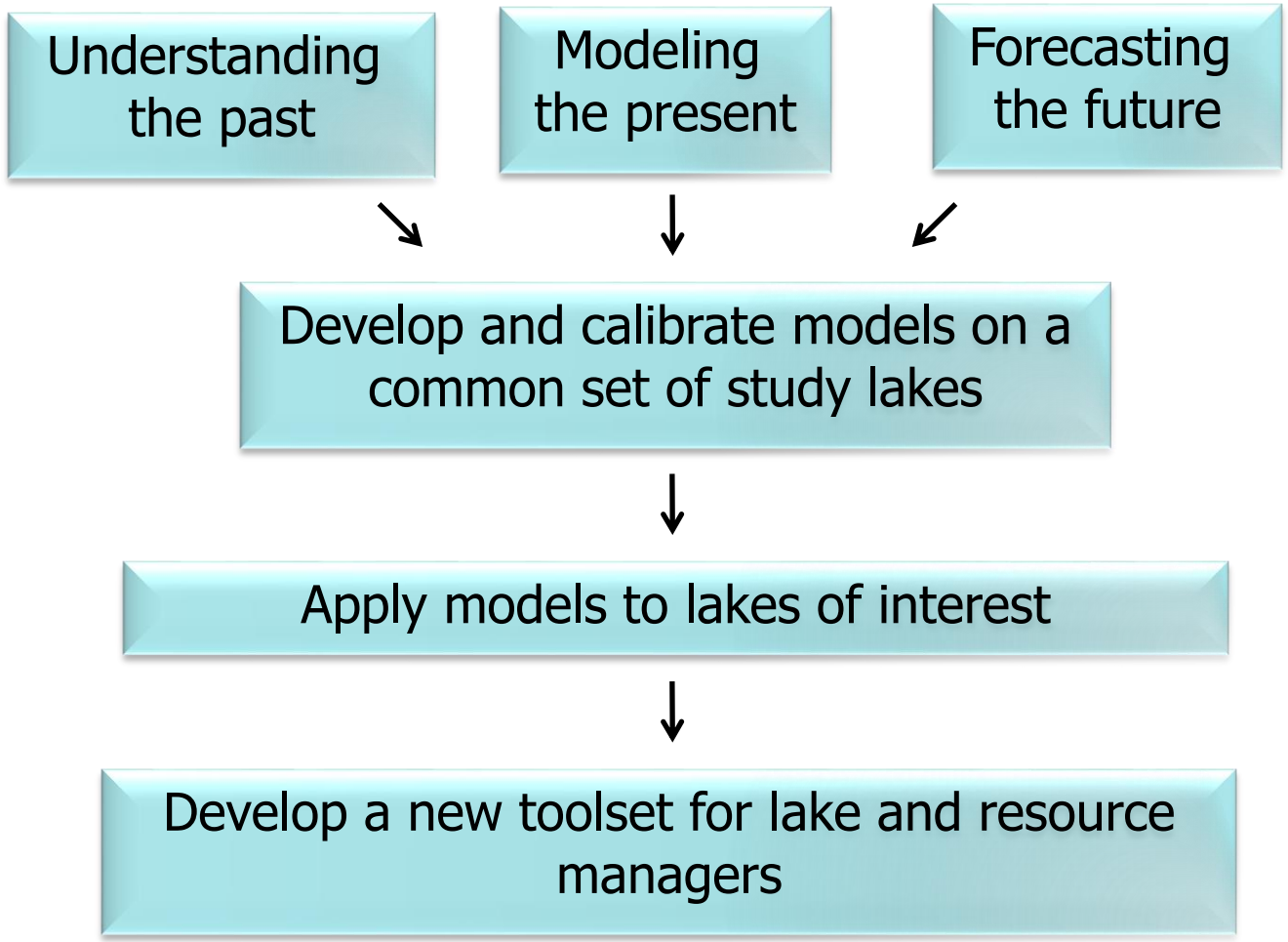
Investigate past TP-DO dynamics in Lake Trout lakes across Ontario

Of interest due to:

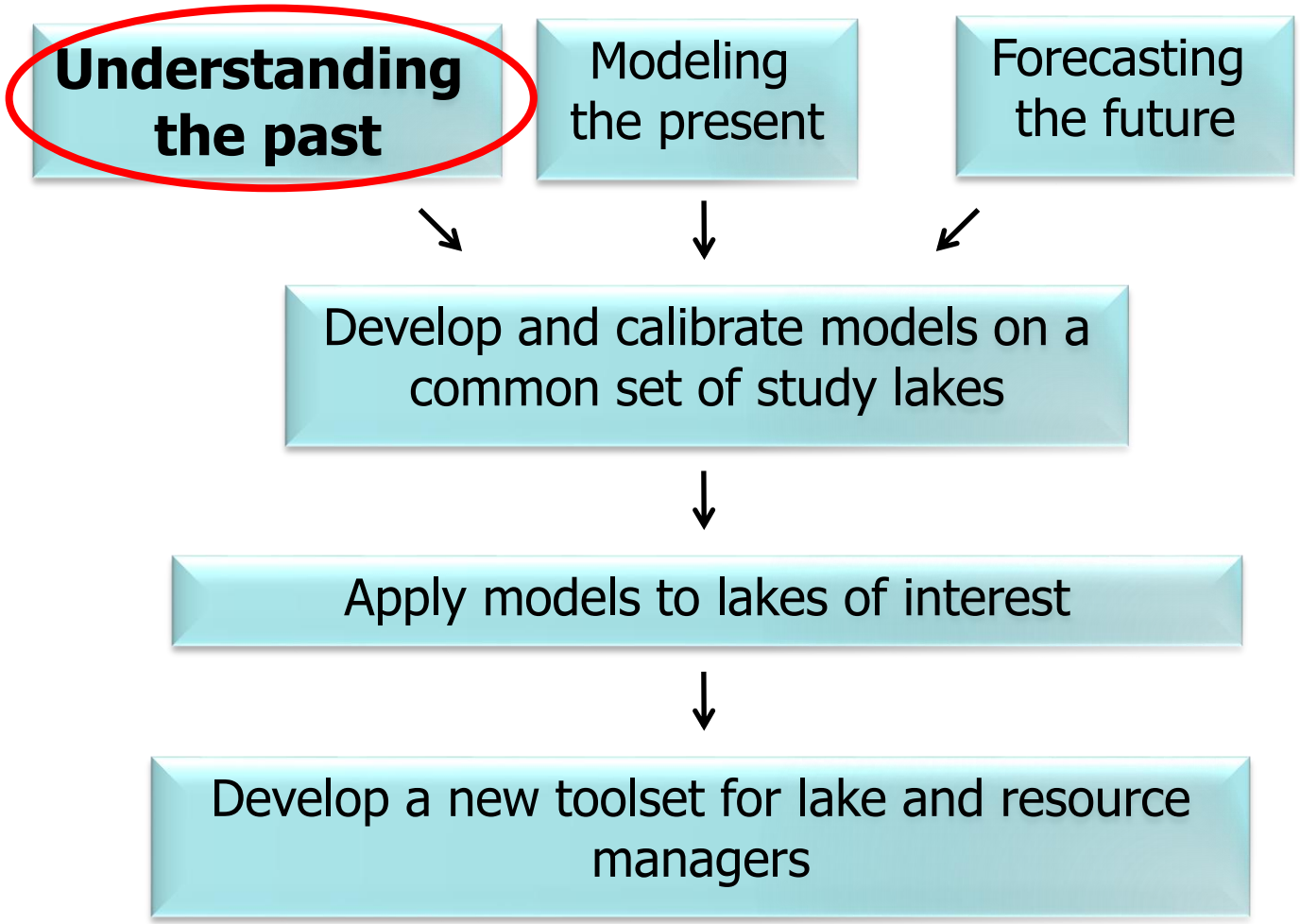
- Inherent link between TP and DO depletion
- Steady or declining TP across Boreal lakes
- Compounded influence of modern stressors
- Implications for habitat management

Muskrat Lake (Oct, 2014)

Study Design



Study Design



Understanding the Past: Paleolimnology

Infer past environmental conditions from indicators preserved in lake sediments

Useful due to a lack of long term monitoring records

Detailed information of past conditions is needed to assess the effects of modern stressors


Eagle Lake (Sept, 2014)

Understanding the Past: Paleolimnology

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Eagle Lake (Sept, 2014)

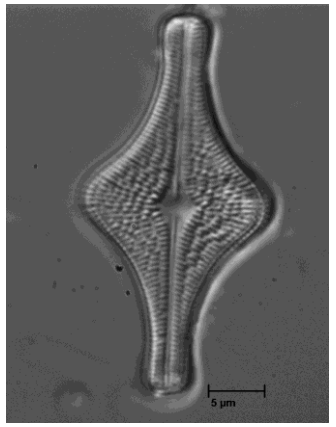
Goal is to reconstruct background conditions, trajectories of change and evaluate models

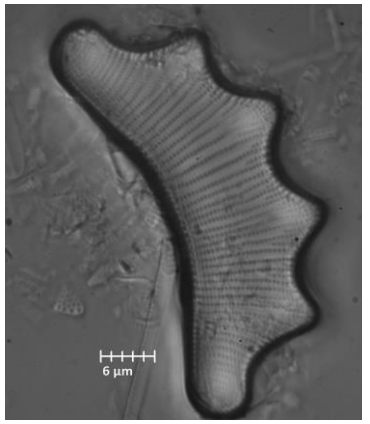
Understanding the Past: Paleolimnology

Indicators proposed to be analyzed:

Diatoms:

- Common siliceous algae
- Readily preserved and identifiable valves
- Used to reconstruct past [TP]





Chironomids:

- Larval remains of non-biting midges
- Identifiable head capsules preserve in sediments
- Used to reconstruct end-of-summer hypolimnetic [O_2]

http://post.queensu.ca/~pearl/cf8/cf8pics.html

Research Questions

1. How have diatom and chironomid assemblages changed over the past ~200 years in Lake Trout lakes across Ontario?
2. How have TP & DO changed?
3. Are the timing of changes consistent across lakes? (i.e. in the same direction and magnitude)

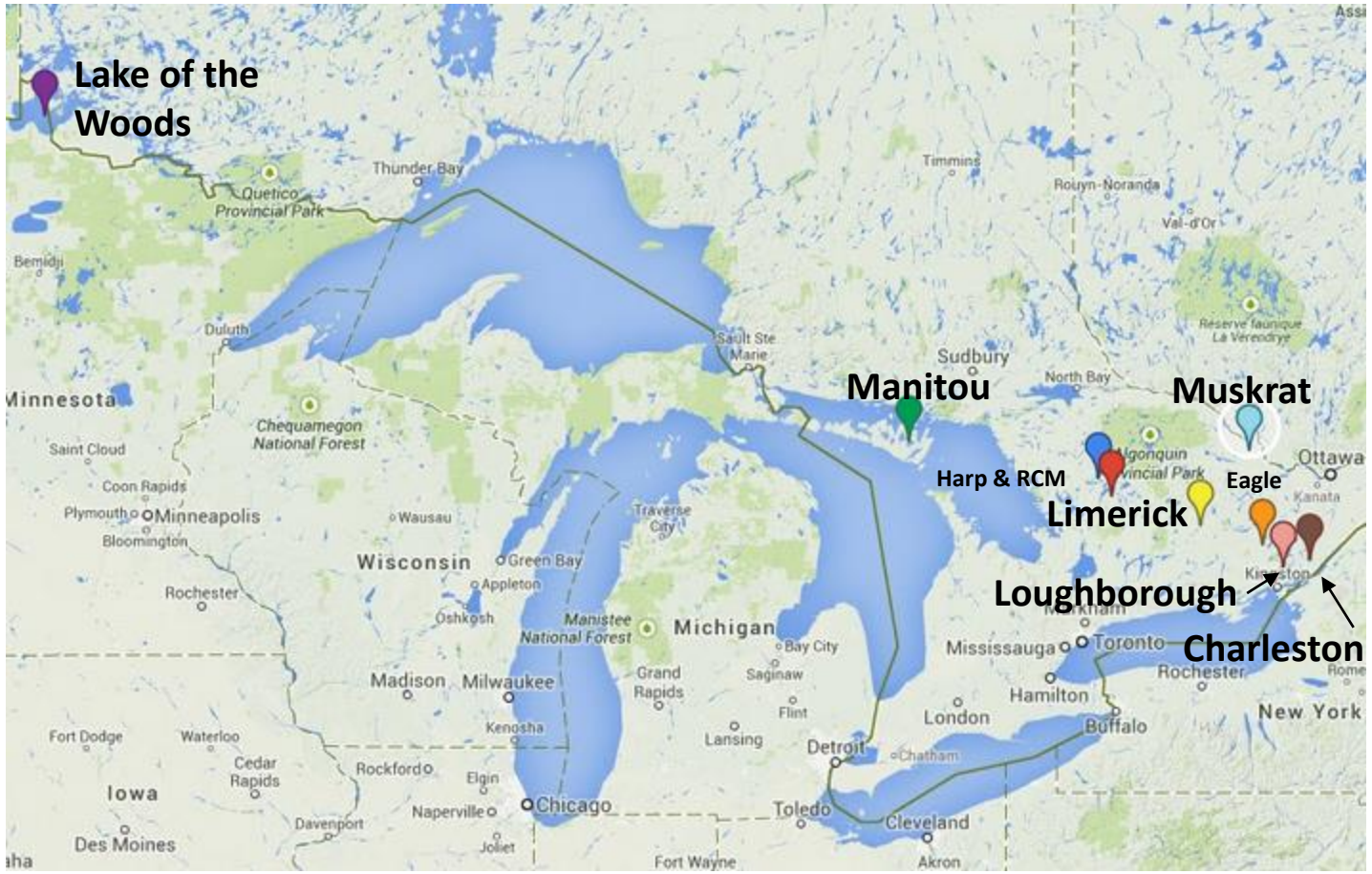
Eagle Lake (Sept, 2014)

Lake Selection

9 Study Lakes

3 lakes have extensive monitoring data (Harp, Red Chalk Main and Eagle) and will be used to ground truth predictive models and paleo reconstructions

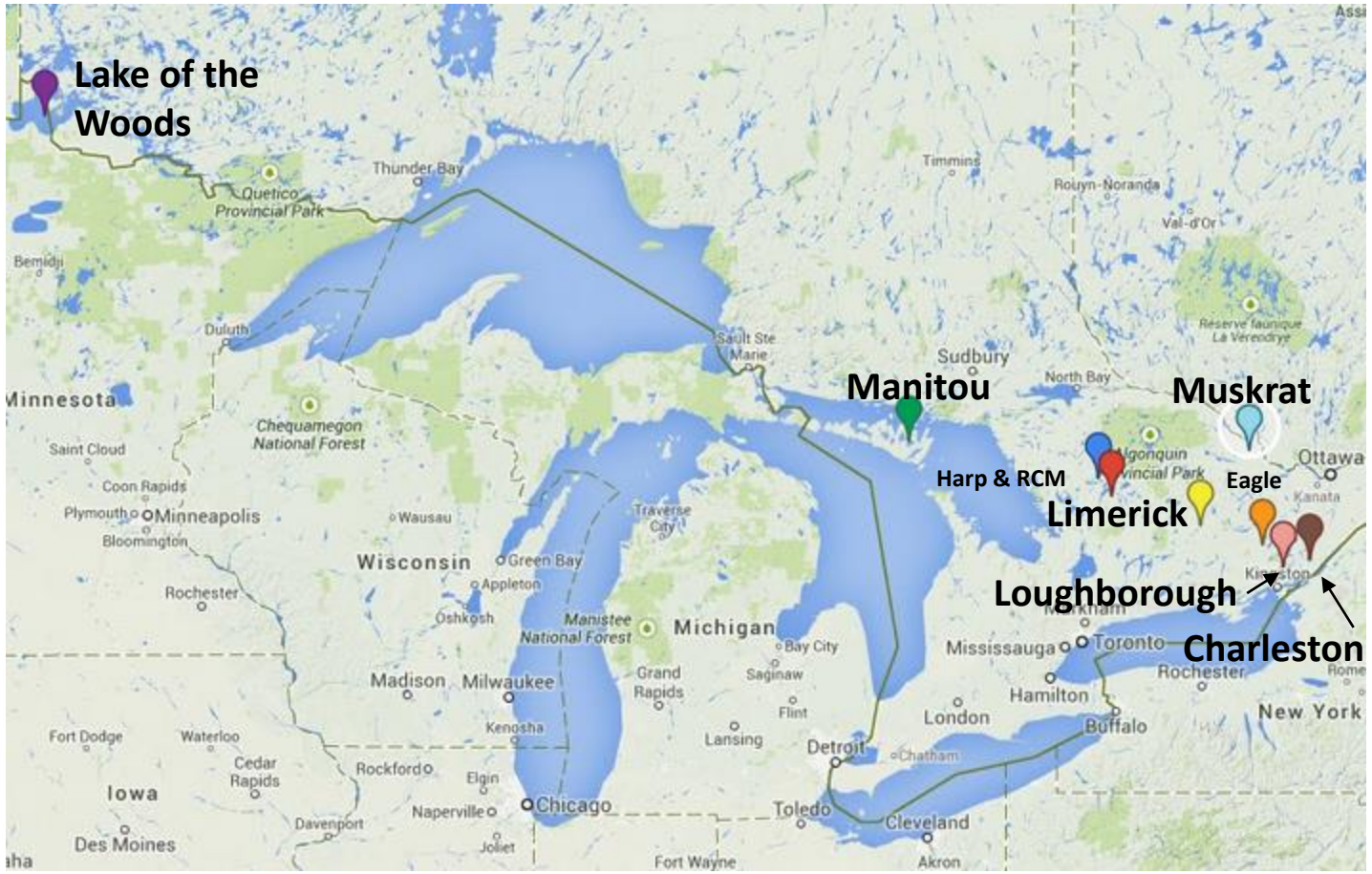
Lake Selection



9 Study Lakes

6 Lakes of Interest:
Charleston, Limerick, Loughborough, Muskrat, Manitou, and Lake of the Woods (Whitefish, Cul de Sac, and Echo bays)

Lake Selection



6 Lakes of Interest:

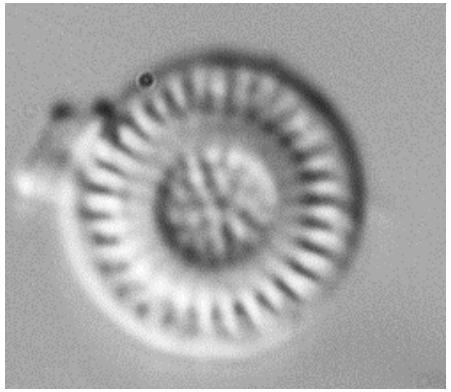
1. Impacted by shoreline development or agricultural stressors
2. Experienced long-term changes in the DO profile
3. Late summer hypolimnetic [DO] near or below 7 mg/L
4. Prior management interest

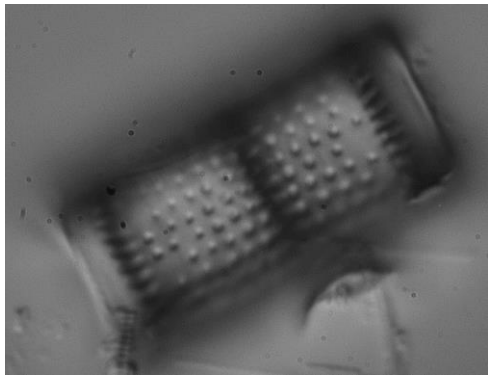
Results

Diatom assessment has been completed for Harp and Red Chalk

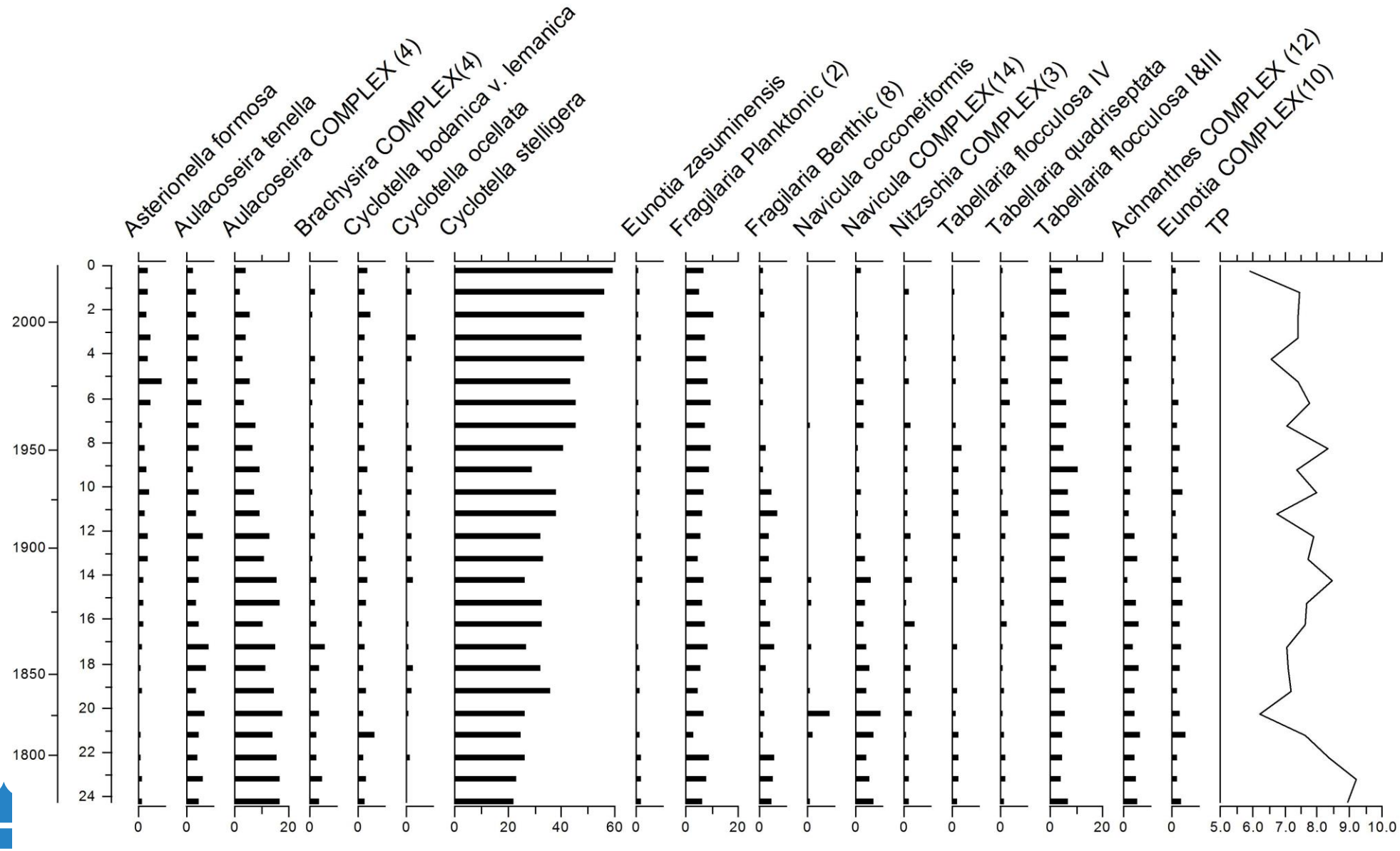
Subtle changes are evident in both lakes

- Increases in small centric & elongate planktonic taxa
- Decreases in the benthic and heavily silicified planktonic taxa
- Indicative of a climate signal – longer ice free season and increased thermal stability (Rühland et al. 2008)



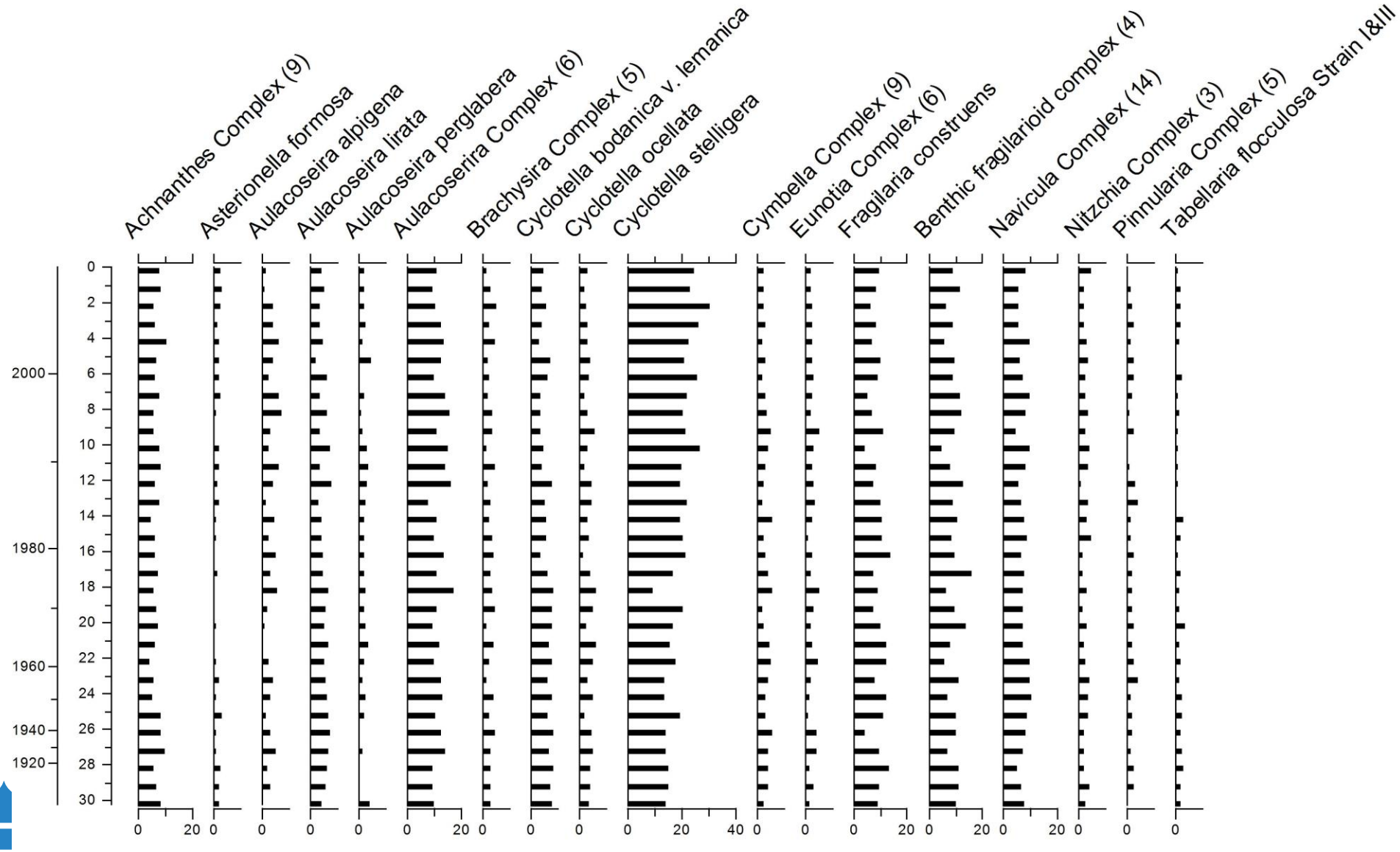


Harp Lake Diatoms



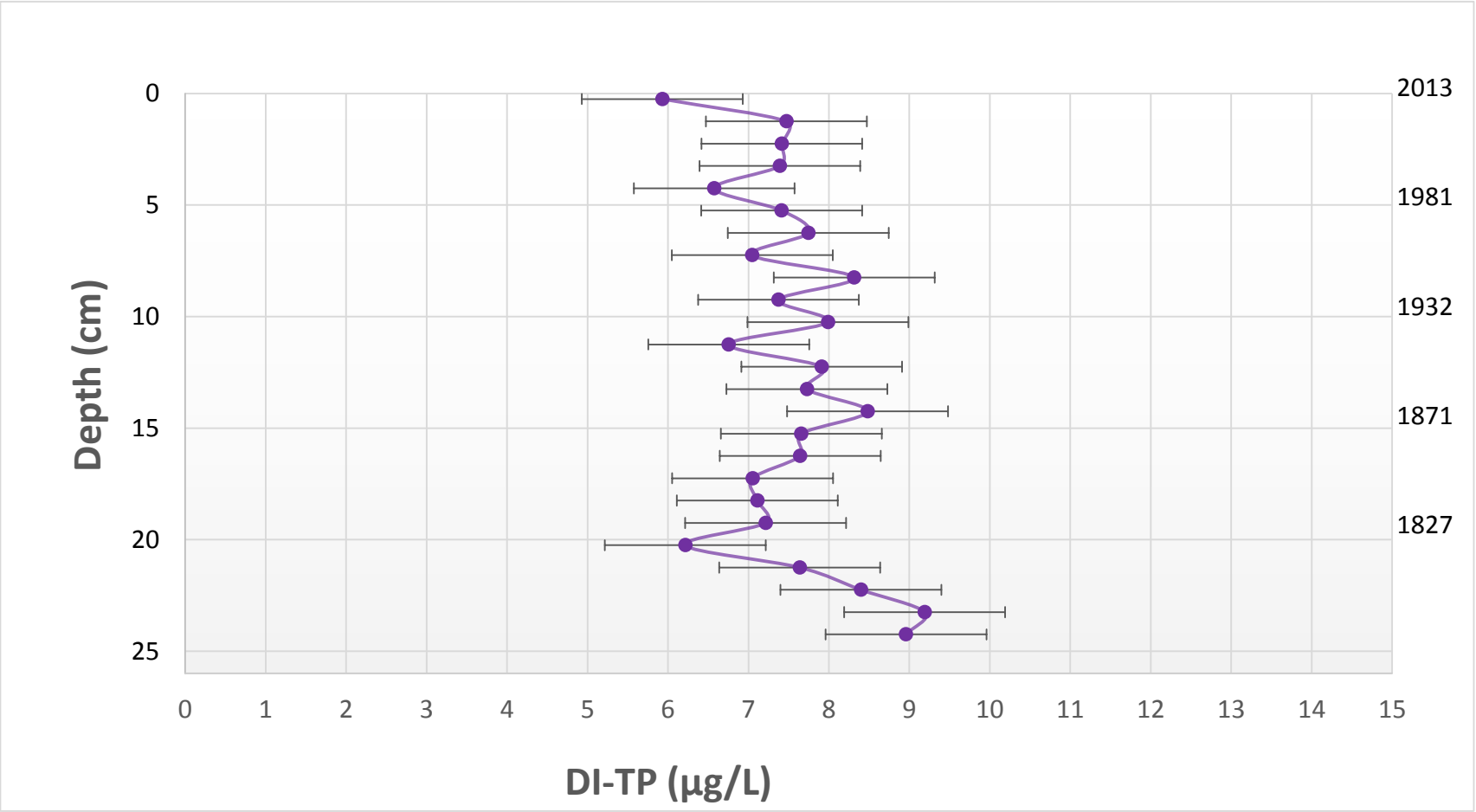
Max Depth: 37.5 m
pH: 6.42
TP: 6.35 µg/L
(Yan et al. 2008)

Red Chalk Lake Diatoms



Max Depth: 38 m
pH: 6.45
TP: 4.65 µg/L
(Yan et al. 2008)

Harp Diatom Inferred TP Reconstruction



- Applied the Hall and Smol (1996) DI-TP model
- TP reconstruction shows a slight decreasing trend
- Predicted values consistent with recent sampling
  - 1980: 9.02 µg/L
  - 2003: 6.35 µg/L

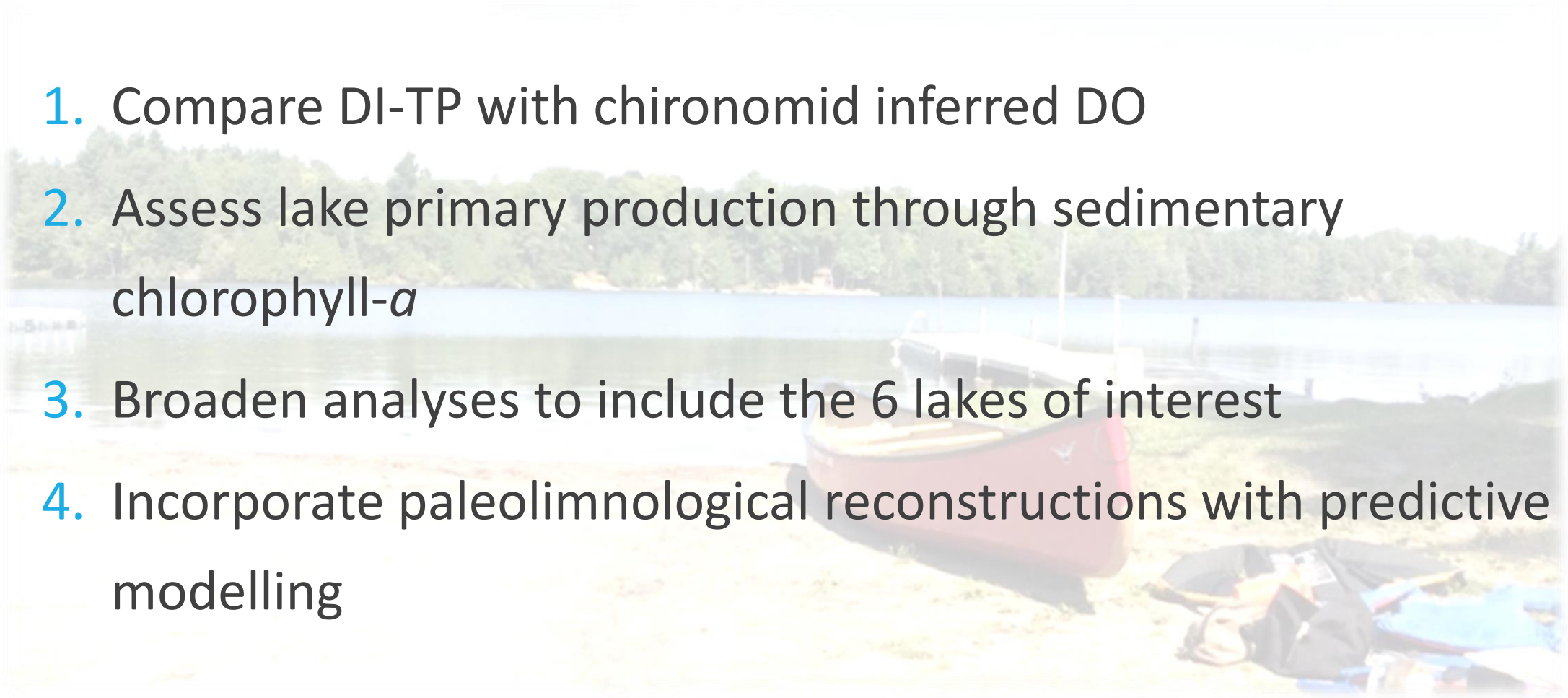
Conclusions

Preliminary results for Harp and Red Chalk lakes show only subtle changes in diatom assemblage over the last ~200 years

- Consistent with long-term monitoring data from the Dorset Environmental Science Centre
- Indicates a climate warming signal in modern sediment suggesting longer stratification (e.g. increase in planktonic taxa)

DI-TP values for Harp Lake are comparable to modern sampling

Next Steps



1. Compare DI-TP with chironomid inferred DO
2. Assess lake primary production through sedimentary chlorophyll-*a*
3. Broaden analyses to include the 6 lakes of interest
4. Incorporate paleolimnological reconstructions with predictive modelling

Acknowledgements

- NSERC
- Environment Canada
- Ontario Ministry of the Environment
- Ontario Ministry of Natural Resources
- Federation of Ontario Cottager's Associations
- Lake of the Woods Water Sustainability Foundation

Lake of the Woods water sustainability foundation

Ontario

NSERC CRSNG

FOCA Federation of Ontario Cottagers' Associations

Environment Canada

Questions?