Project Title: Lake Ice in the Canadian High Arctic

Project Leader:
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Project Team:
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Ernest Groh, University of Toronto, 3359 Mississauga Rd N, Mississauga, ON
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Debbie Iqaluk, Resolute HTA, Resolute NU

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ᑎᐊᐱ ᐃᖃᓗᓯ (Debbie Iqaluk), ᖃᐅᔨᐃᑦᑐᖅ, ᓄᓇᕗᑦ

Abstract:
This year, our research group spent ~ two weeks in May and August, recording snow and ice data and servicing our equipment that stays in place all year on lakes on Cornwallis and Bathurst Islands. We also had one trip to Nanuit Itillinga to service the camera and weather tower located there to maintain the long-term data set in this area. In May, we measured the snow depth and ice thickness on lakes around Cornwallis Island. Similar to the previous two years, the ice thickness was 2.1 m thick (average) on the small lakes near Resolute, with an average of only 13 cm of snow on top of the ice. The ice was thinner up the eastern coast of Cornwallis Island at the larger Laura Lake (1.46 m of ice with 62 cm of snow) and Eleanor Lake (1.62 m with no snow cover in the sampling location). In both May and August, we serviced the trail cameras (the "High Arctic Lake Ice Observation Network") and repaired three that had been damaged. We reinstalled most of them with a different mounting pole to help secure them better in extreme weather. In August, we downloaded and redeployed the ice thickness sensor and successfully measured an entire season of ice thickness on Small Lake near Resolute. We combine this data with the camera imagery from the same lake to see a complete picture of the winter ice season for that lake. We note this year that the ice cover was still on three of the research lakes after we completed our fieldwork, reflective of the cooler summer experienced in the region. The data collected this year contributes to creating a long-term data set of snow and ice thickness, as well as providing

validation data for modelling lake ice (both current and future climate) and satellite-based ice phenology projects (RCM). It is also contributing to two ongoing student research theses.

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Key messages: Concise, plain language summary of key take-away messages of work to date, findings and conclusions. Preferably 3-5 points, in bullet form.

- Lake Ice thickness on Cornwallis Island remains ~ 2 m thick at maximum thickness for small lakes and ~ 1.5 – 1.6 m thick on larger lakes with more snow cover
- The “High Arctic Lake Ice Observation Network” (HALO) cameras were upgraded with new installation posts for better durability to capture the timing of ice and snow across 9 High Arctic lakes.
- The cool summer of 2024 in the High Arctic led to prolonged ice cover on the smaller lakes and a later-than-usual ice break-up

Objectives: Project objectives, preferably in bullet form.

- To investigate the changes that have occurred, are occurring, and may yet occur, to the ice cover on Arctic lakes through monitoring and modelling

- To obtain more detailed in situ observation data to both assist with satellite-based and model-based research, as well as develop a long-term dataset
- To highlight the differences between northern vs. mid-latitude ice processes

Annual activities: A description of activities and methods carried out during the current reporting period. This section should answer the questions: What? Where? When? Who? How? Include dates team members conducted research at remote field sites or collected data (including interviews) in communities; append a map with locations and/or coordinates of remote field sites, if applicable.

2024 Research Team:
Laura Brown, Noah Bacal, Ernest Groh, Alex Cabaj, Debbie Iqaluk

Summaries of Activities:
This year, our field party consisted of four members: Laura Brown, Noah Bacal (MSc Student, year 3), Ernest Groh (BSc student, year 4), and Debbie Iqaluk (Resolute Resident and Research Associate). Our group spent 13 days (May 8-20) and another 14 days (July 27 – Aug. 9) working from PCSP in Resolute, with one brief trip to Nanuit Itillinga, Bathurst Island, for equipment maintenance.

Cornwallis Island:
In May, we measured the snow conditions and ice thickness on Resolute, Small, Meretta, Char, North and Plateau Lakes near Resolute (Figure 1).

Figure 1. Locations of the study lakes on Cornwallis Island: Plateau, North, Small, Meretta, Resolute, Amituk, Sophia, Laura and Eleanor Lakes.

We also went by Twin Otter to Laura Lakes (the weather did not allow visits to Sophia and Eleanor Lakes). We used a small 2" auger attached to a cordless drill to measure the ice thickness and found that the average ice thickness around Resolute was similar to the last two years last year at 2.1 m, and further up Cornwallis Island, the ice was again quite a bit thinner at

Laura Lakes where we drilled at only 1.46 m (as there was a lot of snow on the ice here). Measurements from Eleanor Lake were kindly provided by our team member D. Iqaluk, who visited the site after we had returned south. We will be sharing all of the snow and ice measurements with Dr. Catherine Girard as well for their projects.

In August, we recovered the ice thickness sensor (SWIP: Shallow Water Ice Profiler) from Small Lake and retrieved the data for a full ice season. Combined with the local camera, we can see a full ice season (Figure 2).

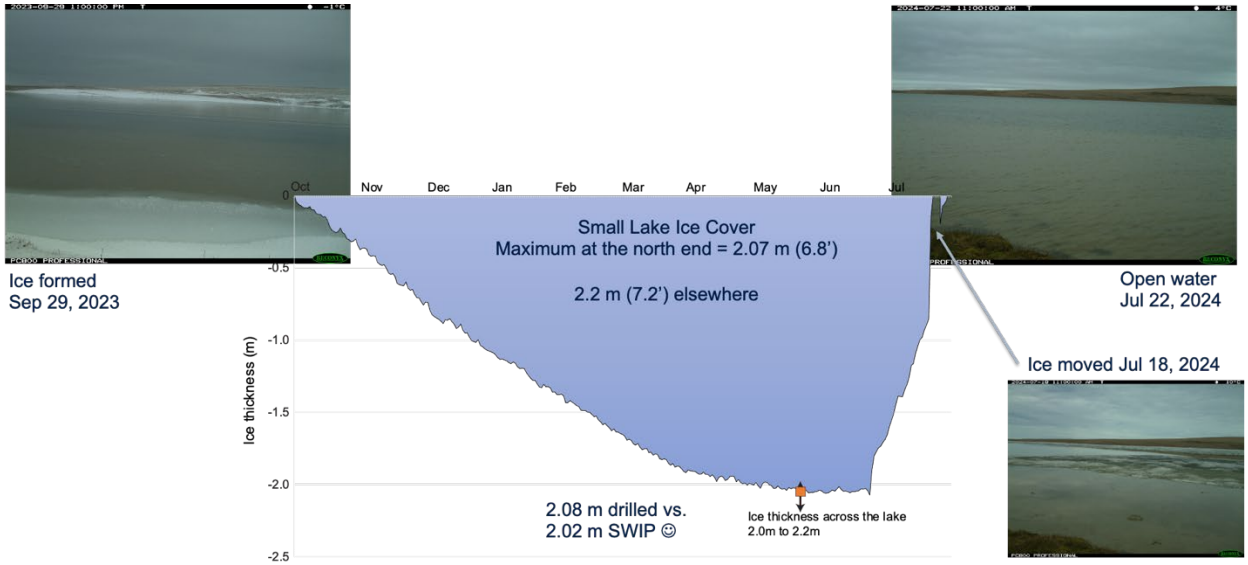

Figure 2. The ice thickness from Small Lake, 2024, along with the view from the shoreline cameras. This data is not yet published.

We also downloaded and repaired some of the local lake ice cameras that are part of my High Arctic Lake Ice Observation Network (HALO), so they were ready for the next year (Figure 3). We have replaced the posts the cameras are mounted on to help prevent them from rotating away from the lakes during extreme weather. We were able to travel to Eleanor, Laura, Sophia and Amituk Lakes to service the cameras, however the ones at Sophia and Amituk Lakes were knocked down and needed to be replaced. The cameras are on the northwest areas of the lakes, aimed to the east to capture the main lake area. We were not able to finish the lake depth maps we had planned because there was too much ice on Char Lake while we were there. We hope to measure this lake next summer.

Figure 3. Destroyed camera at Sophia Lake and new set-up at Laura Lake, Cornwallis Island.

Bathurst Island:

We travelled to Nanuit Itillinga NWA on August 7 and spent 3 hours working there. We were able to download and service the small camera structure on the N shore of Hunting Camp Lake as well as the weather tower (Figure 4), and happily, all was working well. I plan to continue to use Hunting Camp Lake as a representative lake for the area in terms of modelling, as there is an existing climate record and snow cover data available. Claude Labine from Campbell Scientific was not with our team this year but is still an active participant with respect to tower maintenance and data records.

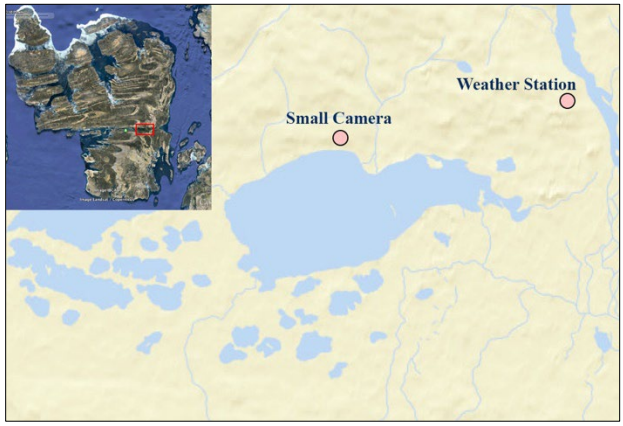

Figure 4. Location of work sites in Nanuit Itillinga, NWA.

Results and Achievements: Findings and results to date of the above activities, highlighting any key research achievements (see guide below for formatting tips regarding tables and figures).

The research activities are ongoing, and we are still analyzing the data collected in summer 2024. Preliminary results are included above for one lake and the annual ice cover dates from the HALO cameras can be found at: https://sites.utm.utoronto.ca/brown/content/lake-ice-cover-dates-nunavut In the coming year, I am hoping to set up a site dedicated to the camera imagery for the project.

Challenges/Obstacles: In this section, please comment on any challenges/obstacles (if any) that you experienced during this project year. If there were any actions to mitigate or resolve these challenges, please list them here. Were any concerns raised regarding the conduct of research team members or the impacts of the project?

We experienced more weather-related delays and challenges this year than usual, but we adapted the research plans as much as we could. We were not able to collect all the data we had hoped for though.

Expected Project Completion Date:
August 2028, or later if funding is renewed

Project website (if applicable): If your project has a presence on the internet, including a website and/or social media page, please provide the link and/or account handle.
NA

POLICY RELEVANCE
Does this research support policy development or decision-making in Nunavut? If yes, please describe.
NA

RESEARCH OUTCOMES: BENEFITS
Community engagement: Briefly list and describe any community consultation, engagement, collaboration and outreach activities that you have undertaken for the project; describe the role(s) that community members and/or specific organizations have played in research co-design and activities.

When the project was originally set up, we connected with the Resolute HTA and the SAO, however, this is a long-term project, so no recent consultation has been done. We have a local community member working with us on the research team for many years who has been invaluable for the success thus far. Most of the recent community engagement that we have done is through informal conversations while we are outside working and interested people stop by. One side-project related to the main project was originally of interest to the community through

the lake depth mapping, and we plan to connect with the community again in the spring to see if they are still interested in the calculated water levels we may be able to provide next summer.

Youth engagement: Briefly list and describe any outreach, school or classroom activities that you have undertaken for the project; describe the role(s) that youth have played in your research activities.

We have made a poster for the local school in previous years, and hope to make an updated version over the next year now that we have met the students and the science teacher and have a better sense of what could work to explain the project to all levels of students.

Training and Employment:
How many Nunavummiut received training from team members? Please describe training and/or compensation provided.
How many team members received training from Nunavummiut? Please describe training received and/or what knowledge sharing and/or skills exchange took place.
How many Nunavummiut received employment? Please describe employment type and length, role(s) and responsibilities, and compensation provided.
How many Nunavummiut received honoraria as research participants? Please describe method of participation (interview, observation, sample, survey, etc.), including compensation provided.

We have one long-term team member from Resolute, NU, who works on our project with us and is paid by the university as a Research Assistant.

Academic Mobility
If you are affiliated with an academic institution, please answer the following question: For which Level
of Project(s) will the data be used? (Check all that may apply)
☐ Research
☐ Post-Doctoral Research
☐ PhD Thesis
☐ Masters (Major Research Paper) / Masters (Thesis)
☐ Graduate Course Project
Staff/Administration Research
☐ Undergraduate Honours Thesis
Other

BUDGET
Please complete the table below to detail your projected and actual research expenditures during the reporting period.

Category	Planned/Approved Expenditure	Actual Expenditure
Travel and Accommodation	$40,000	$33,770
Equipment, Materials and Supplies	$2,000 (shipping)	$2,461
Salaries/Wages for Nunavut residents	$4,000	$5,000
Salaries/Wages for non-Nunavut resident researchers	x – I do not have enough funding to pay my graduate students beyond their annual research stipends they receive (non-specific to this project)	
Professional Fees and services in Nunavut	x	
Professional Fees and Services outside of Nunavut	$2,000	$1,718 (report translation)
TOTAL EXPENDITURES		$42,948

- Excluded: training costs travel to/from training site, first-aid certification costs, firearms licencing costs. Materials and supplies were purchased for this year in previous years

List the total $ amount of funding from each funding source for your full research program, including in- kind support

NSERC Discovery Grant: $35,000 *[* not all of this is allotted for this project, I run a second field site in ON where we do training prior to trips north]*
NSERC Northern Supplement: $17,000
NSTP: $4,000
PCSP: $133,997.76 (in kind)

RESEARCH OUTPUTS / REPORTING TOOLS
What research outputs were generated? Please list below and append copies of each.

Specify which outputs (if any) may be made public on the NRI research licensing database.

No new papers have been published this year. We suffered major data loss due to the COVID-19 restrictions, which left several projects incomplete and either unpublishable or pivoted to geomatics-based only (not using the ground data). One paper has been published, one has been submitted, and two more are nearing completion, hopefully to be submitted in 2025.

Robinson AL, Ariano SS, Brown LC. 2021. The Influence of Snow and Ice Albedo towards Improved Lake Ice Simulations. *Hydrology*, 8(1), 11; https://doi.org/10.3390/hydrology8010011.

This can be made public on NRI site, it is open access (might already be there)

Were non-peer reviewed materials produced to either communicate or synthesize results to the public?

Many presentations related to this project have been given over the last several years. All presentations before 2024 have been reported previously, but I am listing them here for record keeping if that helps. * indicates a trainee working on the project. Many university-based lectures and guest lectures have also used the data from this project but are not listed.

Brown LC and *Cabaj A. Changing ice and snow conditions on High Arctic lakes. Oral Presentation. ArcticNet AC 2024, Ottawa, Dec 13, 2024.

Brown, LC. Lake Ice in the Canadian High Arctic. Science Speaker, Polar Continental Shelf Program All-Staff meeting, Natural Resources Canada, Oct 2, 2024

*Cabaj A, Brown LC, Howell SEL, Brady M. Using RADARSAT observations to investigate Arctic lake ice phenology. CMOS 58th Congress, Winnipeg/Yukon/Online, June 2024.

*Robinson A and Brown LC. Projected simulated open water, seasonal, and annual radiation balance trends for a small High Arctic Lake under CMIP5 RCP 8.5. Canadian Geophysical Union Annual Meeting, Oral presentation, Ottawa, 2024.

Brown LC. Changing ice covers on freshwater lakes: what does the future hold? Keynote lecture, Groupe de recherche interuniversitaire en limnologie et en environment aqatique, Orford Quebec, March 15, 2024.

-- (previously reported in my reports to CWS cc'd to NRI)
*Robinson A and Brown LC. Comparing the Simulated and Observed Radiation Balance for a Small High Arctic Lake during the ice-free period (August: 2019, 2021 and 2022). C33F-1459, Poster presentation, American Geophysical Union Annual Meeting, San Francisco, Dec 2023.

*Lane B and Brown LC. Examining variability in snow and lake ice using digital camera imagery in the Canadian High Arctic. Oral Presentation, Canadian Geophysical Union Annual Meeting, Banff, May 2023.

*Robinson A and Brown LC. Comparison of Observed and Simulated Net Radiation for a Small High Arctic Lake during the ice-free period (August: 2019, 2021 and 2022). Oral presentation, Canadian Geophysical Union Annual Meeting, Banff, May 2023.

*Lane B and Brown LC. Examining variability in lake ice and snow using digital camera imagery in the Canadian High Arctic. Oral Presentation, Queens Northern Research Symposium, Kingston, April 2023. [Same name – updated content from CGU Student conference]

*Lane B and Brown LC. Examining variability in snow and lake ice using digital camera imagery in the Canadian High Arctic. Oral Presentation, Canadian Geophysical Union Student Conference, Waterloo, April 2023.

*Lane B and Brown LC. Changing Arctic Snow and Ice: in situ monitoring using digital camera imagery. Poster Presentation, ArcticNet AMS 2022, Toronto, Dec 2022.

*Robinson A and Brown LC. Comparing Simulated and Observed Net Radiation During the Ice-free Period for a Small High Arctic Lake. Poster Presentation. ArcticNet AMS 2022, Toronto, Dec 2022.

Brown, LC. Past, present, and future of lake ice in the central Canadian High Arctic. Invited Talk (Keynote speaker), Northern Research Basins 23rd symposium, Iceland (online), Aug 25, 2022.

Brown LC. Challenges while collecting Arctic field data: Where did my ice sensor go?? Canadian Young Hydrologic Society Workshop - From failure to progress: lessons learned in hydrology, CGU-CMOS-ESC Congress 2022, June 1, 2022.

*Robison A and Brown LC. Improving Lake Ice Simulations in Canada by including Lake Size. CMOS/CGU/ESC Joint meeting, Online, June 2 2022.

*Lane B and Brown LC. Changing Arctic Snow and Ice: in situ monitoring using digital camera imagery. CMOS/CGU/ESC Joint meeting, poster presentation, June 2 2022.

*Lane B and Brown LC. Changing Arctic Snow and Ice: in situ monitoring using digital camera imagery. Canadian Geophysical Union Student Conference, oral presentation, March 5 2022.

Brown LC. Lake Ice from the High Arctic to the Temperate Region: Monitoring, Modelling and Melting. Dalhousie University, Earth and Environmental Science Seminar Series, Nov 19, 2020.

Brown LC. Lake Ice Processes and Change Across Canada: Ontario vs. Nunavut, Queens University, PEARL Limnology seminar series, Oct 16, 2019.

*Robinson A and Brown LC. A Comparison of Simulated and Observed Lake Ice Cover in Canada 27th International Union of Geodesy and Geophysics General Assembly, Montreal, July 11-14, 2019.

Brown, LC. Lake Ice in Canada. University of Western Ontario, Geography Department Speaker Series, Dec 7, 2018.

*Robinson A and Brown LC. Modelling Melt-onset and Breakup Dates from Southern Ontario to the High Arctic. Poster Presentation, Canadian Geophysical Union Annual Meeting, June 11, 2018

*Robinson A and Brown LC. A Comparison of Simulated and Observed Lake Ice Cover in Canada, Canadian Geophysical Union Eastern Student Conference, Ryerson University, poster presentation, April 13, 2018

*Robinson A and Brown LC. Modelling Melt-onset and Breakup Dates from Southern Ontario to the High Arctic. Poster presentation Canadian Geophysical Union Eastern Section Student Conference, London ON, March 17, 2018.

*Robinson A, and Brown L. Lake Ice modelling of two High Arctic lakes. Canadian Geophysical Union Annual Meeting, Poster Presentation, Vancouver, May 29 2017.

PHOTOGRAPHS

File Name	Location	Description	Subjects	Photographer/Owner	Date
drilling_lake_ice.jpeg	Resolute, NU	Drill in the lake ice	NA	Laura Brown	May 12, 2024
lake_ice_bubbles_cracks.jpeg	Resolute, NU	Interesting features in the lake ice	NA	Laura Brown	May 12, 2024
NI_weather_station.jpeg	Nanuit Itillinga NWA, Bathurst Island	Weather station near the cabin in the NWA	NA	Laura Brown	Aug 7, 2024