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The dynamics of a large northern lake (Lhù'ààn Mān - Kluane Lake, Yukon) in the face of climate change

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INTRODUCTION

Large northern lakes hold vast quantities of freshwater, provide habitat and travel corridors for species, regulate local hydrological processes and climate, and have significant value to local communities. However, as climate change continues to amplify in northern regions, the integrity of and ecosystem services provided by these lakes are increasingly threatened. A growing number of studies show that large northern lakes are sensitive to small physical, chemical, and biological changes, which can lead to state shifts with consequences for surrounding ecosystems and communities (Adrian et al. 2009; Schindler et al. 2009). Despite this, basic knowledge of the water properties and dynamics of these large northern lakes is very limited, and a need for increased research and long-term monitoring has been identified. Lhù'ààn Mān (Kluane Lake) is the Yukon's largest lake (400 km² with a maximum depth of 80 ± 5m , is located within Kluane First Nation and White River First Nation traditional territories and borders Champagne and Aishihik traditional territory, and is an excellent model system to study the impacts of climate change on large northern lakes.

OBJECTIVES

1. Characterize baseline spatial & temporal water property dynamics of Lhù'ààn Mān.
2. Design an effective long-term monitoring program in collaboration and partnership with local Yukon communities and government agencies.
3. Compare pre- and post- Ä'äy Chù "river piracy" event using lake data to determine responses to a significant reduction of cold, glacial water inflowing to the lake.

2015 BASELINE STUDY

- designed and conducted in 2015 in conjunction with KFN
- 28 sampling sites to provide spatial coverage and incorporate sites of community interest (Figure 1)
- Data collected at each site minimum once per season using CTDs, sondes, and water samples: temperature (ºC), conductivity (µS/cm), dissolved oxygen (%), turbidity , total dissolved solids (TDS), total photosynthetic pigments , total nitrogen (TN) and total phosphorous (TP)

2016 Ä'ÄY CHÙ "PIRACY"

The Kaskawulsh Glacier meltwater fed both the Ä'äy Chù and the Kaskawulsh River until recession and terminus changes reached a critical point in 2016, causing the glacier's meltwater to be redirected entirely into the Kaskawulsh River (Shugar et al. 2017) . The Ä'äy Chù now comprises only tributary waters. The reduced inflow to Lhù'ààn Mān has significantly lowered lake levels (Figure 2). The impacts of inflow changes on the lake water properties are unknown.

LONG-TERM MONITORING & COMPARING STATE CHANGES

Spring 2016: funding secured from DKRRC to build and deploy 4 long-term moorings (equipped with temperature and conductivity loggers) in Lhù'ààn Mān with the help of the Department of Fisheries and Oceans (Figure 3).

March 2017: moorings deployed in areas representative of the various ecozones at Lhù'ààn Mān (Figure 1). Early data (first 6 months) from these mooring is shown in Figure 4: different thermal dynamics are observed in different parts of Lhù'ààn Mān, highlighting the significant variability within the lake and importance of spatial and temporal coverage when monitoring large lake systems.

Next steps: comparing thermal and conductivity dynamics between 2015 (baseline data) and 2017 (mooring data) to determine if and how the Ä'äy Chù may be affecting the thermal and conductivity dynamics of Lhù'ààn Mān.

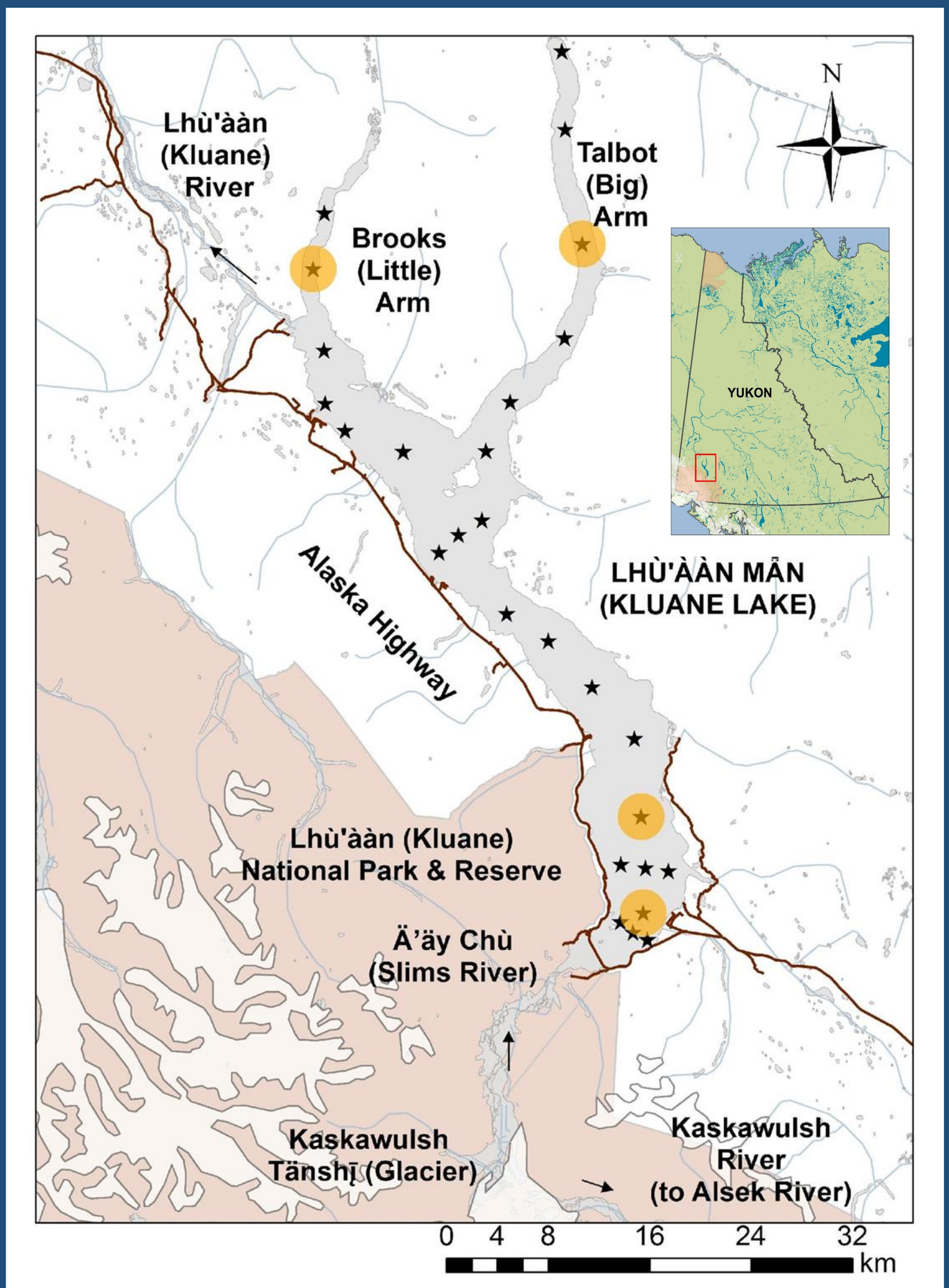
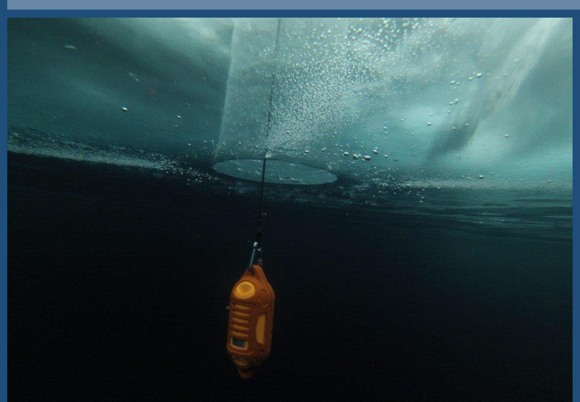


Figure 1. Sampling locations for 2015 baseline data collection (indicated by stars) and long term mooring locations (indicated by circles and deployed in April 2017) at Lhù'ààn Mān.



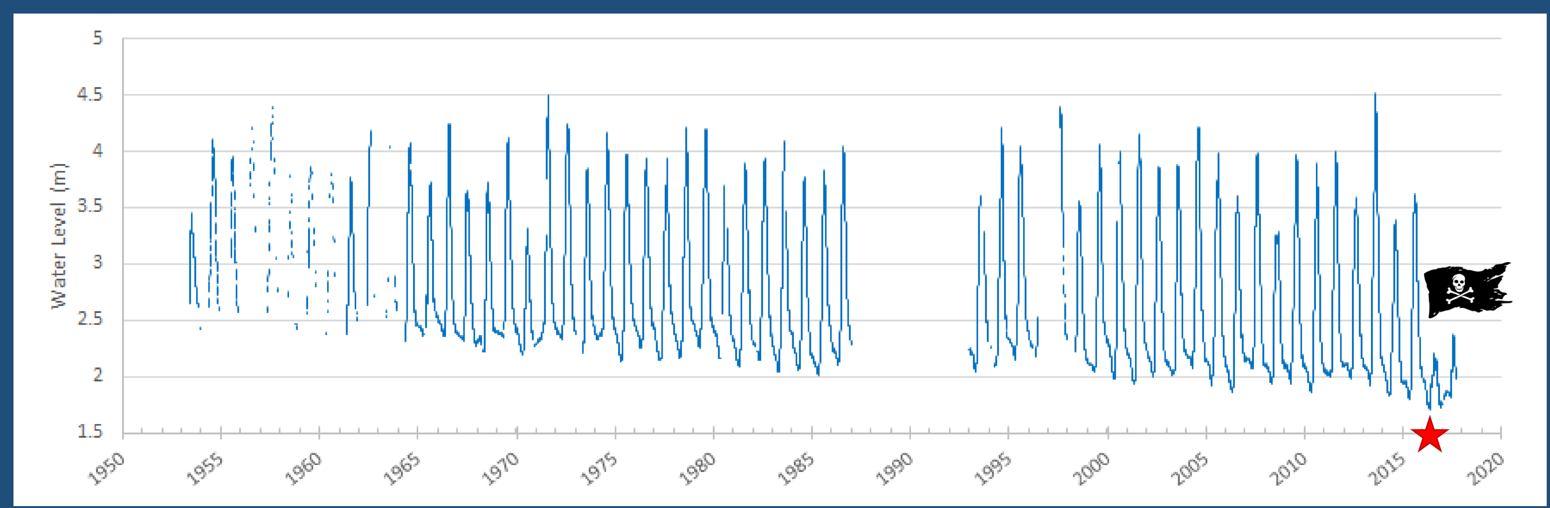


Figure 2. Daily average water levels (m) for Lhù'ààn Mān between 1952 and September 2017. The red star indicates the Ä'äy Chù "piracy" event in spring 2016.

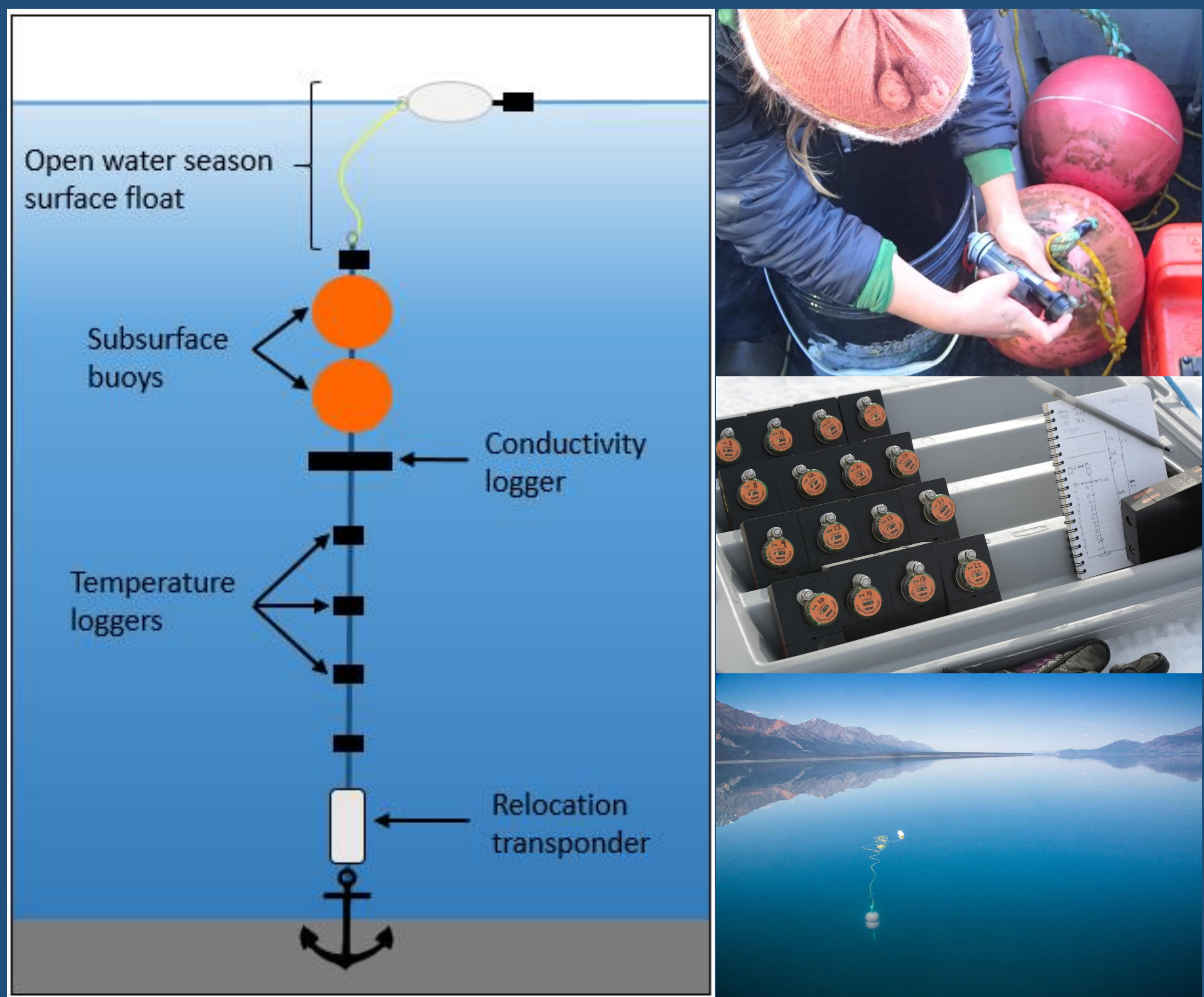
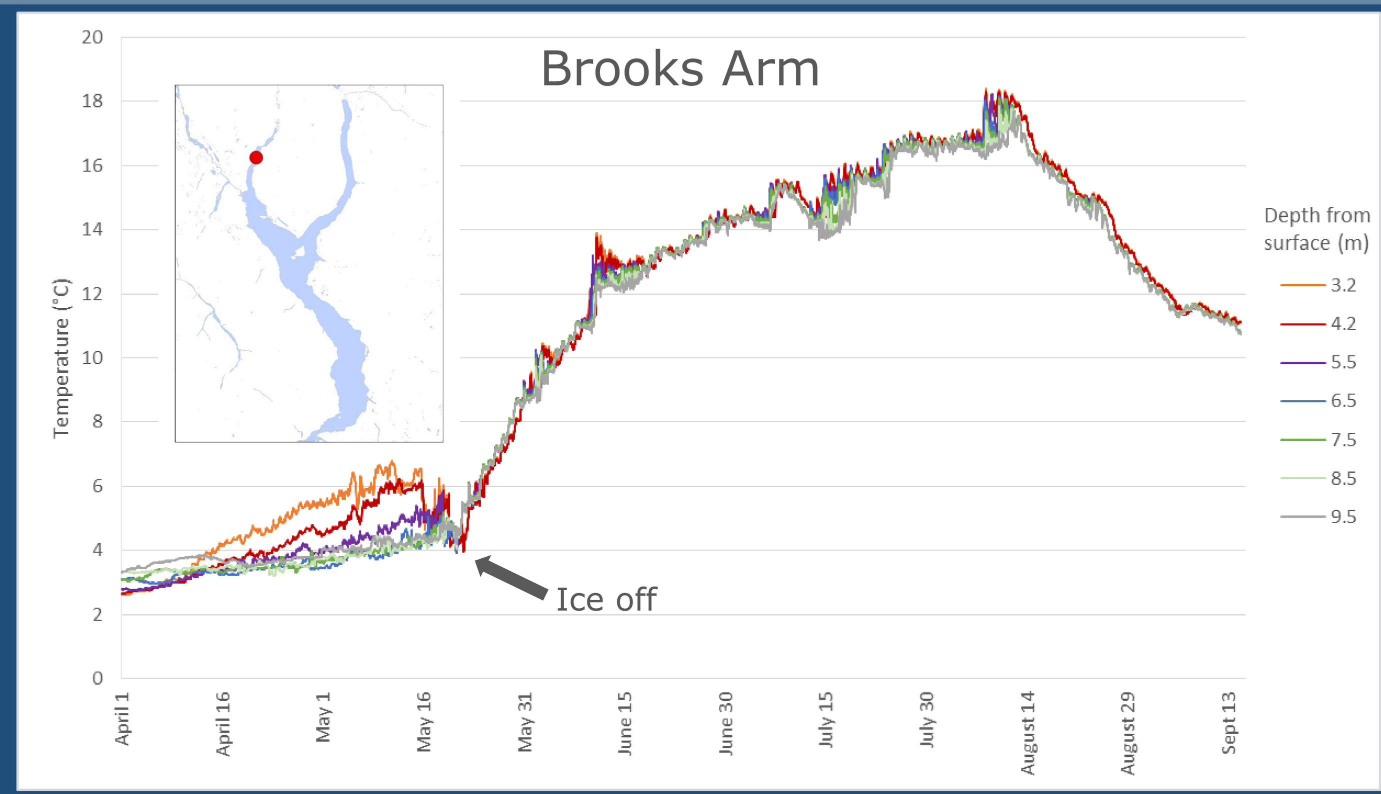
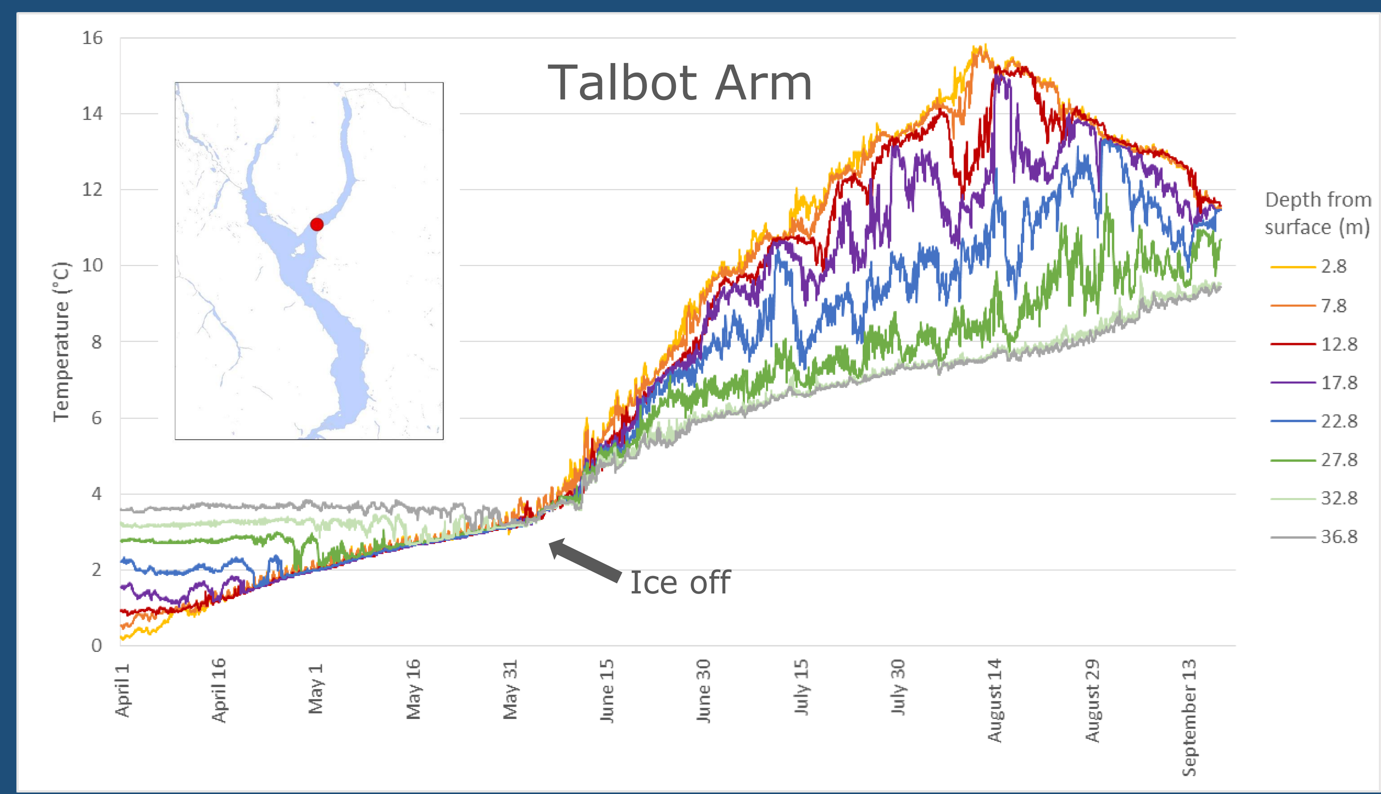


Figure 3. Mooring design : data loggers are HOBO Tidbit (temperature) and HOBO U24 (conductivity), transponder is a SubSea Sonic Accoustic release used as a transponder. Photos show downloading data, mounted loggers and surface float. Photo credits: Pauly Sias , David Hik, Lance Goodwin.





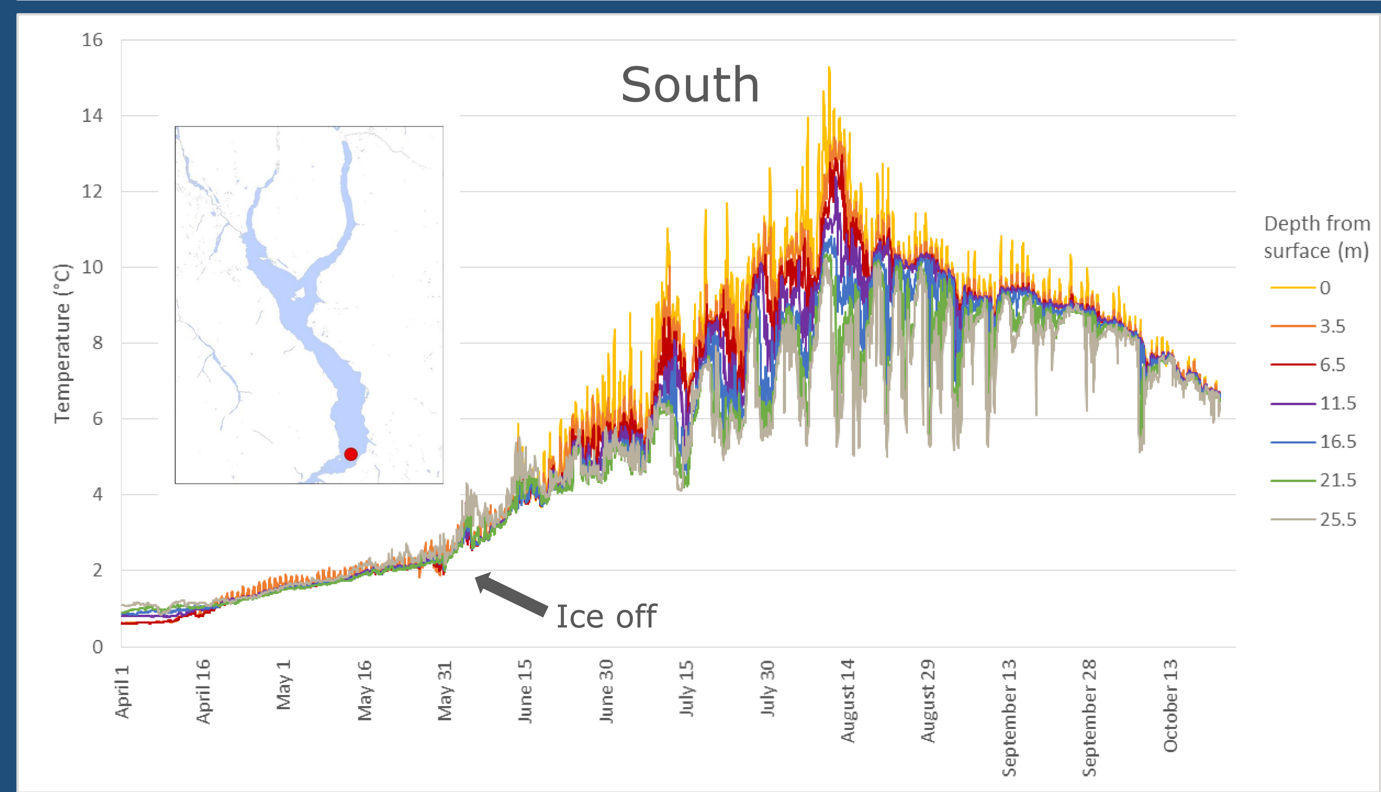


Figure 4. Thermal data (throughout water column, depth is site dependant) collected between April and October 2017 for three of moorings (Brooks Arm, Talbot Arm, and South mooring). Brooks Arm dynamics are categorized by a shallow, fully mixing water column. Talbot Arm exhibits thermal dynamics of a typical relatively deep, dimictic, stratifying lake. **The dynamics at the south end of the lake are erratic and show that the influence of the Ä'äy Chù, even if significantly reduced, is still significant at this end of the lake, with physical and chemical properties that are different enough from the lake to affect stratification and thermal dynamics within the southern basin.**

SIGNIFICANCE

1. Expands our limited understanding of large northern lake dynamics and establishes a model for large lake monitoring in the Yukon and elsewhere in the North.
2. Demonstrates the value of high spatial & temporal resolution monitoring of large northern lakes in order to detect and understand consequences of change in these systems.
3. Examines the consequences of the loss of glacial input to a large northern watershed (via a natural experiment!), a likely more frequent event with future climate change: the Ä'äy Chù piracy event presents a unique opportunity to explore watershed resilience and test theories about how large lakes may shift from one state to another.
4. Realizes the meaningful collaboration between researchers & local communities as a model for future research and environmental monitoring at Lhù'ààn Mān and beyond.

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