Seasonal water dynamics in Ward Hunt Lake at the top of the Canadian high Arctic

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The Arctic is populated by a large number of lakes. It is important to understand the seasonal dynamics in lakes because the organisms that inhabit these lakes are strongly affected by water conditions and its dynamics. High Arctic lakes are undergoing dramatic changes. For example, changes in the ice thickness and lake ice cover, including the seasonal ice disappearance of a once permanently ice-covered lake. However, primarily because of the difficulty of sampling in the winter, there is almost no knowledge about the seasonal and annual dynamics of high Arctic lakes. Ward Hunt Lake (WHL) is Canada's northernmost lake, located on Ward Hunt Island (83°05'N, 74°10'W), ca.6 km north of the northern coast of Ellesmere Island (Fig.1). The climate is extremely dry and cold, where the yearly average air temperature is –17°C and the average precipitation ca.150 mm (Vincent et al. 2011). The water body is ultra-oligotrophic and perennially ice-covered, but record melting of more than 25% of its ice cover occurred in 2008 (Vincent et al. 2009), and the complete loss of ice cover was recorded in 2011, 2012 and 2016 (Paquette et al. 2015). Based on these data, it is evident that WHL is considerably affected by global environmental change and serves as a sensitive indicator of the overall changes occurring in this region.

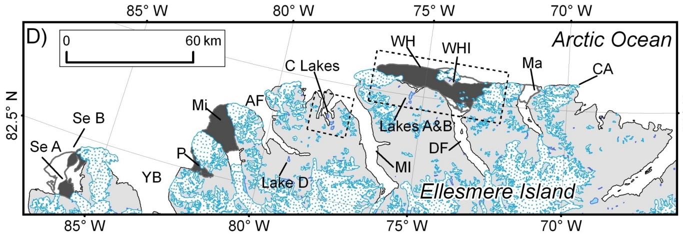

Figure 1. A map of Ward Hunt Island (WHI) and Ellesmere Island.

To address these gaps in understanding, we deployed a mooring system, based on the same method used in ice-covered Antarctic lakes (Tanabe et al. 2008), to continuously record water temperatures, PAR (photosynthetically active radiation), chlorophyll *a*, DO (dissolved oxygen) in WHL for two years from 2016–2018. The PAR and chlorophyll *a* loggers collected data every 30 min, the temperature loggers collected data every 10 min, and the DO logger collected data every 1 min. The water depths at which each logger was deployed are shown in Fig.2. We installed the mooring system at a depth of10 m at the deepest point of Ward Hunt Lake on 20th July 2016 and retrieved the mooring 14th July 2017 and re-installed the same system after downloading all the data on the same day. We then retrieved redeployed the mooring on 20th July 2018.

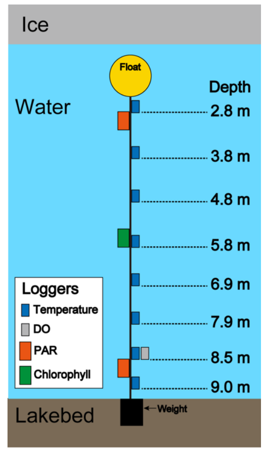

Figure 2. Design of the mooring system

The water column in WHL accumulated heat, rising to 6.5°C at the end of July 2016, the ice cover started to move due to strong winds, and on 15 August 2016 the ice completely disappeared (as shown by an automated camera installed at the edge of the lake). The water column exposed to wind was mixed completely, and temperatures dropped to near 0°C; this represents a complete shift of the temperature regime compared to colder years. Oxygen concentrations remained around 100% until ice-off. The constant mixing of the water while the lake was ice-free kept the oxygen around 90%. Oxygen concentrations dropped rapidly after ice-up, and anoxia was recorded in the bottom waters in December, which was unexpected for such an ultra-oligotrophic lake. The concordance of oxygen and temperature records in July 2016 also revealed an internal wave pattern during the period of ice-cover with a period of approximately 2 hours. Two periods of chlorophyll *a* maximum were observed during the 2016-2017 season. A fall phytoplankton bloom occurred in late August 2016. Fall blooms are observed in the Arctic Ocean due to vertical mixing and higher light availability associated with the loss of ice. The 2017 summer bloom occurred with a sudden reduction of light, for reasons that are not yet clear. These seasonal changes underscore the controlling role of ice cover in affecting light availability, especially with snow accumulation. Our future objectives are to compare this data from 2017-2016 with the 2017-2018 season, with a focus on how the dynamics of the lake after the complete loss of ice cover.

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