Using Sedimentary Diatom and Chironomid Assemblages to Investigate Potential Environmental Triggers for Recent Cyanobacterial Blooms in Ontario Lakes

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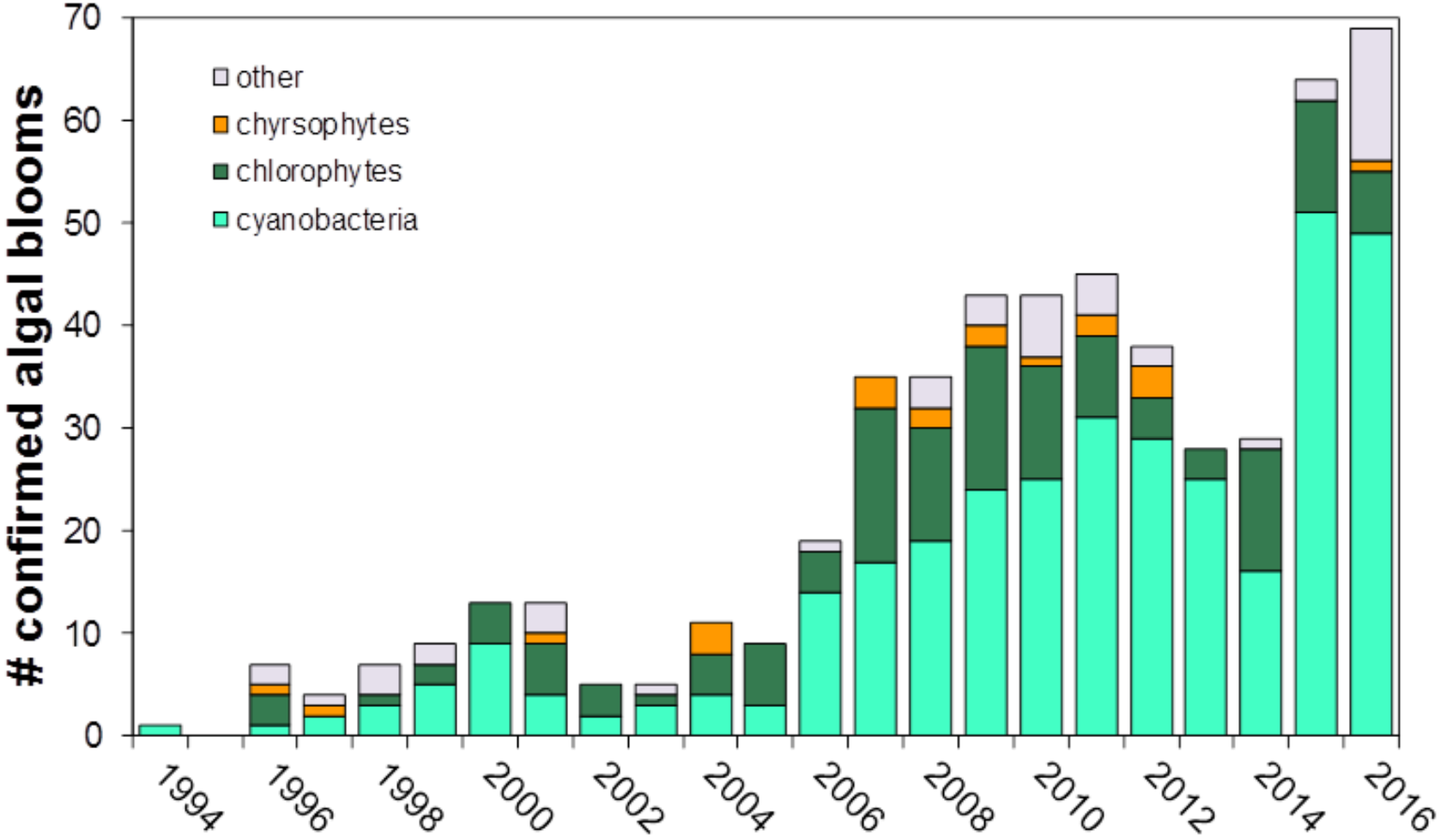
Image credit: algonquinpark.on.ca

Increasing Algal Bloom Reports across Ontario

- Increasing trend in total, cyanobacteria (blue-green algae) and chlorophyte bloom reports over the last two decades:



Winter et al. 2011, Lake and Reservoir Management, Updated by OMOECC 2016

Consequences of Algal Blooms

- Reduced water clarity
- Loss of deep-water oxygen:
  - Reduction of suitable habitat
  - Internal nutrient loading
- Toxins
- Taste and odour issues
- Environmental, social and economic impacts

Image retreived from:
http://storage.thesudburystar.com/v1/dynamic_resize/sws_path/suns-prod-images/1297722697652_ORIGINAL.jpg?quality=80&size=650x&stmp=1436495089821

Causes of Algal Blooms

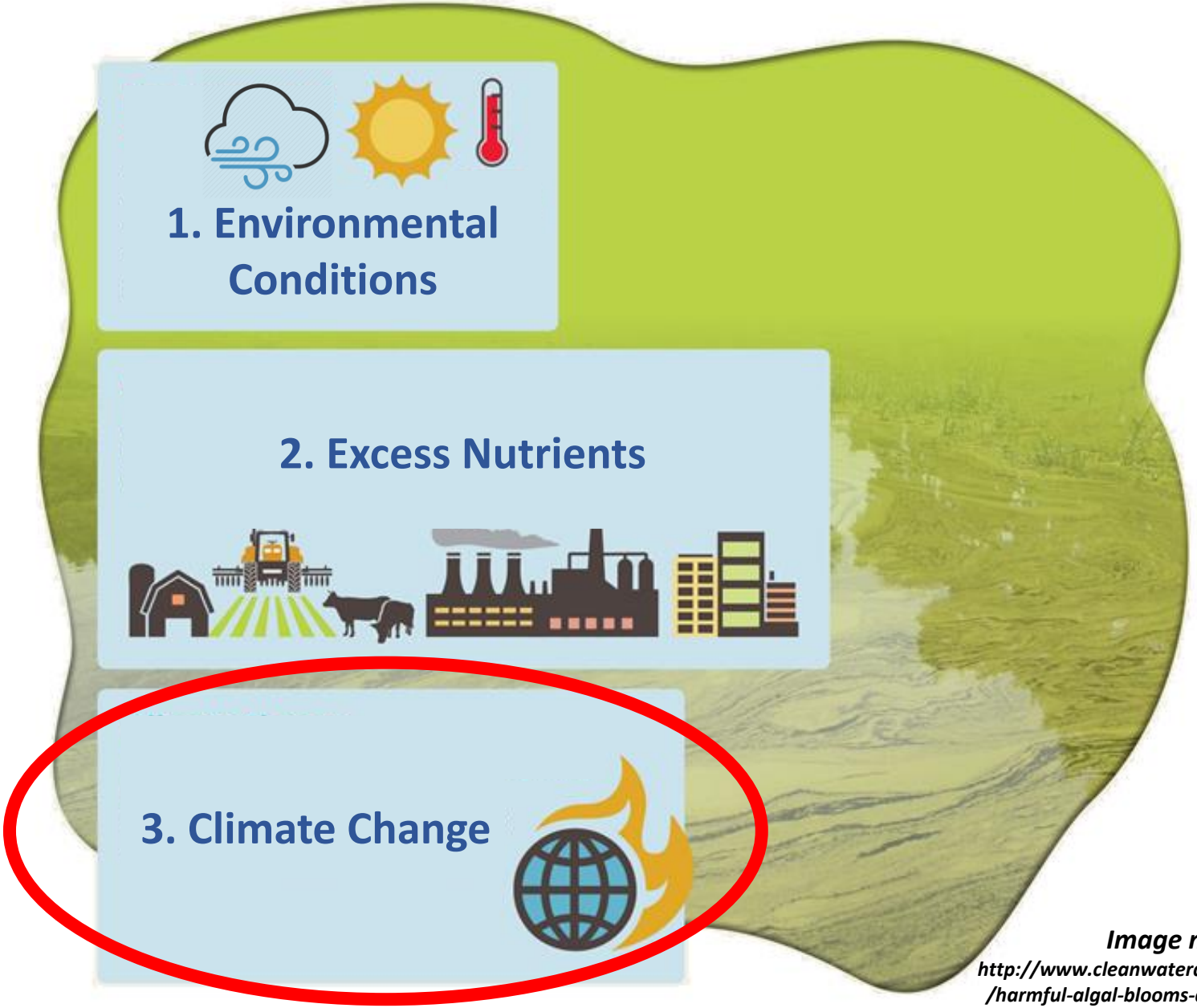


Image modified from:
http://www.cleanwateraction.org/features/harmful-algal-blooms-and-drinking-water

Cyanobacteria and Climate Change

- Cyanobacteria outcompete other types of algae in warmer water
- More stable water column is an advantage to buoyant cyanobacteria species
- Internal phosphorus loading as an indirect result of bloom decomposition provides a positive feedback loop

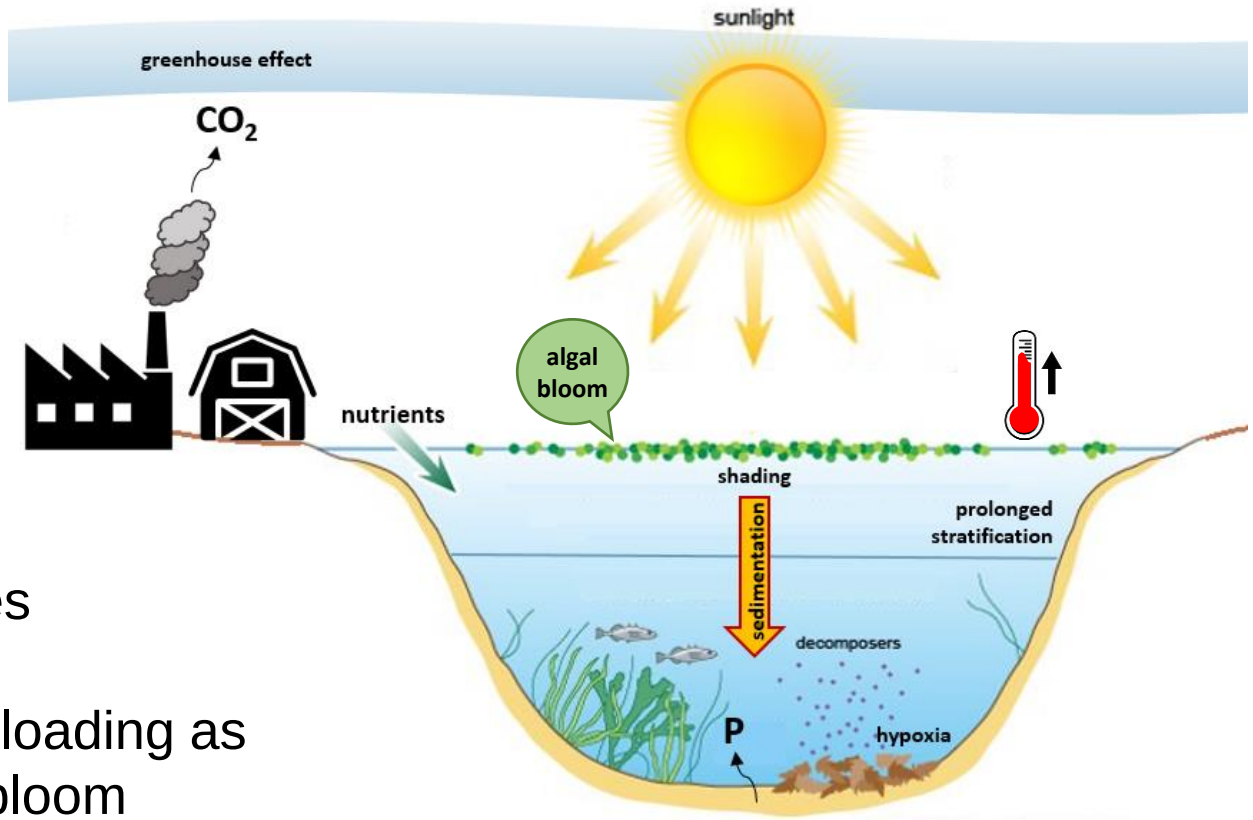
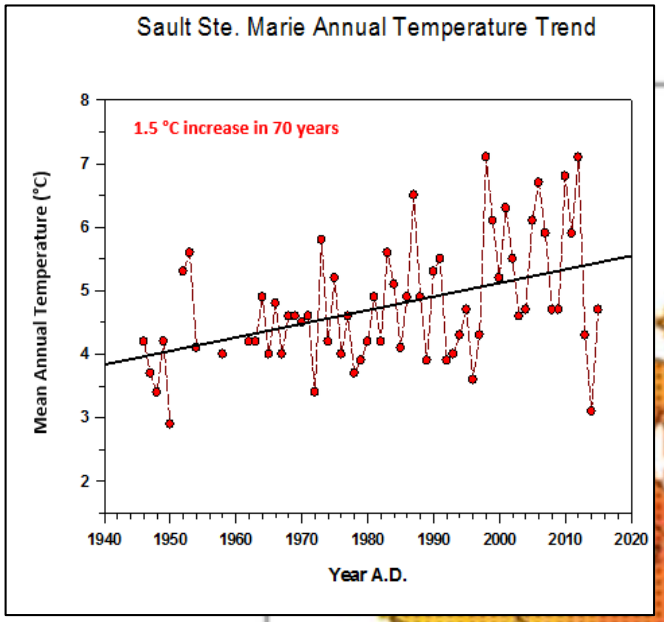
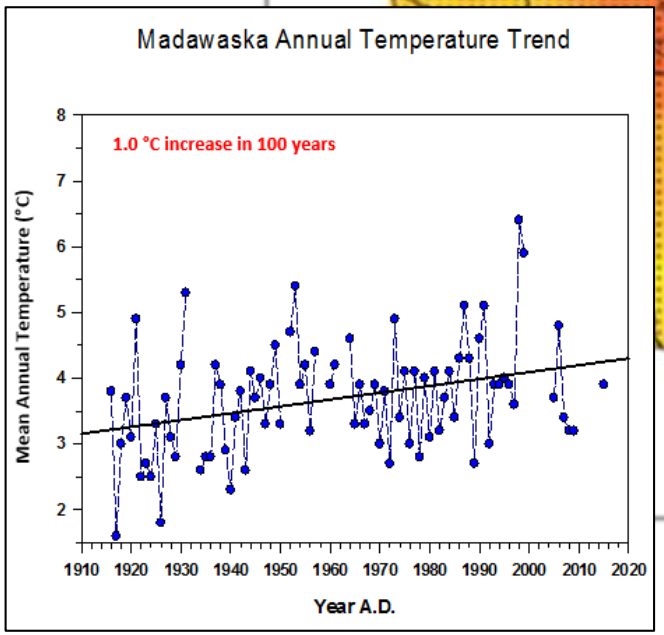


Image Modified from:
https://www.pmfias.com/wp-content/uploads/2016/05/Eutrophication-%E2%80%93-Algal-Bloom.jpg

Climate Link?





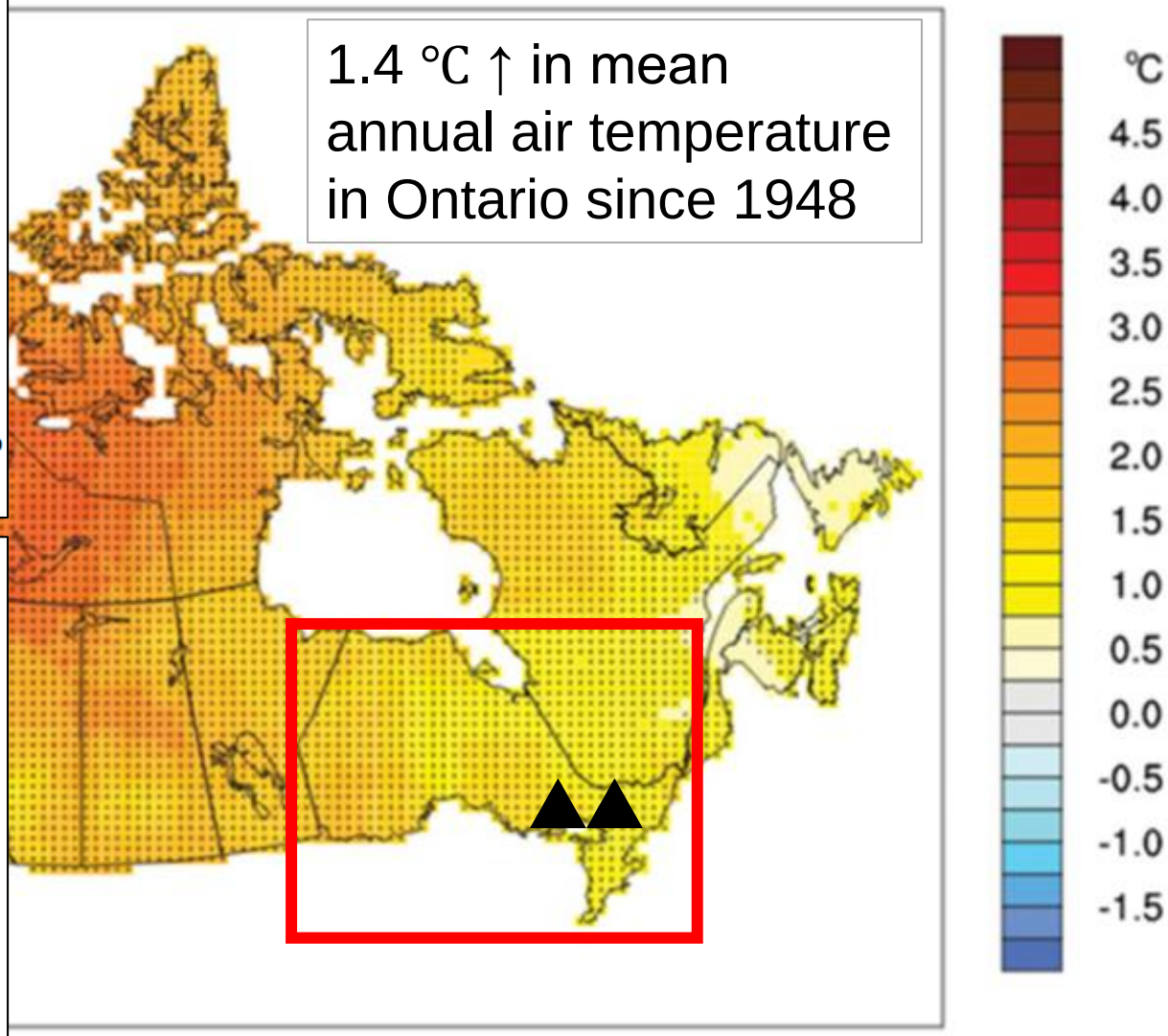
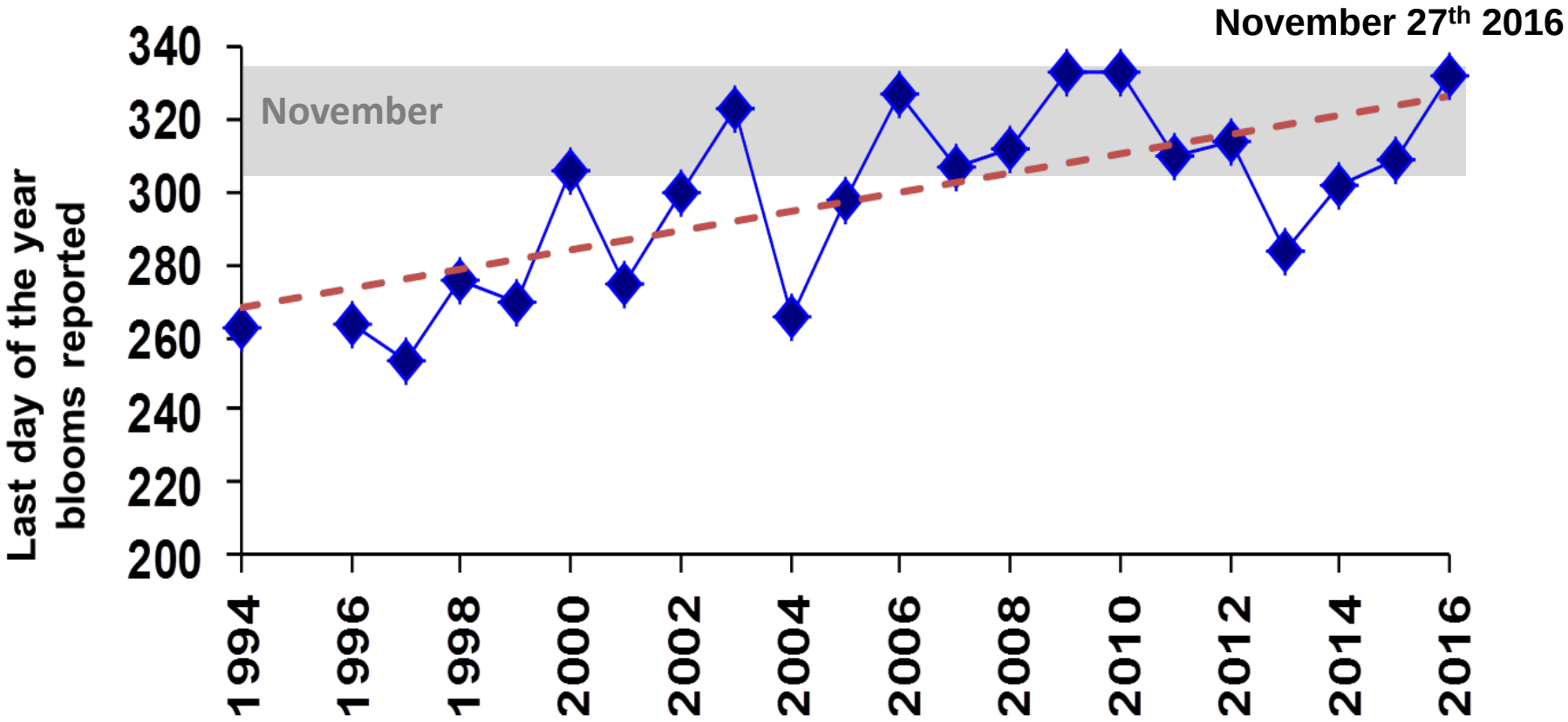


Image modified from: *Vincent et al. 2015. Journal of Climate 28.*

Climate Link?

- Algal blooms occurring significantly later in the year



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The Big Questions

Have blooms occurred in the past?

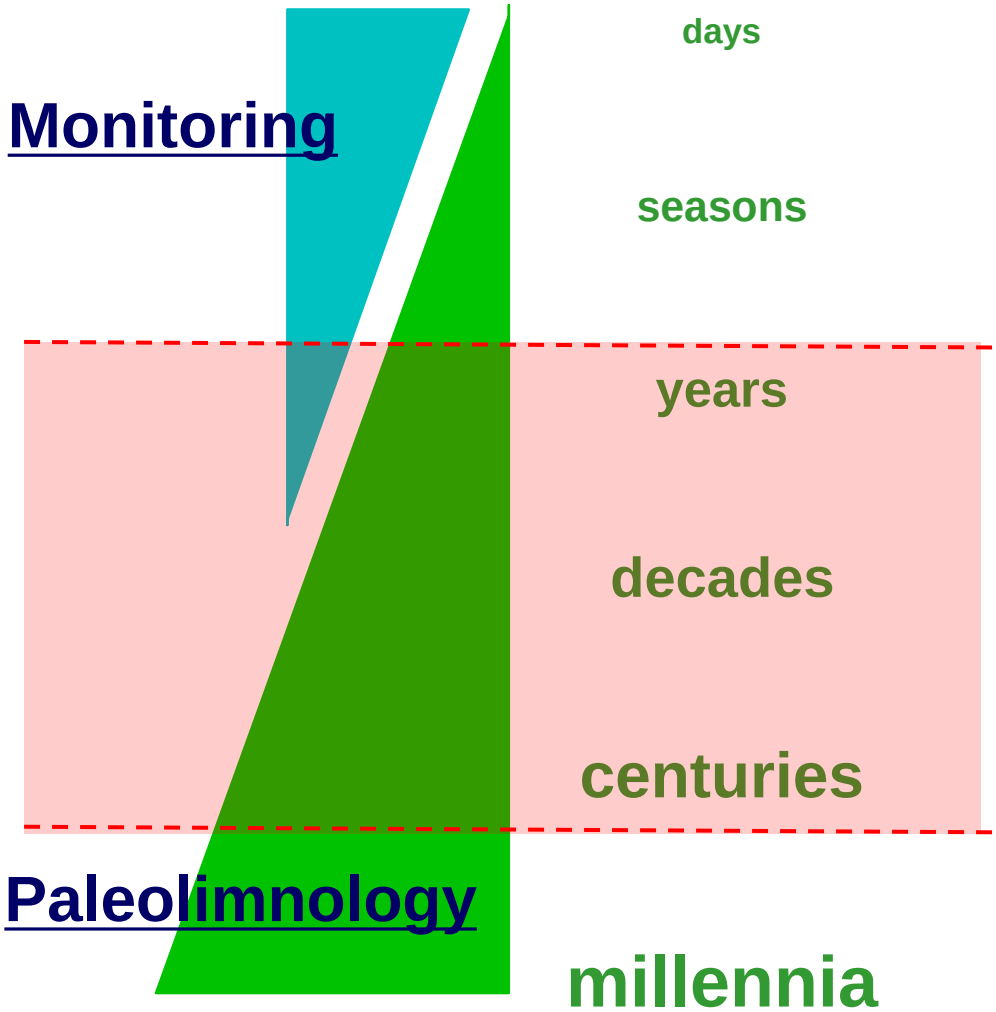
What are the environmental triggers for blooms now?

Will algal blooms continue in the future?

How Paleolimnology Can Help

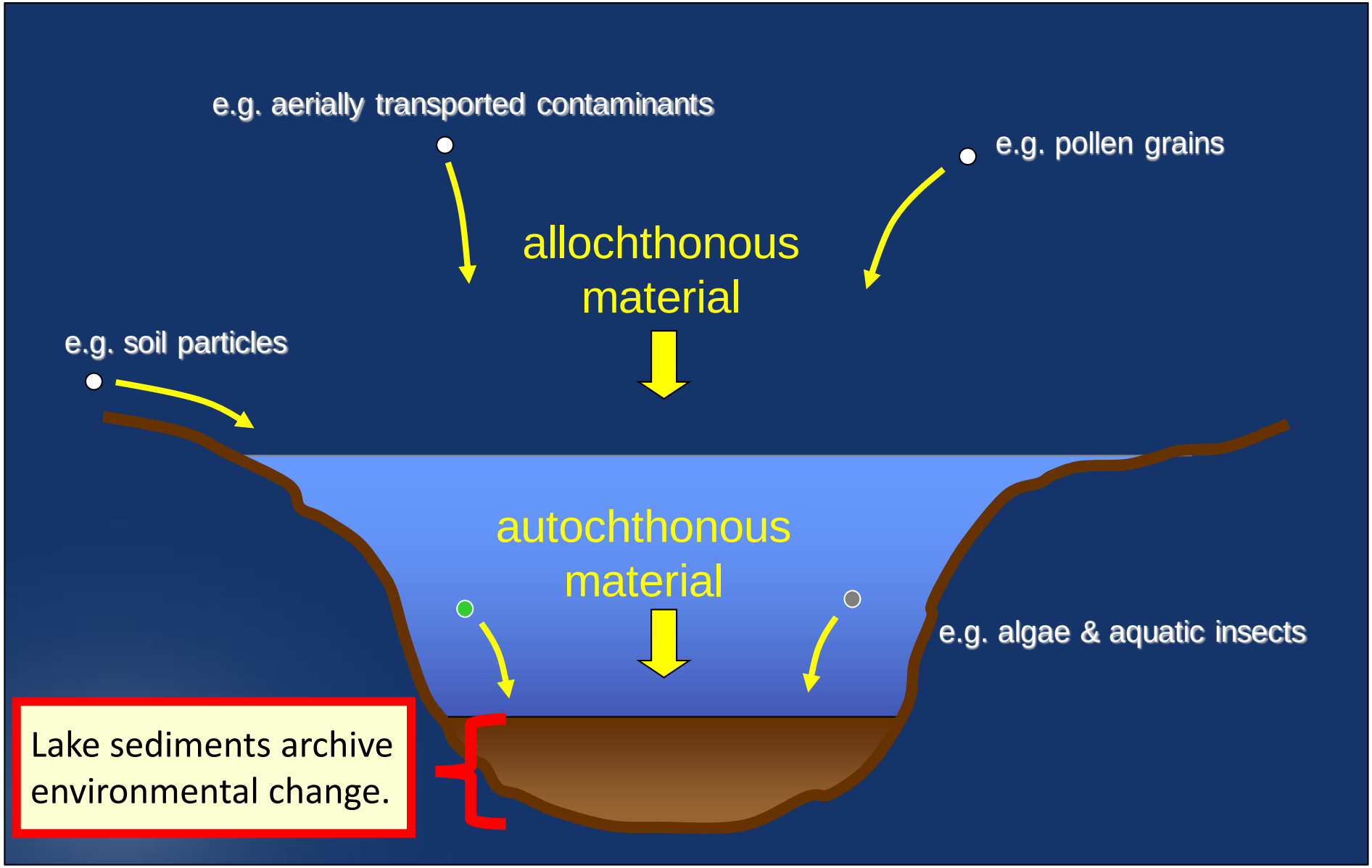
Paleolimnology (Greek: paleon=old, limne=lake, logos=study):

The study of lakes back in time from their sediments and fossils

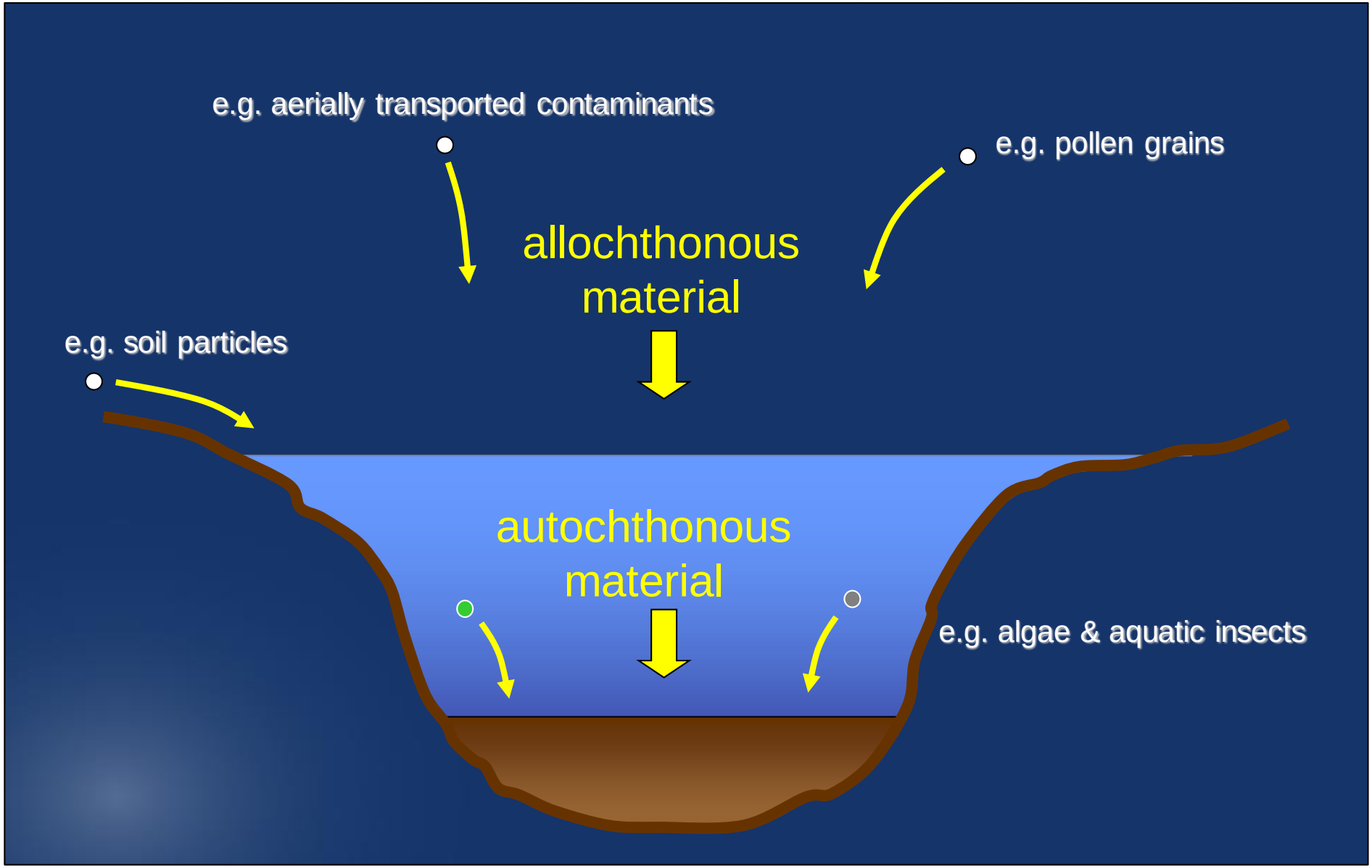


- Extend the monitoring record back in time to understand pre-disturbance/baseline lake conditions
- Apply paleolimnological techniques to blue-green algal bloom-affected lakes in ON in which nutrient enrichment is not the obvious causal factor
- Examine down-core changes in indicators to determine whether trends are indicative of a particular stressor

The Paleo Method



The Paleo Method



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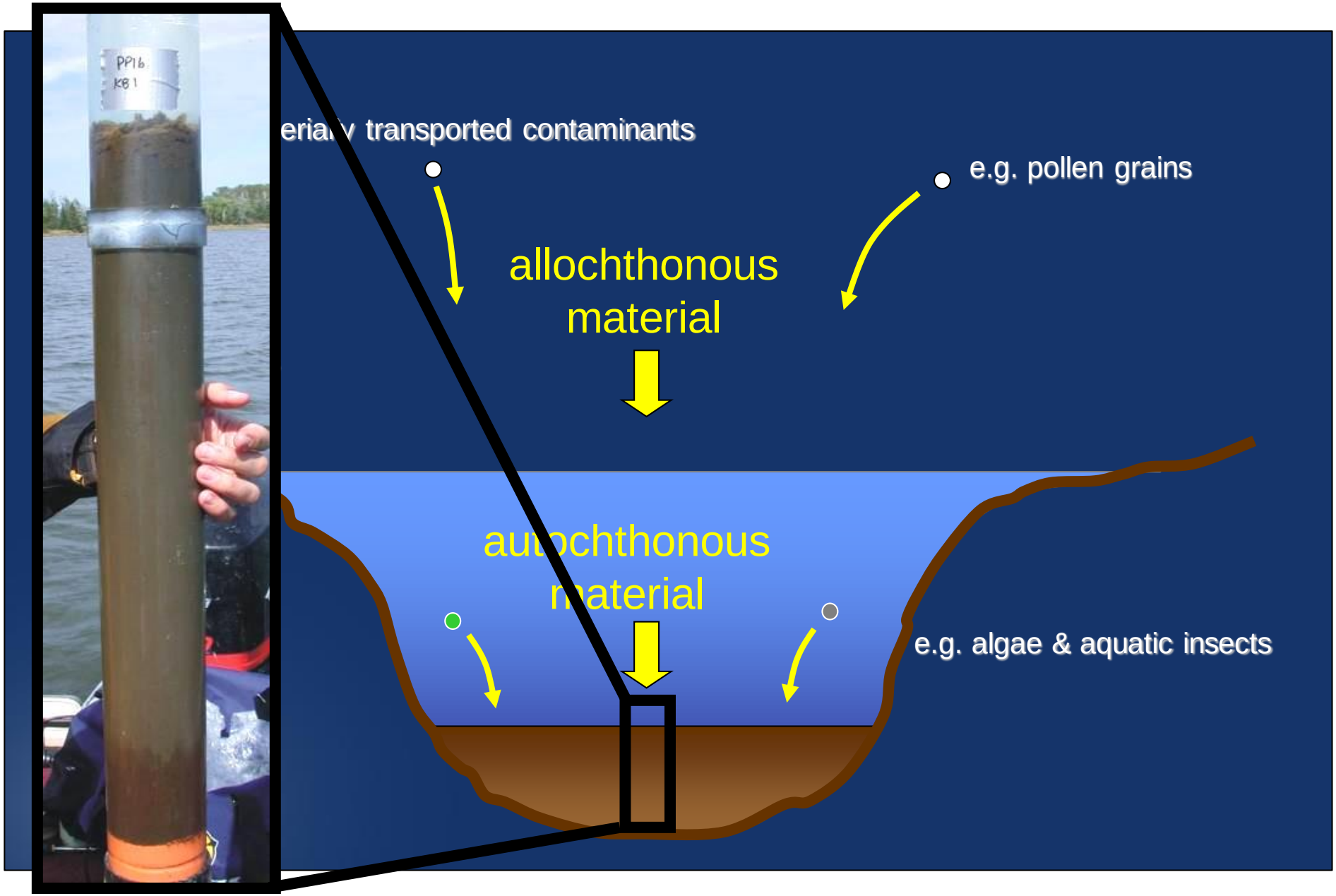
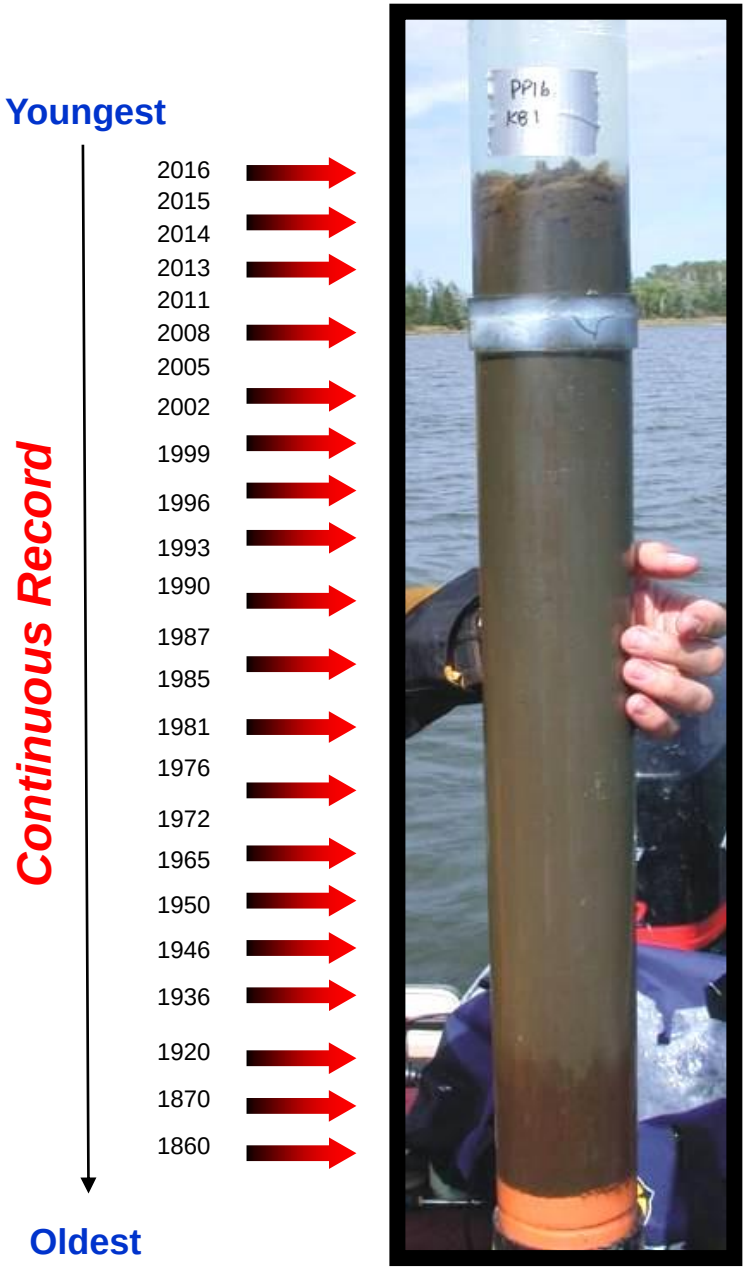
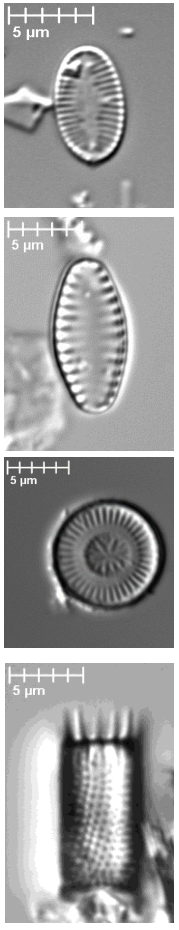


The Paleo Method



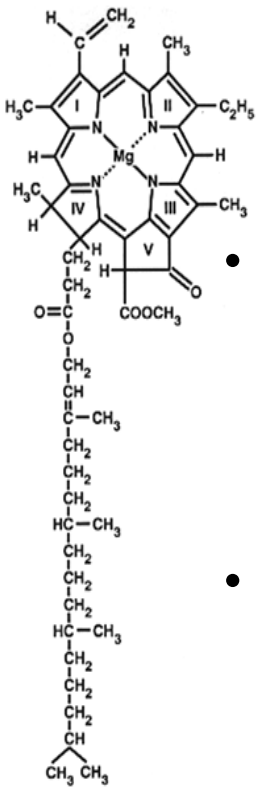
Paleolimnological "Indicators"

Diatoms



- Species abundance data
- Indication of changes in nutrient levels
- Indication of changes in intensity of thermal stratification

Chlorophyll *a*



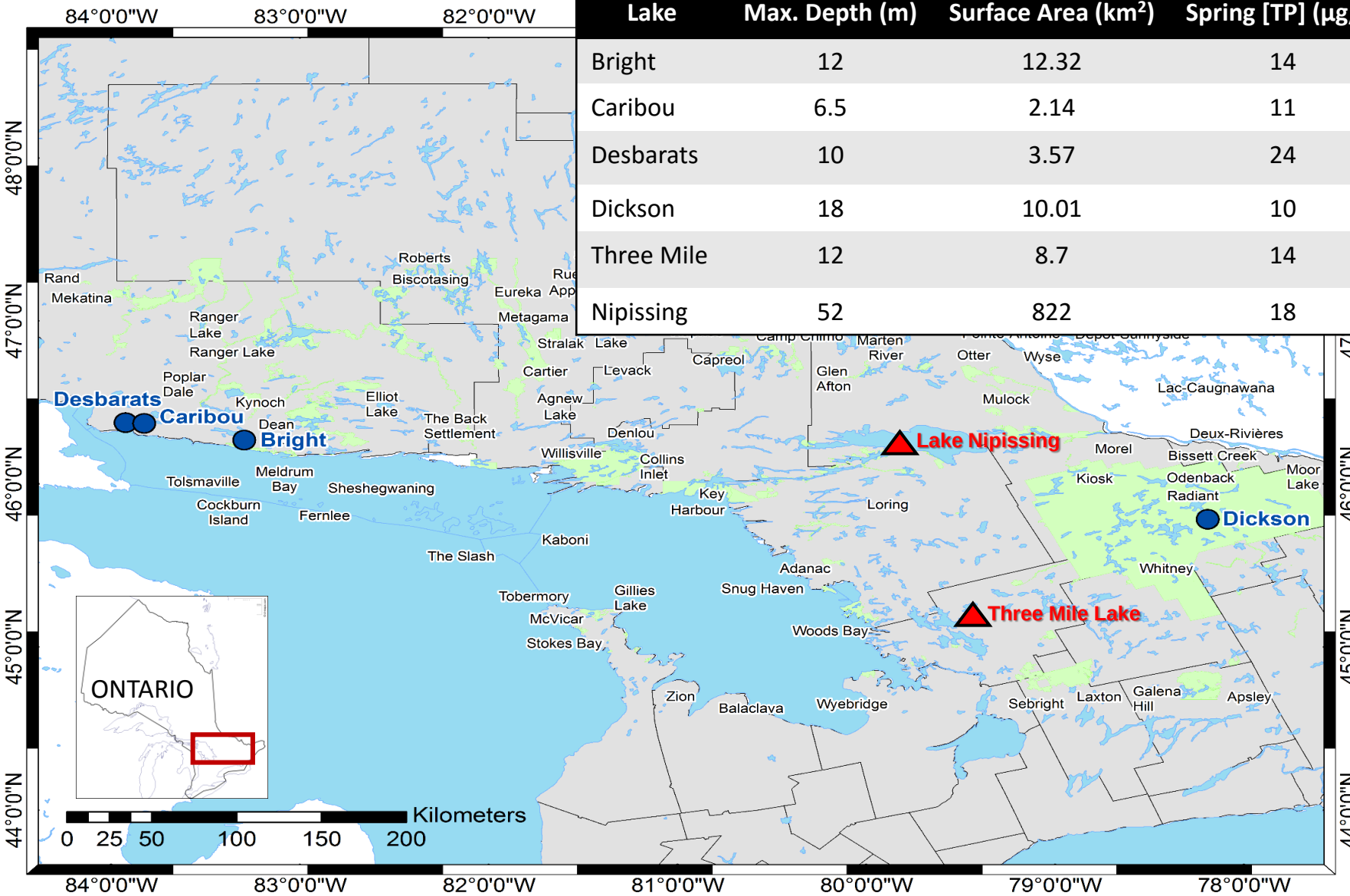
- Photosynthetic pigment in all plants/algae
- Indication of whole lake primary production
- Inferred from sediment using VRS

Chironomids

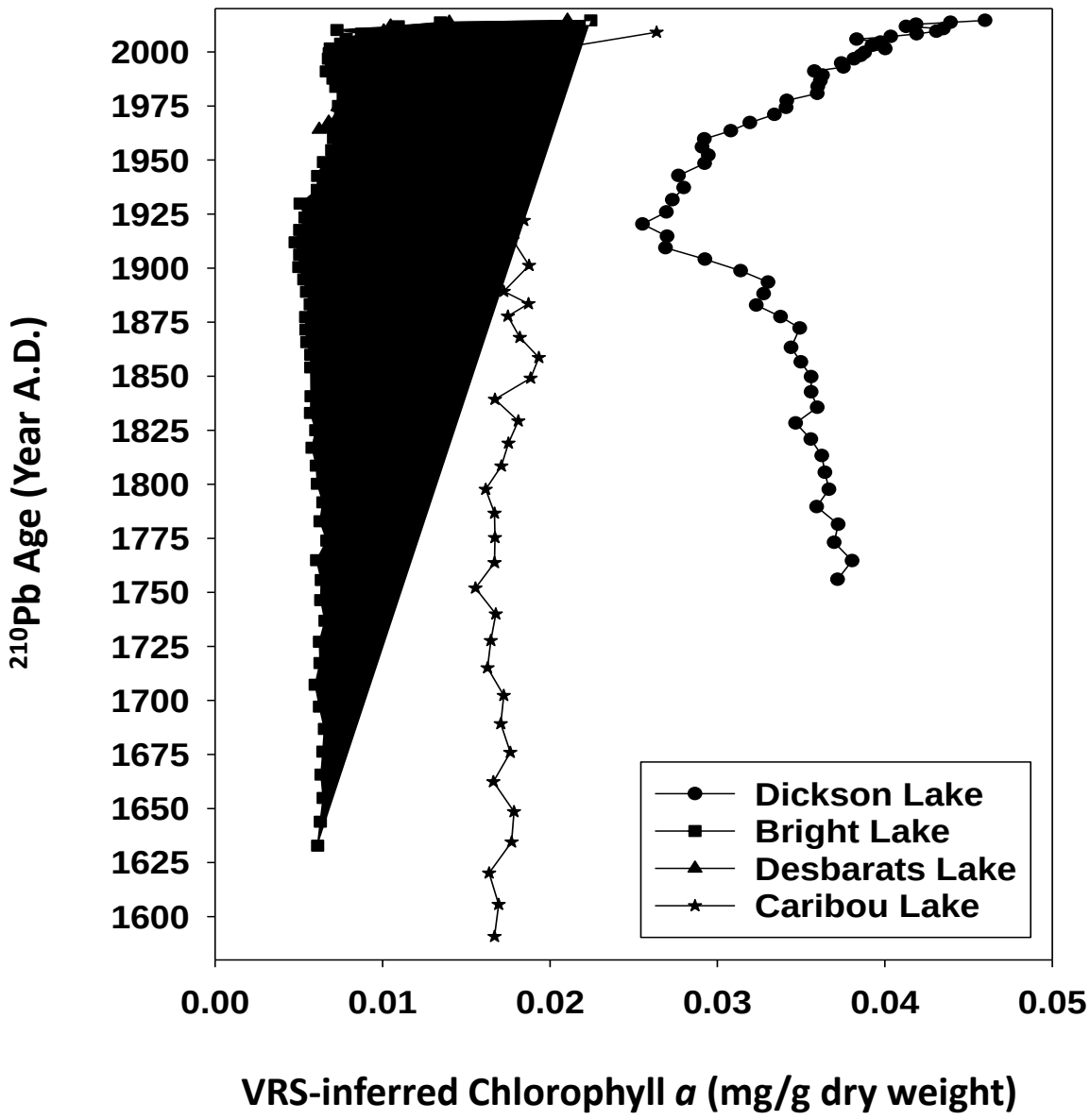
- Species abundance data
- Indication of changes in dissolved oxygen
- Indication of changes in lake productivity

Study Lakes

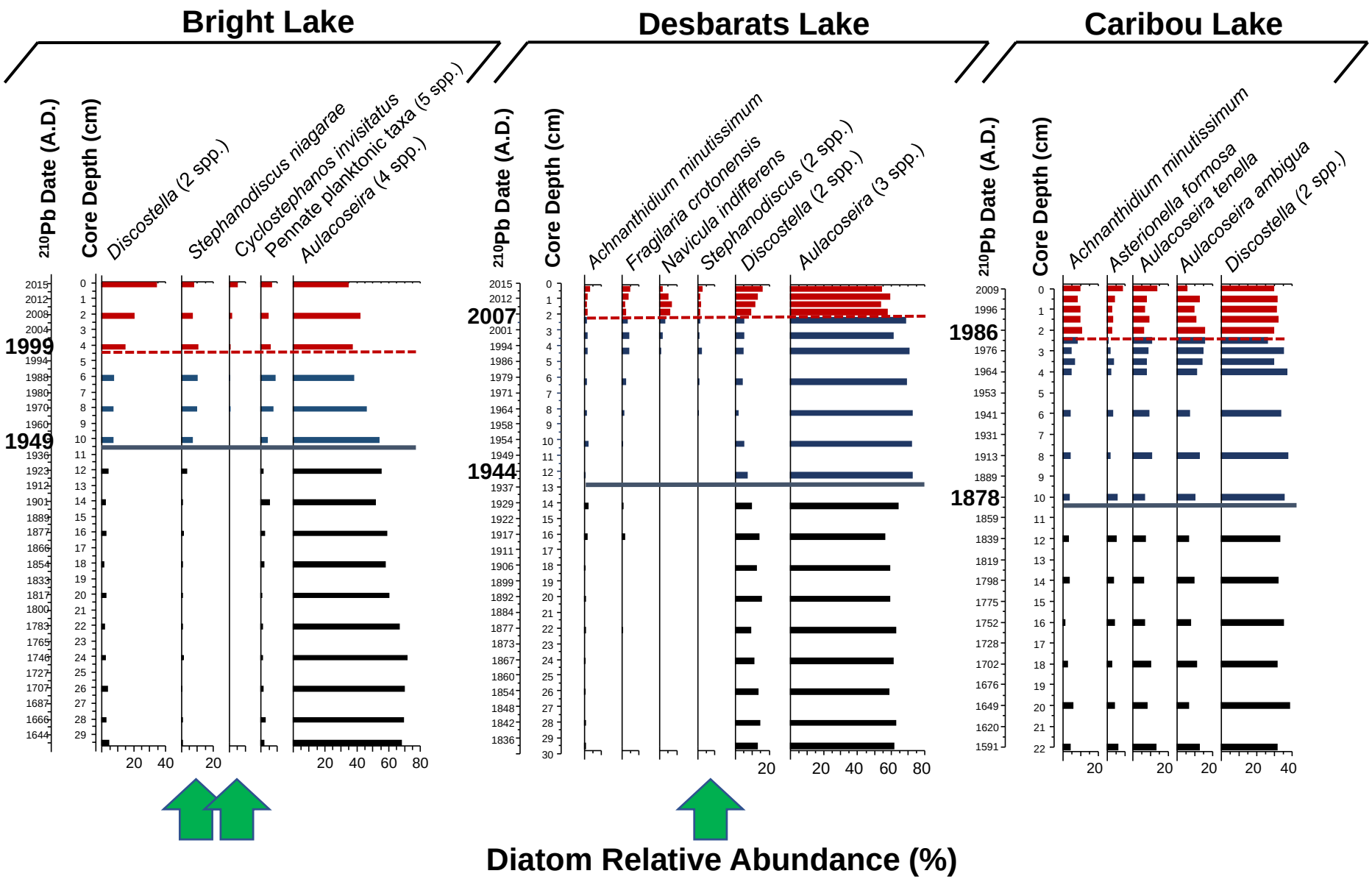
Lake	Max. Depth (m)	Surface Area (km²)	Spring [TP] (µg/L)
Bright	12	12.32	14
Caribou	6.5	2.14	11
Desbarats	10	3.57	24
Dickson	18	10.01	10
Three Mile	12	8.7	14
Nipissing	52	822	18



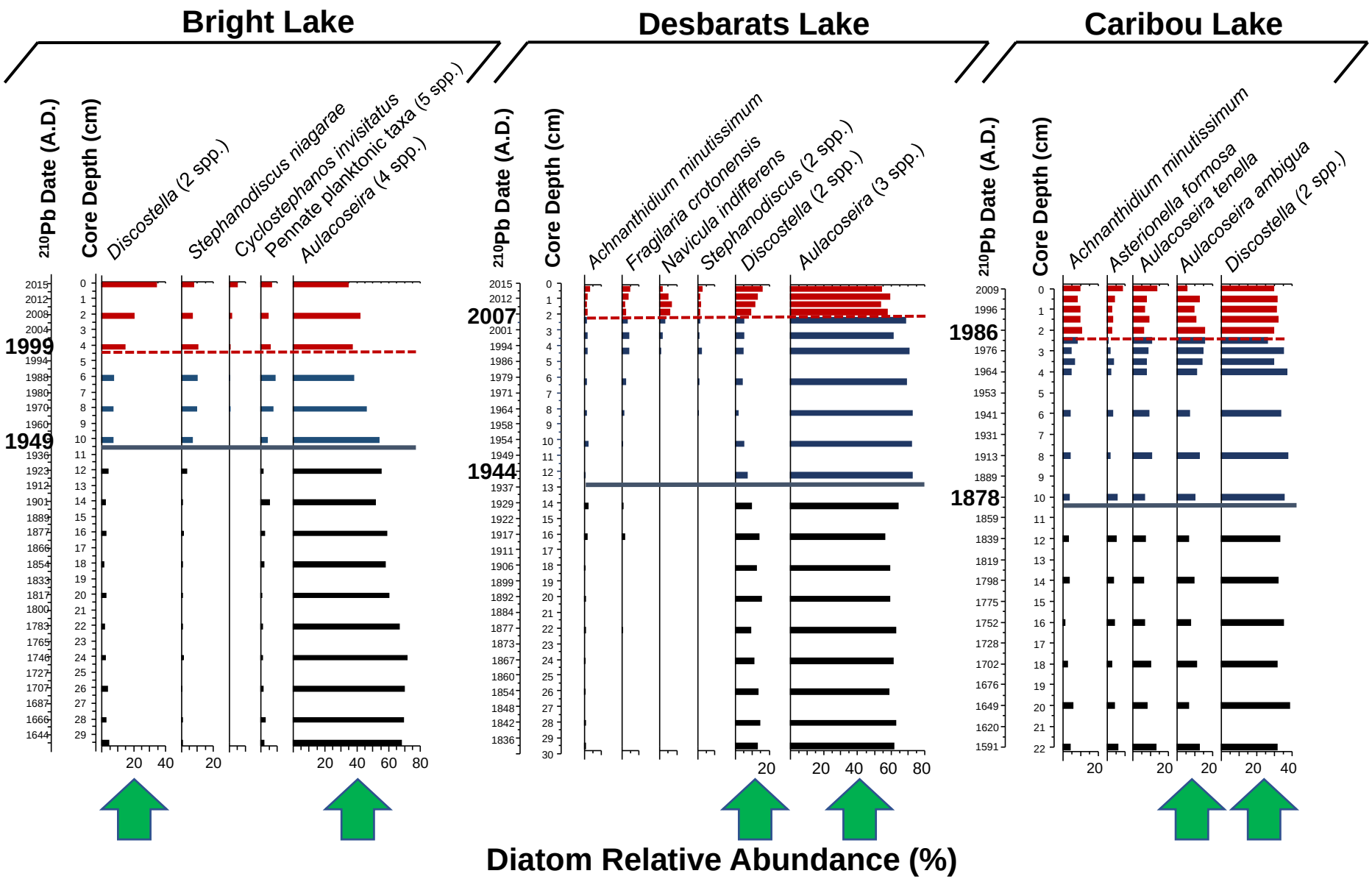
Historical Overall Primary Production



Diatom Results: Algoma Lakes



Diatom Results: Algoma Lakes



Environmental Trigger(s)?

- Study lakes show varying magnitudes of change in the diatom assemblages indicative of response to warming
- Some show minimal change in diatom assemblages throughout the sediment record
- Likely <u>multiple stressors</u> at play (interaction of climate and nutrient enrichment) in varying amounts depending on lake-specific characteristics
- Further investigation and analysis is needed to draw conclusions about whether the frequency of blooms in the study lakes is increasing and if so, what is driving the shift

Ongoing Investigation

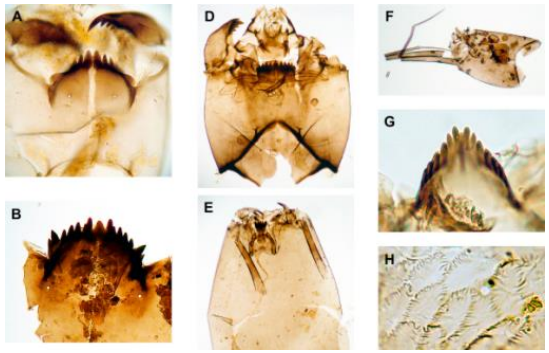


Image retrieved from: https://openi.nlm.nih.gov/imgs/512/390/3021123/PMC3021123_gr4.png

Chironomid analysis to indicate trends in deep-water dissolved oxygen concentrations

Track trends in blue-green algae directly using fossil resting cysts (akinetes)

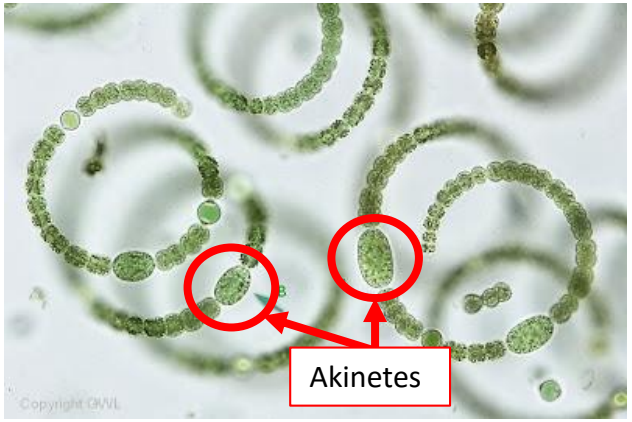


Image modified from: http://orbicafotografie.blogspot.ca/2011/03/my-quest-to-understand-world.html

Image retrieved from: http://www.lake-nipissing-fishing.com/bigmap.jpg

More cases (Lake Nipissing and Three Mile Lake)

Acknowledgements

PEARL
Paleoecological Environmental Assessment & Research Laboratory

Queen's University

Ontario
Ministry of the Environment and Climate Change

NSERC
CRSNG

Image credit: algonquinpark.on.ca

Thank you for listening.

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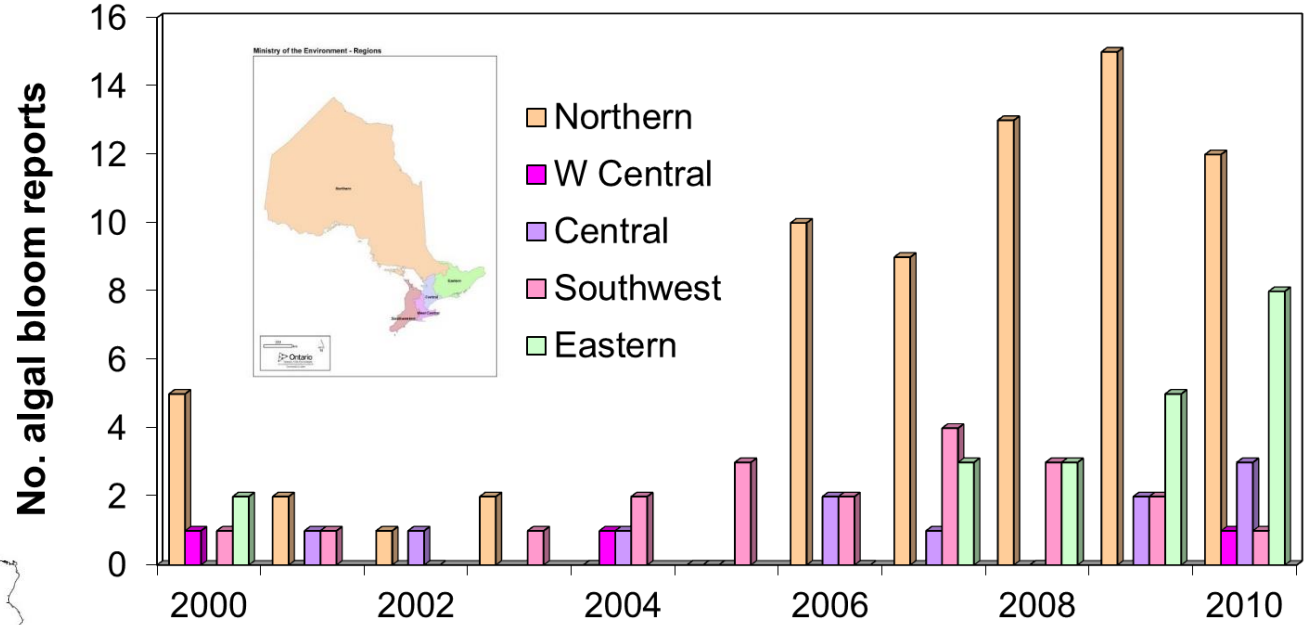
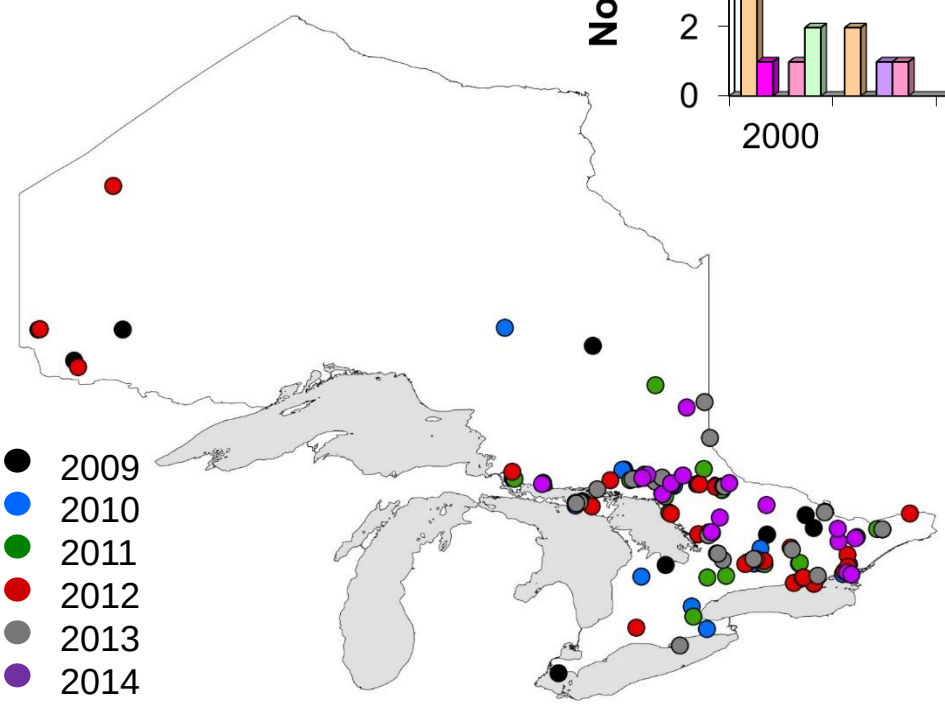
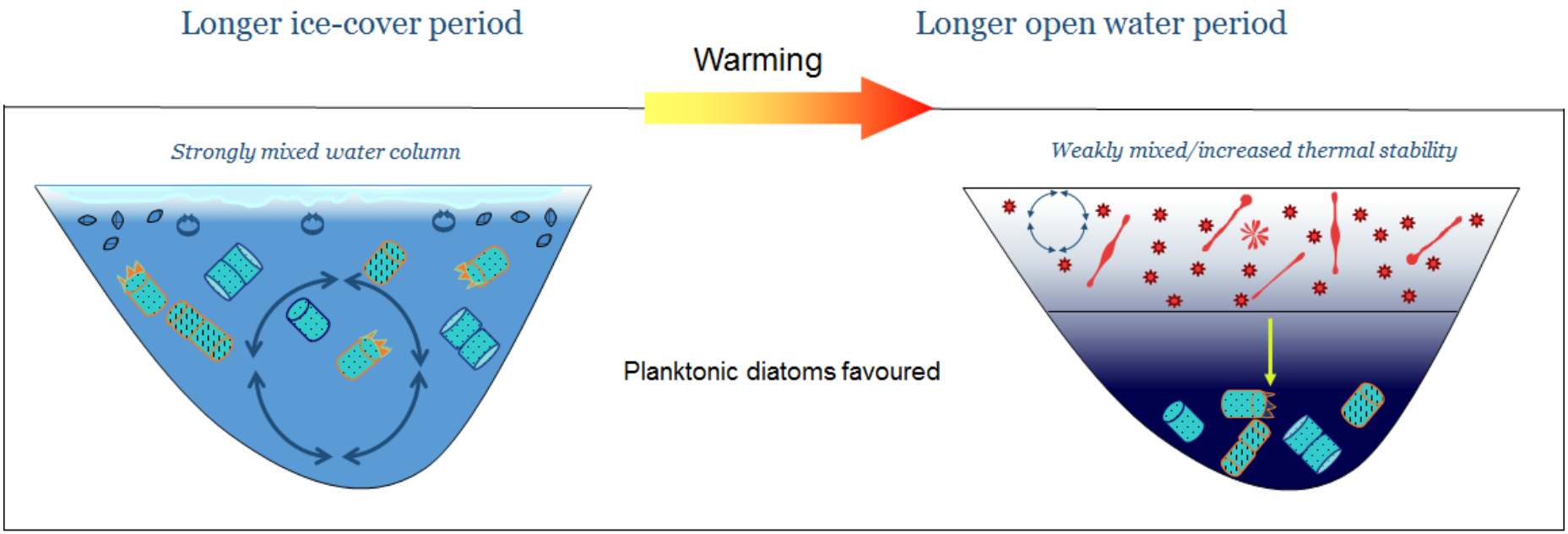




M. Palmer and C. Holeton, MOECC, unpubl. data

Diatom Response to Warming



Modified from Rühland et al. 2015