Impacts of a Warming Arctic on Freshwater Ecosystem Productivity, Biogeochemical Processes, and Resources

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Overview

Lake Hazen, located on Ellesmere Island (82°N) is Canada’s largest lake north of the Arctic Circle. Historically and culturally, this region served as a significant hunting and fishing ground for paleo-Inuit peoples approximately 4000 years ago. Lake Hazen watershed is currently experiencing various impacts of climate change (i.e., warmer temperatures, increased precipitation, decreasing ice cover, etc.). Consequently, this research focuses on how these changes are impacting freshwater processes, specifically primary productivity, which supports aquatic food webs (i.e. fish stocks) with energy necessary for survival. Metabolic process including net primary productivity (NPP) of surface waters, ecosystem respiration, and air-water carbon dioxide (CO₂) fluxes will be quantified during summer 2016 and spring 2017 to assess ice-on and ice-off ecosystem metabolism. A variety of techniques including the application of stable isotopes (δ¹³CO₂, δ¹⁸O), and the analysis of a complete suite of water chemistry parameters will aid in expanding our understanding of biogeochemical processes occurring within this aquatic system. Lake metabolism measurements will provide valuable data on the energetic processes that support aquatic life, allowing us to understand how climate change may impact the security of freshwater resources. This research program will inform and benefit a range of stakeholders, including public health officials and policy makers, as well as help secure the safety of food and water resources for Arctic indigenous communities.

Research Objectives

The objectives of this study are to determine how High-Arctic lakes are responding to climate change by calculating rates of total ecosystem productivity. To achieve these objectives, we aim to collectively quantify:

1. Net Primary Productivity (NPP) in surface waters;
2. Ecosystem Respiration;
3. Air-water CO₂ fluxes;
4. and to characterize water chemistry.

Methods

**Summer 2016**

- Surface water NPP was quantified by deploying a meteorological station raft.
  - Dissolved O₂ stable isotopes (δ¹³O₂) are used to assess whole lake metabolism by separating changes in O₂ saturation due to temperature, and mixing from changes in metabolic activity.

**Spring 2017**

- Continuous Sonde and HOBO logger data collection
- Vertical Water Column Profiles
- Bottle incubations respiration experiment using Presens O₂ Sensor Spots

**Preliminary Results: Summer 2016**

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<th>Chlorophyll (µg/L)</th>
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**Preliminary Results: Spring 2017**

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**Discussion and Observations**

- During Summer 2016, Skeleton Lake is well mixed on 6-July, as indicated by the black solid line in Figure 3. Stratification of the lake occurs between 6-17 July, as shown by the continuous temperature data and water column profiles (Figures 2 and 3).
- During this stratification period, there is a large increase in dissolved oxygen (DO) below the mixed layer (Figures 4 and 5), with a net metabolic rate of 3.3 mg O₂ L⁻¹ d⁻¹.
- The isotopic values δ¹³CO₂ becomes more depleted with depth (Figure 7), indicating high rates of NPP.
- Most of the NPP occurs at the bottom of the lake. Benthic mosses play a large role in this process. Figure 5 displays how chlorophyll-a significantly increases around 4 m depth until the bottom of the lake.

**Acknowledgements**

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