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Polar Continental Shelf Program
SCIENCE REPORT 2019

LOGISTICAL SUPPORT FOR LEADING-EDGE SCIENTIFIC RESEARCH IN CANADA AND ITS ARCTIC

Canada

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Polar Continental Shelf Program Science Report 2019:
Logistical support for leading-edge scientific research in Canada and its Arctic

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Cover photographs: (Top) Ready to start fieldwork on Ward Hunt Island in Quttinirpaaq National Park, Nunavut
(Bottom) Heading back to camp after a day of sampling in the Qarlikturvik Valley on Bylot Island, Nunavut

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Akpas are excellent divers. They are termed pagophilic or "ice-loving" because they have adapted to living in or near ice floes year-round.

MINISTER'S MESSAGE

In Canada's Arctic, wonder and science co-exist in a breathtaking world of ancient traditions, natural beauty and new discoveries.

For more than 60 years, the Polar Continental Shelf Program (PSCP) at Natural Resources Canada has supported leading-edge research that is unlocking the mysteries of Canada's North and supporting Arctic sovereignty. The Government of Canada recognizes this program's essential contributions and the growing demand for its services, which is why it is mentioned in my mandate letter.

In 2019, the PCSP supported 168 Arctic projects, which drew more than 950 participants from various levels of government, as well as dozens of universities and organizations in Canada and abroad.

The PCSP provided essential logistical support for each of those projects, ensuring that the research teams could focus on their important work without worrying about the challenges of working in remote and sometimes difficult landscapes. Northern residents also play important roles in Arctic research, leading and providing guidance on many projects each year.

The PCSP provides another opportunity to collaborate with northern and Indigenous communities to learn more about the wonders of Canada's Arctic and protect it from the effects of climate change. All of this matters because Canadians want to know that the decisions we make as a polar nation are informed by the latest science and are in the best interests of Northerners. This includes the Arctic and Northern Policy Framework, which addresses important northern priorities—from the impact of a changing climate to issues around the sustainable development of the region's vast, untapped resources.

During the COVID-19 pandemic, the importance of Canada's resource sectors – to our national economy, our natural environment and our everyday lives – has been magnified even further. The very best qualities of the PCSP have been demonstrated through its contributions in helping people get home at the beginning of the crisis and using its network of expertise throughout the government's response.

I hope this report will help you to learn more about what the PCSP does and the research it supports, as well as the Government of Canada's commitment to help build a prosperous and sustainable North — for generations to come.

The Honourable Seamus O'Regan
Canada's Minister of Natural Resources

A Twin Otter flies over a radio antenna at Axel Heiberg Island, Nunavut.

ᒥᓂᔅᑕᐅᑉ ᑐᓴᒐᔅᓴᖓ: PCSP ᓱᓇᒃᑯᑖᓂᒃ ᖃᐅᔨᓴᕐᓂᕐᒧᑦ ᐅᓂᒃᑲᓕᐊᑦ 2019

ᑲᓇᑕᐅᑉ ᐅᑭᐅᖅᑕᖅᑐᖓᓂ ᐊᒻᒪᓗ ᓱᓇᒃᑯᑖᓂᒃ ᖃᐅᔨᓴᕐᓂᖅ ᐃᑲᔪᖅᑕᐅᓂᒃᑯᑦ-ᓴᖅᑭᓯᒪᔪᖅ ᐱᐅᔪᒻᒪᕆᐊᓗᒃ ᓯᓚᕐᔪᐊᒥ ᐃᑦᑕᕐᓂᑕᐃᑦ, ᓄᓇᐅᑉ ᐱᐅᓂᖓ ᐊᒻᒪᓗ ᓄᑖᑦ ᕿᒥᕐᕈᐊᕐᓂᖅ.

ᐅᑭᐅᑦ 60 ᐅᖓᑖᓂ, ᐅᑭᐅᖅᑕᖅᑐᖅ ᓄᓇᖓ ᑮᓪᓕᖓ ᐱᓕᕆᐊᔅᓴᖅ (PSCP) ᓄᓇᒥᙶᖅᑐᓂᒃ ᐊᑐᐃᓐᓇᐅᔪᔅᓴᐃᑦ ᑲᓇᑕ ᐃᑲᔪᖅᓯᒪᔪᑦ ᐊᐅᓚᑦᑎᓪᓗᑎᒃ-ᑮᓪᓕᐊ ᓱᓇᒃᑯᑖᓂᒃ ᖃᐅᔨᓴᕐᓂᖅ ᐊᓄᓪᓇᐃᖅᓯᒪᔪᑦ ᖃᐅᔨᒪᔭᐅᙱᑦᑐᓂᒃ ᑲᓇᑕᐅᑉ ᐅᑭᐅᖅᑕᖅᑐᖓᓂ ᐊᒻᒪᓗ ᐃᑲᔪᖅᑐᑎᒃ ᐅᑭᐅᖅᑕᖅᑐᑉ ᐱᔪᓐᓇᐅᑎᖏᓐᓄᑦ. ᒐᕙᒪᑦ ᑲᓇᑕ ᐃᓕᑕᖅᓯᒪᔪᑦ ᑖᔅᓱᒪ ᐱᓕᕆᐊᔅᓴᖓᓄᑦ ᐃᑲᔫᓯᐊᔪᓐᓇᐅᔪᑦ ᐊᒻᒪᓗ ᐱᕈᖅᐸᓪᓕᐊᓂᖓ ᐱᔨᑦᑎᕋᐅᑎᖏᓐᓄᑦ, ᑕᐃᒫᒃ ᐅᖃᐅᓯᕆᔭᐅᓯᒪᔪᑦ ᐱᓕᕆᐊᔅᓴᓄᑦ ᑎᑎᖅᑲᖓᓂ.

ᐊᕐᕌᓂ 2019, ᐅᑭᐅᖅᑕᖅᑐᖅ ᓄᓇᖓ ᑮᓪᓕᖓ ᐱᓕᕆᐊᔅᓴᖅ ᐃᑲᔪᖅᓯᒪᔪᑦ 168 ᐅᑭᐅᖅᑕᖅᑐᒥ ᐱᓕᕆᐊᔅᓴᓄᑦ, ᐃᓚᒋᔭᐅᓯᒪᔪᑦ 950 ᐅᖓᑖᓂ ᐊᔾᔨᒌᙱᑦᑐᒃᑯᑦ ᒐᕙᒪᓕᕆᔨᓂᑦ, ᐊᒻᒪᓗ ᖁᓕᓪᓗ ᒪᕐᕉᒃ ᐅᖓᑖᓂ ᓯᓚᑦᑐᖅᓴᕐᕖᑦ ᐊᒻᒪᓗ ᑲᑐᔾᔨᖃᑎᒌᖑᔪᑦ ᑲᓇᑕᒥ ᐊᒻᒪᓗ ᑲᓇᑕᐅᑉ ᓯᓚᑖᓂ.

ᐅᑭᐅᖅᑕᖅᑐᖅ ᓄᓇᖓ ᑮᓪᓕᖓ ᐱᓕᕆᐊᔅᓴᖅ ᐃᑲᔪᖅᓯᒪᔪᑦ ᑕᐃᒪᐅᓪᓚᕆᓐᓂᒃᑯᑦ ᐱᓕᕆᐊᔅᓴᕆᔭᐅᔪᓕᒫᓄᑦ, ᓇᓗᓇᐃᔭᑦᑎᐊᖅᑐᑎᒃ ᓱᓇᒃᑯᑖᓂᒃ ᖃᐅᔨᓴᕐᓂᖅ ᐃᖅᑲᓇᐃᔭᖅᑎᖏᑦ ᑲᒪᑦᑎᐊᕐᓂᐊᕐᓗᑎᒃ ᐱᓕᕆᐊᔅᓴᖏᓐᓄᑦ ᐃᓱᒫᓗᑎᖃᙱᓪᓗᑎᒃ ᐊᒃᓱᕈᕐᓇᖅᑐᓄᑦ ᐃᖅᑲᓇᐃᔾᔪᓂ ᐅᖓᓯᑦᑐᒥ ᐊᒻᒪᓗ ᐃᓛᓐᓂᒃᑯᑦ ᐊᒃᓱᕈᕐᓇᖅᑐᑦ ᓄᓇᖏᑦ. ᐅᑭᐅᖅᑕᖅᑐᒥᐅᑕᐃᑦ ᑲᒪᒋᔭᕐᖃᖅᑐᑦ ᐱᒻᒪᕆᐅᔪᒥᑦ ᐅᑭᐅᖅᑕᖅᑐᒥ ᖃᐅᔨᓴᕐᓂᕐᒧᑦ ᐊᐅᓚᑦᑎᓂᖅ ᐊᒻᒪᓗ ᐃᑲᔪᖅᓯᔨᐅᓪᓗᑎᒃ ᐊᒥᓱᓄᑦ ᐱᓕᕆᐊᔅᓴᓄᑦ ᐅᑭᐅᑕᒫᑦᓴ.

ᐅᑭᐅᖅᑕᖅᑐᖅ ᓄᓇᖓ ᑮᓪᓕᖓ ᐱᓕᕆᐊᔅᓴᖅ ᑐᓂᓯᔪᑦ ᐊᓯᐊᓂᒃ ᐃᓱᐊᕈᕈᑎᔅᓴᓂᒃ ᐃᑲᔪᖅᑎᓯᔪᓐᓇᕐᓗᑎᒃ ᐅᑭᐅᖅᑕᖅᑐᒥᐅᑕᓄᑦ ᐊᒻᒪᓗ ᓄᓇᖃᖅᑳᖅᓯᒪᔪᓄᑦ ᓄᓇᓕᓐᓄᑦ ᐃᓕᓐᓂᐊᕐᓗᑎᒃ ᑲᓇᑕᐅᑉ ᐅᑭᐅᖅᑕᖅᑐᖓᓂ ᐊᒻᒪᓗ ᓴᐳᒻᒥᓗᒍ ᐱᕙᓪᓕᐊᔪᓄᑦ ᓯᓚᐅᑉ ᐊᓯᙳᖅᐸᓪᓕᐊᓂᖓᓄᑦ. ᑕᒪᓐᓇ ᐱᔾᔪᑎᒋᔭᖅᑐᑦ ᑲᓇᑕᒥᐅᑕᐃᑦ ᖃᐅᔨᒪᔪᒪᓂᕆᓐᓂᓄᑦ ᐃᓱᒪᒃᓴᖅᓯᐅᖅᑕᐅᔪᓄᑦ ᐅᑭᐅᖅᑕᖅᑐᒥ ᓄᓇᖓᓄᑦ ᖃᐅᔨᑎᑕᐅᓯᒪᔪᑦ/ᓇᓗᓇᐃᔭᐃᖅᓯᒪᔪᑦ ᑭᖑᓪᓕᖅᐹᖓᑕ ᓱᓇᒃᑯᑖᓂᒃ ᖃᐅᔨᓴᕐᓂᕐᒧᑦ ᐊᒻᒪᓗ ᐱᐅᓂᖅᐹᒃᑯᑦ ᐱᔪᒪᔭᕆᑎᒍᑦ ᐅᑭᐅᖅᑕᖅᑐᒥᐅᑕᓄᑦ. ᑕᒪᓐᓇ ᐃᓚᒋᔭᖅᑐᑦ ᐅᑭᐅᖅᑕᖅᑐᒥ ᐊᒻᒪᓗ ᐅᑭᐅᖅᑕᖅᑐᖅ ᐊᑐᐊᒐᓄᑦ ᐱᓕᕆᐊᔅᓴᓄᑦ, ᐱᒻᒪᕆᐅᔪᓂᒃ ᓯᕗᓪᓕᐅᑎᑕᐅᔭᕆᐊᖃᖅᑐᓂᒃ-ᐱᕙᓪᓕᐊᔪᓂᑦ ᓯᓚᐅᑉ ᐊᓯᙳᖅᐸᓪᓕᐊᓂᖓᓄᑦ ᐊᑲᐅᙱᑦᑕᐅᑎᑉᐳᑕᐅᔪᓄᑦ ᐊᑲᐅᓈᕈᓐᓇᕐᓂᕐᒧᑦ ᐱᕙᓪᓕᐊᓂᖅ ᓄᓇᐅᑉ ᓄᓇᕐᔪᐊᖓ, ᐊᑦᑐᖅᑕᐅᓯᒪᙱᑦᑐᑦ ᓄᓇᓂᙶᖅᓯᒪᔪᓂᑦ.

ᐳᕕᑎᓐᓇᖅᑐᐊᓗᒃ ᓄᕙᒡᔪᐊᕐᓂᖅ-19, ᐱᒻᒪᕆᐅᓂᖓ ᑲᓇᑕᐅᑉ ᓄᓇᓂᙶᖅᑕᓂᒃ ᐃᑲᔪᖅᓯᔾᔭᑦ-ᑲᓇᑕᕗᑦ ᑮᓇᐅᔭᓕᐅᕐᓂᕆᔭᐅᔪᓄᑦ, ᐊᕙᑎᑦᑎᓂᙶᖅᑐᓯᒪᔪᑦ ᐊᒻᒪᓗ ᐅᓪᓗᑕᒫᑦ ᐃᓅᓂᕐᒧᑦ-ᖃᐅᔨᓴᐅᒃᑲᓐᓂᖅᓯᒪᓕᖅᑐᑦ ᐅᖓᑖᓄᑦ. ᐱᒻᒪᕆᐅᓂᖅᐸᑦ ᓱᓇᐅᓂᖓᑦ ᐅᑭᐅᖅᑕᖅᑐᖅ ᓄᓇᖓ ᑮᓪᓕᖓ ᐱᓕᕆᐊᔅᓴᖅ (PCSP) ᐊᑐᖅᑕᐅᓂᖓᑦ ᐃᑲᔫᓯᐊᓂᒃᑯᑦ ᐃᓄᓐᓂᑦ ᐊᖏᕋᖅᑎᑕᐅᓗᑎᒃ ᐋᓂᐊᕐᓇᖅᑎᓪᓗᒍ ᐊᒻᒪᓗ ᐊᑐᖅᑐᑎᒃ ᖃᐅᔨᒪᔨᒻᒪᑎᓂᒃᑯᑦ ᒐᕙᒪᐅᑉ ᑭᐅᔪᑎᔅᓴᖏᓐᓄᑦ.

ᐃᓱᒪᒍᖓ ᑖᓐᓇ ᐅᓂᒃᑳᓕᐊᖅ ᐃᑲᔪᕐᓂᐊᕐᓗᓂ ᐃᓕᓐᓂᒃ ᐃᓕᓐᓂᐊᕐᓗᑎᑦ ᓱᓕᓂᓲᖑᓂᖏᑦ ᐅᑭᐅᖅᑕᖅᑐᖅ ᓄᓇᖓ ᑮᓪᓕᖓ ᐱᓕᕆᐊᔅᓴᖅ ᐊᒻᒪᓗ ᓱᓇᒃᑯᑖᓂᒃ ᖃᐅᔨᓴᕐᓂᕐᒧᑦ ᐃᑲᔪᓯᐊᖏᓐᓄᑦ, ᐊᒻᒪᓗ ᒐᕙᒪᑦ ᑲᓇᑕ ᐱᔪᒪᔭᖏᓐᓄᑦ ᐃᑲᔪᕐᓂᐊᕐᓗᑎᒃ ᐱᕈᖅᐸᓪᓕᐊᓂᖅ ᐊᑭᓱᐃᑎᒃᑯᑦ ᐊᒻᒪᓗ ᐊᑲᐅᓈᕐᓂᖅ ᐅᑭᐅᖅᑕᖅᑐᖅ-ᓯᕗᓪᓖᓕᕆᓂᐊᖅᑕᖅᑎᓐᓄᑦ.

ᐅᐱᓐᓇᖅᑐᖅ ᓲᒪᔅ ᐆ'ᕋᐃᔭᓐ
ᑲᓇᑕᐅᑉ ᒥᓂᔅᑕ ᓄᓇᓂᙶᖅᓯᒪᔪᓂᑦ ᐊᑐᐃᓐᓇᐅᔪᔅᓴᐃᑦ

The Honourable Seamus O’Regan
Canada’s Minister of Natural Resources

ᐅᐱᓐᓇᖅᑐᖅ ᓲᒪᔅ ᐆ'ᕋᐃᔭᓐ
ᑲᓇᑕᐅᑉ ᒥᓂᔅᑕ ᓄᓇᓂᙶᖅᓯᒪᔪᓂᑦ ᐊᑐᐃᓐᓇᐅᔪᔅᓴᐃᑦ

POLAR CONTINENTAL SHELF PROGRAM

A differential global positioning system is used for a field survey at Grizzly Creek camp, Kluane National Park and Reserve, Yukon.

A research station on Ward Hunt Island in Quttinirpaaq National Park, Nunavut

The Polar Continental Shelf Program (PCSP) has supported scientific research in Canada's North since 1958. This research has helped to lift the veil on the Arctic's resource potential. It has helped us better understand the effects of climate change in the region and beyond. It has also given us clues on how to protect Arctic environments and communities.

The North is experiencing rapid environmental change. With this change come new risks and opportunities. Continued research is needed to help us better understand these changes as they emerge. The support that the PCSP provides ensures this essential research continues.

Today, the PCSP remains the fieldwork logistics provider for the Government of Canada. In 2019, the PCSP provided support to scientific research projects across Canada, with the majority located in the Arctic. These projects are led by a variety of institutions, including:

- Canadian governments (federal, territorial and provincial)
- Canadian universities
- Northern organizations and colleges (including territorial and Indigenous governments)
- International research groups

The PCSP also supports activities each year for government operations. These operations include the maintenance of national parks and remote weather stations. For over a decade, the PCSP has helped Indigenous groups travel to remote and culturally significant locations, where they have shared knowledge of their lands, histories and cultures.

The Canadian North is a vast region where transportation costs are high. Getting to remote areas can be cost-prohibitive and dangerous. To get there, many researchers depend on the PCSP's safe, efficient, and cost-effective logistics services. These include:

- Coordinating air transportation to remote field sites
- Providing fuel for aircraft and field camps
- Lending field equipment
- Accommodations in Resolute, Nunavut
- Communications and safety networks across the Arctic
- Logistics advice for field studies in Canada

BREAKDOWN OF PCSP-SUPPORTED PROJECTS IN 2019

Sampling vegetation on Bylot Island, Nunavut

HIGHLIGHTS OF THE 2019 FIELD SEASON

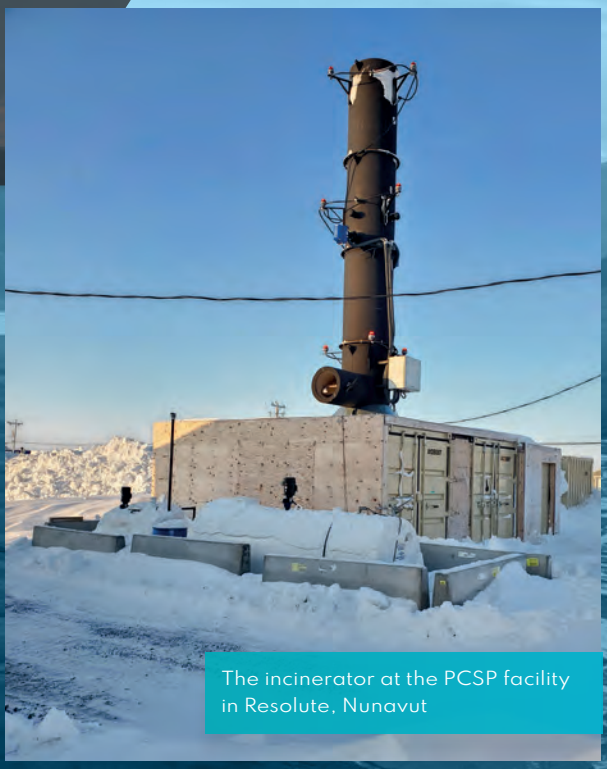
Conducting a field survey of a debris-covered glacier at Grizzly Creek, Kluane National Park and Reserve, Yukon

A NEW PCSP INITIATIVE FOR WASTE MANAGEMENT IN RESOLUTE

Waste management is a challenge for most small Arctic communities because there are fewer resources and less infrastructure than in other parts of Canada. In most communities, waste is collected and burned in landfills. The landfills attract polar bears and other wildlife in search of food. Runoff from these landfills can also contaminate the local area. This situation is not safe for local residents and nor healthful for wildlife.

In 2019, the PCSP began a waste management initiative by installing and testing an incinerator at the PCSP facility in Resolute, Nunavut. This is an environmentally responsible and cost-effective method of waste management. The incinerator is similar to a big oven with two chambers. The first chamber burns the waste, and the second chamber burns the exhaust and gasses from the main chamber, thereby reducing the emissions produced by the unit. In addition, the new incinerator makes use of older, expired fuel that is no longer suitable for aircraft use.

A pilot project is planned for spring 2020 to use the incinerator to burn organic waste from the community of Resolute.



The incinerator at the PCSP facility in Resolute, Nunavut

TUKTOYAKTUK SCIENCE DAY 2019

On August 1, 2019, the PCSP participated in the Tuktoyaktuk Science Day. The event brought together more than 200 participants, including community members from Tuktoyaktuk, Aklavik, and Inuvik, and scientists from federal and territorial governments and universities. The PCSP has had a strong presence in the western Canadian Arctic for many years. The PCSP supports many science projects in the area by providing aircraft coordination and field equipment. In 2019, more than 35% of PCSP-supported Arctic projects took place in the Northwest Territories and Yukon, accounting for more than 1,400 hours of PCSP-chartered aircraft flying time.

Community members have a strong interest in the science that takes place in the region. They are witnessing changes in permafrost conditions and coastal erosion firsthand. Science Day was an excellent opportunity for scientists and community members to engage with one another. Hands-on activities were set up for children and youth, and scientific posters and videos were showcased. Tuktoyaktuk Science Day allowed the community to inform the scientists of the needs of Northerners, helping to influence the focus of future research.

Merven Gruben, Mayor of Tuktoyaktuk (left) and Scott Dallimore, Geological Survey of Canada (right), two organizers of the 2019 Tuktoyaktuk Science Day in Tuktoyaktuk, Northwest Territories

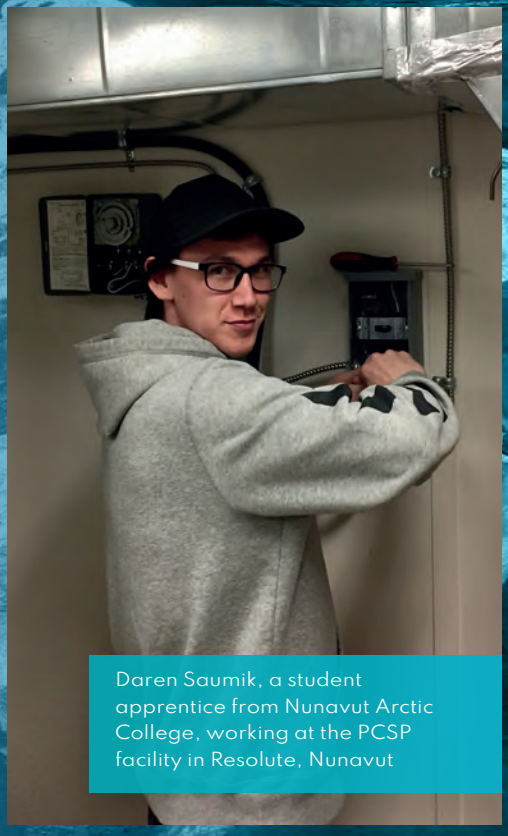
Axel Heiberg Island, Nunavut

SPOTLIGHT: STUDENT APPRENTICE

In 2019, the PCSP hired Daren Saumik, a student apprentice from the Nunavut Arctic College who is training to be an electrician. Daren worked on plumbing, heating, electrical and general maintenance at the PCSP facility in Resolute, Nunavut.

This opportunity arose after a PCSP visit to the college's trade school in Rankin Inlet, Nunavut. The visit was an important step in the PCSP's efforts to recruit and train more Inuit.

Daren quickly became a valued team member. He was eager to learn and never hesitated to get his "hands dirty." The experience he gained while working at the PCSP will bring him closer to achieving his career goals.



Daren Saumik, a student apprentice from Nunavut Arctic College, working at the PCSP facility in Resolute, Nunavut

DID YOU KNOW?

Because of the remoteness of the Canadian Arctic and its minimal infrastructure, the PCSP has developed unique expertise to operate in this environment and provide logistics services for remote field camps. One of these services is managing fuel cache sites – strategic fuel delivery and storage locations across the region. These sites allow the PCSP-contracted aircraft to safely land and refuel before continuing on to their remote destinations. During the 2019 season, the PCSP implemented a life-cycle management project for fuel drums. This initiative will improve the overall management of fuel cache locations, better serve future clients, and contribute to a cleaner Arctic environment.

Refueling a Twin Otter in Eureka on Ellesmere Island, Nunavut

In 2019, the PCSP set up a new food contract with the Tudjaat Co-op in Resolute, Nunavut. The Tudjaat Co-op is a co-operative business owned by members of the community. The new contract ensures that the kitchen at the PCSP facility in Resolute gets fresh stock every week – but it also helps the local community and economy.

The contract has brought in new sales at the Tudjaat Co-op. The revenue earned on these sales help to cover the operating costs of the Co-op and reduce the financial burden on its members.

Increases in supply flights also give the Tudjaat Co-op more opportunities to bring in fresh food. This helps improve the quality and variety of food available at the Co-op store and helps reduce food waste. Increased supply flights also provide more delivery options for Resolute and the nearby communities of Kugaaruk, Arctic Bay, and Pond Inlet.

Tudjaat Co-op in Resolute, Nunavut

HIGHLIGHTS OF THE 2019 FIELD SEASON

39%
Percentage of **Arctic projects** that transited through the PCSP Resolute facility

168
Arctic science and **operations projects** supported

953
Participants in all Arctic science and operations projects

64
Aircraft under contract

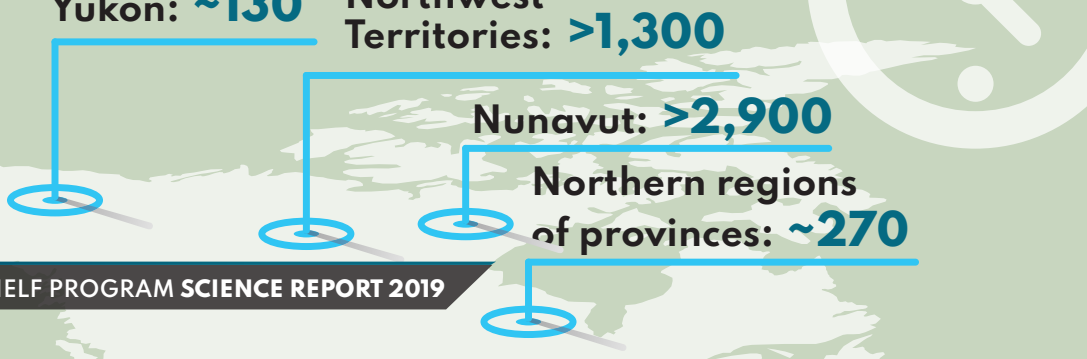
Chartered aircraft hours flown

4,650
(the equivalent of almost **6 months** of non-stop flying)

July
(>1,800 hours)
Month with the **most flying**

$10.6 million
Total value of aircraft hours flown

Flight hours by territory



July
(127 researchers)

Month with the **most researchers** staying at the Resolute facility

53
Federal projects using PCSP **field equipment** across Canada

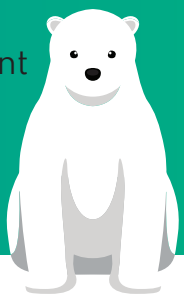
457
Field equipment transactions completed by the PCSP Ottawa and Resolute depots

41,699
Meals served at the PCSP Resolute facility

(the equivalent of **three meals a day** for one person for **38 years**)

499,803 kg
Weight of equipment and fuel shipped by sea

(the equivalent in weight to **1,000 adult male polar bears**)



13,546
Nights of accommodation provided at the PCSP Resolute facility

(the equivalent of more than **37 years of nights** of sleep for one person)

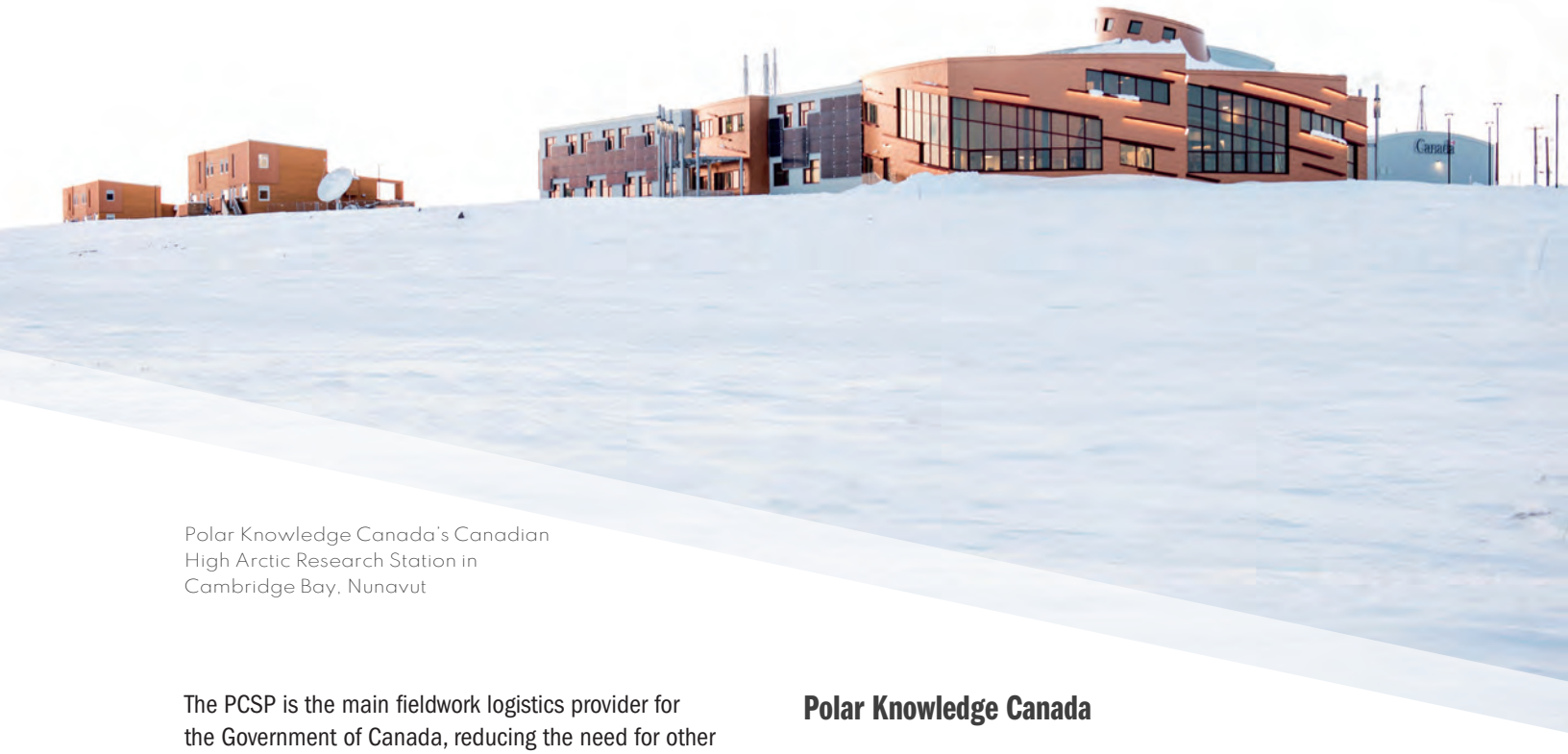
-41°C
on January 11

Coldest day in Resolute in 2019

16°C
on July 26

Warmest day in Resolute in 2019

PCSP PARTNERS



Polar Knowledge Canada's Canadian High Arctic Research Station in Cambridge Bay, Nunavut

The PCSP is the main fieldwork logistics provider for the Government of Canada, reducing the need for other departments or agencies to duplicate this service. This arrangement saves money for government departments and agencies that conduct research or operations across Canada, especially in the Arctic.

Over the years, the PCSP has collaborated with many organizations. These collaborations have helped the PCSP sustain support for science in Canada's North. In 2019, the PCSP collaborated with partners such as:

- Polar Knowledge Canada (POLAR)
- Canada's Department of National Defence (DND)
- ArcticNet
- The W. Garfield Weston Foundation

Polar Knowledge Canada

POLAR is a government agency that runs the Canadian High Arctic Research Station (CHARS) in Cambridge Bay, Nunavut. From CHARS, POLAR conducts and supports scientific research to improve economic opportunities, environmental stewardship, and the quality of life of residents in the Arctic.

In addition to conducting its own research, POLAR also provides funding to Arctic researchers. Research supported by these funds focus on ecosystem monitoring, energy and infrastructure challenges, and effects of environmental change in the North.

The PCSP has an ongoing partnership with POLAR to support scientific activity across the Canadian Arctic. Through this partnership, the PCSP supports research funded by POLAR's Science and Technology Program. Support provided by POLAR helps the PCSP provide greater assistance to its clients – benefiting Arctic researchers across the country.

Department of National Defence

DND runs its Canadian Armed Forces Arctic Training Centre (CAFATC) at the PCSP facility in Resolute, Nunavut. The CAFATC runs training programs for military personnel from January to March in high Arctic environments. The CAFATC relies on the PCSP to coordinate logistics for these training missions.

The creation of the CAFATC in Resolute became a reality thanks to a 25-year partnership formed with the PCSP in 2010. The CAFATC expansion was completed in 2013, adding new accommodations and workspaces to the PCSP facility.

This partnership has brought many benefits to the PCSP and its clients. DND shares the costs of operating the facility, which include electricity, heating, maintenance and upkeep. As a result, the PCSP can focus more funding to support research in the Arctic. PCSP-supported researchers transiting through Resolute also benefit from upgraded accommodations and workspaces at the facility.

ArcticNet

ArcticNet is a large-scale research network that has received new funding from the Government of Canada to bring together Arctic researchers, Inuit organizations, northern communities and other partners. Its goal is to study the social, economic and environmental impacts of climate change and modernization in the coastal Canadian Arctic.

The PCSP and ArcticNet have collaborated since 2004. ArcticNet gives the PCSP additional funding to provide logistics support to researchers who participate in their program. This additional funding enables the PCSP to support more research projects across the Canadian Arctic.

The W. Garfield Weston Foundation

For three generations, The W. Garfield Weston Foundation has worked to enhance and enrich the lives of Canadians. With a focus on health and landscapes, the foundation aims to catalyze inquiry and innovation to bring about long-term change.

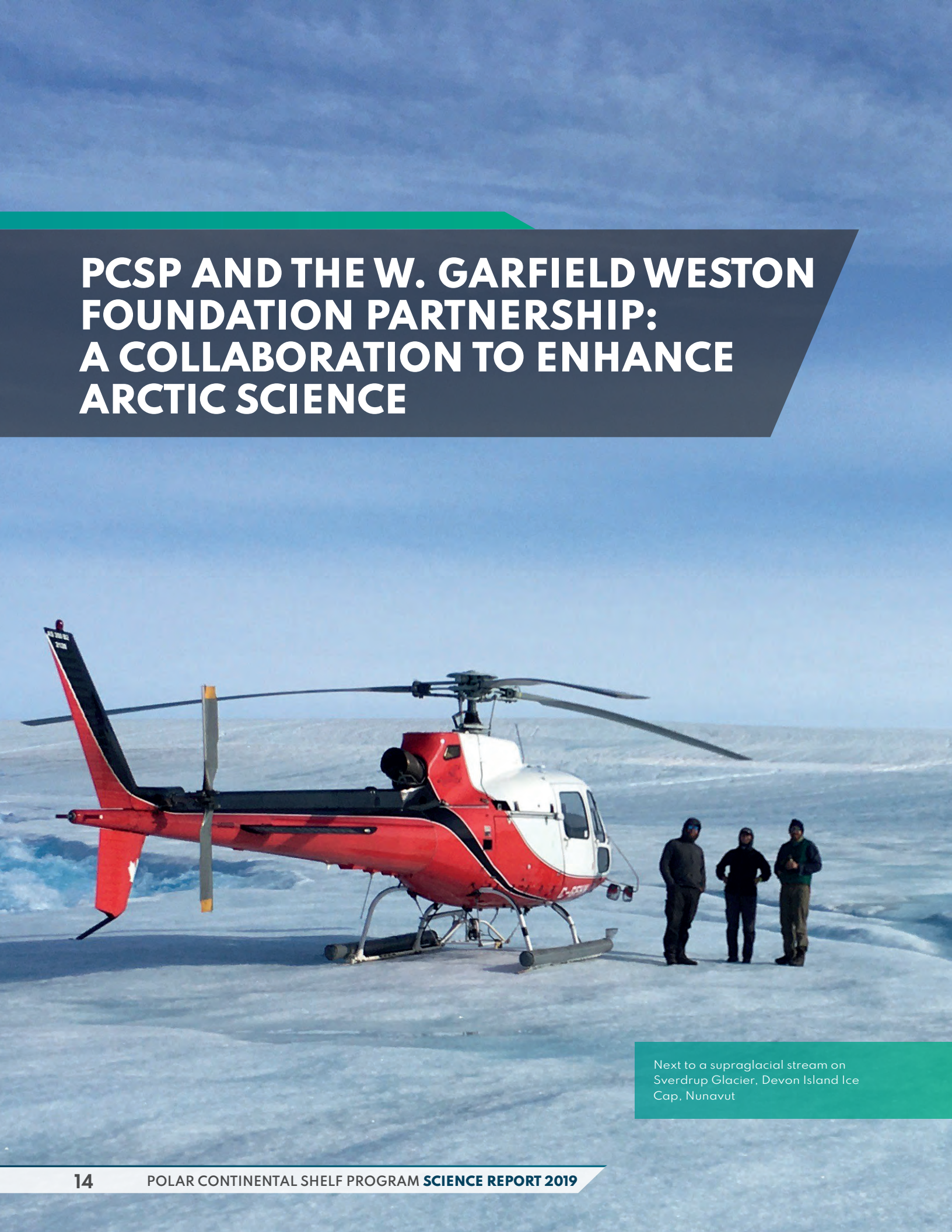
Through its Northern Committee, the foundation's support enables leading Canadian scientists to pursue scientific research in Canada's North. Since 2007, the foundation has dedicated $35 million in this capacity. The foundation has awarded more than 320 scholarships to graduate students and postdoctoral fellows from 27 universities.

In 2019, the PCSP collaborated with the foundation to reduce logistical and financial barriers to research in the Arctic. The foundation provided funding for the logistics costs of six Arctic science projects. This support helped researchers get to remote field sites across Canada's North to study important issues facing the region, such as climate change and environmental conservation.

See the following short summaries of the research projects supported through this partnership in 2019.

Members of the Canadian Armed Forces during Arctic field training near Resolute, Nunavut

PCSP AND THE W. GARFIELD WESTON FOUNDATION PARTNERSHIP: A COLLABORATION TO ENHANCE ARCTIC SCIENCE



Next to a supraglacial stream on Sverdrup Glacier, Devon Island Ice Cap, Nunavut

EXPLORING CLEANUP STRATEGIES FOR POTENTIAL FUEL AND OIL SPILLS IN THE NORTHWEST PASSAGE

Collecting water samples for chemical analysis from Resolute Bay, Nunavut

Supported through the PCSP and The W. Garfield Weston Foundation partnership

Lyle Whyte (McGill University)

Featured story locations on the map: 1

Global warming continues to cause sea ice loss in the Canadian high Arctic. As a result, maritime traffic is expected to increase along the Northwest Passage. This increase puts ecosystems at a higher risk of contamination from potential fuel and oil spills.

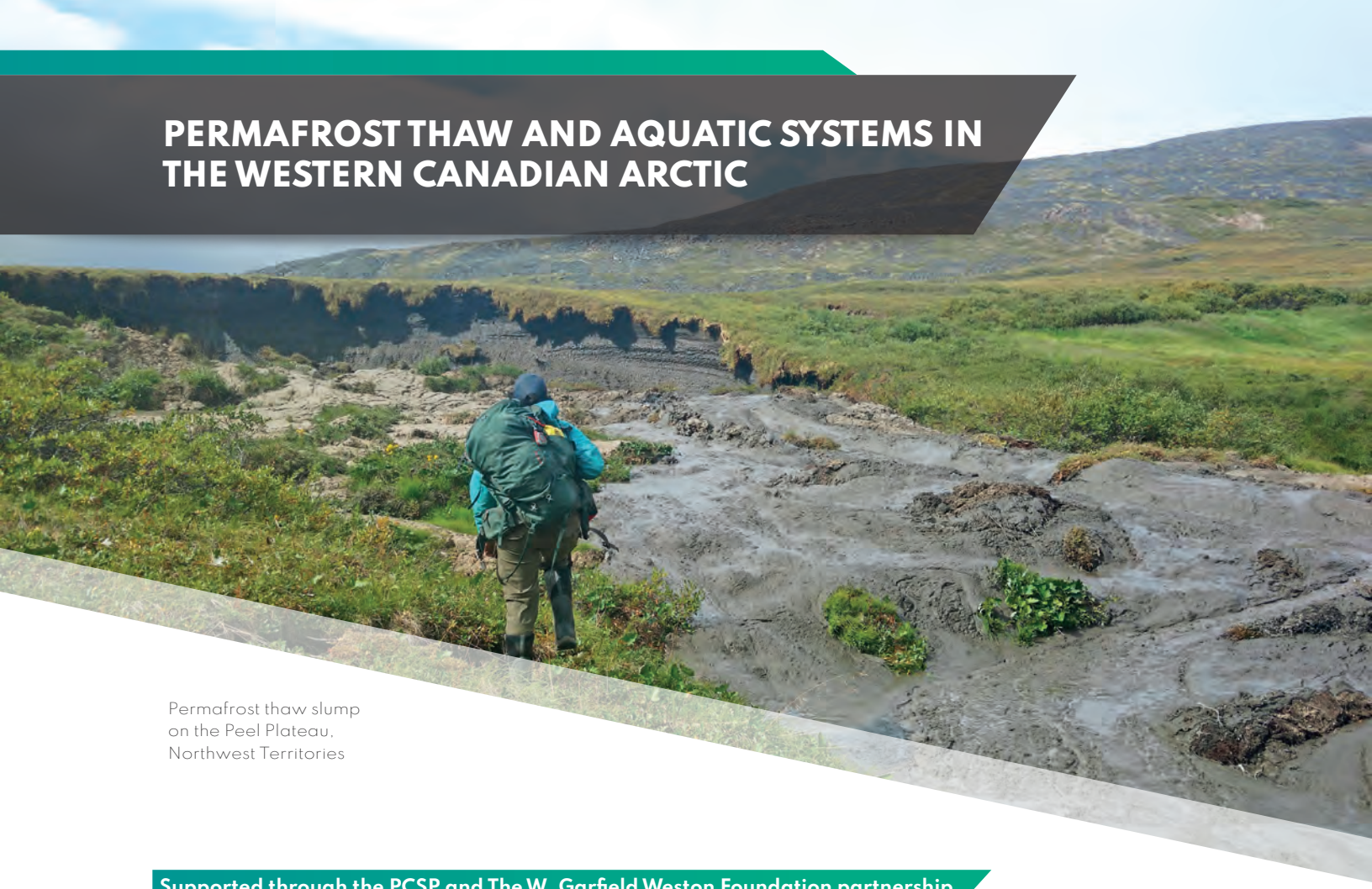
Microbial communities (groups of bacteria and fungi) can sometimes break down fuel and oil for food. Their ability to eat fuel or oil, and the speed at which they do it, depends on many factors. These factors include the type of fuel or oil and the availability of nutrients in the environment. Lyle Whyte's research aims to find out if microbial communities in beaches along the Northwest Passage could break down fuel or oil from spills.

In July 2019, Whyte and his team collected sediment samples from five beaches near Resolute, Nunavut. Their initial findings show that these beaches are poor in nutrients such as nitrogen and phosphorus. This insufficiency would likely limit the ability of microbes at these sites to clean up fuel and oil contamination.

Human intervention can help microbes break down fuel and oil faster. An example is the use of fertilizers on shorelines affected by the Exxon Valdez oil spill. Whyte is exploring whether these types of treatment would also work in high Arctic beaches. This research will provide strategies to reduce environmental damage in the event of future accidental fuel or oil spills in the Northwest Passage.

Collecting beach-sediment cores in Resolute Bay, Nunavut

PERMAFROST THAW AND AQUATIC SYSTEMS IN THE WESTERN CANADIAN ARCTIC



Permafrost thaw slump on the Peel Plateau, Northwest Territories

Supported through the PCSP and The W. Garfield Weston Foundation partnership

Suzanne Tank (University of Alberta)

Featured story location on the map: 2

Retrogressive thaw slumps are landslides that occur when ice-rich permafrost thaws. These slumps expose and transport large amounts of previously frozen ground downslope and into streams, rivers and lakes. The slumps can cause significant changes to the chemical and biological balance of aquatic systems.

Since 2014, Suzanne Tank and her team have worked on the Peel Plateau in the Northwest Territories where massive retrogressive thaw slumps are common. They target the Peel Plateau in particular because slumping in this region exposes deep, mineral-rich soils, which contrast with the organic-rich soils that have been the focus of study at many other sites.

They study the effects of permafrost thaw on the carbon cycle, including measuring the amount of carbon dioxide released into the atmosphere. They also investigate how slumping affects the transport of toxins, such as mercury, and nutrients, such as nitrogen and phosphorus, into aquatic systems. Among other results, they have observed an increase in mercury concentrations downstream from retrogressive thaw slumps.

Future work will include further study of the effects of permafrost thaw on the surrounding environment within the Peel Plateau and other contrasting regions.

EFFECTS OF PERMAFROST CHANGE IN THE HIGH ARCTIC

Surveying a 2007 permafrost disturbance to determine the long-term effects on land stability and water quality on Melville Island, Nunavut

Supported through the PCSP and The W. Garfield Weston Foundation partnership

Scott Lamoureux (Queen's University)

Featured story locations on the map: 3

Permafrost is ground that remains at or below 0°C for at least two years. Permafrost underlies most of the Canadian Arctic, and climate change is causing it to thaw.

Scott Lamoureux aims to understand how permafrost thaw affects land and water in the High Arctic. To achieve this goal, he and his team have conducted research for 17 years at the Cape Bounty Arctic Watershed Observatory on Melville Island, in Nunavut. Here, they study the local rivers, streams, lakes, soil, vegetation, and contaminants as well as carbon and methane emissions.

In 2019, Lamoureux and his team investigated the water quality of several lakes, rivers, and streams and sampled fish for contaminants. They also measured carbon exchanges between water and the atmosphere. Additionally, the team mapped vegetation productivity and zones of permafrost thaw.

Lamoureux hopes to learn more about the processes that affect the water and the land. He also hopes to use this knowledge for future research on watersheds near Resolute, Nunavut. In addition, Lamoureux will take part in the Terrestrial Multidisciplinary distributed Observatories for the Study of Arctic Connections (T-MOSAiC) program in 2020. Through this, he will join an international effort to improve our understanding of the effects of climate change on terrestrial and ocean environments.

SOLVING THE MYSTERIES OF ARCTIC MIGRATORY BIRDS

Preparing to release a tagged lesser golden-plover on Bylot Island, Nunavut

Supported through the PCSP and The W. Garfield Weston Foundation partnership

Joël Bêty (Université du Québec à Rimouski)

Featured story location on the map: 4

Millions of migratory birds breed in the Arctic each summer. They represent an important part of biodiversity and connect the Arctic with the rest of the globe. Several species are hunted and have cultural and economic importance to Canadians, including Northerners. Although they have fascinated humans for centuries, the majority of migratory birds remain poorly understood. Some bird populations are declining while others are increasing rapidly. What will be the consequences of global changes such as climate change on Arctic birds? What explains the recent changes in abundance, and will these changes affect other species of the Arctic tundra? Joël Bêty and his team seek to answer these questions.

During the short Arctic summer of 2019, Bêty and his team visited very isolated study sites where thousands of birds are nesting and followed several species of birds. This work has enabled Bêty to pursue long-term monitoring of populations of migratory birds that nest in the Arctic. The data collected will be added to long-term databases (from 10 to 25 years) on the reproduction, survival, abundance and distribution of several species. These databases are essential for identifying and understanding the effects of multiple environmental factors on Arctic wildlife and for better understanding the consequences of global warming on the Arctic ecosystem.

Capturing and tagging cackling geese on Bylot Island, Nunavut

THE IMPACT OF LESS-ICY SUMMERS ON ARCTIC SEABIRDS

Measuring the morphometrics of an akpa on the Coats Island cliffs, Nunavut

Supported through the PCSP and The W. Garfield Weston Foundation partnership

Kyle Elliott (McGill University)

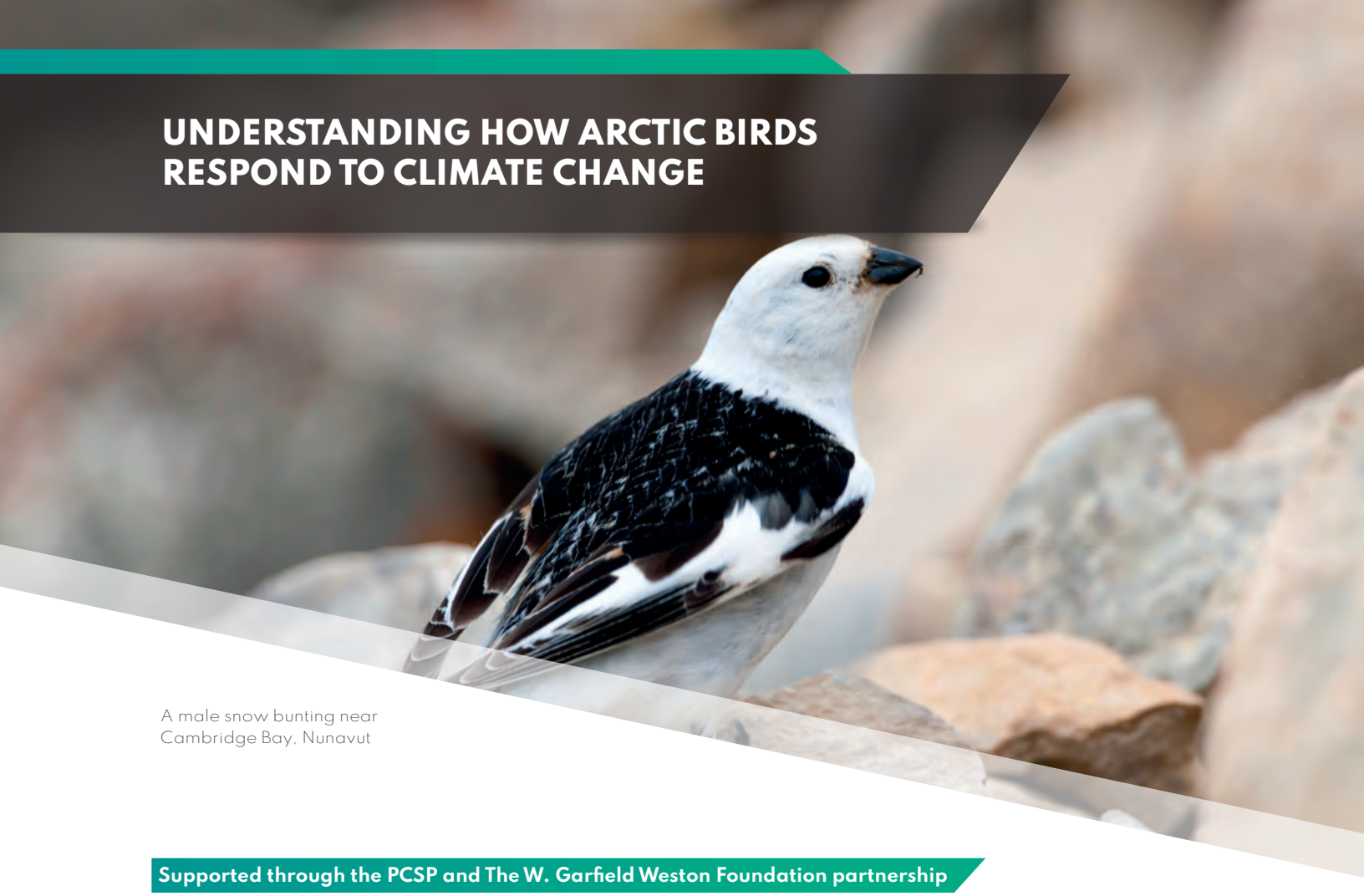
Featured story location on the map: 5

Arctic seabirds act as an indicator of the health of the Arctic and are an important food source for Northerners. In northern Hudson Bay, Coats Island, Nunavut, has one of the longest running population studies for Arctic seabirds in Canada (39 years). Kyle Elliott has participated in this population study since 2003. Over the course of this study, researchers have observed a change in the seabird diet. In the past, they ate fish found in areas largely covered by sea ice (Arctic cod), but now eat fish from water with more moderate temperatures (capelin). Elliott and his team are researching if this change is an indirect effect of climate change.

Coats Island is home to a small colony of akpas (thick-billed murres – seabirds somewhat similar to penguins). Elliott's team also studies this colony, having fitted some akpas with equipment to track where they travel year-round, including their activity under water. The study shows that akpas move into Hudson Bay just as the ice moves out in spring and leave just as the bay freezes in autumn. The team has also installed tiny heart-rate monitors into seven akpas to track the effects of various activities on their health. Future work will look at direct impacts of climate change, including the effect of heat stress on Arctic seabirds.

Akpa pairs take turns holding their egg firmly to the cliff for 32 days to prevent the egg from rolling off.

UNDERSTANDING HOW ARCTIC BIRDS RESPOND TO CLIMATE CHANGE



A male snow bunting near Cambridge Bay, Nunavut

Supported through the PCSP and The W. Garfield Weston Foundation partnership

Oliver Love (University of Windsor)

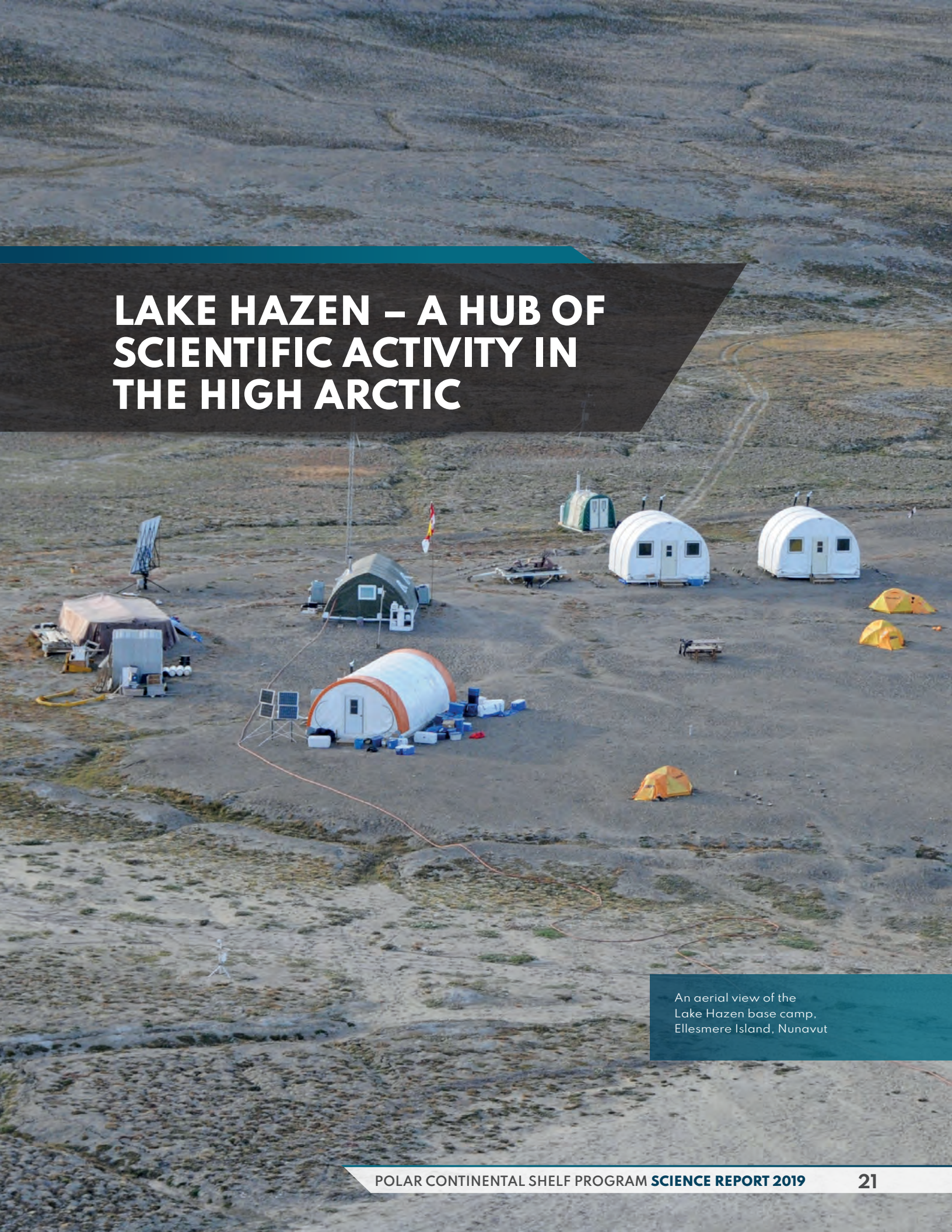
Featured story location on the map: 6

Oliver Love and his team study three important bird species in Nunavut: common eiders, snow buntings and thick-billed murres. They monitor the health, reproduction rates and behaviour of the three species to determine how well they are adapting to climate change. The team follows individual birds over time, assessing how flexible individuals and populations are in response to warming temperatures and changing ice conditions.

One aspect Love and his team examine is if snow buntings overheat while caring for their young. The team found that snow buntings have to choose nesting and foraging sites carefully because the birds may be overheating while spending up to 20 hours a day foraging. The team tracks the heart rates of common eiders to see how the eiders respond to increased air temperatures and polar bear attacks. For thick-billed murres, the team studies feeding behaviours in relation to changes in ice conditions.

Over the next few years, Love and his team will study the performance and breeding success of snow buntings. They will assess the combined effects of increased air temperatures, polar bears and contaminants on common eider nesting behaviours. The team will also examine how well individual thick-billed murres and various breeding colonies are adapting to rapidly changing ice conditions. Understanding the dynamics of these populations will help to focus conservation efforts for Arctic bird species.

LAKE HAZEN – A HUB OF SCIENTIFIC ACTIVITY IN THE HIGH ARCTIC



An aerial view of the Lake Hazen base camp, Ellesmere Island, Nunavut

Collecting samples at the Gilman River, Ellesmere Island, Nunavut

Vincent St. Louis and Martin Sharp (University of Alberta), Igor Lehnherr (University of Toronto-Mississauga), Adam Ferguson, Maryse Mahy, Jill Rajewicz (Parks Canada), and Yonas Dibike and Derek Muir (Environment and Climate Change Canada)

Featured story location on the map: 7

Sharing resources in the Arctic is critical to the success of many research programs. Joining forces and collaborating out of one central location helps to alleviate some of the challenges associated with coordinating fieldwork in a remote and vast region with minimal infrastructure. The Lake Hazen base camp in Nunavut is an excellent example of this sort of collaboration. It is on northern Ellesmere Island in Quttinirpaaq National Park – the most northerly national park in Canada.

The Lake Hazen site was established as a scientific research base in 1957 by the Defence Research Board (formerly part of DND). Parks Canada assumed management of the site in 1988 when the Ellesmere Island National Park Reserve was established, now known as Quttinirpaaq National Park. The base camp supports a wide range of activities, including scientific research, park operations, and tourism. The PCSP has been supporting research and operations in the park for over 25 years.

Parks Canada staff are on site annually between May and early August. They monitor the ecological integrity and cultural resources of the park, welcome visitors, and complete infrastructure maintenance and improvements. When operationally feasible, Parks Canada shares the camp facilities at Lake Hazen with researchers. They also provide staff support to researchers when needed. In return, Parks Canada receives data from the research that feeds into or complements the ecological integrity monitoring of the park.

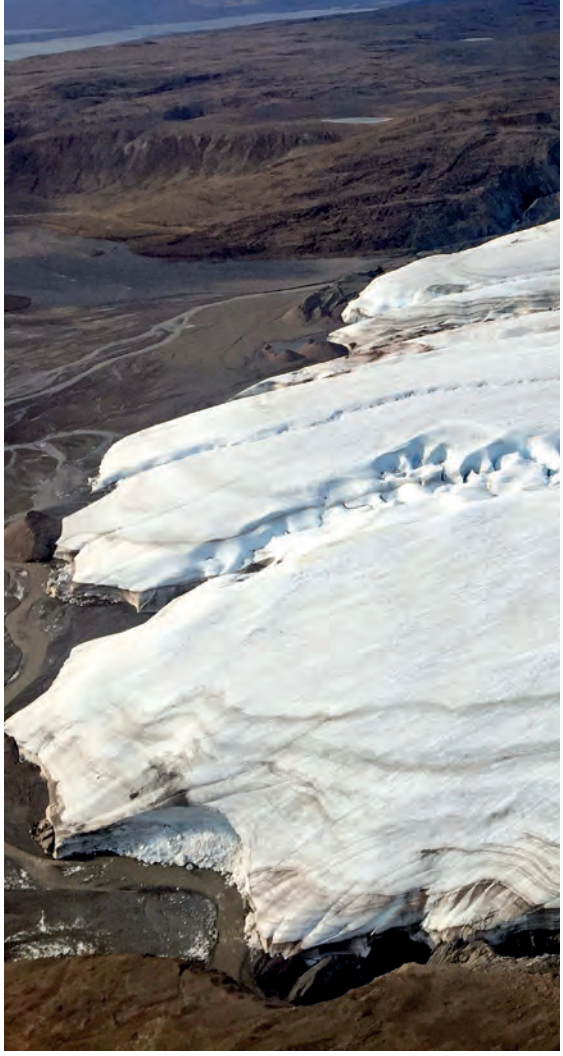
In 2019 at Lake Hazen, Environment and Climate Change Canada (ECCC) continued three long-term scientific projects, one of which is co-led with Parks Canada. ECCC provides expertise and training to Parks Canada employees, and Parks Canada employees carry out the data and sample collection. This collaboration saves money because ECCC does not need to send as many employees into the park, and Parks Canada can rely on the expertise of ECCC. In 2019, these collaborative projects included:

- Derek Muir and his team from ECCC continued to study the long-term impacts of contaminants on Arctic char in Lake Hazen for a project that started in 2003. Parks Canada staff collected fish samples and data following ECCC protocols.
- Yonas Dibike and his team from ECCC continued a project that began in 2010 that investigates the effects of climate change on northern lakes, including monitoring the lake ice. Parks Canada staff helped collect data following ECCC protocols.
- Parks Canada and ECCC employees continued a program started in 1996 that monitors the water flow and depth of the Ruggles River. The Ruggles River flows out of Lake Hazen and across the Hazen Plateau year-round. This project contributes to a Parks Canada program to monitor freshwater in all the parks.

Two long-term, university-led research projects continued in 2019 at Lake Hazen:

- Since 2005, the Lake Hazen watershed has been studied collaboratively by Vincent St. Louis (University of Alberta), Igor Lehnherr (University of Toronto), and Sherry Schiff (University of Waterloo). They investigate the impacts of human-induced climate change and contaminants on ecosystems and the quality of freshwater in the high Arctic.
- Martin Sharp and his team from the University of Alberta continued their work at Lake Hazen, which began in 2016. The team monitors glacier change and mass balance in the Lake Hazen Basin by using continuously recording GPS (Global Positioning System) stations.

With so many activities taking place out of one location, the PCSP was able to share aircraft for the various projects to reduce costs for everyone. Another result was reduced flight traffic within the park. For all of these projects, working together and sharing resources and data increased scientific discovery.

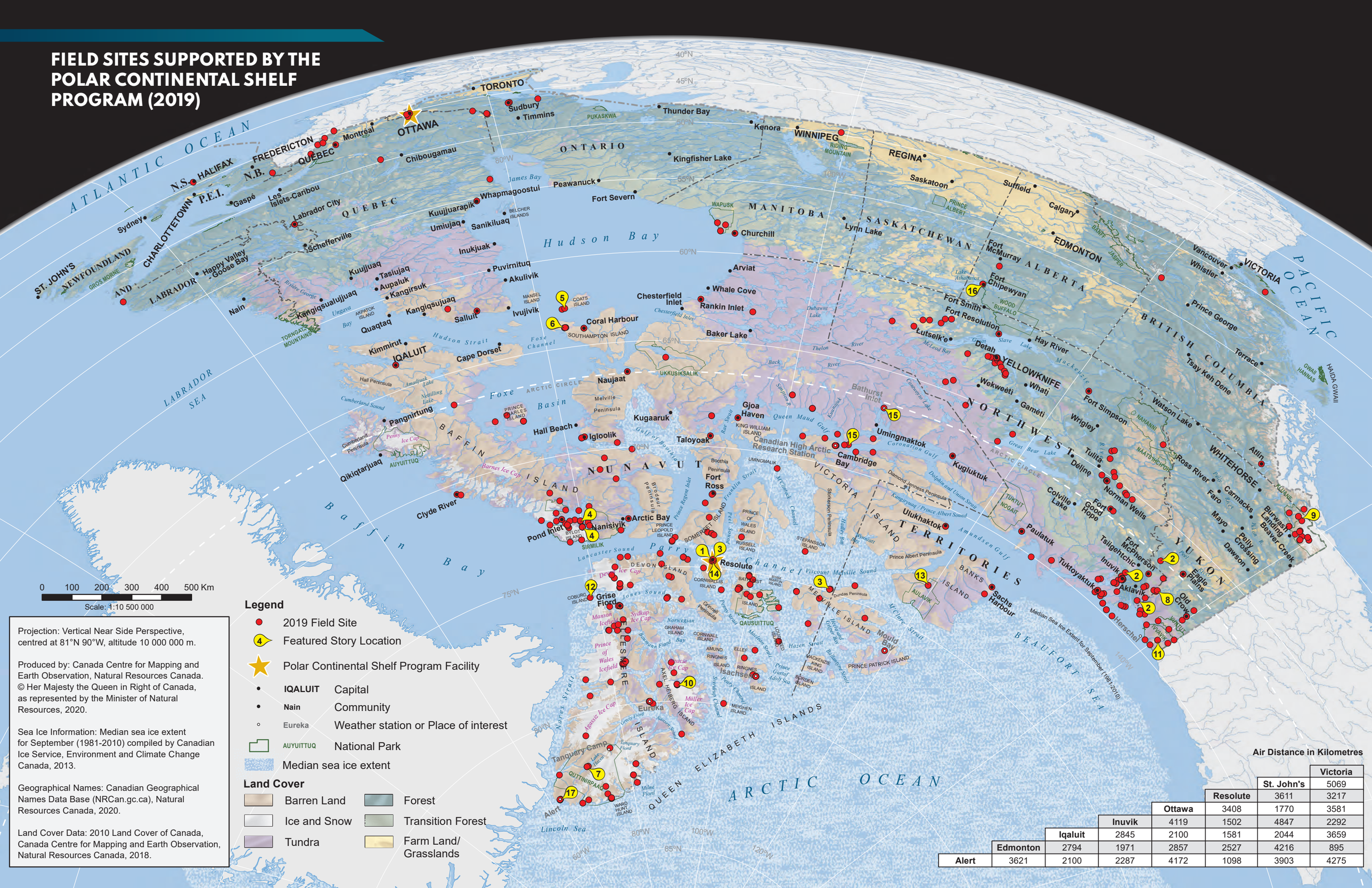


Meltwater from the Gilman Glacier flows into Lake Hazen via the Gilman River on Ellesmere Island, Nunavut

DID YOU KNOW?

The Lake Hazen base camp has many permanent and semi-permanent structures, including sleeping tents, storage sheds, a kitchen and dining shelter, an office tent, and a laboratory. Parks Canada facilities at the base camp run on solar power. The Lake Hazen Research Laboratory has a main working area and an area to process water samples. It has solar-powered electricity, a fume hood, and propane-powered fridges and freezers. These structures reduce the need for each user to transport large amounts of equipment to this remote site every year.

FIELD SITES SUPPORTED BY THE POLAR CONTINENTAL SHELF PROGRAM (2019)



Projection: Vertical Near Side Perspective, centred at 81°N 90°W, altitude 10 000 000 m.

Produced by: Canada Centre for Mapping and Earth Observation, Natural Resources Canada. © Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2020.

Sea Ice Information: Median sea ice extent for September (1981-2010) compiled by Canadian Ice Service, Environment and Climate Change Canada, 2013.

Geographical Names: Canadian Geographical Names Data Base (NRCan.gc.ca), Natural Resources Canada, 2020.

Land Cover Data: 2010 Land Cover of Canada, Canada Centre for Mapping and Earth Observation, Natural Resources Canada, 2018.

Legend

- 2019 Field Site
- 4 — Featured Story Location
- Polar Continental Shelf Program Facility
- IQALUIT — Capital
- Nain — Community
- Eureka — Weather station or Place of interest
- AUYUITTUQ — National Park
- Median sea ice extent

Land Cover

- Barren Land
- Ice and Snow
- Tundra
- Forest
- Transition Forest
- Farm Land/ Grasslands

Air Distance in Kilometres

						St. John's	Victoria
					Resolute	3611	3217
				Ottawa	3408	1770	3581
			Inuvik	4119	1502	4847	2292
		Iqaluit	2845	2100	1581	2044	3659
	Edmonton	2794	1971	2857	2527	4216	895
Alert	3621	2100	2287	4172	1098	3903	4275

Expedition Fiord on Axel Heiberg Island, Nunavut

SCIENCE AND OPERATIONS HIGHLIGHTS FROM 2019

The following stories feature 10 projects that the PCSP supported during the 2019 field season. They cover a wide range of topics, including the effects of climate change in the Arctic, the preservation of Inuit culture, and the history of our universe.

Refer to the featured story location number to view the project's field location(s) on the report's field sites map (page 24–25).

Collecting a core sample of multiyear sea ice off the northeastern coast of Ellesmere Island, Nunavut

BIODIVERSITY INVENTORY OF DÀADZÀII VÀN TERRITORIAL PARK

Collared pika in Dàadzàii Vàn Territorial Park, Yukon

Bruce Bennett (Government of Yukon)

Featured story location on the map: 8

Dàadzàii Vàn is remote area in the Richardson Mountains of north-eastern Yukon. The nearest community is Fort McPherson in the Northwest Territories, 75 km to the south-east. Dàadzàii Vàn means Loon Lake in Gwich'in and is the Gwich'in name for Summit Lake near the border of the Northwest Territories. The area is important to the Vuntut Gwitchin and the Tetlit Gwich'in First Nations.

Plans are in place to designate Dàadzàii Vàn as a territorial park. The 1,525-km^2 park will protect the area between the Whitefish wetlands and the Rat River Gwich'in Conservation Zone. Little is known about the biodiversity of this region. With climate change, monitoring and managing its ecosystems will become increasingly important. Collecting baseline information is an important first step in establishing a long-term monitoring plan for the park.

In 2019, Bruce Bennett and Piia Kukka of the Yukon Department of Environment led an expedition to Dàadzàii Vàn to survey the biodiversity in the area. The PCSP provided helicopter support for the fieldwork, which was essential for completing the survey.

Experts on mammals, birds, insects, and plants participated in the expedition. They surveyed over 50 sites, where they set live-traps for mammals. They also photographed and collected fungi, lichens, invertebrates, and plants, including mosses and liverworts.

The surveys focussed on lesser-known wild species. The team also studied the distribution of the Collared Pika (*Ochotona collaris*) and the Ogilvie Mountains Collared Lemming (*Dicrostonyx nunatakensis*).

Collared Pikas are found from Alaska to the Northwest Territories and in extreme north-eastern British Columbia. They are a species at risk in Canada and are an indicator species for climate change. Dàadzàii Vàn is at the very northern part of the Collared Pika's known range. Bennett and his team hypothesized that as climate warmed in the region, more Collared Pika would migrate there. In 2019, Bennett and his team found that Collared Pikas already occupied most of the suitable habitat in the area.

The Ogilvie Mountains Collared Lemming is native to the Ogilvie Mountains in Tombstone Territorial Park in Yukon. Because the Richardson Mountains provide a similar habitat, Bennett and his team thought it would be a good place to find the species. Although they found many small mammal species, Bennett's team did not find any Ogilvie Mountains Collared Lemmings in Dàadzàii Vàn.

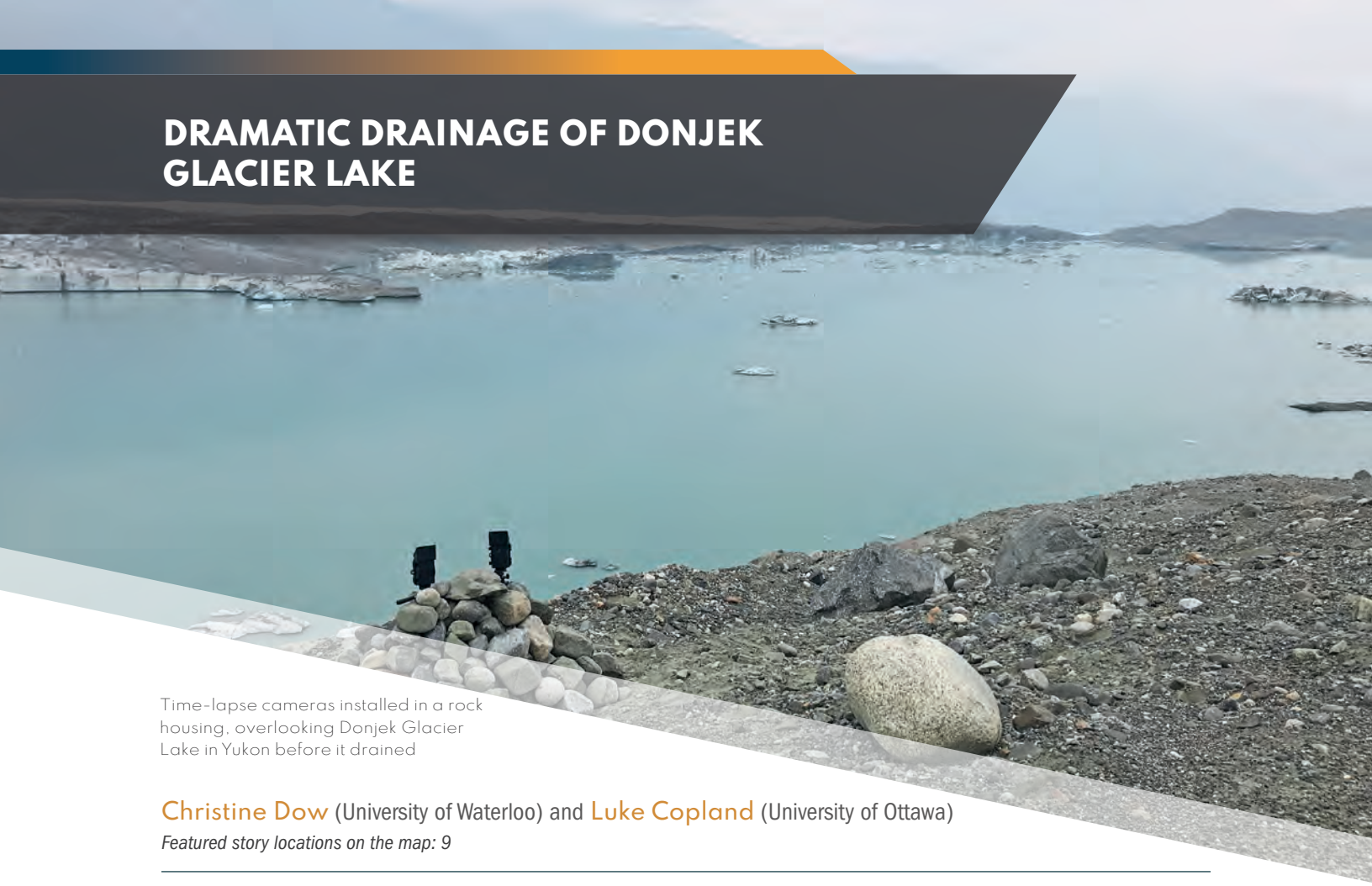
Among the mammals they found were the Singing Vole (*Microtus miurur*) and the Northern Bog Lemming (*Synaptomys borealis*). They also found many species of insects, birds, and plants. Many of these were detected for the first time in the park. They included rare species of plants, including Eurasian Junegrass (*Koeleria asiatica*), Arctic Larkspur (*Delphinium brachycentrum*), and insects, including Suckley's Cuckoo bumble bee (*Bombus suckleyi*), which was recently assessed as Threatened. In addition, they found a squaretail worm (*Eiseniella tetraedra*), which was previously thought to be exotic to North America. They also detected 28 species of birds.

In 2020, Bennett aims to survey Collared Pika and Yukon Podistera (*Podistera yukonensis* – a rare plant) in the Dawson Range. Like the Collared Pika, the Yukon Podistera has been listed as Special Concern under the *Species at Risk Act* because of its vulnerability to climate change. Bennett will map their habitat in detail. This baseline information will help to inform conservation strategies within the park and allow future researchers to identify changes to habitats and biodiversity.

Examining a red-backed vole in Dàadzàii Vàn Territorial Park, Yukon

> *Very little is known about the biodiversity of this region, and as the climate and landscape are changing, it is important that the ecosystems be monitored and responsive management approaches evolve and adapt as needed.*
>
> – Bruce Bennett, Government of Yukon

DRAMATIC DRAINAGE OF DONJEK GLACIER LAKE



Time-lapse cameras installed in a rock housing, overlooking Donjek Glacier Lake in Yukon before it drained

Christine Dow (University of Waterloo) and Luke Copland (University of Ottawa)

Featured story locations on the map: 9

The Donjek Glacier is a surging glacier in the St. Elias Mountains in Kluane National Park in south-west Yukon. Surging glaciers alternate between long periods (tens of years) of slow movement and short periods (about two years) of fast movement. The internal dynamics of the glaciers control the surging. Surging makes the toe (front) of the glacier advance down the valley in a relatively short period. Surging glaciers are uncommon and make up a very small percentage of glaciers worldwide. Understanding how a warming climate will affect this type of glacier requires more research.

Surging of the Donjek Glacier has been recorded since the 1930s, and surges occur about every 12 years. When this glacier surges, an ice dam often forms that blocks the Donjek River and causes a large lake to grow. The lake fills and drains during most summers after the glacier has surged. When the lake drains, it creates a potential hazard for anyone using the valley downstream, particularly when the lake is large. In the past, the lake draining and downstream flooding have reached as far as the Alaska Highway, which is about 50 km downstream from the glacier.

Christine Dow, Luke Copland and their team of graduate students study the Donjek Glacier and the glacial lake that forms at its front. PhD student Will Kochtitzky studied the most recent surge of the Donjek Glacier that ended in 2014. Since then, the lake has formed and drained each year.

When Dow, Copland and their field team arrived in July 2019, the Donjek Lake covered an area of about 2.2 km^2 and was approximately 60 m deep. The team installed three time-lapse cameras overlooking the Donjek Lake to examine the lake evolution and changes to the toe of the glacier. They also installed instruments in the lake to measure drainage rate and on the glacier surface to measure ice velocity.

Before Donjek Glacier Lake started to drain

They finished the installation on July 12, 2019, and within 24 hours, the lake began to drain. The lake drained into the valley below after melting a channel through part of the glacier. The lake drained in less than 48 hours. This was the first time that the lake draining and the outburst flood at the Donjek Glacier was recorded on camera.

Master's student Moya Painter is using the data collected from this project to examine the lake drainage. She is also working with the Kluane First Nation to gather traditional knowledge about past flood events at the Donjek Glacier and the behaviour of other glaciers in the area.

Continued study of the Donjek Glacier and its lake is important for the safety of people visiting Kluane National Park downstream from the glacier. Next year, the team plans to install more cameras to monitor and examine the lake evolution and changes at the toe of the Donjek Glacier. They also plan to take aerial photographs to compare with elevation data of the glacier and the lake basin collected over the last several years.

> *The support from the PCSP on this project was vital for its success. The fieldwork and equipment installation is only possible by helicopter, and we are very grateful for the continued support from the PCSP so that we can continue to collect these data and answer important questions about glacier health, associated hazards, and the impacts of climate change in the St. Elias Mountains.*
>
> – Christine Dow, University of Waterloo

Soon after Donjek Glacier Lake started to drain

More than 24 hours after Donjek Glacier Lake started to drain

After Donjek Glacier Lake completely drained

A NEW WINDOW ON THE UNIVERSE: RADIO ASTRONOMY FROM NORTHERN CANADA

Building a radio antenna as part of an observational cosmology program on Axel Heiberg Island, Nunavut

Hsin Cynthia Chiang (McGill University)

Featured story location on the map: 10

Cosmology is the study of the origins, evolution, and large-scale structure of the universe. It is a rapidly growing area of research thanks to the recent development of precise instruments, such as radio telescopes. Despite all that we have learned about the universe, many mysteries remain.

For example, the period shortly following the Big Bang, known as the dark ages, is unexplored and remains one of the final frontiers in cosmology. A few hundred million years after the Big Bang, ending the dark ages, the first stars in the universe ignited during the period of the cosmic dawn.

Luckily, the universe has given observers a powerful tool for studying its distant past: hydrogen. Around 400,000 years after the Big Bang, the universe cooled enough for hydrogen to form for the first time. To this day, hydrogen remains the most abundant element in the universe. Hydrogen naturally emits light in the form of radio waves, which can be measured by radio telescopes. Cosmologists can access specific periods of the universe's history by tuning radio telescopes to different frequencies.

The first tentative detection of a signal from the cosmic dawn was reported in 2018 by the Experiment to Detect the Global EoR Signature (EDGES) in the remote Australian outback. If this detection is confirmed, it represents our first glimpse of the universe during this period of its evolution.

Signals from the cosmic dawn and dark ages are hard to detect. These low frequency signals (<150 MHz) are exceptionally hard to access because of interference from radio broadcasting stations. The FM band (88 to 108 MHz) in particular is a major source of interference because of FM radio stations that are used widely across the globe. The upper part of the atmosphere can at times also block radio signals from outer space.

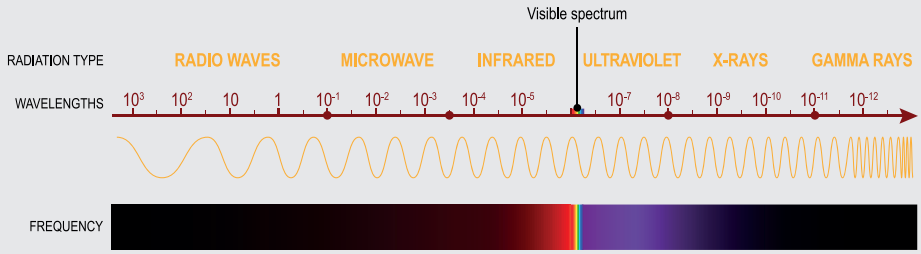
Hsin Cynthia Chiang and her team aim to detect cosmic dawn signals from remote areas in the Canadian Arctic. In 2019, they travelled to the McGill Arctic Research Station (MARS) at Expedition Fjord on Axel Heiberg Island in Nunavut, to assess the site's potential for radio observations of the sky. Chiang considered this remote, Arctic location to be promising because she anticipated that there would be little interference from radio stations and the atmosphere.

Chiang and her team found that the radio-frequency interference at MARS was exceptionally low. In particular, they found the FM band to be remarkably clean. Their measurements suggest that MARS is one of the cleanest observing sites on Earth. It may surpass the South African Karoo and Western Australian deserts, which are two of the most commonly used radio-quiet observing locations. This finding is promising for the future because Chiang and her team hope to weigh in on the EDGES detection of the cosmic dawn and lay the groundwork for future explorations of the dark ages.

Measuring radio-frequency interference levels near Resolute Bay, Nunavut

> *Logistics support from the PCSP was critical for the success of our first field season. As newcomers, any number of things could have gone wrong with trying to work in a remote, unfamiliar location, but our operations went extremely smoothly thanks to all of the help from the PCSP. All of our cargo was delivered safely, our requested gear simply magically appeared and was ready to go. And everyone at the PCSP took time to answer our steady stream of questions and always went out of their way to help!*
>
> – Hsin Cynthia Chiang, McGill University

Electromagnetic spectrum



DID YOU KNOW?

Visible light is a form of electromagnetic radiation that humans can observe with the naked eye. Other types of electromagnetic radiation include gamma-rays, X-rays, ultraviolet, infrared, microwaves and radio waves. These rays are often described as non-visible light. Since we cannot see these forms of light with the naked eye, we rely on technologies such as non-optical telescopes, radios, cell phones and other devices to detect them.

All forms of light (visible and non-visible) travel at a constant speed, which means that the light we observe is from past events. For example, we see the light emitted from light bulbs in our homes virtually immediately (it takes only a few billionths of a second to reach our eyes). However, sunlight, which consists of visible and non-visible light (X-rays, ultraviolet light, infrared light, microwaves and radio waves), takes on average 8 minutes to travel to Earth. Therefore, we observe the sun as it was approximately 8 minutes in the past. The universe is infinitely larger; the farther we peer into it, the farther we peer into its past.

THE INUVIALUIT LIVING HISTORY PROJECT'S IMNIARVIK CULTURE CAMP

Elder Walter Bennett with his catch of char at Sheep Slot, Yukon

Lisa Hodgetts (University of Western Ontario)

Featured story location on the map: 11

Inuit of the western Canadian Arctic are known as Inuvialuit. They trace their origins to the Thule people, who migrated to the Canadian Arctic from Alaska in the 13th century. For generations, Inuvialuit elders have passed on their people's history through spoken stories and in song.

Today, around 5,000 Inuvialuit live in the Inuvialuit Settlement Region. This region covers 1,172,749 km^2 in northern Yukon and the Northwest Territories. This land includes areas surrounding the Beaufort Sea, the Mackenzie River delta, the Yukon North Slope and the western Canadian Arctic islands.

The Inuvialuit Living History (ILH) Project aims to help Inuvialuit find new ways to connect to their history and heritage with digital media. The project is co-directed by Lisa Hodgetts from the University of Western Ontario, Natasha Lyons from Simon Fraser University, and Ursus Heritage Consulting.

The project organizes community events that create, document and share multiple forms of knowledge about Inuvialuit history and heritage. To do this, the project brings together Inuvialuit community members, archaeologists, anthropologists, digital media specialists and museum professionals.

In July 2019, ILH hosted the Imniarvik culture camp for one week in Ivvavik National Park, bringing together several generations of Inuvialuit with ties to the Yukon North Slope.

Participants from the communities of Inuvik and Aklavik included five teenagers, two elders and a cook. They were joined by representatives from Parks Canada, the Inuvialuit Communications Society, Ursus Heritage Consulting, and faculty and students from the Department of Anthropology at the University of Western Ontario. The PCSP brought all 15 participants by Twin Otter to the base camp at Imniarvik.

Youth participants Cassidy Lennie-Ipana and Mataya Gillis practice interview techniques on each other at Niaqulik, Yukon.

Over the course of a week, participants listened to elders' stories and documented their knowledge. They practiced the Inuvialuktun language and handled Inuvialuit artifacts from the Prince of Wales Northern Heritage Centre. Participants also fished, hiked and picked berries and spruce gum.

The PCSP coordinated helicopters for the team to visit several cultural sites, including Qikiqtaruk (Herschel Island) and Niaqulik on the Beaufort Sea coast. Many of the Inuvialuit participants had family links to these places. The site visits allowed them to reconnect with their history, an experience they described as powerful and emotional.

Throughout the camp, youth participants learned interview techniques that they practiced on their elders and each other, creating audio and video recordings. They also drew and wrote in their journals, embroidered, took photographs and made 3D models of places they visited.

Hodgetts, Lyons and their team are planning to expand the ILH website, where they will publish resources co-created with community members during this event and others. They also hope to include information on Inuvialuit artifact collections and cultural sites.

Through the website expansion, the ILH team aims to display traditional Inuvialuit ways of knowing and being. They will gather feedback from communities in the Inuvialuit Settlement Region before officially launching the updated site.

Youth participant Cassidy Lennie-Ipana interviews Elder Renie Arey at her grandparents' cabin at Niaqulik, Yukon.

> *This work is part of a broader movement toward community-based research, which puts community members' needs and voices at the centre of the work. It works to disrupt the colonial underpinnings of traditional approaches to research, which often prioritized western ways of knowing over Indigenous ones.*
>
> – Lisa Hodgetts, University of Western Ontario

WANT TO LEARN MORE?

Videos and other media from these events, many of them produced by Inuvialuit, will be integrated into a revised version of the project website. The site aims to share Inuvialuit perspectives on their history, in their own way.
To learn more, visit www.inuvialuitlivinghistory.ca.

CLEANING UP THE NORTH WATER RESEARCH STATION ON COBURG ISLAND

The abandoned cabin and debris at the former North Water Research Station on Coburg Island, Nunavut

Lisa Pirie-Dominix (Environment and Climate Change Canada)

Featured story location on the map: 12

Coburg Island is about 20 km off the southern tip of Ellesmere Island in Nunavut. To protect seabirds and mammals in the area, the Nirjutiqarvik National Wildlife Area (NWA) was established in 1995. The NWA encompasses Coburg Island and includes the Princess Charlotte Monument (a smaller island) and all adjacent waters within a 10-km radius. ECCC and the Nirjutiqarvik Area Co-management Committee (ACMC) co-manage the NWA. The ACMC is composed of five Inuit from Grise Fiord, Nunavut, and one employee from ECCC's Canadian Wildlife Service.

Coburg Island is the nesting habitat for more than 350,000 seabirds, including thick-billed murres, black-legged kittiwakes, northern fulmars, glaucous gulls, black guillemots and Atlantic puffins. The NWA is important because it provides feeding grounds for a variety of marine mammals, including polar bears, walrus, beluga, narwhal, and ringed, bearded and harp seals. Coburg Island is also important to Inuit living in Grise Fiord, Canada's most northerly community, located on southern Ellesmere Island.

In the 1960s, the North Water Research Station was built on Coburg Island and was used as a base for scientific research by various federal government departments and universities. When operations ceased in the early 1980s, the station was abandoned, but a cabin and a large quantity of debris were left behind.

ECCC began to clean up the site in 1996. They removed all contaminants and disposed of fuel that remained in fuel drums. However, they were not able to remove the debris because of a lack of funding for transportation. Consequently, more than 100 empty fuel drums, a cabin in a state of disrepair, and other debris remained on site. In recent years, Inuit from Grise Fiord identified concerns about the old research station during consultations with ECCC. The ACMC had been trying to acquire funds to clean up the site, but the costs to haul the debris away were too high.

In 2019, the PCSP was able to provide aircraft support for this project, making it possible to complete the clean-up on Coburg Island. The PCSP provided more than 40 hours of Twin Otter flying over 10 flights to remove all the debris from the site.

ECCC hired eight residents from Grise Fiord to participate in the clean-up, along with ECCC staff. The wooden research cabin was cleared of debris, disassembled and burned. The team retrieved empty fuel drums that had migrated along the beach and inland, many of them buried in the sand. The team transported the debris and more than 100 empty drums by Twin Otter to Resolute, Nunavut, from where they were sent south via sealift for proper disposal.

The contaminated sites program at ECCC arranged for a contractor to visit the site at the end of the clean-up to collect soil samples for testing. Preliminary results from the soil tests show that contaminants are within tolerable levels, and no remediation is necessary. The clean-up at the North Water Research Station is complete, and no further work is required. Cleaning up this site within the protected area was a great accomplishment – it has improved the local environment and removed the risk posed to wildlife in the area.

Rocks outline the location of the abandoned cabin after the clean-up.

The clean-up team loads equipment and debris onto Twin Otters.

INVESTIGATING PERMAFROST SLUMPING AND ITS IMPACT ON THE LANDSCAPE IN AULAVIK NATIONAL PARK

An aerial view of the extent of slumping in Aulavik National Park, Northwest Territories

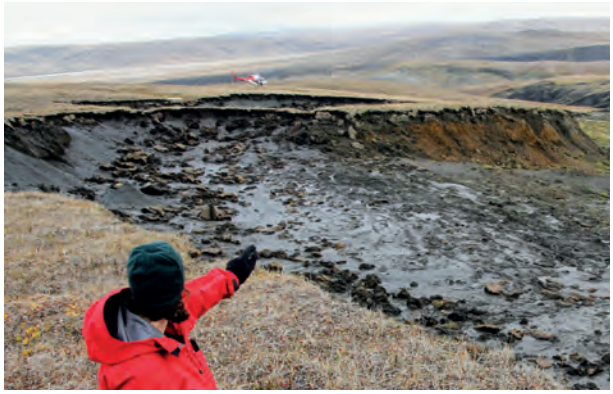
Hayleigh Conway (Parks Canada)

Featured story location on the map: 13

Permafrost thaw caused by a warming climate can cause land to subside, also known as retrogressive thaw slumps or slumping. Observations have shown that Banks Island, Northwest Territories, may have some of the fastest rates of slumping in the Arctic. Aulavik National Park is on Banks Island and within the Inuvialuit Settlement Region. Community members and management bodies in the Inuvialuit Settlement Region are concerned about the impacts of these slumps on fish habitat, water quality, and human safety while travelling on the land.

Hayleigh Conway, from Parks Canada, is leading a multi-year project that began in 2016 to map, analyze and forecast permafrost slumping in the Thomsen River valley, the main watershed in Aulavik National Park. Data from this project will feed into a larger project with the Government of the Northwest Territories to study and map permafrost slumping throughout the territory.

In 2019, Conway returned to Aulavik National Park accompanied by Antoni Lewkowicz, a permafrost scientist from the University of Ottawa, Eric Cheyne, an employee from the Aurora Research Institute, and Alexis Lucas, a resident hired from Sachs Harbour. The team re-visited 11 permafrost slumps that were surveyed in 2017 along the Thomsen River. The goal was to assess if the slumps were still growing and to measure the volume of soil, vegetation and sediment that is being released into the river. Overall, they seek to improve their understanding of the life cycle of slumps in the region.



Examining a permafrost thaw slump in Aulavik National Park, Northwest Territories

Cheyne piloted drones to record and survey nine of the slumps. The team collected ice, soil and water samples from each slump to assess the origin and age of the ice and to determine the impacts of slumping on the watershed. In particular, the team is concerned about the effect of the slumps on fish habitat, water quality and benthic invertebrate communities. Benthic invertebrates are organisms that live on or in the sediment of streams, rivers, and lakes and have no backbone. These organisms are often used as indicators of the health of aquatic ecosystems.

Conway plans to return in the future to continue studying the slumps in the Thomsen River valley. She would like to increase the number of slumps in the study and potentially expand the study area to include another river. She plans to install ground temperature sensors at six locations along the Thomsen River to collect permafrost temperature data at various depths. Conway will also produce communication products about this project to share with the community of Sachs Harbour and for use at the local school.

Collecting soil, vegetation and ice samples from inside a slump

> *Without the support we have received from the PCSP, this project would never have happened! Aulavik is an incredibly remote and hard-to-access park, and we would be unable to visit the park and collect data for this project without the PCSP.*
>
> – Hayleigh Conway, Parks Canada

ALTERNATIVE POWER AND HEATING SOLUTIONS FOR HIGH ARCTIC SHELTER SYSTEMS

Conducting tests on experimental tents near Resolute, Nunavut

Martin Kegel (Natural Resources Canada), Robert Thwaites (Department of National Defence) and Ed Andrukaitis (Defence Research and Development Canada)

Featured story location on the map: 14

In the Canadian High Arctic, soldiers in the Canadian Armed Forces can be deployed for several days to conduct operations for sovereignty, search and rescue, and surveillance. Exposure to extreme cold temperatures (as low as -50°C) is possible, and heating systems are critical to these operations. Diesel fuel is the main source for heating, cooking and lighting. In most cases, these are open-flame heating systems that produce carbon dioxide (CO_2) and carbon monoxide (CO). CO_2 and CO pose health risks to the soldiers, and the open flame increases the risk of the shelter catching fire.

Martin Kegel, Natural Resources Canada, Robert Thwaites, Department of National Defence, and Ed Andrukaitis, Defence Research and Development Canada, are collaborating on a project to eliminate the flame inside the tent. The goal is to reduce the risk to soldiers while deployed on the land by exploring and demonstrating alternative shelter and power solutions.

Temporary field camps have weight restrictions because of the towing capacity of the snowmobiles used for transportation during excursions. Therefore, any solutions to replace the current shelters must not exceed the weight and volume of the current shelter kits.

During 2019, the team travelled to Resolute, Nunavut, to assess and trial shelter and power solutions. They monitored the current high Arctic shelter systems to assess their power requirements. They also trialed different products that might improve the shelter systems. The PCSP shipped their equipment to Resolute and provided them with extreme cold weather clothing and accommodations at its facility.

The team found that insulated tent liners reduced the amount of energy required to heat the tent. These liners have the added benefit of wicking away moisture, which can be a problem when packing the tent for transport. With these improved liners, the team observed about a 50% reduction in heating needs with very little increase to the weight and volume of the kit. They also tested heated floor mats and induction stoves – both providing promising heating and cooking alternatives. They are also looking at options for power generation that will increase efficiency and reduce dependency on diesel fuel.

Further research is required to determine power options for these systems while in the field, including looking into hybrid power solutions and cold weather battery systems. The team will test various tent liners in upcoming years to find the most efficient option. These solutions will improve the quality of life for soldiers while in the field and will benefit anyone facing similar challenges working at a high Arctic field camp.

Installing temperature, carbon monoxide and carbon dioxide sensors in an experimental 10-person tent near Resolute, Nunavut

Demonstrating a heated floor and insulated lining modification in an experimental 10-person tent near Resolute, Nunavut

INUINNAIT HERITAGE: COLLABORATIVE ARCHAEOLOGY IN THE CANADIAN ARCTIC

Taking high-resolution drone images of a large boulder where seal blubber was stored, showing white lines where fat flowed down the side, Bathurst Inlet, Nunavut

Max Friesen (University of Toronto)

Featured story location on the map: 15

The Inuinnait Heritage project is a five-year collaboration that began in 2018 between the Kitikmeot Heritage Society of Cambridge Bay, Nunavut, and Max Friesen, an archaeologist from the University of Toronto. The Kitikmeot Heritage Society (KHS) is a heritage organization that focuses on projects that have critical importance to the revival of Inuit culture, language and history. The Inuinnait are the population of Inuit who originally lived on Banks Island in the Northwest Territories, Victoria Island in the Northwest Territories and Nunavut, and on the adjacent mainland in western Nunavut.

This project, initiated by the KHS, aims to fill the remaining gaps in the 5,000-year history of the Inuinnait region in western Nunavut, from 3000 BC to the present. The team is studying cultural history and archaeology across parts of the Inuinnait region stretching from the town of Cambridge Bay on Victoria Island to Bathurst Inlet. This work will link archaeology with traditional knowledge at key locations and will engage youth in Inuit heritage research. It will also expand the scope of archaeology in the Inuinnait region by generating new data on two poorly understood periods. The first period spans from AD 1800 to present, and the second is the period around 3000 BC.

Prior to the establishment of modern towns such as Cambridge Bay, a key area of Inuit settlement was in the Bathurst Inlet region. Elders from Cambridge Bay want to share their knowledge of the region while visiting the sites where they used to live. During the first visit into the field in 2018, a team of 11, including KHS researchers, archaeologists and Inuinnait Elders, travelled to important locations in the Bathurst Inlet area. They recorded traditional knowledge, including oral histories and place names. This work contributed to the first period of interest, from AD 1800 to the present.

In 2019, a smaller team of two archaeologists (Max Friesen and PhD student Taylor Thornton) and two Inuit trainees from the KHS returned to these important locations to survey, excavate and map the sites. Several of the sites were mapped using a drone, including camp sites, a caribou drive line and specialized storage areas.

During a much earlier period around 3000 BC, the ancient people known as the Paleo-Inuit first migrated into the area from Alaska. Beach ridges that formed during this early period hold small camp sites with tent rings and other stone structures. During 2019, the team visited some of these ancient beach ridges south of Cambridge Bay to collect samples of caribou bone and charcoal. These samples will be used to more accurately date this early migration using radiocarbon dating (a method used to determine the age of an object).

In the future, the team plans to continue surveying for archaeological sites and search for ancient camp sites on beach ridges in the Cambridge Bay area. They will also assess the impacts of climate change on the condition of heritage sites, such as increased erosion that is caused by permafrost thaw. In later years, they plan to run large-scale camps that will combine oral history and archaeology. This project will help preserve the important traditional knowledge of the Inuinnait Elders for the future. Once completed, this research will fill in the gaps of two poorly understood periods in the Inuinnait history.

> *The project would not be possible without PCSP support. The Kitikmeot Heritage Society and the University of Toronto have obtained several grants from federal and territorial sources, but they are insufficient to allow us to run full-scale fieldwork requiring significant amounts of aircraft time and equipment.*
>
> – Max Friesen, University of Toronto

WANT TO LEARN MORE?

Visit the Kitikmeot Heritage Society website to learn more about this project: kitikmeotheritage.ca/archaeology.

An early Inuinnait dwelling in Bathurst Inlet, Nunavut, dated to about AD 1550

DEVELOPMENT OF A MONITORING FRAMEWORK FOR LAKES OF THE PEACE-ATHABASCA DELTA

The southern Athabasca section of the Peace-Athabasca Delta in northern Alberta

Roland Hall (University of Waterloo) and Brent Wolfe (Wilfrid Laurier University)

Featured story location on the map: 16

The Peace-Athabasca Delta (PAD) is one of the world's largest inland deltas. It sits where the Peace, Athabasca, and Birch rivers meet at the western end of Lake Athabasca in north-eastern Alberta. The delta is a large (~6,000 km^2), dynamic, lake-rich floodplain renowned for its ecological, historical and cultural significance.

The PAD is one of the most diverse ecosystems in Canada. The combination of flat landscape, nutrient-enriched floodplain, shallow water and abundant sunshine provides the basis of a rich food web. The PAD is home to 215 species of birds, 42 species of mammals, 20 species of fish and countless invertebrates. These species are important to the local First Nation and Métis people. Local First Nation and Métis have continuously inhabited the PAD for centuries, and many continue to hunt, trap and fish in the region.

Eighty percent of the PAD is within Wood Buffalo National Park (WBNP). The outstanding universal value of the PAD was a major reason WBNP was designated as a UNESCO World Heritage Site in 1983. Its extensive wetlands are a habitat for globally significant migratory bird populations, including the endangered whooping crane.

Since 2000, Roland Hall and Brent Wolfe have investigated environmental concerns in the PAD. These investigations have centred on lake-level drawdown and drying trends within the delta and on contaminant releases from oil sands development approximately 200 km upstream. Informed by scientific research, the scientists worked on a framework to track changes in hydrological and ecological conditions of lakes across the delta.

From 2015 to 2019, Hall, Wolfe and their team studied approximately 60 lakes and 9 river sites, representing the diverse hydrological and ecological features of the PAD.

The team monitored water balances, water and sediment quality, aquatic organisms and contaminants. From each site, they collected samples in mid-May, late-July, and mid-September to determine seasonal variations. They used water isotope tracers to identify relative roles of important hydrological processes on lake water balances, including ice-jam and open-water flooding, rain, snowmelt, and evaporation.

In 2018 and 2019, the team installed data loggers to measure changes in water levels and water-quality parameters at hourly intervals, which captured little-known open-water flooding events in several lakes in the southern Athabasca Delta region.

The research conducted by Hall, Wolfe and their graduate students has yielded several results. They found no evidence of metal pollution in PAD lakes related to oil-sands development. They also found that many parts of the delta are drying because of climate change.

One exception is in an area near the centre of the PAD, which is getting more water because of a natural disruption in the flow of the Athabasca and Embarras rivers. The disruption (known as the Embarras Breakthrough) diverted substantial amounts of water northward and away from the mouths of the two rivers.

Hall and Wolfe also used water isotopes to track the extent and magnitude of an ice-jam flood in the PAD that occurred in 2018. Other methods, such as direct observations from flyovers, did not capture this information.

An important next step for Hall and Wolfe will be to work with Parks Canada to contribute to a long-term monitoring plan for the lakes of the PAD. Currently, the pace and scale of external development (specifically hydroelectric and oil sands development) as well as climate change pose threats to the world heritage values of WBNP and the PAD. Parks Canada announced an action plan in 2019 to enhance research, monitoring and management of the PAD.

Hall and Wolfe have already begun a new research project, in which they are assessing further the timing and causes of hydrological changes in the delta's lakes that have experienced recent drying. They also plan to begin new research to understand hydrological processes that control lake levels in an area to the north of the delta. This area is a critical habitat for the endangered whooping crane population that is protected within WBNP.

Retrieving equipment that measures water quality parameters from a lake in the Peace-Athabasca Delta, Alberta

> *Logistical support of helicopter charter from the PCSP was instrumental to the success and longevity of our field sampling campaign.*
>
> – Roland Hall, University of Waterloo

WHAT DO WE KNOW ABOUT THE OLDEST SEA ICE IN THE ARCTIC?

Piloting a remotely operated vehicle under sea ice off the coast of northern Ellesmere Island, Nunavut

Christine Michel (Fisheries and Oceans Canada)

Featured story location on the map: 17

Ecosystems associated with multiyear sea ice (sea ice that remains for more than one year) are not well understood. Multiyear sea ice is becoming increasingly rare in the Arctic because of climate change. One of the few areas where multiyear sea ice remains is off the coast of northern Ellesmere Island, Nunavut, in the Canadian Arctic. This region is commonly known as the Last Ice Area.

In 2019, the Government of Canada designated this region as the Tuvaijuittuq Marine Protected Area. Tuvaijuittuq means "the place where the ice never melts." Scientists predict that Tuvaijuittuq will be the only place in the Arctic to keep multiyear sea ice over the next decades. Tuvaijuittuq will thus become an increasingly important habitat for ice-dependent and culturally important species such as polar bears, walruses, and seals.

Christine Michel leads the Multidisciplinary Arctic Program (MAP) – Last Ice. Fisheries and Oceans Canada launched the program in 2018. It brings together partners across the federal government and academia to study the productivity, biodiversity, and role of the multiyear ice ecosystem in Tuvaijuittuq. The program will provide the first ecological assessment of the region.

During the spring of 2019, Michel and her team conducted an extensive study of the multiyear sea ice and the ecosystem underneath it. They set up a camp on sea ice, approximately 10 km offshore from Canadian Forces Station Alert. They took regular measurements of weather and ocean conditions, as well as snow, sea ice, and seawater over 11 weeks from March to June.

Their field research also included surveys of organisms living in the area. To study organisms living on the seafloor, they sent a remotely operated vehicle under the ice. The team also conducted aerial marine mammal surveys in mid-June and August to determine the abundance and distribution of animals such as seals, polar bears, walruses and narwhals.

They are investigating how these animals use the habitat created by multiyear ice.

Recent findings by Michel and her team suggest that multiyear ice can provide a more stable habitat for sea ice algae compared to first-year ice. This difference is created by the features of multiyear ice making the snow drift in a more consistent way than the first-year ice. This consistency allows more stable light conditions at the bottom of the ice, where most ice algae live.

Michel and her team have also found Atlantic walrus in Archer Bay, much farther north than their known range. However, they do not have enough observations in the study area to confirm that the Atlantic walrus's range has extended northward. These results highlight how little we know about this extremely remote ecosystem.

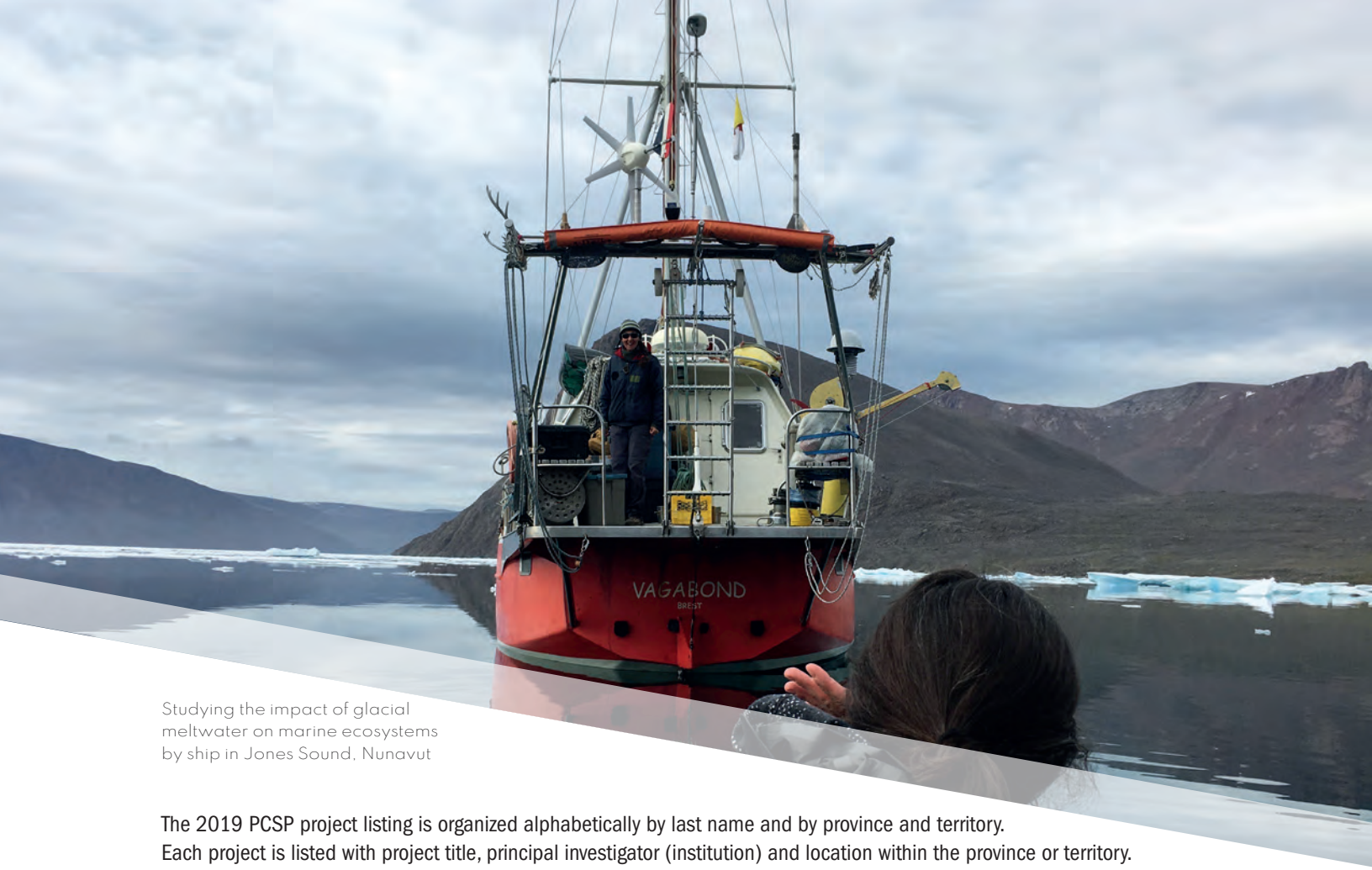
In the future, Michel and her team will return to Tuvaijuittuq to examine the multiyear sea ice over a larger area than was covered in 2019. They will also collect fish to determine how multiyear ice affects the food web, complementing research from the 2019 field season.

Measuring the temperature of a core of first-year sea ice

> *This research program would not be possible without the logistical support received from the PCSP. Through continued, efficient, and experienced Arctic logistics support, the PCSP met complex logistical requests in terms of equipment and fuel transportation, fuel caching, and flight support. All of these were fundamental to the success of our program.*
>
> – Christine Michel, Fisheries and Oceans Canada

LIST OF SUPPORTED PROJECTS IN 2019

A thaw slump caused by permafrost degradation on the Alaska Highway, Yukon, taken by a drone from a height of 100 metres



Studying the impact of glacial meltwater on marine ecosystems by ship in Jones Sound, Nunavut

The 2019 PCSP project listing is organized alphabetically by last name and by province and territory. Each project is listed with project title, principal investigator (institution) and location within the province or territory.

*Projects with field site locations in multiple territories and/or provinces are listed under each applicable region and marked with an asterisk.

ALBERTA

Oil sands reactive transport model 2019
Paul Gammon (Natural Resources Canada)
Muskeg River Mine

Paleolimnological studies to distinguish the roles of river regulation and climate change on persistent low water levels in the Peace-Athabasca Delta
Roland Hall (University of Waterloo)
Fort Chipewyan

Western Canada Gravity and Canadian Base Network surveys and installation*
Jason Silliker (Natural Resources Canada)
Multiple locations

A foundation for aquatic ecosystem monitoring of lakes in the Peace-Athabasca Delta
Brent Wolfe (Wilfrid Laurier University)
Fort Chipewyan

BRITISH COLUMBIA

Sedimentology and stratal architecture of an ancient deep-marine turbidite system, Neoproterozoic Windermere Supergroup, Canadian Cordillera
Bill Arnott (University of Ottawa)
Locations near McBride

Geothermal resource potential of the Garibaldi volcanic belt
Jim Craven (Natural Resources Canada)
Lillooet River North of Pemberton

Targeted Geoscience Initiative 5 - Mantle metal mobility
Christopher Lawley (Natural Resources Canada)
Atlin and Iskut

Prospecting for a buried paleo-channel, Tweedsmuir Glacier, northern British Columbia
Dan Shugar (University of Calgary)
Tweedsmuir Glacier

Western Canada Gravity and Canadian Base Network surveys and installation*
Jason Silliker (Natural Resources Canada)
Multiple locations

MANITOBA

Winter trial (vibration + climatic effect)
Carl De Ladurantaye (Department of National Defence)
Shilo

On ice ecology of polar bears in Hudson Bay
Andrew Derocher (University of Alberta)
Churchill

Sustaining hydroecological monitoring to assess state of the park in Wapusk National Park, Manitoba – 2019
Melissa Gibbons (Parks Canada)
Wapusk National Park

Targeted Geoscience Initiative 5 Project - Chromium and nickel*
Michel Houlé (Natural Resources Canada)
Thompson

Tracking post-breeding dispersal in migratory shorebirds
Erica Nol (Trent University)
Wapusk National Park

Terrestrial food web interactions at the Arctic's edge
James Roth (University of Manitoba)
Wapusk National Park

NEW BRUNSWICK

Regional active control station repairs in New Brunswick
Jason Silliker (Natural Resources Canada)
Saint-Quentin

NEWFOUNDLAND AND LABRADOR

Mary's Harbour site visit
Jennifer Culleton (Natural Resources Canada)
Mary's Harbour

Tectonic controls on gold mineralization
Ian Honsberger (Natural Resources Canada)
Locations in central Newfoundland Island

Lichen mapping and survey in Labrador
Christian Prevost (Natural Resources Canada)
Labrador City

Infrasound and seismic detection of blasts
Reid Van Brabant (Natural Resources Canada)
Wabush, Labrador City and Fermont

NORTHWEST TERRITORIES

Banks Island Seismic Network (BISN): Seismic hazard and natural resource potential across Banks Island, Northwest Territories, and surrounding southwestern Canadian Arctic
Pascal Audet (University of Ottawa)
Ulukhaktok (Victoria Island) **and Inuvik**

Assessing terrain sensitivity to permafrost thaw and fire to understand and predict boreal caribou habitat and forage quality in the Sahtú
Jennifer Baltzer (Wilfrid Laurier University)
Norman Wells

Dall's sheep research project
Édouard Bélanger (Gwich'in Renewable Resources Board)
Richardson Mountains

Changes to Arctic precipitation interception due to land cover changes
Aaron Berg (University of Guelph)
Trail Valley Creek

Glacier mass balance - Queen Elizabeth Islands, Nunavut & Northwest Territories*
David Burgess (Natural Resources Canada)
Melville Ice Cap (Melville Island)

Permafrost and climate change, western Arctic Canada
Christopher Burn (Carleton University)
Garry Island and Illisarvik

Investigation into the extent of slumping and its impact on landscape morphology within the Thomsen River Watershed in Aulavik National Park (Northwest Territories)
Hayleigh Conway (Parks Canada)
Aulavik National Park (Banks Island)

Beaufort Sea Coastal permafrost and geohazard studies
Scott Dallimore (Natural Resources Canada)
Inuvik

Annual maintenance of Environment and Climate Change Canada's automatic weather station array - Arctic Archipelago*
Rich DeVall (Environment and Climate Change Canada)
Mould Bay (Prince Patrick Island) **and Cape Providence** (Melville Island)

Detailed study of the rhyolite dome and surrounding volcanic rocks at Sunset Lake, Slave Craton, Northwest Territories
Michelle DeWolfe (Mount Royal University)
Sunset Lake

PermaSAR Winter fieldwork - Ice road Yellowknife
Hugo Drouin (Natural Resources Canada)
Yellowknife

State and evolution of Canada's glaciers – Mass balance Northern Cordillera, Northwest Territories
Mark Ednie (Natural Resources Canada)
Bologna Glacier

Subarctic metals mobility study
Michael English (Wilfrid Laurier University)
Various locations north of Great Slave Lake

Collecting surface sediment from a lake in the Peace-Athabasca Delta, northern Alberta

Shale basin evolution in the Northwest Territories mainland
Kathryn Fiess (Northwest Territories Geological Survey)
Norman Wells, Imperial River, Mountain River, Gayna Gorge, Carcajou River South and Powell Creek

Early opening of the Mackenzie Valley and the setting of prominent thaw slumps
Duane Froese (University of Alberta)
Keele River, Redstone River, Carcajou Canyon and Dry Falls

Population assessment of Dolly Varden 2019*
Colin Gallagher (Fisheries and Oceans Canada)
Big Fish River

Permafrost active layer geochemistry
Paul Gammon (Natural Resources Canada)
Inuvik to Tuktoyaktuk Highway

Understanding changes in aquatic ecosystem health and water quality in the Fort Good Hope–Ramparts area
Kirsty Gurney (Environment and Climate Change Canada)
Fort Good Hope

Beaufort Sea Coastal Restoration program - Using indigenous plant species to mitigate the impacts of permafrost thaw slumping
Erika Hille (Aurora College)
Water Lake, Peninsula Point, Crumbling Point, Tuktoyaktuk Island and Kugmallit Bay

Investigating the factors driving the water quality of streams in the Beaufort Delta region
Erika Hille (Aurora College)
Midway Lake

The impacts of natural and anthropogenic disturbances on the aquatic health of tundra upland lakes
Erika Hille (Aurora College)
Noell Lake

Evaluating the cumulative impacts of climate change and other stressors on the Great Bear Lake ecosystem
Kimberly Howland (Fisheries and Oceans Canada)
Great Bear Lake

Devonian reference section, source rocks and paleomagnetic study
Pavel Kabanov (Natural Resources Canada)
Prohibition Creek, Norman Wells area

Geo-mapping for energy and minerals community engagement close-outs*
Tom Kingdon (Natural Resources Canada)
Fort Resolution and Norman Wells

Targeted bedrock mapping of Archean volcanic belts and surrounding Archean basement complexes
Bernadette Knox (Northwest Territories Geological Survey)
Newbigging Lake, Desteffany Lake and Point Lake

Integrated methods to monitor permafrost geohazards, northwestern Northwest Territories
Steven Kokelj (Northwest Territories Geological Survey)
Inuvik

Long-term lake ecosystem change in the western Canadian Arctic
Jennifer Korosi (York University)
Inuvik

Vegetation change in the western Arctic*
Trevor Lantz (University of Victoria)
Locations near Anderson River, Outer Delta, Jimmy Lake, Husky Lakes and Sandy Hills

Beluga telemetry and habitat research in the Inuvialuit Settlement Region
Lisa Loseto (Fisheries and Oceans Canada)
Shingle Point, East Whitefish and Hendrickson Island

Movement of coastal fishes in the Ulukhaktok region 2019
Lisa Loseto (Fisheries and Oceans Canada)
Ulukhaktok (Victoria Island)

Aerial survey of the Beaufort Sea beluga population*
Marianne Marcoux (Fisheries and Oceans Canada)
Inuvik

Hydrology and climate of the western Canadian Arctic
Philip Marsh (Wilfrid Laurier University)
Trail Valley Creek

Tectonostratigraphy of the Nonacho Group basin and nature of basement rocks of the Rae Craton, Northwest Territories
Edith Martel (Northwest Territories Geological Survey)
Gray Lake, Tent Lake, Nonacho Lake, MacInnis Lake and Salked Lake

Defining the biothermal envelope of Dolly Varden in the Canadian western Arctic to inform conservation planning
Neil Mochnacz (Fisheries and Oceans Canada)
Fish Creek (Rat River watershed)

Vulnerabilities of Arctic cod early life stages to changing oceanographic conditions in Arctic coastal embayments
Andrea Niemi (Fisheries and Oceans Canada)
Franklin Bay

Collecting digital imagery of significant cultural sites in Aulavik National Park
Ashley Piskor (Parks Canada)
Aulavik National Park (Banks Island)

2,000 years of tree-rings and climate change in the Mackenzie Delta region
Trevor Porter (University of Toronto)
Inuvik

Integrating fixed-wing and helicopter surveys to improve detection and species identification of breeding scoters
Eric Reed (Environment and Climate Change Canada)
Lynx Lake

Western Arctic snow goose management and habitat assessment
Eric Reed (Environment and Climate Change Canada)
Siksik Lake and Banks Harbour (Banks Island) **and Inuvik**

Western Canada Gravity and Canadian Base Network surveys and installation*
Jason Silliker (Natural Resources Canada)
Multiple locations

Measuring the temperature, acidity and salinity of water in Resolute Bay, Nunavut

Abrupt change within the discontinuous permafrost zone
Wendy Sladen (Natural Resources Canada)
Yellowknife

Community engagement close out meetings: Paulatuk and Tuktoyaktuk
Rod Smith (Natural Resources Canada)
Paulatuk and Tuktoyaktuk

Changing permafrost conditions in the Mackenzie Valley
Sharon Smith (Natural Resources Canada)
Inuvik, Normal Wells and Fort Simpson

Land-water linkages and the fate of terrestrial carbon in aquatic ecosystems of the western Canadian Arctic
Suzanne Tank (University of Alberta)
Inuvik and Fort McPherson

Assessment of Dolly Varden stocks in Ivvavik National Park 2019*
David Tavares (Parks Canada)
Inuvik

Radar remote sensing for ice cover mapping
Joost van der Sanden (Natural Resources Canada)
Inuvik

Understanding the acceleration of climate-driven coastal change in the Inuvialuit Settlement Region*
Dustin Whalen (Natural Resources Canada)
Inuvik, Paulatuk, and Tuktoyaktuk

Abrupt change within the discontinuous permafrost zone
Stephen Wolfe (Natural Resources Canada)
Yellowknife

NOVA SCOTIA

Atmospheric deposition 2019
Robert Beaudoin (Natural Resources Canada)
Multiple locations

Climate change – Nova Scotia
Carrie Rickwood (Natural Resources Canada)
Halifax

NUNAVUT

Karrak Lake assessment of continental efforts at population reduction of light geese
Ray Alisauskas (Environment and Climate Change Canada)
Perry River and Karrak Lake

Environmental change in aquatic ecosystems of northern Ellesmere Island
Dermot Antoniades (Université Laval)
Stuckberry Valley and Lake Hazen, Quttinirpaaq National Park (Ellesmere Island)

Ecology of Arctic and red fox on Bylot Island
Dominique Berteaux (Université du Québec à Rimouski)
Bylot Island

Ecology of migratory birds in the Canadian Arctic
Joël Bêty (Université du Québec à Rimouski)
Bylot Island

Impacts of melting tidewater glaciers on marine biogeochemical cycles
Maya Bhatia (University of Alberta)
Sverdrup Glacier and True Love lowlands (Devon Island) **and Grise Fiord** (Ellesmere Island)

Paleolimnological investigations of human and wildlife impacts on Arctic freshwater ecosystems
Jules Blais (University of Ottawa)
Cape Garry, Hazard Inlet and Whaler Point (Somerset Island)**, Bird Pond** (Prince Leopold Island)**, and Fellfoot Point and Cape Vera** (Devon Island)

Sampling snow in the Aishihik watershed in Yukon during surface hoar conditions

National Areal Surveillance Program – NASP
Martin Bouchard (Transport Canada)
Resolute Bay

Power and energy system for underwater acoustic arrays at Gascoyne Inlet
Stéphanie Breton and Eric McDonald (Natural Resources Canada)
Gascoyne Inlet (Devon Island)

Instrument calibration at Eureka weather station as part of the Canadian Brewer Spectrophotometer Network operation
Michael Brohart (Environment and Climate Change Canada)
Eureka (Ellesmere Island)

Lake ice in the Canadian high Arctic
Laura Brown (University of Toronto Mississauga)
Resolute (Cornwallis Island) **and Polar Bear Pass** (Bathurst Island)

Glacier mass balance-Queen Elizabeth Islands, Nunavut & Northwest Territories*
David Burgess (Natural Resources Canada)
Agassiz Ice Cap and Grise Fiord (Ellesmere Island)**, Devon Ice Cap** (Devon Island) **and Meighen Ice Cap** (Meighen Island)

A new window on the universe: Radio astronomy from northern Canada
Hsin Cynthia Chiang (McGill University)
Expedition Fiord (Axel Heiberg Island)

Airborne gravity survey over Devon Ice Cap
Alison Criscitiello (University of Alberta)
Grise Fiord (Ellesmere Island) **and Resolute** (Cornwallis Island)

Viral ecology of the high Canadian Arctic in water, ice and aerosols
Alexander Culley (Université Laval)
Expedition Fiord (Axel Heiberg Island)**, Resolute** (Cornwallis Island)**, Ward Hunt Island and Thores Lake** (Ellesmere Island)

Annual maintenance of Environment and Climate Change Canada's automatic weather station array – Arctic Archipelago*
Rich DeVall (Environment and Climate Change Canada)
Isachsen (Ellef Ringnes Island)**, Rea Point** (Melville Island)**, Stefansson Island, Fort Ross** (Somerset Island)**, Gateshead Island, Cape Liverpool** (Bylot Island)**, Svarteveg** (Axel Heiberg Island) **and Grise Fiord** (Ellesmere Island)

Climate change in the high Arctic: Impact on wildlife and permafrost carbon stocks
Florent Domine (Université Laval)
Bylot Island

Physical properties of seasonal and perennial snow cover in the high Arctic
Florent Domine (Université Laval)
Resolute (Cornwallis Island) **and Ward Hunt Island**

Year-round movement in two ice-associated seabirds at Coats Island: Links to population parameters
Kyle Elliott (McGill University)
Coats Island

A weather station network near Cambridge Bay to support safe travel and fundamental boundary layer meteorology research
Brent Else (University of Calgary)
Cambridge Bay and 30-Mile River (Victoria Island)**, Qikirtaarjuk Island, and Melbourne Island**

Sirmilik National Park Operations 2019
Carey Elverum (Parks Canada)
Locations in Sirmilik National Park (Baffin Island and Bylot Island)

Population dynamics and trophic interactions of Arctic rodents*
Dominique Fauteux (Canadian Museum of Nature)
Cambridge Bay (Victoria Island)

Disturbance and transformation of permafrost Arctic geosystems
Daniel Fortier (Université de Montréal)
Bylot Island

GEO-NEIGE: Geomorphology of northern Ellesmere Island in the global environment
Daniel Fortier (Université de Montréal)
Ward Hunt Island

Fuel drum removal and disposal - Pond Inlet & Bylot Island, Nunavut
Marlene Francis (Natural Resources Canada)
Pond Inlet (Baffin Island)

Annually laminated sediments (varves) of the Canadian high Arctic
Pierre Francus (Institut National de la Recherche Scientifique)
Strathcona Lake (Ellesmere Island)

Inuinnait heritage: A collaborative approach to archaeological research in the Canadian Arctic
Max Friesen (University of Toronto)
Bathurst Inlet and Kent Peninsula

Biology of bird and small tundra mammal populations: Demographics, trophic interactions and climate change
Gilles Gauthier (Université Laval)
Bylot Island

Population studies of eider ducks breeding at East Bay Island and thick-billed murres breeding at Coats Island, Nunavut
Grant Gilchrist (Environment and Climate Change Canada)
East Bay Island (Southampton Island) **and Coats Island**

Population surveys of endangered ivory gulls on Ellesmere and Devon islands
Grant Gilchrist (Environment and Climate Change Canada)
Grise Fiord (Ellesmere Island)

An ice camp located about 10 km offshore from Canadian Forces Station Alert in Nunavut

Aerosol virome of Resolute Bay: Dispersal of microbial populations in a warming Arctic

Catherine Girard (Université Laval)
Resolute (Cornwallis Island)

Connections between the Arctic and distant ecosystems through animal migrations: Consequences on trophic interactions in the Arctic

Marie-Andrée Giroux (Université de Moncton)
Cambridge Bay (Victoria Island) **and Igloolik Island**

Periglacial geomorphology and ground ice investigation in the Haughton impact structure area, Devon Island, Nunavut

Etienne Godin (University of Western Ontario)
Haughton River Valley (Devon Island)

PoLAR-FIT Project 2019: Pliocene paleoclimate, paleontology, and paleoecology, Ellesmere Island: Core archive and proteomics

John Gosse (Dalhousie University)
Grist Fiord, Vendom Fiord, Strathcona Fiord and Fyles Leaf Bed (Ellesmere Island)

Nunavut Engagement

James Haggart (Natural Resources Canada)
Pond Inlet

Fishery independent sampling of Cambridge Bay Arctic char with emphasis on the Lauchlan River stock: Year 2 of 5

Les Harris (Fisheries and Oceans Canada)
Byron Bay (Victoria Island)

Tundra ecosystem responses to 30 years of observed and experimental climate change

Greg Henry (University of British Columbia**)**
Alexandra Fiord, Princess Marie Bay and Sverdrup Pass (Ellesmere Island)

Development of tools and capacity for community-based monitoring of biodiversity shifts and early detection of aquatic invasive species (AIS) in the Canadian Arctic

Kimberly Howland (Fisheries and Oceans Canada)
Ragged Island

Fury and Hecla geoscience project, Melville Peninsula 2019

Alessandro Ielpi (Laurentian University)
Igloolik (Igloolik Island) **and Melville Peninsula**

Assessing risks of food- and vector-borne diseases in wildlife in the Canadian Arctic

Emily Jenkins (University of Saskatchewan)
Karrak Lake and Perry River

Repeater towers

Deborah Johnson (Hamlet of Arctic Bay)
Locations adjacent to Admiralty Inlet (Baffin Island)

Inuit Tapiriit Kanatami's executive training program
Kevin Kablutsiak (Inuit Tapiriit Kanatami)
Cambridge Bay, Gjoa Haven and Taloyoak

Joint Arctic experiment 2019
Martin Kegel (Natural Resources Canada)
Resolute (Cornwallis Island)

Geo-mapping for energy and minerals community engagement close-outs*
Tom Kingdon (Natural Resources Canada)
Baker Lake and Coral Harbour

Spatial heterogeneity of soil-snow-plant interactions in the high Arctic ecosystem
Christophe Kinnard (Université du Québec à Trois-Rivières)
Bylot Island

Holocene ice wedge activity in the Eureka Sound region, high Arctic Canada
Denis Lacelle (University of Ottawa)
Eureka (Ellesmere Island)

Migratory and breeding ecology of birds facing global environmental change
Jean-François Lamarre (Polar Knowledge Canada)
Anderson bay and Icebreaker Channel

Eureka geomagnetic electronic replacement
Mark Lamothe (Natural Resources Canada)
Eureka (Ellesmere Island) **and Resolute** (Cornwallis Island)

Impacts of climate and permafrost change on High Arctic water and land systems
Scott Lamoureux (Queen's University)
Cape Bounty (Melville Island) **and Resolute** (Cornwallis Island)

Effect of climate on Arctic lakes: Seasonality, biogeochemical functioning and greenhouse gas emissions
Isabelle Laurion (Institut national de la recherche scientifique)
Qarlikturvik Valley, Sirmilik National Park (Bylot Island)

Baffin Island goose banding
Jim Leafloor (Environment and Climate Change Canada)
Nikko Island (Baffin Island)

Southampton Island goose banding
Jim Leafloor (Environment and Climate Change Canada)
Coral Harbor (Southampton Island)

Survival in Arctic geese
Jim Leafloor (Environment and Climate Change Canada)
Perry River, Queen Maud Gulf Bird Sanctuary

Fury and Hecla geoscience project
Lorraine Lebeau (Canada-Nunavut Geoscience Office)
Gifford River, Jungerson River and Ivisarak Lake (Baffin Island)

Arctic IMPACTS: Tracking impacts of ecosystem changes in the Arctic
Nicolas Lecomte (Université de Moncton)
Bylot Island, Igloolik Island and Eureka (Ellesmere Island)

Population dynamics of Greater Snow Geese in relation to habitat
Josée Lefebvre (Environment and Climate Change Canada)
Bylot Island

Out of the freezer and into the fire: Climate-warming-driven contaminant mobilization from glaciers to downstream freshwater ecosystemss
Igor Lehnherr (University of Toronto)
Lake Hazen (Ellesmere Island)

Plant community dynamics in a changing environment: Permafrost-vegetation interactions in polar deserts
Esther Lévesque (Université du Québec à Trois-Rivières)
Ward Hunt Island

Restoration of anadromous Arctic char (Salvelinus alpinus) and Dolly Varden (Salvelinus malma malma) near Kugluktuk, Nunavut
Tracey Loewen (Fisheries and Oceans Canada)
Kugluktuk

Stress-mediated mechanisms linking individual state, climate variability and population health in Arctic-breeding birds
Oliver Love (University of Windsor)
East Bay Island (Southampton Island)

Threat and risk assessment for Polar Knowledge Canada's Canadian High Arctic Research Station
Jeremy Mailhot-Gamble (Natural Resources Canada)
Cambridge Bay

Wolf predation and Peary caribou population composition on the Bathurst Island Complex
Conor Mallory (Government of Nunavut)
Various locations on Bathurst Island

Contaminants in seabirds at Prince Leopold Island
Mark Mallory (Acadia University)
Prince Leopold Island

Seabird census and paleo history at Cape Vera, Nunavut
Mark Mallory (Acadia University)
Cape Vera (Devon Island)

Tracking Arctic terns in the high Arctic
Mark Mallory (Acadia University)
Tern Island

Aerial survey of the Beaufort Sea beluga population*
Marianne Marcoux (Fisheries and Oceans Canada)
Resolute (Cornwallis Island)

Narwhal passive ecosystem monitoring in Tremblay Sound
Marianne Marcoux (Fisheries and Oceans Canada)
Tremblay Sound (Baffin Island)

Mixed-stock fisheries analysis near Pond Inlet, Nunavut
Zoya Martin (Fisheries and Oceans Canada)
Pond Inlet (Baffin Island)

Canadian High Arctic Research Station environmental research area
Donald McLennan (Polar Knowledge Canada)
Cambridge Bay (Victoria Island)

Multidisciplinary Arctic Program (MAP) – Last Ice
Christine Michel (Fisheries and Oceans Canada)
Alert (Ellesmere Island)

Disappearing Ice
Gifford Miller (University of Colorado Boulder)
Serpens Ice Cap and Africa Lake (Baffin Island)

Predicting Arctic change through ecosystem molecular proxies (PACEMAP)
Gifford Miller (University of Colorado Boulder)
Clyde River (Baffin Island)

2019 high Arctic and Qiktani water licence, land use and lease inspections
Joseph Monteith (Crown-Indigenous Relations and Northern Affairs Canada)
Locations on Cornwallis Island, Devon Island, Ellef Ringnes Island, King Christian Island, Lougheed Island, Bathurst Island, Melville Island, Ellesmere Island, Somerset Island and Prince Leopold Island

Rapid landscape evolution at the permafrost-glacier interface
Brian Moorman (University of Calgary)
Bylot Island

Dynamics and habitat use by lemmings under climate change
Douglas Morris (Lakehead University)
Cambridge Bay (Victoria Island) **and Walker Bay**

Milne Fiord ice-ocean interactions: Implications for the stability of ice shelves and glaciers in the polar regions
Derek Mueller (Carleton University)
Purple Valley Strip and Milne Ice Shelf (Ellesmere Island)

Investigating potential effects of climate warming on trends of mercury and persistent organic pollutants in Arctic aquatic and terrestrial environments
Derek Muir (Environment and Climate Change Canada)
Resolute and Amiktuk Lake (Cornwallis Island)**, and Cape Bounty** (Melville Island)

ARCTIC Change (Arctic Research and Conservation Trip Investigating Climate Change)
Susan Murch (University of British Columbia)
Resolute Bay (Cornwallis Island)

Aircraft support for Auyuittuq National Park operations and research
Mathew Nauyuq (Parks Canada)
Penny Ice Cap and Pangnirtung (Baffin Island)

Effects of overabundant Arctic geese on other tundra nesting birds
Erica Nol (Trent University)
East Bay Mainland (Southampton Island)

Nunavut transportation and transmission
Greg Oldenborger (Natural Resources Canada)
Rankin Inlet

A multidisciplinary study of glacial and periglacial processes on Axel Heiberg Island, Nunavut
Gordon Osinski (University of Western Ontario)
Buchanan Lake (Axel Heiberg Island)

Fuel depot for CASE 22 - Parry Islands
Karsten Piepjohn (Federal Institute for Geosciences and Natural Resources - Germany)
Resolute (Cornwallis Island)

Quttinirpaaq National Park operating season 2019
Angela Piercey (Parks Canada)
Locations in Quttinirpaaq National Park (Ellesmere Island and Ward Hunt Island)

Nirjutiqavvik National Wildlife Area - North Water Research Station clean-up
Lisa Pirie-Dominix (Environment and Climate Change Canada)
Coburg Island, Nirjutiqavvik National Wildlife Area

Collecting permafrost samples in the Qarlikturvik Valley on Bylot Island, Nunavut

A helicopter at Expedition Fiord on Axel Heiberg Island, Nunavut

McGill Arctic Research Station (MARS) science program
Wayne Pollard (McGill University)
Expedition Fiord (Axel Heiberg Island)

The vulnerability and resiliency of ice-rich permafrost in cold polar desert environments in response to changing climate
Wayne Pollard (McGill University)
Eureka (Ellesmere Island) **and Expedition Fiord** (Axel Heiberg Island)

The vulnerability of high Arctic permafrost to climate change
Wayne Pollard (McGill University)
Expedition Fiord (Axel Heiberg Island)

Functional, structural and biodiversity studies of Arctic freshwater watersheds: Validating protocols for monitoring and cumulative impacts assessment
Michael Power (University of Waterloo)
Cambridge Bay (Victoria Island)

Arctic shorebird monitoring program (Arctic PRISM) - Tier 1 surveys
Jennie Rausch (Environment and Climate Change Canada)
Air Force Island, Prince Charles Island and Rasmussen Lowlands

Population studies of shorebirds at Nanuit Itillinga Polar Bear Pass National Wildlife Area, Nunavut (Arctic PRISM Tier 2 Site)
Jennie Rausch (Environment and Climate Change Canada)
Polar Bear Pass (Bathhurst Island)

Water, carbon and mercury cycling in Arctic terrestrial and freshwater ecosystems
Murray Richardson (Carleton University)
Iqaluit

Understanding Cretaceous High Arctic paleoenvironmental and paleoclimatic change
Claudia Schröder-Adams (Carleton University)
Locations on Axel Heiberg Island and Devon Island

Population plasticity in behavioural responses and their consequences to novel predator-prey interactions under changing biotic and abiotic stressors on Mitivik (East Bay) Island, Nunavut
Christina Semeniuk (University of Windsor)
East Bay Island (Southampton Island)

Dynamics and change of Canadian Arctic ice caps
Martin Sharp (University of Alberta)
Sverdrup Glacier (Devon Island) **and Lake Hazen** (Ellesmere Island)

Qausuittuq National Park operations 2019
Jovan Simic, (Parks Canada)
Locations in Qausuittuq National Park (Bathurst Island)

Inuit Field Training Program at East Bay mainland and Prince Charles Island, Nunavut
Paul Smith and Grant Gilchrist (Environment and Climate Change Canada)
East Bay Mainland (Southampton Island) **and Prince Charles Island**

Population studies of shorebirds at East Bay mainland and Prince Charles Island, Nunavut

Paul Smith and Jennie Rausch (Environment and Climate Change Canada)
East Bay (Southampton Island) **and Prince Charles Island**

Canadian Arctic Underwater Sentinel Experimentation (CAUSE) project

Jennifer Spearman (Defence Research and Development Canada)
Gascoyne Inlet (Devon Island)

Geomagnetic observatory maintenance at Alert, Nunavut

Benoit St-Louis (Natural Resources Canada)
Alert

The impacts of rapidly receding glaciers on downstream freshwater resources and ecological services

Vincent St. Louis (University of Alberta)
Lake Hazen, Quttinirpaaq National Park (Ellesmere Island)

High frequency dynamics of the high Arctic geomagnetic field during the Late Quaternary

Guillaume St-Onge (Université du Québec à Rimouski)
Stuckberry Valley (Ellesmere Island)

Glacier dynamics and downstream impacts on Axel Heiberg Island, Nunavut

Laura Thomson (Queen's University)
Expedition Fiord (Axel Heiberg Island)

North-eastern Baffin Island and Ulinniq surficial geology projects

Tommy Tremblay (Canada-Nunavut Geoscience Office)
Pond Inlet and Clyde River (Baffin Island)

Northern Ellesmere Island in the global environment – Sentinel North

Warwick Vincent (Université Laval)
Resolute (Cornwallis Island)**, Thores Lake** (Ellesmere Island) **and Ward Hunt Island**

Assessment of natural attenuation of an experimental oil spill on an Arctic beach

Lyle Whyte (McGill University)
Resolute Bay (Cornwallis Island)

Microbial investigations of permafrost and cold saline springs in the high Arctic

Lyle Whyte (McGill University)
Expedition Fiord (Axel Heiberg Island)

2019 Ukkusiksalik National Park operations

Monty Yank (Parks Canada)
Locations in Ukkusiksalik National Park

ONTARIO

Cumulative effects from mineral resource development in mining-impacted watersheds

Alexandre Desbarats (Natural Resources Canada)
Cobalt

Hydrogeological and hydrogeochemical factors contributing to landslides in Champlain Sea sediments

Marc Hinton (Natural Resources Canada)
Bilberry Creek and Voyageur Creek

Lands and Minerals sector occupational health and safety training courses 2019

Shelley Hovey (Natural Resources Canada)
Ottawa

Cumulative effects of resource development in mining-impacted watersheds

Micheal Parsons (Natural Resources Canada)
Cobalt

Lands and Minerals sector mining field schools 2019

Micheal Parsons (Natural Resources Canada)
Elliot Lake and Sudbury

Cumulative effects of resource development in mining-impacted watersheds

Jeanne Percival (Natural Resources Canada)
Cobalt

Health Portfolio Operations Centre mobilizations

Violaine Pilote (Public Health Agency of Canada)
Ottawa

Benthic invertebrate surveys in mining impacted areas in Sudbury, Ontario

Carrie Rickwood (Natural Resources Canada)
Sudbury

Targeted Geoscience Initiative-5 -Ni-Cu-PGE mineralization in the Midcontinent Rift, western Ontario

Jennifer Smith (Natural Resources Canada)
Thunder Bay

QUEBEC

Paleoseismic investigations in western Quebec, southeastern and northeastern Ontario

Greg Brooks (Natural Resources Canada)
Locations near Temiscaming and Val-des-Monts

Upgrades to global navigation satellite system in Kuujjuarapik

Stuart Elson (Natural Resources Canada)
Kuujjuarapik

Population dynamics and trophic interactions of Arctic rodents*

Dominique Fauteux (Canadian Museum of Nature)
Salluit

Targeted Geoscience Initiative 5 Project – Chromium and nickel*

Michel Houlé (Natural Resources Canada)
Raglan

Quebec mines expo
Nathalie Jacob (Natural Resources Canada)
Quebec City

Coastal oceanography of the east coast of James Bay
Urs Neumeier (Université du Québec à Rimouski)
James Bay

Canadian-United States border monument maintenance and survey
Luc Robichaud (Natural Resources Canada)
Beauce and Estrie

Canadian-United States border monument maintenance
André Vachon (Natural Resources Canada)
East Hereford, Lac-Mégantic, Saint-Pamphile and Saint-Zacharie

SASKATCHEWAN

Targeted Geoscience Initiative: Uranium fluid pathways
Eric Potter (Natural Resources Canada)
Patterson Lake Corridor

YUKON

Multi-scale assessment of environmental changes impact on glacierized watersheds hydrology of Yukon
Michel Baraer (École de technologie supérieure)
Grizzly Creek, Kluane National Park and Reserve and Silver City

Inventory of species at risk and rare species in Dàadzàii Van Territorial Park in northern Yukon
Bruce Bennett (Yukon Government)
Summit Lake

Permafrost vulnerability in Old Crow Flats, Yukon
Fabrice Calmels (Yukon College)
Eagle Plains

Mass balance, dynamics and recent changes of glaciers in Kluane National Park, Yukon
Luke Copland (University of Ottawa)
Donjek Glacier, Kaskawulsh Glacier and St. Elias ice field, Kluane National Park and Reserve

A comprehensive analysis of surging glacier dynamics and controls in the Yukon Territory, Canada
Christine Dow (University of Waterloo)
Lowell Glacier

Fishing branch river chum salmon instream incubation
Darius Elias (Vuntut Gwitchin Government)
Eagle Plains, Yukon

Observational constraints on glacier form and flow, southwest Yukon, Canada
Gwenn Flowers (Simon Fraser University)
Silver City, Kluane Lake, and locations in Kluane National Park and Reserve

Population assessment of Dolly Varden 2019*
Colin Gallagher (Fisheries and Oceans Canada)
Babbage River and Rat River

Archaeological field research in Vuntut Gwitchin First Nation Traditional Territory, Northern Yukon
Ty Heffner (Government of Yukon)
Old Crow

Inuvialuit living history project: Imniarvik culture and heritage camp
Lisa Hodgetts (University of Western Ontario)
Imniarvik, Ivvavik National Park

Glacial meltwater sampling site at the Sverdrup Glacier, Devon Island, Nunavut

Arctic fireweed on
Axel Heiberg Island, Nunavut

Vegetation change in the western Arctic*
Trevor Lantz (University of Victoria)
Locations near Coal Mine Lake, Blow River and Babbage River

Hydrological and ecological research in Vuntut National Park, Yukon
Ian McDonald (Parks Canada)
Old Crow

Dual-band airborne radar remote sensing for monitoring Arctic climate change processes
Bernhard Rabus (Simon Fraser University)
Kluane National Park and Reserve

A field laboratory for energy and mass exchange at glacier surfaces
Valentina Radic (University of British Columbia)
Kaskawulsh Glacier, Kluane National Park and Reserve

Subglacial hydraulics and glacier dynamics in the Donjek Ranges
Christian Schoof (University of British Columbia)
Kaskawulsh Glacier and Donjek Glacier, Kluane National Park and Reserve

Western Canada Gravity and Canadian Base Network surveys and installation*
Jason Silliker (Natural Resources Canada)
Multiple locations

Van Tat Gwich'in Historic Lifeways Project 2019–20
Shirleen Smith (Vuntut Gwitchin Government)
Upper Timber Creek and Ch'adaghoo Mountain

Assessment of Dolly Varden stocks in Ivvavik National Park 2019*
David Tavares (Parks Canada)
Firth River, Fish Creek, Joe Creek and Sheep Creek

Understanding the acceleration of climate-driven coastal change in the Inuvialuit Settlement Region*
Dustin Whalen (Natural Resources Canada)
Komakuk

Why are kokanee salmon declining in Yukon?
Carmen Wong (Parks Canada)
Sockeye Lake

Pleistocene paleontology of the Old Crow Basin, northern Yukon
Grant Zazula (Government of Yukon)
Old Crow River

INTERNATIONAL

Space Mission C3 - David Saint-Jacques
Edward Tabarah (Canadian Space Agency)
Karaganda, Kazakhstan

ANNEX

Participants of the Imniarvik culture camp hike in the British Mountains, Yukon.

PCSP Project Review Committee

The PCSP Project Review Committee (PRC) reviews and evaluates all logistics requests submitted by university-based researchers. The review process is based on the PRC Scoring Guide, which includes four criteria: feasibility of the requested logistics; quality of the application; scientific recognition of the applicant; and student and local involvement and engagement. For more information on the review process for university applicants, contact the PCSP.

PCSP Project Review Committee Members 2019

Roger Paulen (Chair)
Geological Survey of Canada
Natural Resources Canada

Michael Kristjanson
Polar Continental Shelf Program
Natural Resources Canada

Trevor Lantz
Environmental Studies
University of Victoria

Micheline Manseau
Landscape Science and Technology Division
Environment and Climate Change Canada

Erica Nol
Biology Department
Trent University

Lyle Whyte
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