Predicting dissolved oxygen concentrations in Lake Trout lakes: Developing new tools for a multiple-stressor world

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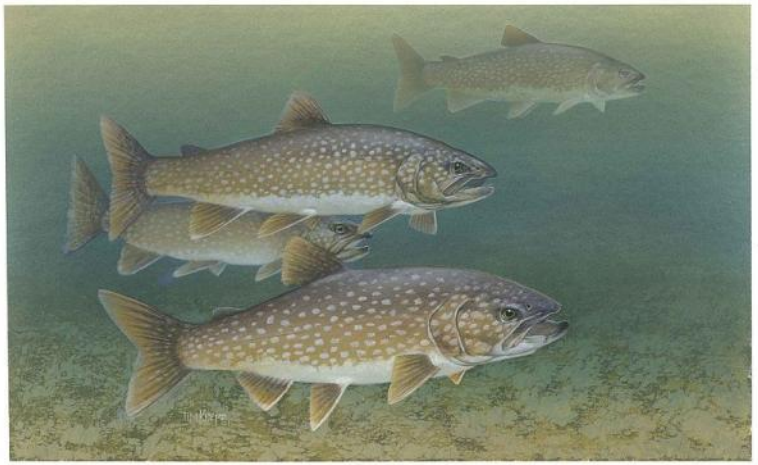
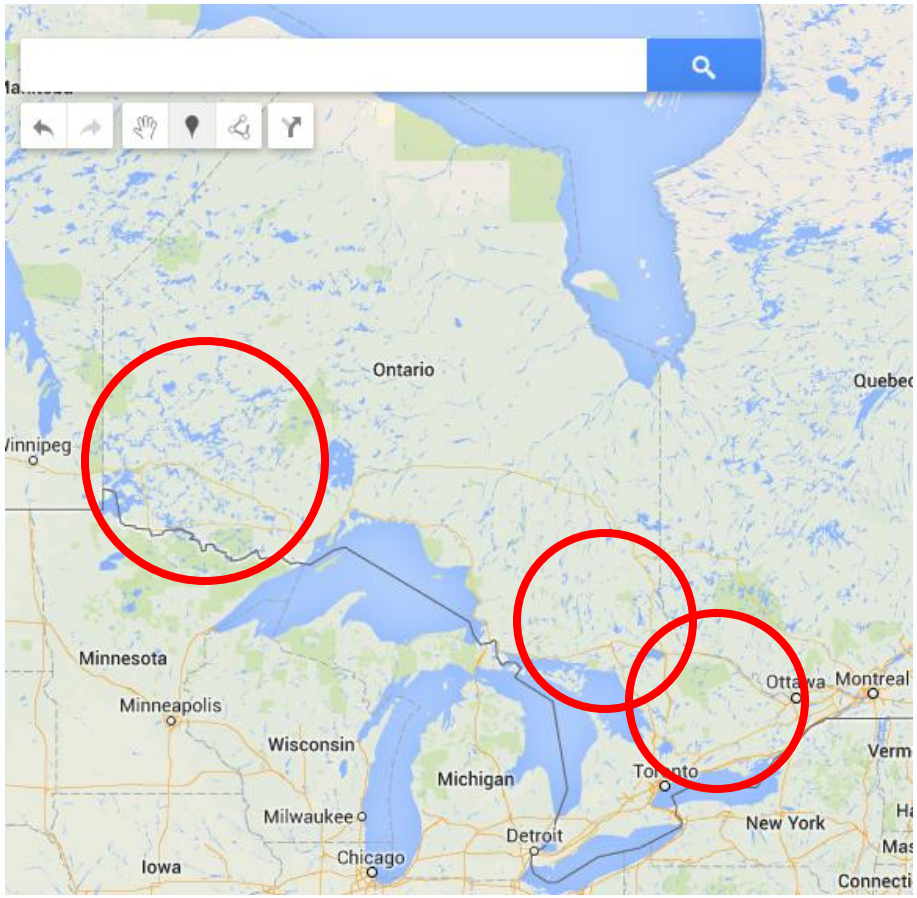
Outline

- Collaborative project examining dissolved oxygen in lake trout lakes
- Climate change and dissolved oxygen
- Project themes
- Paleolimnology
- Progress to date



Lake Trout Lakes

- A rare and valuable resource
- 20-25% of all lake trout lakes are in ON (~2200)
- Many are at or near the southern extent of its range



Multiple Environmental Stressors

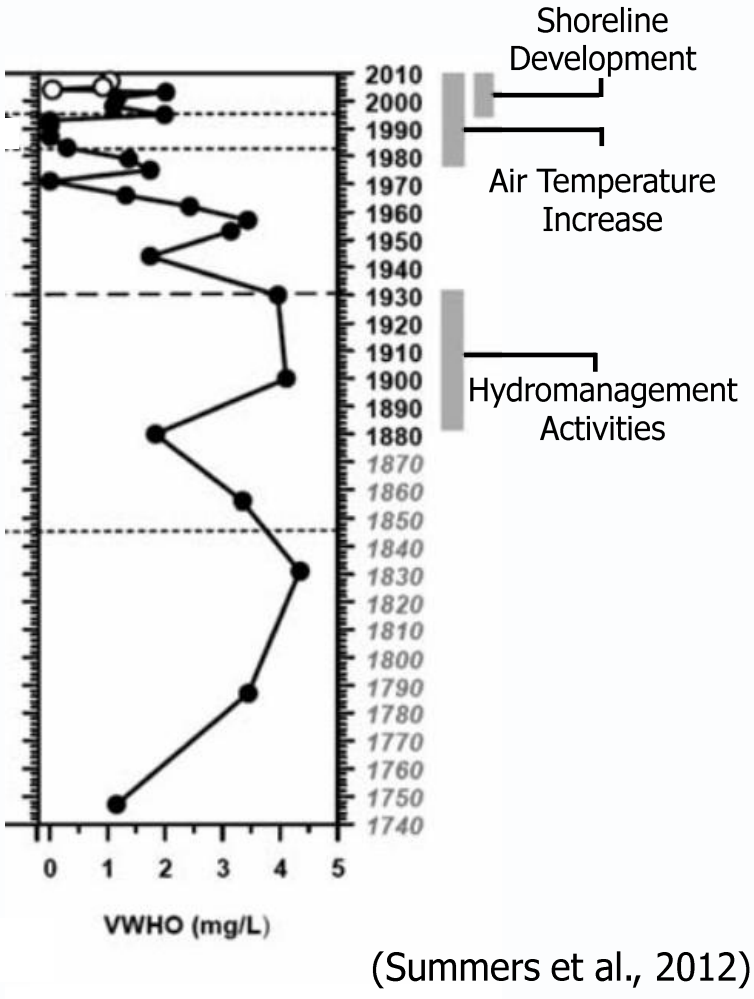
- Lake trout are large-bodied, long-lived, late maturing and vulnerable to many stressors:
  - Shoreline development
  - Exploitation
  - Eutrophication
  - Changing water levels
  - Species introductions
  - Lake acidification
  - Climate warming

Climate and Dissolved Oxygen

- Climate warming a “threat multiplier”
- Many southern lake trout populations live within narrow temperature and dissolved oxygen (DO) boundaries
- Growing concern of reduced available habitat due to oxygen depletion
- Typically, decreased DO associated with excessive nutrient loading

Climate and Dissolved Oxygen

- Growing evidence of decreased deepwater DO in lakes with steady/declining P levels (e.g. Poplar Bay, Lake of the Woods)
- Hypothesized to be due to climate-linked warming effects
- Reduced ice cover and increased strength of lake stratification



(Summers et al., 2012)

Project Overview

Theme 1: Understanding the past

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Paleolimnological reconstructions

Theme 2: Modeling the present

↓

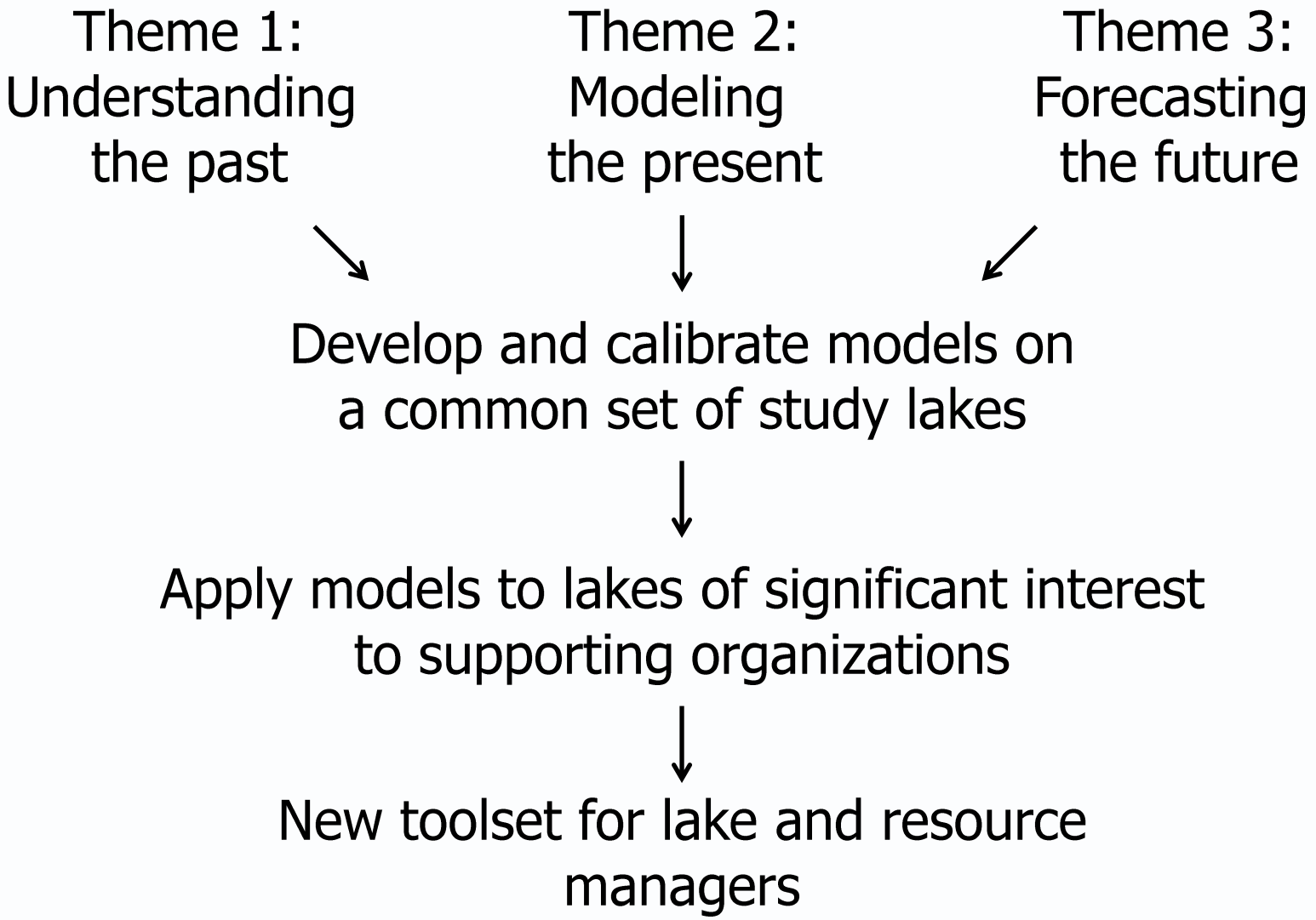
A modern empirical [DO] profile model

Theme 3: Forecasting the future

↓

Dynamic process-based model

Project Overview



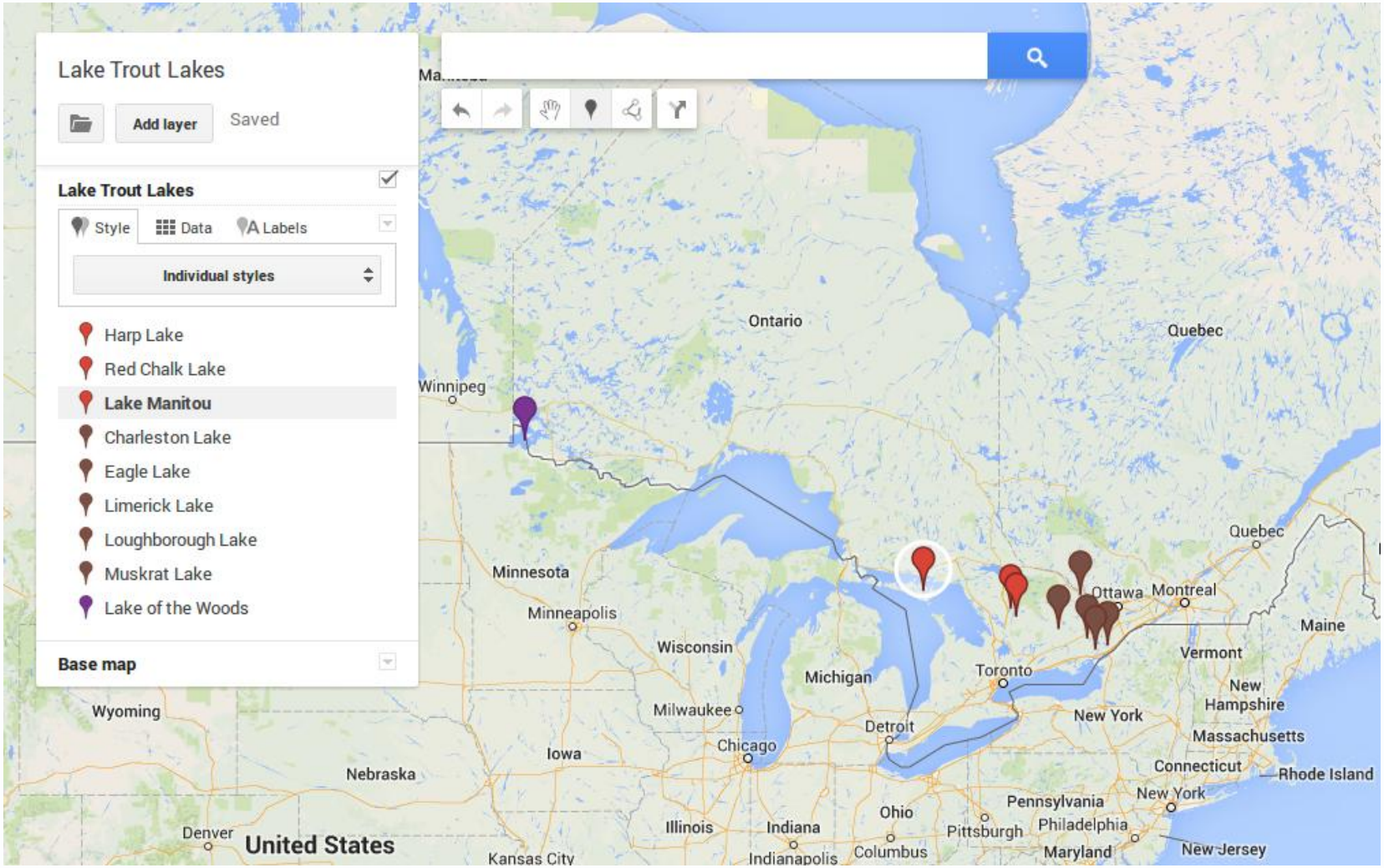
Study Lakes

- Naturally reproducing lake trout populations
- Long-term oxygen data

(+ at least one of)

- Significant shoreline development pressure or agriculture
- Long-term change in hypolimnetic DO
- Near or below 7ppm end-of-summer mean volume-weighted hypolimnetic DO
- Current management concerns

Study Lakes


Lake Trout Lakes
Add layer
Saved
Lake Trout Lakes
Style
Data
Labels
Individual styles
Harp Lake
Red Chalk Lake
Lake Manitou
Charleston Lake
Eagle Lake
Limerick Lake
Loughborough Lake
Muskrat Lake
Lake of the Woods
Base map
Ontario
Quebec
Winnipeg
Minnesota
Minneapolis
Wisconsin
Michigan
Toronto
Ottawa
Montreal
Quebec
Maine
Vermont
New Hampshire
Massachusetts
Connecticut
Rhode Island
New York
Pennsylvania
New York
Philadelphia
New Jersey
Maryland
Pittsburgh
Ohio
Columbus
Indiana
Indianapolis
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Chicago
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Milwaukee
Iowa
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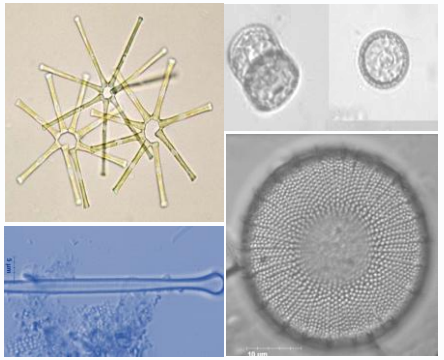
Kansas City
Denver
Wyoming
United States

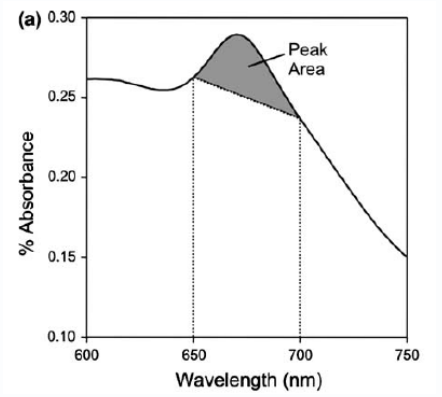
Understanding the past

- Lack of direct monitoring requires inferences of past conditions
- Archive of biological remains preserved in lake sediments
- Surface sediments representative of recent conditions
- Detailed temporal analyses possible

Paleolimnological Indicators

- Historical reconstructions will be used to validate the model hindcasts
  - Diatoms (Nutrients)
  - Chlorophyll *a* inferred from Visible Reflectance Spectroscopy (VRS)
  - Chironomids (Dissolved oxygen)

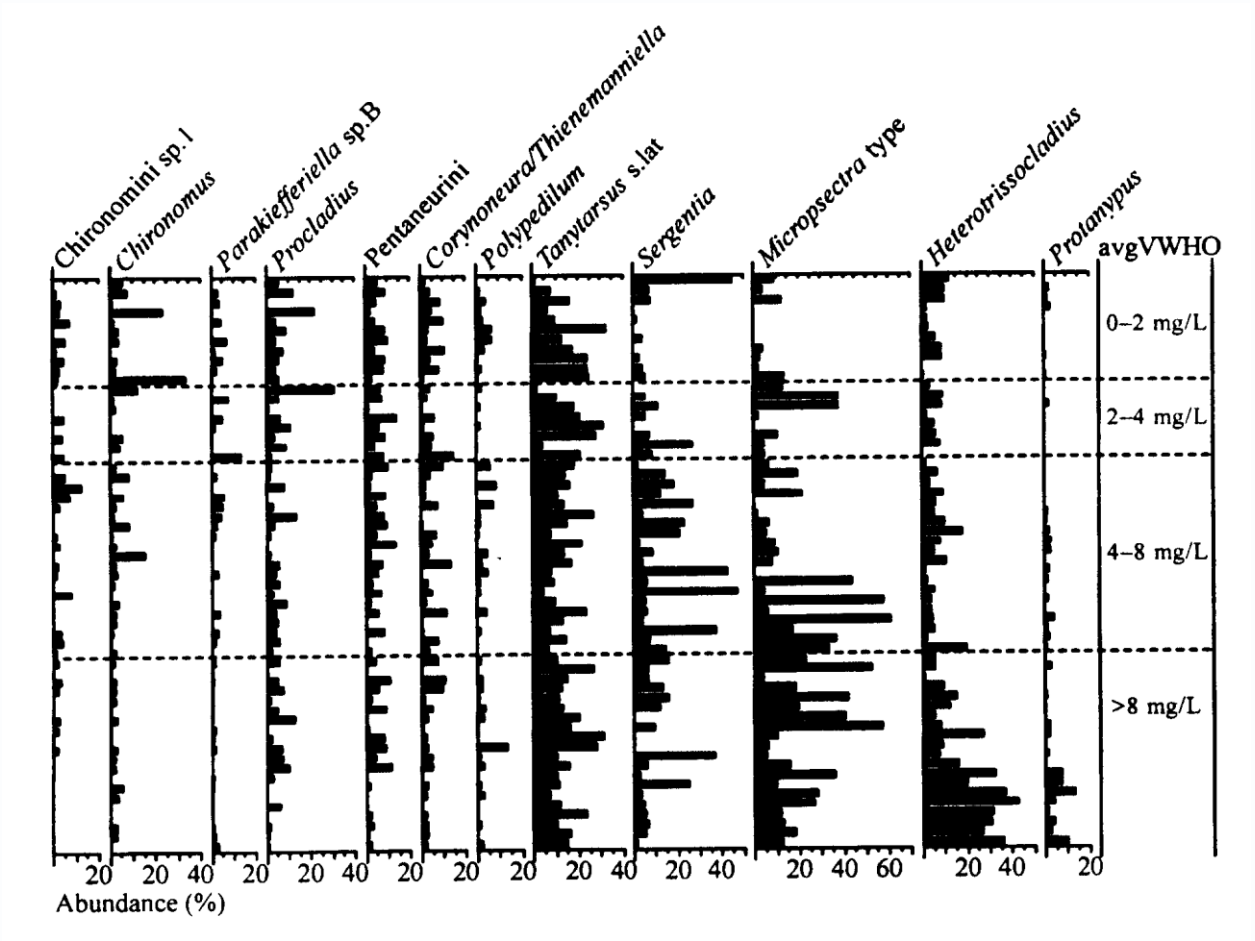




Chironomids

- Larval remains of non-biting midges (Chaoboridae)
- Head capsules preserve in lake sediments and are identifiable to the genus or species level
- Provide an indirect method to reconstruct historical values for end-of-summer hypolimnetic oxygen concentrations

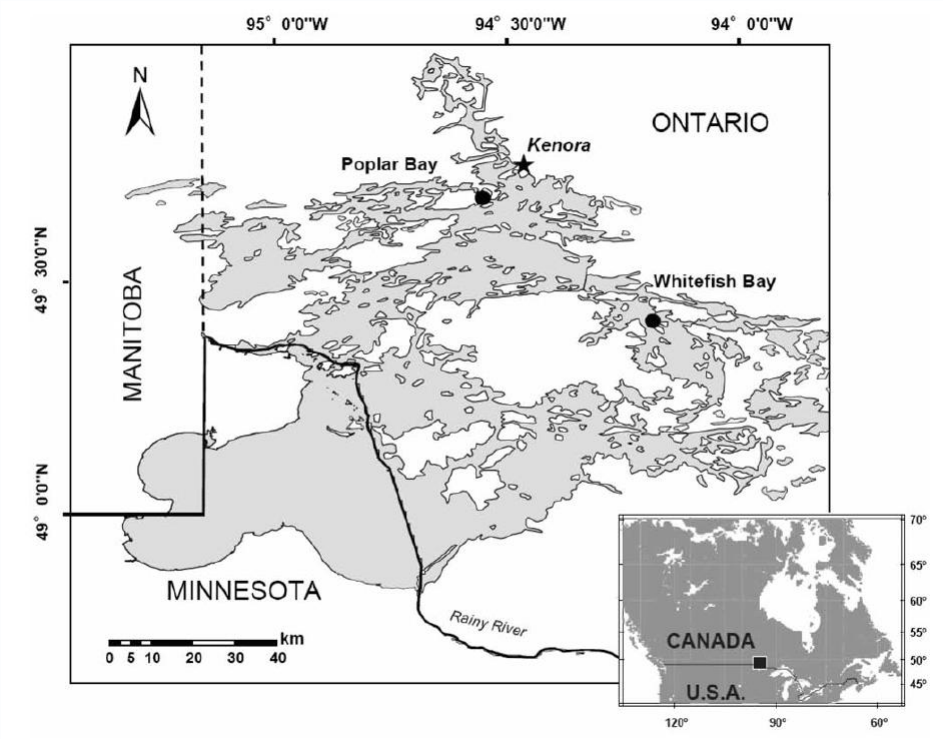
Chironomids



(Quinlan and Smol, 2001)

Poplar Bay, Lake of the Woods

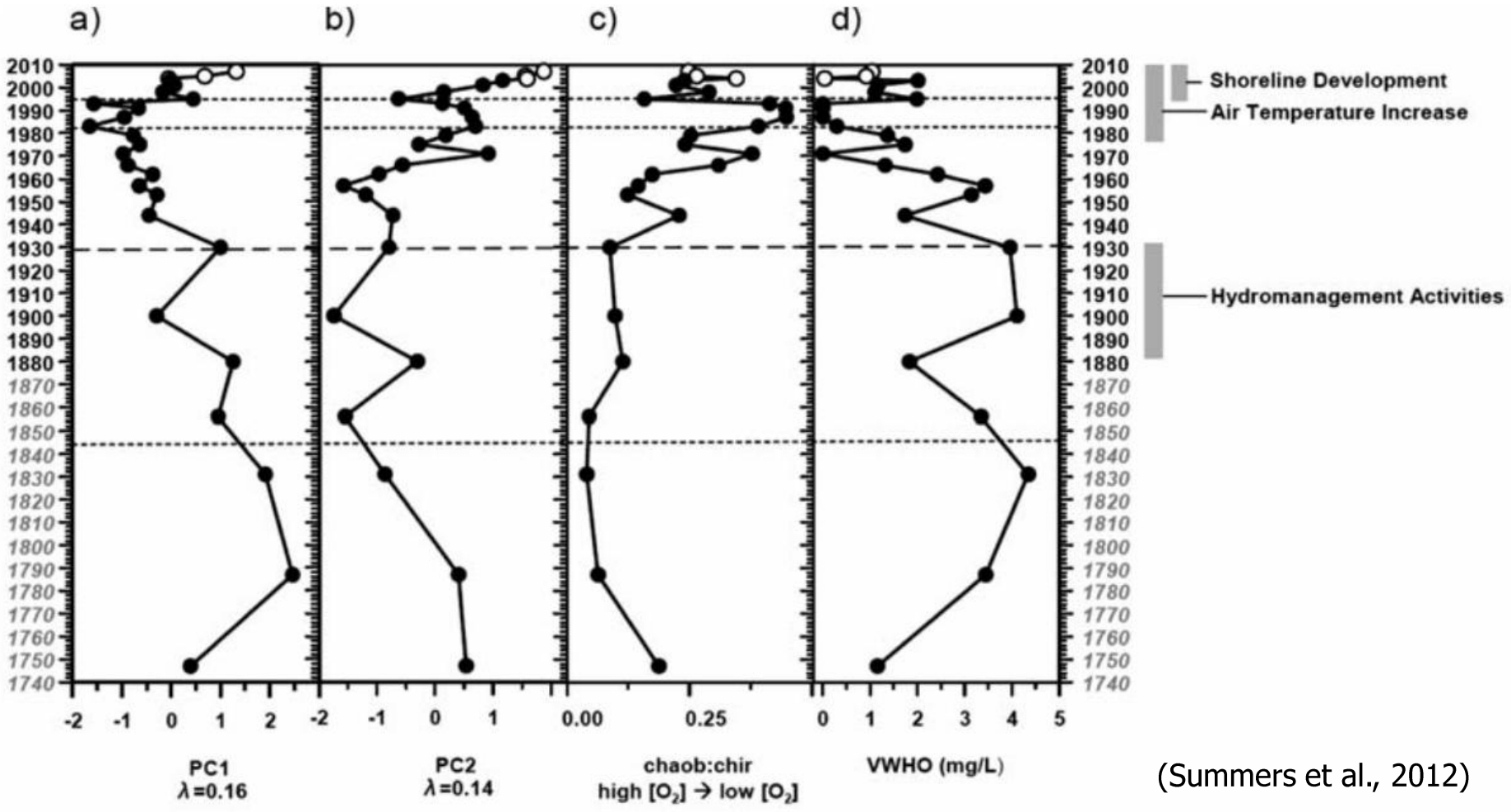
- Prior chironomid-inferred DO analyses
- Poplar Bay in northern Lake of the Woods
- Reports of late-summer hypoxia
- Recent shoreline development (mid-1990s)



(Summers et al., 2012)

Poplar Bay, Lake of the Woods

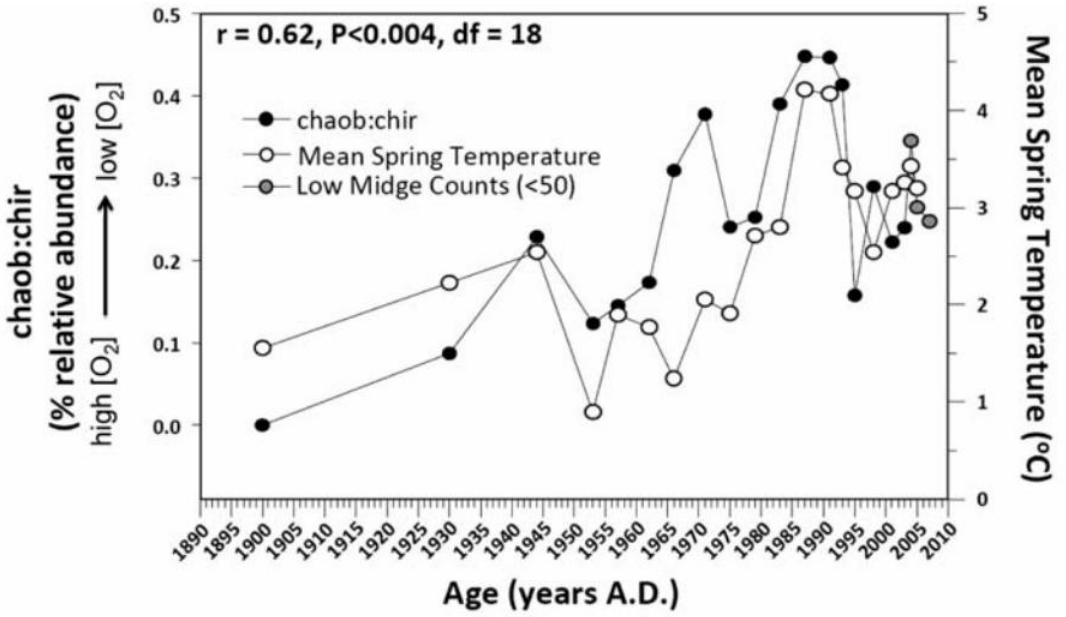
Effects of multiple stressors on Poplar Bay midge assemblages



(Summers et al., 2012)

Poplar Bay, Lake of the Woods

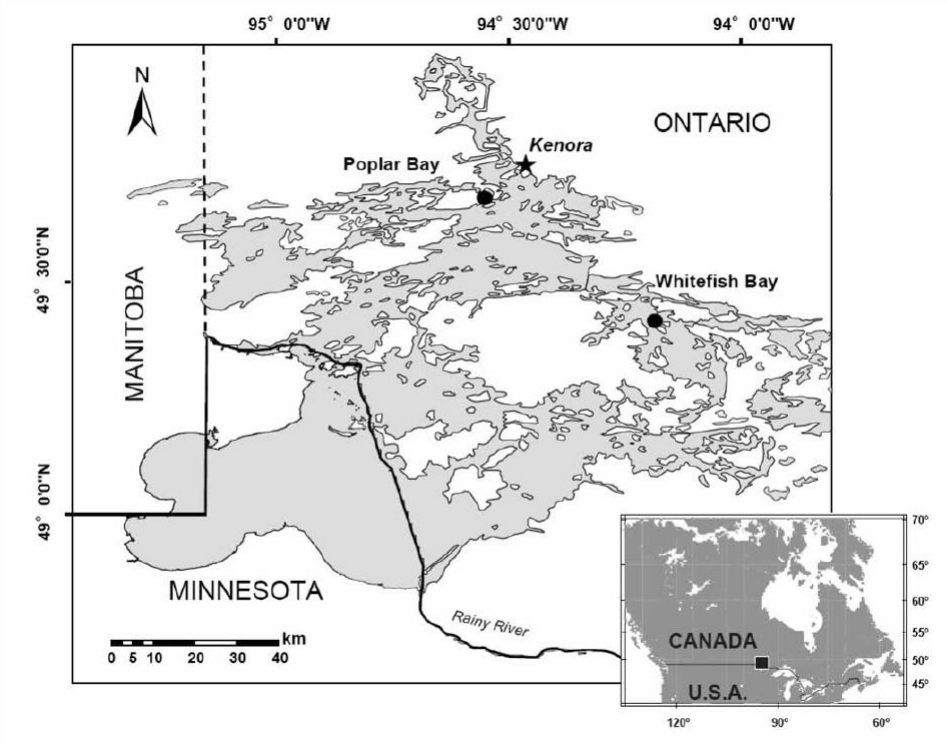
- Importance of climate warming
- Longer ice-free period (~28 days since 1960s)
- Strong relationship between chaob:chir and temperature record



(Summers et al., 2012)

Where next?

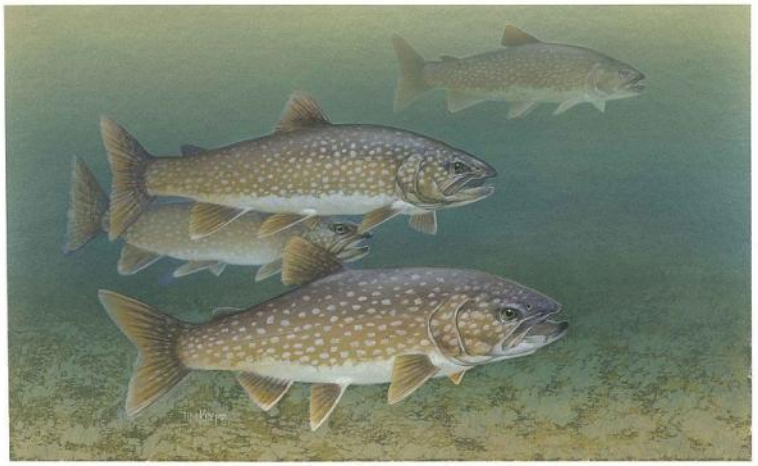
- Analyze cores from other locations in LotW with historical lake trout populations
  - Clearwater Bay
  - Echo Bay
  - Cul de Sac Bay
  - ?



(Summers et al., 2012)

Going Forward

- Students recruited for all three themes
- Central Ontario cores already collected and analyses underway
- Fieldwork planned for later this year
  - Eastern Ontario lakes (Summer)
  - Lake of the Woods (Fall)
- Return with data…



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

References:

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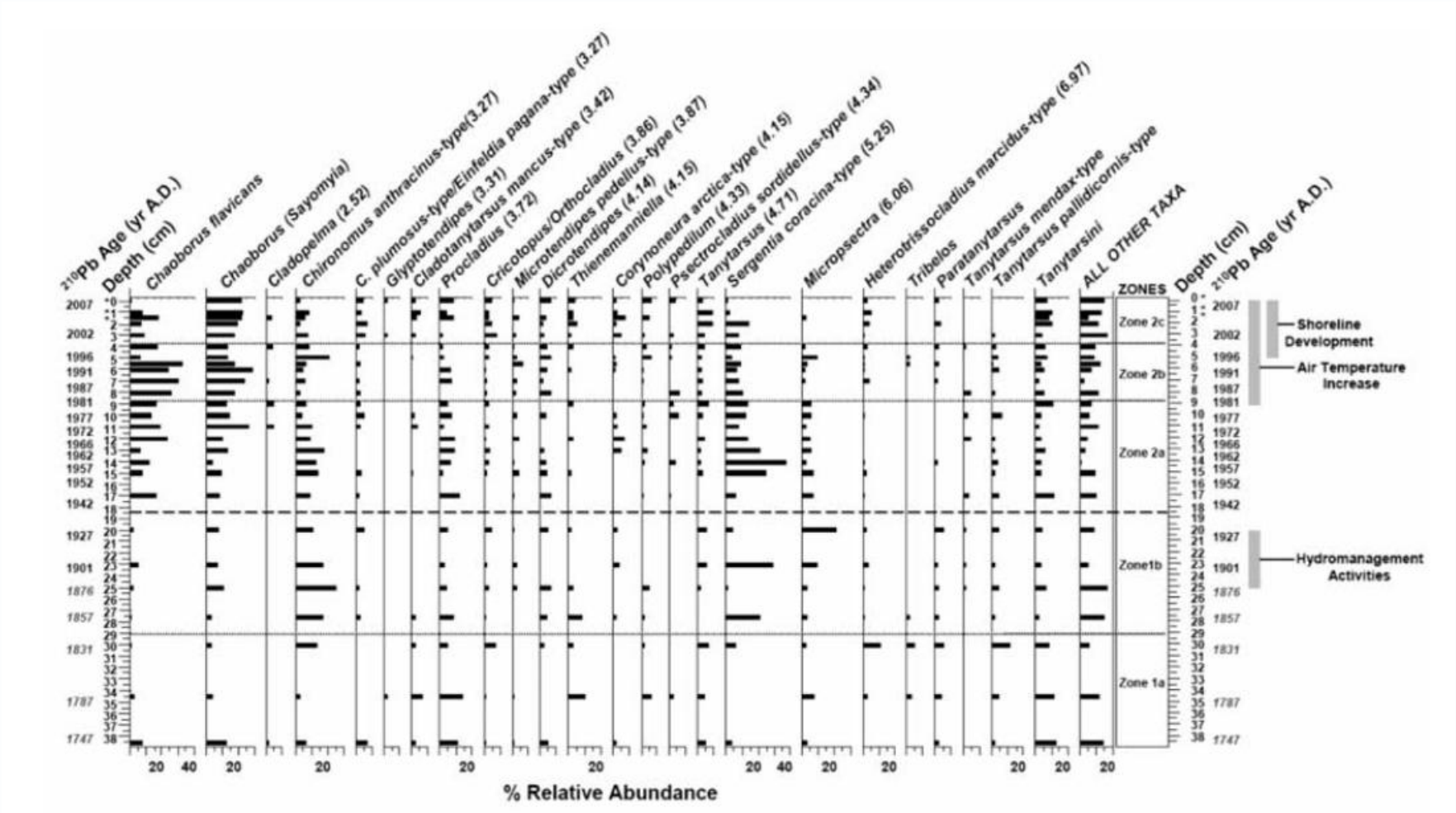
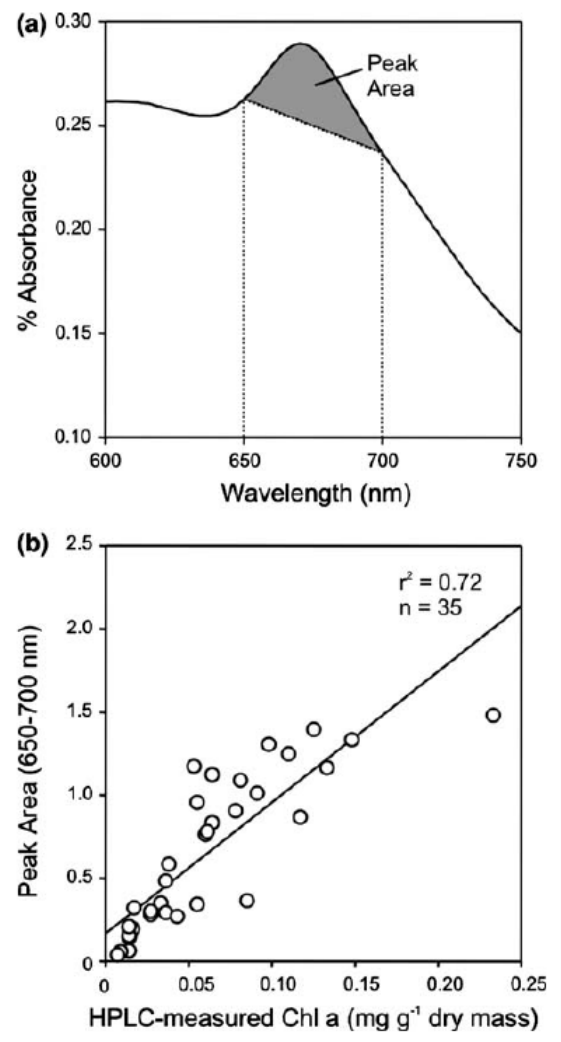
Quinlan R, Smol JP (2001) Chironomid-based inference models for estimating end-of-summer hypolimnetic oxygen from south-central Ontario shield lakes. Freshwater Biology 46: 1529-1551

Poplar Bay, Lake of the Woods



Visible Reflectance Spectroscopy

- Visible Reflectance Spectroscopy (VRS) can infer chlorophyll *a* (and associated breakdown products) concentrations in sediments (Wolfe et al. 2006)
- Similar technique has been developed for downcore inferences of DOC



(Michelutti et al., 2010)