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IN THIS ISSUE

NEW IDEAS ABOUT SOVEREIGNTY AND SECURITY IN THE CANADIAN ARCTIC

Steven C. Bigras

What are the implications of global warming for Canada's sovereignty in the Arctic? A recent international conference in Ottawa has provided much food for thought on this question.

"On Thinning Ice: Climate Change and New Ideas about Sovereignty and Security in the Canadian Arctic" was mounted in January by the Canadian Arctic Resources Committee, The Centre for Military and Strategic Studies at the University of Calgary, and the Canadian Polar Commission. The three national organizations brought together some of the globe's leading experts on climate change, sovereignty and security. By inviting such notables to the conference the organizers were hoping to fuel debate and find answers to questions on the implications of global warming, and whether or not the changing ice regime would bring challenges to Canada's Arctic sovereignty. They were not disappointed.

The Norwegian ambassador kicked off the event by welcoming arctic researchers and conference organizers at an evening reception at his home. Then for the next two days the vast meeting chamber of the Government Conference Centre in Ottawa echoed with the voices of some 30 invited speakers and an audience of nearly 200. Ambassadors, academics, bureaucrats, consultants, military officers, researchers, politicians and university students had gathered to hear what the experts had to say about the warming trend in the Canadian Arctic, and what they predicted the results would mean for country as a whole.

Some scientific experts were telling us that the Arctic is experiencing a decrease in the ice cover thickness and greater areas of open water. If the present warming trend persists the Northwest Passage may soon become a veritable expressway for commercial shipping between Europe and Asia.

This type of scenario brought sovereignty and security issues to the forefront. With the possibility of increased commercial activity in the Arctic, a stronger government presence is necessary to ensure that Canada's sovereignty is upheld. As many of the security experts were quick to point out, a stronger presence may also be needed to deal with such security threats as smuggling and illegal immigration, which may be increasingly attempted in what were once inaccessible locations far from established border checkpoints.

Health issues, lifestyle, and well-being of northerners need to be addressed as a result of increased commercial activity. There are also environmental issues – how to protect and regulate shipping to ensure our waters do not suffer environmental damage, or worse, an environmental catastrophe. There

Canada

is a need to continually monitor water quality to maintain the survival and proliferation of terrestrial and marine species.

As the conference drew to a close, it became increasingly apparent that Canada needs to start strategizing to meet the potential challenges that climate change may bring to bear on our arctic region. The instinctual Canadian response to seek the middle ground when dealing with a problem of this magnitude will not serve the Canadian interest in this instance. What is needed is a radical departure from the status quo.

Through their presentations panelists brought it to our attention that Canada is a polar nation with no national polar research strategy. Canada is seen by other nations as a weak link in terms of its contributions to understanding of the arctic environment and global climate change. For the last five years Canada has seen other nations mount large-scale multinational interdisciplinary research projects in our arctic regions (see "Tundra Northwest 99", *Meridian,* Fall / Winter 2001). This conference has underscored the fact that Canada is ill-equipped to respond to the many and varied challenges global warming may bring. We have gaps in our arctic knowledge base. We have relied on the twin factors of inaccessibility and isolation to deter commercial use of our arctic waters.

The conference concluded with a call for action. Canada needs to step up its research activities in the Arctic. If the Canadian government does not do so – if it continues to ignore the need to increase surveillance and environmental monitoring programs – then the landscape that we fondly call the Canadian Arctic may well undergo a drastic environmental and geopolitical transformation.

Steven C. Bigras is Executive Director of the Canadian Polar Commission.

BIPOLAR SCIENCE: A CANADIAN CONTRIBUTION TO EARTH SYSTEM SCIENCE

Wayne Pollard

EARTH SYSTEM SCIENCE

During the past 40 years developments have combined to reveal to us a new view of the Earth as an integrated system of interacting components. We are just beginning to understand the forcing mechanisms of the Earth's climate system (solar fluctuation, changes in orbit, atmospheric composition, ocean currents) and particularly the role of the polar regions (the cryosphere). Also, after years of debate there is both widespread consensus that human activities are causing global climate change and clear evidence that these changes have already begun.

These scientific advances have been matched by and to some extent stimulated by technological developments. Advances in satellite and manned spacecraft technologies have given us the first global view of the Earth from space. Recent advances in information technology include the capacity to model global systems and analyse the huge databases necessary to look at the Earth as an integrated system.

Possibly the most important development, beginning with the Rio Earth Summit in 1992 and culminating in the Kyoto Protocol in 1997, is the decision to take responsibility for human impacts on the Earth. Earth system science recognises the need to look at whole Earth questions. Polar regions represent one of the biggest unknowns in our attempt to understand the Earth system.

Canadians have a role to play in this process. Not only do we need to work hard as a nation to meet our environmental commitments under the Kyoto Protocol; we also need to expand our scientific vision to include global questions that seek solutions to problems that threaten everyone. We need to look beyond geographically limited problems and join with scientists from other countries on global-scale research programs. Furthermore, we need to take the lead on scientific initiatives in areas where Canadian scientists are internationally recognised, like polar science. Canada remains a world leader in polar science and engineering despite decades of political myopia marked by cutbacks to northern research infrastructure and under-funding.

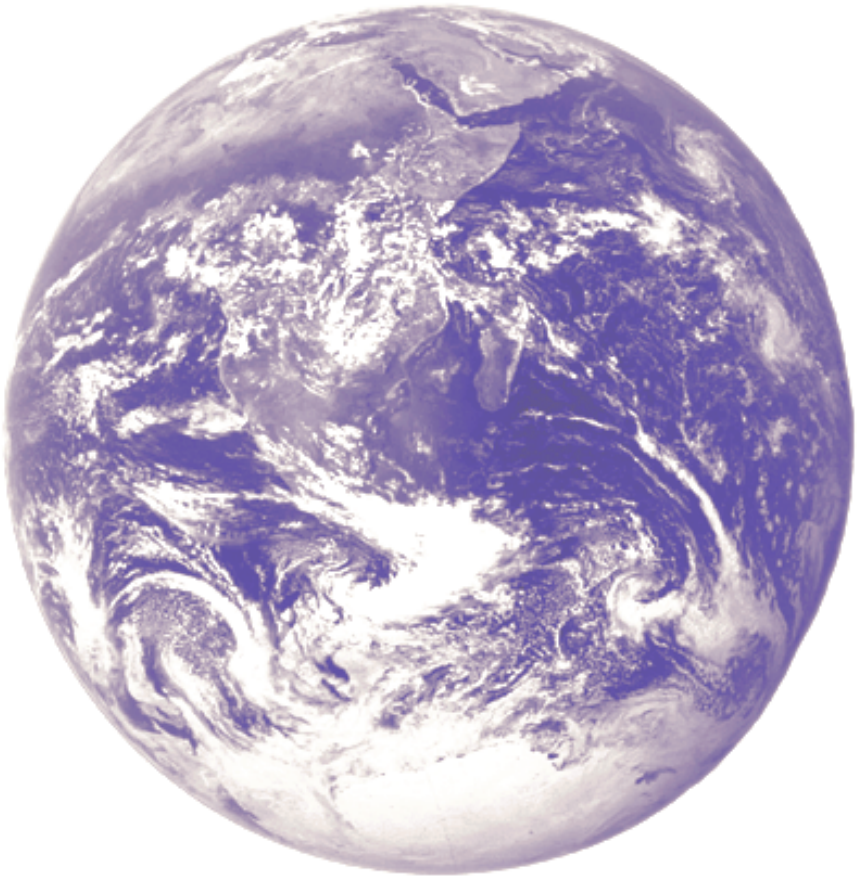


Photo: Courtesy Canadian Space Agency, 2002.

POLAR SCIENCE AND THE CRYOSPHERE

The Earth's planetary properties and geospace relations combine to give our polar regions their extreme environmental character. Polar regions cover at least 20 percent of our planet and play a fundamental role in the physical, chemical and biological operation of the whole Earth system. The predominance of very low temperatures that characterise polar regions produce an integrated environmental system called the cryosphere. The cryosphere is formed through the intimate and interactive linking of the atmosphere, land, oceans and the overall climate setting. This physical system determines the distribution of snow, glaciers, sea ice and permafrost as well as the specialised biology of organisms and the structure and functioning of terrestrial and aquatic ecosystems. Through atmospheric and ocean circulation pathways (and biological migrations), the cryosphere is linked to lower latitudes and is a major driver and modulator of climate. The survival and welfare of northern populations are linked intimately to the cryospheric environment. An understanding of the cryosphere is highly relevant to understanding the global environment and underpins resource utilisation and other activities in polar regions and at lower latitudes. It is therefore of significant strategic importance to Canada.

Five themes are emerging as foci of cryospheric research:

The cryosphere as a major driver of the global climate – Research on the dynamics of the cryosphere contributes to our capacity to understand, monitor and predict the impacts of global change, in particular anthropogenic global warming. Climate change at the poles is forecast to be up to four times the global average and thus will provide early warning and validation of global and regional models.

Palaeoclimate – In both polar regions ice, ocean and atmosphere coexist to form an intimately coupled system with a highly non-linear response to external forcing and complex internal variability. Large spatial and temporal variations exist with both short-term fluctuations and long-term trends. Meteorological records illustrate the degree of natural short-term variability in climate worldwide. However, there is a need to know in more detail how climate has changed both within the Holocene and on longer time scales. The polar regions contain unique deep ice sheets which provide potential records of climate change through many glacial cycles, while lake and marine sediments provide complementary details for both longer and shorter periods.

Depletion of the stratospheric ozone and enhanced UV-B radiation at both poles – The spatial and temporal dynamics of stratospheric ozone provide insights into future change at lower latitudes as well as at the poles.

Exobiology and biodiversity – The polar regions contain unique interconnected systems, and the pattern and variability of the environment are key determinants of their structure. This applies to both terrestrial ecosystems in which climate is the main

determinant and to marine ecosystems in which ocean thermohaline circulation patterns determine the distribution and composition of food webs. The food webs of the two ecosystems are more strongly interconnected than anywhere else in the world. The contrasting geographical isolation of the Arctic and Antarctic also provides a natural laboratory to explore the relative importance of biogeography and environment on ecosystem structure and dynamics. Changes in the distribution and composition of terrestrial systems have feedback effects on climate through albedo and flux of greenhouse gases.

Geospace – The polar regions provide a preeminent platform for both ground-based and space-based research into geospace. Geospace is the outermost region of the Earth's environmental envelope. Storms in geospace triggered by solar activity can interfere with modern navigation and communication systems, damage spacecraft, disrupt terrestrial power systems and pose a health hazard to humans working in space, or travelling in high flying aircraft. The impacts of space weather are global.

POLAR VS. BIPOLAR

The terms polar and bipolar are used to characterise both science and programs whose central focus is defined geographically or environmentally as polar in nature. The programmatic context of these terms is well developed in countries like the United States and Great Britain where Polar and Bipolar Programs are identified explicitly in political agendas and research funding programs. Canada lags behind these countries by failing to recognise and prioritise the strategic importance of polar science at both the funding and political levels.

In addition to the study of natural and social science issues geographically limited to the Earth's polar regions, polar science is also concerned with thematic and systematic investigation of the Earth's polar environments. Studies of polar regions are an essential component of the understanding of the natural dynamics of the world system. Apart from Canada's northern geography, Canadian scientists are interested in the Earth's polar regions for several reasons and as our attention is being drawn to global-scale problems the polar regions are assuming increasingly significant global scientific importance. Canada has a long and distinguished history of polar science and continues to make major contributions to the understanding and exploration of polar regions. Canadians are involved in many polar science issues and are prominent in most, including:

- the influence of polar regions on the global climate system;
- climate change impacts in polar regions;
- stratospheric ozone depletion (seen first in the Antarctic, it is now occurring in the Arctic);
- thermohaline ocean circulation and polar dynamics;
- polar palaeoclimatic records (ice cores and sedimentary records);
- the polar upper atmosphere as a window on space weather processes;
- polar organisms' and ecosystems' unique adaptation to extreme environments;
- polar ocean productivity (supports major fisheries);
- the importance of the cryosphere as reservoir of 80 percent of the Earth's fresh water.

What is Bipolar Science and how does it differ from Polar Science? Bipolar science is a sub-discipline of polar science concerned with the integrated study of both polar environments as part of the whole Earth system. It involves comparative analysis of processes and patterns from both polar environments.

CANADIAN POLAR AND BIPOLAR SCIENCE

Even though only one percent of our population lives in the North, Canada is very much a polar nation and this polar identity is a prominent part of the Canadian psyche. Permafrost and glaciers, the physical manifestations of cold climate that define the North, affect more than 50 percent of Canada's land area and 71 percent of its shoreline (Canada has more shoreline than any other country). It seems only natural that Canada invest in polar science, and implicit in this should be support for bipolar science. Even though the Arctic and the Antarctic are lumped together under the cryosphere label and both have a significant impact on the Earth's circulation and climate patterns,they differ in many respects. Several Canadian scientists and companies are involved in bipolar research activities in a variety of scientific areas, including: remote sensing, glaciology, permafrost and periglacial processes, geology, Quaternary palaeoclimatic reconstruction, microbial ecology, sea ice dynamics, marine ecology, contaminants, ice drilling technology and fisheries, to name a few.

Comparison of polar regions through integrated bipolar studies offers opportunities for interchange of expertise and knowledge between polar regions. A primary vehicle for interchange within Canada is the Arctic-Antarctic Exchange Program. Run by Natural Resources Canada's Polar Continental Shelf Project, which is the primary science logistics agency in the Canadian Arctic, the Arctic-Antarctic Exchange Program provides support to foreign partners in exchange for Antarctic support for Canadian scientists. It has supported two to three projects each year since 1997.

In the foreseeable future Canadian science interest in both the Antarctic and the Arctic will be driven by the following key requirements:

- to provide the basic scientific knowledge of the cryosphere that underpins the understanding of the global environment and all activities carried out in Polar regions;
- to utilise the opportunities provided by Polar regions as a unique laboratory to address questions of global importance and relevance;
- to respond to the needs of industry, government and other users, and in particular to provide the Canadian Government with a high profile presence in the Arctic and Antarctic through quality science, supported by a modern infrastructure and logistic capability.

Science underpins all polar activities ranging from the identification, exploitation, transportation, conservation and management of economic resources to environmental management, and land claims and settlement. It is central to assessing and mitigating impacts on the vulnerable polar environment. Furthermore, high-level and relevant scientific activity supports the political and diplomatic requirements of the Canadian government in respect of its international obligations and legal requirements, among them the Antarctic Treaty, the Convention for the Conservation of Antarctic Marine Living Resources, and the Arctic Environmental Protection Strategy.

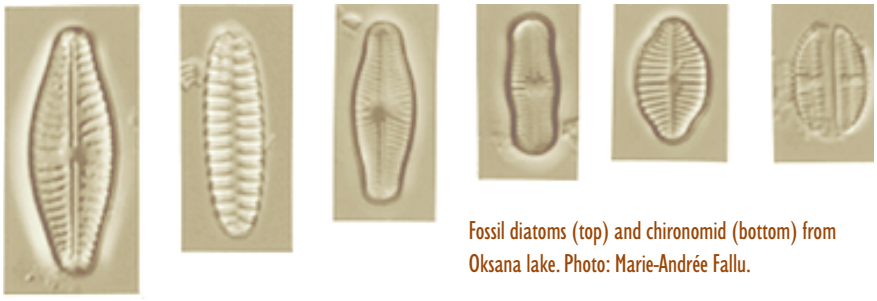
Wayne Pollard is Chair of the Canadian Committee for Antarctic Research.

NORTHERN LAKE SEDIMENT FOSSILS HOLD CLUES TO CLIMATE CHANGE

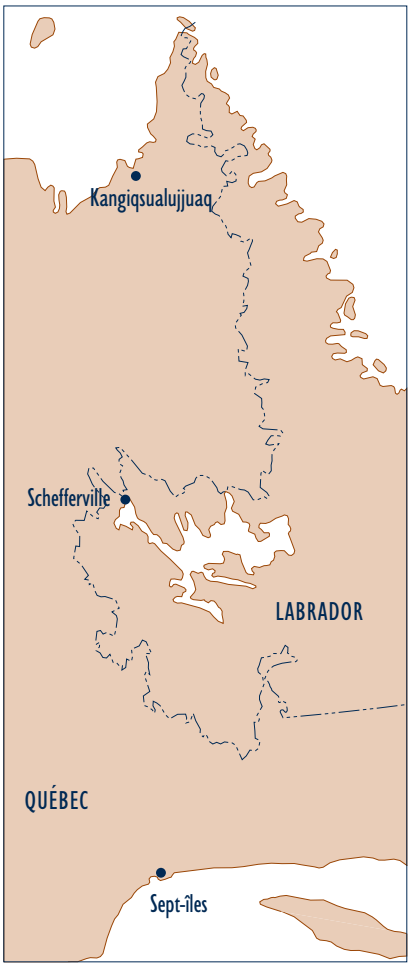
Marie-Andrée Fallu

The northern regions of Canada have sensitive ecosystems that can be affected by seemingly small climate changes. Minor climate modifications could bring drastic changes to terrestrial and aquatic ecosystems, impacting on the inhabitants of these regions. We can use these ecosystems as powerful tools for determining natural response of past aquatic and terrestrial ecosystems to climate changes; and if we understand their dynamics we can predict the effects of future climate changes.

Climate change has transformed innumerable lakes in northern Canada since the glaciers receded (6,000 to 9,000 years ago in central and northern Québec). Recent human activities that degrade the ozone layer and add greenhouse gases to the atmosphere are accentuating natural climatic fluctuations – potentially altering aquatic communities by modifying the moisture regime, and by changing water transparency, thereby changing the penetration of visible and UV light in lakes.



Fossil diatoms (top) and chironomid (bottom) from Oksana lake. Photo: Marie-Andrée Fallu.



But exactly how do these communities change – and how much do they change? Through paleolimnology – the study of past aquatic ecosystem evolution – we can come to understand the long term impacts of climate changes.

Studying past natural fluctuation can help us understand the evolution of ecosystems and their response to environmental change. Learning about these past aquatic communities not only provides a spatial and temporal profile of their evolution, it also gives us information on the environment in which the lakes developed. Few such studies exist for the northern Québec-Labrador region, and we know little about aquatic ecosystem evolution there; and so my work there will fill an important gap.

How do we learn more about past aquatic communities? To find clues we look at evidence that lies buried in the mud at the bottom of northern lakes. Using a long tube-shaped coring device we collect a column of lake sediment, which has been laid down year by year over millennia and constitutes the individual record of each lake's life and times. By identifying the microorganisms (or microfossils) preserved in the sediment record, and understanding the environments where these species live today, we can make inferences about the environment in which they lived in the past.

For this research, I decided to use two different indicators: diatoms and chironomids. My colleagues are using different indicators such as pollen and organic matter content to ensure a complete picture of the past environments.

Diatoms are unicellular algae protected by a silica wall that resists decomposition, allowing the tiny organism to lie preserved for millennia in lake sediment. The silica wall consists of many ornaments, which we use to identify the species. In the northern Québec-Labrador region, freshwater diatoms are good indicators of water alkalinity, water colour, and dissolved organic matter (DOM) concentrations (produced when plants and animals decompose).

Chironomids, also called non-biting midges, are flies (*Diptera*) sensitive to summer water temperature. They begin life as aquatic larvae with a chitinous head capsule that resists decomposition. Variations in the structure of this capsule allow us to identify different species groups from their fossil remains. For both indicators, different species are associated with different environmental conditions, for instance warm versus cool temperatures, or clear versus turbid waters. Changes in species will therefore suggest a change in the environment over time.

The objectives of this study are:

1) to reconstruct a detailed chronology of the environmental and climatic change impacts on aquatic conditions at three sites at different latitudes and in different ecoclimatic zones;
2) to develop a spatial-temporal image of postglacial environmental changes in the Québec-Labrador region using radiocarbon dating; and
3) to compare the synchronicity of several indicators (diatoms, chironomids, and pollen) in order to assess differences between the aquatic and terrestrial organisms' responses to climate changes.

Once we obtain the results we will use them to predict the direct impact of human-derived stresses on the ecosystem – and hence, on human life.

We have collected sediment cores representing the complete postglacial sedimentary sequence from three lakes. Lake K2 (informal name; 58°44'05"N, 65°56'03"W) is located in Nunavik, near Kangiqsualujjuaq. The second site, Oksana (informal name; 54°49'N; 66°50'W) lies near Schefferville. Researchers George A. King and Herb E. Wright (Limnological Research Center, University of Minnesota) provided the last core, extracted from Lac au Sable (51° 24'N, 66°13'W), about 130 km north of Sept-Iles. We used standard techniques to process the samples, and identified and counted diatoms and chironomids at a magnification of 1000X and 40X respectively.

We have recently studied the environmental conditions in which the species live and presented them as a tool to quantitatively infer past environmental variables, based on the fossil assemblages. We applied these tools, called inference models, for the first time in this region. They helped to reconstruct directly (chironomids – water temperature) and indirectly (diatoms – DOM concentrations, water alkalinity, and water

colour) climatic changes and their effects on the drainage basin and on the terrestrial and aquatic communities. We also analysed pollen and sediment organic matter.

Through radiocarbon dating we can establish a good chronology for each core. We used accelerator mass spectrometry carbon 14 dating to determine the timing of events revealed by the fossil records. We now have the basal (oldest) dates for all three lakes, representing the formation of the lake basins. The southernmost lake, Lac au Sable, is the oldest – about 7,000 years old. Next is K2, formed more than 6,100 years ago. Oksana, which lies within the area of a residual ice sheet that persisted until about 6,000 years ago is slightly more than 5,600 years old.

The study is ongoing, but preliminary results from lakes K2 and Oksana are interesting. We found that diatom and chironomid assemblages were influenced when vegetation (determined through pollen analysis) first invaded each lake catchment. Vegetation needed a warmer climate in order to establish itself and increase in density, and the chironomid-based temperature reconstructions do indicate climate warming. Vegetation growing in the catchment led to higher inputs of DOM to the lake, modifying the lake water optical environment (DOM can cause strong water colour, protecting organisms from UV radiation). Diatoms were sensitive to these changes especially during the lakes' early development.

The results also indicated a tendency towards climate cooling over the last 3,500 years, a trend that has been accelerating recently. This cooling is shown by water temperature reconstructions based on chironomids and by DOM reconstructions based on diatoms. Although this may seem contradictory to the global warming scenario, studies of 20th century temperatures have shown that the Québec-Labrador region is presently undergoing a cooling trend.

Field work at Oksana Lake (Schefferville) showing Dr. Reinhard Pienitz, Dr. Ian R. Walker, and Marie-Andrée Fallu extracting a sediment core. Photo: Marie-Andrée Fallu.

In the near future, analyses of pollen and sediment organic matter content will provide further paleobotanical information necessary for comparing the evolution of the terrestrial and aquatic environments. We expect pollen results could show a slight delay in assemblage changes compared with the chironomids, which are directly influenced by water temperature, but shifts in pollen could be synchronous with diatoms, which are indirectly influenced. We will obtain more radiocarbon dates to ensure reliable temporal reconstructions of past environmental changes.

Other researchers are conducting similar studies across northern Canada. Together, these will undoubtedly lead to a better understanding of the impacts of past climate changes on northern ecosystems – and of what the future may hold for Canada's northern environment.

Acknowledgements

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Marie Andrée Fallu, winner of the 2001 Canadian Polar Commission Scholarship (see Meridian *Fall/Winter 2001) is a Ph.D. candidate in Geography at Laval University.*

GLOBAL CHANGE: MUCH MORE THAN A MATTER OF DEGREES

Hadi Dowlatabadi

Concern about global climate change has occupied many environmentalists, scientists and politicians for the past decade. They exhort us to fear runaway anthropogenic climate change and to mind our p's and q's in using fossil fuels and emitting other greenhouse gases.

I have studied climate change for about the same length of time. I believe that it is just one of many challenges we face, and am convinced that a singular focus on climate change will be counterproductive.

In what follows, I will offer my views on four misconceptions about climate change and then suggest their implications for science and policy. These misconceptions are:

- that what matters is the magnitude of climate change;
- that climate change is the only thing we should be worrying about;
- that any climate change is bad and to be avoided; and
- that public mobilization will eliminate climate change.

THE MAGNITUDE OF IMPACTS MATTERS, NOT THE CLIMATE CHANGE

Many people talk about global warming, but climate change is much more than a change in the world's annually averaged temperature. The average annual temperatures of Boston and Vancouver are the same, but the two cities can hardly be thought of as having the same climate. While clouds, precipitation, seasons and winds are all very important to life on earth, what really matters is the synchrony of these changing variables (*i.e.,* weather) and the pulse of life. Rain at the right time leads to blossoms that grow into fruit, and at the wrong time it leads to fruit that rot on the branch.

Most importantly, small changes near different phases of water make a huge difference. A slight change in humidity makes clear air turn cloudy; more moisture still and clouds turn to rain. A small temperature difference around the freezing point of water dictates the difference between rain and snow. The former will flow along the landscape right away, while the latter may stay put for centuries. The impacts of climate change are also context-specific and threshold-sensitive. A small climate change where

Photo: GNWT, RWED.

the system is close to a crucial threshold can lead to monumental impacts. A centimetre more or less rain per year in Vancouver will not have any discernible impact, but the same change in rainfall in the Kalahari desert defines the difference between life and death.

When we think about climate change as a global policy problem we tend to forget that different parts of the world will be experiencing very different levels of climate change. Polar regions are expected to experience the greatest changes. We often forget that the impacts will also be very different. Climate change in Toronto may mean less snow shoveling as well as a higher summer energy bill as use of air conditioning increases. The impact of the same "global climate change" in a low-lying coastal region or island may be permanent inundation. A simple matter of shifts in energy expenses for one person cannot be compared to the loss of homeland for another.

One of the most difficult aspects of challenges like climate change lies in establishing a balance between the economic well-being of some people versus the rights of others, including of course whatever "rights" we accord the innocent by-standers caught up in the action – nature.

WE NEED TO WORRY ABOUT A MULTIPLICITY OF GLOBAL CHANGES, NOT JUST CLIMATE

Climate change is not the only challenge we are facing. In much of the world, Arctic Canada being no exception, we are facing tremendous demographic, social, political, technological, economic and environmental changes – all at the same time. In many locations, most if not all are outpacing climate change. The impacts of many are greater than climate change now, and this will likely remain so for decades. It is the combined negative impacts of these changes that we need to prevent or ameliorate. A focus on climate change alone is guaranteed to be less than productive in solving the problems being faced around the world. One of the challenges we face is that "solutions" to one stress can exacerbate another or even rekindle a dormant problem. We need a systematic analysis of these multiple stresses together with their "solutions" in order to proceed in an informed and productive way rather than staggering like a drunkard from one hot-button issue to the next.

The impacts of changes are more difficult to understand and predict when many are in progress simultaneously. They are more challenging still when the systems are near a threshold (*e.g.,* freezing point of water, edge of a recession, brink of a revolution). Furthermore, both social and ecological systems are complex communities with constituent components that are at different distances from thresholds. The vulnerable subpopulations in each are teetering on the edge of viability. These are highly sensitive to small changes in external variables.

The Arctic is projected to experience the largest change in temperature anywhere on earth. This temperature change will shift the familiar patterns of the ice-water boundary. Current snow and ice routes will grow too dangerous to cross. How this will affect biological patterns – where animals will find water, where plankton will grow and fish find food, which familiar creatures will survive and which foreign creatures will join the new ecosystem of the arctic – is hard to project. Our understanding of how such ecosystems evolve is not sufficiently well developed to make anything but educated guesses. However, where life is finely tuned to old patterns of hunting and fishing, the new ecology will not only make it difficult to traverse old routes across ice-fields, it is also likely to make many of these routes obsolete in purpose.

As if such massive changes were not enough, the Arctic region is undergoing massive changes in many other dimensions. The more recent introduction of modern transportation, communication and navigation technologies has had tremendous impact on fishing and hunting efficiency and on ecology. Sociologically, severe physical hardships may belong to the past, but that welcome loss is marred by psychological hardships associated with needing to find a new way of life as integration into a foreign culture and economy proceeds apace. The rapidly growing population is posing its own challenges. In experiencing so much change, the Arctic is a microcosm of the rest of the world, but it is moving ahead in double time. Climate as well as social and technical changes are all proceeding there at a pace that is faster due to geography of the region, the available resources, and the socio-political changes.

Predicting what will happen to these vulnerable components of the world around us is among the most difficult challenges in science. Protecting their future and steering them clear of danger is among the most difficult of all political challenges.

CHANGE IS PERCEIVED TO BE BAD BECAUSE WE ARE GOOD AT ADAPTING!

For a long time I have wondered why there is so much focus on the negative impacts of climate and other global change phenomena. What seems strange is that it is considered bad everywhere on earth, irrespective of the local climate today. I wondered why our imaginations have been so fertile in conjuring up images of disaster and so bereft of

visions of Elysium. After all, some places nearer to the poles may enjoy the climate of their neighbours nearer to the equator in the near future. These neighbours don't seem to be complaining now, so what is the worry?

I respect the beliefs of those who argue that our climate is perfect as it is because God has made it so, but I have always thought that there has to be more to this than religion. Finally, I had an epiphany. The fact that we are expecting and studying negative impacts of change wherever we live, regardless of current climate, is a reflection of our amazing powers of adaptation. Wherever we find ourselves, given time to grow familiar with the prevailing conditions, we shape our lives, environment and tastes to better enjoy our circumstances.

The key to success in the process of adaptation is the pace of change: having enough time, and knowledge, to react appropriately. If we think the world is not changing but in reality it is, that change will have negative impacts; but if we believe the world is changing and we are cognizant of its speed and direction, we can adapt apace. Furthermore, if for historic reasons we have failed to fully adapt to prevailing conditions in the past, change may provide the opportunity to be better off in the future. It is imperative to help the public recognize that change is afoot and help them utilize their great powers of adaptation.

Archaeologists have found evidence of encampments far further north in the arctic than where Inuit live today. These are relics of times when the climate was warmer. It is difficult to know if the rates of climate change in the past led to widespread famines or hardship. The Dorset people disappeared during the Medieval Warm Period (AD 1000–1300), but the attribution of that event to climate change's impact on local ecology is controversial. So much else – *e.g.,* immigration from Alaska and Europe – was going on at that time.

Mobility has been the key to survival in the arctic. Those who could not respond to the imperative of hunting – following the "footprints" of their prey – perished. But as seasons change, the diet of the Inuit changes also. The Inuit do not follow footprints so much as know where to look for seal, caribou, fish, and walrus. This comes from their knowledge of ecosystem dynamics, rather than seeking prey in a particular geographic location. When climate change shifts specific ecological processes, they are able to know where that shift has taken their prey. Anticipating the new patterns of the ecosystem and incorporating this information into a revised pattern of life is how this lifestyle grew to be so desirable.

Photo: GNWT, RWED.

HELPING THE PUBLIC DEVELOP REALISTIC EXPECTATIONS IS CRITICAL TO ADAPTING TO IMPACTS

I believe the most important determinant of impacts is our expectations. Whether we consider climate change a natural or an anthropogenic process makes a great deal of difference to our acceptance of its consequences. A drought half a century ago would have been considered a rare event, to be endured. A drought today is immediately attributed to climate change – even when it is almost impossible to scientifically show that it is so. When a drought was considered an act of God, we reflected on our own actions and – all but saints amongst us being sinners – saw some justice in being tested. Making the drought a man-made calamity changes how we endure it. We blame the drivers of gas-guzzling SUVs, and uncaring industrialists. Our capacity to cope with the situation and move on is diminished.

Humans have changed the face of the earth since their beginning. Their actions have constantly reshaped their local environments. Now, their "local" environments are growing to encompass the whole earth. It is clear that human actions are leading to significant changes on a global scale, but not all global changes are due to human actions. Thinking they are is a reflection of megalomania.

It is important to realize that some global change phenomena are not amenable to complete human control. The Kyoto Accord for control of greenhouse gases will not have a discernible impact on trends in climate change. We cannot blame the extreme climate events in the past two decades on anthropogenic interference. Storms are part of nature. While our actions may change their pattern and frequency, the impacts they have on denuded hillsides and overdeveloped shorelines is entirely of our making. If we develop realistic expectations about the changes afoot, and realize what leads to loss of life, property and nature, we will be better positioned to adapt successfully.

Unfortunately, environmental activists have steadfastly held on to the idea that by refusing to endorse adaptation, they will be able to secure a stronger plan of action to limit climate change. Their efforts are well intentioned, but costly in our capacity to cope with the coming changes. There can be little doubt that we will continue to increase the atmospheric concentration of greenhouse gases for many decades and that even if the current accords were fully implemented the change in that trend would be hardly noticeable. This hard-nosed pursuit of a greenhouse gas emissions mitigation agenda is leading to inadequate preparedness for adaptation and hence greater hardship.

WHAT CAN SCIENTISTS DO TO HELP?

The foregoing has four implications for scientific activity.

1) We should focus a great deal more effort on understanding the impacts of global change processes, especially for "vulnerable populations" or where systems are close to phase transitions.
2) We should break down the disciplinary approach to problems of global change, acknowledging that there are multiple simultaneous processes ongoing. Through reorganizing our scientific approach to the study and communication of global change, we can hope to influence the political responses that are taking shape.
3) We should employ our skills in the scientific method to learn more effectively about "what works" in numerous natural experiments being conducted all the time.
4) We should communicate more clearly to the public that climate change, and many other changes, have both natural and anthropogenic components and are not amenable to "control" in the manner that we so successfully employed for chemicals that we had synthesized and later found to be undesirable in nature (*e.g.,* CFCs, PCBs, and POPs).

More generally, as we try to address the challenge of prospering socio-economically and protecting the environment while facing multiple interacting processes, we need systematic approaches to understanding what is going on and how to proceed. The approach I have benefited from using to address this challenge is Integrated Assessment. It is a methodology for characterizing the problems we face and the available solutions realistically. It can be used to identify the unknowns (and hence fruits of research) that are critical to making better policy decisions. It can be used to communicate the complex and interactive nature of the challenges at hand, as well as develop priorities for response.

CONCLUSION

As a scientist I wear two hats: one that spurs me on to develop a basic understanding of the world around me, another that reigns me in to focus and bound my query to the information needed to understand and solve public policy questions. The fruits of these two pursuits are not the same. One is basic science, and has scientific merit and intrinsic value. The other is applied science, whose value lies in its ability to solve a real world problem.

The Arctic's pure science agenda may be far less than one could hope for, especially given the vast territory of Canada and the importance of that region for monitoring

and developing a basic understanding of climate change dynamics. However, the people of the circumpolar north do not need fundamental breakthroughs in glaciology or ocean currents to solve many of the challenges they face today and will be facing in the decades ahead. They need better understanding of impacts, processes, and dynamics of systems close to thresholds. They need better understanding of how various development initiatives interact. They need an evaluation of how useful "impact assessments" are, and what factors are critical to making a project successful while protecting the environment.

Experience with nature's variability and extremes give us numerous opportunities to test new strategies and learn what succeeds and what fails. This is the prerequisite to moving forward more surefootedly. Without systematic evaluations of the past and present problems and solutions, the lessons of these experiments will be lost – and we will be groping in the dark towards an unknown future.

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He is grateful for the assistance of Susan Rowley, Curator of Public Archaeology at the UBC Museum of Anthropology and Assistant Professor in the Department of Anthropology and Sociology at UBC, in drafting this article.

INTERVIEW: JEAN BRIGGS

Jean Briggs. Photo: Chris Hammond, MUN Gazette.

Jean Briggs of Memorial University is well known for her pioneering work in psychological anthropology. With support from the Social Sciences and Humanities Research Council she is currently working on a dictionary of the Utkuhiksalingmiut dialect of Inuktitut. The dialect is in danger of disappearing as it gives way to other dialects spoken in Gjoa Haven and Baker Lake, where Utkuhiksalingmiut Inuit now live, and to English. Jean Briggs spoke with Meridian *editor John Bennett. Here are some excerpts from that interview.*

Kindly describe your dictionary project.

I'm making a dictionary of the Utkuhiksalingmiut dialect, which has never been recorded before. In fact there is no published lexicon of any Central Arctic dialect – so I'm helping to fill in that gap.

The dictionary will be bilingual and will include a list of the post-bases, the word parts. Inuktitut is a polysynthetic language: each word consists of a series of word parts, each with its own meaning, which add up to express an idea.

This dictionary is needed partly because Nunavut is trying to rescue as much as possible of Inuit heritage. They are training translators and interpreters and trying to collect enough of a corpus of old Inuit thinking to invent words for new technologies – law, medicine, computers, whatever – and so they need to know how people talk. Linguists need the dictionary too, in order to understand more about the history of Inuktitut and how it has changed over time.

What is your source of words for the dictionary?

I collected about 10,000 words when I was living with the Utkuhuksalingmiut in the 1960s and early 1970s, and I've learned

others along the way in the process of checking the original collection. I was not thinking of making a dictionary in the 1960s; I was learning to speak, and that's quite a different process. I gave a keynote address at the International Arctic Social Sciences Association conference at Laval last spring on this topic of how I learned, and what it means to know a word, and what a dictionary can be about. The collected keynote talks will be published by Laval University. The paper tells you in considerable detail how I learned; I had to begin from scratch. When I arrived in Chantrey Inlet I knew only about six words: yes, no, have some tea, I don't know, have some more tea, thank you – that's it.

I lucked out – I found myself living with a group of people several of whom were extremely inventive language teachers. In fact I'm using their techniques now in teaching introductory Inuktitut to northern native teachers. Allaq and Inutsiaq (these are their pseudonyms from my first book, *Never in Anger*) were the best of all. Inutsiaq was endlessly creative. He would act out things with Allaq as his stooge, if a stooge was necessary. He would say, "*hulirunga?*" (what am I doing?) and I'd say, "*aatsuuk*" (I don't know), and then he would say, "*pihuktunga*", "*nalarunga*" (I'm walking, I'm falling, and so on). I would repeat it and he would correct me, over and over, until finally he said, "yes", when he shouldn't have said yes – he was exhausted!

Eventually I began to take the initiative; I wrote down and asked for definitions or explanations of as many as possible of the words I didn't understand. And I stored them with the speaker's name and the date on three-by-five slips of paper divided in quarters – in empty tobacco tins that they were throwing away.

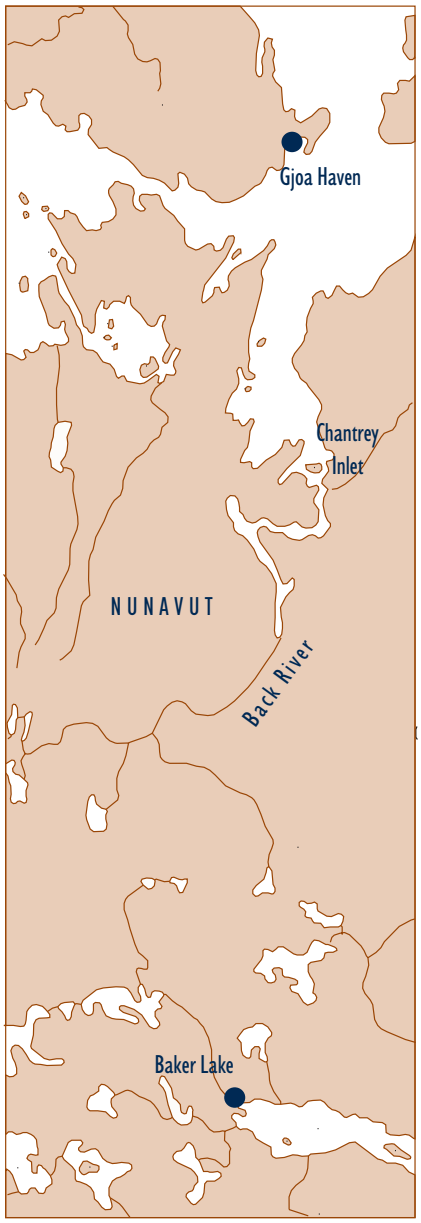
When I had to write this keynote paper, and was casting about for what to say about a dictionary, I began to look at how the Utkuhiksalingmiut had taught me. I discovered how very much they had personalized and contextualized their definitions and taught me in a way that drew me in, socially and emotionally, to what I was learning. That's a very essential part of how I learned, although I didn't know it at the time.

Can you communicate this way of learning in a dictionary? When people use a dictionary they read the definition of the word and it stops there, doesn't it?

Well, that's the way *we* use a dictionary, but there are, I hope, going to be all different kinds of users. I'm suggesting in the keynote that users like young Inuit who have an interest in keeping hold to some degree of Inuit ways of thinking and in getting a vivid sense of what Inuit life was like should take the words they find in the dictionary and go and ask an elder: "What does this mean?". That way, I suspect they'll get definitions that are more like what Allaq is giving me – which will be a much richer use of the dictionary than normal.

How do you determine the correct meaning of a word?

Here's a simple one. There's the word *qiaruq* in my corpus [*r sounds like r in Canadian English*]. I say the word and ask Allaq, "is that right?" (I'm free-translating the exchange between Allaq and I). She says, "yes", and I say, "what does it mean?" She makes the sound of a person crying. I write down, "cry", knowing already that the word means "cry". Sometimes she'll ask, "who taught you that word?" if she doesn't recognise it. I'll tell her, and if she thinks well of the person who taught me the word she'll say, "okay", and if not she'll say, "well, I think that's a Natsilik word", or, "I think that person didn't really speak very good Utkuhiksalingmiutitut", or whatever. But in



this case she recognizes the word *qiaruq,* and it's an Utkuhiksalingmiutitut word.

So I say, reading from my printout, "Can you use that word for the sound that muskoxen make? Somebody told me that was what muskoxen say", and she looks a little nonplussed. She says, "Who told you that?" and I say, "Well, your father". She says, "I think he was probably just trying to make you understand another word, because muskoxen *miaguqtut*" (which means howl; *miaguqtuq* is usually used for dogs).

She says, "I don't think muskoxen really *qiařut;* my father was just trying to make you understand *miaguqtut,* because he knows that you know the word *qiařuq*".

This is one of the reasons why I value her enormously, because another informant might just say, "no". Allaq knows what I'm after and she helps me, and sometimes if I don't ask the right questions she tells me. She probes, and shows me how to probe.

In this case I wouldn't ask if there were a transitive form because it is pretty obvious that there isn't – you can't say, "I cry it" (except perhaps in Shakespearean English), but if it's a word that might have a transitive form, I put a transitive pronoun on the word and I ask, "Can you say such and such?"

We check the form, we check the gloss (the definition), she gives me additional words, and we check their forms and their glosses; and then, if I'm not sure, I say, "Can you use this word in some other context?" If there's a context in my 1968 printout, I ask her about that, and she says yes or no. Then I invent other contexts, trying to find the limits of the domain in which the word can be used. If she says a word can be used for muskoxen, then I ask, "Can you use it for dogs? Can you use it for foxes? Wolves? Seals?" trying to find out if it refers to all mammals, to all land mammals, only to large game animals, or only to muskoxen – so this takes some time. I make one-hour tapes of these interactions with Utkuhiksalingmiutitut speakers in Gjoa Haven or Baker Lake, and transcribe them when I get home. I now have over 500 one-hour tapes, and it takes at least half a day to transcribe one side of one of these tapes. And so you begin to see how the 10,000 word corpus increases to 28,000 – and also how much time the whole process takes!

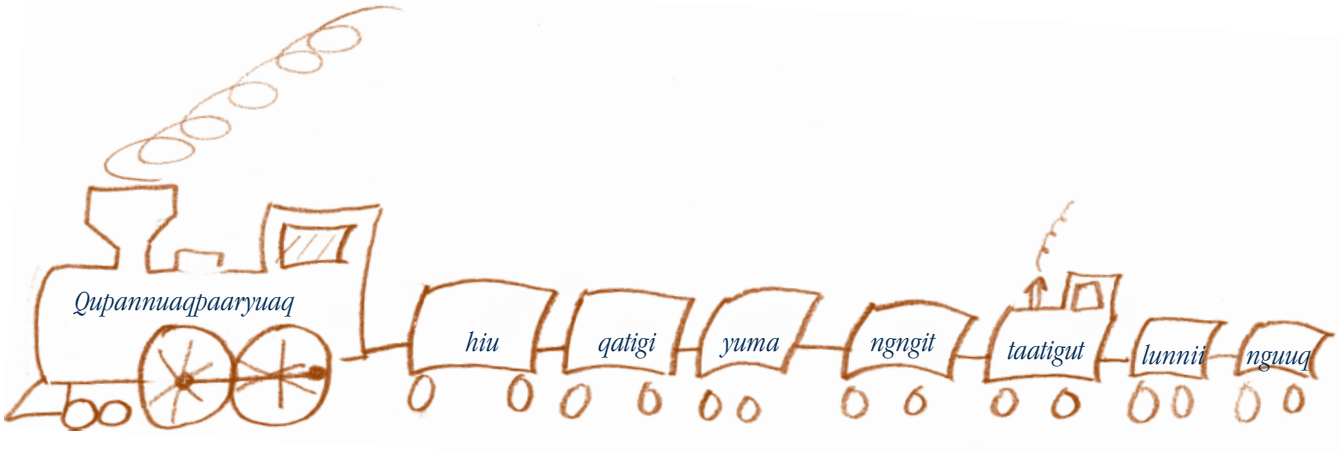
How do you decide which words to include?

This is an important point because the dictionary won't contain anywhere near the total number of words I've recorded. As I was learning to speak the language, I collected words with all kinds of postbases in them, which you don't need to have in the dictionary if the words are going to add up predictably. For instance, my favourite Inuktitut word, which I got from Duncan Pryde years and years ago, was *qupannuaqpaaryuaqhiuqatigiyumangngittaatigutluunniinnguuq,* which means, "they said they didn't even want to come hunting little horned larks with us". But you don't need to include that word because it's all predictable; you can construct the meaning of the whole by adding up the meanings of the individual parts: little horned larks + hunt + together + want + not + they-us + even + they said (or, it was said).

On the other hand, in a word like *qaritauřaq,* when you add up the postbases you get "resembles a brain", but the word actually means "computer"; so you have to put it in the dictionary. But it's not always easy to decide whether a word is predictable or not, because in some cases, in order to build a word correctly, you would have to know an awful lot about the postbases in it, their meanings, and the conditions that govern their presence. All these decisions will be made with my Inuktitut linguist co-investigator, Alana Johns, at the University of Toronto.

Alana and I agree that we should include sample sentences. Steve Jacobson, at the

"I like to think of an Inuktitut word as a train with the base being the engine, the post-bases being the cars, and the pronoun being the caboose. The dictionary will have a list of the 'cars' as well as the 'engines', analysed and with examples."



Alaska Native Language Centre at the University of Alaska, Fairbanks, made a very fine Yupik dictionary that includes sentences (Steven A. Jacobson, *Yup'ik Eskimo Dictionary,* Alaska Native Language Center, University of Alaska, Fairbanks, 1984), and so has Rose Jeddore in Labrador. We intend to use their dictionaries as a kind of model for ours.

Can you use a word to give an example of how someone might use the dictionary?

Let me give you an example from my keynote. Imagine that the word I'm asking about is in the dictionary. The word is *qa'ngulaittuq.* The definition in the dictionary is "he doesn't move" – but that's only the tip of the iceberg!

When I asked Salumoni (a pseudonym), an Utkuhiksalingmiut man, "What does *qa'ngulaittuq* mean?", he said: "*Qa'ngulaittuq* – either a possession or a house – I've had this house for a long time. I acquired it when there were lots of people (I think he probably meant in his household). If it's wanted – if somebody other than me wants it – he could say, 'Salumoni *qa'ngulaittuq* – even though I very much want that house'. That's *qa'ngulaittuq*." So I asked, "You *qa'ngulait-* because you stay here all the time?" (We're speaking Inuktitut: *qa'ngulaittutit tamaaniinnaugavit?*) Salumoni replies: "Yes, because I stay here all the time *qa'ngulaittunga.* Or a rock: If I'm trying to lift it up (and he dramatizes straining unsuccessfully to lift something) *qa'ngulaittuq,* the rock". I ask, "The rock *qa'ngulaittuq?*" Salumoni says, "Yes, *qa'ngulaittuq*".

Now as I say, in the dictionary the reader will find "it won't move". But Salumoni communicates that entirely through his examples. He doesn't ever give me a synonym – but he gives me the emotional flavour of the use of the word; and I get a sense from what he tells me that there's resistance and conflict generated by an almost active refusal to move. You might even see the rock as a metaphor for the person who refuses to get out of the house that is now too big for the needs of his shrunken household. I also learned, by implication, that there's a housing shortage in Salumoni's community. And I suspected that perhaps Salumoni felt under a little pressure to move. In fact, the next year when I went back he was in a different house.

So you see how the dictionary can fit into life. You also see how primitive your understanding would be if you didn't put the word in context – if you kept the dictionary as somehow in a box by itself.

I'm fascinated by the language; I learn more about it every day, not only about its structure, which is fascinating in itself – the domains of words, for instance, like *pilak* [*which in Utkuhiksalingmiutitut, though not every dialect, means to flense a sea mammal, cutting between the blubber and the meat, and has also come to mean surgery*], but also about Utkuhiksalingmiut thinking and life, because of the contextual ways in which Utkuhiksalingmiut explain words to me. If I say, "What does *katsungaittuq* mean?" they don't say, "It means greedy and demanding", they say, "Well, that's the way you were when you wanted to go fishing when Pala didn't want to take you". And this is Allaq talking about an event that happened 34 years ago.

How do you see this work in the context of your nearly 40-year relationship with Inuit? Is the notion of giving something back part of it?

Yes, I do see it as giving something back. And I also see it as an opportunity to maintain my relationships with my family, whom I love – especially Allaq, who is my major informant and collaborator on the dictionary, and her daughters, who appear as small children in *Never in Anger;* and there are kin in Baker Lake, too, who moved there from Chantrey years ago. It keeps me in that social world, to a small degree. And I am happy that the Utkuhiksalingmiut who are helping me with the dictionary express gratitude. I feel grateful, myself, when they make public statements about how much I'm helping, on the radio and in church and that sort of thing. Working on the dictionary, I can feel that I'm doing something that they understand and want.

WHAT'S NEW

CANADIAN POLAR RESEARCHER'S DIRECTORY

The Canadian Polar Information Network Researcher's Directory, a searchable database of specialists in Canadian polar knowledge, is now operational. The Canadian Polar Commission invites you to visit the Directory at www.polarcom.gc.ca.

POLAR RESEARCH FORUM

The Polar Commission has also developed the Polar Research Forum, an online communications centre for the Canadian polar research community. The Forum enables easy and rapid exchange of information and ideas. Researchers may create their own interactive discussion groups and post items of interest on the Forum's bulletin boards. The Polar Commission invites you to try this useful tool (www.polarcom.gc.ca).

HORIZON

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www.let.rug.nl/assw
Contact: K. I. M. van Dam
Arctic Centre Groningen
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9700 AS Groningen
The Netherlands
Tel.: 31-50-3635817
Fax: 31-50-3634900
E-mail: k.i.m.van.dam@let.rug.nl

Congress of the Canadian Meteorological and Oceanographic Society: The Northern Environment
22–25 May 2002
Rimouski, Quebec, Canada
scmo-cmos-2002.osl.gc.ca/

The 19th Polar Libraries Colloquy
17–21 June 2002
Copenhagen, Denmark
Contact: Vibeke Sloth Jakobsen
Danish Polar Center Library
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Denmark
Tel.: 45-3288-0100 or 45-3288-0106
Fax: 45-3288-0101
E-mail: vsj@dpc.dk
www.dpc.dk/plc

13th Inuit Studies Conference
1–3 August 2002
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Director, Department of Alaska Native & Rural Development
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Fax: (907) 279-2716
E-mail: anglp1@uaa.alaska.ed
www.uaf.edu/uafrural/ISC/

17th International Diatom Symposium
23–31 August 2002
Ottawa, Canada
Michel Poulin
Chair, IDS2002 Research Division
Canadian Museum of Nature
P.O. Box 3443, Station D
Ottawa, Ontario K1P 6P4, Canada
Tel: (613) 566-4788 or (613) 364-4033
Fax: (613) 364-4022
E-mail: mpoulin_ids2002@mus-nature.ca.
www.nature.ca/ids2002/ids2002_e.cfm.

Second Northern Research Forum
18–21 September 2002
Great Novgorod, Russia
Northern Research Forum Secretariat
University of Akureyri &
Stefansson Arctic Institute
Nordurslod
IS-600 Akureyri
Iceland
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Fax: 354-463-0589
E-mail: nrf@unak.is

Second AMAP International Symposium on Environmental Pollution in the Arctic
1–4 October 2002
Rovaniemi, Finland
www.amap.no/news/symp2-1an-nopics.pdf.

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