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POLAR CONTINENTAL SHELF PROGRAM

SCIENCE REPORT

2009|2010

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

Canada

Polar Continental Shelf Program Science Report 2009-2010

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Photograph credits

Photograph credits are indicated within the report. Special thanks are due to Janice Lang (2008-2010) and David Ashe (2010) for providing spectacular photographs.

Photograph on cover: Joint NRCan/DFO/DRDC United Nations Convention on the Law Of the Sea (UNCLOS) Program field camp located on sea ice near Borden Island, Nunavut (J. Lang, PCSP/NRCan, CHS/DFO).

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A Twin Otter prepares to land on Devon Island, Nunavut.

J. Lang, PCSP/NRCan

Aerial view over Belcher Glacier, Devon Ice Cap, Devon Island, Nunavut.
J. Lang, PCSP/NRCan

ᒥᓂᔅᑕᐅᑉ ᑐᓴᕐᕆᓴᐅᑎᑕᖓ

ᒐᕙᒪᒃᑯᑦ ᑲᓇᑕᐅᑉ ᐊᖏᖅᓯᒪᕗᑦ ᐃᑲᔪᕐᓂᕐᒧᑦ ᐅᑭᐅᖅᑕᖅᑐᒥ ᐱᔪᓐᓇᖅᓯᓇᓱᐊᖅᑎᓪᓗᒍ.

ᐅᖓᑖᓂ 50 ᐅᑭᐅᑦ, ᐅᑭᐅᖅᑕᖅᑐᒥ ᖃᐅᔨᓴᖅᑐᓂᒃ ᐃᑲᔪᕈᑎ ᐃᑲᔪᕈᑕᐅᕐᑲᑦᑕᖅᓯᒪᕗᖅ ᑲᓇᑕᒥᐅᓂᒃ ᐊᒻᒪ ᓯᓚᕐᔪᐊᕐᒥᐅᓂᒃ ᓱᓇᑐᐃᓐᓇᕐᓂᒃ ᖃᐅᔨᓴᖅᑐᓂᒃ ᓄᓇᓕᕐᔪᐊᑦᑕ ᐅᑭᐅᖅᑕᖅᑐᖓᓂ. ᐊᒻᒪᓗ ᓱᓕ, ᑕᐃᓐᓇ ᐅᑭᐅᖅᑕᖅᑐᒥ ᖃᐅᔨᓴᖅᑐᓂᒃ ᐃᑲᔪᕈᑎ ᐃᑲᔪᕈᑕᐅᕙᑉᐳᖅ ᖃᐅᔨᓴᖅᑎᓂᒃ ᕿᒥᕐᕈᔪᓂᒃ ᑕᒪᐅᔪᓂᒃ ᐊᐱᖅᑯᓯᕆᔭᐅᔪᓂᒃ ᐃᒍᐃᑦᑐᓄᑦ ᐃᓕᖓᔪᓂᒃ ᑎᒥᕐᒥᒃ, ᐃᓗᓯᕐᒥᒃ ᐊᒻᒪ ᐃᓅᓯᕐᒥᒃ ᖃᐅᔨᓴᕐᓂᖅ. ᑖᓐᓇ ᐊᑑᑎᖃᖃᑦᑕᖅᐳᖅ ᑲᓇᑕᐅᑉ ᓇᒻᒥᓂᖅᓱᕐᓂᖓᓄᑦ ᐊᒻᒪ ᑐᑭᓯᐅᒪᓕᖅᐸᑦᓕᕈᑎᕆᕙᑦᑐᑎᒍ ᐊᐅᓐᓂᖅᑐᔪᕐᔪᐊᕐᒥ ᓄᓇᖓᓂᒃ ᐅᑭᐅᖅᑕᖅᑑᑉ.

ᑕᒪᑐᒪᓂ ᐊᕐᕉᒎᓚᐅᖅᑐᒥ ᓄᑖᓂᒃ ᑲᔪᓯᓂᖅᑲᖅᑲᑦᑕᓚᐅᖅᐳᖅ ᐅᑭᐅᖅᑕᖅᑐᒥ ᖃᐅᔨᓴᖅᑐᓂᒃ ᐃᑲᔪᕈᑎ ᐃᑲᔪᕈᑕᐅᓪᓗᓂ ᐱᕕᔾᔪᐊᓂᒃ ᒐᕙᒪᒃᑯᓐᓄᑦ ᐱᓕᕆᐊᖑᔪᓂᒃ ᒪᑯᓂᖓ ᑲᓇᑕᐅᑉ ᑐᓂᓯᓂᖓ ᓯᓚᕐᔪᐊᕐᒥ ᓄᓇᓕᕐᔪᐊᑦ ᑲᑐᔾᔨᖅᑲᑎᒋᖕᒋᑕ ᐊᖏᕈᑎᒋᒍᑎᖓᓐᓄᑦ ᐱᓪᓗᒍ ᒪᓕᒐᖅ ᐃᒫᓂ. ᓯᕗᓪᓕᖅᐹᑦᑎᐊᕐᒥᒃ, ᑲᓇᑕᒥᐅᑕᐃᑦ ᖃᐅᔨᓴᖅᑎᑦ ᐊᑐᓚᐅᖅᐳᑦ ᐃᒻᒥᓂᒃ ᐱᔪᓐᓇᖅᑐᒥᒃ ᐃᖏᕐᕋᔾᔪᑎᒥᒃ ᐊᑖᒍᑦ ᓯᑯᐸ ᐅᖓᓯᑦᑐᒧᑦ ᐊᐅᓪᓚᕈᓐᓇᖅᑐᒥᒃ ᓄᐊᑦᑎᓗᓂ ᑲᑎᖅᓱᖅᓯᓂᒃ ᐱᓪᓗᒍ ᑭᓪᓕᖓ ᑲᓇᑕᐅᑉ ᓄᓇᕐᔪᐊᖓᑕ ᖁᑦᑎᑦᑐᒥ.

ᐅᑭᐅᖅᑕᖅᑐᒥ ᖃᐅᔨᓴᖅᑐᓂᒃ ᐃᑲᔪᕈᑎ ᐃᑲᔪᕈᑕᐅᖏᓐᓇᖅᐳᖅ ᐱᓕᕆᑎᓪᓗᒋᑦ ᐅᔾᔪᕐᓂᐊᖅᑎᑦ ᐃᓚᐅᔪᑦ ᓄᓇᒥᒃ ᓄᓇᖑᐊᓕᐅᕈᑎᖃᕐᓂᕐᒧᑦ ᐊᐅᓚᔪᓐᓇᐅᓕᕆᔾᔪᑎᑦ ᐊᒻᒪ ᐅᔾᔫᕐᓂᐊᕐᕋᓯᓕᕆᔾᔪᑎᑦ ᐱᓕᕆᔾᔪᑎᖓᓐᓄᑦ ᑐᓴᐅᒪᔾᔪᑕᐅᓇᓱᐊᖅᑐᓂᒃ ᓄᓇᐅᑉ ᐊᑐᖅᑕᐅᓂᖓᓄᑦ ᐃᓱᒪᓕᐅᕈᑎᖅᑲᖅᓂᑯᑦ ᐊᒻᒪ ᐊᑐᐊᖅᓯᔾᔪᑎᖅᑲᕈᑕᐅᓗᓂ ᓄᑖᓄᑦ ᖃᓄᖅᑐᓄᑦ ᓴᕕᕋᔭᒃᓴᔭᓂᒃ ᐊᒻᒪ ᐊᐅᓚᔪᓐᓇᐅᑎᒃᓴᓂᒃ. ᑖᓐᓇ ᐱᒋᐊᖅᑎᑕᐅᓯᒪᔪᖅ ᓇᓗᓇᐅᖏᔾᔪᑕᐅᕙᖅ ᒐᕙᒪᖏᑦ ᑲᓇᑕᐅᑉ ᐱᓕᕆᓂᖏᓐᓄᑦ ᐱᑕᖅᑲᖅᑎᑎᓇᓱᐊᖅᑐᑎᒃ ᓄᑖᓂᒃ ᐱᓇᓱᐊᕋᓴᓂᒃ ᐊᒥᓱᓄᑦ ᐅᑭᐅᖅᑕᖅᑐᒥ ᓄᓇᓕᓐᓄᑦ ᐱᕙᓪᓕᐊᑎᑕᐅᓂᖏᑎᒍᑦ ᐊᐅᓚᔪᓐᓇᐅᑎᑦ ᐊᒻᒪ ᓴᕕᕋᔭᒃᓴᔭᐃᑦ ᐱᓇᓱᒐᒃᓴᐃᑦ, ᑕᒪᒃᑯᐊ ᑮᓇᐅᔭᓕᐅᕈᑎᓄᑦ ᐱᕙᓪᓕᐊᔾᔪᑕᐅᒻᒪᑕ ᑲᓇᑕᐅᑉ ᐅᑭᐅᖅᑕᖅᑐᖓᓂ. ᑕᕝᕙᓴᐃᓐᓈᓂᖅᓴᐃᑦ ᐱᓕᐅᓯᐊᒃᓴᐃᑦ ᐅᑭᐅᖅᑕᖅᑐᒥᐅᓄᑦ ᒪᑯᐊᖑᕗᑦ ᓄᑖᑦ ᐱᕆᐅᖅᓴᔾᔪᑎᒃᓴᐃᑦ, ᐱᓇᓱᒍᓐᓇᖅᓯᓂᖅ ᐊᒻᒪ ᐃᖅᑲᓇᐃᔮᒃᓴᐃᑦ ᐱᓇᓱᐊᕋᓴᐃᑦ.

ᐅᑭᐅᖅᑕᖅᑐᒥ ᖃᐅᔨᓴᖅᑐᓂᒃ ᐃᑲᔪᕈᑎ ᐃᓂᒃᓴᖅᑲᖅᑯᑦᑐᒍ ᐊᒻᒪ ᐱᓕᕆᔾᔪᑎᒃᓴᓂᒃ ᐱᔭᕆᐊᖅᑲᖅᑕᕐᖓᓂᒃ ᐊᑯᓂᐅᓂᖅᓴᐅᑎᒐᓱᐊᕐᓗᒍ ᓄᓇᒥ ᐱᓕᕆᕝᕕᒃᓴᖅ ᐊᒻᒪ ᐊᖑᒪᑦᑎᐊᓂᖅᓴᕆᐅᕐᒥᑦ ᐱᔭᕆᐊᖅᑲᖅᑕᕐᒥᑦ ᖃᐅᔨᓴᖅᑎᐅᖅᑲᑎᑦ, ᑖᒃᓯᒪ ᐱᓕᕆᔾᔪᑎᐅᑉ ᐃᑦᑐᖓ ᖃᐅᓯᐃᑦᑐᕐᒥ, ᓄᓇᕗᒥ, ᓴᓇᕆᐊᖅᑕᓚᐅᖅᐳᖅ ᐊᒻᒪ ᐃᓗᕆᐊᖅᑕᐅᑦᑐᓂ ᒪᕿᓐᓂ ᐅᑭᐅᖑᓚᐅᖅᐳᖓᓂ. ᑕᐃᓐᓇ $11-ᒥᓕᐊᓐᑐᖅᑐᖅ ᓴᓇᕆᐊᖅᑕᐅᓂᖓ ᑭᓇᐅᔭᖅᑲᖅᑎᑕᐅᓚᐅᖅᑐᖅ ᐃᓄᓕᕆᔨᖅᑲᖅᑯᑦ ᑲᓇᑕᒥ ᐅᑭᐅᖅᑕᖅᑐᒥ ᖃᐅᔨᓴᕐᓂᕐᒧᑦ ᐊᐅᓚᔪᓐᓇᐅᑎᓄᑦ ᑮᓇᐅᔭᖏᑦ, ᐃᓚᒋᔭᐅᓪᓗᓂ ᑮᓇᐅᔭᓕᐅᕈᑎᓂᒃ ᐱᕙᓪᓕᐊᑎᑦᑎᓇᓱᐊᕐᓂᕐᒧᑦ ᐸᕐᓇᒍᑎ, ᐊᒻᒪ ᐱᓴᓐᓂᖅᑕᐅᓚᐅᖅᐳᖅ ᑭᖑᕙᕆᓂ ᐊᒻᒪ ᓈᒻᒪᓈᖅᑐᒥᑦ ᑮᓇᐅᔭᑦ, ᑕᒪᓐᓇ ᐱᓴᓇᐊᑐᔫᒪᓇᒃ ᐅᖓᓯᓐᓂᖓᓄᑦ ᖁᑦᑎᑦᑐᒥ ᐃᓂᖓ.

ᐅᑭᐅᖅᑕᖅᑐᒥ ᖃᐅᔨᓴᖅᑐᓂᒃ ᐃᑲᔪᕈᑎ ᐃᑲᔪᕐᓂᖅᑲᖅᑕᖅᓯᒪᕗᖅ ᓯᕗᒧᐊᑉᐸᓪᓕᐊᓂᖓᓄᑦ ᓱᓇᑐᐃᓐᓇᕐᓂᒃ ᖃᐅᔨᓴᕐᓂᐅᑉ ᐊᒻᒪ ᖃᐅᔨᒪᔭᐃᑦ ᑕᒪᐅᔪᑎᒍᑦ ᐃᓕᖓᔪᑎᒍᑦ ᐅᑭᐅᖅᑕᖅᑐᒧᑦ, ᒪᑯᑎᒎ ᐆᒪᔪᑦ ᐃᓗᓯᖏᑦ, ᐊᐅᓚᔪᓐᓇᐅᑎᑦ ᐊᒻᒪ ᓴᕕᕋᔭᒃᓴᔭᐃᑦ ᐱᓇᓱᒐᒃᓴᐃᑦ, ᓄᓇᖑᐊᓕᐅᕆᓂᖅ ᐊᒻᒪ ᓯᓚᕐᔪᐊᑉ ᐅᖅᑰᓯᕙᓪᓕᐊᓂᖓ. ᐃᓚᖏᑦ ᐱᒪᓇᐅᓗᐊᖑᐊᖅᑐᑦ ᐆᑦᑐᕋᐅᑎᑦ ᑕᒪᑐᒎᖓ ᐱᓇᓱᐊᕐᓂᕐᒧᑦ ᐅᓂᒃᑲᓴᐅᓯᒪᕗᑦ ᑖᓯᒪᓂ ᐅᓂᒃᑲᓕᐅᕈᑎᒥ, ᑐᓴᖅᑎᑦᑎᔾᔪᑕᐅᓇᓱᐊᖅᑐᒥ ᑲᓇᑕᒥᐅᓂᒃ, ᖃᐅᔨᓴᖅᑎᓂᒃ ᐊᒻᒪ ᐊᑐᐊᒐᓕᕐᕆᓂᒃ ᒐᕙᒪᒃᑯᖅᑕ ᓯᓚᓇᐊᖅᑲᖅᑕᖅᓯᓂᒃ ᐅᑭᐅᖅᑕᖅᑐᒥ. ᑖᓐᓇ ᐱᑕᖅᑲᓇᐊᖅᑲᓪᓚᖅᑐᓂᒃ ᐱᓕᕆᓂᖅ ᓱᕐᕋᐅᑎᓂᖅᑲᓪᓚᑦᑐᖅ ᐱᕙᓪᓕᐊᑎᑦᑎᓂᒃᑯᑦ ᓴᖖᒋᓂᖅᑐᓂᒃ ᐅᑭᐅᖅᑕᖅᑐᒥ ᑮᓇᐅᔭᓕᐅᕈᑎᓂᒃ, ᓴᐳᔾᔭᐅᓂᖅᖏᓐᓄᑦ ᐊᔾᔨᐅᖏᔾᔪᑎᖏᑦ ᐊᒻᒪ ᐊᑦᑐᖅᑕᐅᔭᑦᑐᑦ ᐅᑭᐅᖅᑕᖅᑐᒥ ᐆᒪᔪᐃᑦ ᓄᖅᑭᐅᕕᖅᑭᑦ, ᐱᔪᓐᓇᖅᓯᕙᓪᓕᐊᑎᑦᑎᓂᕐᒧᑦ ᓄᓇᓖᓐᓂ ᐊᒻᒪ ᓴᖅᑭᔭᖅᑎᑦᑎᓂᕐᒧᑦ ᓄᓇᓕᕐᔪᐊᑦᑕ ᓇᒻᒥᓂᖅᓱᕐᓂᖓᓂᒃ. ᐅᑭᐅᖅᑕᖅᑐᒥ ᖃᐅᔨᓴᖅᑐᓂᒃ ᐃᑲᔪᕈᑎᒃᑯᑦ, ᒐᕙᒪᖅᑦ ᑲᓇᑕᐅᑉ ᐱᒪᓇᓪᓕᒃ ᐱᓕᕆᕗᑦ ᓴᖖᒋᓂᖅᑐᒥᒃ ᐊᒻᒪ ᐋᖅᑭᐅᒪᐃᓐᓇᕈᓐᓇᖅᑐᒥᒃ ᓯᕗᓂᒃᓴᖅᑕᖅᑯᑦᑐᒍ ᑲᓇᑕᐅᑉ ᐅᑭᐅᖅᑕᖅᑐᖓᓄᑦ.

ᑕᕝᕙᐅᕗᓯ,

ᒥᓂᔅᑕ ᔫᓕ ᐋᓕᕗ, ᐳᕈᒍᓇᐊᓯᕝ ᑲᓐᓯᕙᑎᒃᑯᑦ,
ᒪᓕᒐᓕᐅᖅᑎᐅᖅᑕᐅᔪᖅ

ᒥᓂᔅᑕᖓᑦ ᓄᓇᒥᐅᑕᓕᕆᔨᒃᑯᑦ

Aerial view of Tanquary Fiord, Ellesmere Island, Nunavut.

D. Ashe, NRCan

Minister's message

The Government of Canada is committed to helping the North realize its true potential.

For over 50 years, the Polar Continental Shelf Program (PCSP) has been supporting Canadian and international scientific research in our nation's Arctic. In addition, the PCSP supports researchers that examine a broad range of questions in the physical, health and social sciences. This contributes to Canada's sovereignty and increases our understanding of the vast regions of the North.

This past year saw new successes by the PCSP in supporting major Government projects such as Canada's submission to the United Nations Convention on the Law of the Sea. For the first time ever, Canadian researchers used an autonomous underwater vehicle under the ice for long-range trips to gather data on the limit of Canada's continental shelf in the High Arctic.

The PCSP continued to support the efforts of geologists involved in the Geo-mapping for Energy and Minerals program to inform land-use decisions and guide new exploration for minerals and energy. This initiative exemplifies how the Government of Canada is working to provide new opportunities to many northern communities through the development of energy and mineral resources, which is a primary source of economic growth in Canada's North. More immediate benefits for northerners include new training, skills and employment opportunities.

In order to give the PCSP the space and tools it needs to extend the field season and better meet the needs of the research community, the program's facility in Resolute, Nunavut, was updated and expanded over the past two years. The $11-million renovation was funded by Aboriginal Affairs and Northern Development Canada's Arctic Research Infrastructure Fund, as part of the Economic Action Plan, and was completed on time and on budget, a particular challenge given the remote High Arctic location.

The PCSP has supported the advancement of science and knowledge in a wide range of areas relevant to the North, such as wildlife health, energy and mineral resources, mapping and global warming. Some key examples of this work are highlighted in this report, which seeks to inform Canadians, researchers and policy-makers of their government's activities in the North. This critical work is instrumental for developing a strong northern economy, protecting the unique and fragile Arctic ecosystem, building capacity in communities and asserting our country's sovereignty. Through the PCSP, the Government of Canada is playing a key role to ensure a strong and sustainable future for Canada's Arctic.

Sincerely,

The Honourable Joe Oliver, P.C., M.P.
Minister of Natural Resources

The Polar Continental Shelf Program

DID YOU KNOW?

The PCSP can ship people, supplies and equipment to remote field camps that do not have airstrips. In snow-cover conditions, the PCSP's chartered Twin Otter aircraft have skis attached to the landing gear—otherwise, they use big tundra tires in order to land on the rough Arctic terrain.

RADIO COMMUNICATION NETWORK

Whether camped out on a remote ice floe or sitting high atop an icefield, scientists can count on the PCSP to maintain radio contact. Field camp parties are required to call in to the PCSP Resolute base every morning and evening to ensure all is well. The PCSP can even connect research parties with their colleagues working elsewhere in the field. They will also stay in touch with chartered aircraft, and collect and share information about weather conditions.

The Canadian Arctic is a vast land mass that is experiencing significant socioeconomic and environmental changes, which in turn have an impact on the lives of Canadians and the people of other nations of the world. It is an awe-inspiring region in which thousands of people live, and over 1100 researchers, students and field technicians conduct important field studies every year. With the increased public, economic, and environmental awareness of the North, these studies are an essential contribution to advances in the social and natural sciences.

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

"PCSP is a unique, wonderful and essential part of Arctic fieldwork."

Michelle Johnston, Canadian Hydraulics Centre, 2010 Ice Buoys Project

Researchers working at field camps in the High Arctic can count on the PCSP to provide a reliable and cost-effective source of equipment, supplies, field support and expert advice. In 2009, the PCSP supported 159 research projects by providing aircraft support, radio communication, accommodations, meals, field equipment, and advice from a number of key northern locations. Most research projects are staged from the PCSP facility at Resolute, Nunavut, which has two living accommodations wings with sleeping quarters for clients and PCSP staff; dining, meeting and recreation areas; and laundry facilities. The working accommodations building houses the facility's office, storage areas for PCSP and client equipment, and field equipment repair and maintenance areas. A stand-alone laboratory provides workspace for basic laboratory and computer needs. A wireless high-speed internet connection is now available to the PCSP's clients staying at the facility.

Field equipment at the PCSP Resolute facility is prepared for transport to field camps.

J. Lang, PCSP/NRCan

PCSP logistics manager Mike Kristjanson at work in Resolute, Nunavut.

J. Lang, PCSP/NRCan

Spotlight on a PCSP employee: Iane Fortin

IANE FORTIN has been working with the PCSP's Technical Field Support Services (TFSS) as the Shipper and Receiver for field equipment since 2008. His work includes ordering and tracking equipment, receiving new equipment and making arrangements with shipping companies. Iane also completes quality analysis and quality control procedures when testing equipment prior to purchase and use, and inspects equipment returned from the field. This ensures that equipment sent with PCSP-supported researchers into remote field locations is in good working order and is able to withstand the test of extreme conditions. This in turn enables the PCSP to provide safe, effective logistical support for researchers conducting work in Canada's Arctic.

Although Iane is based in Ottawa, he has also worked on a rotational basis at the Resolute facility in order to harmonize the storage of information and field equipment between Ottawa and Resolute. Colleagues and clients who have crossed paths with Iane in Ottawa and Resolute are quick to say that he is a very bright, young employee who is a pleasure to work with.

"I love my job and I am committed to the work that is done at TFSS/PCSP. I am keen to share my expertise about the benefits of using inventory systems to track the location of equipment in Ottawa and Resolute."

Iane Fortin

Iane Fortin at work at TFSS in Ottawa.

D. Ashe, NRCan

Iane Fortin opening containers and inspecting equipment returned by PCSP Resolute to TFSS in Ottawa.

D. Ashe, NRCan

WHAT IS PCSP'S TECHNICAL FIELD SUPPORT SERVICES (TFSS)?

TFSS/PCSP serves the field support needs of university and government, independent, private sector and non-Canadian researchers working in isolated and non-isolated areas throughout Canada by ensuring that they have the proper equipment and safe, comfortable working conditions in the field. TFSS is an extensive, large-scale operation, including a 30 000 m2 facility located in Ottawa. TFSS was established in 1930 by the Geological Survey of Canada and has been part of the PCSP since 2008.

The PCSP Resolute facility expansion: Improving support for Arctic science

"Our Government is building on over 50 years of experience in Arctic research and exploration. This is essential if we're to improve our knowledge of the region and better position ourselves to ensure that the potential of the North is realized—for the benefit of not just Northern communities, but all Canadians."

The Honourable Christian Paradis, former Minister of Natural Resources

In January 2009, the Government of Canada announced that the Arctic Research Infrastructure Fund would be established to improve existing research facilities in Canada's North. A call for proposals, led by Aboriginal Affairs and Northern Development Canada, was sent out shortly thereafter, and 20 federal and territorial government, academic, and independent organizations were successful in their submissions to obtain funding for upgrades to their research stations in Canada's Arctic. The PCSP was one of these successful organizations, receiving $11 million to expand and modernize its 25-year old Resolute facility.

In the middle of the operational season, the first stage of construction involved the installation of steel foundation piles deep within the permafrost during June and July 2010 in Resolute. Modules for the new construction were built in Matane, Quebec, in the spring and summer of 2010, and arrived by barge in August. The second stage of construction consisted of the on-site assembly of the modules in Resolute and was completed in November 2010. When completed, the expansion nearly doubles the current capacity of the PCSP to accommodate researchers and includes upgrades to office and recreation space along with a new kitchen and dining area. In addition, a new stand-alone modern laboratory facility was built, and includes freezer storage, fume hoods, a water purification system and working space. The final phase of construction and renovations to the existing facility was completed on March 31, 2011.

In August 2010, Prime Minister Stephen Harper announced that the Canadian High Arctic Research Station would be located in Cambridge Bay, Nunavut, demonstrating a commitment to its Northern Strategy to assert and defend Canada's sovereignty, to protect the unique and fragile Arctic ecosystem, to develop a strong northern economy, and to encourage good governance and greater local control and opportunity.

"The Government of Canada funded the expansion of the Polar Continental Shelf Program not only to strengthen one of the premier Arctic research facilities in the world, but also to ensure that the PCSP can play an integral role in the network of research infrastructure that the new Canadian High Arctic Research Station will anchor."

The Honourable John Duncan, Minister of Aboriginal Affairs and Northern Development[1]

In the past, researchers typically spent a short amount of time at the PCSP Resolute facility each year, just before and after their time in field camps. With the newly expanded facility, it is envisioned that researchers could stay longer at the Resolute facility in order to work on research before or after their field expeditions. The PCSP will continue to build on its ability to support the field requirements of researchers working from these and other science facilities throughout Canada's Arctic.

Ground preparation at the PCSP facility for installation of modules (Resolute, Nunavut).

C. Evans, PCSP/NRCan

The PCSP facility at Resolute on Cornwallis Island, Nunavut.

© 2011 Canadian Forces Combat Camera

1 *This information was derived from an NRCan Press Release that can be viewed at http://www.nrcan-rncan.gc.ca/media/newcom/2010/201075-eng.php.*

PCSP Arctic reflections speaker series 2010

On May 13, 2010, the PCSP hosted the second annual Arctic Reflections Speaker Series, which was organized in partnership with Aboriginal Affairs and Northern Development Canada. This event highlighted the important work of PCSP-supported researchers and collaborating educators in the Arctic, with a focus on discoveries and impacts of Arctic research in Canada.

David Carlson (Director, International Polar Year, International Programme Office) provided an overview of the impacts and outcomes of the International Polar Year (IPY), which ran from 2007 to 2009. Notably, David presented recent information about historical Arctic climate, sea ice extent and thickness, the Greenland ice sheet, the carbon stored in permafrost, and the health of Arctic residents.

Many IPY projects have continued with their PCSP-supported research programs, and one of these researchers, Eddy Carmack (Research Scientist and Climate Oceanographer, Fisheries and Oceans Canada) presented some of his team's research results of their IPY Canada's Three Oceans (C3O) project. The C3O project looks at the interconnectedness of three great oceans—the Atlantic, the Arctic and the Pacific—that surround Canada. Eddy spoke about the Arctic's place in the global climate system, changes in the physical world of ocean currents and sea ice cover, and what such changes would mean in terms of marine life and ecosystems, invasive species, ocean acidification and challenges to governance.

The final speakers, Jen Day and Sophie Crump, were two Ottawa-area high school students who presented a photo journal of their Students on Ice expedition to the Canadian Arctic in 2009. Students on Ice provides students, educators and scientists from around the world with inspiring educational opportunities at the ends of the earth and in doing so, fosters a new understanding and respect for the planet. Jen and Sophie's passion for the Arctic was obvious and their images provided insight into the changes in climate that they witnessed during their expedition.

Eddy Carmack, Climate Oceanographer, discusses the implications of changes in Arctic ocean currents and sea ice cover as they relate to the global climate system.

R. Gal, NRCan

PCSP open house 2010

On August 24, 2010, the PCSP held its third annual open house event at the PCSP Resolute facility. Over 600 guests attended the event, including residents of Resolute, scientists, invited government officials, and members of the Canadian Forces. This open house was held in conjunction with the Department of National Defence's (DND) Operation Nanook[2] Community Day. 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 about Arctic ice surveys, oceanography research, and local Arctic char. One of the PCSP's fantastic cooks, Sarah Harper, also an accomplished singer and song-writer, performed a music medley with a local traditional Inuit throat singer. The Canadian Forces displayed equipment, discussed how they operate in the challenging Arctic environment, and provided a barbeque for the community. Presentations were given by Resolute Mayor Ludy Pudluk, Canadian Space Agency President Steve MacLean, Joint Task Force North Commander Brigadier-General Guy Hamel, and PCSP Director Marty Bergmann.

NRCan's mascot, NRCat, visits with children from Resolute at the PCSP Open House in August 2010.

B. Eckalook, PCSP/ NRCan

2 *Operation Nanook 2010 was the annual joint Department of Defence army, navy and air force exercise to train for disaster and sovereignty patrols in the Arctic.*

PCSP's work with its stakeholders

DID YOU KNOW?

The PCSP is working towards increasing its capacity to accommodate researchers and extend the length of the field season at the Resolute facility through a collaboration with DND to add additional accommodation and work space.

Arctic Research Infrastructure Fund expansion project at the Yukon College, Whitehorse, Yukon.

E. Austin, Yukon College

The PCSP works in partnership with research organizations situated in the Canadian Arctic to deliver effective logistics in support of research. These organizations handle scientific licencing and permitting for field work conducted in Canada's territories, including the Aurora Research Institute (ARI) in the Northwest Territories, the Nunavut Research Institute (NRI), Yukon College and the Government of Yukon (Department of Tourism and Culture). These organizations process licence applications, and some provide accommodations and equipment, work and laboratory space, field technicians or assistance in finding local expertise, and guidance regarding working in the North and communicating with northern communities. The PCSP works closely with these organizations to coordinate logistics and ensure that researchers meet their permitting and licencing requirements prior to the field season. During the summer of 2010, ARI staff came to the PCSP to shadow PCSP activities in Resolute in order to expand on their ability to provide logistical support to researchers working out of the western Canadian Arctic. In March 2011, ARI, NRI and Yukon College completed their Arctic Research Infrastructure Fund expansion projects, with major new infrastructure being built at all three locations, thereby upgrading the network of research facilities in the Arctic in order to meet the increasing demands of Arctic researchers.

The PCSP is collaborating closely with Aboriginal Affairs and Northern Development Canada, providing expert advice and assistance as the Canadian High Arctic Research Station (CHARS) enters the planning and implementation phases.

The PCSP draws on the expertise of the members of its PCSP Advisory Board, which provides advice and guidance regarding the logistical services and future direction of the PCSP to ensure that the needs of Arctic scientists are met. The PCSP Science Screening Committee is a vital part of the PCSP, as this group of volunteer researchers annually reviews and ranks academic, non-Canadian and non-government organization proposals from a science merit perspective.

While local partnerships are integral to the successes the PCSP realizes, the PCSP also works with international partners, such as the United Kingdom, through memoranda of understanding. The current PCSP Director, Marty Bergmann, is the chair of the Forum of Arctic Research Operators (FARO), an international group that aims to facilitate and optimize logistics and operational support for scientific research in the Arctic by encouraging cooperation between countries.

Flags of Canada, Northwest Territories, Nunavut and the Canadian Hydrographic Service fly at the Borden Island Ice Camp.

J.Lang, PCSP/NRCan, CHS/DFO

The scientific legacy of John England
Environmental change across the Canadian Arctic Archipelago: Ice age to present

Professor and Natural Sciences and Engineering Research Council (NSERC) Northern Research Chair (2002-2012)
Department of Earth and Atmospheric Sciences, University of Alberta.

John England has been conducting research across the Canadian Arctic with logistics supported by the PCSP for forty-five years—and he has missed only a handful of field seasons during this time. John's research is focused on clarifying the configuration, dynamics and chronology of the former Laurentide and Innuitian ice sheets, including related sea-level adjustments caused by these temporary ice loads. Together with former and current graduate students, he has surveyed and dated raised marine shorelines across thousands of kilometres of coastline, conducting a transect across the Canadian Arctic Archipelago (CAA) that now spans from Ellesmere to Banks Island. He and colleagues are also studying the nature of sea ice and ocean current changes using driftwood stranded on raised beaches around the Canadian Arctic during the past 10,000 years, which also contributes to understanding the history of the northern Ellesmere Island ice shelves.

John's research group has further diversified the investigation of past environmental change, extending it to lake and ocean sediment cores, and has conducted the first study dating far-travelled, glacial boulders (erratics) deposited across the Arctic islands, tracing them back to specific source areas on the mainland. To date, twenty-four Ph.D. and M.Sc. students have graduated from John's NSERC- and PCSP-supported projects, and an additional five doctoral theses are currently being written regarding the western CAA.

Outreach

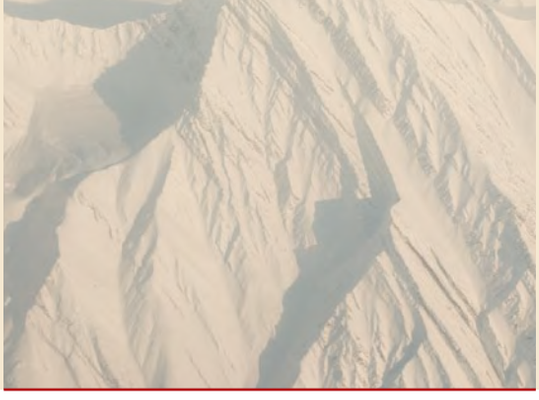
John's position as an NSERC Northern Research Chair has included significant community outreach, most notably through formal partnerships with the Aurora College and the Aurora Research Institute in Inuvik, N.W.T.

John has long recognized that increasing international attention is being placed on high latitude environments since they are being impacted significantly by global climate change. These changes have brought about important social, economic, and geopolitical consequences for northern regions, which Canada can address by using the knowledge gained from PCSP-supported research projects. John England continues to advocate that Canada has both the responsibility and opportunity to demonstrate leadership and stewardship over the largest area of tundra in the world.

Contributions to the establishment of Quttinirpaaq National Park

During the course of his Ph.D. field research in 1972, John wrote a letter from St. Patrick Bay on northeast Ellesmere Island proposing the establishment of what would become Quttinirpaaq National Park, for which he organized and produced the first Natural Resource Inventory (1981), including the park boundary.

John wrote articles in the 1980s to support the long-term commitment that should be placed on the protection of Quttinirpaaq National Park. Following this, Parks Canada adopted a very progressive plan to ensure the park's long-term conservation and integrity. The park was added to the National Parks Act in the late 1990s.



Mountainous terrain at Quttinirpaaq National Park, Nunavut.

J. Lang, PCSP/ NRCan, CHS/DFO

John England (right) and Tom Lakeman (Ph.D. candidate) on the Princess Royal Islands, near Banks Island, Northwest Territories.

C. Lafarge

DID YOU KNOW?

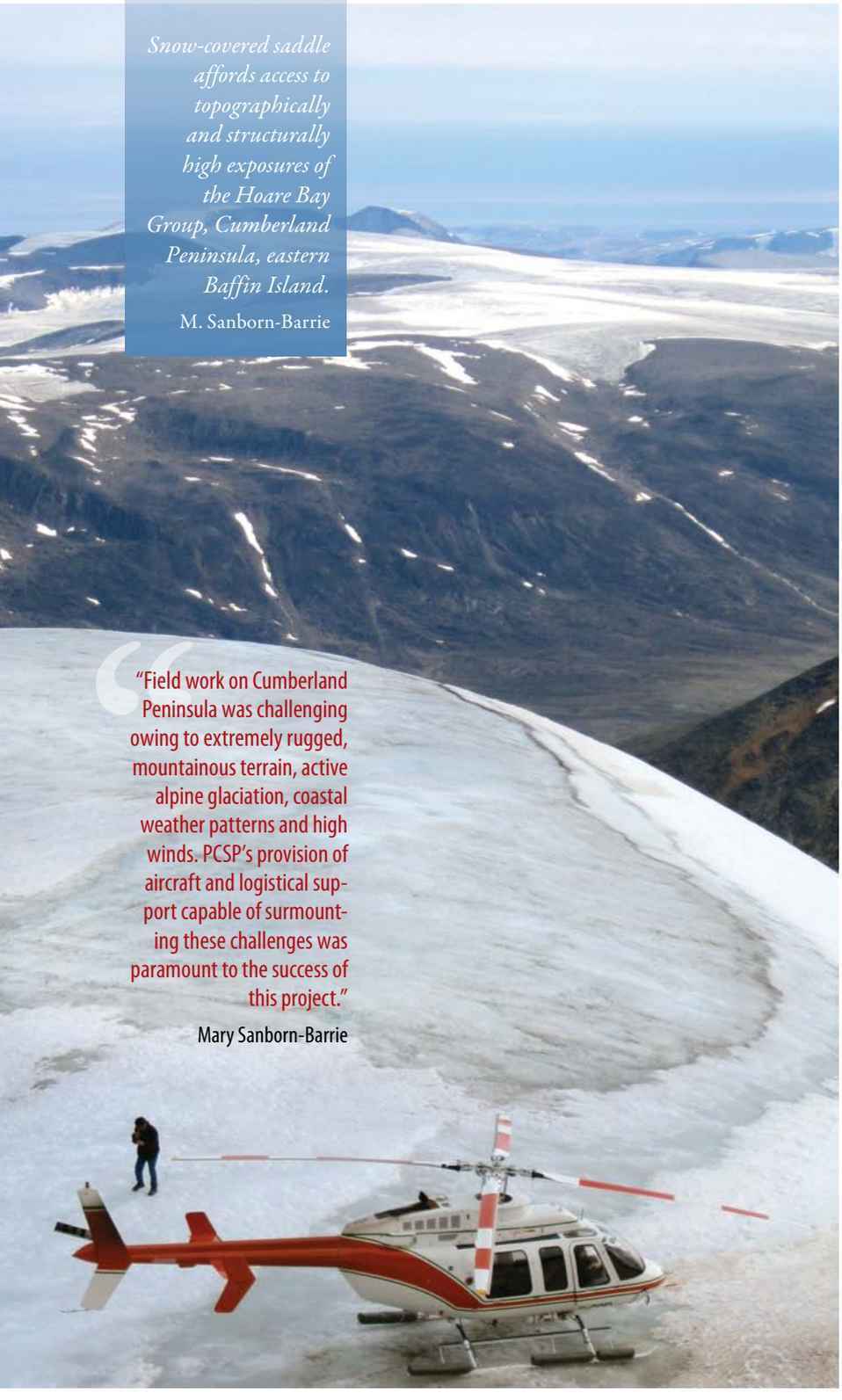
John England found original explorer's notes of Sir George Nares (1876) and Adolphus Greely (1882) on northern Ellesmere Island when he started his research there in 1971-1972. These notes are now stored at Library and Archives Canada. John started his Ph.D. sledding across the sea ice with Ray Bradley (University of Massachusetts) en route to the historic site of the First International Polar Year at Fort Conger (1882-1883), where the Greely notes originated.

DID YOU KNOW?

This PCSP-supported research will provide a long-term perspective on environmental variability at high latitudes, helping to distinguish between natural and human-induced changes in climate.

PCSP-supported projects in the news

From the keen interest in the development of northern mineral and energy resources to the continued loss of ancient ice shelves and multi-year ice diminishing in the Northwest Passage, the Arctic has been at the forefront of media issues on an ongoing basis. Each year, several PCSP-supported projects receive accolades in the media for their important discoveries. We highlight here several of the research projects that have made headlines.



Snow-covered saddle affords access to topographically and structurally high exposures of the Hoare Bay Group, Cumberland Peninsula, eastern Baffin Island.

M. Sanborn-Barrie

"Field work on Cumberland Peninsula was challenging owing to extremely rugged, mountainous terrain, active alpine glaciation, coastal weather patterns and high winds. PCSP's provision of aircraft and logistical support capable of surmounting these challenges was paramount to the success of this project."

Mary Sanborn-Barrie

GEM Cumberland Peninsula mapping project, Baffin Island, Nunavut

Mary Sanborn-Barrie (Geological Survey of Canada-Ottawa, Natural Resources Canada) and Michael Young (Geological Survey of Canada-Atlantic, Natural Resources Canada)

In 2008, the Government of Canada announced funding of $100 million over five years for its new Geo-mapping for Energy and Minerals (GEM) program to provide the geoscience knowledge necessary for private sector exploration companies to guide investment decision, as well as for government to inform land-use decisions such as the creation of parks and other protected areas. The program will run until 2013 and is administered by the Earth Sciences Sector at Natural Resources Canada. During the 2009 and 2010 field seasons, Mary Sanborn-Barrie led a team of researchers, students and Inuit to undertake mapping of bedrock and glacial surficial deposits on Cumberland Peninsula, located on eastern Baffin Island in Nunavut. This mapping significantly improved the knowledge of geoscience in this region, triggered new interest in its mineral potential and reduced the risk for future exploration investment.

Elders and representatives from the Hamlet and the Hunters' and Trappers' Organization of Qikiqtarjuaq, Nunavut, gather after a tour and lunch, GEM Cumberland camp, August 2010.

M. Sanborn-Barrie

Pangnirtung high school students Janis Shukulaq and Lily Kilabuk examine kimberlite indicator minerals, an essential element of diamond exploration, GEM Cumberland camp.

M. Sanborn-Barrie

Ancient igneous intrusive rocks known as tonalite (2.8 to 3.0 billion years old) are now recognized to underlie half of the peninsula. These are overlain by a much younger cover sequence which formed on the continental margin about 1.9 billion years ago. The ancient tonalite "basement" and younger "cover sequence" are intruded by a suite of plutonic rocks, exposed as a 200-km long belt from Pangnirtung to Qikiqtarjuaq.

"The GEM Cumberland Peninsula project highlights the impact of government geoscience whereby a vastly different and improved geological database, attained though targeted fieldwork and analytical support, leads to new mineral exploration plays, and a more knowledgeable, experienced and qualified group of northerners to engage in follow-up exploration activities."

Mary Sanborn-Barrie

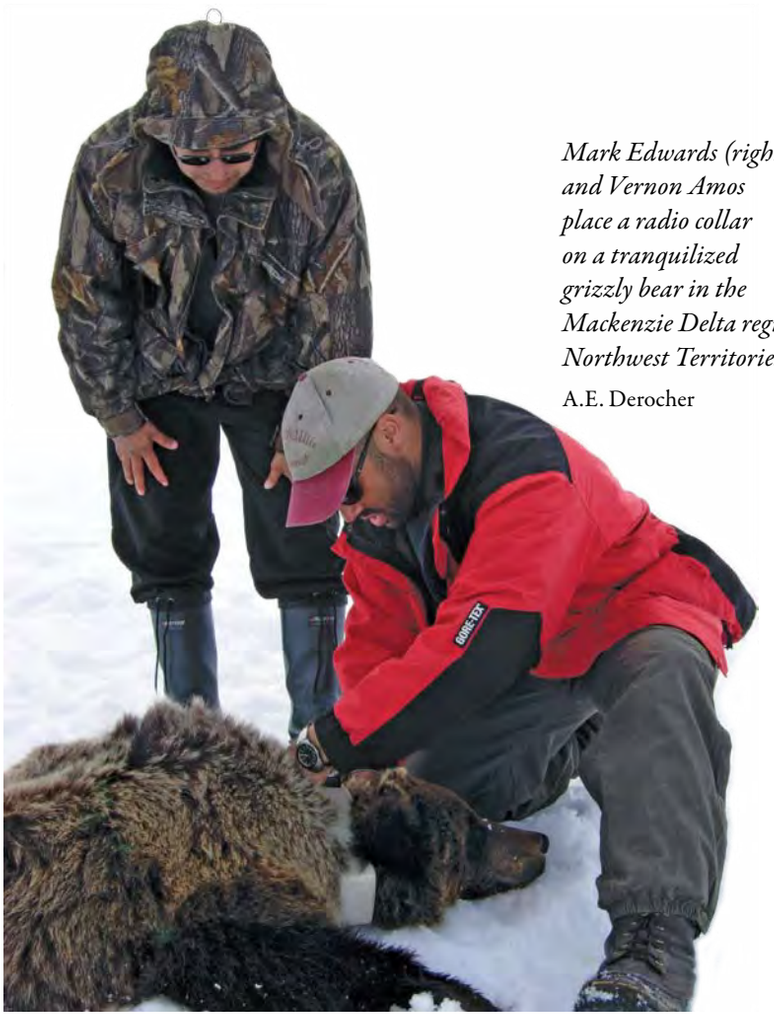
The researchers' discovery of ancient tonalite basement in the area opened up the prospect of diamonds on Cumberland Peninsula. This was highlighted by the fact that the entire 2009 map area was permitted for prospecting after the release of the new map data. The team found that the younger cover sequence consisted of sedimentary and volcanic rocks that contained elevated concentrations of multiple metals, presenting a new exploration target for copper, nickel and gold.

Comprehensive engagement was undertaken with Nunavut agencies and stakeholders, and with the communities of Pangnirtung and Qikiqtarjuaq. This included coordination of First Aid training, employment opportunities for 42 local residents, and assistance for each resident to write an updated resume that captured training and experience stemming from their work with the project. Input was sought from northerners working at the camp regarding how to portray traditional knowledge on a new series of topographic maps for Nunavut. In addition, the researchers led retreats to the field camp so that local high school students could engage in introductory geoscience activities and be exposed to the variety of careers linked to northern research. The research team also hosted an annual camp tour and lunch for Elders and community representatives.

Mapping ecology of grizzly bears in the Mackenzie Delta area

Andrew E. Derocher (Department of Biological Sciences, University of Alberta)

As the climate continues to warm in the Canadian Arctic, grizzly bears have been found at increasingly higher latitudes. Warming may increase ecosystem productivity for grizzly bears and could be beneficial, but industrial development poses an ongoing management concern for this sensitive species. Increased human activity and natural resource development have been detrimental to grizzly bear populations in many areas and proactive management and planning can reduce conflicts.



Mark Edwards (right) and Vernon Amos place a radio collar on a tranquilized grizzly bear in the Mackenzie Delta region, Northwest Territories.

A.E. Derocher

"We discovered that the areas a bear uses drift over time. This is important because it suggests that the resources the bears are seeking may not be as vulnerable to disturbance as they often are for other grizzly bear populations."

Andrew Derocher

As part of this research effort, Andrew Derocher has been leading a multi-disciplinary study involving the capture, immobilization, and Global Positioning System (GPS) collaring of grizzly bears over a study area that covers 20,000 km^2 located in the Mackenzie Delta, N.W.T. From 2003 to 2009, over 70,000 grizzly bear locations were obtained from over 50 grizzly bears. Location data obtained from the GPS collars were used to monitor movement patterns and evaluate the use and importance of different habitats. In 2009, hair, claw shavings, feces, milk, fat, and a premolar tooth were collected from adult female grizzly bears for dietary, health, genealogical, and aging analyses.

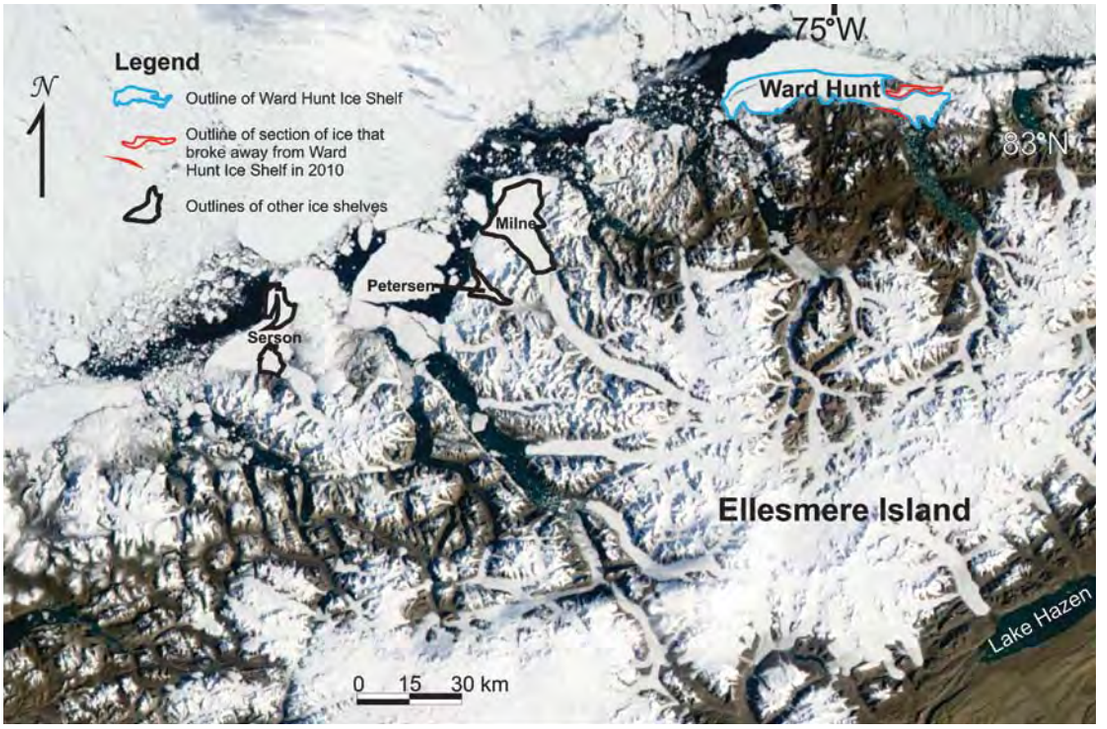
Baseline information was collected to assist with understanding the distribution, abundance, habitat use and den sites of grizzly bears in the Mackenzie Delta. This work is important for monitoring the population relative to the development of natural gas resources in the region. The data is being used to develop models for criteria such as habitat selection for grizzly bears in the Mackenzie Delta area. In addition, annual updates were provided to the Inuvialuit Game Council and the Wildlife Management Advisory Council in the N.W.T., which can use the data for planning purposes.

"Our research discovered a wide variety in the diet of grizzlies in the Delta—some bears live largely as herbivores whereas others are largely carnivorous. The habitat demands are different depending on a bear's diet."

Andrew Derocher

Fog over southern Mackenzie Delta, Northwest Territories.

M. Russell



Satellite image courtesy of NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) from the Aqua satellite. Image acquired on August 18, 2010 when the northeast section of the Ward Hunt Ice Shelf (outlined in red) broke away from the ice shelf (outlined in blue).

NASA

Significant ice loss on the Ward Hunt Ice Shelf, Ellesmere Island

Many PCSP-supported researchers have documented changes in the ice shelves located in the Canadian Arctic, including John England, Warwick Vincent and Derek Mueller.

The Ward Hunt Ice Shelf is the largest ice shelf in the Arctic, located on the north coast of Ellesmere Island in Nunavut. The ice shelf is about 400 km^2 in size, roughly 40 m thick and has been in place for between 3,000 to 6,800 years. The ice shelf was originally part of a larger continuous ice shelf that encompassed the northern coast of Ellesmere Island, of which 90 per cent has been lost in the past century. Unlike many ice shelves, no glacier feeds the Ward Hunt Ice Shelf and advances it seaward. Instead, it forms from compressed sea ice that is gradually replaced by accumulated snow. The cycle of ice loss (also known as the calving cycle) on the Ward Hunt Ice Shelf has quickened, and recovering from the recent losses would take centuries.

"The ice shelves are a unique part of the Canadian landscape, serving as our equivalents to the Egyptian pyramids or the California redwood forests that warrant our interest and attention."

John England

In April 2000, satellite images revealed that a large crack in the Ward Hunt Ice Shelf had begun to form. In 2002, Derek Mueller, a PCSP-supported researcher who studies ice shelves, discovered that the ice sheet had split in two, releasing a huge pool of fresh water from the largest epishelf lake (freshwater overlying sea water in fiords blocked by ice shelves) in the Northern Hemisphere, located in Disraeli Fiord. In April 2008, it was discovered that the shelf was fractured into dozens of deep, multifaceted cracks. In late July 2008, it was announced that nearly 21 km^2 had broken away from the shelf. On August 18, 2010, another 54 km^2 calved off from the northeast section of the ice shelf.

The icebergs released by the breakup pose potential dangers to shipping and offshore exploration and development as the icebergs are very thick and can travel long distances along the eastern Canadian shoreline. Loss of habitat for microbial ecosystems may also have far-ranging ecological impacts.

This signifies a continued shift in the climatic conditions that were in place for the past three to six thousand years that had allowed these ice shelves to remain intact until recently. Warming temperatures, reduced coastal summer sea ice coverage, tides and wind have all played a role in destabilizing the ancient ice shelves.

"So in the core of the ice shelf itself, the fracturing is occurring. I think that's really quite significant, that the most resistant and tenacious part of the ice shelf, many thousands of years old, is now being dismantled."

John England

PCSP-supported field camps in the Canadian Arctic (2009)

Legend

Field Camp Research Themes:

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

Location Type:

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

Actual location 100km North.

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 2009

The PCSP supported 159 scientific research projects in 2009 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 each of these broad categories.

Arctic wolves are seen in the mountains near Eureka, Nunavut.

J. Lang, PCSP/ NRCan, CHS/DFO

Group of killer whales near Kakiak Point, Admiralty Inlet, Nunavut in August 2009.

G. Freund

ECOLOGICAL INTEGRITY

The Canadian Arctic presents a challenging environment to which many plants and animals have adapted. Knowledge about the interactions between humans and these flora and fauna in their natural environment provides a foundation that can be used towards sound decision making. For many Inuit communities that rely on animals for sustenance, knowledge about the contaminant cycle and how climate change is driving uptake of chemicals into the food chain is critical. Understanding how ecosystems work in the Arctic environment can be used to inform wildlife management and land use plans, policy discussions and program development to ensure the ecological integrity of the region is sustained.

Landscape ecology and disturbance in Arctic intertidal zones

Jon Grant and Mike Dowd (Department of Oceanography, Dalhousie University) and Philippe Archambault (Institut des sciences de la mer de Rimouski, University of Québec at Rimouski)

Intertidal areas are important worldwide, forming an interface between land and sea. At low tide, shorebirds have a rich food source available, while at high tide, fishes and crabs are able to feed on animals such as molluscs and marine worms. Jon Grant and his research team are part of the Canadian Healthy Oceans Network (CHONe, pronounced Ko-nee) focused on biodiversity science for the sustainability of Canada's three oceans. They studied sedimentary features and biodiversity of Arctic intertidal zones to assess the effects of climate change and human impacts. The research team studied human-impacted intertidal zones in Iqaluit, Nunavut and compared them to non-human impacted intertidal zones in Pangnirtung, Nunavut.

The team deployed a camera attached to a low altitude helium blimp floating 20 to 150 m in the air to photograph intertidal features. The

The DalBlimp awaiting deployment at a campsite above the town of Pangnirtung, Nunavut. It was walked by road to the intertidal zone of the fiord shown in the background. Postdoctoral fellow Lin Lu is standing next to a helium tank used to fill the blimp.

J. Grant

camera was equipped with a near infrared filter to detect vegetation. At the same time, the team collected sediment samples to measure the invertebrate biodiversity and community structure. The aerial photographs were merged together in the form of a panoramic picture that was used to analyze the data. The imaging produced a complex data layer of intertidal habitat features including algal mats, boulders, sand waves, wet and dry areas, and gravel fields.

In Iqaluit, they found huge boulders, coarse sediments, and low biodiversity. In some areas, the low presence of flora and fauna is attributed to the fact that Iqaluit had historic problems with sewage treatment, and raw sewage was often released directly into the ocean. Sampling in 2009 was designed to match sites sampled in the 1990s, when raw sewage was still being released in Iqaluit. This was done to measure the recovery of the intertidal zone now that the region has better sewage treatment facilities.

At Pangnirtung they conducted research where the Duval River fed into the intertidal zone, resulting in the formation of a large delta. They noted finer sand close to shore, and a rock ring formation at the edge of the intertidal zone. They observed high biodiversity of sediment-dwelling animals, including abundant clams.

"Initial results show that conditions have actually worsened since the previous study, with an increased zone devoid of fauna extending from the sewage effluent."

Jon Grant

The results indicate that pollution can have significant impacts on the biodiversity of intertidal zones in the Arctic and that recovery can take many years. Intertidal zones are also vulnerable to rising sea level that may result from increased glacial melting due to climate change.

Dave Mech and Dean Cluff pose with "Elmer", a stuffed arctic wolf that they use to study wolf demography and interactions.

J. Lang, PCSP/NRCan

Ellesmere Island wolf demography and prey relations

L. David Mech (Biological Resources Division, United States Geological Survey)

David Mech and his research team have completed more than twenty years of research regarding arctic wolves near Eureka on Ellesmere Island, Nunavut. They collected data regarding wolf-pack size, litter sizes, early pup survival, and specific wolf den history. In addition, muskoxen and arctic hare population trends were gathered and the arctic hare population trends were correlated to wolf-pack size. Gathering data can be challenging in the harsh Arctic climate, and the team used a creative method involving satellite collars, e-mail, and internet technology to track the locations and activities of arctic wolves.

Research completed in 2008 determined that the Eureka wolves traveled a daily round-trip distance of at least 40 km from their den. This research provided the first documentation of long daily movements by wolves rearing pups.

In 2009, a collar was attached to the leader of a pack of at least 20 wolves on Ellesmere Island to track his position via satellite. The collar e-mailed 554 precise locations of the pack at 12 hour intervals from July 9, 2009 to April 12, 2010. The pack traveled a minimum of 5,979 km during that time and covered most of the Fosheim Peninsula and parts of east-central Axel Heiberg Island, an area of about 14,000 km^2.

To follow up on these results, the research team returned to the field in 2010 to examine 31 of the 53 clusters, a cluster being at least two consecutive 12-hour locations within 500 m of each other, for the leader of the pack. They found two wolf dens of adults and pups and the remains of one adult caribou and sixteen muskoxen at these sites. It was estimated that the pack killed 25 to 50 adult muskoxen, 1 to 2 adult caribou, and an unknown number of calves and arctic hares during this period. A minimum of 360 muskoxen were counted on the Fosheim Peninsula, and arctic hare were counted.

> "Learning the full extent of travel by the Eureka wolf pack remotely via regular e-mail from the pack's collared member throughout the year was one of the highlights of my 50-year career of studying wolves."
>
> David Mech

The results of this study are valuable in determining the role that the wolf plays in the populations of muskoxen and caribou in the High Arctic, which are important resources for the Inuit for sustenance and traditional use. The data also provides a baseline for possible future studies of the effects of climate change on the predator-prey system.

PROJECTS FOCUSED ON ECOLOGICAL INTEGRITY

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

Location: Karrak Lake and Perry River, N.W.T.

Principal investigator: Ray Alisauskas (Wildlife Research, Environment Canada)

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)

Ecology of the Arctic fox and red fox on Bylot Island

Location: Bylot Island, Nun.

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)

Population estimate using DNA darting for grizzly bears in the Inuvialuit Settlement Area, west of delta eastward

Location: Paulatuk and Rendezvous Lake, N.W.T.

Principal investigator: Marsha Branigan (Environment and Natural Resources, Government of the Northwest Territories)

Establishing legacy conditions of river ecosystem biodiversity and function for CVC assessment—Pangnirtung/Iqaluit program (Part of the ARCTIC Freshwater BIOdiversity Research and Assessment NETwork: ARCTIC-BIONET project)

Locations: Iqaluit and Pangnirtung (Baffin Island), Nun.

Principal investigator: Joseph Culp (Aquatic Ecosystem Impacts Research Division, Environment Canada)

Establishing legacy conditions of river ecosystem biodiversity and function for CVC assessment—Quttinirpaaq program (Part of the ARCTIC Freshwater BIOdiversity Research and Assessment NETwork: ARCTIC-BIONET project)

Location: Lake Hazen (Ellesmere Island), Nun.

Principal investigator: Joseph Culp (Aquatic Ecosystem Impacts Research Division, Environment Canada)

Peary caribou and muskoxen abundance and distribution on northwest Victoria Island, Banks Island, Melville Island, and Prince Patrick Island, Northwest Territories

Location: Polar Bear Cabin and Cape Providence (Melville Island), N.W.T.

Principal investigator: Tracy Davison (Environment and Natural Resources, Government of the Northwest Territories)

An early warning system using seabirds to detect ecosystem change in the High and Low Arctic

Location: Coral Harbour (Southhampton Island), Nun.

Principal investigator: Gail Davoren (Department of Biological Sciences, University of Manitoba)

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)

Arctic fox on Bylot Island, Nunavut.

D. Berteaux

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)

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)

Boulders are present throughout most of the intertidal zone of Pangnirtung Fiord, Nunavut, but are particularly dense in the lower intertidal zone, forming a distinctive rock ring. Seaweed, gravel, and tidal pools comprise some of the other intertidal habitat features.

J. Grant

IPY—Char CVC component: Baseline char study and char community-based monitoring plan for Sachs Harbour

Location: Sachs Harbour (Banks Island), N.W.T.

Principal investigator: Chris Furgal (Environment Sciences and Indigenous Studies, Trent University)

Seabird studies in northern Hudson Bay, Nunavut

Location: Coates and Digges Islands, Nun.

Principal investigator: Tony Gaston (Wildlife Research, Environment Canada)

Biology of tundra bird populations: demographics, trophic interactions and climate change

Location: Bylot Island, Nun.

Principal investigator: Gilles Gauthier (Centre d'Études Nordiques, Université Laval)

Population studies of Common Eider Ducks breeding in East Bay, Nunavut

Location: East Bay (Southampton Island), Nun.

Principal investigator: Grant Gilchrist (Wildlife Research, Environment Canada)

Arctic shorebird monitoring program

Location: East Bay (Southampton Island), Nun.

Principal investigator: Grant Gilchrist (Wildlife Research, Environment Canada)

Flora of the Canadian Arctic Archipelago: diversity and change

Locations: Austin Bay and Wollaston Peninsula (Victoria Island), and Clifton Point and Bernard Harbour, Nun.

Principal investigator: Lynn Gillespie (Canadian Museum of Nature)

Landscape ecology and disturbance in Arctic intertidal zones (part of the CHONe program)

Location: Iqaluit and Pangnirtung (Baffin Island), Nun.

Principal investigator: Jon Grant (Department of Oceanography, Dalhousie University)

Distribution of bowhead whales in the southeast Beaufort Sea during late summer, 2007 to 2009

Locations: Locations in the Beaufort Sea (based from Inuvik, N.W.T.)

Principal investigator: Lois Harwood (Arctic Science, Fisheries and Oceans Canada)

Modeling of migratory patterns to spawning and over-wintering areas of harvested fish species in rivers along the Mackenzie Valley pipeline route

Location: Inuvik, N.W.T.

Principal investigator: Chelsea Hermus (Arctic Aquatic Research, Fisheries and Oceans Canada)

Population assessment of Big Fish River Dolly Varden

Location: Big Fish River, N.W.T.

Principal investigator: Kimberly Howland (Arctic Aquatic Research, Fisheries and Oceans Canada)

Char monitoring at the Hornaday River, Northwest Territories

Location: Hornaday River, N.W.T.

Principal investigator: Kimberly Howland (Arctic Aquatic Research, Fisheries and Oceans Canada)

The biology and ecology of Sympatric Polymorphic Lake Trout (Salvelinus Namaycush) in Great Bear Lake, Northwest Territories

Location: Great Bear Lake, N.W.T.

Principal investigator: Kimberly Howland (Arctic Aquatic Research, Fisheries and Oceans Canada)

North Baffin caribou collaring program, northern Baffin Island, Nunavut

Locations: Pond Inlet and Arctic Bay (Baffin Island), Nun.

Principal investigator: Debbie Jenkins (Wildlife Management, Government of the Northwest Territories)

Arctic shorebird monitoring program

Locations: Mackenzie River Delta, N.W.T., and Arviat and Baker Lake, Nun.

Principal investigator: Victoria Johnston (Canadian Wildlife Service, Environment Canada)

Microbiological and ecological responses to global environmental changes in Canadian Arctic ecoystems

Location: Oobloyah Bay (Ellesmere Island), Nun.

Principal investigator: Hiroshi Kanda (National Institute of Polar Research, Japan)

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)

Bryophytes in extreme environments—colonization, diversity, monitors of environmental change in Arctic Canada

Location: Sverdrup Pass (Ellesmere Island), Nun.

Principal investigator: Catherine La Farge (Department of Biological Sciences, University of Alberta)

Arctic ponds formed by melting permafrost: the production of greenhouse gases, microbial diversity and ecosystem functioning

Location: Bylot Island, Nun.

Principal investigator: Isabelle Laurion (Institut national de la recherche scientifique

Southampton Island and Baffin Island Arctic Goose banding

Location: Coral Harbour (Southampton Island), Nun.

Principal investigator: Jim Leafloor (Canadian Wildlife Service, Environment Canada)

Greater Snow Goose population dynamics in relation to habitat and the Circumpolar Observatory Network

Locations: Eureka (Ellesmere Island) and Bylot Island, Nun.

Principal investigators: Josée Lefebvre and Austin Reed (Canadian Wildlife Service, Environment Canada)

Biogeochemistry of lakes in the Mackenzie Delta

Location: Mackenzie Delta, N.W.T.

Principal investigator: Lance F. W. Lesack (Department of Geography, Simon Fraser University)

Contaminants in seabirds at Prince Leopold Island and Coats Island, Nunavut

Locations: Prince Leopold and Coats Islands, Nun.

Principal investigator: Mark Mallory (Canadian Wildlife Service, Environment Canada)

Ecology of Ross's and Ivory Gulls in Penny Strait, Nunavut

Location: Tern Island, Queen's Channel, Nun.

Principal investigator: Mark Mallory (Canadian Wildlife Service, Environment Canada)

Ivory Gull Survey, High Arctic, Nunavut

Locations: Resolute (Cornwallis Island) and Grise Fiord (Ellesmere Island), Nun.

Principal investigator: Mark Mallory (Canadian Wildlife Service, Environment Canada)

Yukon north slope grizzly project

Locations: Shingle Point and Sheep Creek, Y.T.

Principal investigator: Ramona Maraj (Environment Yukon, Government of Yukon)

Demography, behaviour and prey relations of Arctic wolves

Location: Eureka (Ellesmere Island), Nun.

Principal investigator: David Mech (Biological Resources Division, U.S. Geological Survey)

Hornaday River water quality and quantity

Location: Hornaday River, N.W.T.

Principal investigator: Neil Mochnacz (Arctic Aquatic Research, Fisheries and Oceans Canada)

Seagulls rest on ice along the shore of Truro Island, Nunavut.
J. Lang, PCSP/NRCan

Habitat associations of bull trout and Dolly Varden in the Western Arctic

Locations: Gayna River, Big Fish River, Rat River and Babbage River, N.W.T.

Principal investigator: Neil Mochnacz (Arctic Aquatic Research, Fisheries and Oceans Canada)

Effects of habitat, predators, and global warming on lemming abundance

Location: Walker Bay, Nun.

Principal investigator: Douglas Morris (Department of Biology, Lakehead University)

Ecology and ecophysiology of High Arctic shorebirds

Location: Alert (Ellesmere Island), Nun.

Principal investigator: R.I.G. Morrison (Wildlife Research, Environment Canada)

Investigation of potential regional effects of climate warming on mercury and other contaminants in landlocked Arctic char

Location: Amituk Lake (Cornwallis Island), Nun.

Principal investigator: Derek Muir (Aquatic Ecosystem Protection Research, Environment Canada)

Autonomous microscopy for real-time bacterial imaging in bodies of water

Location: Expedition Fiord (Axel Heiberg Island), Nun.

Principal investigator: Jay Nadeau (Department of Biomedical Engineering, McGill University)

Arctic shorebird monitoring program—Mackenzie Delta

Locations: Taglu Island and Kendall Island Bird Sanctuary, N.W.T.

Principal investigator: Jennie Rausch (Canadian Wildlife Service, Environment Canada)

Cumberland Sound beluga and Admiralty Inlet narwhal aerial surveys 2009

Locations: Iqaluit, Pangnirtung and Arctic Bay (Baffin Island), Nun.

Principal investigator: Pierre Richard (Arctic Aquatic Research, Fisheries and Oceans Canada)

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)

Principal investigator: Evan Richardson (Canadian Wildlife Service, Environment Canada)

Polar bear aerial population survey, Foxe Basin, Nunavut

Locations: Locations around Foxe Basin, Nun.

Principal investigator: Seth Stapleton (University of Minnesota and Department of Environment, Government of Nunavut)

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)

Walrus survey: stock definition and enumeration

Locations: Coastal locations based out of Resolute (Cornwallis Island), Hall Beach and Igloolik (Igloolik Island), Nun.

Principal investigator: Rob Stewart (Arctic Aquatic Research, Fisheries and Oceans Canada)

Comparison study of the biological population structure of fish populations in three different lakes in one watershed

Location: Lac Jacques, N.W.T.

Principal investigator: Ross Tallman (Freshwater Institute - Central and Arctic Regions, Fisheries and Oceans Canada)

Stock delineation and dispersal behaviour of Arctic char in the Cumberland Sound region using microsatellite markers

Location: Pangnirtung (Baffin Island), Nun.

Principal investigator: Ross Tallman (Freshwater Institute - Central and Arctic Regions, Fisheries and Oceans Canada)

An Inuit based non-invasive polar bear activity survey—bridging the old and the new

Locations: Cape Sydney, Gates Head Island, Eastern Boothia Peninsula and Southern Prince of Wales Island, Nun.

Principal investigator: Peter J. van Coeverden De Groot (Department of Biology, Queen's University)

Ecology and management of waterfowl populations from the western Canadian Arctic

Location: Inuvik, N.W.T.

Principal investigator: Cindy Wood (Environmental Stewardship, Environment Canada)

Hydro-ecological responses of Arctic tundra lakes to climate change and landscape perturbation

Location: Inuvik, N.W.T.

Principal investigator: Fred Wrona (Aquatic Ecosystem Impacts Research, Environment Canada)

SUSTAINABLE COMMUNITIES AND CULTURE

Archaeologists have been actively locating formerly inhabited sites in the Arctic to document human exploration and occupation of the Canadian Arctic, which extends over thousands of years. Traditional knowledge provides an important contribution to the collection of historical and cultural information regarding northern residents. These residents 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 knowledge gained from archaeological sites and traditional knowledge provide insight into land and resource usage by past inhabitants, peoples' movements over time, interactions between different groups of people, and many elements of the rich and diverse cultures that have lived in the Canadian Arctic.

(Above) A fish spear, a pair of wooden snow goggles, a polar bear head carved from ivory, and a bone carving were found by Sarah Hazell at an ancient Thule dwelling near Resolute.

J. Lang, PCSP/NRCan

(Right) Underwater ROV image of HMS Investigator looking aft along the starboard side.

Parks Canada

HMS *Investigator* rediscovery project

Henry Cary (Cultural Resource Management, Western Arctic Field Unit, Parks Canada) and Ryan Harris (Underwater Archaeology Service, Ontario Service Centre, Parks Canada)

Sir John Franklin was commissioned in 1845 to lead a Royal Navy expedition in search of a Northwest Passage through what is now Canada's Arctic Archipelago. This expedition ended in disaster, with the death of all of its crew members, including Franklin, and the loss of the expedition's two ships HMS *Erebus* and HMS *Terror*. The final resting place of the ships remains a mystery and a source of considerable interest in Canada and around the world. In 1850, HMS *Investigator*, a Royal Navy vessel, was one of a slew of ships sent to determine the fate of the lost Franklin expedition. HMS *Investigator* itself became trapped in ice and was abandoned in Mercy Bay, Banks Island, N.W.T., in 1853.

In July 2010, Parks Canada launched a combined land and underwater archaeological investigation of HMS *Investigator*. Within days of setting up camp in Mercy Bay, both archaeological teams were fortunate to meet with success: the wreck of HMS

Research team in zodiac towing side-scan sonar in Mercy Bay, Northwest Territories.
Parks Canada

Investigator was found sitting upright on the seabed and in good condition; the graves of three seamen were identified on shore; and numerous artefacts and features were discovered at a depot left behind when the ship was abandoned. In addition to these finds, the land team visited a prehistoric aboriginal site at the bottom of Mercy Bay and radiocarbon samples from collected Paleoeskimo marine mammal bones yielded an age of between 2,400 to 2,500 years old.

The PCSP provided unparalleled expertise in organizing the flight logistics to this challenging part of the Arctic, and coordinated additional helicopter time to explore other archaeological sites in Mercy Bay.

> Halfway through the project, the camp was visited by former Environment Minister Jim Prentice, who had a long-held interest in the HMS *Investigator* story. "I'm elated," said former Minister Prentice as he toured the sites, "it's a special moment linking our past and future in the Canadian Arctic."

Sachs Harbour and Ulukhaktok have historic ties to HMS *Investigator* as it was their Inuit ancestors who travelled to Mercy Bay after the ship was abandoned in order to salvage metal and other items. The archaeological remains in Mercy Bay thus hold a special place in Inuvialuit history. Through the co-management of Aulavik National Park with Parks Canada, Inuvialuit have played an active role in protecting and preserving the Mercy Bay sites.

Inuit stories about HMS *Investigator* have been recorded since the early 20th Century and these were used extensively to research the archaeological potential of Mercy Bay. The information provided by Sachs Harbour residents informed historic research and field work at the site.

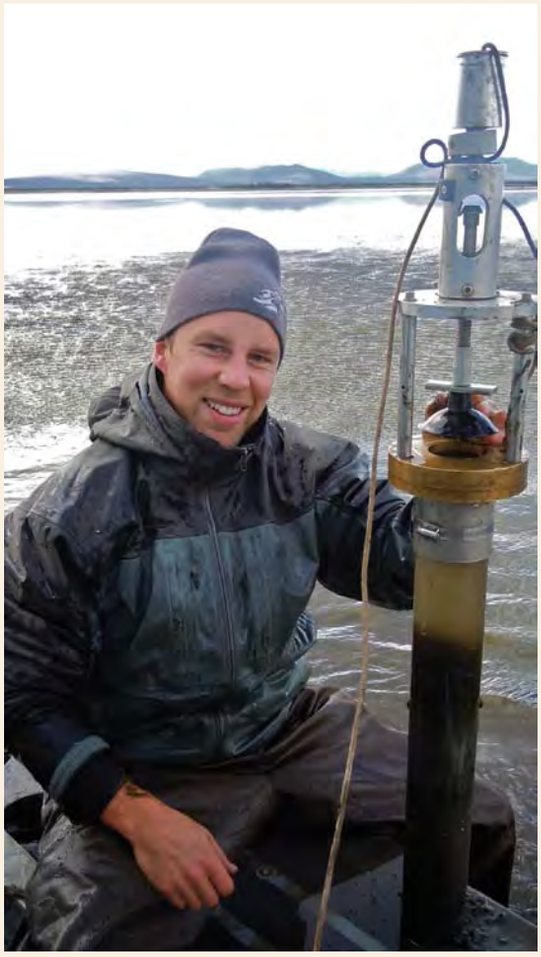
PCSP helicopter transporting field equipment in a sling to the Mercy Bay field camp.
E. Eastaugh, University of Western Ontario

The research team plans to return to Mercy Bay in 2011 to document the wreck and complete further research.

Hydroecology of lakes in the Old Crow Flats, northern Yukon Territory

Brent Wolfe (Department of Geography and Environmental Studies, Wilfrid Laurier University) and Roland Hall (Department of Biology, University of Waterloo)

In the Old Crow Flats (OCF), northern Yukon Territory, declining lake levels threaten wildlife populations and cultural activities of the Vuntut Gwitchin First Nation (VGFN). In 2009, Brent Wolfe, Roland Hall and their students continued with research initiated during the International Polar Year (2007-2009) to further understand the current and historic interactions between climate and the hydroecology of thermokarst lakes (formed from thawing permafrost) in the OCF. This information will help the local First Nation



Kevin Turner, a Ph.D. student in Geography and Environmental Studies, Wilfrid Laurier University, collects a lake sediment core from the floats of a helicopter (August 26, 2010). Analysis of the lake sediment record will provide new knowledge of how thermokarst lakes in the Old Crow Flats have evolved over time and how they may respond to ongoing climate change and variability.

J. Tondu

community develop and implement appropriate adaptation plans to sustain traditional ways in this sensitive Arctic environment. This collaborative project is led by the VGFN, in partnership with university and government researchers.

"Direct observation of the drainage of Zelma Lake in June 2007, one of the largest lakes in the Flats, provided scientific evidence of how dynamic this thermokarst landscape is, but was also a poignant reminder of how devastating such events are to the people of Old Crow."

Brent Wolfe

PROJECT HIGHLIGHT

An NSERC Northern Research Internship was awarded to Ph.D. student Ann Balasubramaniam, University of Waterloo. Ann provided expertise to the Natural Resources Department (NRD) of VGFN and trained NRD staff in field activities towards the development of a community-based hydroecological monitoring program. She delivered a research seminar at the Biennial Gwitchin Gathering and led a science camp for the children of Old Crow.

Helicopter-supported field work during 2007-2009 consisted of sampling water and plants from approximately 60 lakes located across the 5,600 km^2 OCF landscape. Sediment cores were collected from several of these lakes. Results from analyses are being used to document current conditions of the lakes and to understand how the lakes have responded to climatic variations over the past three centuries.

Hydrological analyses indicate that lake water balances are sensitive to changes in meteorological conditions and can be classified into five main types: snowmelt-dominated, rainfall-dominated, groundwater-influenced, evaporation-dominated and drained. For example, marked increases in late winter snow accumulation and spring rainfall can cause lake levels to rise, thereby triggering the erosion and rupture of lake banks, leading to catastrophic thermokarst lake drainage, as was the case for Zelma Lake in 2007. On the other hand, years of low snow accumulation, such as during 2008, combined with a longer ice-free season may lead to greater water loss by evaporation and higher concentration of nutrients in the lake water.

In another instance, sediment core analyses from an evaporation-dominated lake indicate that it likely drained around 1989 in response to above-average precipitation and bank erosion, a finding which is supported by aerial photographs. Ongoing lake sediment core analyses will aim to identify the relative roles of evaporation versus lake drainage over time as processes that cause water loss in thermokarst lakes of the OCF.

Current efforts are focused on implementing a hydroecological monitoring program for the OCF, in partnership with Parks Canada, to identify ongoing climate-driven changes to the ecosystem. The information gathered will assist the community of Old Crow to adapt to changing conditions and will be used by Parks Canada to assess aquatic ecosystem integrity for their State of the Park reports.

Numerous outreach activities have included providing climate change workshops for youth, and research presentations, posters and pamphlets at annual community-researcher meetings. A mapping workshop allowed community members to identify locations of interest and travel routes, including identifying changes they had observed in the Old Crow Flats. This collaboration helped establish lake study sites for the research group.

DID YOU KNOW?

Old Crow Flats was identified as part of the International Biological Program inventory and was designated a wetland of international importance by the Ramsar Convention on May 24, 1982. The Ramsar Convention is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and prudent use of wetlands and their resources.

PROJECTS FOCUSED ON SUSTAINABLE COMMUNITIES AND CULTURE

Banks Island archaeological research project

Location: Fish Lake (Banks Island), N.W.T.

Principal investigator: Charles Arnold (Prince of Wales Northern Heritage Centre, Government of the Northwest Territories)

High Arctic Thule project

Location: Resolute (Cornwallis Island), Nun.

Principal investigator: Sarah Hazell (Department of Anthropology, McGill University)

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)

Van Tat Gwich'in cultural technology project (Year Two)

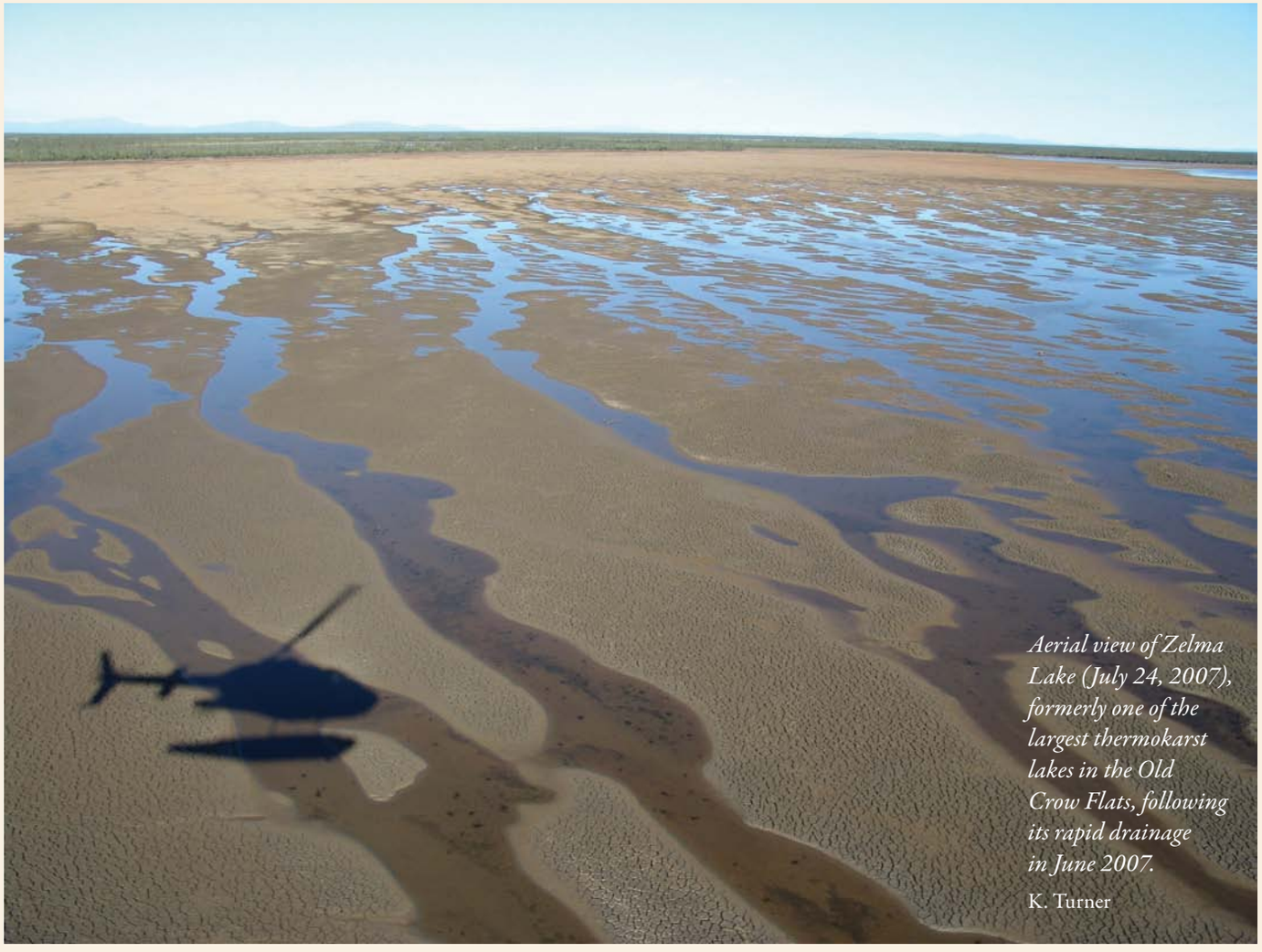
Locations: Old Crow and Fishing Branch River, Y.T.

Principal investigator: Shirleen Smith (Heritage Branch, Vuntut Gwichin First Nation)

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)



Aerial view of Zelma Lake (July 24, 2007), formerly one of the largest thermokarst lakes in the Old Crow Flats, following its rapid drainage in June 2007.

K. Turner

CLIMATE CHANGE

Climate change remains an important issue as it impacts on the physical and socio-economic landscape of the Canadian Arctic and the world. Polar regions have a significant role to play in regulating global climate and they are also vulnerable to environmental changes. The study of these climatic shifts is crucial to understanding the broader implications of climate change. The PCSP supports projects on an annual basis that examine aspects of climate change, such as changing ecosystems, historic climate variability, and adaptation to changing conditions.

Canadian Arctic Sea Ice Mass Balance Observatory (CASIMBO)

Christian Haas (Earth and Atmospheric Sciences, University of Alberta)

Arctic sea ice follows an annual cycle of melting through the warm summer months and refreezing through autumn and winter. Sea ice reflects sunlight, keeping the Arctic region cool and moderating the global climate. While Arctic sea ice extent varies from year to year due to changes in atmosphere and ocean conditions, ice extent at the end of the melt season has shown an overall decline over the past thirty years. Understanding the annual variability in sea ice properties will improve knowledge of the Arctic environment and assist in detecting and adapting to climate change.

Ice chunks in Resolute Bay, Nunavut.
J. Lang, PCSP/NRCan

Since 2004, Christian Haas and his research team have been observing sea ice thickness, ice drift, and other ice properties in the Lincoln Sea, which is located northeast of Ellesmere Island. The data is used to obtain information about Arctic climate and sea-ice change, and to improve the understanding of the Arctic atmosphere-ice-ocean system. Field work included airborne surveys to measure ice thickness using an electromagnetic sensor (also called an "EM bird"), buoy deployments, and the retrieval of snow samples and ice cores during helicopter landings on ice floes.

> "This is the thickest sea ice in the Arctic, but we are only now discovering the range of interannual variability and governing processes and conditions."
>
> Christian Haas

Measurements showed that sea ice thickness did not vary appreciably up to 2007, with average thicknesses greater than 4 m. In 2008, however, significant thinning of up to 1.2 m occurred, which correlates with the Arctic-wide record minimum sea ice coverage in the summer of 2007. Surprisingly, in 2009, the ice thicknesses rebounded to greater than 4 m again, although many had speculated that the ice would not recover from the minimum in 2007 and that Arctic sea ice would disappear soon. In May 2010 there was some thinning again, despite little Arctic-wide changes in the preceding summer.

The results indicate that it may be difficult to relate sea ice changes north of Ellesmere Island to Arctic-wide sea ice behaviour, likely because the region is strongly affected by ice deformation and ice thickness in the study area. This seems to be related to the consequent formation of an extensive ice arch covering the Lincoln Sea between Ellesmere Island and Greenland. Dr. Haas' findings suggest that ice thickness and deformation in the region may play an important role in the amount of sea ice exported south through Nares Strait, which is an important source of freshwater exported from the Arctic Ocean to the North Atlantic.

Oceanography of the Canadian High Arctic in Winter: A Continuation of the International Polar Year (IPY)—Canada's Three Oceans (C3O) Project

Eddy Carmack and Svein Vagle (Institute of Ocean Sciences, Fisheries and Oceans Canada)

The waters and associated sea ice cover of the Canadian High Arctic are undergoing dramatic alterations due to climate change. Despite the importance of these waters to issues concerning sovereignty, resource development, transportation and biodiversity, there is virtually no baseline oceanographic data upon which future changes can be gauged.

BREAKING NEW GROUND:

In 2009, for the first time ever, the research team was able to operate an EM bird from a fixed-wing aircraft (a Basler DC-3), which resulted in significant improvements of range and regional coverage compared to the standard use of helicopters.

Basler DC-3 aircraft with electromagnetic sensor beneath (white with yellow tip) used to take ice thickness measurements.

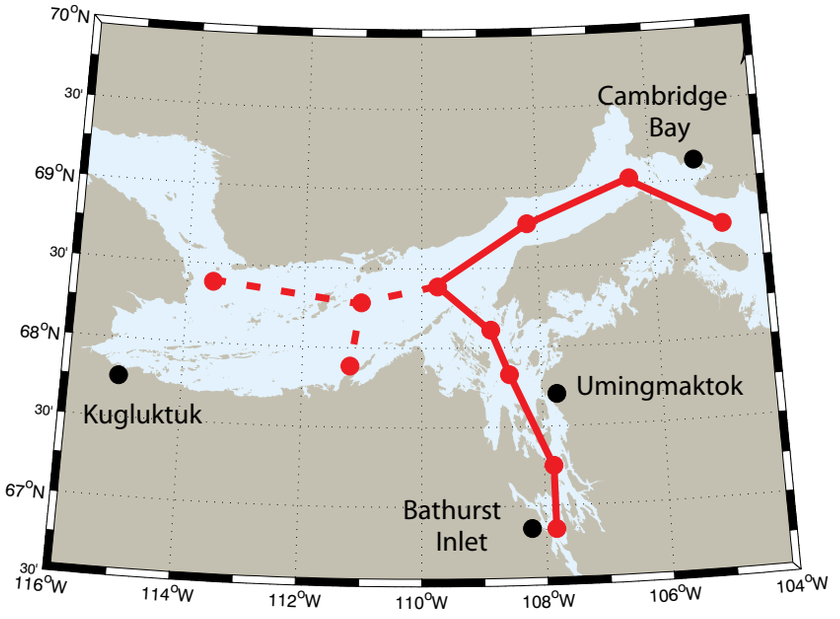
C. Haas

Canada's three oceans (the Atlantic, the Arctic and the Pacific) are dynamically interconnected. The C3O project was designed to take a physical, chemical and biological snapshot of all three oceans to evaluate connections, features and processes within the Canadian ocean environment. It is particularly important to collect data to characterize winter (ice-covered) conditions. The intent is to provide a history and baseline data from which to begin long-term monitoring of Canada's oceans and to identify possible impacts of climate change.

In May 2009, Eddy Carmack and a team of researchers from Fisheries and Oceans Canada received logistical support from the PCSP, based out of Resolute and Cambridge Bay, to carry out aircraft-based oceanographic surveys. The research team conducted the first ever late winter / early spring ice-covered oceanographic survey of Coronation Gulf, located in the western Northwest Passage. Sampling was also completed at 11 stations located throughout the interconnected Coronation Gulf, Bathurst Inlet and Dease Strait. The team returned in 2010, this time working in collaboration with the Ocean University of China, to carry out oceanographic surveys north of the Queen Elizabeth Islands. These surveys are providing new data regarding

Eddy Carmack and Jinping Zhao testing a new, through-ice zooplankton net during a pilot Canada/China collaborative study in 2010.

S. Vagle



Map depicting routes and sampling stations during the ice-based 2009 oceanographic survey.

temperature, salinity, currents, plankton, water properties, and "bioacoustics," or the study of sound wave interactions with living organisms.

The researchers used the data to assess oceanographic conditions within Coronation Gulf, such as its complex circulation patterns, which are the result of warmer, freshwater input from the rivers entering Bathurst Inlet, and tidally-driven vertical mixing in the Dease and Dolphin-Union Straits.

Recent observations show that the sea ice cover in the Canadian High Arctic is thinning and the amount of multiyear sea ice is decreasing. If the sea ice cover continues to retreat or even vanish, the circulation and underlying water would be significantly different from what it is today. It is critically important to obtain current baseline information in order to prepare for and adapt to climate change.

DID YOU KNOW?

This research is a continuation of two International Polar Year (IPY) studies: "Study of Canadian Arctic River-delta Fluxes" and "Snow accumulation, melt and runoff, and small lake processes, at the Arctic forest/tundra transition in the Western Canadian Arctic."

Hydrological studies in the Mackenzie Delta Region

Philip Marsh (National Water Research Institute, Environment Canada)

Climate change is expected to have an impact on the Canadian Arctic in many ways, including the hydrology of the Mackenzie Delta, and on the land cover and composition of its surrounding uplands. This region is dominated by rivers, peatlands and lakes that provide important habitats for fish, waterfowl, shorebirds and mammals. It is also an area of interest due to increased oil and natural gas exploration in the region, with concerns about the future climate and hydrologic conditions under which such developments will exist.

In 2009, a research team led by Philip Marsh continued to collect comprehensive scientific data to determine the long-term hydrology of the Mackenzie Delta, emphasizing the interactions between climate, hydrology and sea levels. The research team also studied impacts of the changing climate on surrounding upland areas including changes in vegetation cover from tundra to shrub-tundra and their impacts on hydrology and feedbacks to the climate. Data was collected in the Mackenzie Delta region with an aim to broaden the knowledge of these processes, and the research provides important scientific baseline data to assist in balancing conservation and development in the Mackenzie Valley and Delta regions.

To better predict the impacts of climate change and natural resources development on this ecosystem, the research team worked towards gaining a better understanding of the complex interactions of stream flow, sea level, ice rich permafrost, and climate. The research team noted an increase in the number of thermokarst lakes as the "active layer" (the top layer of soil that thaws in summer and freezes in autumn in regions dominated by permafrost) becomes thicker, and they noted changes in the rate of catastrophic thermokarst lake drainage. Data gathered through this project are being used internationally to test various atmospheric and hydrologic models required by climate change studies and to compare circumpolar river basins.

Environment Canada staff surveying surface of drained lake, Mackenzie Delta region, Northwest Territories.

C. Onclin

PROJECTS FOCUSED ON CLIMATE CHANGE

Oceans acidification and Arctic carbonates—Elmerson Peninsula, Northwest Ellesmere Island

Locations: Borup Pass, Mount Leigh and Mount Burrill (Ellesmere Island), Nun.

Principal investigator: Benoît Beauchamp (Arctic Institute of North America and Department of Geoscience, University of Calgary)

Interferometric radar monitoring of snow cover changes in the Arctic

Location: Expedition Fiord (Axel Heiberg Island), Nun.

Principal investigator: Paul Budkewitsch (Canada Centre for Remote Sensing, Natural Resources Canada)

Glacier mass balance and snow pollution studies

Locations: Melville Ice Cap (Melville Island), Meighen Ice Cap (Meighen Island), Devon Ice Cap (Devon Island), Grise Fiord and Agassiz Ice Cap (Ellesmere Island), Nun.

Principal investigators: David Burgess (Canada Centre for Remote Sensing, Natural Resources Canada) and Michael Demuth (Geological Survey of Canada, Natural Resources Canada)

Permafrost and climate change, western Arctic Canada

Locations: Old Crow Flats, Herschel Island, Illisarvik and Gary Island, Y.T.

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

Archipelago oceanography in winter: A continuation of International Polar Year—Canada's Three Oceans (C3O) project

Locations: Resolute (Cornwallis Island), Cambridge Bay (Victoria Island) and Kugluktuk, Nun.

Principal Investigator: Eddy Carmack (Ocean Sciences, Fisheries and Oceans Canada)

Paleohydrogeology and climatology in northern Yukon and Northwest Territories

Locations: Old Crow and Ch'it'oo Choo Dha, Y.T. and Inuvik and Bug Creek, N.W.T.

Principal Investigator: Ian Clark (Department of Earth Sciences, University of Ottawa)

Northern Ellesmere ice shelves, ecosystems and climate impacts

Locations: Milne Ice Shelf and Serson Ice Shelf (Ellesmere Island), Nun.

Principal Investigator: Luke Copland (Department of Geography, University of Ottawa)

Ben Lange (M.Sc. candidate, University of Alberta) takes drill-hole ice thickness measurements on an ice floe in the Lincoln Sea, May 2009.

C. Haas

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)

Characterization of freshwater diatom indicators and other paleolimnological analyses from Cape Herschel and area, Ellesmere Island, Nunavut

Location: Cape Herschel (Ellesmere Island), Nun.

Principal Investigator: Marianne Douglas (Faculty of Science, University of Alberta)

The Polar Environment Atmospheric Research Laboratory

Location: Eureka (Ellesmere Island), Nun.

Principal investigator: James Drummond (Department of Physics, University of Toronto)

Arctic radiative environment at the Polar Environment Atmospheric Research Laboratory (PEARL)

Location: Eureka (Ellesmere Island), Nun.

Principal investigator: Thomas J. Duck (Department of Physics and Atmospheric Science, Dalhousie University)

Mass balance of White and Baby Glaciers, Axel Heiberg Island, Nunavut

Location: Expedition Fiord (Axel Heiberg Island), Nun.

Principal investigators: Miles Ecclestone and Graham Cogley (Department of Geography, Trent University)

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)

Relating snowpack water equivalent to passive microwave radiation satellite imagery and evaluating sublimation in the Arctic snowpack

Location: Daring Lake, N.W.T.

Principal investigator: Michael English (Department of Geography and Environmental Studies, Wilfrid Laurier University)

Climate change impacts and adaptation in Arctic coastal communities

Locations: Banks Island, Resolute (Cornwallis Island) and Pond Inlet (Baffin Island), Nun.

Principal investigator: Don Forbes (Geological Survey of Canada, Natural Resources Canada)

Canadian Arctic Sea Ice Mass Balance Observatory (CASIMBO)

Locations: Locations over Arctic Ocean sea ice (based from Alert, Ellesmere Island, Nun.)

Principal investigator: Christian Haas (Department of Earth and Atmospheric Sciences, University of Alberta)

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) and Cape Bounty (Melville Island), Nun.

Principal investigator: Greg Henry (Department of Geography, University of British Columbia)

Buoys-On-Ice 2009

Locations: Locations on the Arctic Ocean (based from Eureka, Ellesmere Island, Nun.)

Principal investigator: Edward Hudson (Meteorological Service of Canada, Environment Canada)

Documenting changes in the temperature and thickness of multi-year ice along its migration route

Locations: Locations on sea ice (based from Resolute, Cornwallis Island, Nun.)

Principal investigator: Michelle Johnston (Canadian Hydraulics Centre, National Research Council)

Integrated landscape and river research: The impact of permafrost disturbance on landscape stability and water quality, Cape Bounty and Shellabear Point, Melville Island

Locations: Cape Bounty (Melville Island, Nun.) and Shellabear Point (Melville Island, N.W.T.)

Principal investigators: Scott Lamoureux and Melissa Lafrenière (Department of Geography, Queen's University)

Arctic ponds formed by melting permafrost: The production of greenhouse gases, microbial diversity and ecosystem functioning

Location: Bylot Island, Nun.

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)

Vegetation dynamics of Bylot Island, biotic interactions and climate Change

Location: Bylot Island, Nun.

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)

Hydrological studies, Mackenzie Delta region

Location: Richards Island, N.W.T.

Principal investigator: Philip Marsh (National Water Research Institute, Environment Canada)

Central Baffin Island disappearing ice caps and vegetation resampling, International Polar Year—Back to the future

Locations: Barnes Ice Cap, Serpens Ice Cap and Iqaluit (Baffin Island), Nun.

Principal Investigator: Gifford Miller (Institute of Arctic and Alpine Research, University of Colorado)

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)

The Polar Environment Atmospheric Research Laboratory—Starphotometer Deployment to Eureka

Location: Eureka (Ellesmere Island), Nun.

Principal Investigator: Norm O'Neill (Université de Sherbrooke)

Paleoclimates of the Foxe Basin and Surrounding Regions

Locations: Steensby Inlet, Melville Pennisula, Taverner Bay and Lake Nettilling, Nun.

Principal investigator: Reinhard Pienitz (Centre d'Études Nordiques, Université Laval)

Impacts of warming climatic conditions on contaminant input to freshwater ecosystems via thawing permafrost

Location: Noel Lake Area, N.W.T. (based from Inuvik)

Principal investigator: Michael Pisaric (Department of Geography and Environmental Studies, Carleton University)

The significance of ground water and ground ice in cold polar environments

Locations: Eureka (Ellesmere Island) and Expedition Fiord (Axel Heiberg Island), Nun.

Principal investigator: Wayne Pollard (Department of Geography, McGill University)

Climate change effects on the hydroecology of northern lakes

Locations: Expedition Fiord and Colour Lake (Axel Heiberg Island) and Alert (Ellesmere Island), Nun.

Principal Investigator: Terry Prowse (Water Science and Technology, Environment Canada)

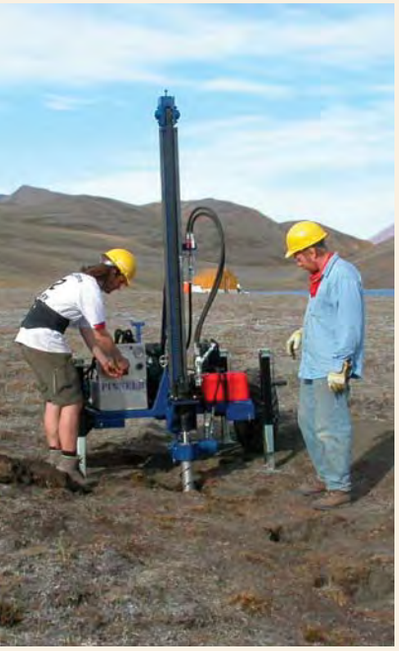
Landscape evolution, paleoecology and climate change in the Tertiary of the High Arctic

Locations: Romulus Lake, Remus Creek and Haughton Impact Crater (Devon Island), Nun.

Principal investigator: Natalia Rybczynski (Research Division - Paleobiology, Canadian Museum of Nature)

Arctic poppies grow near Pond Inlet, overlooking the mountainous terrain on Bylot Island in the background.

C. Evans, PCSP/NRCan



Roland Wilhelm (M.Sc. candidate, McGill University) and Lyle Whyte using a permafrost drill system to obtain permafrost core samples for microbial analyses related to global warming and greenhouse gas emissions from melting permafrost.

L. Whyte

Dynamics and change of the Devon Island Ice Cap

Locations: Devon Ice Cap and Truelove Lowlands (Devon Island), Nun.

Principal investigator: Martin Sharp (Department of Earth and Atmospheric Sciences, University of Alberta)

Pyroconvection measurements with the Stratospheric Lidar at the Polar Environment Atmospheric Research Laboratory

Location: Eureka (Ellesmere Island), Nun.

Principal Investigator: Robert Sica (Department of Physics and Astronomy, University of Western Ontario)

Influence of liquid water on biological activity in Arctic soils

Locations: Eastwind Lake (Ellesmere Island) and Truelove Lowlands (Devon Island), Nun.

Principal investigator: Steven Siciliano (Department of Soil Science, University of Saskatchewan)

Permafrost thermal monitoring—High Arctic observations

Location: Eureka (Ellesmere Island), Nun.

Principal Investigator: Sharon Smith (Geological Survey of Canada, Natural Resources Canada)

Limnology and paleoecology of lakes

Location: Resolute (Cornwallis Island), Nun.

Principal investigators: John Smol (Department of Biology, Queen's University) and Marianne Douglas (Department of Earth and Atmospheric Sciences, University of Alberta)

Net ecosystem exchange of carbon greenhouse gases in High Arctic ecoregions

Locations: Lake Hazen, Quttinirpaaq National Park and Astra Ice Cap (Ellesmere Island), Nun.

Principal Investigator: Vincent St. Louis (Department of Biological Sciences, University of Alberta)

Pan-Arctic measurements and Arctic regional climate model simulations (PAM-ARCMIP)

Locations: Alert, Eureka (Ellesmere Island) and Resolute (Cornwallis Island), Nun.

Principal Investigator: Walter Strapp (Science and Technology, Environment Canada)

Canadian Arctic Buoy Program (CABP)

Location: Resolute (Cornwallis Island), Nun.

Principal Investigator: Bruno Tremblay (Department of Atmospheric and Oceanic Sciences, McGill University)

Northern Ellesmere Island in the Global Environment (NEIGE)

Location: Ward Hunt Island, Nun.

Principal investigator: Warwick Vincent (Centre d'Études Nordiques, Université Laval)

Hydrology of extensive low gradient High Arctic wetlands: an examination of sustainability

Location: Polar Bear Pass (Bathurst Island), Nun.

Principal investigator: Kathy Young (Department of Geography, York University)

Ice island drift tracking

Locations: Resolute (Cornwallis Island) and Eureka (Ellesmere Island), Nun.

Principal Investigator: Vladimir Zabeline (Canadian Ice Service, Environment Canada)

SUSTAINABLE RESOURCES MANAGEMENT

The sustainable management and development of natural resources in the Canadian Arctic, including wildlife, water, petroleum and minerals, is key to ensuring that these resources are available into the future and benefit northern communities. With the acknowledgement that climate change is impacting on possible trade routes and accessibility to natural resources found in the Canadian Arctic, it follows that there is a need to expand the knowledge regarding natural resources in this vast region. The PCSP supports a number of research projects that are examining sustainable development and resource management in the North.

Base camp for a stream sediment survey was located at the Gana River Outfitters lodge on the shore of Palmer Lake in the central Mackenzie Mountains.
H. Falck

DID YOU KNOW?

New mineral showings have been identified by prospectors and geoscientists as a result of the regional stream sediment survey. Expanses of the Mackenzie Mountains have been staked in search of new mineral wealth, utilizing the stream sediments data as a guide.

New stream sediment survey results from the Keele and Mountain Rivers, Mackenzie Mountains, N.W.T.

Hendrik Falck (Northwest Territories Geoscience Office) and Stephen Day (Geological Survey of Canada, Natural Resources Canada)

Regional stream sediment surveys provide important information regarding the chemical composition of stream sediment and water. The Mackenzie Mountains, N.W.T. were identified as a region lacking this type of scientific data in 2002, and surveys have been ongoing since this time. In 2009, Hendrik Falck and Stephen Day led a silt and bulk stream sediment and water survey of the Keele and Mountain river drainage systems in the Northwest Territories. The project goal was to collect stream sediment and water samples from many small streams and analyse their chemistry to develop a snapshot of natural values across the entire Mackenzie Mountains. The results informed government policy regarding the balance between development and conservation in making land-use decisions.

The red streams of the Middlecoff River Valley represent iron-rich water reacting with carbonate water.

H. Falck

Lawrence Caesar of Fort Good Hope demonstrates the correct technique of collecting silt samples.

H. Falck

The research team completed a helicopter-borne reconnaissance survey in 2009 and collected 2,141 silt, 2,103 water and 283 bulk stream sediment samples from 2,100 sites. These samples were then analyzed to determine the amounts (or concentrations) of certain elements found in the samples. High metal concentrations can be indicative of concentrations of metals hosted in the rocks, also known as "showings." Significantly, results from this survey indicated high metal concentrations in areas where showings have not been previously identified, suggesting that further exploration is warranted.

The researchers also found naturally elevated concentrations of several biologically significant elements, including mercury, in certain regions. They noted that the distribution of these elevated concentrations may help to explain unusual concentrations of heavy metals found in the internal organs of moose occupying these mountain ranges.

Each year the new results are presented at meetings with the local band councils and land development officers.

Future plans include completion of a silt sampling program in 2011 in the Coates Lake area in the Northwest Territories. Additional research is being planned to examine the physical and chemical processes involved in the transition from mineral showing to silt sample to better interpret the results of these large regional surveys.

Field camp at Kakiak Point, Admiralty Inlet, Nunavut in August 2009.

C. Matthews

Orcas of the Canadian Arctic

Pierre Richard and Steve Ferguson (Arctic Aquatic Research, Fisheries and Oceans Canada) and Cory Matthews (Ph.D. candidate, University of Manitoba)

Orca (or killer whale) predation has been identified as the main threat to the bowhead whale population, which may be worsened by an expanding Orca population in the Arctic due to climate change. This in turn impacts traditional Inuit subsistence in the region. Pierre Richard, Steve Ferguson and Cory Matthews led a team of researchers and eastern Arctic Inuit residents in August 2009 to study and monitor approximately 20 Orcas in Admiralty Inlet, Nunavut, as part of the "Orcas of the Canadian Arctic" collaborative research project. Understanding eastern Arctic Orca distribution and diet is fundamental to developing appropriate management plans to address conservation challenges posed by a changing Arctic ecosystem.

> "While we suspected these Orcas may overwinter in the open North Atlantic, seeing the distance—and the rate at which they traveled—was truly remarkable."
>
> Cory Matthews

Orcas were approached by boat and researchers used crossbows to deploy satellite transmitter tags on two whales. A skin-blubber biopsy was collected from an additional whale. Photographs were taken of the dorsal fins of the Orcas for photo identification purposes. Wildlife biologists often use the distinctive nicks and wear patterns that develop on the dorsal fins of Orcas to identify individuals in the field.

One satellite transmitter was lost and the other remained in operation for 90 days. The 90-day record provided valuable information on eastern Canadian Arctic Orca movement and migration. The tagged Orca and likely others observed in the group remained in Admiralty Inlet and the Gulf of Boothia during August and September. The Orcas departed via Lancaster Sound in mid-October just before the formation of heavy ice in the area. By mid-November, the tagged Orca had travelled from northern Baffin Island to just west of the Azores archipelago in the mid North Atlantic—a distance of over 5,400 km—in one month. This is one of the longest documented migrations by Orcas and it helps researchers to determine the overall distribution of eastern Arctic Orcas. Final location data received corresponded to areas of Orca sightings by 19th century American whalers called the 'western ground'. The satellite tag ceased to transmit data during the winter months.

The research team plans to return to Admiralty Inlet on an annual basis in order to track and monitor the Orca population and to assist the community to implement a local monitoring program. Data will be used to document how Orca movements in Arctic waters overlap with those of prey, such as narwhal and bowhead whales, and to study migration patterns. Researchers plan to collect additional skin and blubber samples to assess contaminants found in the Orcas, as well as their diet and genetics. They will use these data to determine their feeding ecology and population structure.

The results will be used to anticipate ecosystem changes and develop management options for subsistence hunting and conservation of hunted stocks.

DID YOU KNOW?

Eastern Arctic Orcas can successfully navigate sea ice cover of up to 30 to 50% to reach open water east of Baffin Island when they are migrating in the fall.

Mature male killer whale near Kakiak Point, Admiralty Inlet, Nunavut in August 2009.

G. Freund

PROJECTS FOCUSED ON SUSTAINABLE RESOURCES MANAGEMENT

The landscape near Expedition Fiord, Axel Heiberg Island, Nunavut.
J. Lang, PCSP/NRCan

(GEM) Architecture, evolution and metallogeny of the Mesoproterozoic sedimentary basins of northern Nunavut

Location: Arctic Bay (Baffin Island), Nun.

Principal investigator: Elizabeth Turner (Department of Earth Sciences, Laurentian University)

(GEM) Energy potential of eastern Sverdrup Basin

Locations: Confederation Point and Griesbach Creek (Axel Heiberg Island), Isachsen (Ellef Ringnes Island) and Blind Fiord (Ellesmere Island), Nun.

Principal investigator: Benoît Beauchamp (Department of Earth Sciences, University of Calgary)

(GEM) Northern base and precious metal potential, Victoria Island, Northwest Territories, and Nunavut

Locations: Booth River, Nun. and Ulukhaktok (Victoria Island), N.W.T.

Principal investigator: Jean Bédard (Geological Survey of Canada, Natural Resources Canada)

(GEM) Melville Peninsula geo-mapping project

Location: Melville Peninsula, Nun.

Principal investigator: David Corrigan (Geological Survey of Canada, Natural Resources Canada)

(GEM) Iron Oxide-Copper-Gold deposits and the Great Bear Magmatic Zone

Locations: Lou Lake and Hepburn Lake, N.W.T.

Principal Investigator: Louise Corriveau (Geological Survey of Canada, Natural Resources Canada)

Electromagnetic studies of permafrost in the Mackenzie Delta

Locations: Inuvik and Richards Island, N.W.T.

Principal Investigator: Jim Craven (Geological Survey of Canada, Natural Resources Canada)

Release of methane from warming permafrost and gas hydrates in the Mackenzie Delta, Northwest Territories

Locations: Inuvik and Outer Mackenzie Delta region, N.W.T.

Principal Investigator: Scott Dallimore (Geological Survey of Canada, Natural Resources Canada)

(GEM) Energy western Arctic islands hydrocarbon potential

Location: Ulukhaktok (Victoria Isalnd), N.W.T.

Principal Investigator: Keith Dewing (Geological Survey of Canada, Natural Resources Canada)

Regional stream sediment and water geochemistry survey, Mackenzie Mountains, Northwest Territories

Location: Palmer Lake, N.W.T.

Principal Investigator: Hendrik Falck (Northwest Territories Geoscience Office)

(GEM) Bedrock mapping and structural analysis of Mackenzie Plain and Franklin Mountains

Location: Norman Wells, N.W.T.

Principal Investigator: Karen Fallas (Geological Survey of Canada, Natural Resources Canada)

Determining killer whale movements in the eastern Canadian Arctic and northwest Atlantic using satellite telemetry

Locations: Resolute (Cornwallis Island) and Arctic Bay and Pond Inlet (Baffin Island), Nun.

Principal investigator: Steven H. Ferguson (Arctic Aquatic Research, Fisheries and Oceans Canada)

Hadean crustal remnants, ferropicrites and Archean crustal reworking, Inukjuak, Nunavik

Location: Inukjuak, Nunavik

Principal Investigator: Don Francis (Earth and Planetary Sciences, McGill University)

Regional geoscience studies and petroleum potential of Mackenzie Plain, Mainland Northwest Territories

Location: Norman Wells, N.W.T.

Principal Investigator: Leonard Gal (Northwest Territories Geoscience Office)

Canadian gravity standardization network northern survey

Locations: Salluit (Quebec) and Qikiqtarjuaq, Igloolik, Resolute, Eureka and Alert (Nunavut) and Kugluktuk, Ulukhaktok, Inuvik and Norman Wells, N.W.T.

Principal Investigator: Joe Henton (Canada Centre for Remote Sensing, Natural Resources Canada)

(GEM) Iron Oxide-Copper-Gold Great Bear Magmatic Zone - South Wopmay bedrock mapping project

Locations: Brownwater Lake, Hardisty Lake and Grant Lake, N.W.T.

Principal Investigator: Valerie Jackson (Northwest Territories Geoscience Office)

(GEM) Yukon sustainable energy resources

Location: Eagle Plains, Y.T.

Principal Investigator: Larry S. Lane (Geological Survey of Canada, Natural Resources Canada)

UNCLOS bathymetry and gravity surveys, Ward Hunt Island and Alert, Nunavut

Location: Eureka (Ellesmere Island), Ward Hunt Island and locations on sea ice, Nun.

Principal Investigator: J. Richard MacDougall (Canadian Hydrographic Service, Fisheries and Oceans Canada)

Bonnet Plum and Nadaleen River mapping project

Location: Border Lake, N.W.T.

Principal Investigator: Edith Martel (Northwest Territories Geoscience Office)

Hydrodynamic characterization of a polythermal glacier through a new photogrametric and geophysical approach

Locations: Fountain Glacier (Bylot Island), Nun.

Principal Investigator: Brian J. Moorman (Department of Geography, University of Calgary)

(GEM) Canadian Arctic Petroleum Systems - East (CAPSE), Bylot Island

Location: Pond Inlet (Baffin Island), Nun.

Principal Investigator: Gordon Oakey (Geological Survey of Canada, Natural Resources Canada)

(GEM) Windy-McKinley, Edges Project: mineral potential of the Northern Cordillera exotic terranes

Location: Tin Cup Lake, Y.T.

Principal Investigator: Jim Ryan (Geological Survey of Canada, Natural Resources Canada)

(GEM) Cumberland Peninsula integrated geoscience project

Location: Pangnirtung Area, Cumberland Peninsula, (Baffin Island), Nun.

Principal Investigator: Mary Sandborn-Barrie (Geological Survey of Canada, Natural Resources Canada)

Provenance of clastic sediments in the Sverdrup Basin, Canadian Arctic Islands

Locations: Lake Hazen, (Ellesmere Island), Nun.

Principal Investigator: Robert A. Scott (Cambridge Arctic Shelf Programme, University of Cambridge)

(GEM) Integrated seismic shothole log and shallow geophysical investigation, Mackenzie Corridor and Colville Hills, Northwest Territories

Location: Little Chicago area and Lac de Bois, N.W.T.

Principal Investigator: Rod Smith (Geological Survey of Canada, Natural Resources Canada)

(GEM) Assessment of seismic shothole-associated fugitive gas seeps, Mackenzie Delta, Northwest Territories

Location: Inuvik, N.W.T.

Principal Investigator: Rod Smith (Geological Survey of Canada, Natural Resources Canada)

Coastal and near shore geoenvironmental hazards for development in the southern Beaufort Sea and Mackenzie Delta

Location: Inuvik and Garry Island, N.W.T.

Principal Investigator: Steve Solomon (Geological Survey of Canada - Atlantic, Natural Resources Canada)

NRCan/DFO UNCLOS Program Automated Underwater Vehicle (AUV) which travelled to locations in Canada's High Arctic underneath the sea ice for distances of up to 350 km. The AUV homed into a homing beacon and was retrieved at an ice island floating in the Arctic Ocean.

J. Lang, PCSP/ NRCan, CHS/DFO

Aerial view of the DRDC Northern Watch Technology Demonstration Gascoyne Inlet field camp, Devon Island, Nunavut.

J. Rouleau

PLANETARY SCIENCE AND TECHNOLOGY

The Canadian Arctic is a region with some of the harshest climatic conditions on Earth, and includes locations and environments similar to those that may exist on other planets in our solar system. Certain locations in the Canadian Arctic have been used to better understand how and where life could survive on the planets and how best to plan, and develop technology for, space missions to places such as Mars and our own moon. The Canadian Arctic is also an important region for socioeconomic development and future transportation routes, yet monitoring this region presents immense challenges due to its vast proportions. New technologies are being developed and tested to study telecommunications and monitoring in the Canadian Arctic. The PCSP continues to support several projects each year that are focussed on a wide range of topics within the field of planetary science and technology.

"We were surprised that we did not find bacteria that respire methane at Lost Hammer, but we did find anaerobic organisms —organisms that survive by oxidizing methane and probably breathing sulfate instead of oxygen."

Lyle Whyte

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

Lyle Whyte (Department of Natural Resource Sciences, McGill University)

A multidisciplinary team of researchers from McGill University, the National Research Council of Canada, the University of Toronto and the SETI Institute made a recent discovery that extremely small, relatively simple, methane-eating organisms (bacteria) are able to survive in a spring located on Axel Heiberg Island in Canada's High Arctic.

The Lost Hammer spring is found in a harsh environment and yet is able to support bacterial life forms. It is similar to springs that may exist on Mars, and the results indicate that springs on Mars may also be capable of supporting life.

The Lost Hammer spring represents one of the most extreme environments found on earth, with no consumable oxygen, temperatures as low as -50 degrees Celsius, and water that is so salty it does not freeze. The researchers observed large methane bubbles surfacing at the spring and

Nancy Perreault (Ph.D. candidate, McGill University) taking a water sample for measuring chemical / physical parameters and determining microbial diversity and activity at the Gypsum Hill Spring.
L. Whyte

conducted research to determine whether the gas was being produced geologically or biologically and whether there was evidence for life in the spring. As a comparison, temperatures on Mars reach 0 to -5 degrees Celsius, and methane and water are both found on Mars. Add to this the fact that new gully formations have been found recently on Mars that may have been formed by springs, and an interesting question is brought to mind. Could life survive on Mars? One answer is that there could be springs like Lost Hammer on Mars that do support small organisms.

Northern Watch Technology Demonstration Project

Garry Heard (Defence Research and Development Canada, Department of National Defence))

In the summer of 2009, a research team from Defence Research and Development Canada (DRDC) carried out field work as part of a Technology Demonstration Project for northern surveillance, known as Northern Watch. Northern Watch activities tested remote sensing systems that could be used to track the movement of ships and other vessels along the Northwest Passage, which links the Atlantic and Pacific Oceans. This project is designed to demonstrate the protection of Canadian interests and monitoring of the northern territories.

Using a field camp on Devon Island as a base, DRDC researchers temporarily deployed an underwater sensing system and improved the field camp set-up by erecting temporary buildings and repairing old ones. The underwater sensors were used to collect noise data and monitor passing vessels. The team completed engineering-based research to prove the operational capabilities of the sensors. They demonstrated how the deployment, maintenance and operation of this equipment are possible in the harsh Arctic environment.

The researchers tested a new passive underwater acoustic receiving array technology that is highly capable, but much less expensive than traditional underwater sonar systems. The new DRDC technologies are still undergoing development, but are already being used in international research programs, including marine mammal monitoring, underwater noise and oceanographic studies, and are also being used in autonomous underwater vehicles (AUV). The most recent use of the technology was during the

"If you have a situation where you have very cold salty water, it could potentially support a microbial community, even in that extreme harsh environment."
Lyle Whyte

"Arctic tour boats and other vessels are easily monitored by underwater sensors, Automatic Identification System (AIS), radar, and optical systems."

Garry Heard, DRDC

Derek Clark (lower left), Sean O'Grady (upper left), Nicos Pelavas (middle) and Greg Van Slyke (right) repair data telemetry repeater units.

D. L. Hutt

recent NRCan/DFO/DRDC efforts to map the deep Arctic Ocean seafloor under the ice cover, when it was used as a part of an acoustic homing system that allowed an AUV to navigate to an acoustic beacon from ranges up to 100 km.

DRDC has had a long history of collaboration with the PCSP. Over several decades, the PCSP has frequently served as a base of operations for DRDC. Then, as now, the PCSP has facilitated a significant portion of the DRDC Arctic research program.

The Northern Watch project will continue until 2014, and possibly beyond. In the coming years the research team will deploy new underwater arrays, power systems, communications, radar, and other sensors. The intent is that this research will eventually contribute to enhanced sovereignty in remote regions of the Canadian Arctic.

A Twin Otter arrives with supplies at Camp Gascoyne.

G. Heard

PROJECTS FOCUSED ON PLANETARY SCIENCE AND TECHNOLOGY

Northern Watch Technology Demonstration Project

Location: Gascoyne Inlet (Devon Island), Nun.

Principal investigator: Garry Heard (Defence Research and Development Canada, Department of National Defence)

Canadian Space Agency - Arthur Clarke Mars Greenhouse

Location: Haughton Impact Crater (Devon Island), Nun.

Principal Investigator: Alain Berinstain (Space Science, Canadian Space Agency)

Astronomical site testing on Ellesmere Island

Location: Phillips Inlet (Ellesmere Island), Nun.

Principal investigators: Ray Carlberg and Eric Steinbring (Department of Astronomy and Astrophysics, University of Toronto)

Exploration Core Program

Locations: Resolute (Cornwallis Island), Axel Heiberg Island and Eureka (Ellesmere Island), Nun.

Principal Investigator: Martin Lebeuf (Space Science Development Program, Canadian Space Agency)

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), Nun.

Principal investigator: Pascal Lee (Mars Institute)

Springs, glaciers and landscape evolution on Axel Heiberg Island and implications for Mars

Location: Expedition Fiord (Axel Heiberg Island), Nun.

Principal Investigator: Gordon Osinski (Faculty of Science, University of Western Ontario)

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

Location: Expedition Fiord (Axel Heiberg Island), Nun.

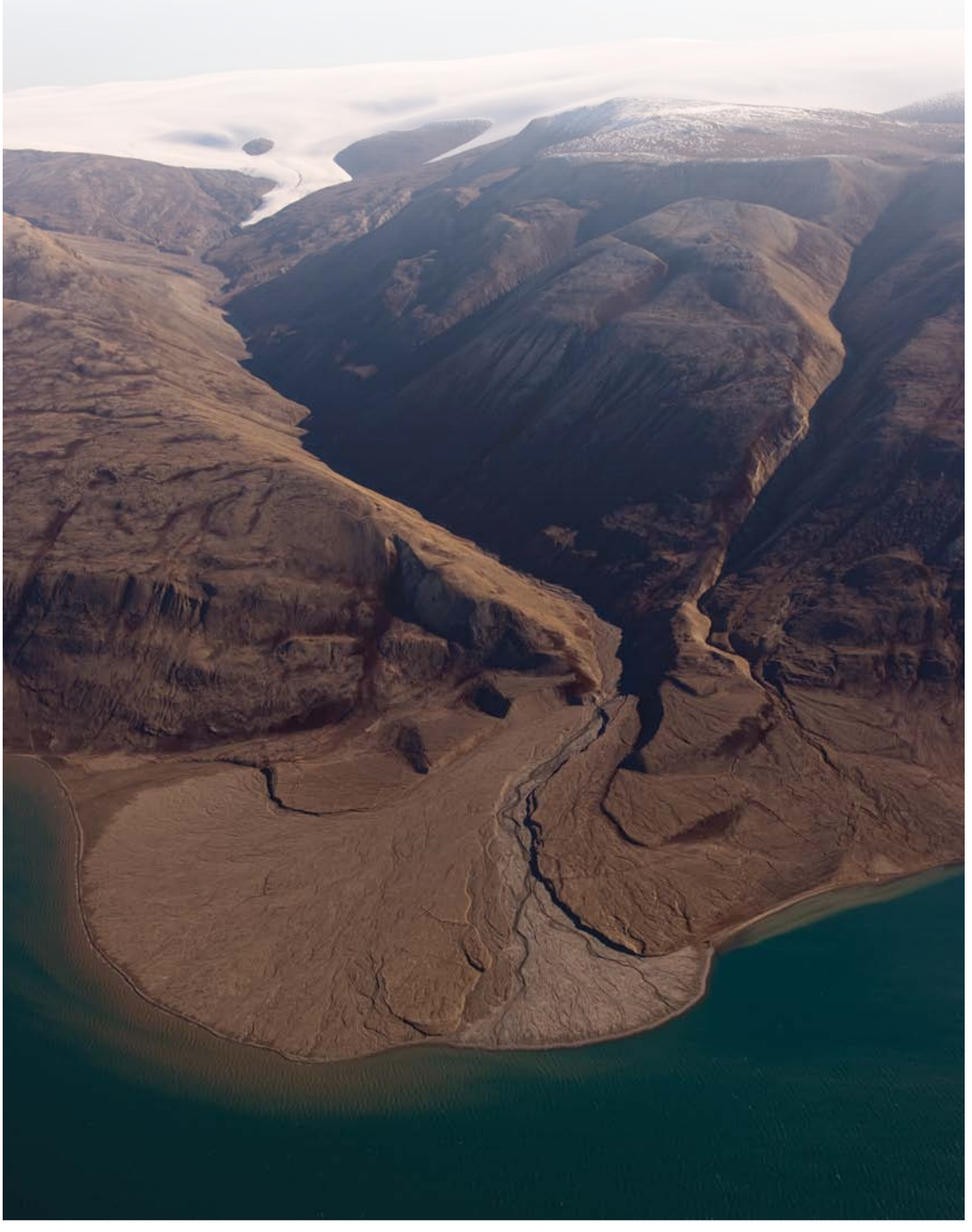
Principal Investigator: Lyle Whyte (Department of Natural Resource Sciences, McGill University)

CCGS DesGrosier leaving Gascoyne Inlet after visiting the field camp.

D. L. Hutt

NATIONAL PARKS AND WEATHER STATIONS

Canada's three territories include eleven national parks and several conservation areas that protect Arctic ecosystems. They encompass diverse landscapes such as forests, rolling tundra, lakes, river valleys, badlands, mountains, sea cliffs and ice caps. The northern national parks are invaluable destinations for visitors to northern areas and provide excellent venues for educational experiences. These areas are increasingly important in order to understand northern environments and the response of the physical, chemical and biological systems to ongoing environmental change in Canada's North. Each 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. In addition, Environment Canada and a number of university-based groups maintain weather stations across the Canadian Arctic that require annual servicing. These stations provide data that is integral to scientific studies and climate monitoring programs.



Quttinirpaaq National Park in Nunavut is dominated by mountainous, desert terrain.

D. Ashe, NRCan

Inuit wildlife monitors working at NRCan/ DFO UNCLOS Program are seen near the camp located on the ice near Borden Island, Northwest Territories

J. Lang, PCSP/ NRCan, CHS/DFO

Quttinirpaaq National Park Arctic Research Infrastructure Fund Project

Project Lead: Ross Glenfield
(Nunavut Field Unit, Parks Canada Agency)
Location: Northern Ellesmere Island, Nunavut

Quttinirpaaq National Park was successful in securing Arctic Research Infrastructure Fund support of $1.15 million to upgrade and improve the three most northern research facilities in the Canadian Arctic that have served the scientific community for over half a century. Existing facilities at Ward Hunt Island, Lake Hazen and Tanquary Fiord were upgraded to include modern living quarters, sanitation, and fuel storage using available solar and wind power. This improved infrastructure expands the capabilities of researchers working in the Canadian High Arctic and continues to build on the existing capacity to accommodate additional researchers.

Polar Environment Atmospheric Research Laboratory (PEARL) Arctic Research Infrastructure Fund Project

Project Lead: James Drummond (Dalhousie University)
Location: Eureka, Nunavut

The Polar Environment Atmospheric Research Laboratory (PEARL) in Eureka, Nunavut is the most northerly atmospheric research facility in Canada run by a university (Dalhousie University) and has been operating since 1992. Dalhousie University was successful in securing Arctic Research Infrastructure Fund support of $1.79 million to improve its infrastructure at the PEARL facility. The facility has been renovated to allow for increased science capacity and to improve the overall health and safety at the facility. The upgrades include an improved telecommunications capability in order to facilitate communications and the transfer of scientific data.

Aerial view of mountain range and glaciers en route to Eureka weather station, Ellesmere Island, Nunavut.

J. Lang, PCSP/NRCan

PROJECTS REGARDING NATIONAL PARKS AND WEATHER STATIONS

Aircraft support for Auyuittuq National Park operations and research

Locations: Locations within Auyuittuq National Park (Baffin Island), Nun.

Principal investigator: Delia Berrouard (Nunavut Field Unit, Parks Canada Agency)

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)

The Polar Environment Atmospheric Research Laboratory

Location: Eureka (Ellesmere Island), Nun.

Principal investigator: James Drummond (Department of Physics, University of Toronto)

Sirmilik National Park operations

Locations: Qaiqsut (Bylot Island) and Paquet Bay and Oliver Sound (Baffin Island), Nun.

Principal investigator: Carey Elverum (Nunavut Field Unit, Parks Canada Agency)

Meterorological station at McGill Arctic Research Station, Expedition Fiord, Axel Heiberg Island, Nunavut.

J. Lang, PCSP/NRCan

Quttinirpaaq National Park operations

Locations: Tanquary Fiord, Lake Hazen, Fort Conger (Ellesmere Island) and Ward Hunt Island, Nun.

Principal investigator: Ross Glenfield (Nunavut Field Unit, Parks Canada Agency)

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, Nun.)

Principal investigator: Jeff Sowiak (Meteorological Service of Canada, Environment Canada)

Ecological monitoring in Vuntut National Park

Location: Vuntut National Park Base Camp, Y.T.

Principal Investigator: Leila Sumi (Western Arctic Field Unit, Parks Canada Agency)

High Arctic ground temperature monitoring

Location: Hot Weather Creek (Ellesmere Island), Nun.

Principal Investigator: Anne Walker (Climate Research Division, Environment Canada)