Canadian National Implementation Plan for Contaminants under AMAP 2008/09

Three major Canadian programs will be conducting research relevant to AMAP in 2008/09. These include the Northern Contaminants Program (NCP), ArcticNet, and a national research program under International Polar Year (IPY).

The bulk of Canada's National Implementation Plan for contaminants under AMAP comprises 51 projects being conducted under the NCP. These projects are organized under three categories: Human Health, Environmental Trends Related to Human Health and International Controls, and Education and Communications. Tables 1a, 1b, and 1c list the titles of each project and Annex 1, contains full plain language summaries for each of these projects.

Canada's IPY program consists of 44 projects related to two priority areas: science for climate change impacts and adaptation, and the health and well-being of Northern communities. These projects are listed in Table 2 and a brief description of each is given in Annex 2.

ArcticNet is a broad based network of researchers with the central objective to translate our growing understanding of the changing Arctic into impact assessments, national policies and adaptation strategies. All 26 ArcticNet projects are listed in Table 3 and described in Annex 3.

Additional updates may be provided over the course of the year to reflect any new projects, particularly as they may relate to issues of interest to AMAP.

Table 1a, Projects being carried out under the Northern Contaminants Program related to Human Health

Project Number	Project Title	Project Leader
H-01	Monitoring Trends of Human Environmental Contaminants in Nunavut (Qikiqtani Region)	Mary Potyrala Janet Brewster (GN-HSS)
H-03	Nunavik Cohort Study on Exposure to Environmental Contaminants and Child Development	Gina Muckle (CHUL)
H-04	Assessment of Contaminant and Dietary Nutrient Interactions in Inuit Health Survey: Nunavut, Nunatsiavut and Inuvialuit	Laurie H.M. Chan (UNBC)
H-05	Contaminant Nutrient Interaction Issues as Part of a Public Health Intervention Study of Inuit Children in Nunavik: Third Year of Data Collection	Huguette Turgeon-O'Brien Gagné (ULaval)
H-06	Contaminant Exposure and Emergence of Cardio-Vascular Diseases in Inuit	Éric Dewailly (CHUL)

Table 1b, Projects being carried out under the Northern Contaminants Program related to Environmental Trends Related to Human Health and International Controls

Project Number	Project Title	Project Leader
M-01	Northern Contaminants Air Monitoring: Organic Pollutant Measurements	Hayley Hung
M-02	Air Measurements of Mercury at Alert	Alexandra Steffen
M-03	Contributing to International Controls on POPs and Mercury: Further Applications of Global Mass Balance Models	Don Mackay
M-04	Temporal Trends of Persistent Organic Pollutants and Metals in Ringed Seals from the Canadian Arctic	Derek Muir
M-05	Temporal and Spatial Trends of Organic and Metal Contaminants in Canadian Polar Bears: Part III	Robert Letcher
M-06	Geographical and time-trend studies on new and emerging persistent halogenated compounds in marine mammals from the Canadian Arctic	Greg Tomy
M-07	Temporal Trends of Heavy Metals and Halogenated Organic Compounds in Arctic Marine Mammals (Beluga, Narwhal and Walrus)	Gary Stern
M-08	Temporal Trends of Contaminants in Arctic Seabird Eggs: Inter-year Variability	Birgit Braune
M-09	Temporal Trends of Spatial Variations in Persistent Organic Pollutants and Metals in Sea Run Char from the Canadian Arctic	Marlene Evans
M-10	Temporal Trends of Persistent Organic Pollutants and Mercury in Landlocked Char in the High Arctic	Derek Muir
M-11	Spatial and Long-term Trends in Persistent Organic Contaminants and Metals in Lake Trout and Burbot from the Northwest Territories	Marlene Evans
M-12	Temporal Trend Studies of Trace Metals and Halogenated Organic Contaminants (HOCs), Including New and Emerging Persistent Compounds in Mackenzie River Burbot, Fort Good Hope, NT	Gary Stern
M-13	Long Term Trends of Halogenated Organic Contaminants and Metals in Lake Trout from Yukon Lakes	Gary Stern
M-14	Caribou and Moose Contaminant Monitoring Program	Mary Gamberg
M-15	Effects of Contaminants on Glaucous Gull Nestlings in the Canadian Arctic	Mark Wayland)
M-16	Source Apportionment of Mercury in Davis Strait Beluga	Peter Outridge
M-18	Atmospheric Deposition and Release of Methylmercury in Glacially-Fed Catchments of Auyuittuq National Park, Baffin Island	Christian Zdanowicz
M-20	Characterizing Contaminant-Related Health Effects in Beluga Whales (Delphinapterus leucas) from the Western Canadian Arctic	Peter Ross
M-21	Trophodynamics of New and Emerging Halogenated Contaminants and Current Use Pesticides in a Marine Food Web from Cumberland Sound (Nunavut)	Gregg Tomy
M-22	Bioaccumulation of Perfluorinated Compounds in the Vegetation-Caribou-Wolf Food Chain	Sharon Katz
M-23	Temporal Trend Studies of the Atmospheric Hg Deposition with Ice-Core/Snow in Canadian High Arctic	Jiancheng (James) Zheng
M-24	Mercury in Caribou Forage	Mary Gamberg
M-25	PCBs in Arctic Ocean Seawater: Addressing a Knowledge Gap in Contaminant Pathways, Processes and Effects	Robie Macdonald
M-26	Environmental Trends Monitoring of Flame Retardants and Pesticides in the Canadian High Arctic via Ice/Snow	Derek Muir

M-27	Improved Screening for New Arctic Contaminants	Wania
M-28	Enhanced investigations of the factors affecting long-term contaminant trends in predatory fish in Great Slave Lake, the Northwest Territories, and Lake Laberge	Evans
M-29	Spatial patterns of contaminants in arctic seabirds	Braune
M-30	Contaminant and energy flow in a low arctic pelagic food web	Braune
M-31	Interspecies sensitivity of arctic marine birds to methylmercury exposure	Braune
M-32	PCB Effects in Black Guillemots in Saglek, Labrador	Burgess
M-33	Influence of climate warming on scavenging of POPs by suspended particulate organic matter in lake waters, as recorded in sediments of Amituk Lake, Cornwallis Island	Outridge
M-34	Marine food web model of an Arctic coastal region - using stable isotopes and fatty acids to model energy transfer and contaminant flow through inshore ecosystems	Reimer

Table 1c, Projects being carried out under the Northern Contaminants Program related to Education and Communications

Project Number	Project Title	Project Leader
C-01	Distribute NCP information to Yukon First Nations Offices and General Assemblies	Cindy Dickson (CYFN)
C-02	Akaitcho Participation in the Northwest Territories Regional Contaminants Committee	Annie Boucher (Akaitcho)
C-03	DehCho Participation in the Northwest Territories Regional Contaminants Committee	Lee Maria Thom (Deh Cho)
C-04	NSMA Participation in the Northwest Territories Regional Contaminants Committee	Sheryl Grieve (NSMA)
C-05	Gwich'in Tribal Council Participation in the Northwest Territories Regional Contaminants Committee	Mardy Semmler (GTC)
C-06	NWTMN Participation in the Northwest Territories Regional Contaminants Committee	NWT Métis Nation
C-07	Sahtu Dene Council Participation in the Northwest Territories Regional Contaminants Committee	Fred Pierrot (Sahtu Dene Council)
C-08	Tli Cho Government Participation in the Northwest Territories Regional Contaminants Committee	Eddie Erasmus (Tli Cho Government)
C-13	Caribou and Moose Contaminant Monitoring Program Training and Capacity Building Workshop	Lorna Skinner (DIAND)
C-14	Building Capacity in Various Frontline Working Groups: Continuing to Meet the Information Needs of Nunatsiavummiut	Mary Denniston (NG)
C-15	International Inuit Contaminant Activities in Support of Global Instruments and Activities	Stephanie Meakin (ICC)
C-16	Communicating Contaminant Information and Northern Research Results to Residents of Inuvialuit Settlement Region	Nellie Cournoyea (IRC)
C-17	Building Capacity Through Education: Development and Delivery of Northern College Module Courses on Contaminants, Wildlife and Health	Shelagh Rowles (Yukon College) Chris Furgal (Trent U)
C-18	Nunatsiavut Inuit Research Advisor	John Lampe (NG)

Table 2. Project being carried out under Canada's IPY program

Project Title	Project Leader
Arctic Freshwater Systems	Environment Canada
Arctic Resiliency and Diversity	Inuit Tapiriit Kanatami with universities and Northern organizations
Arctic Weather and Environmental Prediction Initiative	Gilbert Brunet
Beluga Tagging in the Arctic	Mike Hammill
C3O - Canada's Three Oceans	Eddy Carmack,
The Carbon Cycle in the Canadian Arctic and Sub-Arctic Continental Margin	Charles Gobeil
Carbon, Microbial and Plant Community Dynamics in Low-Arctic Tundra	Suzanne Simard
Changing Forests and Peatlands along the Mackenzie Valley, Northwest Territories	Jagtar Bhatti
The Circumpolar Flaw Lead System Study	David Barber
Climate Change Impacts on Canadian Arctic Tundra	Greg Henry
Climate Variability and Change Effects on Chars in the Arctic	James Reist
Communities in the Changing Arctic	Barry Smit
Constructed Wetlands for Treatment of Wastewater in Arctic Communities	Mark Williamson
Coordinated Effort to Clear Hepatitis Viruses from the Canadian North	Gerald Minuk
Determining the Diet of the Greenland Shark in a Changing Arctic	Aaron Fisk
Dynamic Inuit Societies in Arctic History	Trevor Friesen
Effects of Global Warming on Polar Bears, Seals and Whales	Steven Ferguson
Engaging Communities in the Monitoring of Country Food Safety	Manon Simard
Environmental Change and Traditional Use in the Old Crow Flats in Northern Canada	Shel Graupe
Environmental Change in the High Arctic from Snow and Ice Cores	Jocelyne Bourgeois
Evaluating the Effectiveness of Vaccination against Respiratory Infections for Young Children of the Nunavik Region	Philippe DeWals
How Seabirds Can Help Detect Ecosystem Change in the Arctic	William Montevecchi
Human Papillomavirus (HPV) and Cervical Disease in the Northwest Territories	Judy Niles
Impacts of a Changing Arctic Tree Line	Karen Harper
The Impact of Climate Change on Tundra Wildlife	Gilles Gauthier
The Impacts of Oil and Gas Activity on Peoples in the Arctic	Dawn Bazely
Impacts of Severe Arctic Storms and Climate Change on Coastal Areas	William Perrie
An Integrated Research Program on Arctic Marine Fat and Lipids	Éric Dewailly
Inuit Health Survey: Inuit Health in Transition and Resiliency	Grace Egeland
Inuit History: Climatic Change and Historical Connections in Arctic Canada	Patricia Sutherland
Inuit Sea Ice Use and Occupancy Project	Claudio Aporta
Investigation of the Effect of Climate Change on Nutrient	Roger Francois

and Carbon Cycles in the Arctic Ocean	
Kwaday Dan Ts'inchi Discovery - Expanding our Understanding through Linked Scientific and Community Studies Project	Sheila Greer
Measuring the Impact of Climate Change on Landscape and Water Systems in the High Arctic	Scott Lamoureux
Monitoring the Impacts of Global Change on Caribou and Wild Reindeer and their Link to Human Communities	Don Russell
Northwest Territories Ice Patch Study	Thomas Andrews
Ocean Currents of Arctic Canada	Humfrey Melling
Ocean Production of Trace Gases in the Arctic and their Impact on Climate	Maurice Levasseur
The PEARL near the Pole – Atmospheric Research in the High Arctic	James Drummond
Permafrost Conditions and Climate Change	Antoni Lewkowicz
Polar Ecosystems in Transition: An Interdisciplinary Investigation into the Impacts of Climate Change on Polar Bears	Elizabeth Peacock
Pollutants Travelling in the Air to the Arctic	Hayley Hung
OASIS-CANADA: Understanding Ozone and Mercury in the Air Over the Arctic Ocean	Jan Bottenheim
Variability and Change in the Canadian Cryosphere (Snow and Ice)	Anne Walker

Table 3. Projects being carried out under ArcticNet

Project Title	Project Leader
Permafrost and Climate Change in Northern Coastal Canada	Allard, Michel (Université Laval); Pollard, Wayne (McGill University)
Impact of Climate Change on Arctic Benthos	Archambault, Philippe
The Role of Sea-Ice in ArcticNet IRISes	Barber, David
Freshwater-Marine Coupling in the Hudson Bay IRIS	Barber, David
Analysis of Past Hydro-Climatic Variations in Nunavik	Bégin, Yves
Instability of Coastal Landscapes in Arctic Communities and Regions	Bell, Trevor (Memorial University of Newfoundland); Forbes, Don
Effects of Climate Change on the Canadian Arctic Wildlife	Berteaux, Dominique
The Law and Politics of Canadian Jurisdiction on Arctic Ocean Seabed	Byers, Michael
Population Dynamics of Migratory Caribou in Nunavik/Nunatsiavut	Côté, Steeve
Marine Fatty Acids in a Changing Canadian Arctic	Dewailly, Éric
Multi-Species Tracking of Aquatic Animals in the Canadian Arctic	Dick, Terry
Impacts of Global Warming on Arctic Marine Mammals	Ferguson, Steven
Long-Term Observatories in Canadian Arctic Waters	Gratton, Yves
Impacts of Vegetation Change in the Canadian Arctic: Local and Regional Assessments	Henry, Greg
The Canadian Arctic Seabed: Navigation and Resource Mapping	Hughes Clarke, John
High Arctic hydrological, landscape and ecosystem responses to climate change	Lamoureux, Scott and Lafrenière, Melissa
Development of an Ocean Modeling Capacity for the Canadian Arctic Archipelago	Myers, Paul
Carbon Exchange Dynamics in Coastal and Marine Ecosystems	Papakyriakou, Tim
Growth variability and mercury tissue concentration in anadromous Arctic charr	Power, Michael
Understanding and Responding to the Effects of Climate Change and Modernization in Nunatsiavut	Reimer, Ken (Royal Military College); Biasutti, Marina
Adaptation in a Changing Arctic: Ecosystem Services, Communities and Policy	Smit, Barry
Effects of Climate Change on Contaminant Cycling in the Coastal and Marine Ecosystems	Stern, Gary; Macdonald, Robie and Wang, Feiyue
Coping with Atmospheric-Related Hazards in the Canadian Arctic	Stewart, Ronald
Marine Biological Hotspots: Ecosystem Services and Susceptibility to Climate Change	Tremblay, Jean-Éric
Freshwater Resources of the Eastern Canadian Arctic	Vincent, Warwick
Hydro-ecological responses of Arctic tundra lakes to climate change and landscape perturbation	Wrona, Fred

Annex 1 – Summary of projects conducted under the Northern Contaminants Program

H-01
Monitoring Trends of Human Environmental Contaminants in Nunavut (Qikiqtani Region)

Project leaders: Mary Potyrala (GN) and Janet Brewster (GN)

PLAIN LANGUAGE SUMMARY

The primary aim of this multi-year program (2004-2008) is to provide a second time point in which to monitor temporal trends of maternal exposure to selected environmental contaminants in the Qikiqtani region. Blood and hair have been used as biomarkers. The region was identified as a priority due to its historically high levels of most contaminants of the five regions in NWT and Nunavut that conducted baseline studies between 1994 and 2000. The findings will inform international contaminant monitoring initiatives such as the Global Monitoring Plan under the Stockholm Convention and the 2009 Arctic Monitoring and Assessment Programme (AMAP) Report.

Pregnant Inuit women 36+ weeks gestation were invited to participate in the study. A questionnaire collected demographic information, country food consumption (1 year recall) and other lifestyle factors during pregnancy. Blood samples were analysed for persistent organic pollutants, heavy metals, some emerging contaminants, vitamins and nutrients. Mercury exposure was measured per trimester from collected hair samples.

An extension of four months into 2008-2009 will be required to complete the deliverables. Activities include ensuring that all the communities have been visited to communicate study findings and completion of a plain language summary and final report (with translation).

H-03
Nunavik cohort study on exposure to environmental contaminants and child development

Project leader: Gina Muckle, Centre de recherche du CHUQ, Université Laval

PLAIN LANGUAGE SUMMARY

Prenatal Exposure to PCBs and mercury were associated to growth and developmental effects in children. The Inuit from Nunavik are among the most highly exposed populations to these environmental pollutants due to their bioaccumulation in fish and marine mammals, which are consumed by the Inuit. However, consumption of fish and marine mammals also provides nutrients such as omega-3 fatty acids, which are known to enhance early brain development. We have conducted three studies in Nunavik since the last decade: monitoring of prenatal exposure from cord blood sampling, effect study with infants up to 12 months of age, and effect study at preschool age. The proposed study will follow-up these three cohorts of children at 10 years of age. The aims are to document the long term effects of pre- and postnatal exposure to these contaminants, as well as to new emerging contaminants, and to evaluate if omega-3 fatty acids and selenium can protect against adverse effects. This 5-year study will involve about 300 school age children from the 14 Nunavik communities. The proposed work meets *numerous* NPC blueprint priorities.

H-04

Assessment of contaminant and dietary nutrient interactions in Inuit Health Survey: Nunavut, Nunatsiavut and Inuvialuit

Project leader: Laurie H.M. Chan, BC Leadership Chair in Aboriginal Environmental Health

PLAIN LANGUAGE SUMMARY

The proposal responds to the NCP Blueprint for Human Health priorities related to epidemiologic research which seeks to incorporate contaminants research within broader health research studies rather than fund stand alone contaminants projects. The Inuit Health Survey is a major study that will provide a snapshot and baseline data on the health status of Inuit People across the North for the first time. In 2008-2009 we are planning to expand the project to include communities in Kitikmeot region of Nunavut and Inuvialuit and possibly Nunatsiavut. The Inuit Health Survey has obtained partial funding from the Canadian Institute for Health Research ($1.5 million over 5 years), and from Government of Canada Program for International Polar Year (IPY) (tentatively $6 million over 5 years pending final approval). We seek funding support to measure the amount of environmental contaminants in the bodies of the participants, the risks and benefits associated with the traditional food diet and the relationship between contaminants and health outcomes of the participants. A planning grant was obtained two years ago to plan for the Nunavut portion of the study that took place in 2007. Survey and sample collection was conducted in Nunavut on board of the Coast Guard research vessel Amundsen in 2007, while consultation and planning for the 2008-2009 study in Inuvialuit and Nunatsiavut also took place. This is a participatory research with full partnership with the Inuit organizations and the regional health departments. All necessary measures will be undertaken to increase the capacity of the communities and local health professionals. The key research question is “How do the diets and contaminants affect the health of the Inuit?” Results of the study will provide useful information to assist health professionals and policy makers at the territorial, national and international levels in developing environmental health policies and aid Inuit in making informed dietary choices.

H-05
Contaminant Nutrient Interaction Issues as part of a Public Health Intervention Study of Inuit Children in Nunavik: Third year of data collection

Project leader: Huguette Turgeon-O'Brien, Université Laval

PLAIN LANGUAGE SUMMARY

The present study has been conducted since 2006 within the framework of the Nutrition Program in Child Care Centres of Nunavik which aims to provide preschool children healthy meals containing country/traditional foods, selected market foods and high bioavailable iron. The objectives of this study are (1) to document the contaminant-nutrient interaction issues and (2) to implement a verification process using biomarkers, dietary intakes and clinical information. The following environmental contaminants will be measured twice at one year interval in the same child: total Hg, Pb, selenium, PCBs-pesticides-toxaphens, PFOS-PFOA-PFHxS. It is the first time in the Arctic population, that the contaminant-nutrient interaction is evaluated twice in the same child. The study of temporal variation in levels of contaminants in children is of utmost interest because children's vulnerability to toxic substances increases due to their immature physiology and metabolic processes and often poor nutritional status. It is also a unique opportunity to verify the impact of traditional and market foods on blood levels of contaminants and nutrients. However, in order to determine the contribution of dietary intakes to toxic metal contamination, it is essential to study confounding variables such as the iron, vitamin A, and antioxidants status of the children. Also, vitamin D deficiency may increase metals induced oxidative injuries through a decrease in glutathione levels. Although vitamin D deficiency is common among northern people, very little is known about Nunavik children. For Nunavimmiut parents and authorities, this study will provide clearer information about the use of country foods among preschool children.

H-06
Contaminant exposure and emergence of cardio-vascular diseases in Inuit

Project leader: Éric Dewailly, Centre Hospitalier Universitaire de Québec (CHUQ) and Québec National Institute of Public Health

PLAIN LANGUAGE SUMMARY

Some preliminary data suggests that the cardiovascular system should be considered a potential target for Arctic contaminants. For example, work conducted in the Faeroe Islands in children and in Greenland suggests association between mercury exposure and blood pressure and heart variability which are known risk factors for cardiac health.
Other studies conducted elsewhere suggest association between mercury and heart diseases and between POPs and diabetes. These health conditions are rising in the Arctic and our hypothesis is that this rise is not only due to a changing life style but also to contaminant exposure. This project aims at investigating associations between exposure to Hg and POPs on the emergence of heart diseases and related risk factors using the 3 large epidemiologic studies conducted among adults and children in Nunavik since 1992. Since heart diseases represent the most important causes of death, even a slight negative impact on the cardiovascular system could be of greater public health relevance than any other health effects related to contaminant exposure.

M-01
NORTHERN CONTAMINANTS AIR MONITORING: ORGANIC POLLUTANT MEASUREMENTS

Project leader: Hayley Hung, Environment Canada

PLAIN LANGUAGE SUMMARY

The atmosphere is the main pathway for organochlorine contaminants to enter Arctic ecosystems. This project involves the measurement of these contaminants in Arctic air. It is part of a continuing monitoring program started in 1992. The measurement of amounts and types of contaminants involves collecting large volumes of air through filters. The filter samples are then analyzed in a laboratory. Results from this continuing project are used to negotiate international control agreement and to test atmospheric models that explain the transport of contaminants from sources in the South to the Arctic. In this phase of the project, measurements will continue at the baseline site of Alert, Nunavut. During the International Polar Year (IPY) (2007-2009), monitoring data from Alert will be fed into major IPY programs for studying contaminant transport, distribution and input into the Arctic environment. This information is invaluable due to the long-term monitoring history at this location which can be used as a reference for background levels and contaminant transport history in the Arctic. Starting in Dec 2005, we have extended the program to screen for emerging chemicals, such as current-use pesticides, brominated and organophosphate flame retardants and perfluorinated compounds in Arctic air and we would like to continue this effort in the coming fiscal year. In addition, a newly-developed passive air sampler specifically designed for use in cold environments has been deployed at Alert since Oct 2007. This new equipment will continue to be tested at Alert in FY08/09. Contaminant air concentrations measured using this passive air sampler will be compared with those generated from the long-term monitoring program. The purpose is to test the use of this new passive air sampler for its performance under Arctic conditions in preparation for its use in the future to supplement the baseline air monitoring program.

M-02
AIR MEASUREMENTS OF MERCURY AT ALERT AND LITTLE FOX LAKE

Project leader: A. Steffen, Environment Canada

PLAIN LANGUAGE SUMMARY

Mercury (Hg) is a contaminant found at elevated levels in the tissues of aquatic animals in the Arctic. The goal of this study is to continue measuring the levels of Hg in the Arctic air from Alert, Nunavut and Little Fox Lake, Yukon, to determine whether these levels change with time and from where Hg is transported into the Arctic. As well, this study aims to understand what role the atmosphere plays in how Hg gets into the Arctic ecosystem. Mercury is found in the air as a gas or is attached to airborne particles. Globally, gaseous elemental mercury stays in the air for a long time but mercury found on particles and other forms of mercury can quickly fall onto the snow/ice surfaces. Once it falls, this mercury may enter the food chain. This study will provide data to assess how much mercury is in and brought into the Arctic air and how much falls onto the snow surfaces. This information supports national and international control initiatives and IPY activities. The information generated from this study will contribute to understanding the impact that climate change will have on mercury contamination in the Arctic ecosystem and ultimately its effect on human health.

M-03
Contributing to International Action on POPs and Mercury: Further applications of global mass balance models

Project leader: Donald Mackay, DMER Ltd.

PLAIN LANGUAGE SUMMARY

There is now worldwide acceptance that contamination of the Arctic ecosystem is largely a result of long-range transport (mainly in the atmosphere but also by ocean currents) of chemical substances from the temperate industrial and agricultural regions of the northern hemisphere. An inevitable consequence of this contamination is exposure of the resident population to these substances through diet, air and water. The only feasible approach for reducing levels of these contaminants in the Arctic ecosystem in general and human foods in particular, is to reduce emissions from all global sources and allow global and Arctic levels to fall by natural removal processes. Negotiations to encourage such reductions on an international scale require that foreign governments be convinced that they are one of the sources of these substances and that they must act to reduce or eliminate sources. To justify these actions requires information such as:

• What are the sources of these contaminants?
• From which countries do they originate and in what quantities?
• Are sources increasing or decreasing?
• How are they transported?
• Are there new substances of concern for which controls should now be considered or implemented?
• How long will it take for reductions to become effective?

The objective of this proposal is to contribute to answering to these questions by computer modelling of long range transport based on sound science thereby enhancing Canada's ability to influence international negotiations and agreements. We believe that the combination of NCP and other Northern monitoring programs with modelling is the optimal strategy for convincing international governments and agencies of the need to control sources and thus reduce contamination of Canada's North.

In this 2008 proposal, we will continue to evaluate contaminant levels in different parts of the Arctic, improve evaluations of existing contaminants such as PCBs, mercury, organo-fluorines and hexachlorocyclohexanes, search systematically for "new" or "emerging" contaminants and devise a synoptic indicator of ecosystem contamination. These emphases are largely in response to directions suggested at the Annual NCP Results Workshops held in Victoria, BC in 2006 and in Lake Louise in 2007.

Building on previous work accomplished under NCP contracts, we intend to cooperate fully with those responsible for monitoring the air, biota and foods of the North by conventional and passive sampling techniques, thus adding a complementary modelling element to the monitoring programs. The work will be done at the Canadian Environmental Modelling Centre (CEMC) at Trent University in collaboration with DMER Ltd.

M-04
Temporal trends of persistent organic pollutants and metals in ringed seals from the Canadian Arctic

Project leaders: Derek Muir (Environment Canada), Michael Kwan (Nunavik Research Centre), and Marlene Evans (Environment Canada)

PLAIN LANGUAGE SUMMARY

The objective of this project is to determine changes in concentrations of legacy contaminants, such as PCBs and other persistent organic pollutants (POPs), and mercury, as well as new contaminants, in ringed seals. This project builds on previous work led by our team which collected ringed seal samples with help of the HTAs in 15 communities (Arctic Bay, Arviat, Gjoa Haven, Grise Fiord, Kangiqsujuaq, Kangiqsualujjuaq, Holman, Inukjuaq, Mittimatalik (Pond Inlet), Makkovik, Nain, Pangnirtung, Quaqtaq, Resolute, Sachs Harbour) between 1998 and 2007. Annual sampling is being carried out at Sachs Harbour, Resolute and Arviat. Sampling on a 5 year cycle is continuing at 10 other communities (2 per year); this year (2008) at Gjoa Haven and Ausuittuq (Grise Fiord). Thus over the 5 year period, contaminant trends will be extended for POPs and for mercury at 13 communities altogether. We use samples of blubber of female seals to study trends in concentrations of POPs and liver and kidney of male and female seals to examine trends in mercury and other heavy metals as well as fluorinated chemicals. Muscle samples are analysed for stable isotopes of carbon and nitrogen to assess seal diets and is also archived for possible future dietary contaminant studies. As legacy chemicals, such as PCBs and DDT, continue to decline in most locations, we are focussing increasingly on new classes of chemicals which we have shown are increasing rapidly in the Arctic particularly brominated flame retardants and fluorinated stain repellents. Mercury shows much more year to year variation. Mercury concentrations have increased at Holman and Sachs Harbour since the mid-1990s. However at most eastern Arctic locations they have remained relatively constant or declined over the same period. All sampling is being done with the help of HTAs in each community who are supplied with sampling kits and instructions. Hunters are paid for each animal collected and HTAs receive funding to cover coordination and administrative costs. The work at two communities, Sachs Harbour and Arviat, is coordinated with DFO marine mammal scientists, Lois Harwood and Steve Ferguson.

M-05
Temporal and spatial trends of legacy and emerging organic and metal contaminants in Canadian polar bears

Project leader: Robert Letcher, Environment Canada and Carleton University

PLAIN LANGUAGE SUMMARY

The polar bear (*Ursus maritimus*) is the apex predator of the Arctic marine ecosystem and an integral component of Inuit culture. Due to its position at the top of the marine food web, levels of persistent organic pollutant (POP) and metal contaminants in polar bears are among the highest observed in the Arctic. The last circumpolar spatial/temporal trends assessment of contaminants in polar bears (from populations spanning the western hemispheric Arctic in Alaska, Canada, Greenland and Svalbard (Norway)) was based on tissue samples collected in 2000-2001, and reported on the trends of legacy POPs (PCBs, OC pesticides and methyl sulfonyl-PCB metabolites ($MeSO_2$-PCBs)) and metals (e.g., Hg, Se, Rb, Sr, Ba and Mn).

However, several novel and emerging classes and congeners of POPs of environmental concern were also identified for the first time in polar bear, e.g., the brominated flame retardants (BFRs) polybrominated diphenyl ethers (PBDEs) and hexabromocyclododecanes (HBCDs), perfluoroalkyl compounds (PFCs; e.g., perfluorooctane sulfonates (PFOS)) and several hydroxylated (OH) brominated and chlorinated compounds. Until these 2001-2002 studies there was no or minimal published data on spatial and temporal trends of any BFR or PFC contaminants in polar bears, a core NCP monitoring species. There is currently no

geographically-specific, temporal trends information for any BFR or PFC in polar bears from circumpolar populations (except Baffin Bay and East Greenland).
In the present, ongoing study, liver, fat and muscle tissue samples were collected from bears harvested in late winter/early spring 2007/2008 from locations encompassed within the seven Canadian polar bear management zones. Although not a mandate of NCP directly, similar bear sample sets were also collected and obtained from East Greenland, Svalbard and Alaskan zones. The bear samples collected attempted to adhere as closely as possible to an optimal study design, although sampling was dependent on the bears hunted as part of community harvests, as a result of opportunism in the field, and within the collection quotas permissible for each community. If at all possible, the collected bears adhered to the design to minimize age, reproductive and nutritional variation and thus minimize the effects of these parameters on contaminants, e.g., the bears were adult females between the ages of 5 and 15, and from bear harvests in the late winter/early spring and nearing the end of the hyperphagic period.
Expected results include the first circumpolar temporal trend and spatial change assessments in polar bears for emerging POPs such as PBDEs, HBCDs and PFCs in fat or liver tissue. Sample have been obtained for stable carbon and nitrogen isotopes (SIs; muscle) and a profile of fatty acids (FAs; fat) to be used as ecological tracers of trophic level and diet, respectively, and will be used to assess variations in the ringed seal-polar bear dietary relationships as a function of populations, which may be a variable affecting contaminant trend data.

M-06
Time-trend studies on new and emerging persistent halogenated compounds in beluga from Hendrickson Island and Pangnirtung

Project leader: Gregg Tomy, Department of Fisheries and Oceans (DFO)

PLAIN LANGUAGE SUMMARY

This project attempts to answer the question: are ‘new’ contaminants that have only recently been detected in Arctic animals increasing or decreasing in beluga from Hendrickson Island and Pangnirtung? These animals were selected for this study because (i) they represent an important part of the traditional diet of northern people and, (ii) we have a large time window in which animals were collected from Hendrickson Island. Findings from this study will be delivered to the NWT and Nunavut Contaminants committees and working in partnership with them will develop communication material appropriate from each communities. During the course of the study, we will communicate our findings to the NWTECC and work closely with the representative from the Inuvialuit game council and ITK to develop community communication material on contaminants levels in the beluga from Hendrickson Island. We will take directions from the IGC and the NWTECC on how, what, and when to verbally communicate our findings to the community. A PowerPoint presentation will be prepared that describes, very simply and clearly, the results of our research. A plain language summary of the results generated will also be made available to the communities if advised to do so.

M-07 Temporal trends of heavy metals and halogenated organic compounds in Arctic marine mammals (beluga, narwhal and walrus)

Project leader: Gary A. Stern, Department of Fisheries and Oceans (DFO)

PLAIN LANGUAGE SUMMARY

The objectives of this project are to maintain current data on contaminant levels in marine mammals and to continue to assess the temporal trends of bioaccumulating substances such as heavy metals and halogenated organic compounds (HOCs). This will allow us to determine whether contaminant levels in the marine mammals, and hence exposure to Arctic people who traditionally consume them, are changing with time. These results will also help to test the effectiveness of international controls and, in conjunction with projects such as CASES (Canadian Arctic Shelf Exchange Study) and ArcticNet, to understand the effects that climate variation may have on these contaminant levels. Climate variation has been attributed to observed changes to atmospheric sea-level pressure, wind fields, sea-ice drift, ice cover length of melt season, precipitation patterns, hydrology and ocean currents and water mass distribution. It is almost certain that these primary changes have altered the carbon cycle, trophic relationships between species, and biological systems but the difficulty of observing these changes together with existing irregular, incomplete time series measurements makes it exceedingly difficult to discern what these changes have been (Macdonald 2005). Because contaminants enter global systems and transport through the air and water, the changes listed above will clearly alter contaminants pathways and ultimately the levels observed in the Arctic marine ecosystem.

M-08
Temporal Trends of Contaminants in Arctic Seabird Eggs

Project leader: Birgit Braune, Environment Canada

PLAIN LANGUAGE SUMMARY

Contaminants have been monitored in arctic seabird eggs collected from Prince Leopold Island in the Canadian High Arctic since 1975. Those data have shown declines in most of the legacy organochlorines (e.g. PCBs, DDT) as well as dioxins and furans. Contaminants such as hexachlorocyclohexanes (i.e. β-HCH) and mercury, however, have been increasing, as have some of the newer chemicals such as the brominated flame retardants (BFRs) and perfluorinated compounds (PFCs). In order to examine inter-year variation in the temporal trend data series, we have proposed to collect eggs from each of two species of seabirds (northern fulmar, thick-billed murre) from Prince Leopold Island annually for five years starting in 2005. As well, for comparative purposes, we are also making annual collections of thick-billed murre eggs from Coats Island in northern Hudson Bay (our Low Arctic monitoring colony since 1993) in parallel with the High Arctic collections. As part of the core seabird egg monitoring program, eggs are collected from five species of seabirds (including murres & fulmars) from Prince Leopold Island every five years. The next major monitoring year in the five-year cycle is 2008.

M-09
Temporal trends and spatial variations in persistent organic pollutants and metals in sea-run char from the Canadian Arctic

Project leader: Marlene S. Evans, Environment Canada

PLAIN LANGUAGE SUMMARY

Our study is measuring contaminant levels in sea-run Arctic char as they return from feeding in the ocean for two reasons. First, we want to provide Inuit communities with needed information on contaminant levels in the char that they consume just as other scientists are providing them with information on seal, beluga, and walrus. Second, we want to find out if contaminant levels are changing in Arctic animals and, if so why.
The main focus of our study is to find out if contaminant levels are changing in sea-run char with long-term sampling planned for four sites. These sites are in different parts of the Arctic and may be experiencing different changes in conditions with global warming. These long-term sites are Paulatuk (a warming trend may be occurring here), Cambridge Bay (which has some of the oldest contaminant data in char), Pond Inlet (the most northerly location and also with some good older data) and Nain (in the previous global warming period, this area actually got colder). We also are sampling other communities less frequently to find out how much contaminant concentrations differ from community to community. In 2008, we plan to sample Clyde River and Puvirnituq.
All fish will be collected by community members from areas where they do most of their fishing. Length, age, weight, lipid (fat) content, and sex will be determined for each fish along with stable isotope measures of feeding. These data are proving to be very valuable in investigating why contaminant levels are or are not changing in fish over time. We also are making note of parasites on the fish, whether they seem skinny, discolorations in the liver, etc. as measures of fish health. We will focus our studies on organic contaminants such as PCBs, DDT, and toxaphene and on mercury, but also will obtain information on a broad suite of 31 other metals and on new compounds of interest such as brominated flame retardants (BFRs) and perfluorinated alkyl acids (PFAs).
We plan to visit some communities in summer 2008 to explain the study, collect or arrange for sample collections, and explain previous contaminant results in char and marine mammals. Other communities will be visited by our collaborators. Study results will be communicated back to the communities in 2009.

M-10
Temporal trends of Persistent Organic Pollutants and Mercury in Landlocked char in the High Arctic

Project leaders: Derek Muir (Environment Canada)**,** Günter Köck (Austrian Academy of Sciences) and Klaus Gantner (University of Guelph)

PLAIN LANGUAGE SUMMARY

This purpose of this project is to investigate changes in concentrations of contaminants over time in landlocked Arctic char from lakes in Nunavut. Our approach is to measure concentrations of pollutants such as persistent organic pollutants (POPs) and mercury in the fish each year to see if levels are decreasing or increasing. The project began in 1999 by studying Char and Resolute Lakes because samples had been previously collected from both lakes in 1993. Since then we have continued to sample Resolute Lake each year and have added Amituk Lake, and Hazen Lake in northern Ellesmere Island which were originally sampled in the early 1990s. All of the fish collected so far have been analysed for mercury and other metals. A smaller number have been analysed for PCBs and other persistent organic pollutants (POPs). Levels of mercury in the fish are relatively low in Resolute Lake compared to some of the other lakes in the area. Mercury concentrations have increased in Arctic char from Amituk, Char and Resolute lakes, however, the increases are statistically significant only in Amituk Lake. Mercury concentrations most char from Char Lake and Amituk Lake are above guidelines for human consumption. PCBs and other POPs have

declined overall in all four study lakes over the period 1992/93 to 2007. We have also found that concentrations of brominated flame retardants (BFRs) are increased in char in Resolute and Amituk Lake until about 2005 but are now declining. For 2008-09 we plan to continue annual sampling of Amituk, Hazen,and Resolute lakes and propose to continue at least through 2011 as suggested by the NCP Blueprint. We will analyse samples for mercury and POPs (PCBs, chlorinated pesticides such as DDT as well as BFRs. Sampling will be carried out by hand methods or gill netting. The fishing effort on the lakes near Resolute will utilize the traditional knowledge of local people in the community. Results of the project will be reported to the Hamlet council of the HTA of Resolute Bay in 2008.

M-11

Spatial and long-term trends in persistent organic contaminants and metals in lake trout and burbot from the Northwest Territories

Project leaders: Marlene S. Evans (Environment Canada) and Derek Muir (Environment Canada)

PLAIN LANGUAGE SUMMARY

Our study is continuing to investigate whether contaminant levels are changing in fish in the Northwest Territories with a focus on Great Slave Lake which we have been studying since the early 1990s. We have been looking at lake trout in the West Basin (near Hay River) and East Arm (near Lutsel K'e) since 1993 and propose to continue this research monitoring in 2008. We are looking at lake trout in the West Basin because it receives contaminants from the Slave River, in addition to the air, and because fish grow faster here. In contrast, the East Arm receives most of its contaminants from the air and fish grow slower because the Slave River influence is weaker and the fish are not harvested as much as in the West Basin. As in previous years, lake trout would be collected at Lutsel K'e (East Arm) and from the commercial fisheries at Hay River (West Basin).

We also propose to continue our monitoring of contaminant levels in burbot caught near Fort Resolution in the West Basin near the Slave River inflow. Lake trout are uncommon near Fort Resolution and so burbot is a good fish to monitor for this community. Burbot liver is commonly consumed and, because it is fatty, can be high in organic contaminants. We have been looking at burbot at Fort Resolution since 1993. Burbot sampling at Lutsel K'e was discontinued after 2004, because burbot are rare in this area of the lake.

The NCP also calls for 1-2 additional lakes to be sampled on a five-year cycle in the Northwest Territories with a focus on mercury concentrations in lake trout. We propose to investigate lake trout in Trout Lake and Stark Lake in 2008. We sampled both lakes in 2003, in part because of community concerns with skinny fish. Lake trout from Trout Lake have been measured for mercury concentrations in 1977, 1982, 1990, and 1991.

With the exception of lake trout from the commercial fishery, all fish will be collected by community members. Length, age, weight, lipid (fat) content, and sex will be determined for each fish along with stable isotope measures of feeding. These data are proving to be very valuable in investigating why contaminant levels are or are not changing in fish over time. We also will measure liver weight, gonad weight, and will make note of any abnormalities, e.g., liver colour, parasites, skinny fish, etc.

M-12

Temporal trend studies of trace metals and halogenated organic contaminants (HOCs), including new and emerging persistent compounds, in Mackenzie River burbot, Fort Good Hope, NWT

Project leaders: Gary Stern (DFO) and Gregg Tomy (DFO)

PLAIN LANGUAGE SUMMARY

The objective of this project is to maintain current data on contaminants levels in Mackenzie River burbot and to continue to assess the temporal trends of bioaccumulating substances such as trace metals (e.g. mercury, selenium, arsenic, lead and cadmium), organochlorine contaminants (e.g. PCBs, DDT, toxaphene and selected current use chemicals such as brominated flame retardants (e.g. PBDEs, HBCDD), and fluorinated organic compounds (e.g. PFOS and it's precursors) so as to determine whether the levels of these contaminants in fish (health of the fish stock) and thus exposure to people living in Arctic communities who consume them as part of their traditional diet, are increasing or decreasing with time. These results will also help to test the effectiveness of international controls.

M-13
Long term trends of halogenated organic contaminants and metals in lake trout from two Yukon Lakes; Kasawa and Laberge

Project leaders: Gary Stern (DFO), Gregg Tomy (DFO) and Cindy Dixon (Council of Yukon First Nations)

PLAIN LANGUAGE SUMMARY

The objective of this project is to maintain current data on contaminants levels in lake trout from two Yukon lakes (Laberge and Kusawa) to continue to assess the temporal trends of bioaccumulating substances such as trace metals (e.g. mercury, selenium, arsenic), organochlorine contaminants (e.g. PCBs, DDT, toxaphene), selected current use chemicals such as brominated flame retardants (e.g. PBDEs, HBCDD), and fluorinated organic compounds (e.g. PFOS and it's precursors) so as to determine whether the levels of these contaminants in fish (health of the fish stock) and thus exposure to people who consume them are increasing or decreasing with time. These results will also help to test the effectiveness of international controls.

M-14
Arctic Caribou and Moose Contaminant Monitoring Program

Project leaders: Mary Gamberg (Gamberg Consulting), Lorna Skinner (INAC), Mitch Campbell (Government of Nunavut) and Mary Denniston (Nunatsiavut Government)

PLAIN LANGUAGE SUMMARY

The objective of this project is to determine contaminant levels in caribou and moose in the Canadian Arctic to determine if the animal populations remain healthy (in terms of contaminant loads), whether these important resources remain safe and healthy food choices for northerners and to see if contaminant levels are changing over time. Monitoring populations across the Arctic will also give scientists a better understanding of how contaminants get to the Arctic, and how they behave in different parts of the Arctic. Studies in the Yukon have found that cadmium levels in moose and caribou liver and kidney, and mercury in caribou kidneys are higher than in some other parts of Canada, and higher than in domesticated animals grown for food consumption. This has prompted a health advisory from Yukon Health, based on a health assessment from Health Canada. Although a CINE study confirmed that traditional foods are safe to eat, they did recommend that a trend-

monitoring program be established to ensure that the levels are not rising from local or international inputs and that new contaminants be addressed as they arise.
Two caribou herds, the Porcupine (YT) and the Qamanirjuaq (NU) herds, will be sampled each year while five caribou herds and two moose populations will be sampled every five years. This year, in addition to the annual sampling, Yukon moose will be sampled and samples collected from the Beverly Herd (NWT) in 2007/8 will be analyzed.
In the Yukon, the moose and Porcupine caribou will be sampled as part of an on-going Hunter Survey conducted in cooperation with Environment Yukon, in which local hunters donate tissue samples from their moose and caribou. In Nunavut, the Qamanirjuaq Caribou herds will be sampled as part of the traditional fall harvest in cooperation with the Department of the Environment, Government of Nunavut.
Results of this project will be communicated to each Regional Contaminants Committee in the form of a year-end report, including a plain-language summary and will be presented at NCP symposia annually. All data will be incorporated into the existing database for Canadian Arctic moose and caribou contaminants, currently maintained by INAC, Whitehorse. Plain language summaries, brochures and/or posters focussing on individual herds/populations will be prepared and circulated to stakeholder groups in cooperation with each Regional Contaminants Committee. Results will be made available via the Internet where appropriate. Special presentations may be made as the results dictate, or upon request, in cooperation with the Regional Contaminants Committees

M-15
Effects of contaminants on Glaucous Gull nestlings in the Canadian Arctic

Project leader: Mark Wayland, Environment Canada

PLAIN LANGUAGE SUMMARY

The purpose of this study is to determine whether various contaminants of concern in the arctic pose a risk to the health and fitness of arctic wildlife. The Glaucous Gull was chosen as an indicator species because of the relatively high levels of certain contaminants known to occur in this species. The study approach is to measure contaminant levels and various aspects of health and fitness in 3-4 week old glaucous gull chicks at two locations in Nunavut: a high-arctic marine site and a low-arctic terrestrial site. The former site is located between Ellesmere and Devon Islands. The latter site is located in the Queen Maud Gulf Bird Sanctuary. Field work began in 2004 and was completed in 2007. We have been measuring contaminant levels, body condition, immune competence, stress response, oxidative stress and hormone levels in individual birds. Also, we have examined selected organs for evidence of damage that could be linked to contaminants. Chemical and some biological analyses have been completed or are currently being done on samples from 60 birds. Immune function tests and stress response tests have been done on samples from 33 birds to date. If NCP funds this project, we will complete chemical and biological testing of samples collected in 2007 from 20 birds at the terrestrial Queen Maud Gulf study site. Data analysis and report writing will be done after sample analysis has been completed. Attempts were made to hire Aboriginal people or other northerners to assist with field work from 2004-2006. However, these attempts were unsuccessful.

M-16
Source apportionment of mercury in Davis Strait beluga

Project leader: Peter Outridge, University of Heidelberg

PLAIN LANGUAGE SUMMARY

It is well established that current mercury (Hg) levels in some traditional Arctic country foods such as seals and beluga are very high. But how much higher are levels in country foods now compared to the 19th Century or earlier, before pollution was wide-spread? The answer to this question is of interest to northern communities who rely on these foods, as well as to policy makers considering how much Hg pollution would need to be reduced to return biological Hg to its natural background level.

This project will add to the small literature on this subject, by determining the long-term Hg trend in the beluga population in Davis Strait, Nunavut, using an established approach involving historical and modern teeth. We will also analyse recent decadal change (from 1985 onwards) in tooth Hg in the separate Cumberland Sound (Baffin Island) stock, to compare with the Davis Strait animals. Teeth preserve well over long periods of time, and changes of Hg concentrations in beluga teeth over time are known to correlate strongly to those in meat and muktuk. Davis Strait beluga comprise a shared stock which is harvested by hunters in both Nunavut and Greenland. The historical samples we will use were collected in the 1850s to 1870s on the west coast of Greenland and since then stored in Danish museums. Modern collections in Greenland and Canada started 2 decades ago, and we will use teeth from the 1980s, 1990s and 2005 to determine modern Hg levels and recent changes. To properly interpret Hg changes over time, we will measure the animals' ages and their average feeding habits, which also can be determined from teeth. Finally, we will calculate average Hg levels in meat and muktuk from Davis Strait beluga in the 19th Century, to show how Hg concentrations in these foods have changed over the long-term. The results will be communicated to Inuit organizations, and science assessment groups such as NCP and AMAP.

M-18

Atmospheric Deposition and Release of Methylmercury in Glacially-fed Catchements of Auyuittuq Park, Baffin Island

Project leader: Christian Zdanowicz, University of Ottawa

PLAIN LANGUAGE SUMMARY

Mercury (Hg) is one of the significant contaminants of concern in the Arctic food chain. It is particularly toxic in the bioavailable form of monomethylmercury (MMHg) and can cause serious neurological damage in animals and humans alike. Hg is transported to the Arctic as elemental mercury (Hgo) but prior to deposition must be oxidized to Hg2+. This has been shown to be especially important at polar sunrise and at other times of the year with exposure to solar ultraviolet radiation. Oxidized mercury (Hg2+) is thought to be converted by microbes such as the sulfate reducing bacteria to MMHg to enter the food chain. In the cold Arctic climate this process is likely rate limited by temperature but as climate warms conversion rates are expected to increase. We have found an alternative source of MMHg that comes directly from deposition from the atmosphere into snow which is subsequently released during snow melt and runoff. We propose to evaluate the atmospheric deposition, storage and/or release of inorganic and organic Hg (including MMHg) in a glacierized catchment in Auyuittuq National Park on southern Baffin Island. Field sampling will take place in late winter and spring-summer 2008. The project will complement an International Polar Year (IPY) initiative that seeks to identify deposition trends of contaminants in space and time across the Arctic. This proposal will quantify present and past deposition rates for both total Hg (HgT) and MMHg to the study catchment as well as subsequent runoff to

Arctic aquatic and coastal marine ecosystems. In addition, experiments will be conducted to anticipate the effects of climate warming on the cycling of MMHg between the atmosphere, snow and surface waters.

M-20
Characterizing contaminant-related health effects in Beluga whales (*Delphinapterus leucas*) from the western Canadian Arctic

Project leaders: Peter S. Ross (DFO), Lisa Loseto (University of Victoria), Robie W. Macdonald (DFO), Gregg Tomy (DFO) and Steve Ferguson (DFO)

PLAIN LANGUAGE SUMMARY

While many persistent and bioaccumulative contaminants are toxic, little is known about contaminant-related health effects in Arctic biota. Moderate to relatively high levels of several classes of contaminants have been observed in high trophic level marine mammals including Beluga whales (*Delphinapterus leucas*), raising concerns about possible consequences for their health. A weight of evidence from laboratory, captive feeding and field studies suggests that many Persistent Organic Pollutants (POPs) and related compounds disrupt endocrine processes, and lead to reproductive impairment, reduced immunocompetence, increased susceptibility to disease, and altered growth and development. These health effects may have population level impacts, including decreased growth, increased rates of mortality, and decreased reproductive output. While the consequences of exposure of Artic beluga whales to many environmental contaminants are presently unclear, high levels of some POPs in their tissues and the emergence of some new (unregulated) chemicals in their food webs bear scientific scrutiny. A changing climate and ice regime may have dramatic impacts on contaminant pathways, food web productivity, and beluga feeding ecology, the results of which may signal profound consequences for beluga population health.

We propose to build on a pilot study that we carried out in 2007-08 with a two-year project (2008-10), in order to characterize beluga whale health in the context of contaminants and condition. Major elements of this study include:

- sample up to 20 beluga whales per year in the western Canadian Arctic in collaboration with a subsistence hunt;

- develop new tools to qualitatively (gene array) and quantitatively (measure the specific gene expression of up to 20 hormone receptors) assess the health of beluga;

- measure hormone levels in beluga blood serum and in blubber to assess possible contaminant-related endocrine disruption;

- measure nutrition endpoints including lipids, lipid classes, lipid peroxidation, fatty acid signatures and stable isotopes of specific fatty acids;

- analyse beluga tissues for mercury (Hg), legacy POPs, emerging contaminants, and contaminant metabolites as a foundation for the interpretation of complementary health measurements, modelling efforts and risk characterization;

- evaluate contaminant levels in the context of levels observed in prey, tissue residue guidelines available from multiple international agencies, individual and population-

based models, and health endpoints as measured through genomic tools and condition measures;

- conduct a carefully controlled series of mercury (Hg) toxicity experiments using blood and tissues obtained from traditionally-harvested and captive (Vancouver Aquarium) belugas.

Beluga may be viewed as 'sentinels' of Arctic food web contamination and Arctic ecosystem health. Contaminants in beluga prey or their tissues may compromise their condition and reduce the size of their population, with implications for stock assessment and resource management. In addition, contaminant-related health effects in beluga may signal an emerging health concern for humans that rely on country foods. By documenting the relationship between contaminant exposure and health effects in beluga, this project will provide local, national and international managers and regulators with some of the information needed to make wise decisions about the use of different types of chemicals. If we are able to use such information to protect beluga whales from toxic contaminants, then we will be helping to protect the Arctic food web for all consumers, including humans.

M-21
Trophodynamics of new and emerging halogenated contaminants and current use pesticides in a marine food web from Cumberland Sound (Nunavut)

Project leaders: Gregg Tomy (DFO), Steve Ferguson (DFO), Aaron Fisk (Great Lakes Institute for Environmental Research), Derek Muir (Environment Canada) and Dr. Chris Marvin (Environment Canada)

PLAIN LANGUAGE SUMMARY

This project focuses on understanding the critical initial processes involved in bioaccumulation and transfer of new and emerging halogenated contaminants and current use pesticides in an eastern Arctic marine food web from Cumberland Sound (Nunavut). Particular emphasis will be placed on understanding the trophodynamics of target compounds in the lower food web because bioaccumulative processes occurring at this level tend to drive contaminant concentrations at higher trophic levels. Stable isotopes (δ^{15}N and δ^{13}C) and fatty acid analyses will be done to help construct the relative trophic status of biota. We will use archived samples of phytoplankton, zooplankton and marine mammals recently collected (2007) from this region. Water, sediment samples and fish will be collected in the summer of 2008 as part of an International Polar Year (IPY) project. The work described in this project will be carried out at DFO, GLIER and EC which has the necessary personnel and equipment to successfully complete the work. Information generated from this study will be of significant value to northerners whose cultural lifestyle depends on subsistence foods.

M-22
Bioaccumulation of Perfluorinated Compounds in the Vegetation-Caribou-Wolf Food Chain

Project leaders: Sharon Katz (Aurora Research Institute), Mary Gamberg (Gamberg Consulting) and Derek Muir (Environment Canada)

PLAIN LANGUAGE SUMMARY

This project aims to look at bio-accumulation of contaminants in a northern food-chain: vegetation - caribou - wolves. The contaminants in question are perfluorinated compounds. These compounds are emerging contaminants of concern in the Arctic, and they have been found in relatively high concentrations in caribou from the Canadian north. However, information is lacking as to the degree to which they bioaccumulate in food-webs. The vegetation – caribou – wolf chain is a good model to test bioaccumulation, thanks to its simplicity; it is linear (a chain rather then a web), and is well- separated in food (trophic) levels.
Caribou foods, i.e. plants and lichens will be sampled in the range of the Porcupine caribou herd in north-west Northwest Territories, and Yukon. Caribou samples will be provided from an ongoing NCP program to monitor contaminants in caribou in northern Canada. Wolf samples will be collected from trappers from northern Yukon. Levels of perfluorinated compounds will be measured in caribou foods, caribou, and wolves. The levels will show if these compunds are accumulating through the food chain; that is, increasing from vegetation to caribou to wolves. We will also use an additional analysis (stable isotope ratios) to potentially determine how much of each food the caribou are eating, and likewise what is the relative part of caribou in the wolf diet. We will also analyze some archived Porcupine caribou tissues to determine whether diet and the level of perfluorinated compounds has changed over the last nine years, and whether it changes between spring and fall.

M-23

Temporal trend studies of the atmospheric Hg deposition with ice-core/snow in Canadian High Arctic (to complement a proposal by Dr. Muir and Wania which is entitled "Environmental Trends Monitoring of flame retardants and pesticides in the Canadian High Arctic via Ice/Snow")

Project leader: Jiancheng (James) Zheng, NRCan

PLAIN LANGUAGE SUMMARY

To retrospect to contamination history in pre-instrument times, many natural archives, such as lake sediments, peat bogs, tree rings and ice cores could be suitable. Ice/snow in Polar Regions and alpine glaciers, however are specifically valuable because 1). glaciers are remotely located with only atmospheric inputs; 2). snow/ice accumulation rate can be much higher than other natural archives, therefore, a higher resolution; and 3). once accumulated, ice/snow stays in place in the frozen matrix with little disturbance.
Therefore, we propose to 1). carry out on-site measurements of atmospheric Hg concentrations (26 hourly measurements with different sunlight intensities) and Hg concentrations in surface snow layers; 2). retrieve a record of 30 to 50-year total Hg concentration; and 3). potentially reconstruct an archive pre-dating the Industrial Revolution if resources permit (LOI to CORA of Environment Canada already), and therefore, evaluate the natural atmospheric deposition background of Hg. Our study site is targeted in the Mount Oxford area (~82.2°N, 72.6°W) in the Grant Land Ice Field of northern Ellesmere, Nunavut, where snow accumulation is moderate and disturbance is very limited.
To carry out this task, it is essential to be capable for low to sub-pg/g Hg level measurements for snow samples on site and in base laboratory. Our preliminary results of Hg measurements in air and snow in our 2007 IPY field trip have demonstrated our methodology is practical and our approach is feasible. Our results by field measurements were reasonably comparable to those of comparison samples measured in our Ottawa laboratory in general.
This proposal is based on (or co-executed with) our existing IPY project (Paleo-perspectives on Environmental Change in the High Arctic: the Canadian Contribution. IPY #918).

On completion of this study (one year life span), it is expected to provide a current trend of Hg for the past 30-50 years. On completion of the IPY project (three year life span), a longer archive, a minimum of 100 years, is aimed.

M-24
Mercury in Caribou Forage

Project leader: Mary Gamberg, Gamberg Consulting

PLAIN LANGUAGE SUMMARY

Porcupine caribou provide an important food resource for people of the Yukon. A current population decline is causing serious concern among wildlife managers as well as those using the caribou as a resource. At this point, biologists are uncertain as to the cause(s) of the decline. Recent studies have shown that mercury concentrations in Porcupine caribou kidneys appear to be increasing over time, particularly in females, and also mercury is higher in females than in males. Although mercury levels are not yet at the point where toxicological effects are thought to occur, if concentrations continue to increase, there may come a point where they will (if they have not already) begin to negatively impact the health of the caribou population, or those consuming the caribou.

In order to better understand the dynamics of mercury within these caribou populations and be better able to predict if mercury may become a toxicological issue, we would like to answer the question of why mercury levels are higher in female caribou than in males. To do this, we will sample plants that caribou commonly eat in the spring and summer and analyze them for mercury. We will sample them during the time that the males and females are separated (June) from the calving grounds (where the females are at that time) and further south in the overwintering area (where the males are at that time). This will show us if the female caribou are accumulating higher amounts of mercury during their critical time on the calving grounds in the Northern Yukon.

M-25
PCBs in Arctic Ocean Seawater: Addressing a Knowledge Gap in Contaminant Pathways, Processes and Effects

Project leader: R.W. Macdonald, Institute of Ocean Sciences

PLAIN LANGUAGE SUMMARY

As a result of extensive studies over the past 30 years, much has been learned about traditional contaminants like PCBs and their pathways, processes and effects in the Canadian Arctic. One of the only areas remaining as a major knowledge gap is Arctic seawater. PCB concentration data for Arctic seawaters are rare, largely because opportunities to collect the samples are rare, and also because it is challenging to sample and analyze PCBs at the low concentrations that occur in Arctic seawater without contamination or other biases. As we learn more about these challenges, increasingly it looks like some of the data collected in the past – including some in the Canadian Arctic – may be wrong.

The goal of this project is to obtain new, trustworthy measurements of dissolved PCB concentrations in Canadian Arctic Ocean seawater, guided by recent developments in our understanding of the challenges associated with this work, and how they can be overcome. In spring 2008, we have an opportunity to collect Arctic Ocean seawater samples using very clean techniques, as the Canadian Coast Guard Ship *Amundsen* completes its over wintering period in the Amundsen Gulf region (IPY CFL study area). We plan to deploy in situ pump systems (e.g., Infiltrex) beneath the sea ice, thus sampling Arctic Ocean seawater from the sea ice (rather than a ship) as a platform. The systems are equipped with glass fiber filters to

collect suspended particulates (and associated PCBs) and columns containing XAD-2 resin, which extract dissolved PCBs. Two or more systems will be deployed at the same time to collect replicate data and the systems will be deployed repeatedly over several weeks, thus collecting a time series of the PCB concentrations in the seawater. The PCBs will be analyzed at an ultra-clean facility, which guarantees the necessary ultra-low detection limits. Ultimately, these new data will address what remains a major gap in our understanding of the sources, sinks and reservoirs for PCBs in the Arctic Ocean.

M-26
Environmental Trends Monitoring of flame retardants and pesticides in the Canadian High Arctic via Ice/Snow

Project leaders: Derek Muir (Environment Canada) and Frank Wania (University of Toronto at Scarborough)

PLAIN LANGUAGE SUMMARY

This purpose of this project is to collect snow and ice cores from the Devon Ice cap on Devon Island in the Canadian Arctic archipelago and measure contaminants such as new persistent organic pollutants and current use pesticides. Many pollutants emitted by industrial and agricultural activities in the south are efficiently removed from the atmosphere by snow. The remote Arctic ice caps on Devon and other Islands, where snow accumulation is preserved with limited summer melting, can therefore provide archives of this airborne pollution. Continuous records of pollution can be developed by taking cores and analyzing them for contaminants. Compared to other types of natural archives (e.g., lake sediments, animal teeth), cores from polar ice caps can offer better recent temporal resolution (as good as seasonal) and better preservation of the contaminants in a comparatively simple matrix of frozen water. In 2008 we propose to revisit the Devon ice cap (Devon Island) to sample snow deposited over the past 10 to 15 years at these sites. The samples will be analyzed for organic chemical pollutants such as the brominated flame retardant “decabromodiphenyl ether”, other flame retardants, and current use pesticides. Current arctic air monitoring programs have only just begun to examine “deca” and current use pesticides and they do not measure actual deposition. Funding is requested just to partially cover analytical and logistical costs associated with the project.

M-27
Improved Screening for New Arctic Contaminants

Project leaders: Frank Wania (University of Toronto at Scarborough)

PLAIN LANGUAGE SUMMARY

There is a distinct possibility that some Arctic contaminants exist that have not been identified. They are neither detected, studied, monitored, nor evaluated, let alone regulated. This project uses computer models and a mechanistic understanding of how organic contaminants reach remote polar regions and how they bioaccumulate in the Arctic human food chain to identify currently unrecognised Arctic contaminants. This is achieved by predicting the properties of the multitude of organic substances in commerce and comparing them to the combination of properties that make a substance susceptible to becoming Arctic contaminants. A particular focus will be on an improving the description of long range transport in the model and in predicting chemical properties. The outcome of the project are lists of substances that merit scientific and regulatory

attention by virtue of their persistence, potential for bioaccumulation and potential for long range transport.

M-28

Enhanced investigations of the factors affecting long-term contaminant trends in predatory fish in Great Slave Lake, the Northwest Territories

Project leaders: Marlene Evans and Derek Muir (Environment Canada)

PLAIN LANGUAGE SUMMARY

For several years we have been conducting studies to find out if contaminant levels are changing in lake trout and burbot in Great Slave Lake. We have been seeing some changes with mercury levels increasing and while HCH levels are declining in these fish. However, there have been other changes in the fish, especially lake trout which appear to contain less fat and to be feeding closer to shore than in the 1990s. Because contaminant levels in lake trout and burbot can be affected by changes in their biology and in the lake in which they live, we need to do more studies to find out what is affecting contaminant trends. Specifically, we need to find out if contaminant inputs to the lake have been changing and to learn more about contaminants in the Great Slave Lake food web. Therefore, we propose to conduct three basic kinds of studies over the next two to three years.

First, we begin our effort by collecting sediment cores from Great Slave Lake and analyze them to find out if contaminant levels reaching the lake sediments have changed. We also will conduct some analyses which will tell us if the lake has changed in productivity. Cores will be collected in winter 2009 by working on the ice. Some analyses will be done in 2008-2009 but others will be delayed to 2009-2010.

Second, we propose to conduct contaminant studies of the Great Slave Lake food web, building on the work we conducted in summer 1994 and 1995. This sampling would not begin until summer 2009 and hopefully would continue into summer 2010. However, in 2008/2009, we will analyze some of our archived samples to measure mercury in the food webs around Fort Resolution and Lutsel K'e. We also will resume burbot sampling in the East Arm to see how mercury and organic contaminant trends compare to those observed in the West Basin.

We also will start a review of existing information on the fisheries, limnology, and climate of Great Slave Lake in 2008-2009 with a focus on the fish catch record from the commercial fishery for the West Basin. Fish populations can change with changes in fishing pressure. We will also consider changes in the Slave River water entering the lake by considering the long-term water quality monitoring data collected by Environment Canada at Fort Smith. We also can examine weather data. In addition, we collected zooplankton and benthos samples in Great Slave Lake in 1994 and 1995; by collecting new samples in 2009 and 2010, we will be able to compare these data for large changes in the invertebrate communities. As part of this food web initiative, we will work with various agencies to develop a more comprehensive monitoring and research

program for Great Slave Lake which will complement NCP's contaminant monitoring program.

We also propose to conduct complementary studies in Lake Laberge in the Yukon where we will build on the current lake trout and burbot contaminant trend monitoring; we will seek partnerships that will support much of the collection and some analytical costs. This study is briefly outlined in Annex 1. Such a study will build on our comparative lake studies including sediment cores and food web sampling, with a focus on mercury

M-29

Spatial patterns of contaminants in arctic seabirds

Project leaders: Birgit Braune (Environment Canada)

PLAIN LANGUAGE SUMMARY

As part of the NCP core seabird egg monitoring program, eggs from five seabird species will be collected from Prince Leopold Island in the Canadian High Arctic in 2008 for contaminants analysis. For comparative purposes, we will also be making collections of thick-billed murre eggs from Coats Island in northern Hudson Bay (our Low Arctic monitoring colony since 1993) in parallel with the High Arctic collections. In addition to the legacy POPs, the eggs being collected from Prince Leopold Island in 2008 will be analyzed for perfluorinated compounds (PFCs) and brominated flame retardants (BFRs). It is proposed that the thick-billed murre eggs collected from Coats Island also be analyzed for PFCs to allow comparison of this class of compounds between a high arctic murre colony (Prince Leopold Island) and a low arctic murre colony (Coats Island). As well, it is proposed that a spatial contaminants survey be carried out on seabirds being collected as part of an International Polar Year study on dietary change in marine birds. We propose to analyze birds of both sexes from five colonies located throughout the eastern Canadian Arctic.

M-30

Contaminant and energy flow in a low arctic pelagic food web

Project leaders: Birgit Braune (Environment Canada)

PLAIN LANGUAGE SUMMARY

Thick-billed murres in northern Hudson Bay have been monitored for contaminants since the early 1990s. As part of an International Polar Year (IPY) study, we have the opportunity to obtain samples of zooplankton and fish on which the thick-billed murres feed from northern Hudson Bay. It is proposed that these samples be analyzed for total mercury, legacy POPs as well as brominated flame retardants (BFRs) and perfluorinted compounds (PFCs), stable isotopes and fatty acids to gain information on both the contaminant and energy flow for the northern Hudson Bay pelagic food web being utilized by thick-billed murres. The resulting data should also allow us to calculate contaminant biomagnification factors for this food web.

M-31

Interspecies sensitivity of arctic marine birds to methylmercury exposure

Project leaders: Birgit Braune (Environment Canada)

PLAIN LANGUAGE SUMMARY

Total mercury (Hg) has been increasing in marine birds and mammals in some regions of the Canadian Arctic and in West Greenland over the past several decades. There is also evidence to suggest that current Hg exposures may pose a health risk to some people and animals in the Arctic. The most bioavailable and toxic form of Hg is methylmercury (MeHg) and nearly 100% of the Hg transferred by breeding female birds to their eggs is MeHg. Given that reproduction is one of the most sensitive endpoints of MeHg toxicity, we propose to use protocols developed by the USGS to bring eggs of arctic seabirds into the laboratory where they will be injected with graded concentrations of methylmercury chloride to determine threshold levels of harmful effects. These data for MeHg sensitivity will be used in conjunction with equations for rates of increasing Hg concentrations to predict when environmental mercury exposure levels may reach critical thresholds for the species tested.

M-32

Interspecies sensitivity of arctic marine birds to methylmercury exposure

Project leaders: Neil Burgess (Environment Canada)

PLAIN LANGUAGE SUMMARY

Thirty-five black guillemot chicks were collected in 2007 from different parts of Saglek Bay, Labrador. PCB levels in the livers of the guillemots have declined significantly since 1999, as a result of PCB remediation at Saglek. We propose to analyse several biomarkers of adverse effects of PCBs in the guillemots, to asses the impacts of PCBs on the health and development of the seabird chicks. The results of this study will enable us to derive toxicity thresholds for PCBs in an Arctic seabird, based on PCB levels in sediment, forage fish, or seabird eggs or tissues. These thresholds will be useful to assess the risks associated with marine PCB levels measured elsewhere in the North. The results will also be useful in assessing the success of the PCB remediation efforts at Saglek. This project has been carried out as a partnership with Environment Canada, the Environmental Sciences Group, the Nunatsiavut Government and Parks Canada. Findings will be communicated back to the local community in Nain in collaboration with the Nunatsiavut Government.

M-33

Influence of climate warming on scavenging of POPs by suspended particulate organic matter in lake waters, as recorded in sediments of Amituk Lake, Cornwallis Island.

Project leaders: Peter Outridge (Natural Resources Canada)

PLAIN LANGUAGE SUMMARY

Lake sediments have been widely used to reconstruct the atmospheric deposition rates of persistent organic pollutants (POPs) and other contaminants. But using sediments in this way assumes that the associated environmental pathways and fate processes remain constant over time. Recent Arctic climate warming is known to have dramatically increased the primary productivity of northern lakes. One logical result is higher water column concentrations of suspended particulate organic matter (SPOM) of algal origin. The hydrophobic ("water-hating") nature of many POPs means that they preferentially attach to SPOM and suspended inorganic particles; by doing so their rate of sedimentation is likely to significantly increase. Thus, climate warming may be creating limnological conditions which favour increased scavenging of POPs from the water column, and higher accumulation rates in sediments which are not related to changes in atmospheric POPs concentrations and fluxes.

This one-year project aims to test the idea that recent increases of algal SPOM in lakewaters have significantly influenced the rate of accumulation in Amituk sediments of both "legacy" organochlorine POPs and of newer polybrominated POPs. If the idea is found to be valid, this project will affect the way in which sediment POPs records are interpreted. We will carry out POPs analyses on a 2003 sediment core from Amituk Lake, Cornwallis Island, for which organic geochemistry (RockEval), radiometric dating and diatom enumeration data are already available.

M-34

Marine food web model of an Arctic coastal region – using stable isotopes and fatty acids to model energy transfer and contaminant flow through inshore ecosystems

Project leaders: Ken Reimer (Royal Military College of Canada)

PLAIN LANGUAGE SUMMARY

• The purpose of this study is to better understand coastal marine food web structure in northern Labrador in order to better evaluate energy and contaminant transfer in the food chain. To do this, chemical tracers (stable isotopes and fatty acids) organic contaminants, and mercury will be measured throughout the food chain in Nachvak Fiord and Okak Bay, northern Labrador.

• Nachvak Fiord, one of the northern-most fiords in Labrador, is adjacent to the newly formed Torngat Mountains National Park Reserve. It is experiencing increasing visitor and harvesting pressures. Okak Bay has been identified by the Nunatsiavut Government as a special cultural landscape and is currently experiencing increased harvesting pressure because of mining-related activities in Anaktalak Bay. The inclusion of Nachvak Fiord and Okak Bay will help address Inuit concerns of contaminant levels in harvested foods from these areas.

• Samples collected will include various species of phytoplankton, benthic fauna, zooplankton, fish, and seal. The proposed work will complement separate, but similar food web studies in Saglek Fiord and Anaktalak Bay, northern Labrador.

• Work will be completed from a longliner during the summer and from the CCGS Amundsen in the fall.

• Five Inuit students will provide field assistance for the program.

• A possible change in food web structure due to climate change could have a dramatic effect on contaminant exposure for species like ringed seal. Results of this research will contribute to our interpretation of geographic trends and to our understanding of possible climate change effects on food web structure, energy transfer and contaminant flow due to long range transport within nearshore coastal environments.

C-01
Distribute NCP information to Yukon First Nations offices & General Assemblies

Project leader: Cindy Dickson, Council of Yukon First Nations

PLAIN LANGUAGE SUMMARY

The Northern Contaminants Program was established in 1991 in response to concerns about human exposure to elevated levels of contaminants in fish and wildlife species that make up the traditional diets of northern Indigenous peoples.

Under NCP Phase I research was conducted to determine the levels, geographic extent and source of contaminants that were entering the north. Results from NCP I was published in the 1997 Canadian Arctic Contaminants Assessment Report (CACAR). NCP II began in 1998 and focused on the impacts and risks to human health that may result from current levels of contamination in key Arctic food species. The results of NCP II have been published in CACAR II.

The current focus of the program is to address high priority areas, such as communities where people are being exposed to contaminant levels of concern to health authorities. Although the Yukon Territory is not a high priority area, the Council of Yukon First Nations will need to provide information to Yukon communities about the work being conducted across the north, any new information coming out of the NCP as well as being available for any questions that may arise.

Currently CYFN provides the opportunity for NCP to discuss issues with the Leadership Board and provides the opportunity to seek direction from Leadership and the Grand Chief of CYFN. Information from the CYFN is also given to the First Nations via reports, mail-outs of new information, phone-calls and emails.

C-02
Akaitcho Territory Governments
Participation on the NWT Regional Contaminants Committee (NWT RCC)

Project leaders: Annie Boucher, Diane Giroux and George Low, Akaitcho Territory Government

PLAIN LANGUAGE SUMMARY

The NWT Regional Contaminants Committee (NWT RCC) was established in 1997 with a primary focus on the Northern Contaminants Program. The NWT RCC was formally known as the NWT Environmental Contaminants Committee (NWT ECC). Members are identified by their participating aboriginal organizations and government agencies to represent community concerns relating to contaminants and the NCP program. The committee's role is to develop strategies and priorities each year and provide technical advice, traditional knowledge and perspectives to researchers and the NCP Management team. The committee is made up of a Chair and Vice-chair elected by the committee each year.

A priority within the Blueprint for Education and Communication is "Build capacity among frontline workers (RCC) to identify, understand, and facilitate understanding and uptake of information on long-range contaminant issues". Participation funding will be used by representatives of the Gwich'in Tribal Council, Sahtu Dene Council, Northwest Territories Métis Nation, Deh Cho First Nations, North Slave Métis Alliance, Tli Cho Government, Akaitcho Government and the Dene Nation to build capacity amongst the representatives. This will be achieved through monthly conference calls, providing advice to researchers on best practices, performing a social-cultural review of NCP proposals relative to the NWT, providing advice and guidance to the NCP Management team and acting as a liaison between community members and NCP on contaminant issues, communications and information related to contaminants. It is expected that each member will spend an average of 4 days per month on NWT RCC/NCP activities.

Members are encouraged to provide technical advice to each other to secure funding beyond NCP to address local contaminants concerns, and it continues to seek funding to supplement activities related to various environmental contaminants concerns in the NWT not funded by the NCP. The committee consists of representatives from national and regional Aboriginal partners, as well as various departments in the federal and territorial governments. The network of people making up the committee is an efficient means of relaying contaminants information, research results and research initiatives between NWT communities, relevant organizations, other contaminants programs representatives and the Northern Contaminants Programs staff. This builds relationships between the communities and researchers and provides a forum to discuss results and future research opportunities.

C-03
Deh Cho First Nations
Participation on the NWT Regional Contaminants Committee (NWT RCC)

Project leader: Lee Maria Thom, Deh Cho First Nations

PLAIN LANGUAGE SUMMARY

The NWT Regional Contaminants Committee (NWT RCC) was established in 1997 with a primary focus on the Northern Contaminants Program. The NWT RCC was formally known as the NWT Environmental Contaminants Committee (NWT ECC). Members are identified by their participating aboriginal organizations and government agencies to represent community concerns relating to contaminants and the NCP program. The committee's role is to develop strategies and priorities each year and provide technical advice, traditional knowledge and perspectives to researchers and the NCP Management team. The committee is made up of a Chair and Vice-chair elected by the committee each year.

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related to contaminants. It is expected that each member will spend an average of 4 days per month on NWT RCC/NCP activities.
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C-04
North Slave Métis Alliance
Participation on the NWT Regional Contaminants Committee (NWT RCC)

Project leader: Sheryl Grieve, North Slave Métis Alliance

PLAIN LANGUAGE SUMMARY

The NWT Regional Contaminants Committee (NWT RCC) was established in 1997 with a primary focus on the Northern Contaminants Program. The NWT RCC was formally known as the NWT Environmental Contaminants Committee (NWT ECC). Members are identified by their participating aboriginal organizations and government agencies to represent community concerns relating to contaminants and the NCP program. The committee's role is to develop strategies and priorities each year and provide technical advice, traditional knowledge and perspectives to researchers and the NCP Management team. The committee is made up of a Chair and Vice-chair elected by the committee each year.
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Programs staff. This builds relationships between the communities and researchers and provides a forum to discuss results and future research opportunities.

C-05
Gwich'in Tribal Council
Participation on the NWT Regional Contaminants Committee (NWT RCC)

Project leader: Mardy Semmler, Gwich'in Tribal Council

PLAIN LANGUAGE SUMMARY

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C- 06
Northwest Territory Métis Nation
Participation on the NWT Regional Contaminants Committee (NWT RCC)

Project leader: Northwest Territory Métis Nation

PLAIN LANGUAGE SUMMARY

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Chris Heron is currently the NWT RCC Chair. The chair of each RCC sits on the NCP Management team which meets a minimum of twice per year for three days. The Chair is expected to represent the NWT RCC and provide advice and guidance on issues that will affect the NWT RCC.

C-07
Sahtu Dene Council
Participation on the NWT Regional Contaminants Committee (NWT RCC)

Project leaders: Fred Pierrot and Freda Taniton, Sahtu Dene Council

PLAIN LANGUAGE SUMMARY

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C-08
Tli Cho Government
Participation on the NWT Regional Contaminants Committee (NWT RCC)

Project leaders: Eddie Erasmus and John B. Zoe, Tli Cho Government

PLAIN LANGUAGE SUMMARY

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A priority within the Blueprint for Education and Communication is "Build capacity among frontline workers (RCC) to identify, understand, and facilitate understanding and uptake of information on long-range contaminant issues". Participation funding will be used by representatives of the Gwich'in Tribal Council, Sahtu Dene Council, Northwest Territories Métis Nation, Deh Cho First Nations, North Slave Métis Alliance, Tli Cho Government, Akaitcho Government and the Dene Nation to build capacity amongst the representatives. This will be achieved through monthly conference calls, providing advice to researchers on best practices, performing a social-cultural review of NCP proposals relative to the NWT, providing advice and guidance to the NCP Management team and acting as a liaison between

community members and NCP on contaminant issues, communications and information related to contaminants. It is expected that each member will spend an average of 4 days per month on NWT RCC/NCP activities.
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C-13
Caribou and Moose Contaminant Monitoring Program training and capacity building workshop.

Project leaders: Lorna Skinner (INAC), Chris Heron (NWT Métis Nation), Kevin Antoniak (Aurora College) and Mary Gamberg (Gamberg Consulting)

PLAIN LANGUAGE SUMMARY

This will be the third year of the Moose and Caribou Tissue Sampling Workshop under the Education, Communication Blueprint of the Northern Contaminants Program. Each year the workshop has evolved to change the audience and location of the workshop in order to ensure all levels of community members are reached.
The first year 2006/2007 the workshop was held in Whitehorse. It was well received by community members, academia and RCC members. The second workshop January 2008 has changed location to Yellowknife to include new RCC members, 1 Arctic College student from Iqaluit, 2 community members from the Yukon unfortunately the RCC member from the Nunasiavut Region could not attend. The GNWT has built a new lab in Yellowknife and this workshop will be one of the first activities to be held there.
The objective of 2008/2009 is to provide training to Aurora College, Thebacha Campus students in the Renewable Resources Program at Aurora College in Fort Smith and up to 7 community members on sample processing for studying contaminant levels in caribou and moose in the Canadian Arctic and an understanding of what is a contaminant and why they are monitored. The college expects to have 8 students registered for 2008/2009 in the 2nd year of the Natural Resources program. Students are from Yellowknife, Fort Resolution, Fort Smith, Hay River, Fort Simpson, Tlita and Fort Chip. The workshop will also be open to up to 7 community members This proposed capacity building project will aid students in gathering a better understanding of the process in analyzing contaminants found in caribou and moose, provide a connection to the NCP Program for future graduates and enhance community members understanding of contaminants and the NCP Program.
The Natural Resources Program students will be going on a hunt this March for caribou and have agreed to provide samples of the Beverly Herd to Mary Gamberg to enhance her studies on contaminants in the herd. This workshop will prepare tissue analysis from the Beverly herd after the hunt in March 2009. It is expected to hold the Moose and Caribou Tissue sampling workshop the 3rd week of March in 2009 in order for students to collect samples

through their traditional hunt, prepare the samples and learn about the contaminants currently being monitored through NCP.
Mary Gamberg will prepare the material for the workshop in coordination with the college and the NWT RCC.
Results of this project will be communicated to each of the Regional Contaminants Committees and will be presented at the NCP results workshop in the fall of 2009.

C-14
Building capacity in various frontline working groups: Continuing to meet the information needs of Nunatsiavummiut.

Project leader: Mary Denniston, Nunatsiavut Government (NG)

PLAIN LANGUAGE SUMMARY

The current proposal is for the ongoing activities of the Nunatsiavut Government Research Office in their efforts to communicate and educate the Labrador Inuit population on contaminant, wild foods and health issues so that they may make informed decisions in their daily lives as well as facilitate information flow from research programs like the Northern Contaminants program. This office is also a base in the region for researchers to help them build the necessary contacts and links with communities as well as to help them communicate results. The proposal activities will continue, in cooperation with ITK and other Inuit regions, the development of regional and national long term communication strategies to ensure that communication activities are coordinated at various levels and done in the most responsible and accessible way known. Studies have shown that long rage contaminant concern is low amongst Nunatsiauvummuit, as well as the fact that levels of many legacy6 POPs are decreasing in the North. The main concerns in Nunatsiavut are from issues such as mine development and past mining as well as old Military sities. Although NCP does not deal with local contaminant issues, Inuit diet and decisions are altered due to contaminant concerns, which is important to NCP. Ultimately, the project will support the ongoing provision of support of Labrador Inuit to make informed decisions on these issues in their daily lives.

C-15
International Inuit Contaminant Activities in Support Global Instruments and Activities

Project leader: Stephanie Meakin, Inuit Circumpolar Council – Canada

PLAIN LANGUAGE SUMMARY

The Arctic ecosystem is internationally described as “the barometer of global environmental health”. It has taken over 20 years of science and advocacy to create a global awareness that what happens to the world happens in the Arctic first. We need only to look at the issue of long-range transport of persistent organic pollutants (POPs), emerging new chemicals and heavy metals. Carried by the global forces of wind and water, these chemicals find their way to the Arctic “sink” and make their way into Arctic animals and Inuit. Contemporary science, traditional knowledge and observation together can help inform the world of the effects of these chemicals. The threat of these POPs, emerging chemicals and heavy metals has eroded the confidence Inuit have in country food. Access to safe food is a fundamental human right. Human activities within the Arctic region result in relatively few anthropogenic releases of chemicals and heavy metals, yet concentrations of several hazardous substances in Arctic human populations and ecosystems are among the highest measured anywhere in the world. Emissions of many these hazardous chemicals and heavy metals travel long distances through the air and ocean currents to reach the Arctic, far from the diverse origins and sources of their

local releases. Once these emissions reach the Arctic, they accumulate in living organisms, and can pose a toxic risk to humans and animals. Addressing Arctic pollution problems thus requires international cooperation and policy making, which has evolved over the past several decades to encompass several overlapping regional and global scientific and political initiatives.

Persistent organic pollutants (POPs) and mercury pose risks to Arctic indigenous populations, mainly through the consumption of traditional foods. International instruments of particular relevance include the 1998 United Nations Economic Commission for Europe Protocols on Heavy Metals and POPs to the Convention on Long-Range Transboundary Air Pollution, and the 2003 United Nations Stockholm Convention on POPs. Indigenous groups have invested considerable political and technical support to the negotiation of these instruments and continue to exerted considerable influence on Arctic toxics issues through lobbying of national governments, participation in scientific assessments and international fora, and advocating directly in international political meetings. The engagement on environmental issues has also helped shape circumpolar consciousness and political activism among Inuit and other Arctic indigenous peoples. Important challenges also remain for Arctic indigenous groups and States as they continue to work together on contaminants and issues related to climatic changes across the region. ICC proposes a program of action that builds upon continuing projects related to contaminants. Through national science programmes, International Polar Year (IPY) and AMAP, ICC actively participates in the designing and undertaking of the research that monitors legacy POPs and new and emerging chemicals of concern in the Arctic.

C-16
Communicating Contaminant information and Northern Research results to Residents of Inuvialuit Settlement Region

Project leader: Nellie J. Cournoyea, Inuvialuit Regional Corporation

PLAIN LANGUAGE SUMMARY

The objective of this proposal is to comply with the new NCP blueprint for Education and Communications initiatives in the Inuvialuit Settlement Region, while continuing on to complete projects from the last fiscal year of which include, the newsletter and development of a Health & Environment page on the IRC website with the inclusion of research databases. We will incorporate the three main priorities of NCP into this years work; build capacity among frontline workers, delivering contaminants messages, and communications research. All work this year will be conducted in Inuvik, and unless requested, we will not be entering any of the other ISR communities. To build on the first of the NCP priorities, we will continue regular interface with frontline workers and communicators through participation in meetings, conferences and programs with local bodies such as the Northwest Territories RCC (NWT ECC), Inuvialuit Corporate Group (IRC, IDC etc), and Beaufort Delta Health and Social Services. For the second priority to help deliver contaminants messages, work will continue to develop and advertise the proposed contaminants and research newsletter specifically for frontline workers and continue on with progress to update and complete the Health and Environment page on the IRC website. In terms of the final priority, learning how to best communicate about contaminants, the IRA will work to find ways to best communicate northern research. This will be accomplished through continued involvement in projects such as the “Lessons Learned in the Canadian North” project that the IRA is co-lead of, which examines past research projects from all four Inuit regions in Canada to determine best practices in conducting research in the North. In addition, a priority will also still be

given to assisting researchers and local people to bridge the gap in community involvement, making appropriate community consultation and delivering of results.

C-17
Building Capacity through Education: Development and delivery of Northern College module courses on contaminants, wildlife and health

Project leaders: Shelagh Rowles (Yukon College) and Chris Furgal (Trent University)

PLAIN LANGUAGE SUMMARY

Yukon College and Trent University are proposing to partner and establish module course material for the existing Renewable Resource program at Yukon College as well as two courses at the paraprofessional level for front line people working in areas that require a basic knowledge of northern contaminants (e.g. existing wildlife managers, lands and environment representatives, CHRs, etc). In partnership with the other northern colleges (Aurora and Nunavut Arctic College) for the adaptation and expanded use of this material in the two other Territories, this effort is proposed to introduce a sustainable mechanism through which to transfer and teach important aspects of environmental and environmental health sciences using the latest northern contaminants research and information.

C-18
Inuit Research Advisor

Project leader: John Lampe, Nunatsiavut Government

PLAIN LANGUAGE SUMMARY

Northern Contaminants Program (NCP), ArcticNet and Nasivvik Centre for Inuit Health and Changing Environments have together co-funded an Inuit Research Advisors (IRA) in each of the four Inuit land claim regions of the Arctic-the Inuvialuit settlement region, Nunavut, Nunavik and Nunatsiavut. These four regional representatives are a first step in a more coordinated approach to community involvement and coordination of Arctic science and represent a new way of knowledge sharing and engagement of Inuit in Arctic science.

Annex 2. Canadian International Polar Year Science and Research Projects

A total of 44 Canadian science and research projects were selected for International Polar Year (IPY) 2007-2008 funding from the Government of Canada. The projects focus on science and research activities related to two priority areas: science for climate change impacts and adaptation, and the health and well-being of Northern communities.

Project Descriptions

The following 44 science and research projects were selected for International Polar Year 2007-2008 federal government funding (listed alphabetically):

Project Title: Arctic Freshwater Systems
Project Leader: Environment Canada
Description: Field studies and laboratory analyses will be carried out to develop new knowledge and information to assess the hydrology and ecology of northern freshwater ecosystems.
Locations: Numerous field sites and communities across Canada's North (Yukon, Northwest Territories, Nunavut, Nunavik, Nunatsiavut)

Project Title: Arctic Resiliency and Diversity
Project Leader: Inuit Tapiriit Kanatami with universities and Northern organizations
Description: Northern Aboriginal organizations will guide the development of a study on Arctic resiliency and diversity to examine the factors that determine resiliency in northern communities, and how northern communities are adapting to a changing world. This study will consider how the health of northern communities is expected to evolve with the changing climate, as well as environmental, technological and social changes in the North.
Location(s): Northern Canada

Project Title: Arctic Weather and Environmental Prediction Initiative
Project Leader: Gilbert Brunet, Environment Canada
Description: This initiative involves numerical modeling and data assimilation studies of various components of Arctic weather and climate systems, such as snow processes, polar clouds, sea-ice and ozone layer. The objective of this initiative is to develop and validate a regional Numerical Weather Prediction model over the Arctic. This model will help enhance our weather and environmental forecasting capabilities in polar regions, and improve our understanding of the Arctic and its influence on world weather.
Location(s): In several provinces, through collaboration between government, university and northern communities

Project Title: Beluga Tagging in the Arctic
Project Leader: Mike Hammill, Fisheries and Oceans Canada
Description: The project will provide information on beluga movements, critical habitat and distribution. This information will be used in ocean forecast models to learn more

about water currents and masses. Interactions with hunters will improve understandings of beluga habits and combine traditional and western scientific knowledge.
Location(s): Hudson Bay waters surrounding Nunavik

Project Title: C3O - Canada's Three Oceans
Project Leader: Eddy Carmack, Fisheries and Oceans Canada
Description: C3O will use two Canadian Coast Guard icebreakers, whose current mission tracks encircle Canada, to obtain a snapshot of large-scale ocean and ecosystem properties, and thus establish a scientific basis for sustained monitoring of Canada's Sub-Arctic and Arctic seas in the wake of global warming.
Location(s): C3O will measure ocean and ecosystem properties from Vancouver Island to Nova Scotia, including the Gulf of Alaska, the Bering, Chukchi and Beaufort Seas, the deep Canada Basin, the Northwest Passage from Amundsen Gulf to Lancaster Sound, Baffin Bay and the Labrador Sea. In all, approximately 12,000 km of ocean track will be covered.

Project Title: The Carbon Cycle in the Canadian Arctic and Sub-Arctic Continental Margin
Project Leader: Charles Gobeil, Université du Québec
Description: The intent of this project is to collect sediment cores along sections on the margin of Canada's three oceans, with the view that these sections span the present-day marginal ice zone. The change in the ice conditions of the Arctic Ocean's margin can then be assessed against other margins that will exhibit no such change. With this work, the Canadian science community will take a leadership role in understanding the interactions between climate change and elemental cycles in the Arctic Ocean.
Location(s): The study area includes the sub-Arctic Pacific (margin leading up to the Aleutians), the Bering, Chukchi and Beaufort Seas, the Baffin Bay and Davis Strait, and the Canadian Archipelago

Project Title: Carbon, Microbial and Plant Community Dynamics in Low-Arctic Tundra
Project Leader: Suzanne Simard, University of British Columbia
Description: Arctic ecosystems store large amounts of carbon in organic matter that may contribute to carbon dioxide production as climate warms, further enhancing the greenhouse effect. This research will expand on cutting-edge technology involving the use of stable isotopes and molecular methods to: 1) examine the role of mycorrhizal fungal networks in facilitating below ground transfer of carbon among tundra plants; 2) determine how carbon flux within plant-mycorrhizal systems varies during the growing season; 3) identify key microbial groups involved in the cycling of carbon in arctic tundra; and 4) examine how soil microbial communities respond to warmer climate conditions.
Location(s): Alaska

Project Title: Changing Forests and Peatlands along the Mackenzie Valley, Northwest Territories
Project Leader: Jagtar Bhatti, Natural Resources Canada

Description: The Mackenzie Valley region of northwestern Canada is undergoing the most warming of any region, which is likely causing important changes in forests and peatlands. A five-year study of the Mackenzie Valley region in northwestern Canada will determine how thawing permafrost will affect greenhouse gas emissions and how warming will affect vegetation.
Location(s): The study will take place in four regions spread along a latitudinal gradient in the Mackenzie Valley

Project Title: The Circumpolar Flaw Lead System Study
Project Leader: David Barber, University of Manitoba
Description: This project will examine the importance of climate processes in changing the nature of a flaw lead system (a unique area where open water persists throughout the winter) in the Northern Hemisphere, and the effect these changes have on the marine ecosystem, contaminant transport, carbon fluxes and greenhouse gases. The project requires the Canadian Research Icebreaker *CCGS Amundsen* to spend the winter in the Banks Island flaw lead in the Southern Beaufort Sea.
Location(s): Southern Beaufort Sea

Project Title: Climate Change Impacts on Canadian Arctic Tundra
Project Leader: Greg Henry, University of British Columbia
Description: The project will examine how tundra ecosystems respond to climate variation using warming experiments and transects across a wide variety of tundra landscapes. It will provide the most complete assessment of tundra ecosystems in Canada, which can be used to evaluate climate changes in the future. The information from this project will be useful to Northerners, land and wildlife managers, and policy makers who need to understand the role of tundra in carbon populations.
Location(s): Canadian Arctic

Project Title: Climate Variability and Change Effects on Chars in the Arctic
Project Leader: James Reist, Fisheries and Oceans Canada
Description: This project is focused on understanding the effects of climate change on char (species of freshwater fish) biodiversity, how this responds to climate change, and the consequences of this to human beings. The work also examines linkages between climate change and mercury bioaccumulation.
Location(s): Nunavut, Nunavik, Labrador and the Northwest Territories

Project Title: Communities in the Changing Arctic
Project Leader: Barry Smit, University of Guelph
Description: The aim of this project is to systematically assess the vulnerability of communities across the Arctic to changing environmental conditions and identify opportunities to enhance adaptive capacities to sustain their natural resources, livelihoods and well-being. The research will draw on scientific, local and traditional knowledge to identify conditions that contribute to more sustainable northern communities in the circumpolar region.
Location(s): Labrador, Northwest Territories and Nunavut

Project Title: Constructed Wetlands for Treatment of Wastewater in Arctic Communities
Project Leader: Mark Williamson, Fleming College
Description: This project will develop new engineering and technology solutions to assist Northern people to adapt to changing settlement patterns and the associated wastewater treatment health issues that arise. Constructed wetland systems for wastewater treatment are an example of a sustainable, environmentally progressive technology that is in its infancy in polar regions. The research activities at the Centre for Alternative Wastewater Treatment at Fleming College will focus on arriving at a prototype design specific to Arctic needs.
Location(s): Kivalliq Region, Nunavut

Project Title: Coordinated Effort to Clear Hepatitis Viruses from the Canadian North
Project Leader: Gerald Minuk, University of Manitoba
Description: Viruses that cause long-term infections of the liver are very common among Canadians living in the North (5-15 per cent of the general population). This project brings together scientists, doctors, nurses, administrators and community leaders who have an interest in this problem, and seeks to develop strategies that will lead to a better understanding of how the viruses cause liver disease (such as cirrhosis or liver cancer). The project also examines what can be done to prevent these outcomes. The group's efforts will start with an examination of the most dangerous liver virus – the Hepatitis B virus.
Location(s): Northwest Territories, Nunavut

Project Title: Determining the Diet of the Greenland Shark in a Changing Arctic
Project Leader: Aaron Fisk, University of Windsor
Description: This project will determine the role of the Greenland shark in Arctic ecosystems, particularly its predation on marine mammals during winter ice cover and summer open water periods. This information is critical for managing other important animal populations in the Arctic such as ringed seals.
Location(s): Nunavut

Project Title: Dynamic Inuit Societies in Arctic History
Project Leader: Trevor Friesen, University of Toronto
Description: Archaeologists and other scientists from across Canada will collaborate with Inuit community and heritage organizations to better understand how Inuit culture has developed and changed over the past 1,000 years. Research teams will bring together Inuit knowledge, the excavation of important archaeological sites, and information about changing Arctic environments.
Location(s): across the Canadian Arctic

Project Title: Effects of Global Warming on Polar Bears, Seals and Whales
Project Leader: Steven Ferguson, Fisheries and Oceans Canada
Description: This research project will find out how marine mammals will adapt to global warming and whether they will be able to survive into the future. The project team will study the relationship between warming temperatures and changes in where polar bears, seals, and whales will survive and reproduce, and how many will remain. The team will use satellite telemetry to tell us how they move, tissue samples from hunters to tell us what they eat, and new technologies like genetics and modeling to tell us what the future will be like. Knowing how polar bears, seals, and whales adapt to shrinking sea ice may help save them and the Inuit culture that relies on them for food.
Location(s): Hudson Bay

Project Title: Engaging Communities in the Monitoring of Country Food Safety
Project Leader: Manon Simard, Makivik Corporation
Description: This project has three goals: to document known international and national distribution and abundance of *Trichinella* and *Toxoplasma pathogens* in Arctic wildlife; to provide regional infrastructure, equipment and training for wildlife sampling, coordinating and diagnosing diseases of food safety interest; and to develop/refine simplified (field) diagnostic tests for *Toxoplasma* and E.coli 0157:H7. This project will provide basic facilities, training of Northern personnel for future wildlife monitoring and disease diagnostics, as well as increase local knowledge on food safety.
Location(s): Labrador, Nunavik, Northwest Territories, and the Yukon

Project Title: Environmental Change and Traditional Use in the Old Crow Flats in Northern Canada
Project Leader: Shel Graupe, Vuntut Gwitch'in First Nation
Description: This project will study the impacts of climate change on the environment in the Vuntut Gwitch'in First Nation's traditional territory. This includes looking at the changes in the health of members of the Vuntut Gwitch'in First Nation and the food they eat (Porcupine Caribou Herd), vegetation, water quality, volcanic soil, muskrat populations, moose populations, and permafrost in comparison to the climatic changes since time immemorial.
Location(s): Yukon

Project Title: Environmental Change in the High Arctic from Snow and Ice Cores
Project Leader: Jocelyne Bourgeois

Description: International teams of scientists will collaborate to retrieve ice cores and snow pit samples from the Canadian High Arctic and Greenland to study past climate, contaminants concentrations and environmental change. The overall objectives are to understand past climate variability in the High Arctic, with a particular focus on summer temperature; concentration variability of contaminants entering the High Arctic regions; and, the role of Greenland's ice sheet with respect to sea level change.
Location(s): Nunavut and northern Greenland

Project Title: Evaluating the Effectiveness of Vaccination against Respiratory Infections for Young Children of the Nunavik Region
Project Leader: Philippe DeWals, Centre de Recherche du Centre hospitalier de l'Université Laval
Description: This project will analyse medical records of approximately 3000 children born in Nunavik between 1994 and 2005 to verify whether vaccination of young children reduces the number of respiratory infections, prescriptions for antibiotics, hospitalizations and hearing disorders. The results of this study could be used to inform vaccination programs for all populations living in the Arctic.
Location(s): Nunavik

Project Title: How Seabirds Can Help Detect Ecosystem Change in the Arctic
Project Leader: William Montevecchi, Memorial University
Description: Climate changes that have been underway for several decades are influencing marine life in Arctic waters. Diving and surface-feeding seabirds (murres, fulmars, gannets, storm-petrels) will be studied during summer and when migrating throughout the High and Low Arctic during fall, winter and spring. The project will use previous surveys of seabird diets throughout Nunavut and Newfoundland and Labrador during the 1970s and 1980s to assess changes that have occurred in High and Low Arctic marine food webs and to establish a current baseline against which future change can be assessed.
Location(s): Nunavut, Newfoundland and Labrador

Project Title: Human Papillomavirus (HPV) and Cervical Disease in the Northwest Territories
Project Leader: Judy Niles, Public Health Agency of Canada
Description: The high occurrence and mortality rate of cervical cancer in Aboriginal populations of the Northwest Territories has led to concerns about current screening methods. This research will determine the prevalence of type specific HPV infection and cervical dysplasia (precancerous cells) in women of the Northwest Territories and provide scientific evidence for policy makers and local public health workers in the Northwest Territories to plan and implement more effective cancer control programs.
Location(s): Northwest Territories

Project Title: Impacts of a Changing Arctic Tree Line
Project Leader: Karen Harper, Dalhousie University
Description: Together with its international partners, this project will establish a network of long term monitoring and experimental plots to track future changes in the vegetation at the forest limit in the Canadian Arctic. This project is expected to link

recent changes in tree and shrub distributions at the tundra border to environmental change, and demonstrate how these changes will impact the health and well-being of northern communities.
Location(s): Yukon, Northwest Territories, Nunavut, Manitoba, Ontario, Quebec, Newfoundland and Labrador

Project Title: The Impact of Climate Change on Tundra Wildlife
Project Leader: Gilles Gauthier, Université Laval
Description: This project aims to document direct and indirect impacts of climate change on terrestrial animal biodiversity (insects, mammals, birds), and forecast future impacts on these populations and the Arctic ecosystem. The project will evaluate how arctic biodiversity will be impacted by climate change and will develop strategies to adapt to it.
Location(s): The project will take place at several sites in the Canadian Arctic, including national/ territorial parks in Nunavut, Yukon and Manitoba

Project Title: The Impacts of Oil and Gas Activity on Peoples in the Arctic
Project Leader: Dawn Bazely, York University
Description: Over centuries, people in the Arctic have learned to adapt and thrive in an uncertain, harsh environment. Today, change is occurring at an unprecedented rate. Local peoples' capacity to cope and adapt is under pressure. Natural and social scientists will join with members of Arctic communities in Canada, Norway, Alaska and Russia to study the impacts of oil and gas activity on the health, traditional livelihoods, economic development and ecosystem change in the Arctic. The research will develop a broad range of community-driven grassroots indicators and methods to assess future change. The research will also broaden international collaboration and communication among circumpolar communities through focus group workshops on oil and gas impacts in local communities.
Location(s): Various locations throughout Canada's territories

Project Title: Impacts of Severe Arctic Storms and Climate Change on Coastal Areas
Project Leader: William Perrie, Fisheries and Oceans Canada
Description: The focus of this project is to understand coastal oceanographic processes in the Southern Beaufort Sea, and the related waters of the Western Canadian Arctic, driven by intense storms and severe weather. This area is important because the use of the coastal marine and terrestrial environment by Canadian Northerners is an integral part of their life style, and these environments are being impacted by coastal erosion processes, related to marine storms that tend to be growing stronger.
Location(s): Beaufort Sea, and coastal areas of the Yukon and Northwest Territories

Project Title: An Integrated Research Program on Arctic Marine Fat and Lipids
Project Leader: Éric Dewailly, Centre de Recherche du Centre hospitalier de l'Université Laval
Description: This program will involve the collection and analysis of data in four regions through three projects that examine the importance of marine fat (omega-3) in the prevention of cardio vascular and mental disorders among Canadian Inuit. The bad

influence of trans-fat acids from junk food will also be examined. A fourth project involves conducting interviews and focus groups on the changing value of traditional fats and contemporary fats in communities at different levels of westernization.
Location(s): Nunavut, Nunatsiavut, Nunavik, and the Northwest Territories

Project Title: Inuit Health Survey: Inuit Health in Transition and Resiliency
Project Leader: Grace Egeland, McGill University
Description: Inuit have concerns regarding the health impact of the pressures of change that have occurred and continue to occur in all dimensions of life and culture, from changing physical and natural environments to changes in sustenance, social life, and health and well-being. In the face of these rapid changes, Inuit have proven to be a resilient and adaptive people. A health survey will form baseline information for future comparisons and provide opportunities for improving our understanding of the changes that are occurring and how they affect the health and well-being of Inuit.
Location(s): Nunavut, Nunatsiavut, and the Inuvialuit Settlement Region of the Northwest Territories

Project Title: Inuit History: Climatic Change and Historical Connections in Arctic Canada
Project Leader: Patricia Sutherland, Canadian Museum of Civilization
Description: Archaeologists and palaeo environmental researchers will collaborate in investigating archaeological sites occupied during the period between AD 1000 and 1900, when ancestral Inuit first arrived in Arctic Canada. The sites have been selected in order to shed light on the interactions between Inuit, their Tuniit (Dorset culture) predecessors, and early Europeans.
Location(s): Nunavut and the Northwest Territories

Project Title: Inuit Sea Ice Use and Occupancy Project
Project Leader: Claudio Aporta, Carleton University
Description: This project's aim is to provide a broad snapshot of Inuit knowledge and use of sea ice in the Canadian Arctic. The project also allocates resources to contribute to scientific, educational, and policy initiatives that seek to incorporate Inuit and scientific knowledge in investigating, or addressing environmental phenomena and/or change.
Location(s): Nunavut, Nunavik

Project Title: Investigation of the Effect of Climate Change on Nutrient and Carbon Cycles in the Arctic Ocean
Project Leader: Roger Francois, University of British Columbia
Description: This study will provide crucial information that will enable scientists to better predict the effect of changes in temperature, ice cover and fresh water discharge on the productivity, ecosystem structure and carbon sequestration capacity of the Arctic Ocean. This information will also help predict the impact of climate change on the socio-economic sustainability of northern Canadian communities.
Location(s): Two oceanic research cruises in the Beaufort Sea and the Chukchi Sea

Project Title: Kwaday Dan Ts'inchi Discovery - Expanding our Understanding through Linked Scientific and Community Studies Project
Project Leader: Sheila Greer, Champagne and Aishihik First Nation
Description: To address the information gaps in our understanding related to the remains of a young adult aboriginal male found eroding out of a receding glacier in Tatshenshini-Alsek Park in northern British Columbia in 1999, a research program focusing on the artefacts recovered as well as on the discovery site landscape and setting will be initiated. This will include studying the DNA of animal parts on the artifacts to establish the species represented; analysis of pigments on artifacts to determine their source/origin; and producing both detailed site and local context maps, including maps of former glacial extent. The community-based studies will include: documenting traditional knowledge regarding the find; reproducing the gopher robe, one of the key artifact finds; investigating local indigenous paint sources; and investigating aboriginal travel routes in the area of the find, to tie in with the reconstructed glacial extent maps; and place names research.
Location(s): northern British Columbia

Project Title: Measuring the Impact of Climate Change on Landscape and Water Systems in the High Arctic
Project Leader: Scott Lamoureux, Queen's University
Description: This research will investigate how climate change effects Arctic rivers, soils and vegetation, and provide an understanding of the hydrological and ecosystem processes that are sensitive to climate change. The research also seeks to predict and anticipate future climate change effects. There are plans to train young adults in environmental science methods and educate them about the research. In addition, the research team will work with community leaders to develop a science learning program for elementary students in northern communities.
Location(s): Nunavut

Project Title: Monitoring the Impacts of Global Change on Caribou and Wild Reindeer and their Link to Human Communities.
Project Leader: Don Russell, Yukon College
Description: An international network of scientists, managers and community representatives will work to improve our understanding of the impacts of changes in the Arctic on caribou and wild reindeer herds, as well as the people that depend on them for survival.
Location(s): Northwest Territories

Project Title: Northwest Territories Ice Patch Study
Project Leader: Thomas Andrews, Prince of Wales Northern Heritage Centre
Description: The Northwest Territories Ice Patch Study combines archaeology, biology and geology to investigate ancient hunting artifacts and animal remains preserved in alpine ice patches. The field research will focus on recovering artifacts and biological samples from ice patches in the Mackenzie Mountains. This information will help manage caribou populations in the Northwest Territories and contribute to the sustained health and cultural well being of Aboriginal communities that rely on caribou for traditional subsistence activities.
Location(s): Mackenzie Mountains, Northwest Territories

Project Title: Ocean Currents of Arctic Canada
Project Leader: Humfrey Melling, Fisheries and Oceans Canada
Description: This project will measure how much fresh water, salt water and sea ice pass from the Arctic Ocean to the Labrador Sea through the Canadian Archipelago each year. It will also determine what drives this flow, and how it will change with changing climate. Fresh water mixed into ocean surface water is critical to: (1) protecting Arctic ice from warm ocean water; (2) the productivity of Arctic marine ecosystems; and (3) the occurrence of ocean overturning in the Labrador Sea that removes climate-warming carbon dioxide from the atmosphere. Because a warmer climate may deliver much more fresh water to the Arctic, this research will clarify climate change impacts on local marine ecosystems and human activities, and also the impact of climate change on global deep ocean circulation.
Location(s): Qikiqtaaluk Region in Nunavut

Project Title: Ocean Production of Trace Gases in the Arctic and their Impact on Climate
Project Leader: Maurice Levasseur, Université Laval
Description: The biological and photochemical production of a number of climate-active trace gases and related atmospheric compounds, including aerosols, will be measured during two autumn expeditions on board the ice-breaker *CCGS Amundsen* in 2007 and 2008. This project's goal is to provide critical knowledge on the interactions between sea ice, gas circulations and emissions, and particles in the Arctic. The end goal is to help reduce uncertainties surrounding these climate processes.
Location(s): an East-West transect across Baffin Bay and Lancaster Sound/Barrow Strait in Nunavut

Project Title: The PEARL near the Pole – Atmospheric Research in the High Arctic
Project Leader: James Drummond, University of Toronto
Description: PEARL is a new atmospheric research laboratory at Eureka, Nunavut. International Polar Year observations at this site will be intensified and several specific research projects will be conducted. Coordinated atmospheric experiments will be run in conjunction with other similar laboratories around the Arctic. The Arctic atmosphere is expected to undergo many changes in the coming years, many of them much larger and faster than will occur at lower latitudes.
Location(s): Nunavut

Project Title: Permafrost Conditions and Climate Change
Project Leader: Antoni Lewkowicz, University of Ottawa
Description: The goal of this project is to provide a snapshot of permafrost conditions during the International Polar Year that we can use to make predictions about the future. Permafrost and the ice it contains make it difficult to build houses, roads and pipelines in the North. However, if the permafrost thaws this may cause new problems. Research is needed to understand how quickly change is happening and to help prepare northern residents and communities – as well as industry and governments – for the future.
Location(s): Yukon, Northwest Territories and Nunavut

Project Title: Polar Ecosystems in Transition: An Interdisciplinary Investigation into the Impacts of Climate Change on Polar Bears
Project Leader: Elizabeth Peacock, Government of Nunavut
Description: This project's objective is to gather scientific and Inuit knowledge on changes in the polar bear ecology. The project will examine foraging ecology (changes and variations in terrestrial feeding, and the correlation of seal and polar bear growth) in four populations. The study will also record Inuit knowledge related to the subject in one of the populations. Finally, the study will examine how the accumulation of contaminants in one population has changed with increasing temperatures.
Location(s): Nunavut, Manitoba, Nunavik, Nunatsiavut

Project Title: Pollutants Travelling in the Air to the Arctic
Project Leader: Hayley Hung, Environment Canada

Description: This project will measure toxic chemicals produced from human activity and carried through the air to the Arctic. The chemicals will be measured in the air around the Pacific Rim to find out where they have come from and how they ended up in the Arctic. As these chemicals reach the Arctic, they fall to the ground, potentially affecting the health of both humans and animals. This project will help to determine where these chemicals have come from and how the weather influences their presence in the Arctic.
Location(s): Little Fox Lake, Yukon (closest community: Whitehorse), and Alert, Nunavut (closest community: Grise Fjiord).

Project Title: OASIS-CANADA: Understanding Ozone and Mercury in the Air Over the Arctic Ocean
Project Leader: Jan Bottenheim, Environment Canada
Description: When the sun rises in the Arctic, both tropospheric ozone gas and toxic chemical mercury mysteriously disappear from the air in the lowest layers of the atmosphere. OASIS-CANADA aims to understand the causes of their disappearance while investigating the effects of reduced ozone on Arctic's environment and whether the disappearing mercury ends up in the Arctic food supply. It will also look at how this might contribute to climate change.
Location(s): The Arctic Ocean

Project Title: Variability and Change in the Canadian Cryosphere (Snow and Ice)
Project Leader: Anne Walker, Environment Canada
Description: Research activities involve investigating the current state and past change of the cryosphere (snow, lake and river ice, sea ice, frozen ground, glaciers and ice caps) through analysis of satellite data and images, field measurements, and historical data. Projections of future climate change will be evaluated and enhanced by improving the representation of the cryosphere in Canadian climate models. This project will provide new satellite derived information products to meet the needs of a wide variety of users including northern communities and water resource management and operations. It will also support climate impact studies and the development of adaptation strategies.
Location(s): Yukon Territory**,** Northwest Territories, Nunavut, northern Quebec

Annex 3. Summary of ArcticNet projects potentially related to AMAP

Broad Objective: The central objective of the Network is to translate our growing understanding of the changing Arctic into impact assessments, national policies and adaptation strategies.

Activities under ArcticNet are organized into projects that fit within one of four Themes. Some general information about specific projects and the elements of those projects that might be relevant to an AMAP are provided below.

Associations with AMAP: All of the projects described below are associated with AMAP and its climate change science related mandate. Some project are directly related to AMAP contaminants monitoring with links to the Northern Contaminants Program.

Permafrost and Climate Change in Northern Coastal Canada
Project Leader(s):
Allard, Michel
Pollard, Wayne

This project will analyze how permafrost, or permanently frozen ground, is likely to respond to a changing climate in the coming decades. Permafrost is the foundation upon which northern communities and ecosystems depend, so determining its fate is important to a number of different disciplines. Regional climate models (which provide a better snapshot of local conditions than do large-scale general circulation models) will be used to determine ground surface temperatures, both under current climate conditions and under projected ones. The impact of melting permafrost is often a function of how much ice is found below the ground surface, so an important component of the project is to assess where this ground ice is located. Other factors that have a bearing on the impact of warming permafrost are the type of soil, the vegetation cover, snow depths, and soil moisture, so these are elements that will be considered as well. The regional model is being modified so that changes to the ground surface will be incorporated as feedbacks into successive runs of the model; this will provide a more realistic projection of the temperature response of permafrost than is currently available. Changes to the landscape as a result of the changing permafrost temperatures will be monitored, including the development of landforms such as slumps, changes in the type of vegetation, modification of drainage patterns, and coastal erosion. A range of environments will be examined so that naturally occurring changes can be clearly distinguished from ones generated by development or land use. Projected permafrost temperatures and modifications to the landscape will be mapped to provide policy makers, managers, and land use planners with the tools needed to assess the impact of a changing environment.

Impact of Climate Change on Arctic Benthos
Project Leader(s)
Archambault, Philippe

Life on the ocean floor is astonishingly diverse, but still very poorly known, especially in polar regions where ice cover has restricted sampling. Climate warming is driving a rapid transformation of polar ecosystems, and we urgently need to study the vulnerability of seafloor biodiversity to changes that are already underway. For instance, as wide areas of the Arctic are shifting from arctic to subarctic conditions, water temperatures are rising and ice cover is diminishing. Both of these factors will alter productivity patterns in the surface ocean and thus alter the delivery of organic matter to the seafloor. Major changes in food input will propagate throughout the benthic ecosystem, affecting biodiversity and ecosystem processes. Changes in ice cover are also likely to bring increased human economic activity to arctic seas, some of which (eg. bottom trawling) will directly impact seafloor ecosystems. In this context of potential widespread changes to deep-water benthic communities in the Arctic, we propose to establish benchmarks at biodiversity 'hotspots' - areas with a high number of species and abundance - and 'coldspots' where opposite conditions prevail. We anticipate that impacts of climate warming on the benthos will be amplified at these sentinel sites that represent extremes of benthic productivity and biodiversity. Hotspots are areas of concentrated utilization of surface productivity by the benthos, as a result of current patterns or direct sedimentation from above. Coldspots are, in turn, areas of the seafloor with a much-reduced food supply as a result of unfavorable horizontal transport or low overlying productivity. Knowledge resulting from our research efforts will enable us to better understand how the arctic benthos will be affected by climate-driven changes in oceanographic conditions and resource exploitation. We have a unique opportunity to document almost pristine conditions before the Arctic Ocean undergoes major changes. Specific objectives of this research program are therefore i) to describe and compare the biodiversity and secondary productivity of demersal fish, macro benthic and meiobenthic communities in areas of enhanced and reduced productivity and diversity ("hotspots" and "coldspots", respectively), ii) to document the diversity and substratum-related abundances of megafauna as a baseline reference for future comparisons as Arctic conditions change, iii) to examine the role of biohermal structures in promoting the diversity of demersal species, iv) to test whether food-chain length changes with resource availability in response to climate ecosystem changes, v) to establish an ecological baseline through biological, chemical and geological signatures in sediment deposits, and finally vi) to identify features unique to regional hotspots. Overall, this research program will enhance our knowledge of the role of the benthos in the Arctic marine ecosystem and will help our partners to establish monitoring programs and conservation strategies to respond to the challenges of environmental change.

The Role of Sea-Ice in ArcticNet IRISes
Project Leader(s)
Barber, David G.

The observed decline in the summer sea ice, in terms of both magnitude and trend, is alarming. We are changing the arctic from one that has been dominated by multiyear sea ice to one that will now be dominated by first-year sea-icerelated processes. We can expect a seasonally ice free arctic early in this century. It is important to note that our planet has not had a seasonally ice-free Arctic for at least the past 1.1 million years. This reduction in sea ice is of critical importance to all peoples of the world because of the role that the Arctic plays in the ventilation of the Atlantic and Pacific (Carmack et al. 2006) and because of the large effect that the sea ice albedo-feedback mechanism has on acceleration of warming and increased fluxes of green house gases to the atmosphere (due to permafrost melt). Both flora and fauna have evolved over millions of years to take advantage of the presence and timing of the seasonal sea ice life cycle. Now, northern peoples increasingly are finding their traditional way of life under pressure from these changes as they struggle to adapt. Global warming changes both dynamic and thermodynamic processes of snowcovered sea ice and these changes have an impact throughout both the physical and biogeochemical cycling in the Arctic marine system. The next few decades will proceed with significant challenges for the Arctic. Marine ecosystems will come under increasing pressure; industrial activity will increase as more exploration and development occurs; and the Inuit people will increasingly find it a challenge to use sea ice for cultural and subsistence purposes. This project will provide sea ice expertise to the coordinated ArcticNet IRISs of the coastal Canadian Arctic, supplying the required information for sound management of these challenges.

Freshwater-Marine Coupling in the Hudson Bay IRIS
Project Leader(s)
Barber, David G.
Sydor, Kevin

Climate models predict warming in the Hudson Bay watershed that may alter the amount and timing of runoff and hence, of the load of suspended solids, dissolved organic matter and other major nutrients, and heat delivered to the Bay. In the Churchill and Nelson estuaries, such changes will be superimposed on earlier changes in the hydrological regime – diversion of Churchill River flows into the Nelson River and a shift of a third of total discharge from summer to winter. Our study of transfer pathways through river estuaries into Hudson Bay will improve our understanding of the effects of these changes. The overarching objective of this project is to describe the impact of freshwater quality and quantity on marine processes within Hudson Bay. In particular we are interested in understanding the principal processes which couple the freshwater and marine systems in Hudson Bay and to examine the cumulative impacts of climate change and hydroelectric development on Hudson Bay. Our key industry partner (Manitoba Hydro) will use this information to examine aspects of environmental impacts due to development of dams along the Nelson River, including the planned development of Conawapa in 2010. More specifically our team will determine the fluxes, pathways and fate of suspended solids

and dissolved organic matter transferred through the Churchill and Nelson estuaries during the open water season when mixing in the estuary is determined by wind-driven waves, tides and fluvial and marine currents, and under ice, when mixing is determined by tides and fluvial and marine currents alone. We will also investigate the relative significance of fluvial loading and littoral resuspension to concentrations of suspended solids in the estuaries and Hudson Bay and to study the effect of suspended solids and dissolved organic matter on radiative transfer in the estuary and nearby Hudson Bay. This team will also investigate historical effects of climate on Hudson Bay by interpretation of data stored in bottom sediments within our three supersites – the estuaries of the Nelson and Churchill Rivers, and of the Grande Rivière de la Baleine – and also in sediments deposited at the Bay-wide scale.

Analysis of Past Hydro-Climatic Variations in Nunavik
Project Leader(s)
Bégin, Yves

Nunavik is one of the areas of the Northern hemisphere where climate change was the most important during the thirty last years. Precipitations diminished by about 15% in Central Québec over this period. The situation could have serious socio-economic consequences insofar as nearly 50% of the hydroelectric production of the province comes precisely from this area. It is important to be able to locate the recent trend of the hydro-climatic conditions from the long-term point of view The short weather registers available do not allow such assessment of a trend. This project proposes to reconstruct the natural variability in the long term, especially the hydroclimatic variables used in modeling precipitations and runoff. Using an extended network of tree-ring chronologies, the project consists in studying temporal and geographical hydroclimatic variations over the past 250 years and, at some locations, over the last millennium at a yearly resolution. Our result will be compared with the reconstruction of the last 50 years climatic variations form the Canadian Regional Model of Climate (CRMC). Statistics from the model runs and from our tree-ring reconstructions will also be compared over Nunavik. The analysis of the temporal variability of hydro-climatic conditions will also be extended to the last millenium by developing lonbg chronologies with coarse woody materials in lakes. The records and the reconstructions of climatic variables will be used to get a picture of the climatic variations over the pre- and post-industrial period. We intend to share our results with other work done in other IRISes to detect any regional differences in climatic trends, as suggested by the recent literature.

Instability of Coastal Landscapes in Arctic Communities and Regions
Project Leader(s)
Bell, Trevor
Forbes, Donald

Future climate scenarios and impacts modeling predict changes in climate variables that may increase coastal landscape instability and hazard risk. Projecting the future response of the coastal land system to these changes in climate forcing is a prerequisite for an effective adaptation strategy and forms the core of this ArcticNet project. Through

improved understanding of changes in climate, sea-level, sea ice, storms and wave climate, seasonal thaw depths, and other aspects of environmental forcing we will assess integrated impacts on coastal landscape stability, including flooding, erosion, habitat integrity, and community vulnerability. Together with northern communities and partners we plan to integrate local and external research and knowledge on climate-change trends and impacts in order to provide a common basis for decision-making at all levels, thereby enhancing community adaptive capacity. Ultimately the goal is to promote informed choices of adaptation measures and enhanced resilience in northern coastal communities.

Effects of Climate Change on the Canadian Arctic Wildlife
Project Leader(s)
Berteaux, Dominique

Many northern biological systems are undergoing major shifts related to climate change. An understanding of this transformation and of the significance of its consequences is critical to anticipating ways in which potential negative and positive effects to wildlife populations (and ultimately humans) may be mitigated or used through sound management and intelligent policy. Our overall goal is to provide the wildlife-related knowledge necessary to conduct the integrated regional impact studies of the "Eastern Arctic" and "Hudson Bay", two of the four regions identified by ArcticNet to conduct regional impact studies. We will work through 4 specific objectives. First, we will identify the main vulnerabilities of Arctic wildlife with regards to climate change. Second, we will implement a second phase of the wildlife monitoring program that this project has conducted from 2004-2007. We will monitor more than 30 wildlife populations (mostly tundra wildlife and marine birds) at 6 main study sites located in the Eastern Canadian Arctic (from South to North: Belcher Islands, Rankin Inlet, Coats Island, East Bay-Southampton Island, Bylot Island, and St.Helena Island). Third, we will use data from our own field work and from the available literature to describe and analyze past and present responses of wildlife to climatic variability in order to develop Impact Models. Finally, we will project some wildlife patterns by forcing these Impact Models with regional climate change scenarios. This project is a collaboration between ArcticNet researchers and a number of partners including the Canadian Wildlife Service, Parks Canada Agency, Wildlife Conservation Society Canada, Nunavut Tunngavik Inc., Nunavut Wildlife Management Board, and Ouranos consortium on regional climatology and adaptation to climate change. Our project will allow ArcticNet impact studies to provide decision makers in the wildlife sector with a sound basis for working at adaptation strategies in a changing climate.

The Law and Politics of Canadian Jurisdiction on Arctic Ocean Seabed
Project Leader(s)
Byers, Michael

The possibility that the Arctic Ocean seabed contains vast deposits of hydrocarbons is attracting considerable attention. Under the 1982 UN Convention on the Law of the Sea (UNCLOS), any state party may, within 10 years of ratifying, seek to extend certain sovereign rights over the seabed beyond its 200 nautical mile Exclusive Economic Zone.

To do so, it must establish—through the collection and submission of information concerning topography and geology—that the area of seabed in question is a "natural prolongation" of the continental shelf within 200 miles. Canada, which ratified UNCLOS in 2003, is currently mapping the seabed along its northern coastline so that it can submit the necessary information to the UN Commission on the Limits of the Continental Shelf by 2013. The United States, Denmark and Russia are undertaking similar exercises, albeit with different timelines. This international, interdisciplinary research project focuses on several outstanding maritime boundary disputes—involving the United States, Denmark and potentially Russia—that must be resolved before Canada can submit a comprehensive package of information to the UN Commission. The resolution of these disputes is highly desirable because the Commission lacks authority to deal with information submitted by a state where it is possible that another state will have a claim to that same area. The project will analyze the legal and political differences involved in the different disputes, explore the various options for resolving them, and provide detailed recommendations. These recommendations will specify a series of considered options occupying progressive positions on the scale of political and technical acceptability. Then, the government of the day will be able freely to select the option that best suits its priorities and objectives, or use the input from this project to craft a better option of its own.

Population Dynamics of Migratory Caribou in Nunavik/Nunatsiavut
Project Leader(s)
Côté, Steeve

Migratory caribou are now abundant in northern Québec and Labrador, where they are central to the economy and traditional life of northern peoples. They are also economically important for a major outfitting industry, much of it involving Aboriginals. Scientific and Aboriginal Traditional Knowledge, however, indicate that populations of migratory caribou undergo drastic changes over several decades. Caribou herds are declining almost everywhere else in Canada, and the factors responsible for those declines are poorly known. Caribou also face threats from expanding resource-extraction industries and from climate change. A major preoccupation is that warmer weather may delay the freeze-up of hydroelectric reservoirs, possibly disrupting migration routes or mass drownings if caribou attempt to cross on thin ice. Through the cooperation of government agencies, Aboriginal groups and industry partners we will combine existing long-term data, monitoring of known-age caribou with satellite collars, new statistical techniques, satellite-derived information on plant productivity and small-scale climate manipulations to establish how climate and population density affect the food resources of caribou, their habitat use, choice of calving site, body growth and condition, recruitment and age-specific survival. These are the most important factors currently thought to affect caribou abundance and distribution in the Arctic. We will also address the effects of industrial activities on caribou ecology and quantify the impact of caribou on vegetation in key seasonal ranges. Of the two large herds of caribou in northern Québec and Labrador, the Rivière aux Feuilles herd appears to be declining, while the Rivière George herd declined substantially over the past decade but now seems to be recovering, as suggested by improvements in calf recruitment and body condition. In

addition to identifying the factors responsible for changes in population density and distribution, our work will provide managers and Aboriginal Peoples with new tools to monitor the demography of caribou and therefore improve their conservation in the face of climate change.

Marine Fatty Acids in a Changing Canadian Arctic
Project Leader(s)
Dewailly, Éric

To survive in the Arctic, Inuit had for centuries to rely on fish, mammals and some plants. They were able to derived most of their essential nutrients from the sea. Marine lipids were extremely important not only for energy but even more for their essential role in all human biological functions. Inuit are still one of a unique group of human beings which still rely on wild animals for their diet as the hunter gathers did thousands years ago. Omega-3 fatty acids are one of the most important factors which could explain why Inuit are protected against chronic conditions such as cancer, diabetes and cardiac diseases and why they give birth to big babies. The Arctic environment is changing. A warming climate might be responsible to changes in micro algae lipid composition affecting the entire arctic food chain including humans. Contaminants are now reaching the North and have entered the food chain affecting Inuit children and adults. How far those toxic effects are partially antagonized by omega-3 is a key issue. The society itself is changing. The modernization of the society now affects the diet. More sugar and a silent invasion of industrial-made fats (trans-fats) might change the health profile of Inuit soon. With a better understanding of all these questions, we will be able to orient public policies and thus prevent the consequences of these changes.

Multi-Species Tracking of Aquatic Animals in the Canadian Arctic
Project Leader(s)
Dick, Terry

Humanity is currently at a crossroads where our choices will dramatically influence the fate of the planet's life. Researchers are only beginning to understand Earth's oceans and marine life, and how they act as essential parts of the planet's life support system. Making better choices as stewards of the planet involves a greater understanding of Earth's life support system and the impact of climate change. The Arctic serves as a large-scale model, which is already offering insight into the dramatic changes associated with global warming. The Ocean Tracking Network (OTN), in partnership with ArcticNet, aims to provide current and long-term monitoring of the Arctic Ocean using Canadian-made sensory arrays that record the physical and chemical conditions of the water column and simultaneously record the movement and behaviour of marine animals tagged with acoustic tags. Tags can be surgically implanted into animals as small as 20 gram Arctic char or attached externally to larger animals such as a 20 tonne Bowhead whales. This Arctic research is connected to a several northern communities and a post secondary institute and will contribute to the technical capacity and decision-making ability of Arctic communities. This project is part of a global ocean monitoring network that aims to provide new knowledge so people can make better choices related not only to

consumption of local plant and animal life and the environment, but to society, economics, culture and health; life changing choices that will ultimately determine the fate of humanity, wildlife and the life support system we all depend on.

Impacts of Global Warming on Arctic Marine Mammals
Project Leader(s)
Ferguson, Steven

This project will examine global warming and the effects on water-based mammals in the Arctic. Research will answer: • How will marine mammals adapt to global warming – and what are the possibilities for future survival? • What is the relationship between warming temperatures and the habitats of polar bears, seals, and whales? • What are the potential effects of global warming on reproduction, and how many mammals will survive? • What will be the effects of changes on northern communities and Inuit lifestyle? • How can we reduce the effects of these changes and shelter the people and animals into an uncertain future? Several areas of mammal health will be studied, including diet, diseases, contaminants, and stress. Satellite tracking, tissue samples from local hunters, genetic and population modeling, are the methods that will be used to understand change. Knowing how polar ecosystems may change with global warming will help to develop strategies for conservation and species management. It is important to recognize the changing distribution and numbers of Arctic mammals. Northerners depend on these species as a food source and as an integral part of their unique culture. Research results will help Inuit communities adapt to changes to marine mammal distribution and abundance while preserving their cultural lifestyle.

Long-Term Observatories in Canadian Arctic Waters
Project Leader(s)
Gratton, Yves

The Arctic is rapidly changing! Preliminary observations show that the Arctic ice cover was 20% smaller in September 2007 than in 2005, the year with the smallest ice cover on record. The ice cover is the insulation between the atmosphere and the ocean. A shrinking ice cover means that more light and more heat are going to penetrate in the Arctic Ocean and totally change the Arctic environment. The objective of this project is to monitor these changes in physical, biological and geochemical properties of the Canadian Arctic waters. We plan to deploy twelve ocean observatories in Hudson bay, Baffin Bay, Beaufort Sea and the Eastern Arctic Ocean. These observatories are the oceanic equivalent of atmospheric meteorological stations. They will be deployed and recuperated one year later. While in the water, they will record temperature, salinity, velocity, dissolved oxygen, nutrients, light intensity, fluorescence (an indicator of micro-algae biomass) and ice motion. Hydrophones will also record the vocalization of whales and other marine mammals. The data will be used to describe the seasonal and annual variations in the Arctic environment and its local ecosystems. This will, in turn, enable us to understand how global warming is affecting the Arctic and how fast.

Impacts of Vegetation Change in the Canadian Arctic: Local and Regional Assessments
Project Leader(s)
Henry, Greg

The tundra across the Canadian Arctic is already reacting to climate change. Northerners and scientists are observing changes, such as shrubs getting taller and more numerous. The taller shrubs catch more snow, and change the depth and pattern of snow drifting, which could affect travel and caribou migration. Increases in the cover of shrubs will also result in more sunlight being absorbed by the leaves and this will increase the temperature even further. We will study these changes near Arctic communities across the North. Community members will be involved in designing the studies and in conducting measurements on tundra vegetation. One important aspect will be to measure the changes in amounts of berries produced each year in traditional berry picking areas near the communities. Experimental studies including warming with small open-top greenhouses and altering snow deposition with snow fences will also be established. These studies can be incorporated into science studies in the local schools and used to show students how we can put traditional knowledge and scientific studies together. The results will be used in the communities and will contribute to national and international efforts to understand the responses of tundra ecosystems to climate variability and change.

The Canadian Arctic Seabed: Navigation and Resource Mapping
Project Leader(s)
Hughes Clarke, John

This project undertakes the core seabed mapping component of the ArcticNet research program. Underway acoustic mapping of the seabed relief, sediment distribution and shallow subsurface sediments are the prime datasets used by researchers to understand the geological processes shaping the seafloor, to assess natural hazards and coastal habitats and to reconstruct the history of past climatic changes. These mapping results are applied to specific projects in this proposal including : - Marine geohazards to hydrocarbon development - Canada has potentially huge economic benefits to gain by having access to the natural resources of the Arctic Archipelago region. Exploitation in this manner however, can only proceed in a safe and responsible manner, by managing the potential detrimental impacts to the environment. A key requirement is to be able to assess potential natural hazards that might result in harmful affects both to persons and the environment. Natural hazards such as underwater landslides, collapse of offshore structures built on gassy seabeds and the impacts of glacial and sea ice must be known and their risk managed. - Opening new shipping lanes and improving navigational charting. Despite previous focused mapping programs in the bottleneck regions, the Archipelago region remains poorly mapped with shipping normally restricted to narrow singular corridors that may be ice covered. Because the Amundsen is operating a multipurpose mission throughout the region, there is a golden opportunity to simultaneously map uncharted regions to provide alternate pathways. - Past to present evolution of sea-ice regime Understanding past climatic history is the key to predicting

potential future ramifications of a changing sea ice regime. To responsibly plan adaptation strategies, we need to be able to predict future climatic responses and their consequences. It is also the key to understanding the nature of these changes-i.e. are they part of a natural cycle or induced by present excess of greenhouse gases.

High Arctic hydrological, landscape and ecosystem responses to climate change
Project Leader(s)
Lamoureux, Scott
Lafreniere, Melissa

Research at the Cape Bounty Arctic Watershed Observatory, Melville Island, Nunavut, will investigate how climate change will affect rivers, permafrost, soils, vegetation, greenhouse gas emissions and the release of contaminants into High Arctic rivers and lakes. An exceptionally warm summer in 2007, which resulted in widespread permafrost disturbance, will provide the opportunity to evaluate the direct impacts of permafrost melt on High Arctic rivers, ecosystems and landscapes. We will also use satellite images to measure vegetation and water in the soil to extend our results over a larger area and to develop ways to monitor future changes in the arctic. Finally, we will use sediments from lakes to reconstruct past changes in the landscape to identify what changes have already occurred over both the short and long term (500+ years). This integrated watershed network will provide an unprecedented understanding of the sensitivity and anticipated future effects of climate change the High Arctic water, permafrost and ecosystem. We will develop impact models based on river flow and related environmental systems to contribute to the preparation of ArcticNet Integrated Regional Impact Assessment (IRIS) summaries that will be intended for use by northerners and other stakeholders to identify and adapt to environmental, social and health impacts that arise from climate change.

Development of an Ocean Modeling Capacity for the Canadian Arctic Archipelago
Project Leader(s)
Myers, Paul

This community-based, community-managed research is conducted in collaboration with Inuit hunters and sea-ice scientists. It focuses on recording traditional or local knowledge observations and scientific observations relating to sea ice, water currents, snow conditions and weather phenomena. Primary sampling sites will also be used to develop time-series information on physical, chemical, and biological parameters that can potentially be related to the freshwater, nutrient, heat, and mercury fluxes associated with major freshwater inputs in the region. These are key indicators of climate change and the effects of these changes have physical, biological, social and health implications of utmost interest to Inuit. This project provides an essential component, the inclusion of multi-generational expertise of Inuit hunters, in the current assessment of climate change in the Hudson Bay region. This research collaborates with other science-based research, including other projects within the Hudson Bay IRIS, and with Inuit and Cree throughout the Hudson Bay Coastal Region who have monitored climate changes for thousands of years in this area, using traditional observational methods.

Carbon Exchange Dynamics in Coastal and Marine Ecosystems
Project Leader(s)
Papakyriakou, Tim N.

Absorption and release of carbon dioxide by the oceans is one of the primary factors controlling the atmospheric CO2 concentration, and some of the highest CO2 uptake rates reported anywhere have been observed within the Arctic's peripheral seas. However there is a striking amount of spatio-temporal variability in fluxes that have been observed both within and between the Arctic's peripheral seas, and therefore the net strength of the Arctic marine CO2 sink and its potential for change are uncertain. Despite recent increases in research activity, carbon exchange studies in the Arctic Ocean and its peripheral seas are still sparse: ship observations are limited in space and time and attempts to apply remote sensing to estimating air-sea CO2 fluxes in Arctic seas have so far been limited by sea ice, extensive cloud cover, seasonally high pelagic biomass accumulation, and the 'non-universality' of empiricallyderived sea surface temperature – pCO2 relationships. If we are to understand the role of the Arctic Ocean in controlling the modern and future atmospheric CO2 concentration, continuing advancements in process-level understanding of the air-sea flux, as well as improved spatial and temporal coverage of in situ observations, must now be combined with advancements in integrated modelling and scaling methodologies that will allow us to see how the complex factors of the system interact to generate net fluxes. In order to improve our capacity to model CO2 fluxes in the Arctic Ocean, we plan to undertake field studies to parameterize the effects of several factors affecting both the distribution of dissolved CO2 in Arctic surface water and the mechanism by which the gas is exchanged with the atmosphere. Newly developed parameterizations will be implemented into a coupled atmosphere-sea ice-ocean biogeochemistry model to learn how the ocean's response (physical, biogeochemical and biological) to climate change and variability will affect the atmosphere-ocean cycling of CO2 within the ArcticNet domain.

Growth variability and mercury tissue concentration in anadromous Arctic charr
Project Leader(s)
Power, Michael

The project will build on prior work that examined probable climate change related impacts on land-locked populations of Arctic charr by extending the analysis to include migratory or anadromous populations of Arctic charr. Differences in THg accumulation rates in the two life-history (land-locked and migratory) types of Arctic charr will be analysed and the relative influences of diet, temperature and habitat on growth and THg accumulation along a north south gradient from Nain to Pond Inlet will be assessed. Individual variation in marine growth as it relates to temperature will be measured in conjunction with Inuit led population management initiatives in Ungava Bay and validated against cohort-specific growth rates as computed from detailed long-term studies of the Nain Arctic charr fishery. Samples from existing studies will be compared to archival samples to determine if significant temporal differences exist. Collected data will improve current understanding of the interactions of temperature and feeding behaviours in the marine environment and facilitate improved understanding of the

importance of growth for THg dilution. Furthermore, study results will yield the first insights into marine habitat associated rates of change in THg accumulation associated with climate warming and allow direct comparison with existing models of accumulation rates in lake environments. Enhanced understanding of habitat-specific accumulation rates and growth variation will permit more accurate prediction of the effects of climate change on the important anadromous stocks of Arctic charr exploited by the Inuit in traditional subsistence fisheries. Such information will also form a core information input to the regional IRISes to be completed for the Eastern Arctic and sub-Arctic regions under the auspices of ArcticNet. Finally, study information will improve management abilities to make informed decisions about the risks associated with continued country food consumption in the face of climate warming.

Understanding and Responding to the Effects of Climate Change and Modernization in Nunatsiavut
Project Leader(s)
Reimer, Ken
Biasutti, Marina

Nunatsiavut Nuluak is addressing Inuit concerns about the impacts of climate change, modernization and contaminants on the health of marine ecosystems and communities of Northern Labrador. The overarching goal of NN is to involve Inuit and Inuit knowledge in all aspects of the project to ensure the results are meaningful to local communities and industries and to help build scientific capacity in the region. The project co-leads (Nunatsiavut Government, NG, and the Environmental Sciences Group, ESG) have developed core partnerships with organizations such as Parks Canada, the Department of National Defence, INCO (Voisey's Bay Nickel Company), Sikumiut Environmental Management Ltd., the Canadian Wildlife Service, and the Department of Fisheries and Oceans. Together these research partnerships are providing important insights into how the environment of Northern Labrador is changing, what this means for the long term health of marine ecosystems and how Northern communities will access and manage their land and freshwater resources in the future. The development of new partnerships focusing on environmental and public health issues related to weather impacts and water quality brings a logical and important dimension to Nunatsiavut Nuluak. The involvement of the Inuit, the Nunatsiavut Government and federal agencies in all aspects of the project will ensure that new scientific understandings are used to develop adaptation strategies and polices that have direct relevance for the people, industries and environment of Northern Labrador.

Adaptation in a Changing Arctic: Ecosystem Services, Communities and Policy
Project Leader(s)
Smit, Barry

This project documents the changing physical, biological and socio-economic conditions that are affecting people in the Arctic and identifies policies and strategies to assist communities in dealing with these changes. The project builds on previous work on the vulnerabilities of Arctic communities, and it is feasible because of established

collaborations with northern people and organizations. The project includes case studies in all four of the ArcticNet IRIS regions. One main focus of the project involves integrating scientific and traditional knowledge of ice, permafrost, coastal dynamics and wildlife with information about community use of these ecosystem services. The other main thrust is to identify the opportunities in existing policies and co-management arrangements for adaptation strategies to help communities deal with changing conditions.

Effects of Climate Change on Contaminant Cycling in the Coastal and Marine Ecosystems
Project Leader(s)
Stern, Gary A.
Macdonald, Robie W.
Wang, Feiyue

Contaminants pose a potential hazard to Arctic fish and marine mammal health, and ultimately to northerners that consume their tissues as part of their traditional diets. It is therefore imperative that we strive to understand how climate variability in physical forcing and the biogeochemical response to this primary forcing will affect among others 1) contaminant transport processes and cycling; 2) biomagnification through Arctic marine food webs; 3) foraging behaviour of marine mammals (e.g. in response to changing sea ice regimes); 4) changes to hunting patterns and diets of northerners to reflect availability of traditional foods (e.g. less ice may lead to reduced reproductive success of ringed seals forcing northerners to consume more beluga tissues which typically have 10-fold higher contaminant concentrations). Overall, results from our research will help assess the vulnerability of coastal Inuit communities to climate change, document and project impacts of climate change on traditional food security and community health and provide the information required by communities, scientists and policy makers to help develop adaptation strategies. Our findings will help to test and shape the policy for the future management of contaminants emissions and long range transport to the Arctic and will support integrated ocean management programs such as Marine Protected and Large Ocean Management Areas (MPA & LOMA, respectively) such as zone 1(a)s in the Beaufort Sea.

Coping with Atmospheric-Related Hazards in the Canadian Arctic
Project Leader(s)
Stewart, Ronald

Atmospheric-related hazards are a major concern to residents in all regions of the Arctic. This study focuses on its eastern region. Some of the most important of these hazards are strong and variable low-level winds, heavy snow, and freezing precipitation. These are difficult to predict and there are indications that, in the context of global climatic change, there are changes in the local prevailing weather conditions at many communities of the Canadian Arctic. Such changes are stronger and more variable surface winds, heavier precipitation in some regions, less precipitation in others, as well as more frequent occurrence of freezing precipitation. These changes are associated with a perceived

reduced predictability of hazardous weather conditions. Vulnerabilities to changing weather conditions have been identified in several communities. This study will address this issue head-on through a combined effort among local communities, social scientists and physical scientists. It will assess our current knowledge of atmospheric hazards, and it will identify past and current hazardous events with the latter ones benefiting from enhanced measurements. It will suggest improvements in the better prediction of these hazards and it will produce suggestions for adaptation to present as well as future conditions. The results of this study will contribute to ArcticNet's IRIS strategy and will be conveyed to local communities and the public at large.

Marine Biological Hotspots: Ecosystem Services and Susceptibility to Climate Change
Project Leader(s)
Tremblay, Jean-Eric
Gosselin, Michel

Some implications of climate change for the marine Arctic ecosystem are fairly intuitive. For instance, polar bears and ringed seals are bound to be negatively impacted by the loss of ice that provides the physical platform for their hunting and reproduction. Other consequences are less obvious. The micro-algae that grow in the brine channels of ice and in surface waters are the ultimate source of food for the marine food web, much like grass sustains cattle on land. Will the production of these microscopic plants increase or decrease and will the transfer of this production toward harvestable resources become more or less efficient? How will the biomass, distribution and species dominance of microalgae, zooplankton and fish change? Is the capacity of the Arctic Ocean to absorb the greenhouse gas CO2 decreasing or increasing? We will seek answers to these questions by looking at how changes in the physical environment (e.g. loss of sea-ice, increasing temperature and freshwater supply, enhanced episodic mixing of the water column by storms during spring and autumn, increased penetration of Atlantic waters) affect the productivity and species dominance of organisms in the lower part of the food web. Changes in the lower food web are bound to affect the nutrition and spatial distribution of higher trophic level organisms such as seals, whales, and polar bears. We will collaborate with other ArcticNet projects to assemble a comprehensive synthesis of the food web and inform stakeholders via our contribution to Integrated Regional Impact Studies (IRISES).

Freshwater Resources of the Eastern Canadian Arctic
Project Leader(s)
Vincent, Warwick

Lakes and wetlands are major ecological features of the circumpolar Arctic, and they provide many essential services including habitats for aquatic wildlife, drinking water supplies for northern residents, and water for industrial activities. Inuit communities and northern scientists have increasingly observed that these resources are highly vulnerable to ongoing climate change. The project proposed here will continue and extend our observations on lakes and wetlands at key sites in the eastern Canadian Arctic, to identify

and measure aquatic indicators of environmental change in the past and present. These studies will allow us to make assessments of future changes in northern freshwater ecosystems to help guide the formulation of environmental management policies. We will continue our research on lakes, ice shelves and contaminants along the northern Ellesmere Island coastline based out of Ward Hunt Island Observatory, where we will work with Parks Canada to develop facilities, indicators and protocols for long term monitoring. This coastline lies at latitude 83oN, at the northern limit of Nunavut and thus North America, and it is characterized by many climate-sensitive aquatic ecosystems that are highly dependent on ice. We will extend our research to wetlands by assessing the snow storage and melt patterns in Polar Bear Pass on Bathurst Island (75oN). This Wildlife Sanctuary is composed of a mosaic of lakes and ponds, and seasonal snowmelt is considered the most important source of water to this wetland. The resultant models and understanding should be of broad application to arctic wetland wildlife habitats that have begun to respond strongly to climate change. Permafrost thaw lakes are a prominent component of northern wetland ecosystems, and we will work at two sites, Bylot Island (73oN) and Kuujjuarapik (55oN), to determine the environmental factors that control their ecosystem metabolism and net production of greenhouse gases in the present and future. We will analyze sediment cores from northern waters to assess the natural climate variability in arctic and subarctic Canada, and to identify regional variations in climate sensitivity. Finally we will develop and apply new DNA-based techniques to assess the diversity and function of microscopic life in lakes and wetlands and to develop state-of-the-art molecular indicators of climate responses by northern aquatic ecosystems. We will contribute our findings and expertise on Canadian arctic water resources to the ArcticNet IRISs and regional climate impact assessments.

Hydro-ecological responses of Arctic tundra lakes to climate change and landscape perturbation
Project Leader(s)
Wrona, Fred

The Arctic Climate Impact Assessment (2005) concluded that the annual mean warming for the areas north of 60°N to be 3.7°C for the period 2070-2089. Hence, the Arctic is expected to display a warming that is more than twice the global average, show decreases in snow cover and ice extent, display further retreat/degradation of permafrost, and have increased inter-annual variability in extreme precipitation events. Such significant changes/shifts in climatic regimes are expected to have far-reaching impacts on the hydrology and ecology of Arctic freshwater ecosystems, which are highly sensitive to climate variability and change (CVC). Large-scale permafrost degradation (i.e., increased depth of seasonal active layer and/or landscape slumping) is predicted to increase with the effects of climate warming, along with enhanced addition of geochemical loadings (e.g., carbon, nitrogen, phosphorus) to the freshwater environment. In addition, changes in the timing and duration of lake-ice characteristics in conjunction with altered geochemical loadings are projected to dramatically affect affecting freshwater ecosystem productivity levels, energy mobilization pathways and community structure. The goals of this proposal are to: 1) conduct three integrated landscape-lake process and modeling studies that will improve our regional understanding of the sensitivities/responses of

upland tundra lakes to CVC, and; 2) to develop and validate an integrated landscape-geochemical, lake-ice, hydroecological model applicable to cold regions/Arctic systems. The project will produce legacy data and products of direct benefit to the development of adaptation options for the conservation, protection and management of arctic freshwater ecosystems to present and future climate variability and change.