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Polar Continental Shelf Program

SCIENCE REPORT 2016

Logistical support for leading-edge scientific research in Canada and its Arctic

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Polar Continental Shelf Program Science Report 2016: Logistical support for leading-edge scientific research in Canada and its Arctic

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Cover photograph: A meteorological, snow and permafrost data station in the Qarlikturvik valley, Bylot Island, Nunavut. The data from this station will be used to quantify the impact of willow growth on the permafrost thermal regime.

Section header image: Preparing for departure on the Agassiz Ice Cap, Northern Ellesmere Island, after a successful ice core drilling mission.

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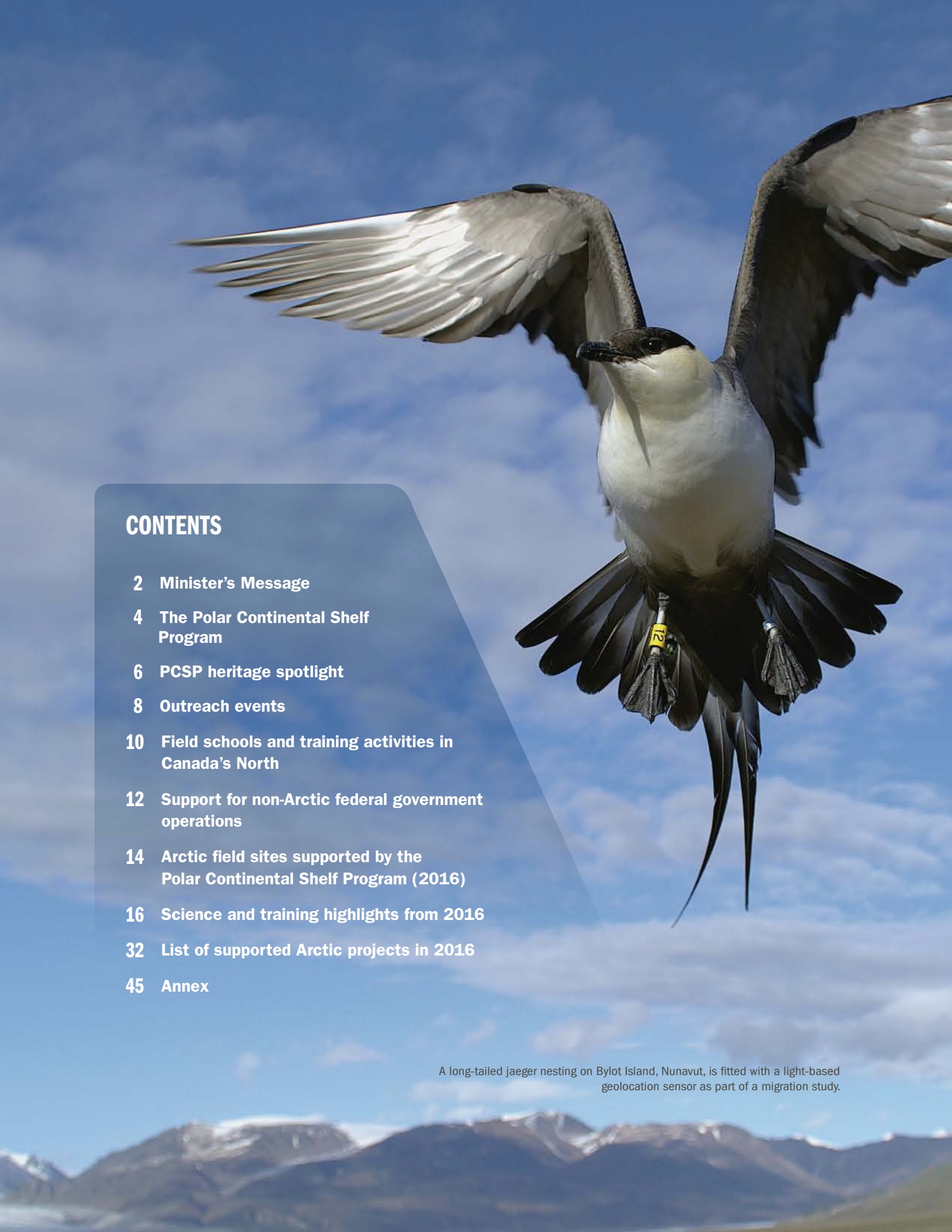

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A long-tailed jaeger nesting on Bylot Island, Nunavut, is fitted with a light-based geolocation sensor as part of a migration study.

The 1 billion-year-old Aquigilik Formation looms over the fog-enshrouded Elwin Inlet, northern Baffin Island.

Minister's Message

Canada's North is a fundamental part of our heritage, our identity and our future. As we celebrate the 150th anniversary of Confederation, it is remarkable to see how far we have come in our understanding of the North. From the adventures of early explorers to the latest scientific discoveries and the use of traditional knowledge, we continue to unlock its mysteries and discover its potential.

This pursuit of scientific understanding is helping to create economic growth and improve the quality of life of northerners while supporting environmental stewardship of the land.

The Polar Continental Shelf Program (PCSP) plays a central role in these efforts by providing the logistical support essential to research and discovery, supporting everything from understanding the impacts of climate change to informing adaptation and from gathering critical data to strengthening mineral exploration and sustainable resource development.

Last year, the PCSP supported 145 Arctic research projects involving more than 750 participants from federal and territorial government departments and Canadian and international universities, as well as a host of international research organizations. This support included chartering aircraft, supplying field equipment to research teams and accommodating hundreds of scientists and students at the PCSP Resolute facility in Nunavut — all with the goal of enhancing the collective knowledge of the North.

For 150 years, this vast, magnificent part of our country has challenged us, inspired us and intrigued us. Thanks to the work of the PCSP, it continues to teach us.

The Honourable Jim Carr,
Canada's Minister of Natural Resources

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ᑲᓇᑕᐅᑉ ᐅᑭᐅᖅᑕᖅᑐᖓ ᐃᓚᒋᔭᐅᓪᓚᕆᖓᑦ ᐃᓕᖅᑯᓯᑐᖅᑲᑦᑎᓐᓄᑦ, ᓇᓗᓇᐃᒃᑯᑎᑦᑎᓐᓄᑦ ᐊᒻᒪ ᓯᕗᓂᒃᓴᑦᑎᓐᓄᑦ. ᖁᕕᐊᓱᒋᑦᑎᖃᑎᓪᓗᑕ 150-ᓂ ᐊᕐᕌᒍᓂ ᑲᓇᑕᐅᑉ ᒐᕙᒪᒃᑯᖏᓐᓂᑦ, ᑕᐃᒪᓕ ᐱᒃᑯᓇᖅᐳᖅ ᑐᑭᓯᓯᒪᓂᖅᓴᐅᓕᕐᓂᑦᑎᓐᓂᑦ ᐅᑭᐅᖅᑕᖅᑐᕐᒥᑦ. ᒪᑯᓇᙵᑦ ᖃᐅᔨᓴᖅᑎᓂᑦ ᓄᓇᓯᐅᕐᓂᕐᒥᑦ ᒪᐅᖓ ᓄᑖᖑᓚᖕᓄᑦ ᖃᐅᔨᓴᑦᑐᓕᕆᓂᒃᑯᑦ ᖃᐅᔨᓴᐅᕙᓪᓕᐊᔪᓂᑦ ᐊᒻᒪᓗ ᐊᑐᖅᐸᒃᑎᒃ ᐃᓄᐃᑦ ᖃᐅᔨᒪᔭᑐᖅᑲᖏᓐᓂᑦ, ᑲᔪᓯᓐᓇᖅᐳᒍ ᓴᕿᑎᑦᑎᕙᓪᓕᐊᓂᕐᒥᑦ ᖃᐅᔨᒪᓇᖏᑦᑐᓂᑦ ᐊᒻᒪ ᖃᐅᔨᕙᓪᓕᐊᓪᓗᑕ ᐋᖏᖅᑲᐳᓇᕐᓂᖏᓐᓂᑦ.

ᐅᓇ ᖃᐅᔨᓴᖅᑐᓕᕆᓂᒃᑯᑦ ᑐᑭᓯᐅᒪᓂᖅ ᐃᑲᔫᑎᖃᖅᐳᖅ ᓴᕿᑎᑦᑎᕙᓪᓕᐊᓂᕐᒥᑦ ᑮᓇᐅᔭᓕᐅᕐᓂᒃᑯᑦ ᐱᔫᖅᐸᓪᓕᐊᓂᕐᒥᑦ ᐊᒻᒪ ᐱᐅᓯᕚᓪᓕᖅᑎᑦᑎᓂᕐᒥᑦ ᐅᑭᐅᖅᑕᖅᑐᕐᒥᐅᑦ ᐃᓅᓯᖏᓐᓂᑦ ᐃᑲᔪᖅᐸᓪᓕᐊᓂᒃᑯᑦ ᐊᕙᑎᒋᔭᒧᑦ ᓄᓇᒥ ᑲᒪᔨᐅᔪᓂᑦ.

ᐅᑭᐅᖅᑕᖅᑐᕐᒥᑦ ᖃᐅᔨᓴᖅᑐᓕᕆᓂᕐᒧᑦ ᐱᓕᕆᓂᖅ (PCSP) ᐃᑲᔫᑎᐅᕗᖅ ᐱᓕᕆᓇᓱᐊᖅᑐᓂ ᐃᓂᕐᑲᖅᑎᑦᑎᕙᖕᓂᒃᑯᑦ ᖃᐅᔨᓴᕐᑲᑦᑕᖅᑐᓂᑦ ᐊᒻᒪ ᖃᐅᔨᔭᐅᕙᓪᓕᐊᔪᓂᑦ, ᐃᑲᔪᖅᐸᒃᐳᑎᒃ ᒫᓐᓇᑦ ᑐᑭᓯᐅᒪᑎᑦᑎᓂᕐᒥᑦ ᓯᓚᐅᑉ ᐊᓯᙳᖅᐸᓪᓕᐊᓂᖓᓂᑦ ᒪᐅᖓ ᑐᓴᐅᒪᑎᑦᑎᓂᕐᒥ ᑕᒪᑐᒥᖓ ᐊᑐᕈᓐᓇᕐᓯᕐᓂᒧᑦ ᐊᒻᒪ ᑲᑎᕐᓯᐃᕙᒃᐳᑎᒃ ᖃᐅᔨᔭᐅᕙᓪᓕᐊᔪᓂᑦ ᓴᖏᑎᑦᑎᔾᔪᑎᐅᔪᓐᓇᖅᑐᓂᑦ ᐅᔭᕋᐅᔭᐃᑦ ᖃᐅᔨᓴᖅᑕᐅᕙᓪᓕᐊᓂᖏᓐᓄᑦ ᐊᒻᒪ ᐊᑐᒃᑲᓂᕈᓐᓇᖅᑐᓕᕆᓂᕐᒥᑦ ᓄᓇᒥᖑᖅᑐᓂᑦ.

ᐊᕐᕌᓂᐅᓚᐅᕐᑐᖅ, PCSP-ᑯᑦ ᐃᑲᔪᖅᑐᐃᓯᒪᓚᐅᕐᐳᑦ 145-ᓂ ᐅᑭᐅᖅᑕᖅᑐᕐᒥᑦ ᖃᐅᔨᓴᖅᑕᐅᓂᐅᔪᓂᑦ ᐱᓕᕆᑎᑦᑎᓯᒪᓪᓗᑎᒃ 750 ᐅᖓᑖᓂᑦ ᐃᓄᖕᓂᑦ ᒫᓐᓇᑦ ᒐᕙᒪᑐᖃᒃᑯᓐᓂᑦ, ᓄᓇᕗᑦ ᒐᕙᒪᒃᑯᖏᓐᓂᑦ ᐊᒻᒪ ᑲᓇᑕᒥ ᐊᒻᒪ ᓄᓇᕐᔪᐊᕐᒥ ᓯᓚᑦᑐᖅᓴᕐᕕᖕᓂᑦ ᔫᓂᕕᓯᑎᓂ, ᐊᒻᒪᓗ ᑐᖓᓱᒃᑎᑦᑎᔨᐅᓯᒪᓪᓗᑎᒃ ᓄᓇᕐᔪᐊᕐᒥ ᖃᐅᔨᓴᖅᑐᓕᕆᓂᕐᒧᑦ ᐱᓕᕆᐊᕐᑲᕐᑲᑦᑕᖅᑐᓂᑦ. ᐅᓇ ᐃᑲᔪᕐᑲᑦᑕᕐᓂᖅ ᐃᒪᓐᓇᐅᕐᑲᑦᑕᖅᐳᖅ ᖃᖓᑕᓲᓂᑦ ᐊᑐᖅᑐᐊᖅᑎᑦᑎᓂᕐᒥᑦ, ᖃᐅᔨᓴᕝᕕᐅᓂᐊᖅᑐᓂᑦ ᐱᕐᑯᑎᕐᑲᖅᑎᑦᑎᓂᕐᒥᑦ ᐊᒻᒪᓗ ᐃᓂᕐᑲᕐᑲᑦᑕᖅᑎᑦᑎᓂᕐᒥᑦ ᐊᒥᓲᒪᓇᖕᓂᑦ ᖃᐅᔨᓴᖅᑎᓂᑦ ᐊᒻᒪ ᐃᓕᓐᓂᐊᖅᑎᓂᑦ ᐅᕙᓂ PCSP-ᑯᑦ ᐱᓕᕆᐕᐊᓂᑦ ᖃᐅᓯᐃᑦᑐᖅ, ᓄᓇᕗᒻᒥ - ᑕᒪᐃᓐᓂᒡᓗ ᑐᕌᒐᕐᑲᖅᑲᐳᑎᒃ ᖃᐅᔨᕙᓪᓕᐊᒐᓱᖕᓂᕐᒥᑦ ᐅᑭᐅᖅᑕᖅᑐᕐᒥᑦ.

ᐊᕐᕌᒍᓕᖅᑐᓂᑦ 150-ᓂ ᐅᑭᐅᓂ, ᐅᓇ ᐊᖏᔪᒻᒪᕆᐊᓗᒃ, ᐱᐅᓪᓚᕆᒃᐳᓂᓗ ᓄᓇᑦᑕ ᐃᓚᖓ ᐅᕙᑦᑎᓐᓂᑦ ᐱᓕᕆᑎᑦᑎᓯᒪᓪᓚᕆᖕᒪᑦ, ᐱᓇᓱᐊᖅᑎᑦᑎᓯᒪᓪᓗᓂ ᐊᒻᒪ ᐅᐱᒍᓱᓕᕐᓇᖅᐳᓂ. ᖁᔭᓐᓇᒦᑦ PCSP-ᑯᑦ ᐱᓇᓱᐊᕙᖏᓐᓂᑦ, ᑲᔪᓯᕙᓪᓕᐊᓂᖏᓐᓂᑦ ᐅᕙᑦᑎᓐᓂ ᖃᐅᔨᕖᓪᓕᖅᐸᓪᓕᐊᑎᑦᑎᓂᕐᒥᑦ.

ᐅᐱᓐᓇᖅᑐᖅ ᔨᒻ ᑳᕐ, ᓄᓇᒥ ᐊᑐᖅᑲᓐᓂᕈᓐᓇᖅᑐᓄᑦ ᒥᓂᔅᑕ

The Honourable Jim Carr
Canada's MInister of
Natural Resources

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The Polar Continental Shelf Program

Scientific fieldwork in remote areas of Canada requires strong logistics support to enable a safe, efficient and successful field season. Since 1958, Natural Resources Canada's (NRCan) Polar Continental Shelf Program (PCSP) has provided logistics support for fieldwork in support of scientific research, federal government operations and training activities taking place across Canada, particularly in Canada's North. This includes logistics planning and coordination assistance to researchers, including chartered fixed- and rotary-wing aircraft, field equipment, a communications network for field parties, advice regarding fieldwork in the Canadian Arctic, and accommodations at the PCSP facility in Resolute, Nunavut.

Each year, the PCSP supports field projects conducted by federal and territorial government departments and agencies, universities, northern organizations, and international research groups. In 2016, PCSP-supported projects included over 1,500 participants and many of the field teams include northern residents, volunteers, and students. Fieldwork provides students with opportunities to gain invaluable experience as they train to become the next generation of Arctic researchers. The PCSP offers field equipment for use by federal government organizations working at locations across Canada. From camp equipment to outdoor clothing to boats and all-terrain vehicles (ATV), the program can supply the gear needed for most types of fieldwork by utilizing its large inventory, which is located at depots in Ottawa, Resolute and Cambridge Bay.

PCSP staff loads fuel drums at the PCSP Resolute Facility for transport to remote Arctic fuel cache locations.

The PCSP leverages its partnerships with Polar Knowledge Canada (POLAR), the Department of National Defence and ArcticNet to boost logistics support for its clients. Through these collaborations more fieldwork can be supported, more important scientific discoveries can be made, and more training activities are completed. Researchers can count on the PCSP to provide safe, professional logistics and expert advice for fieldwork in some of the most remote places in Canada.

The PCSP also offers logistics support for federal government researchers working in non-Arctic areas of Canada, largely in the form of field equipment for loan from its large inventory. Recent projects that received equipment for fieldwork in non-Arctic areas include geologists working in the western Canadian cordillera, technicians maintaining border markers along Canada's international border with the United States, and scientists surveying lands across the country.

Did you know?

The Field Equipment Unit (FEU) officers at the PCSP have expertise in many areas to meet the needs of clients. The officers must be experts on clothing, tents and shelters, ATVs, snowmobiles, inspecting and maintaining outdoor and camping equipment, air, ground, and sea shipping, inspecting and maintaining boats, carpentry, and much more. During the 2016 field season, the FEU shipped more than 330 tonnes of field equipment and facility supplies via sealift.

Highlights of the 2016 field season

145
Arctic projects supported

1,417
Field equipment requests filled by the PCSP Ottawa and Resolute depots

3,141
Chartered aircraft hours flown

more than 1,500
Participants in all projects

more than 301,145 kg
Weight of equipment and fuel shipped by sea, road and air

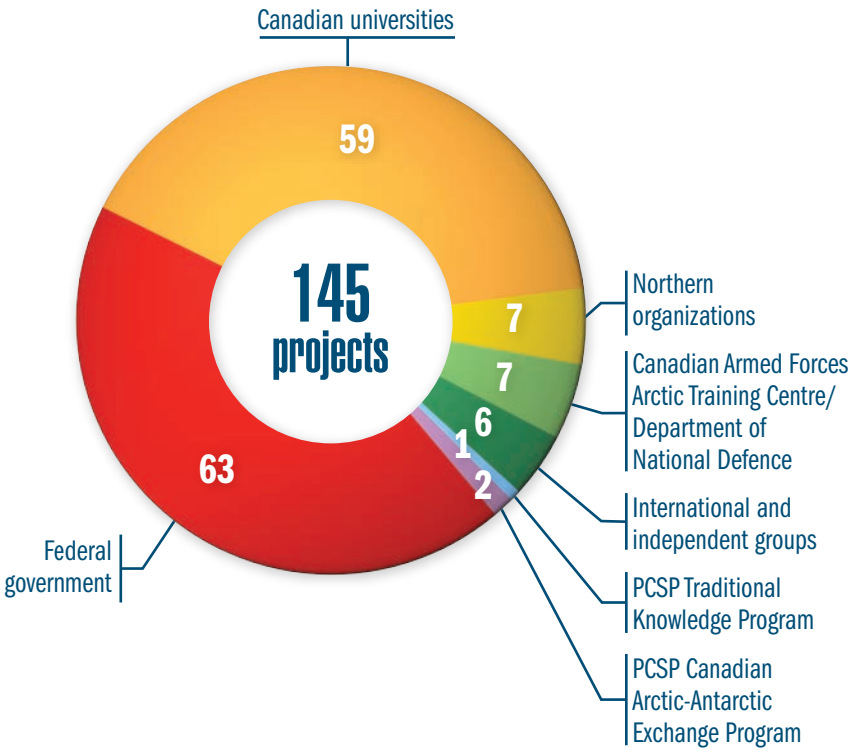
98
Aircraft under contract

12,718
Nights of accommodation provided at the PCSP Resolute facility

36,734
Meals served at the PCSP Resolute facility

42%
of Arctic projects transited through the PSCP Resolute facility

Breakdown of PCSP-supported Arctic projects in 2016



Did you know?

The PCSP has 42 snowmobiles and 56 ATVs for client use, which is more than the average dealership! This allows for a proper life-cycle management in which every vehicle that goes into the field has been inspected, maintained and refitted. The goal is to supply top-notch machines to clients that will operate smoothly in isolated locations so there are no surprise maintenance issues to deal with while in the field. There is nothing quite like changing the oil on a snowmobile at -60°C. These machines are issued to clients two to three times per year.

The PCSP has 250 three-person tents in the warehouse, and if these were lined up end to end, they would run 937 metres, which is equivalent to the length of 6.8 Canadian football fields!

Scientists like their sleep, and over the past two years, 232 requests for self-inflatable air mattresses were filled!

PCSP heritage spotlight

Remembering Dr. Ernest Frederick Roots: A visionary and the founding director of the PCSP

Dr. Ernest Frederick (Fred) Roots, a legend of polar exploration, passed away in October 2016. He spent more than 40 field seasons in remote areas, including Arctic North America, Antarctica, the Himalayas and the Rockies. He was renowned and respected worldwide as a scientist, a leader, a visionary and an intellect. Roots was trained as a meteorologist, surveyor and geologist and held an M.Sc. in geological engineering and a Ph.D. in geology. He was the first co-ordinator and the founding director of the Polar Continental Shelf Project (the forerunner of today's program) from 1958 to 1971.

Early in his career, Roots took part in numerous interdisciplinary expeditions, which illustrated to him the advantages and possibilities that come from multi-scientist collaboration. One of these expeditions was Operation Stikine (1956 to 1958), the first integrated geological study of the Canadian Northern Cordillera. Near the end of this expedition, in the autumn of 1958, Fred Roots, Hugh Bostock and Jim Harrison conceived the ideas for the PCSP while having lunch on a huge boulder near the terminus of the Chutine Glacier in northern British Columbia. Having worked together on numerous multi-disciplinary projects in remote areas, they observed first-hand the significant benefits that come from this type of collaboration on both field logistics and the advancement of scientific knowledge.

Polar scientist and explorer Dr. Fred Roots takes in the majestic Evigsfjord in Greenland during the 2016 Students on Ice Expedition.

During his early years as director, Roots and his team laid the foundation for the PCSP, which paved the way for future work in the region. He oversaw the development of field logistics to enable efficient and safe arctic fieldwork, the establishment of an Arctic navigation system and the completion of numerous surveying studies. One of these surveying studies corrected the placement of Meighen Island on maps, which was originally drawn several kilometres out of place. The PCSP initially focused on geology, geophysics and oceanography and by the 1970s studies expanded to include wildlife, vegetation and archaeology.

Roots has been honoured and acknowledged for his major contributions to polar research and exploration with many medals and awards, including the Massey Medal from the Royal Canadian Geographical Society in 1979, the Order of Canada in 1987, and most recently the Explorers Club medal in March 2016. A mountain range in Antarctica, "Roots Range," was named after him to honour his lifetime of accomplishments.

Roots had a special interest in mentoring future generations and instilling in them the importance of the polar regions to the health of the planet. In 2015, at the age of 92, he travelled to the PCSP facility in Resolute with a group of more than 100 students from Students on Ice (SOI). SOI is an organization that educates youth from around the world about the polar regions. Roots had been involved with SOI since its development in the 1990s. While at the PCSP facility, following a two-week expedition to western Greenland and the Northwest Passage, Roots and PCSP staff taught the students about the PCSP's origins and current operations. The vision that was conceived in 1958 by Roots and his colleagues has since become a reality and has evolved over the years into the PCSP today. Roots leaves behind the PCSP as an incredible legacy that will continue to enable scientific research across the Canadian Arctic for years to come.

Dr. Ernest Frederick Roots, the founding director of the PCSP.

Did you know?

During the first international scientific study of the Antarctic region, the famous Norwegian-British-Swedish Antarctic Expedition of 1949 to 1952, Dr. Fred Roots set the record for the longest unsupported dogsled journey in history: a 189-day scientific journey into the Antarctic interior.

"We all live in a planet where nature has designed the playing field, and nature sets the rules of the game, no matter what we think."

– Fred Roots

Outreach events

Science Odyssey Funfest

Science Odyssey is an annual event that invites Canadians to learn more about science, technology and innovation. As part of Science Odyssey, NRCan hosted a funfest event on May 14, 2016, in Ottawa, which was the largest public outreach initiative by NRCan in 2016. Interactive displays were set up by NRCan, other federal government departments, local post-secondary education institutions, and private science education groups at this family-friendly event that welcomed about 3,000 visitors.

The PCSP, NRCan's Geological Survey of Canada (GSC) and POLAR collaborated to produce an interactive display at the event. Visitors had the chance to experience the feel of an Arctic field camp with tents, field equipment and winter clothing. Children also enjoyed sitting on an ATV and crawling into a sleeping tent. Researchers from the GSC were on hand to talk about fieldwork and their research, and POLAR had a display about the effects of permafrost degradation on infrastructure.

NRCat took part in the Science Odyssey Funfest in Ottawa.

Junior students present their science fair project at Qarmartalik School Science Fair.

Qarmartalik School Science Fair

The third annual Qarmartalik School Science Fair took place in Resolute on June 3, 2016. The PCSP participated in this event by arranging judges for the fair, offering a healthy snack to participants, providing science fair certificates, and bringing NRCan's mascot, NRCat, for a visit to the school. The entire school participated in the fair, with winners announced in junior (grades 1 to 6) and senior (grades 7 to 12) categories. Science fair projects were judged by PCSP staff, university scientists and a community member. This event allows children and youth in Resolute to learn more about areas of science that interest them and inspires them to consider careers in a scientific field. The fair provides an important opportunity each year for the PCSP and some of its supported scientists to engage with residents of Resolute and be part of an important community event.

ArcticNet Annual Scientific Meeting 2016

In December 2016, the PCSP participated in the ArcticNet Annual Scientific Meeting in Winnipeg, Manitoba. The PCSP staffed an information booth, where they interacted with current and prospective clients working in the Canadian Arctic. The PCSP distributed copies of a round circumpolar map produced jointly by NRCan and POLAR. The map featured polar projections of both the north and south poles and was a great tool to engage participants. By attending this annual meeting, the PCSP has the opportunity to stay informed about ongoing and emerging issues related to conducting fieldwork in the North, learn about clients' newest scientific discoveries, and discuss northern research with northern residents and other research support organizations.

Senior students present their science fair projects at the Qarmartalik School Science Fair.

Field schools and training activities in Canada's North

Several PCSP-supported projects include an education component, including Arctic field schools and training activities. These initiatives give the opportunity to engage northern residents and non-northern residents in Arctic research. The PCSP can provide equipment and accommodations to these groups, offering unique educational experiences in the dynamic Canadian Arctic. Two of these exceptional education initiatives are highlighted in this section.

Taloyoak Geoscience Field School 2016

A key component of NRCan's Geo-mapping for Energy and Minerals (GEM) program is collaboration and engagement with northern communities to develop inclusive research programs that bring geoscience data to northerners. GEM's Geoscience of the Northwest Passage: Boothia Peninsula-Somerset Island activity is focused on improving limited, outdated geoscience information for the study region. Collecting geological data and creating detailed bedrock maps will support resource assessments along the Northwest Passage. This activity began in August 2016 with a community engagement initiative that focused on involving and training northerners in relevant field-based geoscience, learning from residents, and fostering their support for, and involvement in, field studies planned for 2017 and 2018.

Youth learn about geological maps during the 2016 Taloyoak Geoscience Field School.

In collaboration with the Canada-Nunavut Geoscience Office and other partners, the leaders of this GEM activity held a five-day field school near Taloyoak, Nunavut. The field school welcomed an impressive 140 residents from the community with a population of 800, and they ranged in age from 3 to 85 years. The residents participated in interactive activities in the areas of geology, geophysics, glaciology, digital mapping using geographic information systems, and geocaching. Participants rotated through the various "geo-stations" at half-hour intervals, with time to return to those that most interested them or to head out onto the geocaching course. In addition to geoscience, the field school had a cooking and nutrition component, which included daily preparation of lunches by a nutritionist using locally sourced ingredients and discussions related to career cooking opportunities and wholesome food choices.

This field school was successful in engaging residents of all ages from Taloyoak in northern geology and provided an important forum for discussing fieldwork planned in the area over the course of the Boothia Peninsula-Somerset Island activity.

> *"It was a highly effective approach to two-way engagement of a broad demographic over a sustained period, where the amazing insight into Earth's history recorded by rocks and glacial till was communicated and appreciated and will be anticipated through future mapping!"*
>
> – Mary Sanborn-Barrie

McGill Arctic Research Initiative 2016

The McGill Arctic Research Initiative (MARI) is part of McGill University's Field Study Semester program, involving a full semester of courses based in a remote field location. MARI was launched in 2016 and included activities in Iqaluit, Resolute and the McGill Arctic Research Station (MARS) on Axel Heiberg Island, Nunavut. MARI is more than a field school. It trains students in all aspects of northern fieldwork, including Arctic logistics, cold environment wilderness first aid, field safety, communication protocols, firearms safety, aircraft safety, aviation weather, ATV safety, and basic camp procedures. The primary mission of MARI is to train senior undergraduate students in Arctic science and field best practices, providing them with valuable fieldwork experience and helping them to become skilled Arctic field researchers. MARI involves an extended period of fieldwork, as well as laboratory research and data analysis at McGill University.

In 2016, the field program was coordinated by Professor Wayne Pollard and involved three professors and six senior undergraduate students. The seven-week field program began at Nunavut Arctic College in Iqaluit, where the students learned about the basic challenges of living in a northern community, the Nunavut Land Claims Agreement, and the resource-based nature of Nunavut's economy. The students were then based at the PCSP facility in Resolute before and after going to the MARS. While in Resolute, the students were involved in three geoscience and environmental courses that were designed to provide them with a solid knowledge base in the Arctic environment and research methods. These courses involved group discussions and lectures, structured field activities, and an independent research project that fit into a larger scientific question. Each student designed their own field research projects, which were carried out under the supervision of a MARI leader. Project topics included Arctic geomorphology, ice and snow chemistry, biogeography, limnology, and entomology. PCSP staff helped to train students in aspects of field operations while they stayed in Resolute. The MARI leaders plan to continue running the field school, with the eventual goal to make it an inter-university program.

MARI students trek to study geology on Wolf Mountain, Axel Heiberg Island, Nunavut.

"We believe that the training of a field scientist should include more than working as a field assistant. Students need to be involved in all phases of the research process from the identification of a problem and design of the field methods to the collection and analysis of the data and its ultimate inclusion in a scientific publication."

– Wayne Pollard

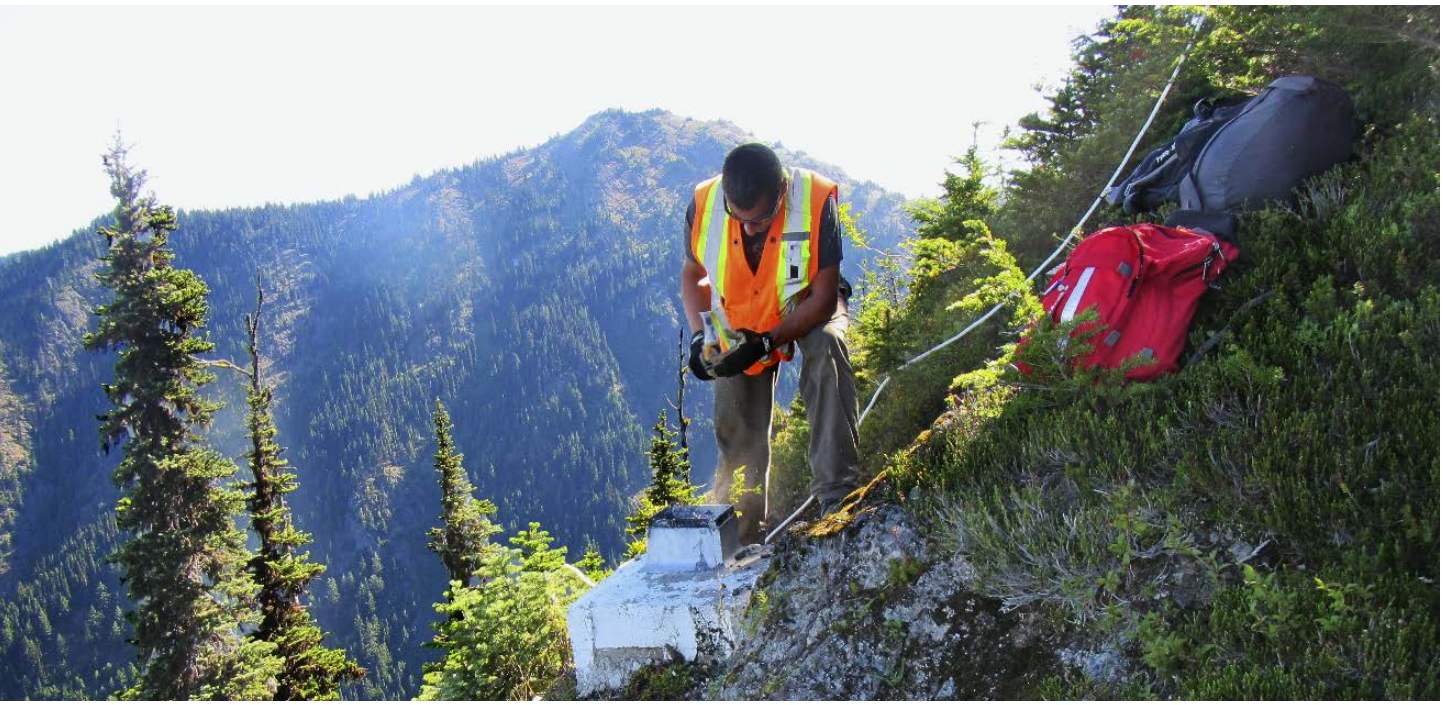
Support for non-Arctic federal government operations

The PCSP also provides logistical support, including field equipment loans and shipping and receiving coordination and advice, to federal government projects outside of the Arctic and across Canada.

International Boundary Commission

The Canada-United States border stretches for 8,891 kilometres (km) (5,525 miles) from the St. Croix River on the Atlantic Ocean to the Strait of Juan de Fuca on the Pacific Ocean, and from the Tongass Passage on the Pacific Ocean to the Arctic Ocean. This constitutes the world's longest land border between two adjoining countries. Marking and maintaining the boundary has been the mandate of the International Boundary Commission (IBC) since June 4, 1908. The IBC is a joint Canada-United States commission that has six main categories of activities: inspection, vista clearing, monument maintenance, demarcation enhancement, surveying, and communications and reporting.

Embedded within the Surveyor General Branch, the Canadian section of the IBC has benefited from a long and fruitful collaboration with the PCSP to fulfil its mandate. A visit to the PCSP Ottawa warehouse is a mandatory stop before the start of each field season, whether for helicopter helmets, construction tools, ATVs or safety equipment. Through this collaboration with the PCSP, Canadian teams of the IBC completed surveying projects in the British Columbian Rockies and in the rugged mountainous section between Quebec and Maine, as well as boundary monument maintenance along the border between Quebec and New York state.



International Boundary Commission employee repairs a monument in British Columbia's Cascade Mountains.

A Geological Survey of Canada scientist is all packed up after a long day of coring on Lac Duparquet in western Quebec.

Arctic field sites supported by the Polar Continental Shelf Program (2016)

Legend

- 2016 Field Site
- Featured Story Location
- Polar Continental Shelf Program Arctic Logistics Hub
- • Arviat — Community
- ○ Eureka — Weather station or Place of interest
- AULAVIK — National Park
- Median sea ice extent

Land Cover

- Ice and Snow
- Tundra
- Barren Land
- Transitional Forest
- Forest
- Farm Land

Air Distances in Kilometres

					Resolute
				Ottawa	3408
			Inuvik	4119	1502
		Iqaluit	2845	2100	1581
	Edmonton	2794	1971	2857	2527
Alert	3621	2100	2287	4172	1098

Kilometres 0 100 200 400 600

Scale: 1:7 000 000
Projection: Vertical Near Side Perspective, centred at 85°N 79.57°W, altitude 3 000 000 metres.

Sea Ice Information: Canadian Ice Service, Environment Canada, Ottawa, Canada (www.ice-glaces.ec.gc.ca) with data from the National Snow and Ice Data Center, Boulder, CO, U.S.A. (nsidc.org) outside of Canadian waters.

Geographical Names: Canadian Geographical Names Data Base (NRCan.gc.ca), Natural Resources Canada, 2017.

Land Cover Data: "AVHRR [Advanced Very High Resolution Radiometer] Land Cover Data, Canada-Vegetation"; from GeoGratis (GeoGratis.gc.ca), Canada Centre for Mapping and Earth Observation, Natural Resources Canada, 1993.

Produced by: Canada Centre for Mapping and Earth Observation, Natural Resources Canada.

Science and training highlights from 2016

In 2016, the PCSP provided logistical support to 145 projects across the Canadian Arctic. The PCSP supports Arctic researchers from a broad range of social and natural science disciplines. These researchers report on a variety of issues, including climate change, environmental integrity and conservation, cultural history, and sustainable resource management. Many of these studies are collaborative across organizations and disciplines to improve field efficiencies and broaden the outcome of the study. The PCSP is recognized as Canada's centre of excellence for field logistics and for contributing to the advancement of scientific knowledge across Canada. The following stories highlight a selection of the Arctic research projects that took place in 2016. Refer to the featured story location number to locate the project's study area on the map. These stories are followed by a list of the 2016 PCSP-supported projects.

Arctic Cultural Heritage at Risk: Climate Change Impacts on Inuvialuit Archaeological Sites

Max Friesen (University of Toronto)

Featured story location on the map: 1

The circumpolar archaeological record is currently under threat of widespread destruction from the changing climate. In the Mackenzie Delta region of the western Canadian Arctic, the combination of rising sea levels and the degradation of ice-rich permafrost is leading to dramatic increases in coastal erosion. This erosion is a direct threat to significant archaeological sites located along the coast, some of which have already been completely destroyed, while others are currently actively eroding. The Arctic Cultural Heritage at Risk (Arctic CHAR) project began in 2013 as a collaboration between university-based scientists and the Inuvialuit Cultural Resource Centre (ICRC). It was designed to understand, and mitigate, climate change-related destruction of the archaeological record in the Mackenzie Delta region, home to the Inuvialuit, the most populous and socially complex Inuit population in the pre-contact Canadian Arctic.

A geographic information systems (GIS) model will be created through the Arctic CHAR project to understand and assess threats to archaeology across the study area. The GIS model will be created by using baseline data on permafrost, surficial geology, coastal erosion, recent Inuvialuit land-use patterns, wildlife distributions and known archaeological site distributions, among other factors. By conducting extensive helicopter surveys of selected coastal zones, the project has also located unrecorded sites and assessed the condition of known sites. This survey is helping to guide decisions about which sites should be excavated, with particular attention paid to evidence for erosion, instability, and thawing of permafrost soils. The project also conducted large-scale excavations of selected sites based on these investigations.

Max Friesen and his research team, in collaboration with the ICRC and including three Inuvialuit individuals, focused the 2016 excavation at Kuukpak, a very large Inuvialuit beluga-hunting site originally occupied around AD 1400. The Kuukpak site is most likely the largest Inuvialuit site ever occupied and contains over 20 very large driftwood houses, many of which are under direct threat of erosion. Inuvialuit of the Mackenzie Delta lived in very large houses containing three alcoves, each of which held one to two families. These houses are well described in Inuvialuit traditional knowledge and by early explorers and missionaries, but none had been fully excavated until now. In 2016, Friesen's team completed the excavation of the largest and best-preserved Inuvialuit communal house encountered on the site. During

A team excavates the large Inuvialuit house that was built using the abundant driftwood from the Mackenzie River.

the excavation process, the team recovered many artifacts, including needles, ulus, bone daggers, harpoon heads, arrowheads, and snow knives.

Friesen and his research team will return to Kuukpak next year to excavate a second house, which is extremely important as it is the only one known from the late 19th century period and is currently actively eroding. Based on early test excavations, this house was occupied by Inuvialuit who were still living a traditional way of life, but who had begun to import selected Euro-Canadian goods such as glass beads. The Arctic CHAR surveys conducted up to now have illustrated that excavations will only be able to scratch the surface of the region's rich history, but that each additional field season will salvage another small portion of the region's irreplaceable cultural record.

"After working with Inuvialuit archaeology for three decades, it was an incredible feeling to finally see a complete three-alcove communal house emerge from the excavated dirt. Its perfect preservation allowed us to see just how complex and finely constructed this ancient architecture was."

– Max Friesen

Did you know?

The Inuvialuit built their houses out of driftwood because there were no trees in the area, and they are referred to as a cruciform house because of their shape. These houses have three alcoves and an entrance tunnel and look like a cross from above. They were built into the earth and covered with skins and sod for insulation. Eventually abandoned, they collapsed into the permafrost where they were preserved in the frozen ground.

Want to learn more?

Max Friesen's research was featured in two fascinating episodes of "Wild Archaeology" on the Aboriginal Peoples Television Network (Season 1, episodes 4 and 5). Watch these episodes here: aptn.ca/fullepisodes/wildarchaeology/.

Have a look at the Inuvialuit Cultural Resource Centre website to see a virtual museum exhibit of cultural objects and natural history specimens – Inuvialuit Pitqusiit Inuuniarutait: Inuvialuit Living History - inuvialuitlivinghistory.ca/.

Core Zone Surficial Mapping Project (GEM)

Roger Paulen (Geological Survey of Canada)

Featured story location on the map: 2

The surficial geology, also known as the loose rocky materials lying on top of the bedrock, is poorly documented in the remote parts of northern Quebec and Labrador. There are limited surficial geology maps, till geochemical data, and indicator mineral knowledge in this region. This knowledge gap results in poorly understood drift thickness, glacial history and dispersal mechanisms, ultimately hindering mineral exploration in the region. Roger Paulen, along with his team at the Geological Survey of Canada, has undertaken surficial geological mapping in northeast Quebec and west central Labrador to address these knowledge gaps. This Core Zone Surficial Mapping Project is part of NRCan's Geo-mapping for Energy and Minerals (GEM) program, as one of the Hudson-Ungava GEM projects. The main purpose of GEM is to lay the foundation for sustainable economic development in the North through evidence-based exploration for new energy and mineral resources. The knowledge produced by GEM enables northern communities to make informed decisions about their land, economy and society.

A Ph.D. student records measurements of glacial striae near the former centre of the Laurentide Ice Sheet where opposing glacial flow directions are observed.

The overall objective of Paulen's research is to produce new regional geoscience data including surficial geology, geochemistry, and radiometric maps. These data will increase geological knowledge and support natural resource exploration and development in the Hudson-Ungava region. Paulen and his team focused the surficial geological mapping activities over the Woods Lake (NTS 23I) and Lac Résolution (NTS 23P) map sheets, straddling the Quebec-Labrador border. They investigated the distribution, composition and sedimentological properties of surficial sediments, as well as the region's erosion history. Over the three field seasons since 2014, 483 field locations were visited, where samples and data were collected relating to surficial geology and ice flow indicators.

In 2016, the team visited 172 sites and collected samples of bedrock and surficial materials (i.e. till) every 10 to 12 km over the study area, which were tested for composition, age and origin. Striae and other glacial erosion indicators and landforms were identified to help determine the former Laurentide Ice Sheet flow dynamics and to map glacial erosion history. The study area was found to have multiple ice-flow trajectories, including ice-flow reversals, indicating that this region has an extensive and complex glacial history. The subglacial regime fluctuated drastically across the study area such that some regions were affected by high rates of erosion, large sediment deposition and long glacial transport distances. Other regions are characterized by low levels of till production, large erratics and more complex glacial transport histories.

The fieldwork for this project is now complete, and over the next year the data collected will be used to produce new surficial geology maps of the area. A general ice-flow hypothesis has been established and will be tested against the measured field and lab data to check for accuracy. Through this work, a better understanding of surficial deposits and glacial dispersal of materials will be obtained. These data will greatly increase geological knowledge and support natural resource exploration and responsible resource development in the region.

"This is an exciting region to work in; it was the former ice centre of the Labrador sector of the Laurentide Ice Sheet and also one of the last regions of North America where the continental ice sheets melted. Our research has implications for not only mineral exploration, but our documentation of the deglacial history is extremely important for global climate modellers who are trying to better understand the transition from full glacial to modern times."

– Roger Paulen

A Ph.D. student digs a deep sample pit into the former beach of glacial Lake McLean to collect samples for an optically stimulated luminescence date.

Retreat, thinning and slow-down dominate a half-century of changes at White Glacier, Axel Heiberg Island, Nunavut

Laura Thomson (University of Ottawa)
Supervisor: **Luke Copland** (University of Ottawa)
Featured story location on the map: 3

The second largest contributor to sea level rise since the start of the 21st century, next to the continental ice sheets, is the significant volume of ice that exists within the Canadian Arctic Archipelago. This region is currently experiencing some of the greatest rates of climate warming, and glacier melt rates are at their highest levels in over 4,000 years. Consequently, the glaciers of Arctic Canada require a commitment to long-term monitoring by northern scientists. Glaciological studies of White Glacier on Axel Heiberg Island, Nunavut, have been conducted since 1960 and represent the longest mass balance record for an alpine glacier in the Canadian Arctic. The goal of this research, led by Laura Thomson, was to determine climate-driven changes to glacier mass-balance (the difference between snow accumulation and ice melt), dynamics (ice velocity), and geometry (area, volume, and terminus position), and to assess the long-term impact of a warming climate on glacier stability.

Thomson combines the use of remote sensing with field geophysical techniques. Advancements in remote sensing methods are promising for future glacier monitoring, but to detect and understand climatic trends in context, datasets from long-term monitoring programs that pre-date the satellite era are required. Detailed ground-based studies are a crucial component of understanding the individual roles, interconnectivity, and persistence of the glacier-climate processes causing large-scale changes.

During the spring of 2016, mass balance measurements were carried out at White Glacier, contributing to the nearly continuous record since 1960. The McGill Arctic Research Station, located only 2.5 km from the terminus of White Glacier, has been the base from which this long-term monitoring has taken place. Thomson and her colleague Miles Ecclestone (Trent University) measured snow accumulation levels via snow-pit analysis at upper

Travelling by snowmobile on the eastern margin of White Glacier near the location of an ice-dammed lake (~600 m a.s.l.).

elevations. They also measured ice melt at lower elevations from the exposure of stakes that were installed in the glacier the previous year. Dual-frequency GPS was used to measure ice velocities at various stations along the glacier. Glacier velocity varies greatly across the width and along the length of glaciers, and is the result of the thickness of the glacier, steepness of the slope, and temperature of the ice. Summer field observations involved continued monitoring of ice velocities, surface melt, runoff through pro-glacial stream measurements, and the detection of glacier speed-up events. Glacier speed-up events can be dramatic and can lead to velocities of more than 200% of the background motion.

An aerial photo survey that was conducted in 2014 allowed Thomson to produce a digital elevation model (DEM – a 3D representation of the terrain's surface) of White Glacier. This DEM facilitated the production of a new topographic map of White Glacier, from which changes in ice thickness and glacier hypsometry (area-elevation distribution) were determined. This map will also help to improve the accuracy of future mass balance calculations. Overall, they have detected ice thinning and negative mass balance at White Glacier and decreases in annual and seasonal velocities of 10 to 45% since the 1960s. Motivated by these findings, a new project at White Glacier aims to determine how changing ice temperatures within Arctic alpine glaciers will impact their long-term sensitivity and stability with climate warming.

"Glacier monitoring provides one of the best sources of information of how the Arctic climate has changed over the past half century, and Laura Thomson's work has provided significant new insights into how White Glacier has thinned and slowed down during a period of rapid recent warming."

– Luke Copland

Did you know?

Ice temperature is a critical parameter defining the rate of ice deformation; e.g. ice near 0°C deforms 100-times faster than ice at temperatures near -20°C. While most non-polar glaciers are temperate with ice at temperatures close to the melting point, Arctic glaciers are polythermal, having zones of warm ice (very close to melting point) and cold ice (temperatures well below 0°C) at their bed.

Want to learn more?

An overview of the history of White Glacier, along with current and historical research can be found at whiteglacier.org.

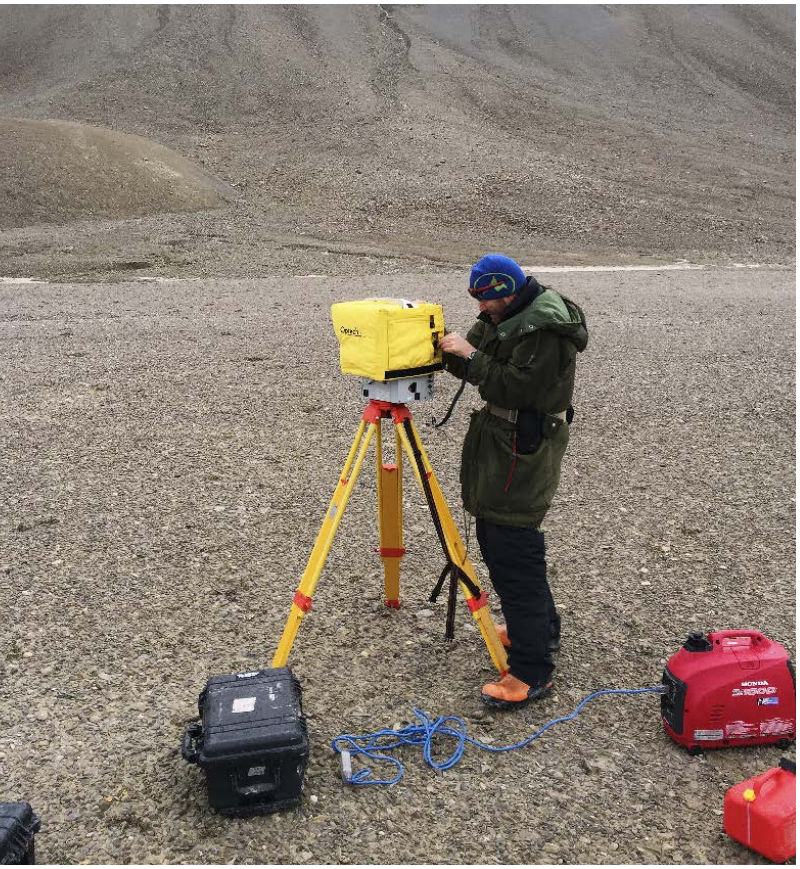
A dual-frequency GPS station at 870 m a.s.l. on White Glacier where ice velocities of about 10 cm/day are observed.

Exploring meteorite impact craters in the Canadian North

Gordon Osinski (University of Western Ontario)

Featured story location on the map: 4

Meteorite impact cratering is now widely accepted as one of the most important geological processes in the solar system, and evidence of these events can be seen on Earth, other terrestrial planets, asteroids, and moons. These impact events have played an important role in Earth's history, having shaped the geological landscape and affected the evolution of life. The most well-known impact crater, the Chicxulub impact structure in Mexico, was discovered in the 1990s. It has negative associations because of its link to the mass extinction event 66 million years ago that included the extinction of the dinosaurs. In contrast, Gordon Osinski's research focuses on the beneficial effects of meteorite impacts. These beneficial effects include providing new habitats for microbial communities on Earth, the generation of economic benefits through mineral resource exploitation and providing a detailed history of the environment since impact from the intra-crater lake deposits. The only known deposit that preserves the remains of flora and fauna from the early Miocene Arctic (23 to 5.3 million years ago) is found in the post-impact sediments of the Haughton impact structure in Nunavut.



Setting up a lidar in Thomas Lee Inlet, Nunavut, with the goal of imaging the gullies in the background.

Globally, about 190 impact craters are recognized to date, 30 of which are located in Canada. Many of these are in remote locations in northern Ontario and Quebec, Labrador, the Northwest Territories, and Nunavut. Impact craters on Earth are subject to varying degrees of erosion and may be buried under soil and vegetation, which makes it difficult to estimate the original size of the crater. Osinski and his research team have been studying the Haughton impact structure in Nunavut and the Tunnunik impact structure in the Northwest Territories for over a decade. They have performed detailed mapping of these two structures, both of which are located in a polar desert environment, are exceptionally well exposed, and offer quite different levels of erosion.

In 2016, Osinski returned with a field team to the Haughton impact structure on Devon Island for the 13th time since 1999. This impact structure is 23 km in diameter, 24 million years old and displays many landforms that are also common on Mars. During the field season, they investigated gullies, sub-glacial channels, and polygonal, patterned terrain, and installed a weather station in the structure. These investigations help to determine the history of Devon Island since the end of the last Ice Age. By comparing structures observed on Earth, scientists can use this research as an analogue to better understand formations observed on Mars, Mercury and the moon.

Another aspect of Osinski's research is on shatter cones, which are rare geological features, and one of the most reliable indicators of meteorite impact. Shatter cones are not yet fully understood, and there is some controversy

about how they are formed. Osinski has made observations that help to better understand the formation of shatter cones and have also developed a new and more accurate method to estimate the original size of craters on Earth. Using this new method, they have re-calculated estimates for the diameter of eight well-known impact craters.

The team plans to return to Devon Island in 2017 to continue the work investigating gullies and sub-glacial channels. Osinski and his team are also producing some educational activities, displays and hands-on "rock kits" that they hope to deliver to the Qarmartalik School in Resolute, Nunavut, during the 2017 field season.

Want to learn more?

Gordon Osinski's work on shatter cones was published in the journal Science Advances in August 2015: advances.sciencemag.org/content/2/8/e1600616.

Read a blog post from Canadian Geographic: canadiangeographic.ca/article/exposing-secrets-largest-arctic-meteorite-crater-found-decade.

"The only reason we have been able to conduct this research on shatter cones is because of the unique exposure of the Haughton and Tunnunik structures because of the polar desert environment of the High Arctic. There are no other craters on Earth where this would be possible."

– Gordon Osinski

A giant shatter cone in the newly discovered Tunnunik impact structure, Northwest Territories.

Changing Arctic water resources under a rapidly warming and drying climate

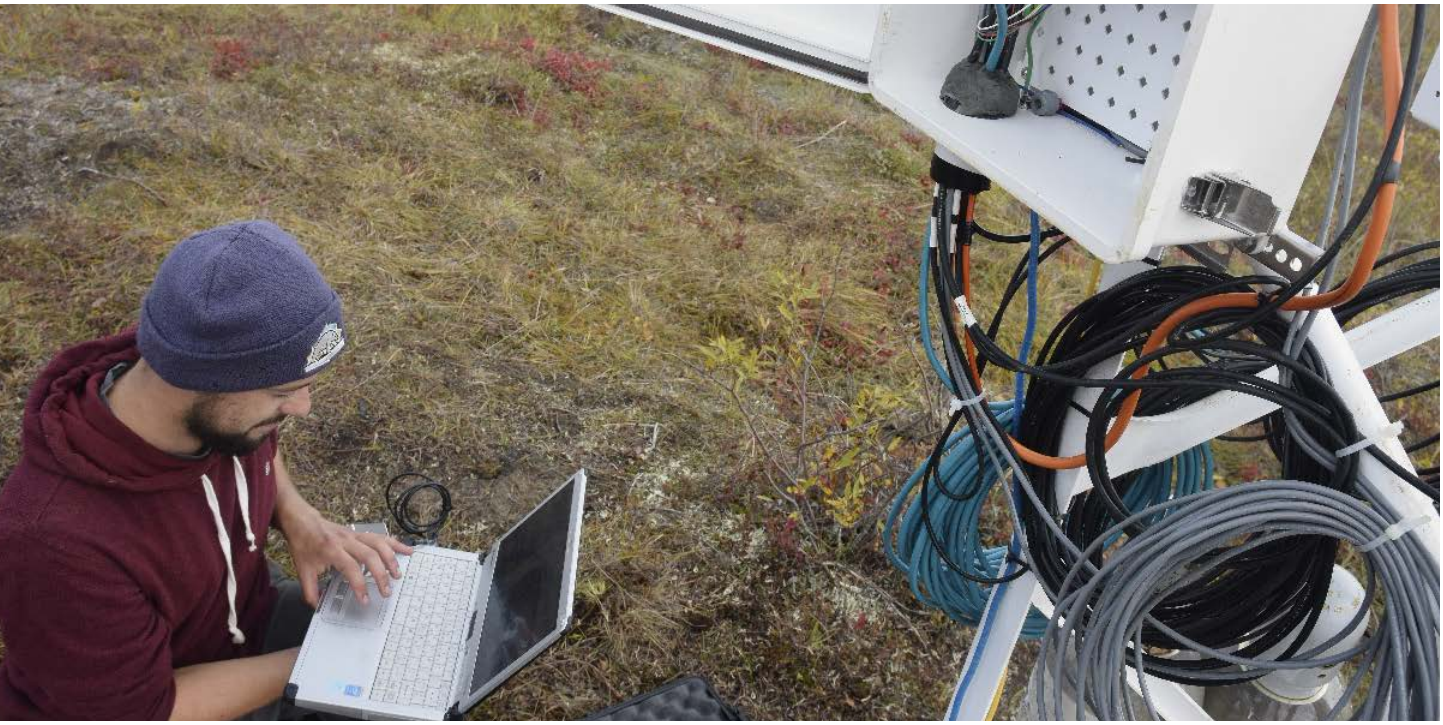
Philip Marsh (Wilfrid Laurier University)

Featured story location on the map: 5

Recent climate warming in the Mackenzie Delta region in the western Canadian Arctic has resulted in changes in snow accumulation, water storage, evaporation and discharge. Such changes in the hydrology (the scientific study of water) can have significant impacts on the regional ecology, as well as implications for northern development, including highways and natural resources. Philip Marsh's research aims to understand the impact of climate change on Arctic hydrology through investigations into the complex linkages between hydrology, vegetation cover, and permafrost conditions using detailed field observations, remote sensing and scientific modelling.

Marsh and his colleagues have been conducting research in the Mackenzie Delta near Inuvik at Trail Valley Creek (TVC) and Havikpak Creek (HPC) research watersheds for more than two decades. These sites represent typical watersheds at the tundra-forest transition zone, and results from these sites will be used to test and develop models that can be applied to wider areas across the Arctic. The results of this research contribute to a 10-year partnership between the Government of the Northwest Territories (GNWT) and Wilfrid Laurier University. This partnership will help the GNWT expand their capacity to conduct environmental research and monitoring and better manage natural resources in the region.

During 2016, Marsh's research team was in the field at TVC Research Station from mid-April until early June and in August, though instrumentation records data year round. The team used a variety of novel techniques to gather data about snow depth and accumulation, snowmelt timing, lake levels, and streamflow, among other variables. An unmanned aerial system (UAS or drone) with a multispectral camera



Downloading climate and soil condition data from a meteorological station at the Trail Valley Creek Research Station.

took high resolution aerial photographs daily to map snow cover and vegetation. Cosmic ray sensors measured soil moisture and snow water equivalent (amount of water contained within the snowpack). Several weather stations are set up in the study area to collect climatological data throughout the year, including air temperature and precipitation. They also map snow depths across long survey transects by utilizing an instrument that automatically measures and records snow depths in conjunction with GPS and captures small-scale variations in snow depth across the large study area.

Using data collected over the past two decades at TVC and HPC, Marsh and his team have observed that the western Canadian Arctic is rapidly warming and drying. Air temperatures have increased in recent decades, and both summer and winter precipitation has decreased. Snow on the ground at the end of the 2015 winter was the lowest observed over the past 30 years, and the snowmelt period was one of the earliest on record. They have observed that the snowmelt runoff and streamflow response is delayed despite rising spring air temperatures and earlier snowmelt. Major knowledge gaps still exist about the hydrological response to climate warming in this study region. Research is ongoing at these sites and aims to increase the understanding around these occurrences to better predict future changes in the Mackenzie Delta region and to test and improve hydrological models.

"In 1991, I began a collaborative research project at the Trail Valley and Havikpak Creek research watersheds near Inuvik. These two sites are typical watersheds straddling the treeline, with excellent logistical support from the Aurora Research Institute, and are great locations for studying processes and changes and for testing and developing predictive models, which can then be applied to wider areas across the Arctic."

– Philip Marsh

Measuring snow depth along a snow survey transect to capture small-scale variations across a large study area.

Want to learn more?

Check out the Trail Valley Creek research camp blog from 2016: tvc-hydro-research.tumblr.com/.

Geoscience mapping in the Tehery Lake-Wager Bay area: A frontier region in Nunavut

Natasha Wodicka (Geological Survey of Canada) and
Holly Steenkamp (Canada-Nunavut Geoscience Office)

Featured story location on the map: 6

The Tehery Lake-Wager Bay area, one of the least known and under-explored regions of Nunavut, represents a frontier region for geoscience research. Prior to this study, major knowledge gaps existed about the resource potential in the region and the types and ages of rocks it contains. The Geo-mapping for Energy and Minerals Phase 2 (GEM-2) Tehery-Wager geoscience mapping activity began in 2015. It is a collaborative effort between the Geological Survey of Canada and the Canada-Nunavut Geoscience Office, with participants from Canadian universities and the Nunavut Arctic College. Natasha Wodicka, Holly Steenkamp and their research team aim to increase the level of geological knowledge of this region in the Canadian Arctic. They will evaluate the region's potential for a variety of commodities (e.g. diamonds and other gemstones, base and precious metals, industrial minerals, carving stone, and aggregate) and help northerners and the resource-exploration industry make future land-use decisions.

Over the course of two summers, the field team examined bedrock at over 1,000 sites. The goals were to gain a better understanding of the composition of major rock formations and to determine how and when they were formed and later transformed by tectonic processes that created an ancient mountain belt. Thus far, they have identified previously unknown rock units that likely form part of the Snowbird Tectonic Zone. This major, roughly 2,800-km long tectonic feature of the North American craton (the central core of present-day North America) marks the collision between two ancient crustal blocks. A multicopter drone equipped with the latest technology in high-resolution imagery was used to create a photo mosaic to shed further light on the potential for economically important metal deposits (silver, copper, bismuth and gold) in the region.

The field team gathered data on the nature, distribution, and patterns of surficial sediments and landforms. They

Heading out on a foot traverse outside of camp situated on the Lorillard River, Nunavut.

also documented changes in ice-flow trends during the last glaciation and later ice retreat. This work is leading to a better understanding of the glacial dispersal pattern in the study area, which is characterized by either the absence of ice-flow indicators or by the presence of opposing directions. These results are important because they will allow better constraints to be placed on glacial dispersal trains in an area known to contain kimberlite intrusions, which are a type of diamond-bearing igneous rock.

Future research plans for the Tehery-Wager geoscience mapping activity include laboratory analysis of collected samples using cutting-edge techniques and the production of geological maps of bedrock and surficial geology, activity reports, and journal publications. In 2017, the field team will return to the study area to gain further insight into the geological history and mineral potential of the region through the study of metamorphic rocks and major fault structures. Overall, this project benefitted greatly from the help of residents from several communities in Nunavut, who helped with the collection of data and geological samples, camp logistics, monitoring wildlife and assisting the cook. Combined with a visit from community representatives to the field camp, these initiatives provided unique opportunities to exchange skills and knowledge about the land.

Preparing the flight path of a multicopter drone over a package of rusty rocks known to contain elevated concentrations of multiple metals, including silver, copper, bismuth and gold.

"Our fieldwork would not have been possible without the valuable help, organizational support and expediting services we received from the local communities of Chesterfield Inlet and Baker Lake."

– Natasha Wodicka

The response of surface water quality to climate warming and changing permafrost, the Cape Bounty Arctic Watershed Observatory, Melville Island, Nunavut

Melissa Lafrenière (Queen's University)

Featured story location on the map: 7

Current climate change is substantially affecting permafrost dynamics, landscape stability and hydrological conditions in the Arctic. Permafrost degradation and warming caused by climate change can lead to structural instability of the land and may cause mass movements (active layer detachment failures and thaw slumps). These disturbances cause large-scale and multi-year impacts on watershed hydrology and surface water quality. The disturbances expose and mobilize biologically important elements, including organic carbon and inorganic nutrients that were previously frozen and buried within the active layer and the permafrost. These changes impact the productivity and function of aquatic ecosystems in High Arctic rivers and lakes. Furthermore, newly exposed organic carbon can degrade and produce carbon dioxide (CO_2), which may increase the concentration of atmospheric CO_2. Measuring the quantity of degradable carbon that is stored in permafrost will enable researchers to integrate this data into climate models, resulting in more accurate climate change projections.

Melissa Lafrenière and her colleague Scott Lamoureux (Queen's University) are part of a long-term interdisciplinary research project at the Cape Bounty Arctic Watershed Observatory (CBAWO), which has operated since 2003. CBAWO is located on south-central Melville Island in the Canadian Arctic Archipelago and consists of a pair of unglacierised watersheds (two neighbouring drainage basins). Lafrenière and her research team are working to better understand the hydrological and biogeochemical (physical, chemical, biological and geological) processes in the High Arctic permafrost environment at CBAWO.

Sampling water from a pond within an active layer detachment slide to determine the molecular characterization and dating of the dissolved organic matter.

During the 2016 field season, Lafrenière and collaborators investigated many aspects of climate, permafrost, hydrology and lake chemistry at CBAWO. They monitored and investigated changes in precipitation (snow and summer rainfall) and permafrost conditions (permafrost temperatures and the progression, depth and disturbances of the active layer). They also investigated the development of subsurface flow pathways and the movement and variability of biologically important elements, including inorganic nitrogen and dissolved organic carbon.

Results from Lafrenière's long-term research at CBAWO indicate that the disturbance of permafrost in High Arctic watersheds releases more biodegradable dissolved organic carbon and nutrients from either thawed permafrost or increased microbial activity. Consequently, these disturbances may strengthen the permafrost-carbon feedback on climate change, potentially accelerating CO_2 emissions. They have also observed that these disturbances lead to increases in total dissolved solute concentrations in surface water and that these increases continue for up to seven years. Field and laboratory work for this project are ongoing. Lafrenière and her team will continue to investigate the spatial and seasonal variability of biogeochemical processes that control water quality, carbon, and nutrient exports in this High Arctic permafrost environment.

"In the span of just over a decade of working at Cape Bounty, we have witnessed striking changes in the landscape and hydrology. My research examines the direct (but invisible) consequences of these climate-induced changes on water quality, which stand to have important impacts on downstream lake and marine ecosystems and the carbon cycle."

– Melissa Lafrenière

Algae blooming in a small channel fed by subsurface water emanating from the base of the slope in the background.

Want to learn more?

Have a look at the Cape Bounty Arctic Watershed Observatory (CBAWO) blog: cbawo.blogspot.ca/

Tectonics, sedimentation, and paleoenvironments in the Sverdrup Basin, Arctic Canada

Benoit Beauchamp (University of Calgary)

Featured story location on the map: 8

The Sverdrup Basin covers a vast area of the Canadian Arctic Archipelago, from Ellesmere Island, Nunavut, in the northeast to Prince Patrick Island, Northwest Territories, to the southwest. This area accumulated as much as 13 km of sediment between the Carboniferous (359 million years ago) and Paleogene (23 million years ago) periods. These sediment accumulations are a record of this long interval of Earth's history. They were affected by a range of powerful tectonic forces that first led to the formation of the basin through crustal extension and later to its termination through mountain building. The record of these tectonic forces is now preserved as sedimentary rocks. The study of these sedimentary rocks enables geoscientists to reconstruct large segments of Earth's history, especially as it relates to past environmental changes.

Benoit Beauchamp's research focuses on the intervals of time known as the Carboniferous, Permian and Triassic periods, spanning 158 million years between 359 and 201 million years ago. This was a time of great upheaval in Earth's systems.

Beauchamp, along with his research colleagues, have identified six major critical transitions that were caused by tectonic forces and environmental change. These transitions lead to the largest known mass extinction in Earth's history that occurred about 252 million years ago. Some of these transitions were relatively rapid and were associated with the buildup of CO_2 in the atmosphere and global warming. Beauchamp's research thus provides examples of the kind of environmental and climatic shifts that Earth may experience in the future if atmospheric CO_2 continues to increase.

In 2016, Beauchamp visited the northern end of Axel Heiberg Island, along with two graduate students, to investigate the cause of three of these critical transitions. They studied a well-exposed rocky outcrop succession (visible section of sedimentary rock) along prominent mountain ranges of the Sverdrup Basin. The relative age of the sedimentary rock sequence is determined by using the fossil assemblages contained within them and correlating these with other studies in the area and in other parts of the world. Anirudh Bhargava, an M.Sc. student, gathered data on the paleo environmental interpretation of rocks that were deposited in the earliest stage of the Sverdrup Basin. That stage relates to the first two state shifts that occurred 310 and 299 million years ago, a time when extensional tectonic forces led to the thinning of the Earth's crust. Daniel Alonso Torres, another M.Sc. student working with Beauchamp, studied a younger rock succession that was deposited when compressional tectonic forces led to mountain building 272 million years ago.

Through many years of research, Beauchamp and collaborators from around the world have determined that ocean acidification accompanied the buildup of CO_2 in the atmosphere. These environmental changes were associated with a major warming episode that lead to the Permian-Triassic mass extinction. They have studied the abrupt environmental shifts that preceded the extinction, the chemical and environmental changes that occurred across the extinction, and the very slow environmental and biological recovery that followed. Beauchamp will focus the next portion of his research in the remote northern portion of Ellesmere Island, which is a location rich with information on Earth's history that has not yet been investigated.

"For the past 10 years, through the prism of remarkable rock exposures in the High Arctic, we have learned a great deal about past abrupt changes in the Earth systems that bear remarkable similarities with some of the environmental thresholds, critical transitions and state shifts our planet is likely to be subjected to in the future if we don't change our ways in a dramatic fashion."

– Benoit Beauchamp

University of Calgary graduate students conducting geological fieldwork on Northern Axel Heiberg Island, Nunavut.

List of supported Arctic projects in 2016

Impacts of ship-source air pollutant emissions on lake ecosystem health in the Arctic

Principal investigator: Julian Aherne (Trent University)
Location: Iqaluit (Baffin Island), Nunavut

Karrak Lake assessment of continental efforts at population reduction of Light Geese

Principal investigator: Ray Alisauskas (Environment and Climate Change Canada)
Locations: Karrak Lake and Perry River, Nunavut

INAC High Arctic inspections

Principal investigator: Erik Allain (Indigenous and Northern Affairs Canada)
Locations: Locations in the Resolute (Cornwallis Island) and Iqaluit (Baffin Island) areas, Nunavut

Distribution and abundance of Peary caribou and muskoxen on central Ellesmere Island

Principal investigator: Morgan Anderson (Government of Nunavut, Department of Environment)
Locations: Grise Fiord and Eureka (Ellesmere Island), Nunavut

Distribution and abundance of Peary caribou and muskoxen on Prince of Wales and Somerset islands

Principal investigator: Morgan Anderson (Government of Nunavut, Department of Environment)
Locations: Resolute (Cornwallis Island) and Taloyoak, Nunavut

Landscape genetics of Peary caribou on the Arctic Archipelago

Principal investigator: Morgan Anderson (Government of Nunavut, Department of Environment)
Locations: Locations on Bathurst Island and Lougheed Island, Nunavut

Checking out the landing strip by Lake Hazen, Quttinirpaaq National Park, Northern Ellesmere Island, Nunavut.

Icefield snowpack response to daily weather variations in the Ragged Range, Nahanni National Park Reserve

Principal investigator: David Atkinson (University of Victoria)
Locations: Locations in the Ragged Range, Nahanni National Park Reserve, Northwest Territories

GreenEdge

Principal investigator: Marcel Babin (Université Laval)
Location: Qikiqtarjuaq (Baffin Island), Nunavut

Drivers of shrub proliferation on the subarctic tundra

Principal investigator: Jennifer Baltzer (Wilfrid Laurier University)
Location: Trail Valley Creek, Northwest Territories

The impacts of permafrost slumping on mercury levels within the Thomsen River in Aulavik National Park, Northwest Territories

Principal investigator: Sarah Beattie (Parks Canada)
Location: Polar Bear Cabin (Banks Island), Northwest Territories

Geological record of past thresholds, critical transitions and state shifts in the biosphere and the oceans

Principal investigator: Benoit Beauchamp (University of Calgary)
Location: Bunde Fiord and other locations on Axel Heiberg Island, Nunavut

Evaluating soil moisture retrievals from the soil moisture active passive satellite over arctic tundra

Principal investigator: Aaron Berg (University of Guelph)
Location: Trail Valley Creek, Northwest Territories

Thelon-Chantrey geoscience project

Principal investigator: Rob Berman (Natural Resources Canada)
Locations: Ellice River area, Goose Lake and Bathurst Inlet, Nunavut

Ecology of arctic and red fox on Bylot Island

Principal investigator: Dominique Berteaux (Université du Québec à Rimouski)
Locations: Locations on Bylot Island, Nunavut

Tectonic significance of the Nolan-Zemlak domain boundary, southwest Rae Province, Saskatchewan

Principal investigator: Kathryn Bethune (University of Calgary)
Locations: Tazin Lake, Saskatchewan, and Waugh Lake, Alberta

Ecology of migratory birds in the Canadian Arctic

Principal investigator: Joël Bêty (Université du Québec à Rimouski)
Locations: Locations on Bylot Island and East Bay Island, Nunavut

Coats Island seabird studies and infrastructure upgrade

Principal investigator: Amie Black (Environment and Climate Change Canada)
Location: Coats Island, Nunavut

Public Health Agency of Canada - Quebec Region

Principal investigator: Marie-France Blain (Public Health Agency of Canada)
Locations: Kuujjuaq and Kangirsuk, Quebec

Monitoring Greater Snow Geese nesting near a secondary research camp on Bylot Island, Nunavut.

A month's worth of food and supplies and the last view of a Twin Otter before three week's work at Coats seabird camp.

Haul-out behaviour and genetic mark-recapture of Atlantic Walrus (Odobenus rosmarus rosmarus) in Foxe Basin and Hudson Bay, Nunavut

Principal investigator: Paul Blanchfield (Fisheries and Oceans Canada)
Locations: Coral Harbour (Southampton Island) and Walrus Island, Nunavut

Lake ice in the Canadian High Arctic

Principal investigator: Laura Brown (University of Toronto Mississauga)
Locations: Resolute (Cornwallis Island) and Polar Bear Pass (Bathurst Island), Nunavut

National Aerial Surveillance Program

Principal investigator: Steve Buckles (Transport Canada)
Location: Resolute (Cornwallis Island), Nunavut

State and evolution of Canada's glaciers/Essential climate variables – mass balance – Queen Elizabeth Islands, Nunavut and Northwest Territories

Principal investigator: David Burgess (Natural Resources Canada)
Locations: Agassiz Ice Cap and Grise Fiord (Ellesmere Island), Devon Ice Cap (Devon Island), Meighen Ice Cap (Meighen Island), Nunavut, and Melville Ice Cap (Melville Island), Northwest Territories

Investigations of permafrost and climate change, western Arctic Canada

Principal investigator: Christopher Burn (Carleton University)
Locations: Garry Island and Illisarvik, Northwest Territories

Public Health Agency of Canada activities in Nunavut

Principal investigator: Alixanderia Clymans (Public Health Agency of Canada)
Location: Iqaluit (Baffin Island), Nunavut

Monitoring of glaciers and ice shelves across the northern Queen Elizabeth Islands

Principal investigator: Luke Copland (University of Ottawa)
Locations: Expedition Fiord (Axel Heiberg Island) and Purple Valley (Ellesmere Island), Nunavut

Core zone and bounding orogens: Hudson-Ungava project

Principal investigator: David Corrigan (Natural Resources Canada)
Locations: Kuujjuaq, Schefferville and Strange Lake, Quebec

Arctic sea ice and climate histories from a shallow ice core, Agassiz Ice Cap, Ellesmere Island

Principal investigator: Alison Criscitiello (University of Calgary)
Location: Agassiz Ice Cap (Ellesmere Island), Nunavut

The characterization of wild viral communities in the Canadian High Arctic

Principal investigator: Alexander Culley (Université Laval)
Location: Ward Hunt Island and Resolute (Cornwallis Island), Nunavut

Planet spy - Animals on the move

Principal investigator: Philip Dalton (John Downer Productions)
Location: Eureka (Ellesmere Island), Nunavut

Legal survey of a portion of the administrative boundary between the Northwest Territories and Nunavut mining districts (NWT-Nunavut territorial boundary)

Principal investigator: Dagen Deslauriers (Opus Stewart Weir Ltd.)
Locations: Cape Bounty (Melville Island) and Resolute (Cornwallis Island), Nunavut

Annual inspection and servicing of various automatic weather stations across the Arctic Archipelago

Principal investigator: Rich DeVall (Environment and Climate Change Canada)
Locations: Cape Providence (Melville Island) and Mould Bay (Prince Patrick Island), Northwest Territories, and Alert (Ellesmere Island), Cape Liverpool (Bylot Island), Eureka (Ellesmere Island), Fort Ross (Somerset Island), Isachsen (Ellef Ringnes Island), Rea Point (Melville Island), Stefansson Island and Svartevaeg (Axel Heiberg Island), Nunavut

Study of the acceleration of permafrost thawing by climate-induced changes in snow physical properties

Principal investigator: Florent Domine (Université Laval)
Locations: Locations on Bylot Island, Nunavut

Snow-climate relationships in Canada's northern frontier

Principal investigator: Florent Domine (Université Laval)
Locations: Ward Hunt Island and Resolute (Cornwallis Island), Nunavut

Estimating the abundance of polar bears in the Gulf of Boothia subpopulation by genetic mark-recapture

Principal investigator: Markus Dyck (Government of Nunavut, Department of Environment)
Locations: Fort Ross (Somerset Island) and Kugaaruk, Nunavut

Estimating the abundance of polar bears in M'Clintock Channel using genetic mark-recapture

Principal investigator: Markus Dyck (Government of Nunavut, Department of Environment)
Locations: Cape Sidney and Gjoa Haven (King William Island), Fort Ross (Somerset Island) and Sydney Webb Point (Prince of Wales Island), Nunavut

Troubleshooting the automatic weather station on Sverdrup Glacier, Devon Island, Nunavut.

State and evolution of Canada's glaciers/Essential climate variables – mass balance – Northern Cordillera, Northwest Territories

Principal investigator: Mark Ednie (Natural Resources Canada)
Location: Bologna Glacier, Northwest Territories

Plasticity in foraging patterns and reproductive timing in an Arctic seabird, and its relation with sea-ice breakup

Principal investigator: Kyle Elliott (McGill University)
Location: Coats Island, Nunavut

Sirmilik National Park operations 2016

Principal investigator: Carey Elverum (Parks Canada)
Locations: Aktineq Glacier, Dufour Point, Mount Thule, Paquet Bay, Triangle Mountain and Quiqsut (Bylot Island) and Mala River (Baffin Island), Nunavut

Vertebrates of the ancient Arctic seas: Palaeontology of the late Cretaceous Anderson River formation, northern Northwest Territories, Canada

Principal investigator: David Evans and Matthew Vavrek (Royal Ontario Museum)
Location: Anderson River area, Northwest Territories

Mackenzie project – Shield to Selwyn activity

Principal investigator: Karen Fallas (Natural Resources Canada)
Location: Arctic Red River, Northwest Territories

Ringed seal abundance and density in a developing high-Arctic

Principal investigator: Steve Ferguson (Fisheries and Oceans Canada)
Location: Pond Inlet (Baffin Island), Nunavut

Executive Inuit training program

Principal investigator: Erin Filliter (Inuit Tapiriit Kanatami)
Location: Inuvialuit Settlement Region, Northwest Territories

Tracking the migratory behaviour of sea-run Arctic char in the Cambridge Bay area using acoustic telemetry

Principal investigator: Aaron Fisk (University of Windsor)
Locations: Ferguson Lake, Heart Lake and Surrey Lake (Victoria Island), Nunavut

GEO-NEIGE: Geomorphology of northern Ellesmere Island in the global environment

Principal investigator: Daniel Fortier (Université de Montréal)
Locations: Ward Hunt Island and Resolute (Cornwallis Island), Nunavut

Conducting an ice-penetrating radar survey of the Milne Glacier, Nunavut.

Arctic cultural heritage at risk: Climate change impacts on the archaeological record in the western Canadian Arctic

Principal investigator: Max Friesen (University of Toronto)
Location: Kuukpak, Richards Island, Northwest Territories

Postglacial climates of the Canadian Arctic

Principal investigator: Konrad Gajewski (University of Ottawa)
Locations: Locations in Polar Bear Pass (Bathurst Island) and on Prince of Wales Island, Nunavut

Population assessment of Dolly Varden 2016

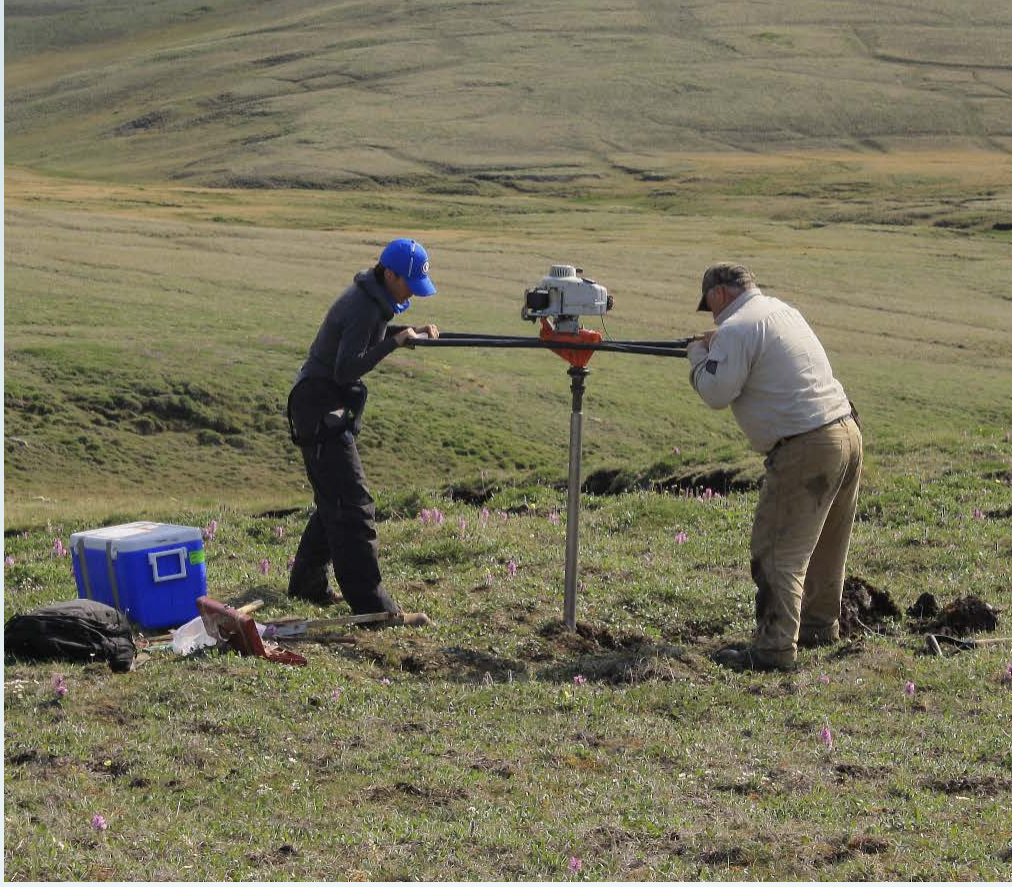
Principal investigator: Colin Gallagher (Fisheries and Oceans Canada)
Location: Inuvik, Northwest Territories

Biology of bird and small tundra mammal populations: Demographics, trophic interactions and climate change

Principal investigator: Gilles Gauthier (Université Laval)
Locations: Locations on Bylot Island, Nunavut

Population studies of eider ducks and thick-billed murres breeding at East Bay Island and Cape Graham Moore, Nunavut

Principal investigator: Grant Gilchrist (Environment and Climate Change Canada)
Locations: Cape Graham Moore (Bylot Island) and East Bay area (Southampton Island), Nunavut



Taking permafrost cores near a major slump site in Aulavik National Park, Banks Island, Northwest Territories.

Arctic-P³ Science Network: Arctic paleoclimate, paleoenvironment, paleoecology science network

Principal investigator: John Gosse (Dalhousie University)
Locations: Strathcona Fiord, Ekblaw Lake and Tanquary Fiord (Ellesmere Island), Nunavut, and locations on Prince Patrick Island, Northwest Territories

High Arctic Large Igneous Province: Western Arctic Geo-mapping for Energy and Minerals (GEM) project

Principal investigator: Stephen Grasby (Natural Resources Canada)
Locations: Arthaber Creek, Middle Fiord and Rens Fiord (Axel Heiberg Island) and Van Hauen Pass, Hare Fiord and Otto Fiord (Ellesmere Island), Nunavut

Canadian Arctic Sea Ice Mass Balance Observatory (CASIMBO)

Principal investigator: Christian Haas (York University)
Locations: Cambridge Bay (Victoria Island), Resolute (Cornwallis Island), Alert and Eureka (Ellesmere Island), Nunavut, and Inuvik, Northwest Territories

Shield to Selwyn - Fort McPherson

Principal investigator: Thomas Hadlari (Natural Resources Canada)
Locations: Fort McPherson and Norman Wells, Northwest Territories

Age, correlation, and tectonic context of the Borden Basin, Baffin Island

Principal investigator: Galen Halverson (McGill University)
Locations: Alfred Point, Elwin Inlet South, Nauyat, Strathcona River and Upper Alpha River (Baffin Island), Nunavut

Investigating mineralogical reactions at the top of the permafrost, northern Cornwallis Island, Nunavut.

The ca. 1000 Ga record of eukaryotic diversification in the Mesoproterozoic Bylot Supergroup, Baffin Island

Principal investigator: Galen Halverson (McGill University)
Locations: Alfred Point, Elwin Inlet South, Nauyat, Strathcona River and Upper Alpha River (Baffin Island), Nunavut

Quttinirpaaq National Park operating season and infrastructure project

Principal investigator: Emma Hansen (Parks Canada)
Locations: Fort Conger, Lake Hazen, Tanquary Fiord and Ward Hunt Island (Ellesmere Island), Nunavut

Qausuittuq National Park - Ecotype mapping

Principal investigator: Tyler Harbidge (Parks Canada)
Location: Polar Bear Pass (Bathurst Island), Nunavut

Qausuittuq National Park - Operations

Principal investigator: Tyler Harbidge (Parks Canada)
Locations: May Inlet, Stokes Range and Young Inlet (Bathurst Island) and Hosken Islands, Sherard Osborn Island and locations on Helena Island, Nunavut

Species and ecosystem constraints on increasing vegetation cover in the High Arctic in a warming climate

Principal investigator: Greg Henry (University of British Columbia)
Locations: Alexandra Fiord and Sverdrup Pass (Ellesmere Island) and Princess Marie Bay (Axel Heiberg Island), Nunavut

Improved retrievals of snow depth on sea ice for numerical sea ice prediction applications

Principal investigator: Stephen Howell (Environment and Climate Change Canada)
Location: Eureka (Ellesmere Island), Nunavut

Long-term monitoring of Great Bear Lake fisheries and the aquatic ecosystem

Principal investigator: Kimberly Howland (Fisheries and Oceans Canada)
Location: Smith Arm, Great Bear Lake, Northwest Territories

Impacts of shrub expansion in Canada's Low Arctic

Principal investigator: Elyn Humphreys (Carleton University)
Location: Daring Lake, Northwest Territories

Assessment of habitat degradation at snow goose breeding colonies in the eastern Arctic

Principal investigator: Joel Ingram (Environment and Climate Change Canada)
Locations: Koukdjuaq River and Nikko Island (Baffin Island) and Putnam Island, Nunavut

FOX-C Ekalugad Fiord long-term monitoring program

Principal investigator: Lilianne Kydd (Indigenous and Northern Affairs Canada)
Location: Ekalugad Fiord (Baffin Island), Nunavut

Origin of ice-rich landscape in the Peel Plateau - Richardson Mountains (Northwest Territories) and its response during the Younger Dryas - early Holocene interval (the last time the climate warmed rapidly)

Principal investigator: Denis Lacelle (University of Ottawa)
Location: Inuvik, Northwest Territories

The 39th ParlAmericas Board of Directors meeting

Principal investigator: Clélia Lacroix (House of Commons, International and Inter-parliamentary Affairs)
Location: Ottawa, Ontario

Integrated watershed impacts of recent and long-term climate and permafrost change

Principal investigator: Scott Lamoureux (Queen's University)
Locations: Cape Bounty (Melville Island) and Nicolay Lake (Cornwall Island), Nunavut

Drivers and constraints of ecological change in the western Arctic

Principal investigator: Trevor Lantz (University of Victoria)
Locations: Sitidji Lake and locations in the Jimmy Lake, Husky Lake and Tuktoyaktuk areas, Northwest Territories

Innervation North Youth Summer Program 2016

Principal investigator: Joyce Laprise (Government of Nunavut, Department of Family Services)
Location: Resolute (Cornwallis Island), Nunavut

Greenhouse gas emissions from Arctic lakes and ponds: Influences of geomorphology, primary production and carbon lability

Principal investigator: Isabelle Laurion (Institut national de la recherche scientifique, Centre Eau Terre Environnement)
Locations: Locations on Bylot Island, Nunavut

Baffin Island goose banding

Principal investigator: Jim Leafloor (Environment and Climate Change Canada)
Locations: Koukjuak River and Nikko Island (Baffin Island), Nunavut

Southampton Island goose banding

Principal investigator: Jim Leafloor (Environment and Climate Change Canada)
Location: Coral Harbour (Southampton Island), Nunavut

Collecting lake sediment cores for microbial analysis within the Mackenzie River Delta, Northwest Territories.

Survival in Arctic geese (Perry River, Queen Maud Gulf Bird Sanctuary)

Principal investigator: Jim Leafloor (Environment and Climate Change Canada)
Location: Perry River, Nunavut

ARCTIC IMPACT: Arctic Integrative Monitoring of Predators in the ArCtic Tundra

Principal investigator: Nicolas Lecomte (Université de Moncton)
Locations: Igloolik area (Igloolik Island) and Bylot Island, Nunavut

Population dynamics of Greater Snow Geese in relation to habitat

Principal investigator: Josée Lefebvre (Environment and Climate Change Canada)
Location: Bylot Island, Nunavut

Climate change impacts on mercury and methylmercury sources to Arctic ecosystems

Principal investigator: Igor Lehnherr (University of Toronto-Mississauga)
Location: Lake Hazen (Ellesmere Island), Nunavut

Limnology and biogeochemistry of Arctic delta lakes

Principal investigator: Lance Lesack (Simon Fraser University)
Location: Inuvik, Northwest Territories

REP-ARC2: Arctic periglacial ecosystem response to climate change

Principal investigator: Esther Lévesque (Université du Québec à Trois-Rivières)
Locations: Locations on Bylot Island, Nunavut

Stress-mediated mechanisms linking individual state, climatic mechanisms and population health in Arctic-breeding birds

Principal investigator: Oliver Love (University of Windsor)
Locations: East Bay Island and East Bay mainland (Southampton Island), Nunavut

Contaminants monitoring in seabirds at Prince Leopold Island, Nunavut

Principal investigator: Mark Mallory (Acadia University)
Location: Prince Leopold Island, Nunavut

Effects of overabundant Arctic geese on freshwater ecosystems

Principal investigator: Mark Mallory (Acadia University)
Location: East Bay Mainland (Southampton Island), Nunavut

Tagging and tracking High Arctic Thayer's and Sabine's gulls

Principal investigator: Mark Mallory (Acadia University)
Locations: Cape Vera (Devon Island), St. Helena Island and Tern Island, Nunavut

Northern Hudson Bay narwhal aerial population survey

Principal investigator: Marianne Marcoux (Fisheries and Oceans Canada)
Locations: Pond Inlet (Baffin Island) and Repulse Bay, Nunavut

Ice flowing along a side-channel of the Mackenzie River East channel near Inuvik, Northwest Territories, on May 13, 2016.

Measuring light fluxes in snow at Ward Hunt Island to calculate the detailed energy budget of the surface.

Hydrological studies of the Mackenzie Delta region

Principal investigator: Philip Marsh (Wilfrid Laurier University)
Location: Trail Valley Creek, Northwest Territories

Resolute seismic station operations

Principal investigator: David McCormack (Natural Resources Canada)
Location: Resolute (Cornwallis Island), Nunavut

Hydrological and ecological research in Vuntut National Park, Yukon

Principal investigator: Ian McDonald (Parks Canada)
Location: Old Crow, Yukon

Polar Knowledge Canada fieldwork in the Cambridge Bay area, Nunavut

Principal investigator: Donald McLennan (Polar Knowledge Canada)
Locations: Locations in the Cambridge Bay area (Victoria Island), Nunavut

Hazardous sea ice in the Canadian Archipelago

Principal investigator: Humfrey Melling (Fisheries and Oceans Canada)
Locations: Resolute (Cornwallis Island) and sea ice locations on Byam Martin Channel, Nunavut

Hydrodynamics of permafrost-glacier systems

Principal investigator: Brian Moorman (University of Calgary)
Locations: Locations on Bylot Island, Nunavut

Dynamics and habitat use by lemmings under climate change

Principal investigator: Douglas Morris (Lakehead University)
Locations: Cambridge Bay (Victoria Island) and Walker Bay, Nunavut

Investigating the role of ocean dynamics and meltwater input on the fate of Ellesmere Island ice shelves and epishelf lakes

Principal investigator: Derek Mueller (Carleton University)
Locations: Milne Glacier, Milne Ice Shelf and Purple Valley (Ellesmere Island), Nunavut

Investigating potential effects of climate warming on trends of mercury and persistent organic pollutants in arctic aquatic and terrestrial environments

Principal investigator: Derek Muir (Environment and Climate Change Canada)
Locations: Cape Bounty (Melville Island) and Resolute (Cornwallis Island), Nunavut

Aircraft support for Auyuittuq National Park operations and research

Principal investigator: Mathew Nauyuq (Parks Canada)
Locations: Glacier Lake, June Valley, Maktak Fiord, Owl River, Overlord Peak, Owl River, Pangnirtung, Penny Ice Cap, Summit Lake and Windy Lake repeater station (Baffin Island), Nunavut

Metal mining – Northern baselines

Principal investigator: Lisa Neville (Natural Resources Canada)
Location: Yellowknife, Northwest Territories

Effects of overabundant arctic geese on other tundra nesting birds

Principal investigator: Erica Nol (Trent University)
Location: Coats Island, Nunavut

Ice core processing on the summit of Agassiz Ice Cap, northern Ellesmere Island, Nunavut.

White Wolves: Ghosts of the Arctic

Principal investigator: Ivo Nörenberg (Gulo Film Productions)
Locations: Eureka and locations on the Fosheim Peninsula (Ellesmere Island), Nunavut

North Baffin narwhal tagging

Principal investigator: Jack Orr (Fisheries and Oceans Canada)
Location: Tremblay Sound (Baffin Island), Nunavut

Geological and geomorphological studies of the Haughton impact structure and surrounding terrains, Devon Island, Nunavut

Principal investigator: Gordon Osinski (University of Western Ontario)
Location: Haughton River Valley (Devon Island), Nunavut

Sustaining hydroecological monitoring to assess state of the park in Wapusk National Park, Manitoba – 2016

Principal investigator: Chantal Ouimet (Parks Canada)
Locations: Locations in Wapusk National Park, Manitoba

Fuel caching to Tanquary Fiord to support 2017 GEM-2 activities

Principal investigator: Carl Ozyer (Natural Resources Canada)
Location: Tanquary Fiord (Ellesmere Island), Nunavut

GEM-2 - Hudson Ungava project, Core zone surficial

Principal investigator: Roger Paulen (Natural Resources Canada)
Location: Schefferville, Quebec

Parks Canada operations

Principal investigator: Nelson Perry (Parks Canada)
Location: Polar Bear Cabin (Banks Island), Northwest Territories

Mine waste in Arctic environments

Principal investigator: Ronald Peterson (Queen's University)
Locations: Locations on Cornwallis Island, Nunavut

Fuel depot for CASE 20 Peayra in 2017

Principal investigator: Karsten Piepjohn (Federal Institute for Geosciences and Natural Resources [Germany])
Locations: Taconite Inlet and Tanquary Fiord (Ellesmere Island), Nunavut, and Polar Bear Cabin (Banks Island), Northwest Territories

The McGill Arctic Research Initiative (MARI)

Principal investigator: Wayne Pollard (McGill University)
Location: Resolute (Cornwallis Island), Nunavut

McGill Arctic Research Station (MARS) science program

Principal investigator: Wayne Pollard (McGill University)
Location: Expedition Fiord (Axel Heiberg Island), Nunavut

The vulnerability and resiliency of high Arctic permafrost to climate change

Principal investigator: Wayne Pollard (McGill University)
Locations: Expedition Fiord (Axel Heiberg Island) and Eureka (Ellesmere Island), Nunavut

The influence of landscape condition on biotic production in a warming Arctic environment

Principal investigator: Roberto Quinlan (York University)
Location: Inuvik, Northwest Territories

Arctic Shorebird Monitoring Program (Arctic PRISM) - Tier 1 surveys

Principal investigator: Jennie Rausch (Environment and Climate Change Canada)
Locations: Igloolik, Kugaaruk, Repulse Bay and locations in Ukkusiksalik National Park, Nunavut

Population studies of shorebirds at Polar Bear Pass National Wildlife Area, Nunavut (Arctic PRISM Tier 2 Site)

Principal investigator: Jennie Rausch (Environment and Climate Change Canada)
Location: Polar Bear Pass (Bathurst Island), Nunavut

Aerial surveys of Pacific Common Eiders in the central Canadian Arctic

Principal investigator: Eric Reed (Environment and Climate Change Canada)
Locations: Cambridge Bay (Victoria Island), Bathurst Inlet and Queen Maud Gulf, Nunavut

Western Arctic Snow Goose management

Principal investigator: Eric Reed (Environment and Climate Change Canada)
Location: Siksik Lake (Banks Island), Northwest Territories

GEM-2 cordillera project: Re-definition of crustal blocks

Principal investigator: Jim Ryan (Natural Resources Canada)
Location: Nisling River area, Yukon

Boothia-Somerset: Integrated geoscience along the Northwest Passage

Principal investigator: Mary Sanborn-Barrie (Natural Resources Canada)
Location: Taloyoak area, Nunavut

Paleoeskimo occupation history of Foxe Basin, Nunavut

Principal investigator: James Savelle (McGill University)
Location: Hooper Inlet, Nunavut

Watershed biogeochemical changes in Arctic environments under a changing climate

Principal investigator: Sherry Schiff (University of Waterloo)
Location: Lake Hazen (Ellesmere Island), Nunavut

Seasonal variations of the Inuit gut microbiome and interactions with dietary contaminants from traditional food

Principal investigator: Jesse Shapiro (Université de Montréal)
Location: Resolute (Cornwallis Island), Nunavut

Dynamics and change of Canadian Arctic glaciers

Principal investigator: Martin Sharp (University of Alberta)
Locations: Devon Ice Cap (Devon Island) and Lake Hazen (Ellesmere Island), Nunavut

Producing an accurate forage quality map for barren-ground caribou using drone and satellite images

Principal investigator: Peter Sinkins (Parks Canada)
Location: Uyarsivik Lake, Northwest Territories

Permafrost monitoring in the Mackenzie Valley

Principal investigator: Sharon Smith (Natural Resources Canada)
Locations: Inuvik and Norman Wells, Northwest Territories

Van Tat Gwich'in Historic Lifeways Project

Principal investigator: Shirleen Smith (Vuntut Gwitchin Government)
Locations: Upper Driftwood River and Upper Fishing Branch River, Yukon

Geo-mapping for Energy and Minerals program - Banks Island project

Principal investigator: Rod Smith (Natural Resources Canada)
Locations: Nelson Head, Polar Bear Cabin and Sachs Harbour (Banks Island), Northwest Territories

Research infrastructure development for environmental baseline information in Foxe Basin

Principal investigator: Paul Smith (Environment and Climate Change Canada)
Locations: Igloolik (Igloolik Island) and locations in the Foxe Basin area, Nunavut

Population studies of shorebirds at East Bay Mainland and Coats Island, Nunavut

Principal investigator: Paul Smith and Jennie Rausch (Environment and Climate Change Canada)
Locations: Coats Island and East Bay Mainland and Boas River (Southampton Island), Nunavut

Establishing a meso-network of micrometeorological towers for eddy covariance measurements along a latitudinal permafrost and climate gradient across the Taiga Plains, Northwest Territories

Principal investigator: Oliver Sonnentag (Université de Montréal)
Locations: Scotty Creek, Trail Valley Creek and Smith Creek, Northwest Territories

The Lake Hazen watershed as a sentinel of Arctic environmental change

Principal investigator: Vincent St. Louis (University of Alberta)
Location: Lake Hazen (Ellesmere Island), Nunavut

The effect of Arctic marine traffic on air quality in Arctic communities

Principal investigator: Ralf Staebler (Environment and Climate Change Canada)
Location: Resolute (Cornwallis Island), Nunavut

Land-water linkages and the fate of terrestrial carbon in aquatic ecosystems of the western Canadian Arctic

Principal investigator: Suzanne Tank (University of Alberta)
Locations: Inuvik and Fort McPherson, Northwest Territories

Surficial Geology Mapping and Geochemistry Sylvia Grinnell Lake area

Principal investigator: Tommy Tremblay (Canada-Nunavut Geoscience Office)
Location: Sylvia Grinnell Lake area (Baffin Island), Nunavut

Mesoproterozoic Aston-Hunting basin, Somerset Island

Principal investigator: Elizabeth Turner (Laurentian University)
Location: Hunting River area (Somerset Island), Nunavut

Investigating the influence of climate-induced land cover change on export of water and carbon in Old Crow Flats, Yukon, Canada

Principal investigator: Kevin Turner (Brock University)
Location: Old Crow, Yukon

Northern Ellesmere Island in the global environment - Northern frontier

Principal investigator: Warwick Vincent (Université Laval)
Locations: Ward Hunt Island and Resolute (Cornwallis Island), Nunavut

Survey of coastal fish community in the Darnley Bay area

Principal investigator: Wojciech Walkusz (Fisheries and Oceans Canada)
Location: Darnley Bay, Northwest Territories

Beaufort sea coastal geoscience: Ports and coastal infrastructure long-term monitoring program, Northwest Territories

Principal investigator: Dustin Whalen (Natural Resources Canada)
Location: Inuvik, Northwest Territories

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

Principal investigator: Lyle Whyte (McGill University)
Location: Expedition Fiord (Axel Heiberg Island), Nunavut

Tehery-Wager geoscience mapping

Principal investigator: Natasha Wodicka (Natural Resources Canada)
Locations: Lorillard River, Fehet Lake and Wager Bay areas, Nunavut

Essential monitoring of abrupt changes within the discontinuous permafrost zone

Principal investigator: Stephen Wolfe (Natural Resources Canada)
Location: Yellowknife, Northwest Territories

Ukkusiksalik National Park operations

Principal investigator: Monty Yank (Parks Canada)
Locations: Repeater sites at Douglas Harbour, Repulse Bay, Snowbank, Wager Bay repeater sites and Sila Lodge, Nunavut

Canadian Armed Forces Arctic Training Centre (CAFATC) training activities based in Resolute (Cornwallis Island), Nunavut, in 2016:

- CAFATC Support Group
- Canadian Forces School of Survival and Aeromedical Training
- 3rd Canadian Division ARCTIC RAM
- Canadian Forces School of Search and Rescue Course
- Arctic Operations Advisor Course
- Joint Task Force North – Nunalivut 16
- Joint Task Force North – Op NEVUS
- CAFATC Winter and Summer Reconnaissance

Annex

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 regarding the review process for university applicants, contact the PCSP.

PCSP Project Review Committee Members 2016

Mark Mallory (Chair)
Biology Department
Acadia University

Christopher Burn
Department of Geography and Environmental Studies
Carleton University

Michael Kristjanson
Polar Continental Shelf Program
Natural Resources Canada

Maribeth Murray
Department of Anthropology and Archaeology
University of Calgary

Roger Paulen
Geological Survey of Canada
Natural Resources Canada

Johann Wagner
Polar Knowledge Canada

Visiting and downloading meteorological data from the on-ice weather station, Bologna glacier, Northwest Territories, spring 2016.

Directing the helicopter pilot during a camp move on the Milne Ice Shelf, Nunavut.