IMPLICATION OF CLIMATE CHANGE ON LAKE THERMAL PROPERTIES AND RESIDENT ALGAL COMMUNITIES IN A DIMICTIC SEASONALLY ICE-COVERED LAKE

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Abstract

Winter conditions are rapidly altering in the seasonally ice-covered temperate systems due to climate-driven shifts in air temperature and precipitation regime. However, it remains uncertain how these climatological changes will impact the physical, chemical, biological attributes of temperate seasonally ice-covered lakes. In this study, we estimated the potential impact of climate change on lake thermal properties and algal community response. The purpose of this study is to provide a "screening assessment" intended to broad insights into government-led lake monitoring programs and related basin management options. Based on our review of literature, we hypothesized that climate-driven shifts in the air temperature and precipitation affect lake thermal structure including the depth and stability of thermal stratification, which in turn influence algal community dynamics. To test this hypothesis, we assessed the shifts in vertical thermal profile and algal communities in a dimictic seasonally ice-covered lake in central Alberta between two time periods (1985-1995, 2005-2017). Our preliminary analyses identified a significant increase in the summer epilimnion temperature and increased frequency and duration of the thermocline. Shifts in the algal composition also evident, with an increase in Haptophyte and Cyanobacterial density in the recent decade, reflecting an indirect effect of climate warming.

Background

Literature review

- Global temperature has increased nearly 1°C since the beginning of the industrial revolution, which is pronounced in last three decades and historical warmest in between 2015 -17 (CCCR 2019)
- Projected increase is 3 - 4 degrees by the end of this century (Global climate model)
- Consistent with the temperature increase, precipitation pattern has changed (CCCR, 2019)
- Current and projected change will impact hydro-chemical properties and algal community dynamics in temperate lakes (O'Reilly et al. 2015)
- Climate change impacts on harmful algal bloom developments in lakes and reservoirs (Chapra et al. 2017)

Research Goals

- To assess the impacts of climatological changes on the thermal properties of the seasonally ice-covered temperate lakes
- To investigate the influence of thermal changes on algal community dynamics

Study Site

- Ethel lake is a dimictic, mesotrophic lake; located about 18 km northwest of the town of Cold lake city
- Lake mean depth is 6.6 m, and the maximum depth is 30 m (southwest bay, Fig.1)
- Lake area is around 5 km,^{2} and the drainage area is 542 km^2
- Samples were collected from the southwest bay of the lake

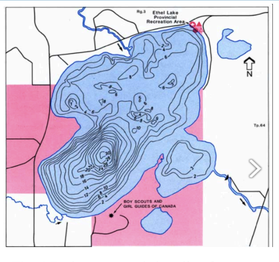

Fig. 1 Bathymetry and shoreline features of Ethel lake.
Bathymetry source: Atlas Alberta lakes

Methods

Data collection

- 30 + years (1985-2017) of hydro-chemical data and algal community data have collected from the Alberta Environment and Parks Canada's long-term lake monitoring program
- Data lapse/deficient in between 1996-2004
- Climatic data (monthly) has collected from the Environment Canada's weather station and Alberta Climate Information Services

Table 1: Statistical analyses

Statistical analyses and packages	Purpose
Twelve months moving average (zoo)	See the historical changes in regional air temperature
Two sample t-test	See the differences in group variables
Thermal depth, water column stability, stratification (rLakeAnalyzer)	Determine the changes in lake thermal properties
Non-metric multidimensional scaling NMDS (Vegan)	Assess algal community separation

Preliminary results

Climatic

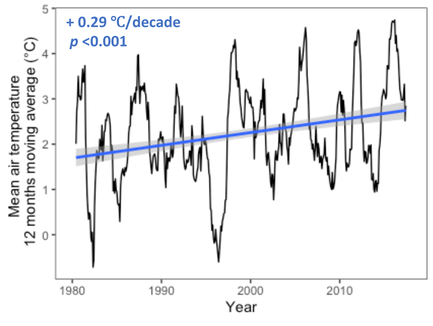

Fig. 2 12-months moving average of regional mean air temperature during 1980-2020. The blue line shows the linear trend. The symbol "+" in the blue text represents the increase in mean air temperature per decade.

Lake thermal properties

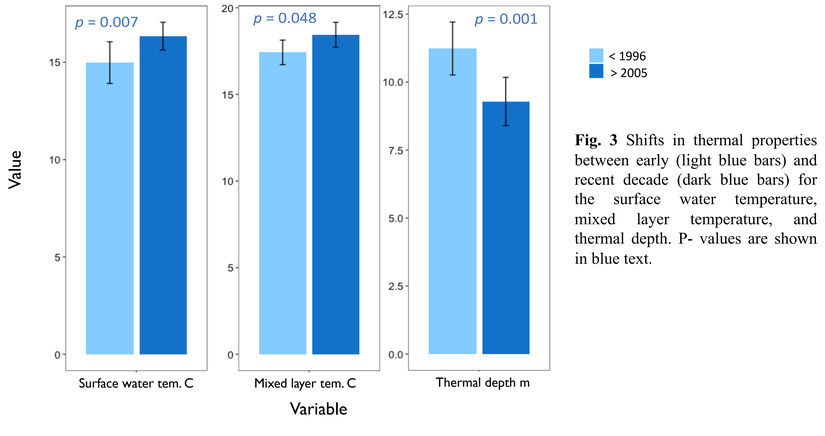

Fig. 3 Shifts in thermal properties between early (light blue bars) and recent decade (dark blue bars) for the surface water temperature, mixed layer temperature, and thermal depth. P- values are shown in blue text.

Preliminary results

Algal composition

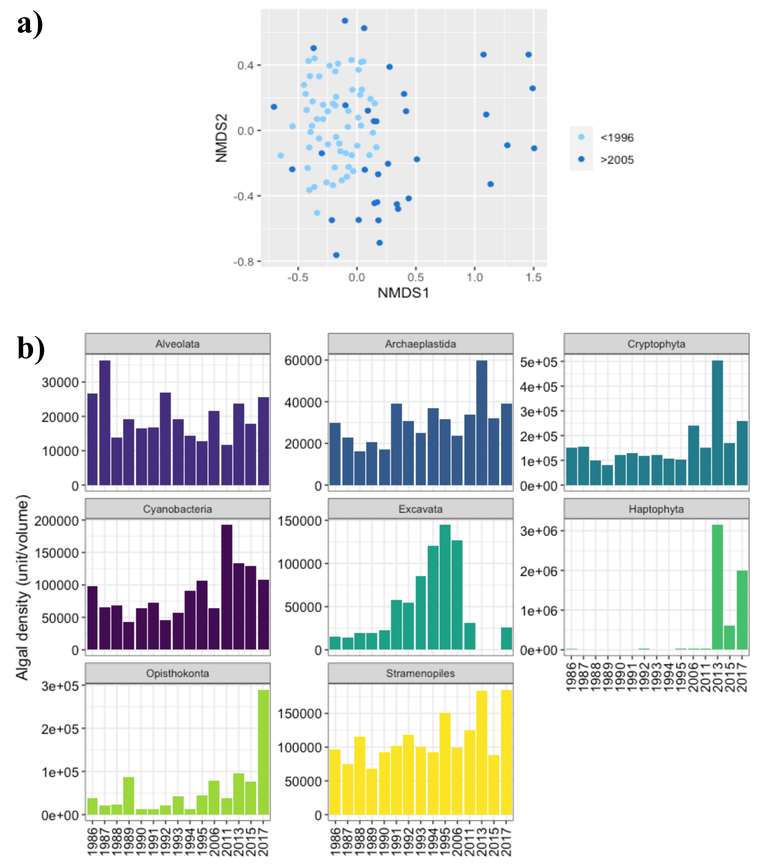

Fig. 4 Shifts in algal communities: a) ordination plot (Non-metric multidimensional scaling) of algal communities from 1985-1995 (light blue) and 2005-2017 (dark blue), b) shifts in the density (yearly mean) of major taxonomic group (rank-2).

Implication

- Provide useful insight to long-term changes in hydro-chemical properties and algal communities in the temperate lakes
- Enable improved predictions of how lakes in the cold region will be responding to current and projected climate variability and change

References

- Canada's Changing Climate Report (2019)
- O'Reilly et al. (2015) Geophysical Research Letters, 42(24), pp.10-773.
- Chapra et al. (2017) Environmental Science & Technology, 51(16), pp.8933-8943.

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