

Report on 2022 Research Activities

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Research Title: “Weather, Ice, Ocean, and Freshwater Measurements to Understand Greenhouse Gas Cycles and Aquatic Ecosystems”

Project Overview and Objectives: This project tries to understand how greenhouse gases move through the Arctic environment. Greenhouse gases are the cause of climate change, and most people know that humans make them when we do things like drive cars, or heat our homes. But, greenhouse gases are also a natural part of ecosystems. One important place to find natural greenhouse gases like methane (CH₄) and carbon dioxide (CO₂) is in freshwater and seawater, where they exist as dissolved gases. CO₂ and CH₄ are important parts of these ecosystems, because some organisms that live in the water make these gases, while others use them. For example, algae and other plants take CO₂ out of the water to make oxygen, while certain types of bacteria use up oxygen and make CH₄. We want to study how gases like CO₂ and CH₄ work in these systems, and how those gases might eventually get into the atmosphere. It is challenging to do a good job of this in the Arctic, because we need to make these measurements all year-round.

A second objective of this project is to find ways to make our science useful to northern communities. We have been able to do this in the past. For example, we measure greenhouse gases at weather stations, and so we have worked with the HTO to set up weather stations at important locations. Data from those weather stations can be accessed online, and used when traveling. We think our measurements of dissolved gases in freshwater and seawater might also be interesting to the community, because there may be important links to wildlife. For example, spots that have high dissolved methane also usually have low dissolved oxygen, and these are places that fish like Arctic Char will avoid. Also, human impacts like sewage disposal in Cambridge Bay may affect greenhouse gases in the ocean. We are committed to working with the HTO and other stakeholders to make our research relevant.

2022 Activities

Sample Collection Dates: Apr 26 – Jul. 24, 2022

Locations: Cambridge Bay and Surrounding Areas.

Weather Station Operations: May 15 – Dec. 31, 2022

Locations: Halokvik River (30 Mile), Melbourne Island, Finlayson Islands

Weather Stations

Normally, we have three weather stations working near Cambridge Bay (see photos and map below). The big weather station was damaged by ice in spring 2019, and was repaired in 2021. The Melbourne Island weather station was repaired in 2021, and the Halokvik River weather station was repaired this year. The community weather stations measure air temperature, wind speed, wind direction, relative humidity, and pressure. They report every hour, and the data can be viewed at https://people.ucalgary.ca/~belse/Brent_Else/WX.html and at <http://siku.org>. At the Qikirtarjuk Island station, we also measure incoming energy (from the sun and atmosphere), and carbon dioxide in the atmosphere.

Ice and Seawater Measurements

In most years we collect seawater, freshwater, and sea ice samples, to help us understand how the atmosphere interacts with water or ice surfaces. They are also used to study how water moves through the landscape and into the ocean. Water and ice samples are preserved and shipped back to our laboratory at the University of Calgary, where we analyze them for salinity, pH, CO₂, CH₄, and isotopic composition. At each of our water collection locations, we typically measure ice thickness, snow depth (in the winter), water temperature, salinity, dissolved oxygen, and chlorophyll-*a* content.

In 2022 seawater and sea ice samples were collected at two stations: one just west of Cambridge Bay, and one near the Finlayson Islands (see map below). Between April 26 – Jun. 4 we stayed at CHARS and traveled to the sites by snowmobile. During this time, we installed (and then removed) instruments at the two sampling sites. These instruments measured under-ice currents, dissolved oxygen, salinity, temperature, and nutrients. Collaborators from Japan, Belgium, and Norway helped collect samples at these sites. In addition to our usual samples, these guests also collected measurements of sea ice algae, nutrients, and water samples to better understand sea ice ecosystems. The team from Environment Canada collected seawater samples for their Northern Contaminants Program project. Between Jun. 4 – Jul. 4 we set up a camp at Qikirtarjuk Island where we operated the weather station and continued our usual measurements in sea ice and seawater around the island. We hired guides from the HTO and several local field assistants to help with this work, and to keep everyone safe.

Estuary and River Measurements

In 2022, our collaborators from the USA measured greenhouse gases in Greiner Lake, Freshwater Creek, the Freshwater Creek estuary (Cambridge Bay) and 5 surrounding

ponds over a three week period when the ice thawed and broke up using the JetYak and a suite of sensors. We are able to compare surface waters to waters up to 10 m deep. In addition to the JetYak sensors, water samples were collected. These measurements are helping us to compare the greenhouse gas emissions from the different types of water bodies. A drone was used to image ice change. The team from USA did about 5 classroom visits and hosted a community event at CHARS to explain their research.

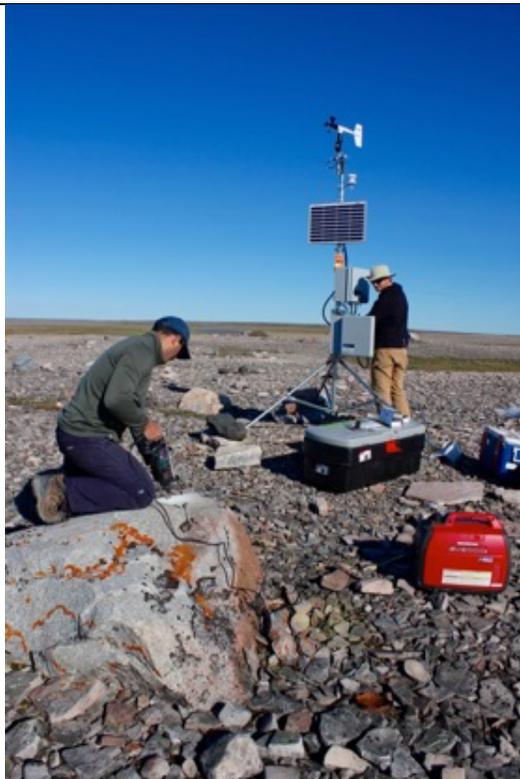
River and Lake Measurements

Surface water samples were collected at 22 locations in the Greiner Lake watershed during the ice-free season. Between July 7-24, we stayed at CHARS and travelled via ATV, collecting 30mL water samples from each of the sites, accompanied by a local field assistant. For the remainder of the season until freeze-up, samples were collected on a weekly basis by local team members. These samples were then tested for stable isotopes to better understand the storage and flow pathways of water sources in the Greiner Lake watershed.

Photos and Maps Illustrating 2022 Activities:



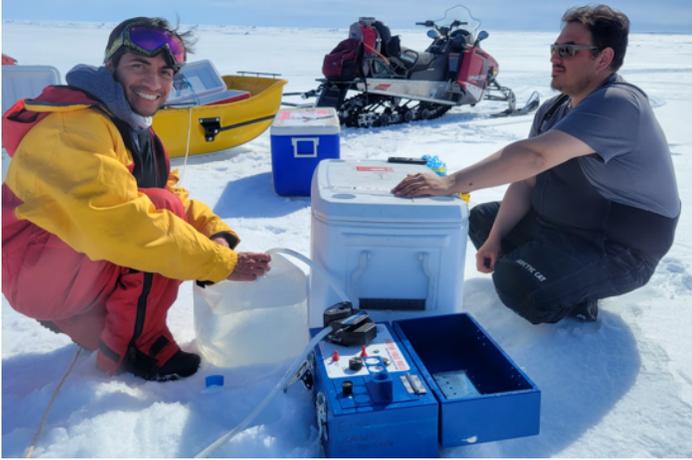
Map of weather station locations, and location of ice and sea water sampling stations.



The weather station at 30 Mile. A similar weather station is located at Melbourne Island.



The weather station at Qikirtaarjuk Island after being repaired.



Collecting seawater on the ice.



Tent holding the instruments that were deployed on the ice for about 1 month.



A picture of the camp at Qikirtaarjuk Island.



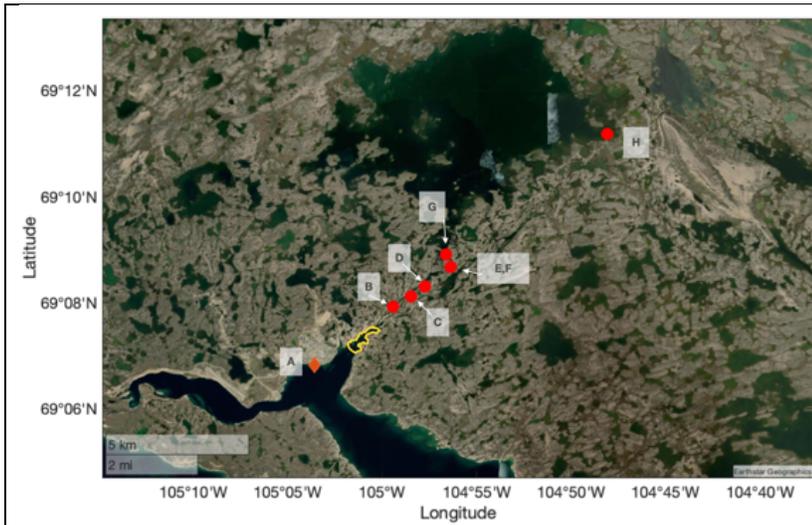
Collecting sea ice samples.



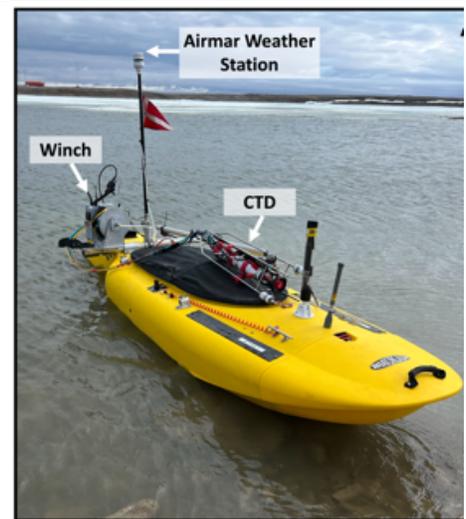
Team members from Japan & Cambridge Bay



Getting ready at CHARS



A map of where samples were collected as part of the JetYak sampling program during spring break-up.



Photograph of the JetYak sampling program.



A map of where freshwater samples were collected during summer open water. Yellow indicates weekly, blue monthly, and red once.



Photograph of the freshwater sampling program.

Planned Activities for 2022-2023

Team Members:

Brent Else (Associate Professor, Project Leader, University of Calgary)
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Christina Braybrook (Graduate Student, University of Calgary)
Nicole Johnson (Undergraduate Student, University of Calgary)
Elise Imbeau (Research Assistant, Cambridge Bay)
Gabriel Ferland (Research Assitant, Cambridge Bay)
Brendan Langan (Research Assistant, Cambridge Bay)

Planned Activities for 2023: We hope to be able to do more research near Cambridge Bay this spring. Most activities are similar to what we have done in the past.

1. Weather Stations

In the coming year, we will visit the three weather stations near Cambridge Bay for repairs. We will hire at least one more Cambridge Bay resident to help with the weather stations throughout the year. The pandemic made it difficult for us to discuss the future of this weather station project with the community, and to advertise the project. We have an outreach video (<https://vimeo.com/362146773>) that we will circulate on social media.

2. Sea Ice Sampling

In 2022, our focus will be on sea ice and seawater sampling near the weather station at the Finlayson Islands. Starting in May, we will travel by snowmobile to collect samples. Most of the sea ice samples will be melted and returned to our labs in the south for analysis of CO₂, salinity, dissolved oxygen, and nutrients. On sea ice, our disturbances will be small, only leaving auger holes (maximum 10"). We will not be carrying much chemicals, so the risk of a spill is low. We will take care with snowmobiles, and generators to minimize the risk of fuel or oil spills.

This sea ice project involves collaborators from other countries. The current plan for international researchers associated with this team is:

Country/Institution	Number of Participants
Japan (Hokkaido University)	4

These visiting scientists will stay at the Canadian High Arctic Research Station (CHARS). To ensure that this team is safe while we are traveling to the sea ice sites, we plan to hire one local field technician, and employ guides from the HTO.

3. Camp at Finlayson Islands

We will end the sea ice sampling project based out of CHARS in late May when melt ponds are forming. To continue collecting samples near the weather station in June and July, we plan to set up a camp at the Finlayson Islands. The camp will consist of one or two cooking tents, and several sleeping tents. We will continue sampling on the sea ice as long as the ice is thick enough, and then switch our sampling activities to a small boat.

The team for this camp will be small, consisting of only 2-3 scientists. We will hire people from Cambridge Bay to help with the camp, probably one research assistant and one guide. People and supplies will be moved back and forth from the island every two weeks by helicopter. When operating the helicopter we will fly high enough to avoid startling wildlife and disturbing campers. When planning our route from Cambridge Bay to Finlayson Islands we will avoid flying over any sensitive areas.

4. Winter Lake Sampling at Greiner and Kitigak

In 2019 and 2021, we collected lake water samples from beneath ice at many small lakes around Cambridge Bay. These samples were used mainly to measure dissolved gases like CO₂ and CH₄. In 2022, we would like to collect similar samples from Greiner and Kitigak Lake. We will travel to the lakes in May, use an ice fishing auger to make 10” holes, and then collect water samples. We will also use instruments to measure temperature, dissolved oxygen and other variables, and record snow and ice thickness. We would also like to use an underwater camera to try and take pictures of fish. We will share images of fish with the community. We could also share where we have drilled holes, in case community members want to use them for fishing. Our goal will be to collect samples in many different locations on both lakes, probably 20-30. Local research assistants and/or guides will be used for this activity.

5. Summer Freshwater Sampling

In summer, we will collect water samples from the banks of lakes/rivers, or from small boats. Our collaborators at the U of C (Dr. Stadnyk) and U of M (Dr. Brown) will be involved in water collection. For lakes and rivers, we will collect water by driving up to the shore, and then pumping water using a small pump. Like our ocean sampling, lake and river sampling will have minimal impacts. We will continue to be careful to avoid spills. In addition to working in the Greiner Lake watershed, we also would like to collect samples from the Fergusun Lake watershed, and the Kitikga Lake watershed.

6. Summer Ocean Sampling

It is currently uncertain whether the R/V *Martin Bergmann* will be able to sail out of Cambridge Bay this summer. If it is possible, we will use that ship to collect samples for CH₄, CO₂, oxygen, temperature, and salinity. We will also use our “underway system” to measure pH, CO₂, salinity, and water temperature while the ship is travelling. We will visit our usual sampling locations, which are shown in a map below. We usually hire one community member to help with the sampling.

7. JetYak (remote controlled research boat)

In 2018 and 2022, we worked with some researchers from the United States (Dr. Anna Michel, Woods Hole Oceanographic Institution) who operated a remotely controlled kayak near Cambridge Bay. The kayak makes measurements of CO₂, CH₄, temperature, and salinity as it drives around. These researchers would like to use the JetYak again during the ice breakup time next spring. The JetYak is powered by a gasoline engine, so we will be careful to make sure no fuel spills occur. Otherwise, this is unlikely to have any impacts on the environment. The JetYak will be used in the river plume area that opens up near Freshwater Creek when it first starts running in June. We are also interested in using it in Freshwater Creek and Greiner Lake. We may fly a small drone to collect images over Freshwater Creek and Greiner Lake. The current plan for international researchers associated with this team is:

Country/Institution	Number of Participants
USA (Woods Hole Oceanographic)	5

8. Outreach Activity/Knowledge Co-Generation Session

We plan to host a knowledge sharing session where members of our research team and a group of community members look at scientific data collected in Greiner Lake, Freshwater Creek, and the coastal ocean in Cambridge Bay and work together to make interpretations based on the results. Research results will be presented using maps and images and the session will allow discussion and annotation of the maps and images to make changes, improvements, or additions based on local knowledge and views. The session may also be used to propose new study sites or research activities based on community priorities. The outcomes will be included in a PhD thesis and related academic publications and the participants in the session will be co-authors (if they wish) on the publications/products that arise from the session. We received ethics approval for this knowledge co-generation activity in the spring of 2020 (REB19-2110) and will work with the University ethics board to implement additional COVID risk mitigations and modifications.