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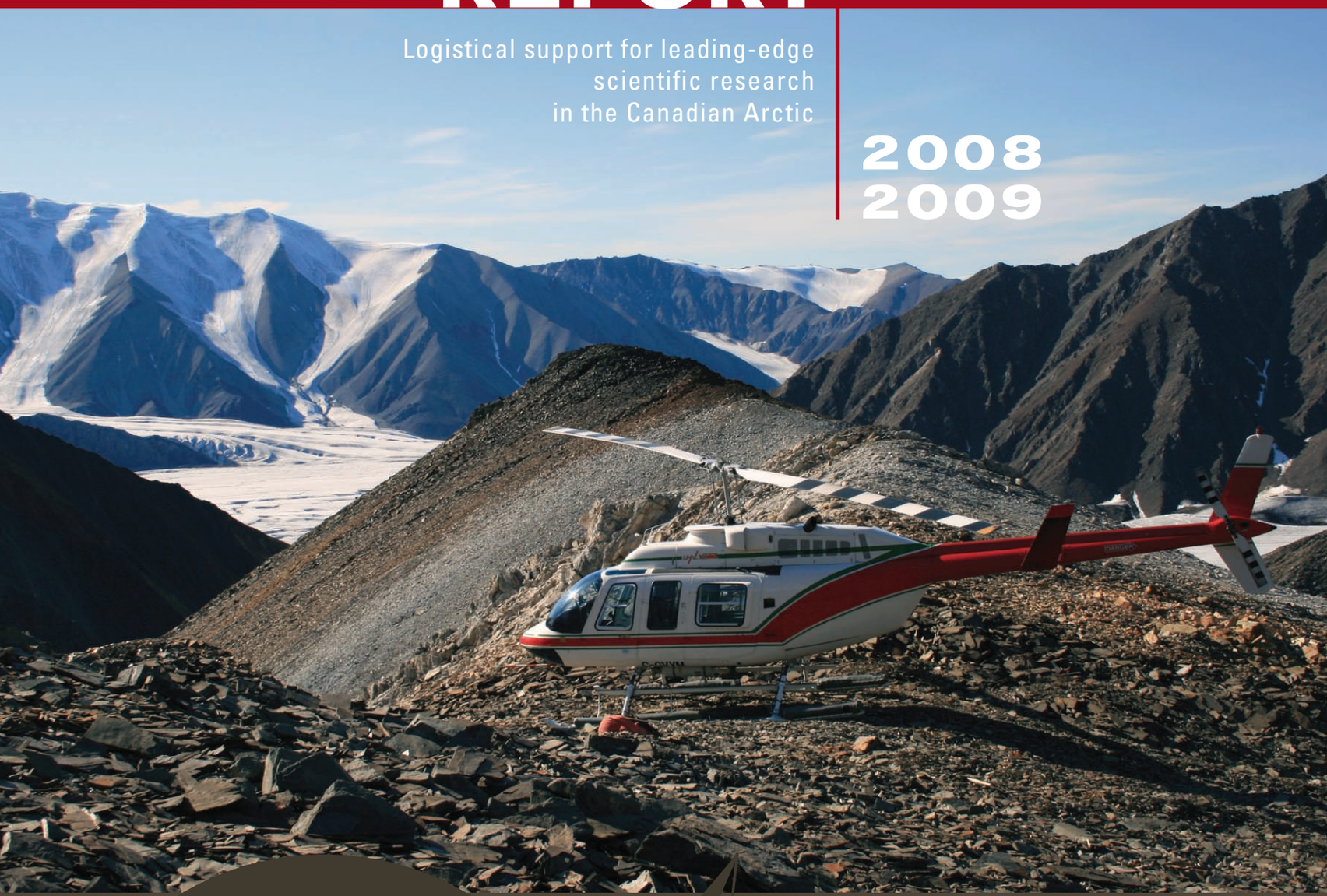
POLAR CONTINENTAL SHELF PROGRAM

SCIENCE REPORT

Logistical support for leading-edge scientific research in the Canadian Arctic

2008
2009



Canada

Polar Continental Shelf Program
Science Report 2008/09: Logistical support for leading-edge scientific research in the Canadian Arctic

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Cover photograph information

A helicopter sits at a study site in the mountains of northern Ellesmere Island, Nunavut.

(Credit: W. von Gosen)

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A Twin Otter beside a field camp at Alexandra Fiord,Ellesmere Island, Nunavut

J. Lang, PCSP/NRCan

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ᐊᕐᕋᒍᐃᑦ 50 ᐅᖓᑖᓂᒃ ᐊᓂᒍᖅᓯᒪᔪᓂ ᐃᑲᔪᖅᓱᐃᓯᒪᐃᓐᓇᖅᓱᑎᒃ ᐅᑭᐅᖅᑕᖅᑐᒥ ᖃᐅᔨᓴᐃᓂᕐᒥᒃ, ᐅᑭᐅᖅᑕᖅᑐᒥ ᓄᓇᐅᓂᖓ ᑕᓇᐅᕐᒦᑦᑐᖅ ᐃᖅᑲᖓᓂᒃ ᖃᐅᔨᓴᖅᑕᐅᓯᒪᔪᑦ ᓱᓕ ᓂᕆᐅᒋᔭᐅᒐᑦ ᐱᐅᓂᖅᓴᑦᑎᐊᓪᒪᕆᐅᓂᐊᖅᑐᔫᕐᓂᖅ ᑲᔪᓯᓂᕆᓂᐊᖅᑕᖏᓐᓂ.

ᐊᕐᕌᒍᒋᓕᖅᑕᕗᑦ ᐱᒋᐊᓕᓵᖅᑎᑦᓱᖕᒋᑦ, ᖁᕕᐊᒋᔭᐅᓂᖕᒋᑦ ᐅᑭᐅᖅᑕᖅᑐᒥ ᓄᓇᓂᒃ ᑕᓇᐅᕐᒥᒃ ᐃᖅᑲᖓᓃᑦᑐᓂᒃ ᖃᐅᔨᓴᐃᓂᖅ ᐃᓚᖓᒍᑦ ᐱᔾᔪᑎᖃᓚᐅᖅᑐᖅ ᐊᖏᔪᓪᒪᕆᖕᒥᒃ ᓴᓇᔭᐅᓯᒪᔪᖃᓕᕐᓂᖕᒋᓐᓂᒃ ᐱᓲᑎᕋᕕᖕᓂᒃ ᑲᓇᑕᐅᑉ ᐅᑭᐅᖅᑕᖅᑐᒥ ᖁᑦᑎᒃᑐᕐᒥᐅᓂ.

ᐃᓂᕐᑲᖅᓱᑎᒃ ᑲᓇᑕᐅᑉ ᐅᑭᐅᖅᑕᖅᑐᓂᖅᐸᓇᔭᖓᓂ ᓄᓇᓕᖕᒥ, ᖃᐅᔨᓴᖅᑕᐅᔪᑦ ᐃᕿᖓᓃᑦᑐᑦ ᓄᓇᐃᑦ ᖁᑦᑎᒃᑐᒥ ᖃᐅᔨᓴᕐᕕᖓᑦ ᖃᐅᓱᐃᑦᑐᕐᒦᑦᑐᖅ, ᓄᓇᕗᒻᒥ, ᐊᖏᓪᓕᒋᐊᖅᑕᐅᓂᐊᓕᕐᒪᑦ ᓄᑖᕈᓇᐊᖅᑕᐅᓗᓂᓗ ᑐᔪᕐᒥᕕᖕᒋᑦ ᐊᒻᒪᓗ ᓄᑖᓂᒃ ᐃᓚᔭᐅᓗᑎᒃ ᖃᐅᔨᓴᕐᕕᒃᓴᐃᑦ ᐊᙳᒪᖁᑦᑐᒋᑦ ᒫᓐᓇᐅᔪᖅ ᓯᕗᓂᒃᓴᒥᓗ ᐅᑭᐅᖅᑕᖅᑐᒥ ᖃᐅᔨᓴᖅᑎᑦ ᖃᐅᔨᓴᓇᐊᖅᑲᕐᓂᐊᕐᓂᖕᒋᓐᓂᒃ ᐊᒻᒪᓗ ᓯᓚᕐᔪᐊᕐᒥᐅᑦ ᖃᐅᔨᓴᕈᓐᓇᕐᓂᖕᒋᓐᓄᑦ ᑲᓇᑕᐅᑉ ᐅᑭᐅᖅᑕᖅᑐᖓᓂ.

ᖃᐅᔨᓴᐃᖃᑦᑕᕐᓂᖅ ᐱᔾᔪᑕᐅᖕᒋᓐᓇᕐᒪᑦ ᑲᓇᑕᐅᑉ ᐃᓚᒋᔭᐅᖃᑦᑕᕐᓂᖓᓄᑦ ᐅᑭᐅᖅᑕᖅᑐᒥ. ᐅᑭᐅᖅᑕᖅᑐᒥ ᓄᓇᓂᒃ ᑕᓇᐅᕐᒦᓂᖕᒋᓐᓂᒃ ᐃᖅᑲᖓᓃᑦᑐᑦ ᖃᐅᔨᓴᖅᑕᐅᓂᖕᒋᑦ ᐃᓕᑕᓇᔭᐅᓯᒪᖕᒪᑕ ᑲᓇᑕᓕᒦᒥ ᓯᓚᕐᔪᐊᕐᒥᐅᓄᓗ, ᐱᐅᔪᓪᒪᓇᐅᓂᖕᒋᓐᓄᑦ ᐃᑲᔪᖅᓱᖅᑕᐅᕝᕕᐅᔪᓐᓇᖃᑦᑕᕐᓂᕐᒍᑦ ᖃᐅᔨᖃᑕᐅᔪᓄᑦ ᐅᑭᐅᖅᑕᖅᑐᒥ ᑲᓇᑕᒥ. ᑐᓐᖓᕕᐅᑦᓗᑎᒃ ᓄᓇᕐᔪᐊᓕᒫᒥ ᑲᑐᔾᔨᖅᑲᑎᒌᒃᔪᐊᑦ ᑲᑎᒪᔨᖏᑦ ᒪᓕᒐᓕᕆᓂᖏᑦ ᑕᕆᐅᖏᑦ (UNCLOS-ᑯᑦ) ᐊᒻᒪᓗ ᓄᓇᙳᐊᓕᐊᕆᔭᐅᕙᓪᓕᐊᓂᖕᒋᑦ ᐆᒪᖁᑎᒃᓴᓕᕆᓂᖏᑦ ᐊᒻᒪᓗ ᐅᔭᕆᖕᓂᐊᒐᒃᓴᓕᕆᓂᖏᑦ ᐊᑐᖅᑕᐅᔪᓂ ᐃᓚᔭᐅᓯᒪᔪᓂᒃ ᐅᓂᒃᑳᖕᒋᑦ ᑖᒃᑯᓄᖓ ᐅᓂᒃᑳᓕᐊᓄᑦ, ᐅᑭᐅᖅᑕᖅᑐᒥ ᓄᓇᓂᒃ ᑕᓇᐅᕐᒦᓂᖕᒋᓐᓂᒃ ᐃᖅᑲᖓᓃᑦᑐᑦ ᖃᐅᔨᓴᖅᑕᐅᓂᖕᒋᑦ ᓱᓕ ᑲᔪᓯᓂᐊᖅᐳᑦ ᐱᓪᒪᕆᐅᔪᒥᒃ ᐱᓕᕆᐊᙳᓗᑎᒃ ᓯᕗᒻᒧᐊᒃᑎᑎᕙᓪᓕᐊᓂᖏᑦ ᑲᓇᑕᐅᑉ ᓴᕙᒪᒃᑯᖕᒋᑦᑕ ᐅᑭᐅᖅᑕᖅᑐᒥ ᖃᓄᐃᓕᐅᕈᑎᒋᓯᒪᔭᖕᒋᓐᓄᑦ.

ᑕᒪᓐᓇ ᐃᓱᒪᒋᑦᓱᒍ, ᐅᑭᐅᖅᑕᖅᑐᒥ ᓄᓇᓂᒃ ᑕᓇᐅᕐᒦᓂᖕᒋᓐᓂᒃ ᐃᖅᑲᖓᓃᑦᑐᑦ ᖃᐅᔨᓴᖅᑕᐅᓂᖕᒋᑦ ᖁᑦᑎᒃᑐᕐᒥᐅᓂ ᐅᓂᒃᑳᓕᐊᕆᔭᐅᓯᒪᕗᑦ ᑲᓇᑕᒥᐅᑦ ᑐᓴᐅᒪᖁᑦᓱᒋᑦ ᓴᕙᒪᒃᑯᑦ ᐱᓕᕆᐊᕆᔭᖕᒋᓐᓂᒃ ᐅᑭᐅᖅᑕᖅᑐᒥ. ᑲᒪᔨᐅᒐᑦᑕ ᐅᔾᔨᖅᑐᕐᓂᕐᒧᑦ ᑲᔪᓰᓐᓇᕈᓐᓇᕐᓂᐊᖅᑐᒥᒃ ᓯᕗᓂᒃᓴᖅᑲᑦᑐᐊᓇᐊᖅᑲᕐᓂᖓᓂᒃ ᑲᓇᑕᐅᑉ ᐅᑭᐅᖅᑕᖅᑐᐊᓂᒃ, ᐊᒻᒪᓗ ᖃᐅᔨᒪᓂᓇᔅᑎᓐᓂᒃ ᐱᕈᖅᑎᑦᑎᓂᕐᒥᒃ ᑕᒃᑯᓂᖓ ᓄᓇᓂᒃ ᐊᔾᔨᒃᖏᑦᑐᓂᒃ, ᑕᐃᒫᒃ ᑲᓇᑕᐅᑉ ᐅᑭᐅᖅᑕᖅᑐᖓ ᐱᓐᖑᖅᑎᑦᑎᔪᓐᓇᕐᓂᐊᕐᒪᑕ ᐃᓅᖁᑎᒥᓄᑦ ᐊᒻᒪᓗ ᕿᓇᐅᔭᓕᐅᖅᑕᐅᔪᓐᓇᕐᓂᕐᒥᓄᑦ ᐊᔪᖏᓐᓂᕐᒥᒃ ᓯᕗᓂᒃᓴᖅᑎᐊᕐᓗᑎᒃ ᐅᓗᓇᐊᓇᖕᒋᑦᑐᒥᒃ ᐊᒻᒪᓗ ᑲᔪᓰᓐᓇᕈᓐᓇᕐᓂᐊᖅᑐᒥᒃ.

ᑎᑎᕋᖅᑐᖅ,

ᓂᕈᐊᖅᑕᐅᓯᒪᔪᖅ ᑯᓇᔅᑎᐊᓐ ᐸᐅᓇᑎ, P.C.-ᑯᓂ ᑲᓇᑕᒥ ᒪᓕᒐᓕᐅᕐᕕᖕᒥ
ᒪᓕᒐᓕᐅᖅᑎᐅᔪᖅ,
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Minister's Message

After over 50 years of dedicated support for Arctic science, the Polar Continental Shelf Program (PCSP) is poised for even greater successes.

At the beginning of this new decade, the excitement at the PCSP is in part due to a major infrastructure expansion in Canada's High Arctic. Under Canada's Economic Action Plan, the PCSP is benefiting from $11 million in funding over the next two years — part of the $85-million Arctic Research Infrastructure Fund.

Strategically located in Canada's second most northern community, the PCSP facility in Resolute, Nunavut, is expanding and upgrading its current living accommodations and adding modern lab facilities to support current and future needs of Arctic researchers and world-class science in the Canadian Arctic.

Science has always been a driving force behind Canada's involvement in the North. The PCSP is recognized nationally and internationally for its excellence in providing logistical support to researchers working in the Canadian Arctic. Building on the successes of the United Nations Convention on the Law of the Sea (UNCLOS) and the Geo-mapping for Energy and Minerals (GEM) programs included in this report, the PCSP will continue to play a key role in advancing the Government of Canada's Northern Strategy.

To this end, the PCSP Science Report is intended to keep Canadians informed of their government's activities in the North. We have a responsibility to ensure a sustainable future for Canada's Arctic and to expand our knowledge of this unique land so that the Canadian North will realize its full social and economic potential with a future that is secure and sustainable.

Sincerely,

The Honourable Christian Paradis, P.C., M.P.
Minister of Natural Resources

The Polar Continental Shelf Program

The Canadian Arctic is important culturally, environmentally and economically to Canada and the world. It is a beautiful region in which thousands of people live and hundreds of scientists conduct important field studies each year. With an ever-changing Arctic environment and increased public and economic focus on the North, these studies are of vital importance to fields throughout the social and natural sciences.

The PCSP supports more than 165 research projects each year that involve more than 1100 scientists, students and field support technicians. Aircraft support is offered from a number of key northern locations, but most projects are staged from Resolute, Nunavut, where the PCSP's main northern facility is located. This facility has a living accommodations building with sleeping quarters for clients and the PCSP staff, dining and recreation areas, and laundry facilities. The working accommodations building houses the facility's office; storage areas for the PCSP and client equipment; field equipment repair and maintenance areas; and workspace for basic laboratory and computer needs. A wireless high-speed internet connection, which was significantly upgraded in 2009, is now available to the PCSP's clients staying at the facility. Researchers typically spend a short amount of time at the Resolute facility each year, just before and after their time in field camps.

The PCSP facility at Resolute on Cornwallis Island, Nunavut *J. Lang, PCSP/NRCan*

The Polar Continental Shelf Program (PCSP) is an organization that provides logistical support to researchers conducting field studies at locations throughout the Canadian Arctic. This region provides a challenging environment in which to conduct research and also in which to provide logistical services in support of Arctic science. As a part of Natural Resources Canada (NRCan), the PCSP's main services include air and ground transportation to and from remote field camps; accommodations and meals at the PCSP's Resolute facility and Environment Canada's Eureka facility; equipment for loan through the PCSP's Technical Field Support Services; fuel for camps, equipment and aircraft; and a communications network that links the PCSP with the science teams located in camps dispersed throughout the North.

Spotlight on a PCSP employee: George Benoit

George Benoit is currently the PCSP's longest-standing employee of legendary stature within the research logistics community, having started as a cook's assistant at the Resolute facility in February 1975. Over the past 35 operational seasons, George has held positions including Stores Helper, Labourer and Warehouse Manager, and he is now Stores Supervisor. George oversees equipment and fuel stores, loads and unloads aircraft, and handles all types of inquiries from scientists. He has never missed a season in Resolute and his wealth of experience makes him highly knowledgeable of aircraft load limits, fuel needs for camps and the best types of camp equipment to use. George says the key to helping researchers is to "put yourself into their boots and think about what you would take if you went out to a camp."

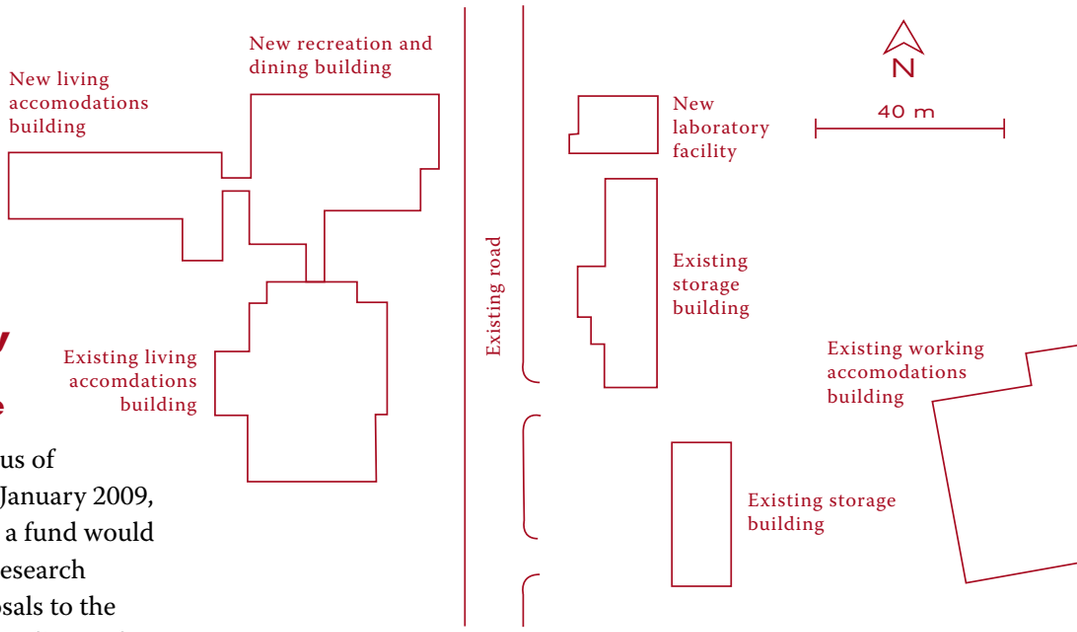
George Benoit at the PCSP Resolute facility *J. Lang, PCSP/NRCan*

The PCSP Resolute facility has field equipment for loan and equipment storage areas for researchers. *J. Lang, PCSP/NRCan*

George has been a critical logistics part of many research initiatives, including the PCSP's ice island operations in the 1980s and the Lomonosov Ridge Experiment and the Canadian Expedition to Study the Alpha Ridge programs. As a camp technician at these sea ice camps, George would cut ice for kitchen use; move dynamite (used for geophysical tests) to safe places as the ice shifted; oversee fuel storage; and handle aircraft loads. George played an important role when the original ice island camp was first established. Although the camp building pieces were labelled by number for set-up by different groups planning to conduct research on the ice island, they became disordered during the transport process from southern Canada. Due to these developments, George flew to Eureka, Nunavut, to reorganize the pieces and ensure that they were flown in order to the ice island. He has also assisted at numerous field camps on land, including one on the Agassiz Ice Cap, where he oversaw the transport of ice cores by air and then by ship to southern laboratories.

Born and still living today on the island of Newfoundland, George had never visited the Arctic before his work with the PCSP, but he has now visited most of the Arctic Archipelago. He enjoys Resolute, but his favourite Arctic spot is Alexandra Fiord, Ellesmere Island. George has worked with four PCSP Directors and 14 Base Managers and has seen many changes at the PCSP Resolute facility, from working in rustic wooden buildings to the modern facilities. As scientists will be quick to say, George can find or make nearly anything you may need and always has sound and helpful advice for all who ask.

PCSP Resolute Facility Expansion



The PCSP Resolute facility expansion: Improving support for Arctic science

In response to a series of reports on the status of Canadian Arctic research infrastructure, in January 2009, the Government of Canada announced that a fund would be established for improvements on active research facilities in Canada's North. A call for proposals to the Arctic Research Infrastructure Fund, led by Indian and Northern Affairs Canada, was sent out shortly thereafter, and 20 federal and territorial government, academic and independent organizations were successful in acquiring funds for upgrades to stations in Canada's Arctic research network (www.ainc-inac.gc.ca/nth/st/arf-eng.asp). The PCSP was one of these successful organizations, receiving $11 million to expand and modernize its 20-year-old Resolute facility.

In recent years, the PCSP has seen an increasing number of researchers requesting use of the PCSP Resolute facility. During peak periods of operation, the PCSP has had to operate beyond capacity, causing some scientists to be housed at local hotels or in large tents beside the facility. Facility usage is expected to increase with continued growing interest in northern research.

To meet the current and future needs of its clients, the PCSP will expand its living accommodations building and add a modern laboratory facility in Resolute. The PCSP will add new bedrooms, construct a new kitchen and dining facility, and add more recreational and meeting space to the existing living accommodations building. In the working accommodations building, the PCSP will develop a larger, more functional office space for PCSP personnel. Construction will be completed in spring 2011. This expansion will nearly double the capacity of the facility and provide scientists and PCSP staff with more comfortable and effective accommodations and work spaces.

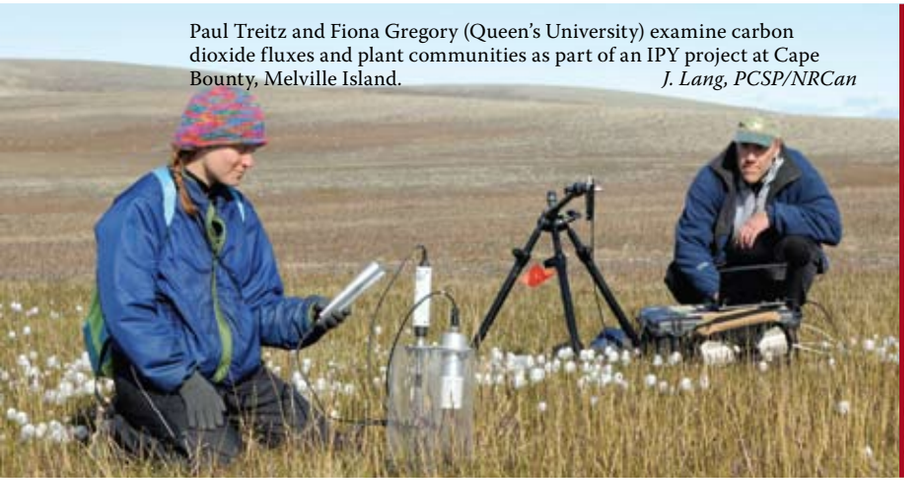
Canadian Space Agency President Steven MacLean makes presentations to former Resolute mayor Saroomie Manik, Monique Carpentier (NRCan) and Marty Bergmann (PCSP/NRCan).
N. LaSalle, PCSP/NRCan

PCSP Open House 2009

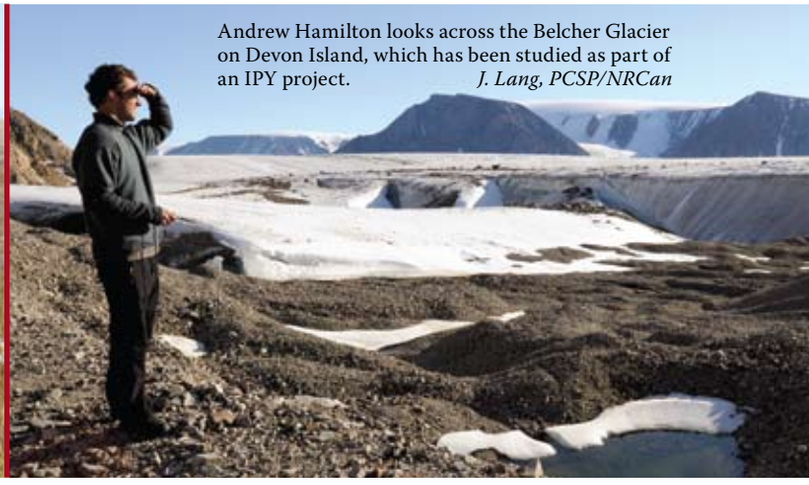
On July 29, 2009, the PCSP held its second open house event at the PCSP Resolute facility. Approximately 200 guests attended the event, including residents of Resolute, scientists and government officials. Participants had the opportunity to visit several booths with "hands-on" activities to show the work being done by Arctic scientists who receive PCSP support. These booths included information on High Arctic birds, fossils from the Haughton Crater on Devon Island, local Arctic char, and tundra vegetation studies. Traditional Inuit drum dancing and throat singing performances were highlights of the day, and presentations were given by Resolute Mayor Saroomie Manik, Canadian Space Agency President Steve MacLean, Joint Task Force North Commander Brigadier-General David Millar and PCSP Director Marty Bergmann.

PCSP's work with research organizations in Canada's North

The PCSP works closely with the organizations that handle scientific licensing for field work conducted in Canada's territories, including the Aurora Research Institute in the Northwest Territories, the Nunavut Research Institute, the Government of Yukon (Department of Tourism and Culture), and Yukon College. These organizations process licence applications and some provide transient accommodations; equipment rental; field technicians or assistance in finding such expertise; work and laboratory space; and advice for working in the North and communicating with northern communities. The PCSP continues to work with these organizations to ensure effective and efficient provision of support for Arctic scientists.



Paul Treitz and Fiona Gregory (Queen's University) examine carbon dioxide fluxes and plant communities as part of an IPY project at Cape Bounty, Melville Island. *J. Lang, PCSP/NRCan*



Andrew Hamilton looks across the Belcher Glacier on Devon Island, which has been studied as part of an IPY project. *J. Lang, PCSP/NRCan*

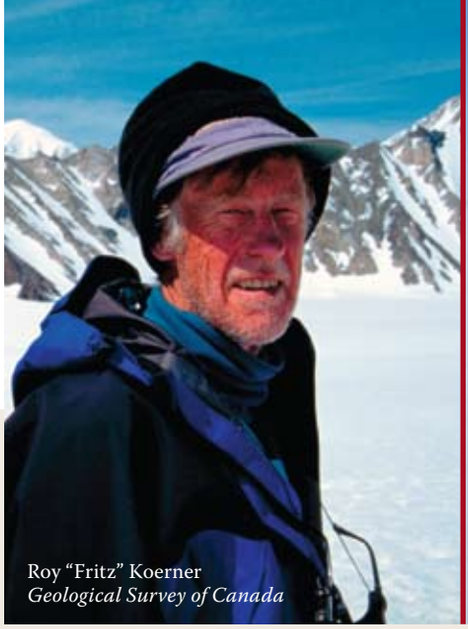
International Polar Year

International Polar Year (IPY) is a recurring major research initiative that has taken place four times in the past 130 years. The most recent IPY was held from March 2007 to March 2009. This IPY was a highly successful research initiative that brought together scientists from more than 60 countries for an intensive period of collaborative studies in many fields of polar natural and social sciences. This research program provided many scientists with additional research funds to allow them to conduct new and innovative studies.

IPY brought increased focus to polar issues and developed a wealth of data and information that will continue to grow over the coming years as more study results become available. It involved numerous students and had its own International Youth Steering Committee, with related committees in various countries.

IPY had a strong focus on people living in the circumpolar Arctic. Many research projects had significant contributions by northern residents as researchers or participants. Some studies involved Traditional Knowledge, and many had educational and outreach components for northern communities and schools.

Canada played a major role in the most recent IPY, having 43 research projects selected for IPY funding from the Government of Canada. These studies directly related to climate change impacts and adaptation and/or the health and well-being of northern communities. The PCSP supported 25 IPY projects in 2007 and 42 IPY projects in 2008, in a range of fields, including archaeology, climate change, glaciology, northern health and culture, hydrology, sea ice processes, tundra ecosystems, and wildlife habitat and behaviour. Despite the official end of IPY in March 2009, many important IPY projects are linked to long-term field studies, including 33 PCSP-supported IPY projects in 2009.



Roy "Fritz" Koerner
Geological Survey of Canada

Roy Koerner at work on a High Arctic ice cap
D. Burgess

The scientific legacy of Roy Koerner

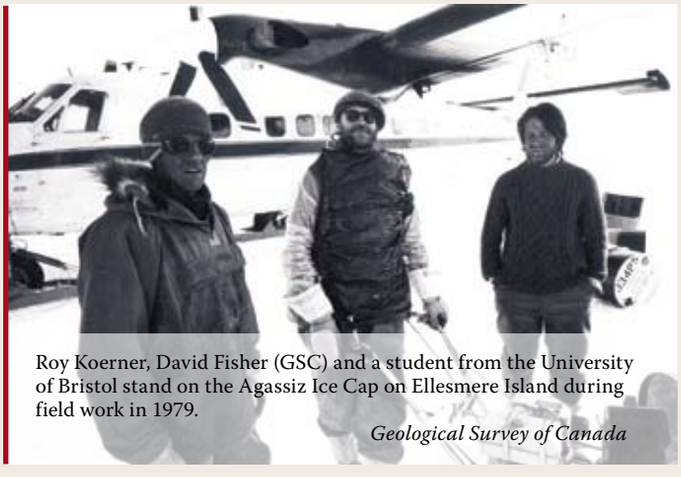
Dr. Roy "Fritz" Koerner had a long career as a glaciologist with NRCan. In the early 1960s, he was involved in the set-up of a network of equipment to monitor the Canadian High Arctic ice cap mass balance, and, after joining the PCSP in 1969, he became responsible for overseeing it. Dr. Koerner later led the Geological Survey of Canada's (GSC's) glaciology group. After his retirement in 1999, he continued his work as an emeritus scientist at NRCan until his passing in May 2008. His mass balance monitoring program is the longest-running PCSP-supported project, having begun in 1961.

Canada's northern ice caps are highly sensitive to climate variability. Dr. Koerner's mass balance measurements on the Devon, Agassiz, Melville and Meighen Ice Caps have become invaluable climate records for high-latitude, high-elevation regions where minimal data is available. Negative mass balance (more ice melt than accumulation) has been recorded at the ice caps since the 1980s. These nearly 50-year-long records are of importance not only to the Canadian scientific community, but also internationally. David Burgess (GSC, NRCan) now oversees the mass balance monitoring program and is incorporating new technologies to monitor the ice caps, including using satellite imagery to complement field measurements.

Dr. Koerner also led studies to collect ice cores from the ice caps and pioneered a method of studying their summer melt layers to develop summer temperature records. He and his research team developed Canadian Arctic summer temperature records that span the past 11 000 years. Most climate records from ice cores worldwide are developed using stable isotopes, which can be difficult to interpret. By having both stable isotope and melt layer records to examine, Dr. Koerner's research team could identify and evaluate differences in the records. This work has led to more robust ice core paleoclimate records. Dr. Koerner also established the first ice core chemistry laboratory in Canada, where he and his research team examined trends in acid pollution in Arctic ice caps.

According to GSC colleague David Fisher, Dr. Koerner greatly enjoyed going to the field and felt comfortable in any type of weather. Before joining NRCan, he was part of the four-person British Trans-Arctic Expedition that travelled across the Arctic Ocean by dog sled over 16 months in 1968–69. As the expedition's scientist, Dr. Koerner collected information on meteorology and on sea ice properties that is still referenced today.

Dr. Koerner was also an excellent educator. He was involved with Students On Ice (www.studentsonice.com) in recent years and accompanied voyages to both poles as a lecturer. Beginning in 1992, he also began studies on an ice cap near Grise Fiord, where he involved local residents in field work each year. The research programs begun and developed by Dr. Koerner continue today through the work of several researchers at NRCan. His research findings remain highly relevant today because the issue of climate change and its effects on ice masses continues to be of great importance in the Canadian Arctic and globally.



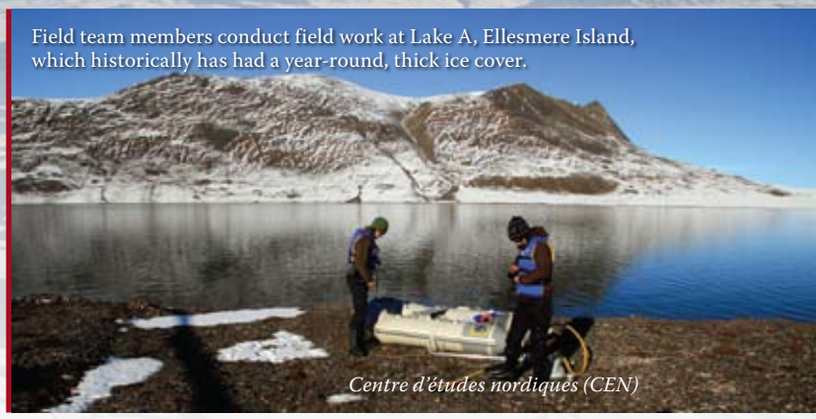
Roy Koerner, David Fisher (GSC) and a student from the University of Bristol stand on the Agassiz Ice Cap on Ellesmere Island during field work in 1979.
Geological Survey of Canada

Major fracturing of the Ward Hunt Ice Shelf and loss of ice pieces into Disraeli Fiord in August 2008

Centre d'études nordiques (CEN)

PCSP-supported projects in the news

With northern environmental and resource issues at the forefront of many minds, the Canadian Arctic is often discussed by the media. Each year, several PCSP-supported projects receive media attention for their important results. In this section, we highlight some studies that have made headlines.



Field team members conduct field work at Lake A, Ellesmere Island, which historically has had a year-round, thick ice cover.

Centre d'études nordiques (CEN)

Dramatic changes in ice shelves and ecosystems of northern Ellesmere Island

Warwick Vincent (Centre d'Études Nordiques, Université Laval), Derek Mueller (Canadian Ice Service, Environment Canada) and Luke Copland (University of Ottawa)

Canada's ice shelves on the northern coast of Ellesmere Island are some of the most beautiful features of the High Arctic, but regional environmental changes have recently affected them and the ecosystems they support. Since 1998, Warwick Vincent has been leading studies that examine the changing state of Canada's ice shelves, including the IPY project Microbiological and Ecological Responses to Global Environmental Change in the Polar Regions (MERGE). Luke Copland and Derek Mueller are also leading ongoing studies of the ice shelves, which have contributed to the IPY projects MERGE and Variability and Change in the Canadian Cryosphere.

In 2002, Derek Mueller discovered that the largest remaining Arctic ice shelf, the Ward Hunt Ice Shelf, had cracked in half. In 2005, the nearby Ayles Ice Shelf broke away from the coast, and in August 2008, Warwick Vincent's field team arrived to study the Markham Ice Shelf and was shocked to find that it was gone. These ice shelves, dated at 3500 to 5000 years old, once formed a continuous large shelf along the coast, but the research teams have found that 90 percent of this ice complex has been lost during the past century, with particularly high rates of ice loss during the past few years. In addition to warming regional temperatures, study results show that reduced coastal summer sea ice coverage, tides and wind have also played roles in destabilizing the ice. When floating in the Arctic Ocean, the ice shelf pieces are a major concern for areas of offshore oil and gas development because their thickness often exceeds 40 metres (m).

Luke Copland and Derek Mueller found that, in 2008 alone, 23 percent of the ice from the remaining ice shelves and vast areas of 50 to 70-year-old landfast sea ice (sea ice attached to the shore) in the study area were lost. This research team uses satellite imagery and field measurements to examine structural properties and movement of the ice shelves and surrounding sea ice and fiord ice. They recently installed a weather station at Milne Fiord and a new mass balance monitoring network on the remaining ice shelves to examine changes in the amount of ice accumulated and lost each year. They also study ice cores to improve accuracy for interpreting satellite imagery of the study area.

> ***These ecosystems at the top of Canada contain a remarkable diversity of life, but climate change is pushing them to the brink of extinction.***
> – Warwick Vincent

The changing ice shelves are greatly affecting ecosystems that depend on the ice for their existence. Microbial mats (communities of algae, bacteria and microscopic animals) that live in ponds on the surface of ice shelves and aquatic life in epishelf lakes (freshwater overlying sea water in fiords blocked by ice shelves) are losing their habitat due to ice shelf degradation. Warwick Vincent's research team studies changes in biodiversity, vegetation and ecosystem functions to better understand how life survives in these extreme High Arctic environments and to monitor the ongoing impact of climate change.

The research teams have shared their results at school and community presentations in Resolute and Iqaluit. Further information continues to be disseminated through national and international media coverage, journal publications, public lectures, and presentations within Canada and abroad.

Mary Dawson, Liz Ross and Natalia Rybczynski examine fossils at their field camp on Devon Island, Nunavut.

M. Lipman, Canadian Museum of Nature

The discovery of Puijila darwini: A missing link is found

Natalia Rybczynski,
Canadian Museum of Nature

Fossil discoveries can provide a wealth of information about ancient animal species, their evolution into modern-day species, and the climate in which they lived. In summer 2007, Natalia Rybczynski and her field team were working in the Haughton impact crater on Devon Island, Nunavut, when one of their all-terrain vehicles ran out of gas. While student Elizabeth Ross (Carleton University) waited for fuel with Mary Dawson (Carnegie Museum of Natural History, U.S.A.), she found a small black bone. From this chance discovery, the team unearthed a nearly complete, 1.1-m-long skeleton of a seal-like creature, over the course of three field seasons. In consultation with the Inuit Qaujimajatuqangit Katimajiit, this new fossil was given the scientific name *Puijila darwini*.

From careful examination of the fossil skeleton, the research team determined that *Puijila darwini* was a carnivore that could walk and swim with its webbed feet, allowing it to hunt on land and in water. It is considered a transitional animal in the evolution of a group called pinnipeds, which includes seals, sea lions and walruses. *Puijila* acts as a missing link between ancient land mammals to those that now thrive in aquatic environments. It lived approximately 20 to 24 million years ago during a time when a warmer climate allowed forests to flourish on Devon Island.

> **Puijila** ***is important because it is a transitional fossil: a missing link. It is the first fossil evidence to support the hypothesis that the warm ancient Arctic played an important role in the early evolution of pinnipeds.*** – Natalia Rybczynski

This discovery raises important questions for palaeontologists studying the evolution of pinnipeds. Scientists once believed that seals evolved separately from sea lions and walruses, with separate ancestors for each group moving from land to sea. However, recent evidence indicates a single origin for pinnipeds. The discovery of *Puijila* provides evidence for what the earliest pinnipeds would have looked like.

Natalia Rybczynski and colleagues Mary Dawson and Richard Tedford (American Museum of Natural History, U.S.A.) published a paper about *Puijila* in the prestigious journal *Nature* in spring 2009. The fossil was unveiled at the Canadian Museum of Nature on April 28, 2009, and a replica will be on display at the American Museum of Natural History. The research team presented their work at the PCSP 2009 Open House, where residents of Resolute and other guests had the opportunity to see replica and real bones from *Puijila* and compare them with those of more familiar modern relatives: seals. In future, the research team will be examining where *Puijila* fits in the pinniped family tree, which will provide a framework for determining how pinnipeds moved from land habitats to the aquatic environment.

Natalia Rybczynski holds a fossil of part of the skull of *Puijila darwini* beside a model of the ancient creature's skeleton.

M. Lipman, ©Canadian Museum of Nature

Mapping Canada's Arctic continental shelves: Science to support Canada's submission on the United Nations Convention on the Law of the Sea

Natural Resources Canada and Fisheries and Oceans Canada

The United Nations Convention on the Law of the Sea (UNCLOS) was developed to regulate the use of the world's oceans and their resources. More than 150 countries have ratified the Convention, including Canada in 2003. Member countries have internationally recognized rights over mineral and biological resources on and beneath the ocean floor and control over environmental and conservation matters within 200 nautical miles of their shores. This area represents a country's Exclusive Economic Zone (EEZ). However, countries also have rights over an extended area if they can demonstrate that the outer limit of their continental shelf (a zone of relatively shallow water that extends off the coast) exists beyond the current EEZ. The UNCLOS specifies standard methods to determine the outer limit of a country's continental shelf using scientific information about the seabed.

By its deadline of 2013, Canada will prepare a submission to the United Nation's Commission on the Limits of the Continental Shelf (CLCS) to provide scientific evidence in support of an extended continental shelf area. A team of scientists from NRCan and Fisheries and Oceans Canada are collecting and analysing the detailed data required for Canada's submission. In 2008, they worked from a sea ice camp to examine an area north of Ellesmere Island, including the Alpha Ridge, an underwater mountain chain that stretches across part of the Arctic Ocean Basin. In 2009, a field camp was established north of Ward Hunt Island, where Danish and Canadian scientists worked together to examine another underwater mountain chain, the Lomonosov Ridge, and its surrounding area near the boundary between Greenland and Canada. At each site, bathymetric and gravity data were collected to better understand the shape of the seafloor.

Ship work in support of UNCLOS was also conducted in summer 2009, when Canadian scientists aboard the icebreaker CCGS *Louis S. St. Laurent* worked alongside

A field team member takes measurements using a gravity meter placed on sea ice to get information on rock density beneath the Arctic Ocean seabed.

J. Lang PCSP/NRCan

> ***The data collection in the Arctic has been extremely challenging. However, due to the dedication of our scientists and technical staff, we have been able to collect high-quality information across the entire Arctic. This will allow Canada to put forward a strong submission to the UN Commission by its deadline of 2013.*** – Jacob Verhoef, Canada's UNCLOS Program Director, NRCan

American researchers on the USCG *Healy* to collect seismic and bathymetric data in the western Arctic. In coming years, research will focus on an area west of Alpha Ridge, where bathymetric data will be collected using, for the first time, Autonomous Underwater Vehicles. Further studies will be done in the northern part of Alpha Ridge and in the Canada Basin. It is expected that the field program will be completed in 2011. All the existing data, including the data collected in this program, will be compiled and analyzed to assess the outer limit of Canada's Arctic continental shelf.

The UNCLOS project is highly important to Canada. A positive recommendation from the CLCS to Canada's submission will be a key factor for Canada to gain international recognition of the area over which Canada has sovereign rights along its Arctic and Atlantic coasts. This recognition will provide the basis for discussions of future resource development, management and conservation on Canada's continental shelves.

PCSP-supported field camps in the Canadian Arctic (2008)

Legend

Field Camp Research Themes:

- Ecological Integrity
- Sustainable Communities and Culture
- Climate Change
- Northern Resources and Development
- Planetary Science
- National Parks and Weather Stations
- Multiple project types

Location Type:

- Communities
- PCSP Resolute Facilities
- Military Outposts
- National Parks

Air Distances In Kilometers

			Iqaluit
		Alert	2091
	Inuvik	2274	2843
Resolute	1503	1090	1573

Air distances and directions follow great circle routes: the shortest distance between places on the globe, and the route most often taken by aircraft.

Community names derived from the Canadian Geographical Names Data Base and Furgal, C., Kalhok, S., Loring, E. and Smith, S. 2003. *Knowledge in action: Northern Contaminants Program structures, processes and products*. Indian and Northern Affairs Canada, Canadian Arctic Contaminants Assessment Report II, 90 pp.

Vertical Near Side Perspective Projection, height adjusted to 3000 km above the Earth

PCSP-supported projects in 2008

The PCSP supported 139 scientific research projects in 2008 that examined a range of research questions across many scientific disciplines. To highlight the importance of this research to major issues commonly discussed, the projects were assigned to general research categories, with the understanding that some projects fit into more than one category. In this section, several projects are highlighted as representative studies within these broad categories.

A blind, used to observe birds from a close distance, stands on a cliff top at a study plot on Prince Leopold Island, Nunavut.
A.J. Gaston, Environment Canada

A Long-tailed Duck sits on her nest at Alexandra Fiord, Ellesmere Island, Nunavut. *J. Lang, PCSP/NRCan*

Black-legged Kittiwakes with chicks at Prince Leopold Island, Nunavut
A.J. Gaston, Environment Canada

Ecological integrity

The Canadian Arctic boasts a great diversity of animals and plants that are specialized to live in the challenging northern environment. Changing environmental conditions and pollution from areas far away are influencing these vital components of the Arctic ecosystem. Understanding animal behaviour, dynamics between species, and the effects of contaminants on northern ecosystems will not only allow for a greater knowledge of the Arctic environment, but will also inform discussions of proper species management and policy discussions for Canada's North.

How seabirds can help detect ecosystem change in the Arctic

Tony Gaston (Wildlife Research, Environment Canada)

More than 300 bird species live partially or exclusively in the marine environment and more than 50 seabird species breed in Canada, including many in the Arctic. Studies about the effects of ongoing environmental change on Canada's seabirds are key to developing long-term conservation and management policies. Since 1979, Tony Gaston and colleagues from the Nunavut Research Institute, University of Ottawa, University of Manitoba, Memorial University of Newfoundland and Environment Canada have been conducting studies to examine the ecology of Arctic seabirds.

In 2008, the research team conducted studies in the eastern Arctic, where they examined the diets, adult body condition and nestling (baby bird) growth of birds including Thick-billed Murres, Northern Fulmars and Glaucous Gulls. Small devices to record locations were used along with ship-based acoustic surveys of marine prey concentrations to examine seabird hunting behaviour. The retrieved devices showed that Murres breeding in Hudson Bay remained there until late November to early December, instead of departing from the bay in September, as was previously assumed. Results also showed that Murres from Hudson Bay and a colony at Prince Leopold Island winter mainly in southern Davis Strait and the northern Labrador Sea, while those from the Akpait colony on the Cumberland Peninsula of Baffin Island winter in areas from Newfoundland and Labrador to southern Greenland. The separation of these populations in winter was previously unknown, and these results provide important information on the vulnerability of different populations to oil pollution and hunting in various areas.

Data on seabird diets that was collected in collaboration with northern hunters is being compared with surveys conducted in the eastern Arctic in the 1970s and 1980s to examine how marine food webs have been affected by environmental changes. The research team studies bird diving behaviour by using tiny depth sensors and also bands birds during field studies. When hunters find

Field assistant Annie Levasseur looks for shorebirds on the outer Mackenzie Delta, Northwest Territories. *J. Rausch*

a banded bird, they can report the number and help the research team to study seabird movements. The research team also has examined seabird feathers and tissue samples for mercury and other contaminants as part of the IPY project Ecosystem Studies of Subarctic and Arctic Regions. They found that many Arctic-breeding seabirds are increasingly mistaking plastic fragments for food, which may cause bird injury and death in future.

Since 1984, Tony Gaston has also studied population dynamics, reproductive success and survival rates of a major Thick-billed Murre colony on Coats Island. The data from this work comprises the longest continuous monitoring record for any seabird in Canada. The trend towards earlier ice break-up in Hudson Bay is causing earlier phytoplankton blooms and associated peaks in zooplankton, which greatly influences the marine food web. However, the birds at Coats Island have been unable to adjust the timing of their breeding, when their food requirements are highest, to match the changing peak time of food availability. This situation is resulting in reduced growth of chicks. This ongoing research is providing the knowledge needed to develop further monitoring, conservation and management plans for Arctic seabirds.

> **Did You Know:** ***A Thick-billed Murre can dive up to 150 m? During its research on Arctic-breeding seabirds, Tony Gaston's team recorded this record dive, which lasted just under four minutes.***

Arctic Shorebird Monitoring Program

Jennie Rausch and Vicky Johnston (Canadian Wildlife Service, Environment Canada)

Nearly half of all shorebirds (birds that live in wetland and coastal environments) in Canada breed in the Arctic, including Whimbrel and many types of sandpipers and plovers. Up to 80 percent of Canadian shorebird populations are in decline, with a disproportionate number being Arctic species. Since 1997, northern shorebird studies, led by Jennie Rausch and Vicky Johnston, have been contributing key ecosystem information to inform environmental assessment processes and species monitoring, management, and conservation efforts in Canada's North.

The Arctic Shorebird Monitoring Program is Canada's only widespread shorebird monitoring initiative on Arctic breeding grounds. This research is part of the joint Canadian-American Program for Regional and International Shorebird Monitoring (PRISM), which focuses on collecting baseline information on Arctic shorebirds and creating maps of shorebird distribution, abundance, and habitat. Since 1997, the research team has conducted aerial and ground surveys at more than 1500 study sites in the Canadian Arctic, covering an area of 232 square kilometres. They have documented nearly 9000 pairs of shorebirds who represent 34 species and have calculated population estimates for 19 species.

Since 2005, the research team has worked in the Mackenzie Delta for the PRISM program and in support of environmental assessments relating to potential hydrocarbon developments. The population health of Whimbrel has been of particular interest in this area, and the team has learned much about their habitat preferences and behaviour. The research team has also been studying nesting areas and breeding behaviours of shorebirds in the Kendall Island Bird Sanctuary. In 2008 and 2009, surveys were also conducted in the region of Arviat and Baker Lake, Nunavut, as part of the IPY project Climate Change Impacts on Canadian Arctic Tundra. Satellite imagery was used to identify possible shorebird habitat areas, and subsequent surveys showed that the area is rich in shorebird species.

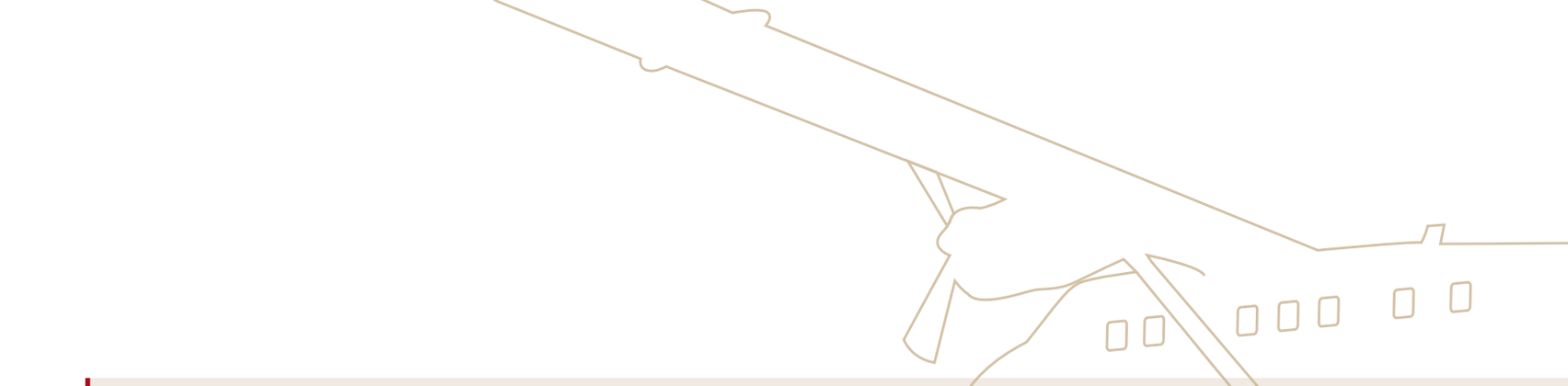
Each field season, students from northern communities are part of field research activities, and, in May 2008, the research team used IPY support to run a field science camp for students from Arviat. The camp focused on local shorebirds, climate change influences and careers in biology. Students got hands-on experience using field equipment and benefitted from the involvement of community Elders, who shared their knowledge of local bird populations.

With shorebird population estimates now determined for half of the Canadian Arctic PRISM study regions, the monitoring team are finishing the first round of surveys and finalizing population estimates. After the first round is complete, they will begin the second round of surveys and begin to examine trends in shorebird populations on a larger scale than was previously possible. The research team is nearing completion of a monograph of their work from 1997 to 2007, which will be released in 2010.

An American Golden-Plover shows a distraction display to lure potential predators away from her nest in Queen Maud Gulf Bird Sanctuary, Nunavut. *J. Rausch*

> ***Shorebird populations are experiencing declines. We need to know how many birds there are and get accurate estimates of the rate and magnitude of declines so that we can determine the causes and how to reverse these negatives trends, or for species that are already at risk, how their recovery can be managed.*** – Jennie Rausch

Jennie Rausch shows youth from Qitiqliq Middle School in Arviat, Nunavut, how to look for and identify shorebirds. *T. Mulders*



Projects focused on ecological integrity

Karrak Lake assessment of continental efforts at population reduction of Light Geese
Locations: Karrak Lake and Perry River, N.W.T.
Principal investigator: Ray Alisauskas (Wildlife Research, Environment Canada)
E-mail: ray.alisauskas@ec.gc.ca

Survival in Arctic geese (Perry River, Queen Maud, Gulf Bird Sanctuary)
Location: Perry River, N.W.T.
Principal investigator: Ray Alisauskas (Wildlife Research, Environment Canada)
E-mail: ray.alisauskas@ec.gc.ca

The Red Throated Loon as an environmental indicator for offshore oil and gas activity
Locations: Coastal Beaufort Sea areas (based out of Inuvik, N.W.T)
Principal investigator: Jessica Beaubier (Northern Conservation Division, Environment Canada)
E-mail: Jessica.beaubier@ec.gc.ca

Ecology of the Arctic fox and red fox on Bylot Island
Location: Bylot Island, NU
Principal investigators: Dominique Berteaux (Centre d'Études Nordiques, Université du Québec à Rimouski) and Jean-François Giroux (Département des sciences biologiques, Université du Québec à Montréal)
E-mail: Dominique_berteaux@uqar.qc.ca

Population estimate using DNA darting for grizzly bears in the Inuvialuit Settlement Area, west of delta eastward
Locations: Paulatuk and Rendezvous Lake, N.W.T.
Principal investigator: Marsha Branigan (Environment and Natural Resources, Government of the Northwest Territories)
E-mail: Marsha_Branigan@gov.nt.ca

Baffin Island goose banding
Location: Nikko Island, NU
Principal investigator: Dale Caswell (Canadian Wildlife Service, Environment Canada)
E-mail: Dale.caswell@ec.gc.ca

Fishing Branch (Ni'iinlii'njik) River, Yukon: hydrological and ecological connections
Location: Fishing Branch River, Y.T.
Principal investigator: Ian Clark (Department of Earth Science, University of Ottawa)
E-mail: idclark@uottawa.ca

Establishing legacy conditions of river ecosystem biodiversity and function for climate variability and change assessment – Pangnirtung/Iqaluit program (Part of the ARCTIC Freshwater BIOdiversity Research and Assessment NETwork: ARCTIC-BIONET project)
Locations: Iqaluit and Pangnirtung, NU
Principal investigator: Joseph Culp (Aquatic Ecosystem Impacts Research Division, Environment Canada)
E-mail: Joseph.culp@ec.gc.ca

Establishing legacy conditions of river ecosystem biodiversity and function for climate variability and change assessment – Quttinirpaaq program (Part of the ARCTIC Freshwater BIOdiversity Research and Assessment NETwork: ARCTIC-BIONET project)
Location: Lake Hazen (Ellesmere Island, NU)
Principal investigator: Joseph Culp (Environment Canada)
E-mail: Joseph.culp@ec.gc.ca

Fossil fishes from a Lower Devonian marine environment in Arctic Canada
Location: Anderson River, N.W.T.
Principal investigator: Stephen Cumbaa (Canadian Museum of Nature)
E-mail: scumbaa@mus-nature.ca

Ecology of grizzly bears in the Mackenzie Delta oil and gas development area
Locations: Locations in the Mackenzie River Delta, N.W.T. (based from Inuvik)
Principal investigator: Andrew Derocher (Department of Biological Sciences, University of Alberta)
E-mail: derocher@ualberta.ca

Movement patterns and dispersal of juvenile polar bears in the Beaufort Sea
Locations: Locations on the Beaufort Sea (based from Tuktoyaktuk, N.W.T.)
Principal investigator: Andrew Derocher (Department of Biological Sciences, University of Alberta)
E-mail: derocher@ualberta.ca

Identification of Beaufort Sea migration corridor for Sea Ducks
Location: Sik Sik Lake (Banks Island, N.W.T.)
Principal investigator: Lynne Dickson (Canadian Wildlife Service, Environment Canada)
E-mail: lynne.dickson@ec.gc.ca

Pacific Common Eider population status in the Bathurst Inlet area of Nunavut
Location: Nauyak Lake, N.W.T.
Principal investigator: Lynne Dickson (Canadian Wildlife Service, Environment Canada)
E-mail: lynne.dickson@ec.gc.ca

Paleontology of the Bonnet Plume Formation, Yukon Territory, Canada
Location: Bonnet Plume basin, Y.T.
Principal investigator: David Evans (Department of Ecology and Evolutionary Biology, University of Toronto)
E-mail: d.evans@utoronto.ca

Regional stream sediment and water geochemistry survey, Mackenzie Mountains, Northwest Territories
Locations: Arctic Red Lodge and Palmer Lake, N.W.T.
Principal investigator: Hendrik Falck (Northwest Territories Geoscience Office, Government of the Northwest Territories)
E-mail: Hendrik_falck@gov.nt.ca

Investigating potential regional effects of climate warming on mercury concentrations in landlocked Arctic char *(Salvelinus Alpinus)*
Location: Resolute, NU
Principal investigator: Nikolaus Gantner (Department of Environmental Biology, University of Guelph)
E-mail: ngantner@uoguelph.ca

How seabirds can help detect ecosystem change in the Arctic – a component of the ecosystem studies of Subarctic and Arctic regions
Location: Prince Leopold Island, NU
Principal investigator: Tony Gaston (Wildlife Research, Environment Canada)
E-mail: Tony.gaston@ec.gc.ca

Seabird studies at Coats Island, Nunavut
Locations: Coats Island and Digges Island, NU
Principal investigator: Tony Gaston (Wildlife Research, Environment Canada)
E-mail: Tony.gaston@ec.gc.ca

Biology of tundra bird populations: demographics, trophic interactions and climate change
Location: Bylot Island, NU
Principal investigator: Gilles Gauthier (Centre d'Études Nordiques, Université Laval)
E-mail: gilles.gauthier@bio.ulaval.ca

Population studies of Common Eider Ducks breeding in East Bay, Nunavut
Location: East Bay (Southampton Island, NU)
Principal investigator: Grant Gilchrist (Wildlife Research, Environment Canada)
E-mail: grant.gilchrist@ec.gc.ca

Population surveys of Eider Ducks wintering in the Belcher Islands, Nunavut, March 2008
Location: Belcher Islands, NU (based from Sanikiluaq)
Principal investigator: Grant Gilchrist (Wildlife Research, Environment Canada)
E-mail: grant.gilchrist@ec.gc.ca

Flora of the Canadian Arctic: diversity and change
Locations: Austin Bay and Wollaston Peninsula (Victoria Island, NU) and Clifton Point and Bernard Harbour, NU
Principal investigator: Lynn Gillespie (Canadian Museum of Nature)
E-mail: lgillespie@mus-nature.ca

Distribution of bowhead whales in the south east Beaufort Sea during late summer, 2007–2009
Locations: Locations in the Beaufort Sea (based from Inuvik, N.W.T.)
Principal investigator: Lois Harwood (Arctic Science, Fisheries and Oceans Canada)
E-mail: harwoodl@dfo-mpo.gc.ca

Ecology and management of waterfowl populations from the western Canadian Arctic
Locations: Mackenzie River Delta and Sik Sik Lake (Banks Island, N.W.T.)
Principal investigator: Jim Hines (Canadian Wildlife Service, Environment Canada)
E-mail: jim.hines@ec.gc.ca

Long-term monitoring of lake trout stocks in Great Bear Lake
Location: Great Bear Lake, N.W.T.
Principal investigator: Kimberly Howland (Arctic Aquatic Research, Fisheries and Oceans Canada)
E-mail: kimberly.howland@dfo-mpo.gc.ca

Estimating the abundance, composition and distribution of Peary caribou and muskoxen on Devon Island, Nunavut
Location: Expedition Fiord (Axel Heiberg Island, NU)
Principal investigator: Debbie Jenkins (Wildlife Management, Government of the Northwest Territories)
E-mail: pondbiologist@qinq.com

Silurian brachiopods and graptolites of the central Arctic Islands, Canada: Implications for biostratigraphy and paleoenvironment
Locations: Abbott River and Read Bay (Cornwallis Island, NU) and Baillie Hamilton Island, NU
Principal investigator: Jisuo Jin (Department of Earth Sciences, University of Western Ontario)
E-mail: jjin@uwo.ca

Fish survey/ecosystem structure of nearshore coastal waters, Yukon North Slope
Location: Phillips Bay, Y.T.
Principal investigator: Jim Johnson (Arctic Aquatic Research, Fisheries and Oceans Canada)
E-mail: johnsonj@dfo-mpo.gc.ca

Arctic Shorebird Monitoring Program
Location: East Bay (Southampton Island, NU)
Principal investigators: Victoria Johnston (Canadian Wildlife Service, Environment Canada) and Grant Gilchrist (Wildlife Research, Environment Canada)
E-mail: vicky.johnston@ec.gc.ca

Arctic Shorebird Monitoring Program
Locations: Mackenzie River Delta, N.W.T., and Arviat and Baker Lake, NU
Principal investigator: Victoria Johnston and Jennie Rausch (Canadian Wildlife Service, Environment Canada)
E-mail: jennie.rausch@ec.gc.ca

Terrestrial trophic interactions in the ecology of western Arctic small mammals
Locations: Herschel Island, Shingle Point, and Komakuk Beach, Y.T. and Walker Bay, N.W.T.
Principal investigator: Charles Krebs (Faculty of Science, University of British Columbia)
E-mail: krebs@zoology.ubc.ca

Southampton Island goose banding
Location: Coral Harbour, NU
Principal investigator: Jim Leafloor (Canadian Wildlife Service, Environment Canada)
E-mail: Jim.leafloor@ec.gc.ca

Greater Snow Goose population dynamics in relation to habitat and the Circumpolar Observatory Network
Locations: Eureka (Ellesmere Island, NU) and Bylot Island, NU
Principal investigators: Josée Lefebvre and Austin Reed (Canadian Wildlife Service, Environment Canada)
E-mail: Josee.lefebvre@ec.gc.ca

Contaminants in seabirds at Prince Leopold Island and Coats Island, Nunavut
Locations: Prince Leopold Island and Coats Island, NU
Principal investigator: Mark Mallory (Canadian Wildlife Service, Environment Canada)
E-mail: mark.mallory@ec.gc.ca

Ecology of Ross's and Ivory Gulls in Penny Strait, Nunavut
Location: Tern Island, Queen's Channel, NU
Principal investigator: Mark Mallory (Canadian Wildlife Service, Environment Canada)
E-mail: mark.mallory@ec.gc.ca

Yukon North Slope Grizzly Project
Locations: Shingle Point and Sheep Creek, Y.T.
Principal investigator: Ramona Maraj (Environment Yukon, Government of Yukon)
E-mail: Ramona.Maraj@gov.yk.ca

Demography, behaviour and prey relations of Arctic wolves
Location: Eureka (Ellesmere Island, NU)
Principal investigator: David Mech (University of Minnesota, U.S.A.)
E-mail: david_mech@usgs.gov

Hornaday River water quality and quantity
Location: Hornaday River, N.W.T.
Principal investigator: Neil Mochnacz (Arctic Aquatic Research, Fisheries and Oceans Canada)
E-mail: mochnacznj@dfo-mpo.gc.ca

Ecology and ecophysiology of High Arctic shorebirds
Location: Alert (Ellesmere Island, NU)
Principal investigator: R.I.G. Morrison (Wildlife Research, Environment Canada)
E-mail: guy.morrison@ec.gc.ca

Deposition of halogenated organic contaminants in the Canadian Arctic inferred from ice caps and lake sediments
Location: Devon Ice Cap (Devon Island, NU)
Principal investigator: Derek Muir (Aquatic Ecosystem Protection Research Division, Environment Canada)
E-mail: Derek.muir@ec.gc.ca

Polar bear population inventory and habitat selection study, Foxe Basin, Nunavut
Locations: Locations around Foxe Basin, NU
Principal investigator: Elizabeth Peacock (Department of Environment, Government of Nunavut)
E-mail: epeacock@nunavutwildlife.ca

Assessment of possible impacts of oil and gas activities in the outer Mackenzie Delta and nearshore southern Beaufort Sea on polar bears
Locations: Locations on the Mackenzie River Delta, N.W.T. and coastal Beaufort Sea (based out of Inuvik and Tuktoyaktuk, N.W.T.)
Principal investigator: Evan Richardson (Canadian Wildlife Service, Environment Canada)
E-mail: Evan.Richardson@ec.gc.ca

Late Devonian vertebrates of Ellesmere Island
Locations: Bird Fiord, Skrap Valley, and Okse Point (Ellesmere Island, NU)
Principal investigator: Neil Shubin (Department of Anatomy, University of Chicago)
E-mail: Nshubin@uchicago.edu

Reproductive ecology and habitat selection of declining duck species nesting in the lower Mackenzie Valley, Northwest Territories
Location: Cardinal Lake, N.W.T.
Principal investigator: Stuart Slattery (Ducks Unlimited Canada)
E-mail: s_slattery@ducks.ca

Rare and threatened species inventory in the northern Yukon
Location: Sheep Creek, Y.T.
Principal investigator: Barney Smith (Environment Yukon, Government of Yukon)
E-mail: barney.smith@gov.yk.ca

Mercury speciation in the Mackenzie River Delta, N.W.T.
Locations: Locations on the Mackenzie River Delta, N.W.T. (based from Inuvik)
Principal investigator: Gary Stern (Freshwater Institute, Fisheries and Oceans Canada)
E-mail: sterng@dfo-mpo.gc.ca

Walrus stock definition and enumeration
Locations: Coastal locations based out of Resolute, Hall Beach and Iqaluit, NU
Principal investigator: Rob Stewart (Arctic Aquatic Research, Fisheries and Oceans Canada)
E-mail: Robert.ea.stewart@dfo-mpo.gc.ca

Modeling of migratory patterns to spawning and over-wintering areas of harvested fish species in rivers along the Mackenzie Valley pipeline route
Locations: Locations along the Mackenzie River, N.W.T.
Principal investigators: Melanie VanGerwen-Toyne and Ross Tallman (Arctic Aquatic Research, Fisheries and Oceans Canada)
E-mail: Melanie.Toyne@dfo-mpo.gc.ca

Microbial investigations of cold saline springs and permafrost in the High Arctic
Locations: Expedition Fiord (Axel Heiberg Island, NU) and Eureka (Ellesmere Island, NU)
Principal investigator: Lyle Whyte (Department of Natural Resource Sciences, McGill University)
E-mail: Lyle.Whyte@mcgill.ca

The impacts of a changing cryosphere on the hydrology, geochemistry, and food web structure in lotic ecosystems in the western Canadian Arctic (IPY Arctic BIONET – Western Arctic Riverine Watershed Component)
Location: Inuvik, N.W.T.
Principal investigator: Fred Wrona (Aquatic Ecosystem Impacts Research Division, Environment Canada)
E-mail: fred.wrona@ec.gc.ca

Sustainable communities and culture

Humans have occupied the Canadian Arctic for thousands of years, and archaeologists have been actively locating formerly inhabited sites to help explain this important part of our history. Research at these sites provides insight into land and resource usage by past inhabitants, peoples' movements over time, interactions between groups of people, and many elements of the rich and diverse cultures that have lived in the Canadian Arctic. Much historical information can also be found through the Traditional Knowledge of northern residents, who often lead or participate in studies designed to develop recorded information about culturally important locations and former and current ways of life in northern communities that can be shared between generations.

The site of an ancient Thule dwelling on Somerset Island, Nunavut
J. Lang, PCSP/NRCan

Helluland Archaeology Project

Pat Sutherland (Canadian Museum of Civilization)

Information about human activity in the ancient past is provided primarily by archaeological research that has shown that Canada's Arctic has a long and rich cultural history. The Helluland Archaeology Project, led by Pat Sutherland, is examining the interactions between the aboriginal peoples (the Dorset Palaeo-Eskimos and the Thule Inuit) and early Europeans, who met in the eastern Arctic in the centuries around AD 1000. Helluland was the name given by the Norse to a barren land to the west of Greenland and likely refers to Baffin Island and the Labrador region.

The research for the Helluland Project began in 1999 when unusual artifacts resembling those recovered from Norse sites in Greenland were found in archaeological collections from a Dorset Palaeo-Eskimo site on northern Baffin Island. Since the initial discovery, similar artifacts, including spun yarn, whetstones for sharpening metal tools, and a range of wooden and whalebone artifacts have been found in collections from two other Dorset sites on Baffin Island and one in Labrador. Over several field seasons, Pat Sutherland and her field teams, which have included youth from local communities, have carried out investigations at these sites and located additional sites of interest. In 2008, field work was focused on the excavation of anomalous architectural features at one of the Dorset sites on the south coast of Baffin Island that may be related to Norse visits to this area. Museum collections in Canada and abroad and Norse sites in Greenland have been examined as part of this ongoing research project. Results to date indicate more complex and extensive interactions between the Dorset Palaeo-Eskimos and early Europeans than previously suspected. The period of contact appears to have spanned several centuries and to have involved

A bowhead whale bone artifact from an excavated Thule dwelling site on Somerset Island, Nunavut *J. Lang, PCSP/NRCan*

Archaeological excavations at a Dorset site on the south coast of Baffin Island *P. Sutherland*

trade. Investigations into Norse/Inuit interaction have also been undertaken, including a re-examination of archaeological collections from Thule Inuit sites. Findings suggest a different pattern of contact and one that was more limited.

This study is part of the IPY project Inuit History-Climatic Change and Historical Connections, 1000–1900 A.D. Collaborators on this project include Marianne Douglas (University of Alberta) and John Smol (Queen's University). In 2008 they and their students sampled sediment from ponds at several Dorset Palaeo-Eskimo and Thule Inuit sites on the south coast of Baffin Island. The data collected are being used to reconstruct environmental conditions during the time when these groups of people occupied the area and when the Norse may have established shore stations along this coast.

The Helluland research, recently reported in a feature article in *Canadian Geographic*, on "The Nature of Things," and in other national and international media, is providing a new perspective on human interaction in the Canadian Arctic in the centuries around AD 1000.

Finding their footprints: Long-term history of the cultural landscape of northern Banks Island, Northwest Territories

Lisa Hodgetts (Department of Anthropology, University of Western Ontario)

Inland areas of Banks Island, Northwest Territories, were important for travelling and hunting in centuries past. Lisa Hodgetts is leading a project to locate and examine formerly inhabited places to better understand past land usage within Aulavik National Park. Through archaeological examination of these sites and use of Traditional Knowledge, the research team is learning about interactions between people and their environment both in the past and today.

In 2008, the research team recorded 76 new archaeological sites along two creeks that flow into the Thomsen River. Most of the sites date to the Inuinnait (historic Copper Inuit) period, lasting from the late-1700s to early-1900s. The team found stone features, including tent rings, food caches, outdoor cooking hearths and skin and meat drying structures. Variations in tent sizes, shapes and features suggest that different people used the area over time, including single and multiple family groups. The sites were used repeatedly and features were rebuilt. The limited number of artifacts found suggests that the sites were used for short periods as people passed through the area during summer, and animal bones at the sites indicate that the Inuinnait hunted muskox, Peary caribou and snow geese.

Traditional Knowledge is a key component of this research. Sachs Harbour elders have contributed their knowledge of activities in hunting camps, animal movements, features at the archaeological sites, Inuvialuktun place names, and past land use in Aulavik National Park. They have also assisted in mapping traditional land use in the study area. This information is allowing the research team to better interpret the archaeological sites through a stronger understanding of traditional land use practices in the area.

This research has also involved youth through a field camp developed in collaboration with Parks Canada. In 2008, six students from Sachs Harbour and Inuvik were part of the camp, where they learned from an elder participating in the event and assisted with archaeological research. The students developed a multimedia presentation about their experiences and presented it to their communities.

Building on the success of this first camp, future camps are planned. The research team also frequently shares their findings at open house events and school visits in Sachs Harbour and Inuvik. They are also developing a Web site that will show three-dimensional reconstructions of the excavated sites and artifacts.

During the next three years, the research team will begin archaeological excavations to better understand the use of the Inuinnait tents and will continue to map traditional land use. They will also examine the bone chemistry and DNA of ancient muskoxen and caribou to learn more about past populations, which will help to inform resource management decisions today.

> ***We are combining traditional Inuvialuit knowledge with archaeological research in order to tell the story of past peoples' interactions with their landscape on northern Banks Island.***
> – Lisa Hodgetts

Elders Lena Wolki and Jean Harry at Head Hill on Banks Island, Northwest Territories *L. Hodgetts*

Projects focused on sustainable communities and culture

Dynamic Inuit social strategies: environment and society during the Thule migration
Location: Cambridge Bay, NU
Principal investigator: Max Friesen (Department of Anthropology, University of Toronto)
E-mail: max.friesen@utoronto.ca

Finding their footprints: long-term history of the cultural landscape of northern Banks Island, N.W.T.
Locations: Locations in Aulavik National Park (Banks Island, N.W.T.)
Principal investigator: Lisa Hodgetts (Department of Anthropology, University of Western Ontario)
E-mail: lisa.hodgetts@uwo.ca
Web site: http://anthropology.uwo.ca/Faculty/Hodgetts/Research.html

Cultural continuity and change in the interior of southern Baffin Island: revisiting the Pre-Dorset/Dorset transition
Location: Mingo Lake (Baffin Island, NU)
Principal investigator: S. Brooke Milne (Department of Anthropology, University of Manitoba)
E-mail: milnes@cc.umanitoba.ca

Regional impacts of climate change: sea ice and human history of the Northwest Passage
Locations: Rowley Island, Wales Island, Arlagnuk Point (Melville Peninsula), and Cape Chapman (Simpson Peninsula), NU
Principal investigators: James Savelle (Department of Anthropology, McGill University) and Arthur Dyke (Geological Survey of Canada, Natural Resources Canada)
E-mail: James.savelle@mcgill.ca

Van Tat Gwich'in Cultural Technology Project (Year Two)
Locations: Old Crow and Fishing Branch River, Y.T.
Principal investigator: Shirleen Smith (Heritage Branch, Vuntut Gwichin First Nation)
E-mail: xmith@interbaun.com

Helluland Archaeology Project
Location: Cape Tanfield (Baffin Island, NU)
Principal investigator: Pat Sutherland (Canadian Museum of Civilization)
E-mail: Patricia.Sutherland@civilization.ca

Meltwater streams flow off the Belcher Glacier, Devon Island, Nunavut.
J. Lang, PCSP/NRCan

Field team members collect water samples from a river at Cape Bounty to examine nutrient transport. *S. Lamoureux*

Climate change

Climate change remains a major issue for the Canadian Arctic and the world as a whole. The important role that polar areas play in regulating global climate makes them areas of particular interest for understanding climate processes. The sensitivity of these regions to environmental change makes them important areas for studying the impacts of ongoing change. The PCSP continues to support many projects annually that are examining components of the climate system, past climate variability, ecosystem changes and adaptation to changing conditions.

Cape Bounty Arctic Watershed Observatory

Scott Lamoureux (Department of Geography, Queen's University)

To understand the responses of Arctic landscape, river and lake systems to climate change and predict possible future conditions, current processes must be examined, and recent changes must be placed in the context of long-term variability. Since 2003, Scott Lamoureux has been leading a multidisciplinary study at Cape Bounty, Melville Island, Nunavut, to examine hydrological and ecosystem processes in two adjacent drainage basins and the influences of ongoing regional environmental change on these systems over time.

During IPY, this research evolved into the IPY project Measuring the Impact of Climate Change on Landscape and Water Systems in the High Arctic, which has involved examining river flow, permafrost stability, vegetation communities, greenhouse gas (GHG) fluxes, and sediment, nutrient (carbon and nitrogen) and contaminant transport within the study catchments. Water and vegetation samples, sediment cores, GHG measurements and satellite imagery are collected every year and used to examine and monitor landscape and ecosystem processes over time. Paleoclimate (past climate) records developed from annually laminated lake sediments have also been examined to determine long-term changes in climate, hydrology and ecology in the study catchments.

In 2007, temperatures higher than 20°C were recorded at Cape Bounty for the first time since regional records began in 1950. This unusual warmth melted the soil surface to a depth of approximately 1 m, which is nearly double the usual summer melt depth. With unusually heavy July rainfall events, soil instability followed, and large areas of soil moved downslope – in some cases, directly into river channels. The sediment altered river flow, impacted water quality, and significantly increased the amount of sediment that was transported to lakes. Based on these events, the research team determined that a single period of unusually warm weather can have a major influence on Arctic landscape processes and result in widespread, but localized, disturbance to the permafrost, with impacts on overall water quality that can last for years to potentially decades. This information is important for informing discussions of northern water resource management and the development and maintenance of infrastructure in areas prone to permafrost disturbance. The high temperatures and slope disturbances at Cape Bounty received extensive media attention at national and international levels.

Project results were presented to the Resolute Hamlet Council in 2008, and as part of IPY, class lessons and activities were developed for Qarmartalik School to connect the youth of Resolute to the work being done at Cape Bounty.

> ***Our work has shown how rapidly this High Arctic landscape can respond to even one exceptionally warm year and the long term impacts that cascade through the natural systems.***
> – Scott Lamoureux

A ground temperature monitoring site on Herschel Island overlooks an oil and gas drilling platform in Thetis Bay. *C.R. Burn*

Field team members drill a hole to install a ground temperature monitoring cable on Herschel Island. *C.R. Burn*

Permafrost in the Western Arctic

Chris Burn (Department of Geography and Environmental Studies, Carleton University)

Permafrost, a dominant feature of Canada's North, is being significantly affected by ongoing environmental change. When ground temperatures in permafrost areas increase, ground ice melts and land subsidence and erosion can result. These landscape changes affect ecosystems and northern infrastructure. Chris Burn is leading research to better understand the permafrost environment of the western Canadian Arctic, particularly the Mackenzie Delta region of the Northwest Territories, and how it is being influenced by warming air temperatures in the area since 1970. This research involves many students and collaborators, including J. Ross Mackay (University of British Columbia), Steve Kokelj (Indian and Northern Affairs Canada) and Douglas Esagok (Inuvialuit Game Council).

The project's main field sites are Illisarvik (outer Mackenzie Delta), Garry Island, Herschel Island and Paulatuk. By using ground temperature sensors installed at the sites to depths of up to 50 m, the research team can examine the response of permafrost to warming air temperatures. They also study summer thaw in a thin layer of ground above the permafrost (active layer) and the influences of ground surface conditions, including winter snow depth, on permafrost.

In 2008, as part of the IPY project Thermal State of Permafrost, the research team examined ground temperature profiles and active-layer thickness at Herschel Island, Illisarvik and Paulatuk. Through field studies since 1983, the team has developed the longest record of active layer thickness in North America at the Illisarvik site. The data indicate that the depth of summer thaw has increased 10 centimetres over the past 25 years, causing ground settlement issues and changes in vegetation. The team also found a strong relationship between climate conditions recorded at Herschel Island and ground temperatures from 1899 to 2007. During the past century, permafrost has warmed to a depth of 100 m, with a total of 2°C of warming at the top of the permafrost.

Northern residents have been part of the field team each year, including students from Inuvik during the 2008 and 2009 field seasons. The research team has recently published results in a special issue of *Permafrost and Periglacial Processes* and in *Journal of Geophysical Research*. They also published a map of ground temperatures in the Mackenzie Delta area, which is being compared with a similar one created by J. Ross Mackay in 1974 to examine regional changes in permafrost conditions.

Future plans involve continuing the permafrost monitoring program, with increased focus on changes in landscape conditions as a result of the observed ground warming. Subsiding ground is of great importance when considering northern energy development and existing infrastructure in northern communities. The team will also complete a study of the temperature system within a Herschel Island ice cellar built by whale hunters 110 years ago but still in use.

> ***Our data link explicitly how ground temperatures are changing as the climate warms, and they point to the key sites where the terrain will become more sensitive to climate change in the future.*** – Chris Burn

Impacts of climate variability and change on High Arctic tundra ecosystems and soils

Greg Henry (Department of Geography, University of British Columbia) and Steve Siciliano (Department of Soil Science, University of Saskatchewan)

Tundra ecosystems dominate the landscape of Canada's North, and studies of these environments provide key information for determining the response of Arctic vegetation and soils to predicted warmer conditions. Since 1992, Greg Henry has studied tundra vegetation and its response to climate change at Alexandra Fiord, Ellesmere Island. As part of the research team, Steve Siciliano has also conducted complementary studies on the influence of biological soil processes on GHG fluxes from tundra ecosystems. This ongoing work is part of the International Tundra Experiment (ITEX) and the IPY project Climate Change Impacts on Canadian Arctic Tundra.

The research team studies seven types of Arctic vegetation communities occurring in conditions ranging from wet sedge to polar desert. By using small greenhouse enclosures (1.5 m diameter) with open tops to surround different types of tundra vegetation, the research team is examining how vegetation and soil react to different levels of warming, melt season length and nutrient availability. The enclosures imitate potential future conditions over areas of tundra. The enclosures raise the temperature of the air and soil surface in the plots by 1°C to 3°C during summer. In some plots, the research team also controls the amount of snow cover and/or adds fertilizer to examine the effects of warming in combination with changing melt season length and nutrient availability. In 2008, the team also began to study the flux of GHGs, including nitrous oxide (N_2O), carbon dioxide and methane, from the soil of the study plots. Tiny soil organisms (microbes and bacteria) play major roles in producing and consuming GHGs, and the experimental plots are used to examine how warmer temperatures, snow cover and fertilizer affect the soil's ability to take in and release GHGs. Control plots (study areas with no experimentation) are also used for comparison with the experimental plots.

Steve Siciliano checks a spectrometer that is used to measure soil greenhouse gas fluxes at Alexandra Fiord, Ellesmere Island.
J. Lang, PCSP/NRCan

The study's results show that experimental warming increases plant growth and seed production for most tundra vegetation. Warming also has a greater influence on species composition and abundance than changes in snow cover. Species diversity is decreased under warmer conditions, and larger plants (e.g. small shrubs) become more dominant as lichen and moss abundance decreases. Nitrogen, an important nutrient, is also found at higher levels in the soil of warmed study plots. These results apply to all vegetation communities studied, although the response to warming is greatest in the driest ones. Although the research team expected the driest sites to produce limited amounts of GHGs, they recorded substantial amounts released when the study plots were warmed. The plots also released larger amounts of N_2O than anticipated.

The tundra study plots at Alexandra Fiord represent the longest-running warming experiments of their type in Canada. This ongoing research is important for developing more accurate predictions of the response of the extensive tundra ecosystems to their changing climate and their contributions to global climate change.

> ***Alexandra Fiord is the longest-running climate change experiment in the Arctic and encompasses seven major vegetation communities found throughout the Arctic. It is truly a national and international treasure trove of scientific information.*** – Steve Siciliano

Sea ice east of Resolute, Nunavut, in summer 2008 *J. Lang, PCSP/NRCan*

Projects focused on climate change

Arctic coastal dynamics under changing relative sea level and environmental forcing
Locations: Cape Charles York (Baffin Island), Pond Inlet (Baffin Island), Lowther Island and Griffith Island, NU
Principal investigator: Trevor Bell (Department of Geography, Memorial University of Newfoundland)
E-mail: tbell@mun.ca

Effects of cryoturbation on carbon and nitrogen dynamics in Arctic soils
Location: Truelove Lowlands (Devon Island, NU)
Principal investigator: Angela Bedard-Haughn (Department of Soil Science, University of Saskatchewan)
E-mail: angela.bedard-haughn@usask.ca

Calibration and validation of the Cryosat-2 radar altimeter: field experiments on the Devon Ice Cap, Nunavut, Canada
Location: Devon Ice Cap (Devon Island, NU)
Principal investigators: David Burgess and Michael Demuth (Geological Survey of Canada, Natural Resources Canada)
E-mail: David.Burgess@nrcan.gc.ca

Permafrost and climate change, western Arctic Canada
Locations: Herschel Island, Y.T., and Illisarvik and Paulatuk, N.W.T.
Principal investigator: Chris Burn (Department of Geography and Environmental Studies, Carleton University)
E-mail: crburn@ccs.carleton.ca

An integrated study of permafrost conditions on Herschel Island
Location: Herschel Island, Y.T.
Principal investigators: Nicole Couture (Geological Survey of Canada, Natural Resources Canada) and Wayne Pollard (Department of Geography, McGill University)
E-mail: NicoleJ.Couture@nrcan-rncan.gc.ca

Inuit history: climate change and cultural relationships in the eastern Arctic, AD1000-1900 (Paleolimnological analyses)
Location: Cape Tanfield (Baffin Island, NU)
Principal investigators: Marianne Douglas (Department of Earth and Atmospheric Sciences, University of Alberta), John Smol (Department of Biology, Queen's University) and Pat Sutherland (Canadian Museum of Civilization)
E-mail: marianne.douglas@ualberta.ca

The Polar Environment Atmospheric Research Laboratory
Location: Eureka (Ellesmere Island, NU)
Principal investigator: James Drummond (Department of Physics, University of Toronto)
E-mail: james.drummond@utoronto.ca

Mass balance of White and Baby Glaciers, Axel Heiberg Island, Nunavut
Location: Expedition Fiord (Axel Heiberg Island, NU)
Principal investigators: Miles Ecclestone and Graham Cogley (Department of Geography, Trent University)
E-mail: mecclestone@trentu.ca

Environmental change in Arctic Canada: ice age to present
Locations: Parker Point, Antler Cove, Green Cabin, Castel Bay, Jesse Bay and Durham Heights (Banks Island, N.W.T.)
Principal investigator: John England (Department of Earth and Atmospheric Sciences, University of Alberta)
E-mail: John.England@ualberta.ca

Paleoenvironments and Thule social change on the Melville Peninsula, Nunavut
Location: Sarcpa Lake, NU
Principal investigator: Sarah Finkelstein (Department of Geography, University of Toronto)
E-mail: Finkelstein@geog.utoronto.ca

Using paleolimnology to identify "hotspots" of environmental change in aquatic ecosystems of Sirmilik National Park, Nunavut
Locations: Locations within Sirmilik National Park, NU (based from Pond Inlet)
Principal investigator: Sarah Finkelstein (Department of Geography, University of Toronto)
E-mail: Finkelstein@geog.utoronto.ca

Coastal impacts and climate change adaptation options in Arctic communities
Locations: Clyde River, Hall Beach and Iqaluit, NU
Principal investigator: Don Forbes (Geological Survey of Canada, Natural Resources Canada)
E-mail: dforbes@nrcan.gc.ca

DAMOCLES Arctic Ocean buoy deployment and ice camp support
Locations: Eureka (Ellesmere Island, NU) and a camp on Arctic Ocean sea ice
Principal investigator: Rene Forsberg (Geodynamics Department, Danish National Space Center, Denmark)
E-mail: rf@space.dtu.dk

Quantify paleoclimate from high-resolution lacustrine sequences in the Canadian High Arctic
Location: South Sawtooth Lake (Ellesmere Island, NU)
Principal investigator: Pierre Francus (Institut national de la recherche scientifique)
E-mail: pfrancus@ete.inrs.ca

Old Crow basin, northern Yukon: developing analogues for a future warmer Arctic
Locations: Eagle River and Hidden Bluff, Y.T.
Principal investigator: Duane Froese (Department of Earth and Atmospheric Sciences, University of Alberta)
E-mail: Duane.froese@ualberta.ca

Postglacial paleoclimatology of the central and western Arctic islands
Location: Banks Island, N.W.T.
Principal investigator: Konrad Gajewski (Department of Geography, University of Ottawa)
E-mail: gajewski@uottawa.ca

Genome size and climate
Locations: Amituk and Aqiatusuk Lakes (Cornwallis Island, NU), Sapphire Lake (Devon Island, NU) and Boomerang Lake (Somerset Island, NU)
Principal investigator: T. Ryan Gregory (Department of Integrative Biology, University of Guelph)
E-mail: rgregory@uoguelph.ca

Helicopter electromagnetic measurements of the sea ice mass balance
Locations: Locations over Arctic Ocean sea ice (based from Alert, Ellesmere Island, NU)
Principal investigator: Christian Haas (Department of Earth and Atmospheric Sciences, University of Alberta)
E-mail: Christian.Haas@ualberta.ca

Impacts of climate variability and change on High Arctic tundra ecosystems
Locations: Alexandra Fiord, Princess Marie Bay, Sverdrup Pass, Eastwind Lake and Lake Hazen (Ellesmere Island, NU) and Cape Bounty (Melville Island, NU)
Principal investigator: Greg Henry (Department of Geography, University of British Columbia)
E-mail: ghenry@geog.ubc.ca

Buoys-0n-Ice 2008
Locations: Locations on the Arctic Ocean (based from Eureka, Ellesmere Island, NU)
Principal investigator: Edward Hudson (Meteorological Service of Canada, Environment Canada)
E-mail: edward.hudson@ec.gc.ca

Microbiological and ecological responses to global environmental changes in Canadian Arctic ecosystems
Location: Oobloya Bay (Ellesmere Island, NU)
Principal investigator: Hiroshi Kanda (Arctic Environment Research Center, National Institute of Polar Research, Japan)
E-mail: kanda@nipr.ac.jp

Mass balance and snow pollution
Locations: Melville South Ice Cap (Melville Island, N.W.T.) Meighen Ice Cap (Meighen Island, NU), Devon Ice Cap (Devon Island, NU) and Agassiz Ice Cap and an ice cap near Grise Fiord (Ellesmere Island, NU)
Principal investigators: Roy Koerner and David Burgess (Geological Survey of Canada, Natural Resources Canada)
E-mail: David.Burgess@nrcan.gc.ca

The impact of climate variability and permafrost disturbance on watershed fluxes: integrated watershed research at Cape Bounty, Melville Island
Locations: Cape Bounty (Melville Island, NU) and Shellabear Point (Melville Island, N.W.T.)
Principal investigators: Scott Lamoureux and Melissa Lafrenière (Department of Geography, Queen's University)
E-mail: Scott.lamoureux@queensu.ca
Web site: www.geog.queensu.ca/cbawo/

The microbial diversity of thermokarst ponds and their production of greenhouse gases. Phase II (2008–2009): Carbon assessment and ecosystem approach
Location: Bylot Island, NU
Principal investigators: Isabelle Laurion (Centre d'Études Nordiques, Institut national de la recherche scientifique) and Laurier Poissant (Environment Canada, University of Ottawa and Centre d'Études Nordiques)
E-mail: Isabelle.laurion@ete.inrs.ca

Biogeochemistry of lakes in the Mackenzie Delta
Locations: Locations on the Mackenzie River Delta, N.W.T. (based from Inuvik)
Principal investigator: Lance Lesack (Department of Geography, Simon Fraser University)
E-mail: Lance_Lesack@sfu.ca

Vegetation dynamics of Bylot Island, biotic interactions and climate change
Location: Bylot Island, NU
Principal investigators: Esther Lévesque (Centre d'Études Nordiques, Université du Québec à Trois-Rivières), Line Rochefort (Centre d'Études Nordiques, Université Laval) and Daniel Fortier (Yukon Cold Climate and Innovation Centre, Yukon College)
E-mail: Esther.Levesque@uqtr.ca

Hydrological studies, Mackenzie Delta region
Location: Richards Island, N.W.T.
Principal investigator: Philip Marsh (National Water Research Institute, Environment Canada)
E-mail: Philip.Marsh@ec.gc.ca

Glacio-hydrological characterization of an Arctic polythermal glacier
Location: Fountain Glacier (Bylot Island, NU)
Principal investigator: Brian Moorman (Department of Geography, University of Calgary)
E-mail: moorman@ucalgary.ca

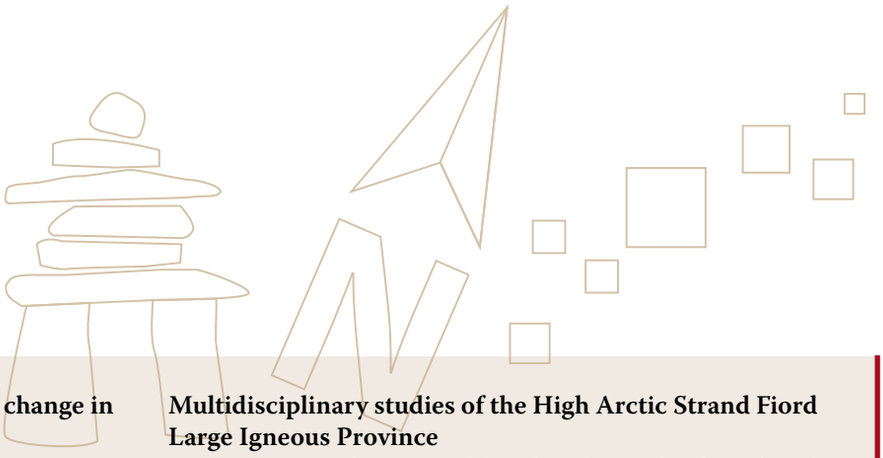
Permafrost monitoring in Mackenzie Valley
Locations: Locations along the Mackenzie River Valley, N.W.T. (based from Inuvik)
Principal investigator: Mark Nixon (Geological Survey of Canada, Natural Resources Canada)
E-mail: mnixon@nrcan.gc.ca

Global change and animal population impacts on northern lake ecosystems
Location: Bylot Island, NU
Principal investigator: Reinhard Pienitz (Centre d'Études Nordiques, Université Laval)
E-mail: reinhard.pienitz@cen.ulaval.ca

Dendroclimatic and paleoecological investigations of the Mackenzie Delta, NWT
Locations: Locations on the Mackenzie River Delta, N.W.T. (based from Inuvik)
Principal investigator: Michael Pisaric (Department of Geography and Environmental Studies, Carleton University)
E-mail: michael_pisaric@carleton.ca

The significance of ground water and ground ice in cold polar environments
Locations: Eureka (Ellesmere Island, NU) and Expedition Fiord (Axel Heiberg Island, NU)
Principal investigator: Wayne Pollard (Department of Geography, McGill University)
E-mail: Wayne.pollard@mcgill.ca

Assessment of the Arctic char of Quttinirpaaq National Park, NU
Location: Lake Hazen (Ellesmere Island, NU)
Principal investigator: Jim Reist (Arctic Aquatic Research Division, Fisheries and Oceans Canada)
E-mail: jim.reist@dfo-mpo.gc.ca



Landscape evolution, paleoecology and climate change in the Tertiary of the High Arctic
Locations: Ballast Brook, Log River, Castel Bay and Muskox River (Banks Island, N.W.T.), Strathcona Fiord (Ellesmere Island, NU) and Haughton Impact crater (Devon Island, NU)
Principal investigator: Natalia Rybczynski (Canadian Museum of Nature)
E-mail: nrybczynski@mus-nature.ca

Recent thickness changes of the Devon Island Ice Cap and their causes
Locations: Devon Ice Cap and Truelove Lowlands (Devon Island, NU)
Principal investigator: Martin Sharp (Department of Earth and Atmospheric Sciences, University of Alberta)
E-mail: martin.sharp@ualberta.ca

The dynamic response of Arctic glaciers to global warming
Location: Devon Ice Cap (Devon Island, NU)
Principal investigator: Martin Sharp (Department of Earth and Atmospheric Sciences, University of Alberta)
E-mail: martin.sharp@ualberta.ca

Geospatial dependency of greenhouse gas emissions from Arctic soils
Location: Alexandra Fiord (Ellesmere Island, NU)
Principal investigator: Steven Siciliano (Department of Soil Science, University of Saskatchewan)
E-mail: Steven.siciliano@usask.ca

Influence of liquid water on biological activity in Arctic soils
Locations: Eastwind Lake (Ellesmere Island, NU) and Truelove Lowlands (Devon Island, NU)
Principal investigator: Steven Siciliano (Department of Soil Science, University of Saskatchewan)
E-mail: Steven.siciliano@usask.ca

Limnology and paleoecology of lakes
Location: Resolute, NU
Principal investigators: John Smol (Department of Biology, Queen's University) and Marianne Douglas (Department of Earth and Atmospheric Sciences, University of Alberta)
E-mail: smolj@queensu.ca

Multidisciplinary studies of the High Arctic Strand Fiord Large Igneous Province
Locations: Expedition Fiord (Axel Heiberg Island, NU) and Audhild Bay and Yelverton Inlet (Ellesmere Island, NU)
Principal investigator: John Tarduno (Department of Earth and Environmental Sciences, University of Rochester, U.S.A.)
E-mail: john@earth.rochester.edu

Climate change impacts on Canadian Arctic tundra ecosystems: interdisciplinary and multi-scale assessments
Locations: Tanquary Fiord and Lake Hazen (Ellesmere Island, NU)
Principal investigator: Charles Tarnocai (Agriculture and Agri-Food Canada)
E-mail: tarnocaict@agr.gc.ca

Northern Ellesmere Island in the Global Environment (NEIGE)
Location: Ward Hunt Island, NU
Principal investigator: Warwick Vincent (Centre d'Études Nordiques, Université Laval)
E-mail: warwick.vincent@bio.ulaval.ca
Web site: www.cen.ulaval.ca/merge/

High Arctic ground temperature monitoring
Location: Hot Weather Creek (Ellesmere Island, NU)
Principal investigator: Anne Walker (Climate Research Division, Environment Canada)
E-mail: anne.walker@ec.gc.ca

Hydroecology of the Old Crow Flats, northern Yukon Territory
Location: Old Crow Flats, Y.T.
Principal investigator: Brent Wolfe (Department of Geography and Environmental Studies, Wilfrid Laurier University)
E-mail: bwolfe@wlu.ca

Hydrology of extensive low gradient High Arctic wetlands: an examination of sustainability
Location: Polar Bear Pass (Bathurst Island, NU)
Principal investigator: Kathy Young (Department of Geography, York University)
E-mail: klyoung@yorku.ca

Glacier mass balance and snow pollution monitoring, Auyuittuq National Park
Location: Penny Ice Cap (Baffin Island, NU)
Principal investigator: Christian Zdanowicz (Geological Survey of Canada, Natural Resources Canada)
E-mail: czdanowi@nrcan.gc.ca

Northern resources and development

Geo-mapping for Energy and Minerals (GEM)

Natural Resources Canada

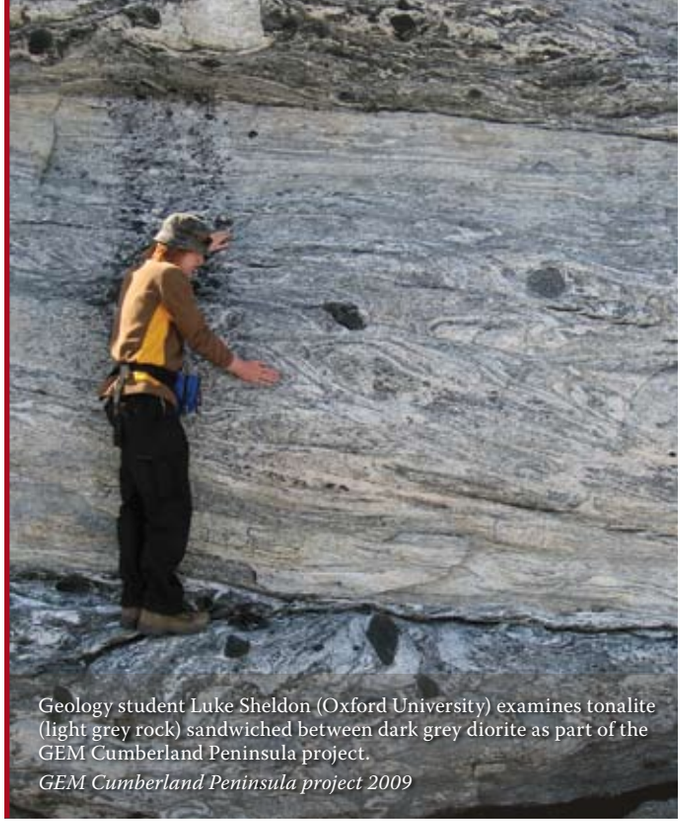
In Budget 2008, the Government of Canada described a bold "Vision for a New North," which included a two-year, $34-million investment in the Geo-mapping for Energy and Minerals (GEM) program (www.gsc.nrcan.gc.ca/gem). This program was designed to provide public geoscience (Earth science) information across the North to help guide investment decisions and lead to more effective exploration, discovery and development of new energy and mineral resources. On August 26, 2008, the Prime Minister announced that GEM would be funded at $100 million over 5 years (2008–2013).

Natural Resources Canada's Geological Survey of Canada (GSC) is leading the federal contributions to GEM in collaboration with government geoscience agencies and academic researchers from across Canada. In large areas of the North, there is insufficient public geoscience information to attract and guide effective private sector investment in exploration. While new geological mapping is important across the North, it is particularly needed in the territories. In Nunavut, adequate geological knowledge to support resource exploration is available for only approximately one third of the territory. In consideration of this knowledge gap, most of the federal GEM program's funding (at least 75 percent) is allocated for geoscience studies and subsequent public data and information development in the territories. However, the northern economic development goals of GEM are also important in the provinces, where work will be done on a cost-shared basis with provincial agencies. With the current level of resources, it is estimated that it will take 10 years to complete the tasks outlined for the GEM program. Although geo-mapping activities for energy and minerals are often quite distinct scientifically and geographically, GEM program planning and delivery will be centrally coordinated to ensure the public policy goal that northerners benefit from economic development related to resource exploration and eventual development.

GEM projects aimed at energy resources focus on developing scientific data needed to create and publish resource assessments to support exploration activity and development in under-explored areas. This work includes consideration of uranium. Minerals-related GEM projects target specific mineral commodities with significant exploration potential and include studies in areas of uncertain mineral potential. Method development is also a critical component of all GEM research, specifically where it significantly enhances the effectiveness of, or accelerates, public access to new data and knowledge and the geological assessment of resource potential.

Pangnirtung Elders visit the GEM Cumberland Peninsula camp in summer 2009. *GEM Cumberland Peninsula project 2009*

A CASE-11 project field camp at Taconite River, Ellesmere Island
W. von Gosen



Geology student Luke Sheldon (Oxford University) examines tonalite (light grey rock) sandwiched between dark grey diorite as part of the GEM Cumberland Peninsula project.
GEM Cumberland Peninsula project 2009

The Circum-Arctic Structural Events (CASE) 11 – Pearya Geological Study

Karsten Piepjohn (Federal Institute for Geosciences and Natural Resources, Germany)

Knowing an area's geology is important for understanding its long-term development and determining natural resource potential. Karsten Piepjohn and colleagues from Germany, Canada and the United States are leading a study to examine an unusual geological complex at the top of Ellesmere Island as part of the ongoing Circum-Arctic Structural Events (CASE) project. The CASE 11-Pearya study focuses on the Pearya exotic terrane, which is 300 km wide and 75 km long. Earth's crust is divided into many moving pieces called tectonic plates, and an exotic terrane is a small piece of crust that attaches to a tectonic plate. The Pearya terrane is of interest because its geological history differs from that of the North American plate. Studying the terrane provides insight into the opening of the Arctic Ocean, starting approximately 150 million years ago.

This study examines 500 million years of the geological development of the Pearya terrane. In 2008, the research team studied rock formations and flew aeromagnetic surveys (measurements of Earth's magnetic field taken from an airplane) over 12 000 km^2 of both offshore and onshore areas. By studying sediments deposited on land, deformation events in Earth's crust and magnetic data from the area, the research team is learning how the former supercontinent Laurasia broke into the modern-day continents that circle the Arctic Ocean and how Arctic Ocean basins formed.

Initial results indicate that the Pearya terrane has a similar geological history to western Svalbard (located 1500 km away) and that both areas were once part of the Eurasian continental plate. The research team has determined that approximately 350 million years ago, the Pearya terrane collided with Ellesmere Island and became part of the Laurasian supercontinent. When this supercontinent broke apart, the Pearya terrane remained in its position at the north margin of the North American plate. The study reveals the structure and evolution of the Arctic continental margin of North America. This knowledge is of importance for determining hydrocarbon potential and contributing information for Canada's submission in support of an extended continental shelf area under the terms of the UNCLOS.

The long-term CASE project has future studies planned for Ellesmere Island and other areas of interest in the circumpolar Arctic. The CASE project work on Ellesmere Island has included community involvement, with several residents of Resolute participating as field and camp assistants. The research team has also developed outreach activities in Germany, including an interactive exhibit, IPY presentations and media coverage. They also recently published their results in a GSC bulletin, which includes five new geological maps for the Nares Strait area.

> ***It is important to continue our long-term studies on Ellesmere Island, Svalbard, and North Greenland because they represent key areas for understanding the geological development of the Arctic.*** – Karsten Piepjohn

Field team members examine a rock outcrop on northern Ellesmere Island, Nunavut. *W. von Gosen*

Debbie Iqaluk examines rocks on Truro Island as part of an instructional course on prospecting.
J. Lang, PCSP/NRCan

Projects focused on northern resources and development

Northern Watch Technology Demonstration Project
Location: Gascoyne Inlet (Devon Island, NU)
Principal investigator: Dan Brookes (Defence Research and Development Canada)
E-mail: dan.brookes@drdc-rddc.gc.ca

Interferometric radar monitoring of evaporite uplift in the Sverdrup Basin
Locations: Expedition Fiord and Colour Lake (Axel Heiberg Island, NU)
Principal investigator: Paul Budkewitsch (Canada Centre for Remote Sensing, Natural Resources Canada)
E-mail: paul.budkewitsch@ccrs.nrcan.gc.ca

Southampton Island Integrated Geoscience Project (SIIG)
Locations: Locations on Southampton Island, NU (based from Coral Harbour)
Principal investigators: Joyia Chakungal (Canada-Nunavut Geoscience Office) and Mary Sanborn-Barrie (Geological Survey of Canada, Natural Resources Canada)
E-mail: msanborn@nrcan.gc.ca

Assessment of environmental, permafrost, and vegetation conditions related to oil and gas development in the outer Mackenzie Delta
Locations: Locations on the outer Mackenzie River Delta, N.W.T.
Principal investigators: Michelle Côté, Scott Dallimore, and Fred Wright (Geological Survey of Canada, Natural Resources Canada)
E-mail: micote@nrcan.gc.ca

Field studies of gas seepage from the Mackenzie Delta, N.W.T.
Locations: Locations on the outer Mackenzie River Delta, N.W.T.
Principal investigators: Scott Dallimore and Fred Wright (Geological Survey of Canada, Natural Resources Canada)
E-mail: sdallimo@nrcan.gc.ca

Alpha Ridge Test of Appurtenance (ARTA)
Location: Camp on the Arctic Ocean sea ice (based from Eureka, Ellesmere Island, NU)
Principal investigator: Ruth Jackson (Geological Survey of Canada, Natural Resources Canada)
E-mail: rujackson@nrcan.gc.ca

Documenting changes in the temperature and thickness of multi-year ice along its migration route
Locations: Locations on sea ice (based from Resolute, NU)
Principal investigator: Michelle Johnston (Canadian Hydraulics Centre, National Research Council)
E-mail: michelle.johnston@ nrc-cnrc.gc.ca

Sekwi Mountains Bedrock Mapping Project, Mackenzie Mountains, Northwest Territories
Locations: Palmer and Willow Handle Lakes, N.W.T.
Principal investigator: Edith Martel (Northwest Territories Geoscience Office)
E-mail: edith_martel@gov.nt.ca

CASE 11-Pearya
Location: Taconite Inlet (Ellesmere Island, NU)
Principal investigator: Karsten Piepjohn (Federal Institute for Geosciences and Natural Resources (BGR), Germany)
E-mail: Karsten.Piepjohn@bgr.de
Web site: www.bgr.bund.de/cln_101/nn_336670/EN/Themen/MeerPolar/Polarforschung/Arktis/arktis__node__en.html?__nnn=true

Provenance of clastic sediments in the Sverdrup Basin, Canadian Arctic Islands
Locations: Bunde Fiord (Axel Heiberg Island, NU) and Vesle Fiord (Ellesmere Island, NU)
Principal investigator: R. A. Scott (CASP, University of Cambridge, U.K.)
E-mail: robert.scott@casp.cam.ac.uk

Coastal and nearshore geohazards in the Mackenzie Delta region
Location: Gary Island, N.W.T.
Principal investigator: Steven Solomon (Geological Survey of Canada, Natural Resources Canada)
E-mail: ssolomon@nrcan.gc.ca

Tom Lamarche (Canadian Space Agency) uses a LIDAR (Light Detection and Ranging) sensor to collect topography data at the McGill Arctic Research Station.
J. Sliwinski, ©Canadian Space Agency

Planetary science

Certain locations in the Canadian Arctic have been used for examining how similar environments may exist on other planets; how life may have begun and could exist on other planets; and how best to plan, develop technology for, and coordinate space missions to places such as Mars and our own Moon. The PCSP continues to support several projects each year that are focussed on a wide range of topics within the field of planetary science.

Planetary analogue research: Preparing exploration missions to the Moon and Mars

Canadian Space Agency

Future exploration missions to the Moon, Mars and other planetary bodies will involve many fields of study and require years of practice in remote, hostile environments. Planetary analogue research in the Canadian High Arctic attracts a dedicated community of scientists, engineers, physicians and students who compete annually for support from the Canadian Space Agency's (CSA) Canadian Analogue Research Network (CARN) program. This program was created in 2005 to enable Canadian and international scientists and engineers to carry out activities at analogue sites (locations with similar environments to the Moon and Mars) in Canada. These sites provide unique opportunities to advance scientific understanding of planetary bodies by studying geological and biological processes on Earth. Many of the remote, barren, and often unexplored regions of the Canadian Arctic are compelling analogues for the Moon and Mars.

The goals of establishing the CARN program were to

- create a coordinated network of planetary analogue sites in Canada
- provide Canadian and international scientists greater access to the Arctic to perform field-based analogue research
- promote the use of remote sensing datasets (collected by satellites and airplanes) and space technologies in analogue research
- foster collaboration among the CSA, other federal government departments, universities, industry and international partners
- increase the competitiveness and level of participation of Canadian engineers and scientists in space missions and the development of exploration equipment
- provide field laboratories to test and transfer technologies for use by northern communities, stakeholders and industry partners

Jason Mah (Carleton University) uses a portable Electromagnetic Induction Sounder to detect changes in the resistivity of the ground at Expedition Fiord, Axel Heiberg Island.
C. Samson

In 2008, research projects in engineering, geology, geophysics, mineralogy, microbiology, operational space medicine (monitoring astronaut health and handling emergency situations), exploration medicine (long-term astronaut health care), and scientific research and exploration management were conducted from two bases of operations in the High Arctic. The bases are the Haughton-Mars Project Research Station (HMP) on Devon Island and the McGill Arctic Research Station (MARS) on Axel Heiberg Island. These research bases are in areas that are geologically similar to parts of the Moon and Mars. At HMP, scientists have access to a large, well-preserved impact crater that provides a realistic setting for world-class analogue research projects. At MARS, the presence of active springs and mineral deposits associated with salt domes enables scientists involved in the search for ancient life on Mars to study bacteria that form in chemically extreme environments.

An important aspect of preparing for future space exploration missions is determining how efficiently scientists can perform site surveys by using portable instruments. Field testing of lightweight, robust instruments and close monitoring of the quality of the data they record will eventually lead to Canadian-built, innovative space equipment that meets the strict requirements of future space missions. The harsh conditions on other planetary bodies require that instruments are compact, durable, reliable and capable of withstanding extreme temperatures, rough terrain, ice or dust build-up, and radiation.

Research projects in the polar desert environment usually start with the same question: how do the extreme environmental conditions affect the performance of human crews, scientific instruments and supporting technologies? A new field of expertise has developed through analogue research that focuses on all aspects of planning, conducting and analysing data from scientific sampling and exploration programs by foot or vehicle. Topographic maps and air photographs are no longer the only planning tools available to Arctic field scientists. Now geospatial analysts support CSA field crews by providing cartographic, elevation and remote sensing data to assist in planning fly

Patrick Sullivan (Astronaut Office, Canadian Space Agency) participates in an assessment of telemedicine technologies and procedures.
CSA-Martin Lipman

camp activities and study traverses from MARS and HMP. Data collected from field studies are stored in databases and used for direct comparison with space exploration mission scenarios. Field and space mission managers can use the data to determine the efficiency of scientific traverses by humans and robots, compare the results and improve future field work and space missions.

In space, astronauts do not have access to medical care as they do on Earth, and assistance from medical professionals on Earth, connected to a mission's crew by telecommunications technology, may be required. At HMP, Canadian Space Agency physicians and other medical professionals provide basic medical support to field research teams and develop medical support and emergency situation policies for field expedition and space exploration medicine. Each medical assessment or scenario is carefully documented, reviewed and integrated into a database that can be used when considering space missions and conditions at future planetary outposts. CSA and CARN projects in the field of operational space medicine are related through a strong emphasis on patient monitoring and emergency care through telecommunications (telepatient health care) that rely on medical imaging to diagnose patients and remote-control technologies to operate equipment. The results of this work are also applicable to telehealth care on Earth.

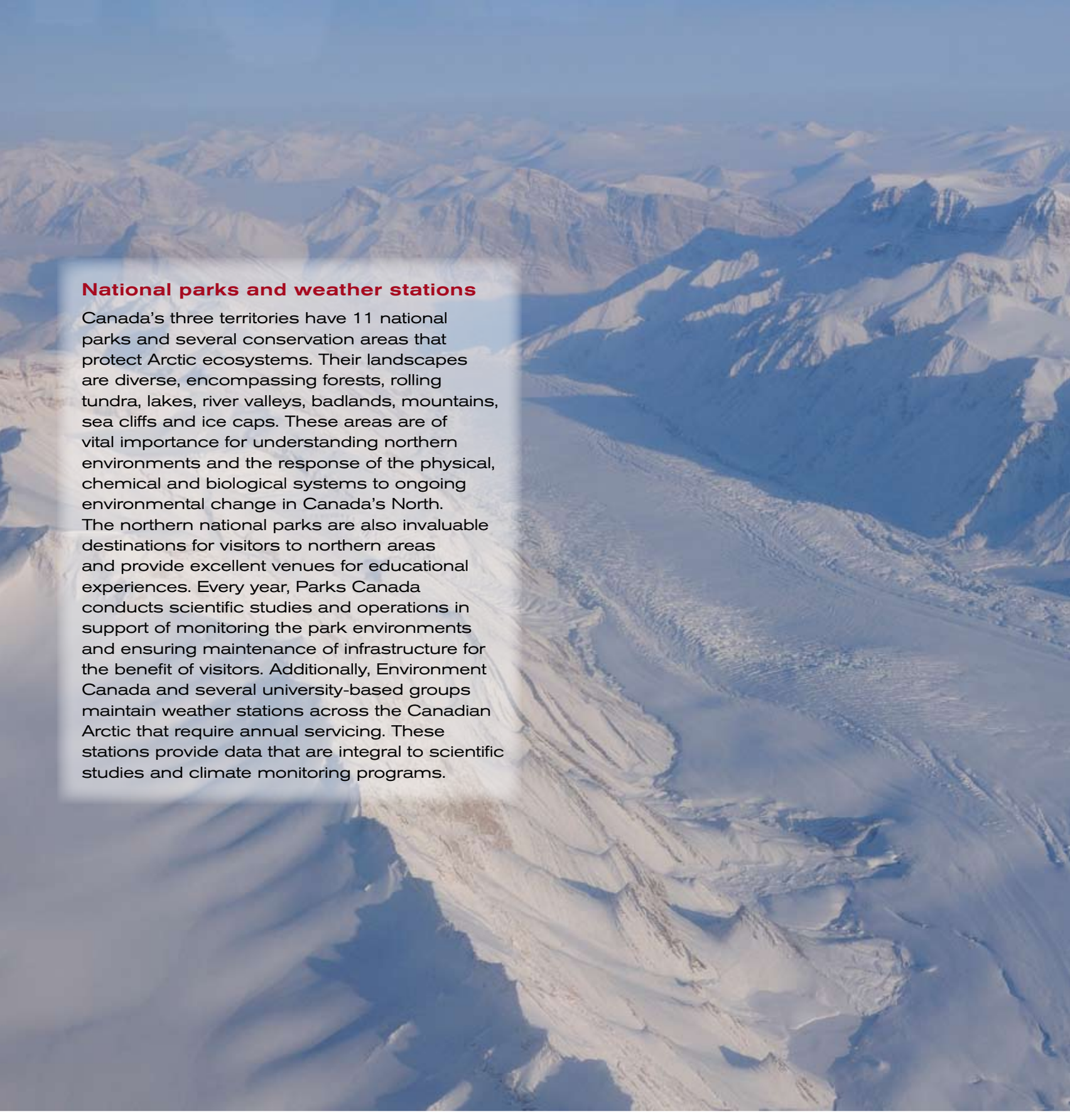
Projects focused on planetary science

Astronomical site testing on Ellesmere Island
Location: Phillips Inlet (Ellesmere Island, NU)
Principal investigators: Ray Carlberg and Eric Steinbring (Department of Astronomy and Astrophysics, University of Toronto)
E-mail: carlberg@astro.utoronto.ca

Haughton-Mars Project (HMP): Planetary analogue field studies at Haughton Crater and surrounding terrain, Devon Island, Nunavut, Canadian High Arctic
Location: Haughton Impact Crater (Devon Island, NU)
Principal investigator: Pascal Lee (Mars Institute)
E-mail: pascal.lee@marsinstitute.net

Planetary analogue research studies at the Haughton Impact Structure, Devon Island, Nunavut
Location: Haughton Impact Crater (Devon Island, NU)
Principal investigators: Marie-Claude Williamson (Geological Survey of Canada, Natural Resources Canada) and Martin Lebeuf (Canadian Space Agency)
E-mail: Marie-Claude.Williamson@nrcan-rncan.gc.ca
Web site: www.asc-csa.gc.ca/eng/exploration/carn.asp

Planetary analogue research studies at the McGill Arctic Research Station, Axel Heiberg Island, Nunavut
Locations: McGill Arctic Research Station, Expedition Fiord, Lightfoot River and East Fiord (Axel Heiberg Island, NU)
Principal investigators: Marie-Claude Williamson (Geological Survey of Canada, Natural Resources Canada) and Martin Lebeuf (Canadian Space Agency)
E-mail: Marie-Claude.Williamson@nrcan-rncan.gc.ca
Web site: www.asc-csa.gc.ca/eng/exploration/carn.asp



National parks and weather stations

Canada's three territories have 11 national parks and several conservation areas that protect Arctic ecosystems. Their landscapes are diverse, encompassing forests, rolling tundra, lakes, river valleys, badlands, mountains, sea cliffs and ice caps. These areas are of vital importance for understanding northern environments and the response of the physical, chemical and biological systems to ongoing environmental change in Canada's North. The northern national parks are also invaluable destinations for visitors to northern areas and provide excellent venues for educational experiences. Every year, Parks Canada conducts scientific studies and operations in support of monitoring the park environments and ensuring maintenance of infrastructure for the benefit of visitors. Additionally, Environment Canada and several university-based groups maintain weather stations across the Canadian Arctic that require annual servicing. These stations provide data that are integral to scientific studies and climate monitoring programs.

The glacially-carved landscape of Quttinirpaaq National Park on northern Ellesmere Island, Nunavut.
J. Lang, PCSP/NRCan, CHS/DFO

Projects focused on national parks and weather stations

Aircraft support for Auyuittuq National Park operations and research
Locations: Locations within Auyuittuq National Park (Baffin Island, NU)
Principal investigator: David Argument (Nunavut Field Unit, Parks Canada Agency)
E-mail: David.argument@pc.gc.ca

Yearly servicing of automatic weather stations at Isachsen, Mould Bay, Stefansson Island, Rae Point and Grise Fiord
Locations: Weather stations on Ellef Ringnes, Prince Patrick, Stefansson, Melville and Ellesmere islands (based from Resolute, NU)
Principal investigator: Phil Barg (Meteorological Service of Canada, Environment Canada)
E-mail: Phil.barg@ec.gc.ca

Aulavik National Park cultural resource monitoring
Location: Mercy Bay (Banks Island, N.W.T.)
Principal investigator: Lindsay Croken (Western Arctic Field Unit, Parks Canada Agency)
E-mail: Lindsay.croken@pc.gc.ca

Sirmilik National Park operations
Locations: Qaiqsut (Bylot Island, NU) and Paquet Bay and Oliver Sound (Baffin Island, NU)
Principal investigator: Carey Elverum (Nunavut Field Unit, Parks Canada Agency)
E-mail: Carey.Elverum@pc.gc.ca

Quttinirpaaq National Park operations
Locations: Tanquary Fiord, Lake Hazen, and Fort Conger (Ellesmere Island, NU) and Ward Hunt Island, NU
Principal investigator: Ross Glenfield (Nunavut Field Unit, Parks Canada Agency)
E-mail: Ross.Glenfield@pc.gc.ca

Establishing landing sites in the north end of Aulavik National Park
Locations: Locations in Aulavik National Park (Banks Island, N.W.T.)
Principal investigator: David Haogak (Western Arctic Field Unit, Parks Canada Agency)
E-mail: David.Haogak@pc.gc.ca

Acknowledgements

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Ice chunks along the shore of Truro Island, Nunavut.
J. Lang, PCSP/NRCan