

Long-Term Ecological Research (LTER) and Climate Change

An overview of the IISD Experimental Lakes Area (ELA)
Climate Change research program

Presented by: Scott Higgins

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www.IISD.org/ELA

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Co-Authors & Contributors

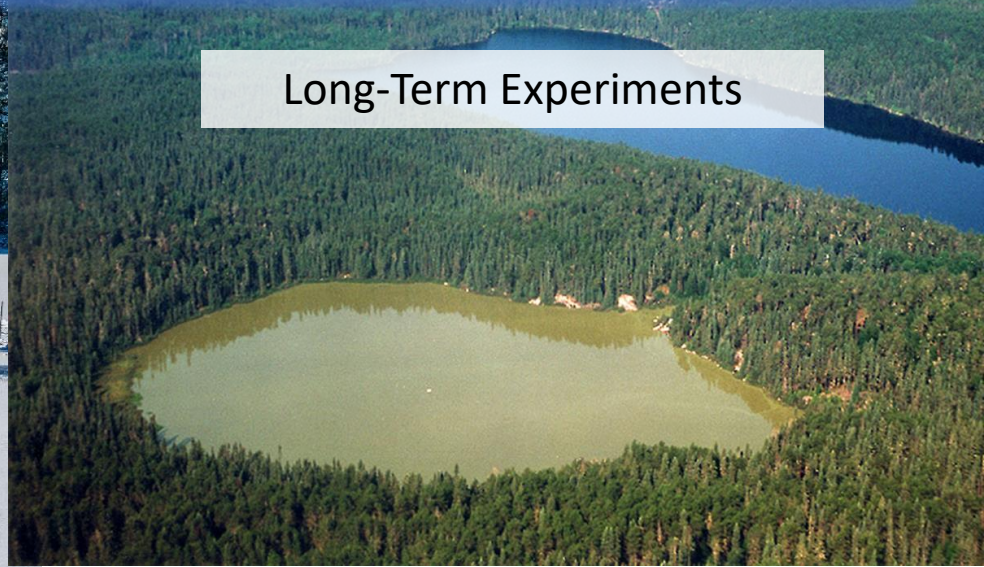
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Woody Nero							

Why are LTER programs important?

Long-Term Observations



Long-Term Experiments



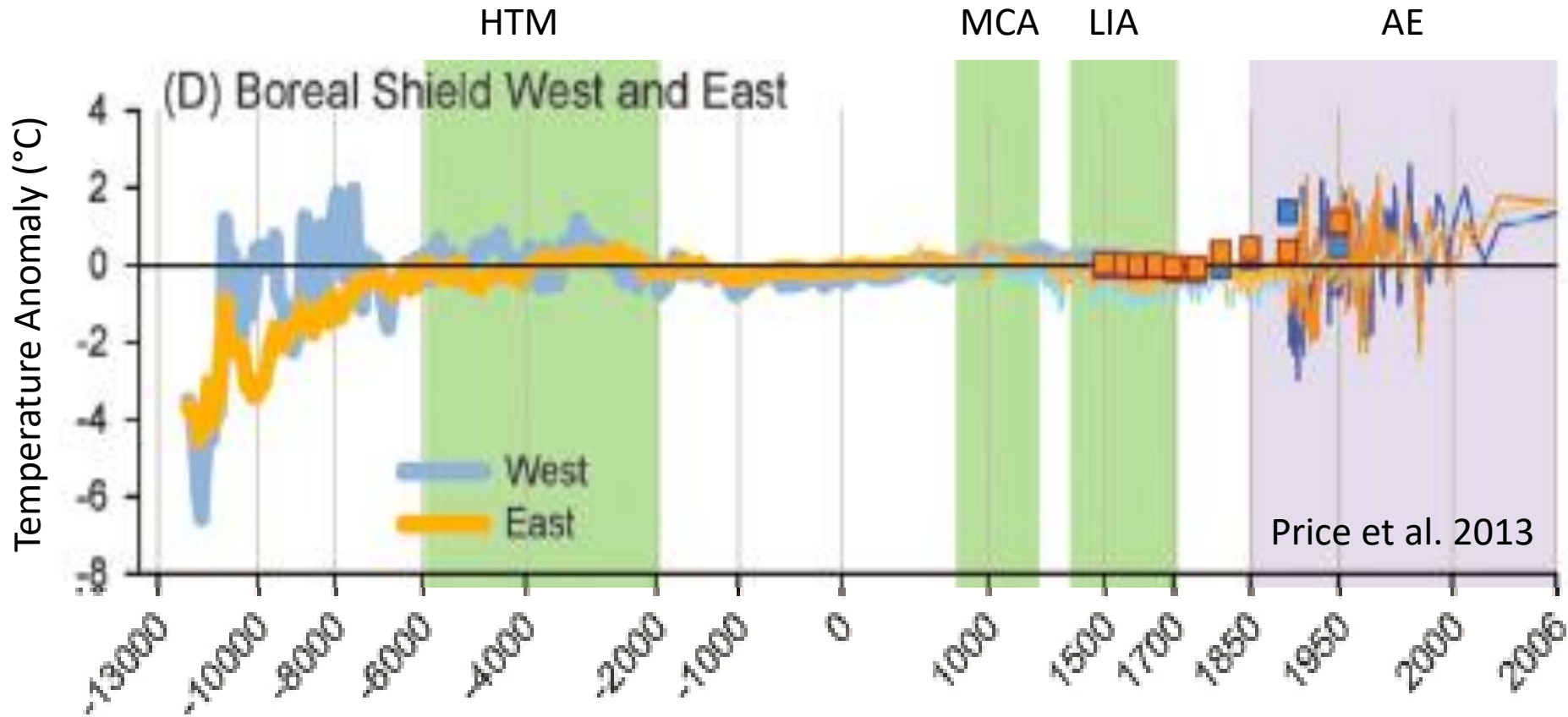
Long-Term Relationships



New Opportunities

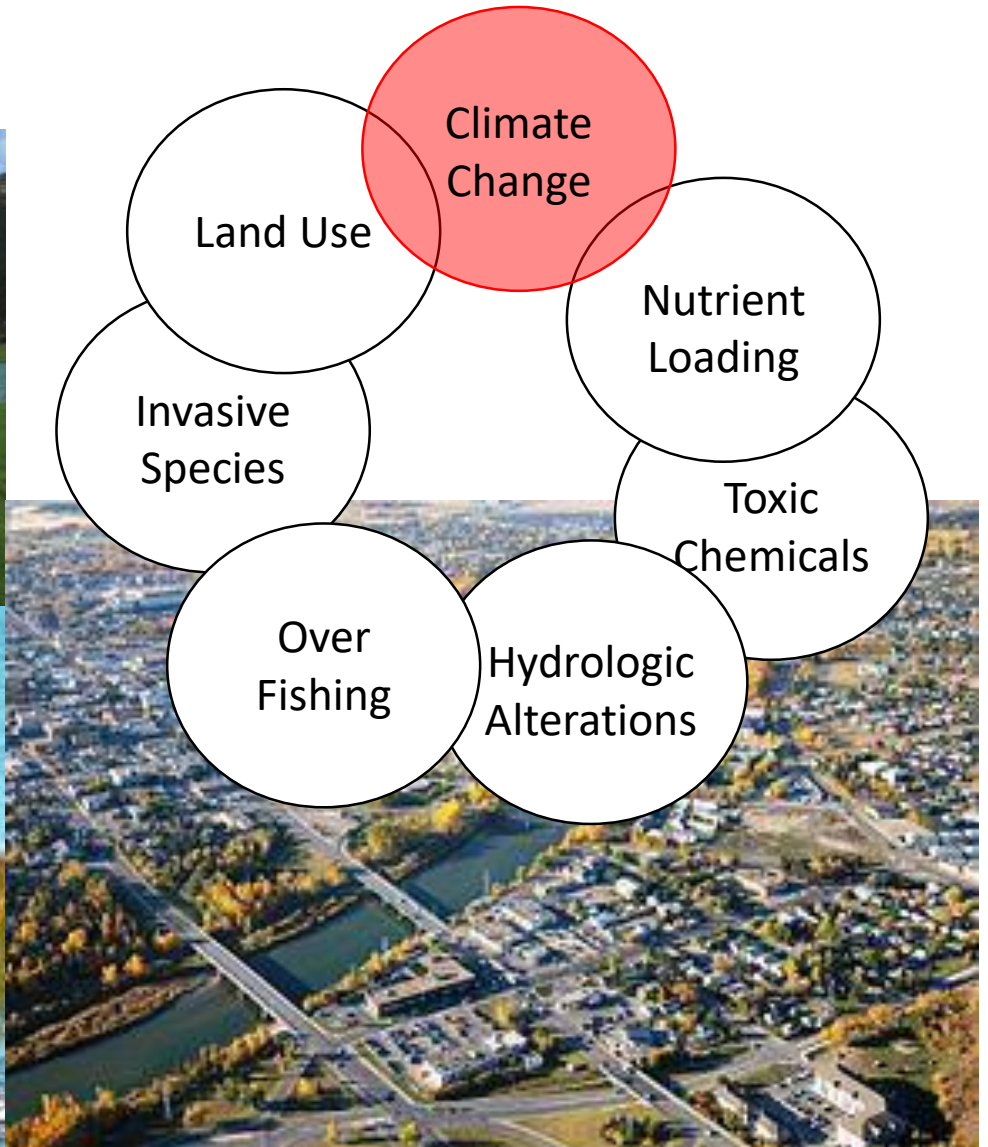


Long-term Air Temperature Anomaly



HTM= Holocene thermal maxima; MCA= Medieval climate anomaly,
LIA= Little ice age; AE= Anthropocene era

The Problem of Multiple Stressors



Experimental Lakes Area Research Station

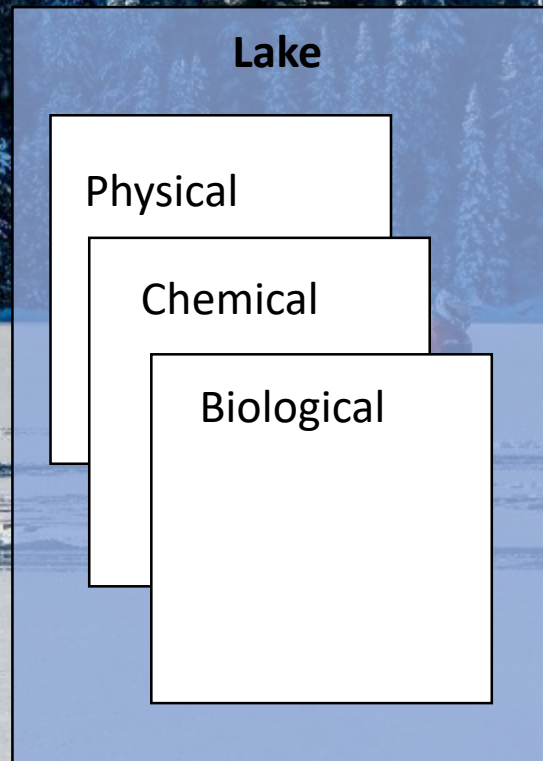
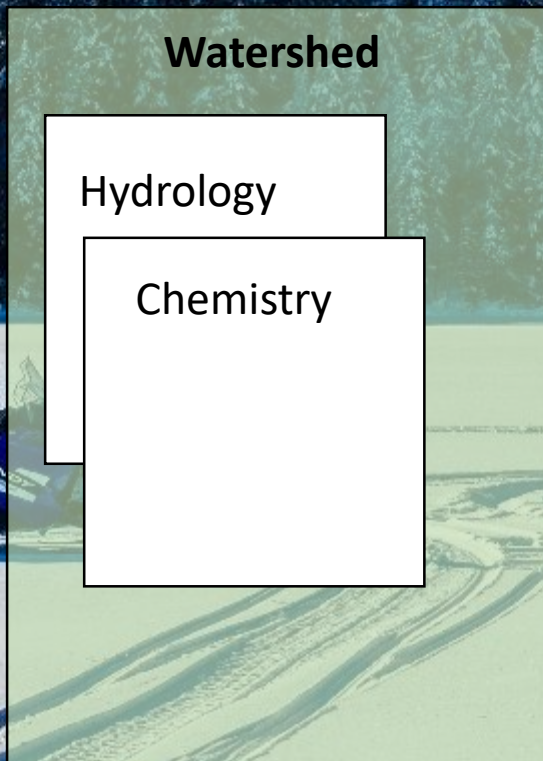


Canada's Boreal Forest

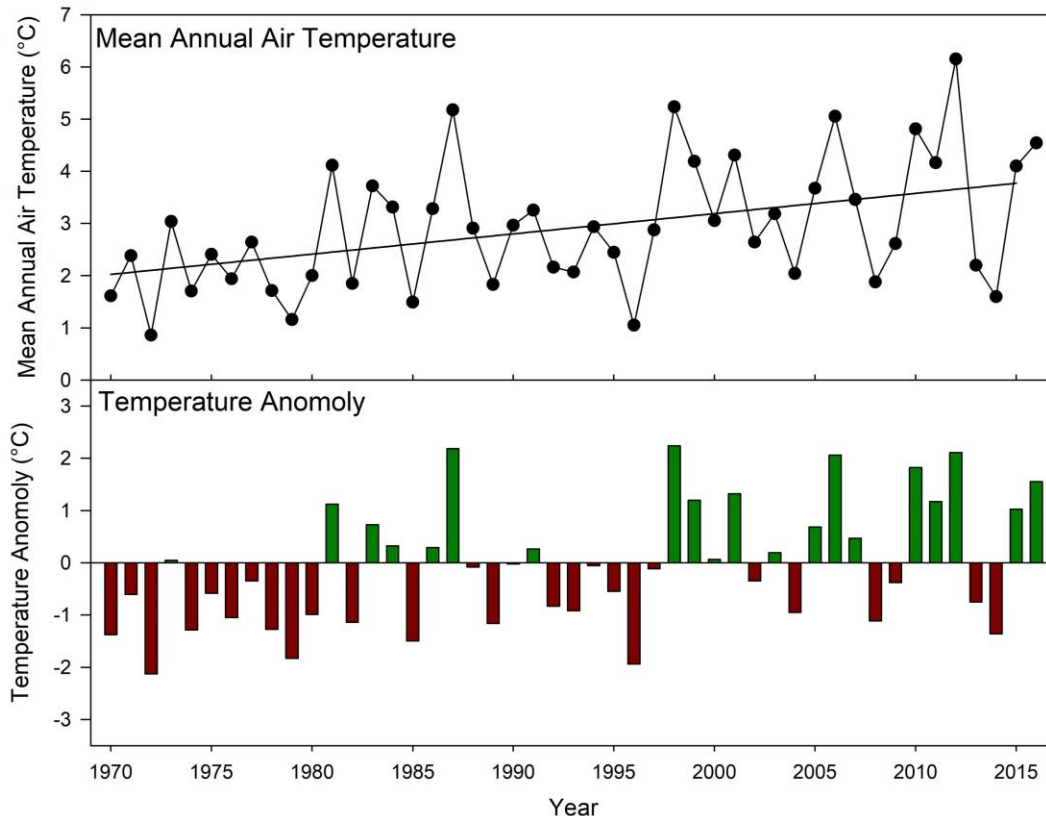


Long-Term Observations

Meteorology and Atmospheric Chemistry

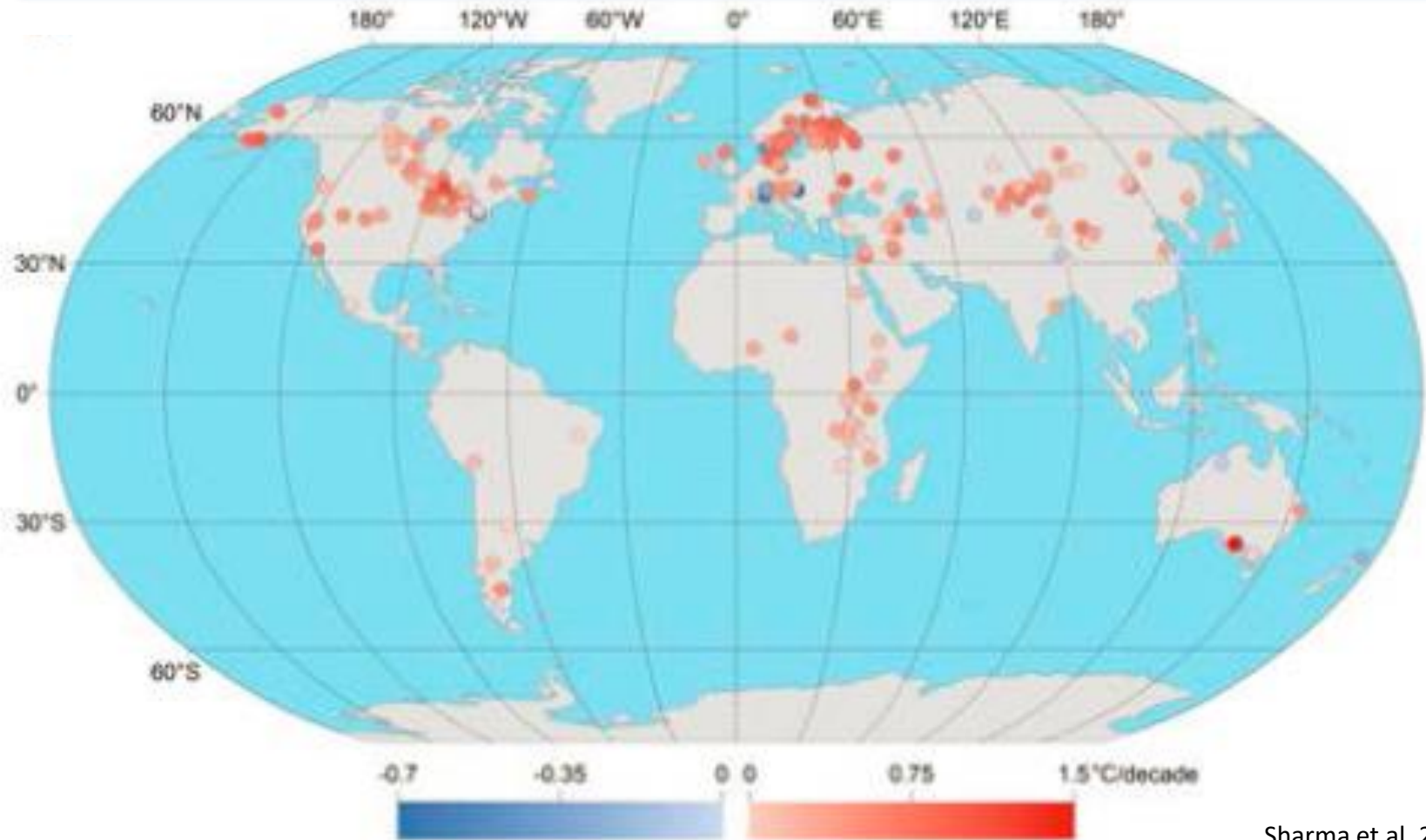


Air Temperature at ELA – The past 50 years



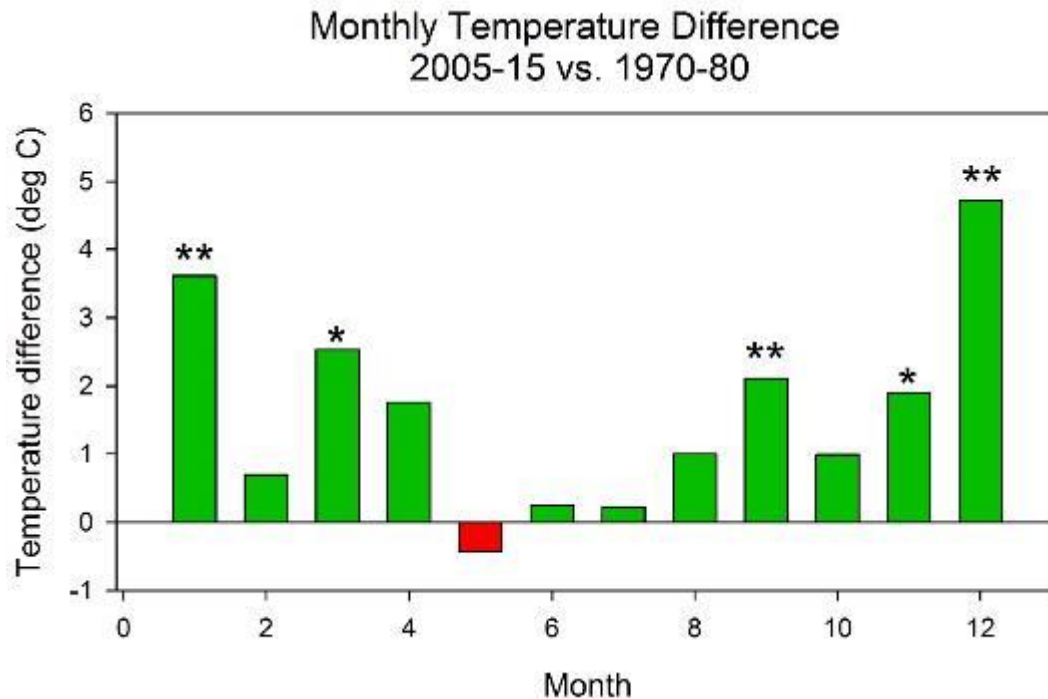
- Mean annual air temperature rising by $0.41\text{ }^{\circ}\text{C}/\text{decade}$ ($> 2\text{ }^{\circ}\text{C}$ since 1970)
- Global average is $\sim 0.07 - 0.08\text{ }^{\circ}\text{C}/\text{decade}$ (since 1880, NOAA)

Lake Surface Temperatures Increasing Globally



- ELA contributed to a global analysis of lake surface temperature.
- 236 lakes, using *in situ* and satellite data. Figure represents period between 1985-2009 (i.e. where satellite data was available).

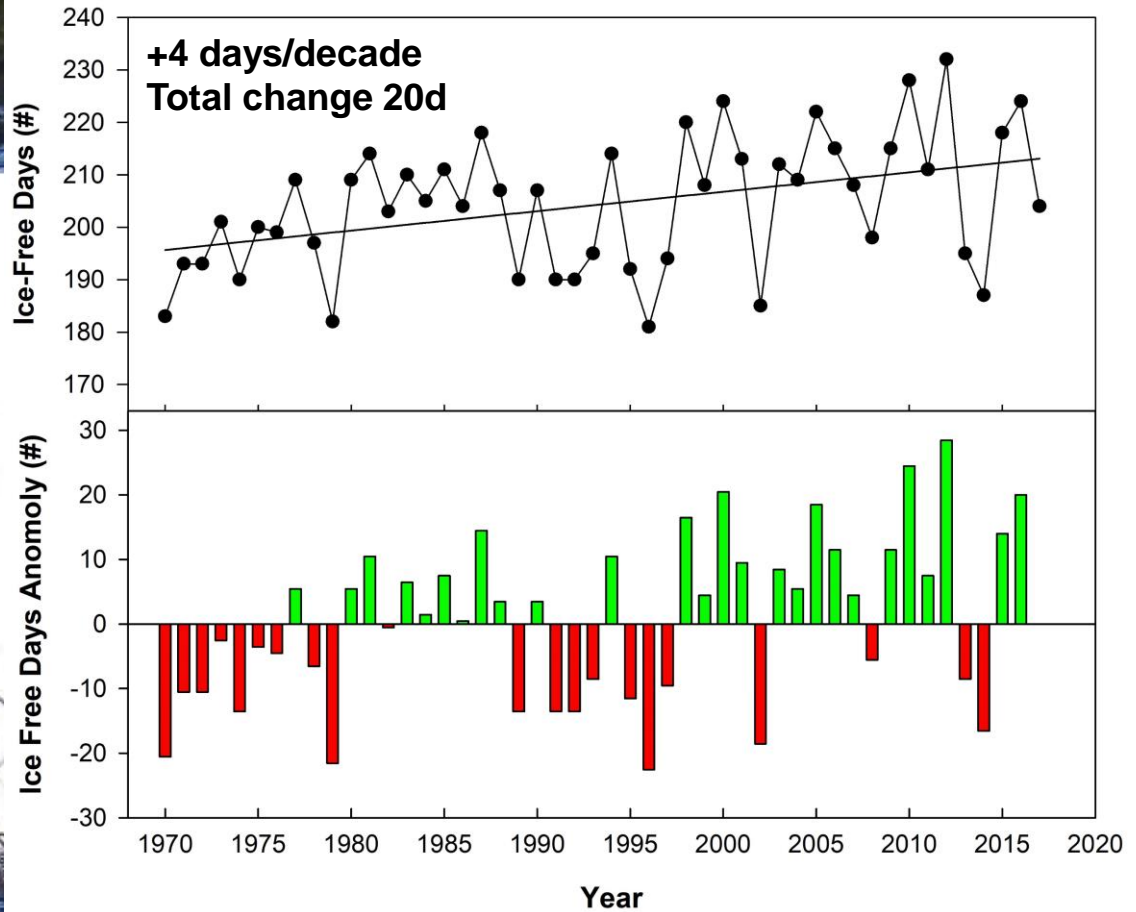
Air Temperature at ELA – Seasonality



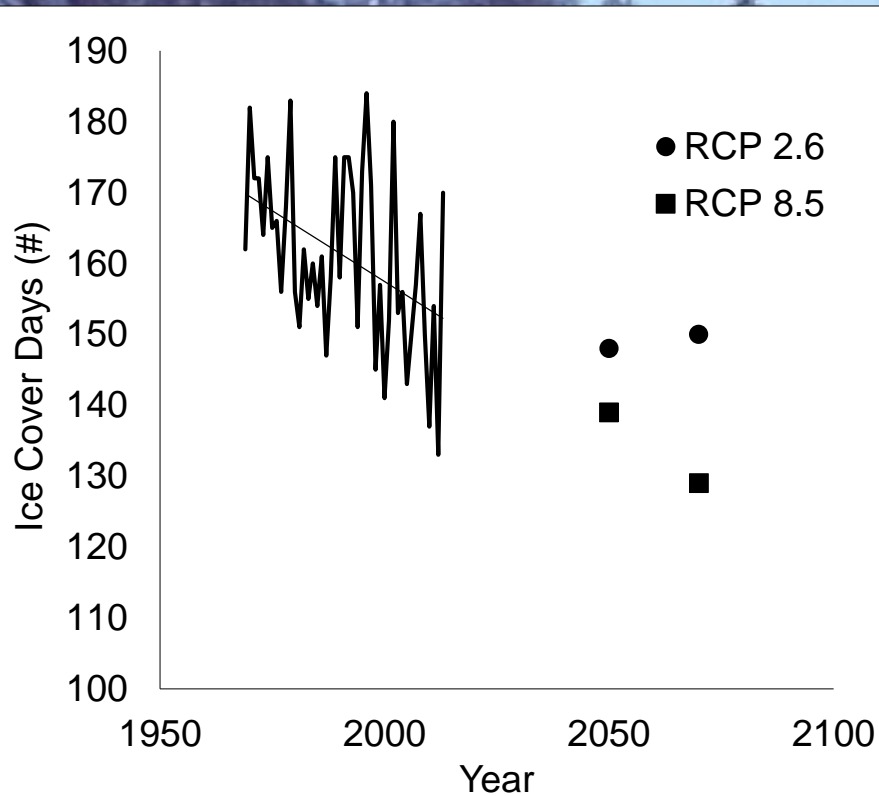
- Majority of temperature change in region occurs during winter and shoulder seasons (this is true for most of the northern hemisphere mid-latitudes)
- No significant change in temperature during summer period

- * $p < 0.05$, ** $p < 0.01$ of long-term monthly trends
- Long-term trends in December were $1.3\text{ }^{\circ}\text{C}/\text{decade}$ ($\sim 6\text{ }^{\circ}\text{C}$ since 1970)
- Long-term trends in March were $0.74\text{ }^{\circ}\text{C}/\text{decade}$ ($>3\text{ }^{\circ}\text{C}$ since 1970)

Increased Ice-Free Season



Projected Changes in Ice-Cover



- Projections based on regional downscaled projections; mean of 20 climate models.
- Projected decrease in ice-cover period 50 days over the 1970-2070 period.

How are lakes affected by climate?

“Most impacts of climate warming on boreal aquatic systems and carbon dynamics are anticipated to be a result of processes that link the terrestrial soils of watersheds to streams, wetlands and lakes rather than the direct impacts of temperature.”

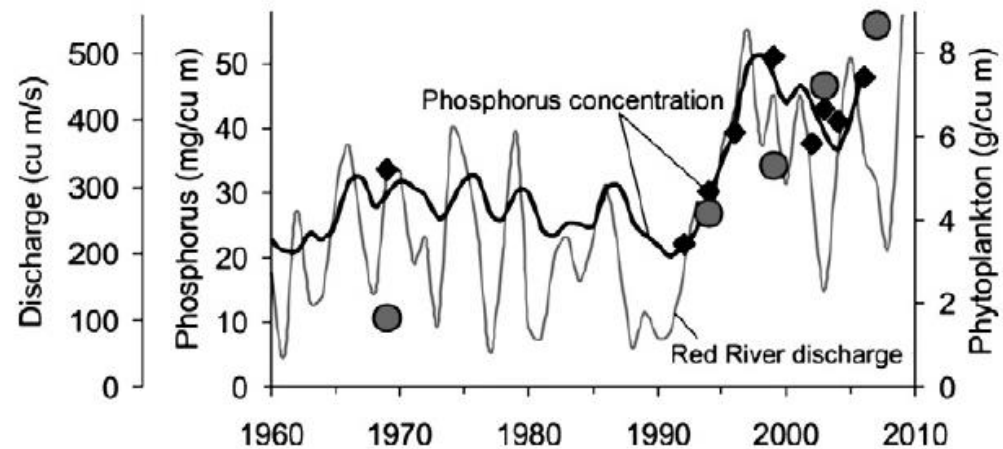
Benoy et al. (2007) *Environ Rev*

Williamson et al. (2008) *Front Ecol Environ*

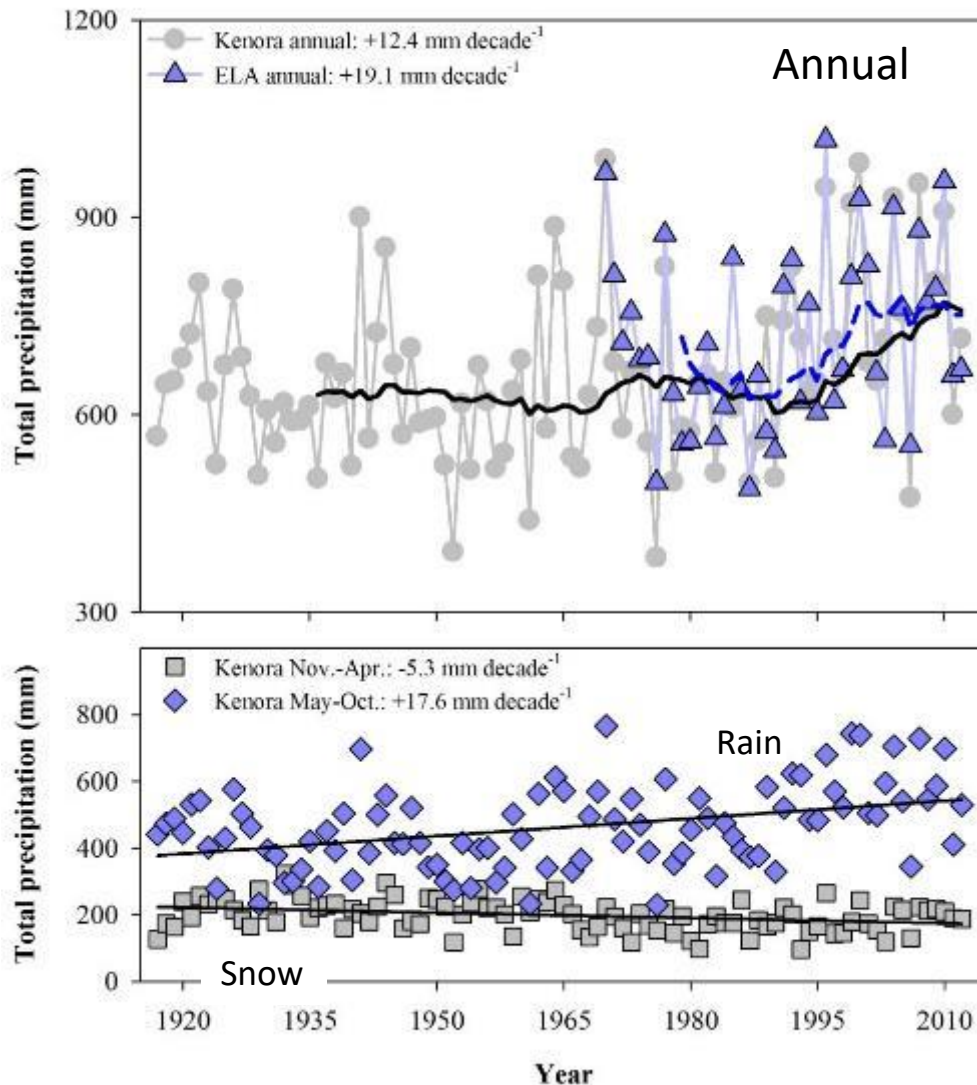


Climate change and algal blooms

- Algal blooms in Lake Winnipeg and Lake Erie are associated with both point source and non-point source phosphorus loading;
- Large increases in blooms since 1990 are related to land-use and higher than normal precipitation associated with climate change;

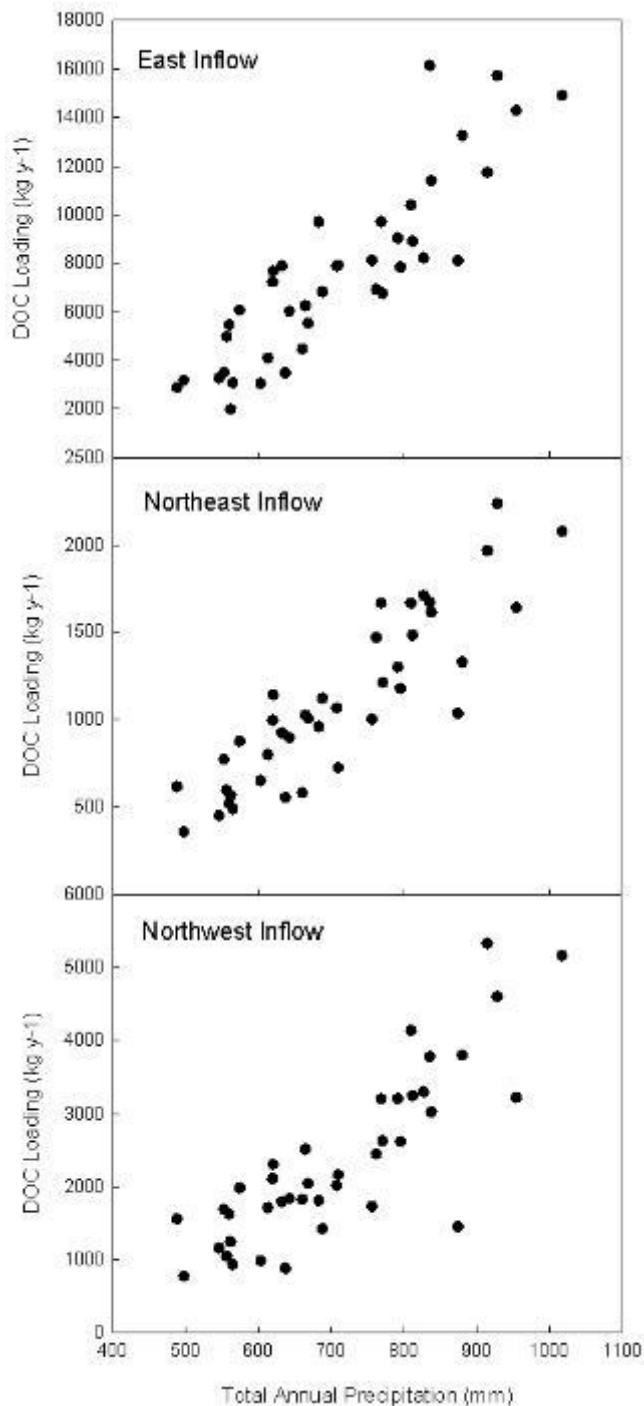


Is It Getting Wetter?

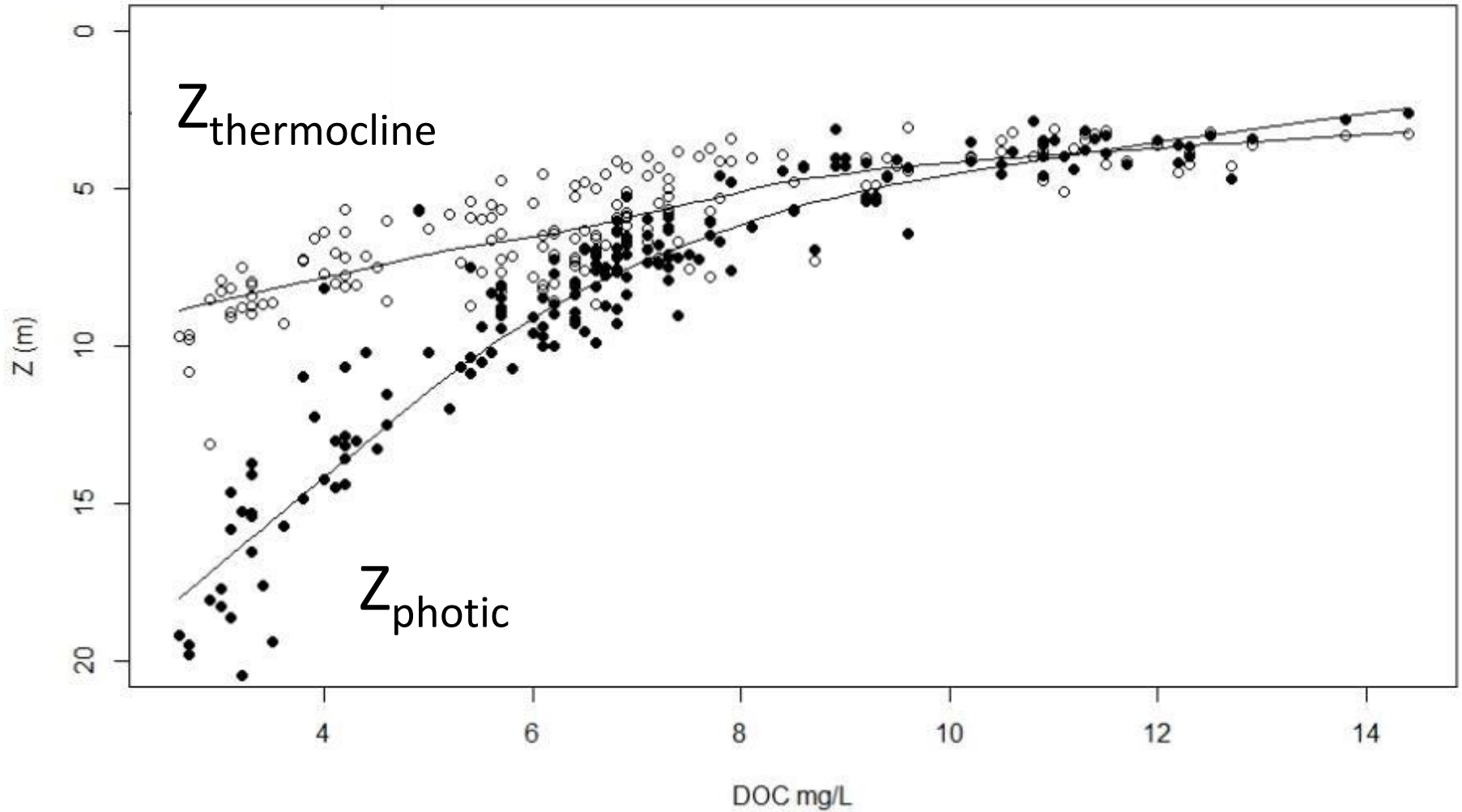


- Large inter-annual variation in precipitation;
 - Rainfall during earlier portions of the time series have strong periodicity ($\sim 31 \text{ y}$ period);
- Importance of long time-series**
- Significant increases in total annual precipitation detected; Driven by changes in summer rainfall.

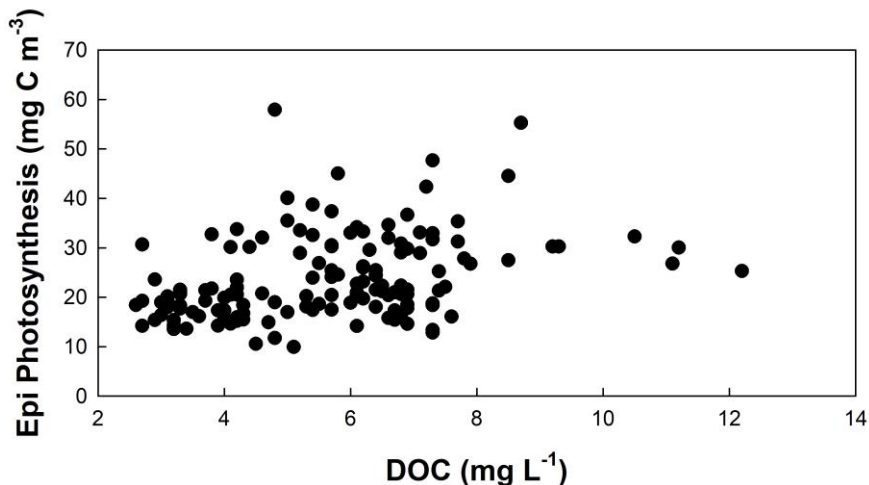
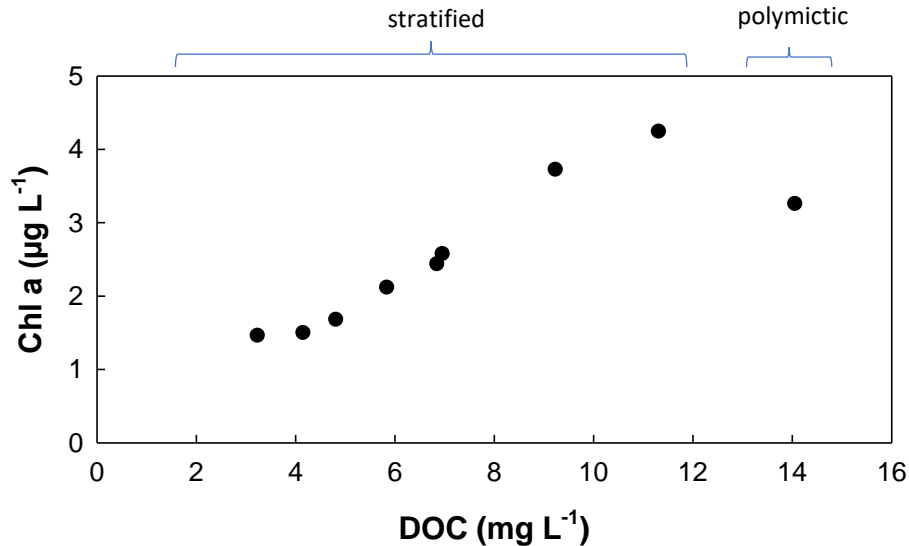
Precipitation vs. Dissolved Organic Matter (DOM)



More Rain - Lakes Getting Darker

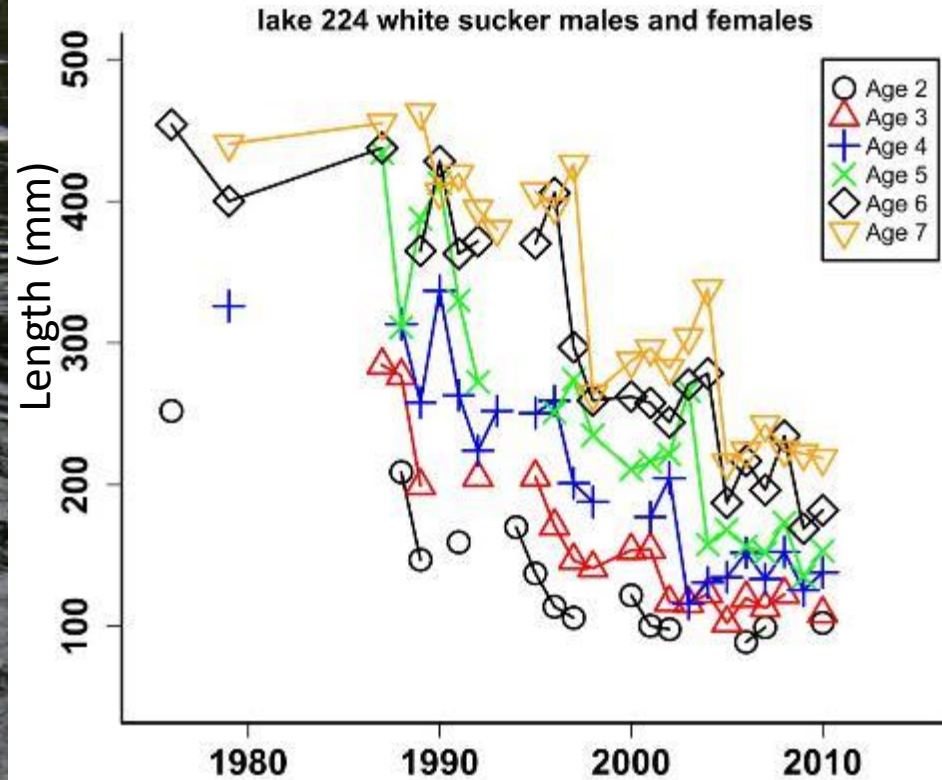


Phytoplankton



- DOC associated with increases in epilimnetic biomass and photosynthesis despite declines in water clarity;
- However, depth integrated photosynthesis either remains unchanged or slightly negative;

Warmwater Fish

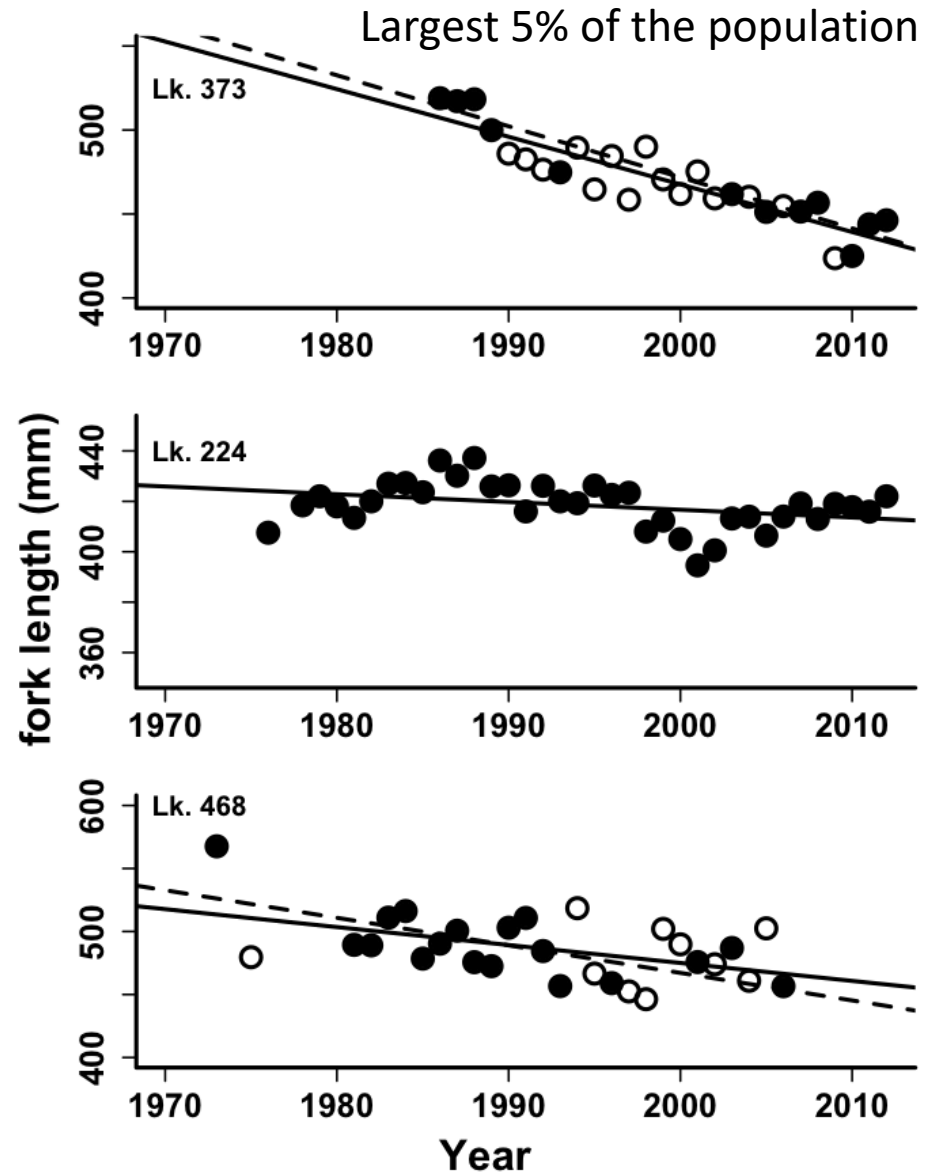


- Decline in size at age at many age classes; pattern observed in multiple lakes;
- No change in abundance detected, but apparent shift towards younger size classes

Coldwater Fish – Trophy Fish



- No significant changes in abundance detected
- Reduced adult survival (shift in age class to younger fish)
- Shift in length at age (fish getting 'shorter')
- Shift in fitness (reduced mass per unit length)
- Reductions in trophy fish

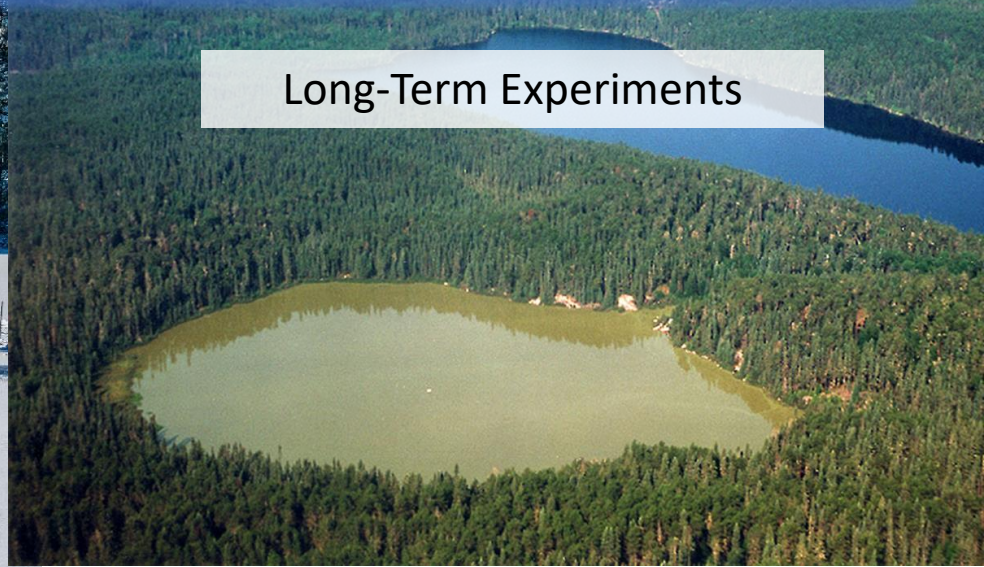


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Long-Term Relationships



Expanding Opportunities



Acknowledgements

The IISD-ELA is located on the traditional homelands of the Anishinaabe First Nation;

Fisheries Research Board of Canada and Fisheries and Oceans Canada operated the ELA from 1968-2013, after which the IISD Experimental Lakes Area assumed operation;

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