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Climate Change and ARCTIC Sustainable Development

scientific, social, cultural and educational challenges

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This book should be cited as:
UNESCO. 2009. *Climate Change and Arctic Sustainable Development: scientific, social, cultural and educational challenges.* UNESCO: Paris, 376 pp.

This UNESCO publication is a collaborative effort of the:
Natural Sciences Sector (SC) and the Intergovernmental Oceanographic Commission (IOC)
Social and Human Sciences Sector (SHS)
Culture Sector (CLT) and the World Heritage Centre (WHC)
Education Sector (ED)

Coordinator
Douglas Nakashima, Chief, Small Islands and Indigenous Knowledge Section, SC

Intersectoral Team
Keith Alverson, Chief, Ocean Observations and Services Section, IOC
Fernando Brugman, Section of Intangible Cultural Heritage, CLT
Bernard Combes, Education for Sustainable Development Coordination Section, ED
John Crowley, Chief, Ethics of Science and Technology Section, SHS
Peter Dogsé, Ecological Sciences and Biodiversity Section, SC
Cécile Duvelle, Chief, Section of Intangible Cultural Heritage, CLT
Tom Gross, Ocean Observations and Services Section, IOC
Mechtild Rössler, Chief, Europe and North America Section, WHC

Editor
Peter Bates, Small Islands and Indigenous Knowledge Section, SC

Project Support Team (Small Islands and Indigenous Knowledge Section, SC)
Julia Cheftel, Stéphanie Ledauphin, Kremena Nikolova, Donara Sydeeva
Ernestine Ngondji, Administrative Office, SC

Design & Production
Stéphane Rébillon – www.stephanerebillon.com

Cover images
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Published in 2009 by the United Nations Educational, Scientific and Cultural Organization
UNESCO, 7 Place de Fontenoy, 73752 Paris 07 SP, France

ISBN 978-92-3-104139-6

For further information, please contact:
Douglas Nakashima
Small Islands and Indigenous Knowledge Section
UNESCO – 1, rue Miollis, 75732 Paris Cedex 15 France
Email: links@unesco.org

With thanks to the Principality of Monaco for their support and guidance

Foreword by HSH Prince Albert II of Monaco

During a recent expedition to Antarctica I visited the scientists working there, to see their facilities, discover their living conditions and testify to the importance of their task.

This experience, witnessing the dedication of these polar scientists, confirmed for me that in the last few years we have witnessed a revolution: for centuries humans have spent a large part of their energy plundering the Earth's resources and destroying the natural environment, heedless of the consequences of their actions. This trend is in the process of being reversed. Even despite the financial crisis that is shaking our world, the growing environmental concern has not waned. On the contrary, people's minds have opened up to a new awareness and connection with the environment, including the distant polar regions. Such attention can be explained in part by the International Polar Year, with its intense global agenda on climatic issues.

Of course, the destructive power of modern technologies makes the damage already incurred all the more difficult to control and repair. We are only at the beginning of a very long process, and we cannot predict if it will achieve the lofty ambitions we all share. Today, however, we do know the world can change, and this gives us reason for hope and the motivation to press forward.

Moving ahead now means broadening the spectrum of our concerns to include what may have seemed forgotten in mobilisation for the environment: people. We must put them back at the centre of the debate, never forgetting that the major issue has always been and will always be humankind. In the case of the Arctic this means attention to the many human processes originating from both inside and outside of the Arctic that impact on the region. It also requires attention to the peoples who stand to be most affected by changes wrought in the Arctic: its indigenous inhabitants.

For these reasons I was proud to support and participate in the international meeting organised by UNESCO on 'Climate Change and Arctic Sustainable Development' which took place in Monaco in March 2009. The true significance of this meeting, as I see it, was the building of sustainable development thanks to science, whilst focusing on collective action that is social, cultural and educational. This publication represents just one facet of the diverse outcomes from this meeting.

HSH Prince Albert II of Monaco

Foreword by the UNESCO Director-General

For many of us climate change remains a distant future hazard. In the Arctic, however, climate change is very much a reality. Its impacts are already being seen in the physical environment and biological systems of the region, and are experienced directly by the region's many human inhabitants.

The United Nations Secretary-General has labelled climate change as the 'defining issue of our era'. Understanding and responding to an issue as momentous as global climate change is a challenge that requires the unified efforts of local communities, scientists, governments and national and international organisations from across the globe. To understand climate change, we must move beyond assessing causes and monitoring impacts and trends. Major change in the world's climate is already an unavoidable reality. Adaptation and response are therefore essential, even though they remain as yet largely unexplored. The development of appropriate adaptation and response strategies has therefore emerged as a central preoccupation of all actors, including the UN System.

Adaptation requires a broad interdisciplinary response. This must be rooted firmly in the knowledge base of Earth-system processes and climate science, and consider impacts on the biological systems that sustain life on the planet. But more than anything else, adaptation relates to the ability of different societies to respond to the challenges put before them by climate change, meaning that social, economic and cultural considerations must be addressed. As a UN specialised agency, UNESCO is uniquely placed to address the challenge of adaptation, in that the Organization brings together the natural sciences, social sciences, culture, education and environmental ethics and can therefore respond to climate change in an interdisciplinary manner. UNESCO, together with the World Meteorological Organization, has also been charged with the role of convenor for United Nations agencies active in the cross-cutting climate change area of science, assessment, monitoring and early warning.

UNESCO was pleased to have had the opportunity to organise a meeting on 'Climate Change and Arctic Sustainable Development: scientific, social, cultural and educational challenges' in Monaco, 3-6 March 2009. I offer my sincere thanks to His Serene Highness Prince Albert II of Monaco for the leadership and vision expressed by his support for this event. The expert meeting brought together 42 participants from 13 countries, including all Arctic states and Greenland. Participants were experts in the fields of the natural and social sciences, indigenous issues, education, ethics, law, health and international affairs. The papers arising from the interdisciplinary discussions in Monaco are presented here, offering a crucial contribution to efforts to address the full range of issues necessary to attain Arctic sustainable development in the face of climate change.

Koïchiro Matsuura
UNESCO Director-General

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OPENING MESSAGES

Message from the Arctic Council

When the Kingdom of Denmark – Denmark, Greenland and the Faroe Islands – took over the chairmanship of the Arctic Council in April 2009 I emphasised the human dimension as the core of Arctic Council work. Developments in the Arctic – for good or for bad – directly influence life and living conditions for the Arctic populations. To develop tools for a better future for the peoples of the Arctic is essential at the present stage of changes in the Arctic.

The core of the Arctic Council work is scientific reports, of an outstanding quality, on developments in the Arctic – challenges and opportunities – related to the climate, pollution, biodiversity and the sustainable use of the Arctic's living resources, the sustainable exploitation of renewable and non-renewable natural resources and, not least, the socio-economic conditions of the peoples of the Arctic. These reports with their findings, conclusions and recommendations serve as decision shaping tools for policy decisions at the national and regional levels as well as international organisations.

In this way the Arctic Council has a leadership role when it comes to Arctic challenges and opportunities – as acknowledged by the Arctic Ministers in their declaration from their last Arctic Council Ministerial Meeting. But not least as a result of climate change the world's attention is increasingly directed to the Arctic, and we welcome that, because it contributes to and complements the work being undertaken in the Arctic Council.

Thus, we welcomed the UNESCO-organised International Expert Meeting, 'Climate Change and Arctic Sustainable Development: scientific, social, cultural and educational challenges' that took place in Monaco on 3-6 March 2009. We also welcome the present publication which – as a follow-up to the expert meeting – will undoubtedly spread the messages from the meeting to a much wider audience, when it is launched at the COP 15 meeting in Copenhagen in December 2009.

Per Stig Møller
Minister for Foreign Affairs of Denmark
Chairman of Arctic Council

Message from UNEP

If you look at climate change in the context of the Arctic you are witnessing humanity's capacity for irrationality at its zenith. Science informs us that there is an unprecedented melting of the Arctic, perhaps symbolised most acutely by the opening of the Northwest Passage and a scramble to exploit the region's rich and abundant resources as they become increasingly accessible. Yet many of these very resources and in particular the Arctic's hydrocarbons are the very factors fuelling the melting in the first place as a result of the build-up of greenhouse gases triggering climate change.

These choices and these dilemmas have been brought into sharp relief not only by climate change, but also by the financial and then economic crises of 2008-2009. In order to stabilise the global economy, countries have mobilised some $3 trillion in the form of stimulus packages. UNEP's focus has been on whether this will flow into the old, brown economy of yesterday or into a new Green Economy able to respond to contemporary and emerging challenges including climate change in far broader and more transformational ways.

This is why UNEP has been championing a Global Green New Deal in order to provide a forward-looking suite of policies that focuses a proportion of the stimulus packages on the kinds of environmental investments that can set the stage for a low carbon, resource efficient twenty-first century Green Economy. Investments that also reflect the inordinate returns from investing not only in sustainable transportation, renewable energies and energy efficiencies, but also in the planet's ecosystem infrastructure such as forests and freshwaters alongside generating new kinds of decent, Green Jobs.

We live today in world that has the technology, resources and knowledge, and thus the choice, to go in one direction or another. This conversation has to happen now, and is indeed happening, but there is a great risk that short-term economic fixing will take precedence over this historic opportunity to invest in a different economic pathway - the drive for hydrocarbons in the Arctic set against the challenge of climate change illustrates that dilemma.

There is of course a larger issue underpinning environmental change, as the impacts amount to an unethical equation. With climate change, the actions of some alter the life conditions of others who have done nothing to cause these phenomena. The Arctic, with Small Island Developing States, is in the frontline of climate change. This is one reason why in UNEP we have reinforced our efforts to support work under the Arctic Council and the International Polar Year. This is in particular being spearheaded through UNEP/GRID-Arendal which is at the forefront of the Many Strong Voices Project. It aims to match the dilemmas faced by communities from small islands and the Arctic with the expertise needed to make a sustainable difference. Trying to amplify those voices and bring their reality into households all over the world is something that UNEP, UNESCO and the Secretary General himself have made one of their key tasks.

This can, along with many strong voices elsewhere, play an important role in focusing over 190 nations to Seal the Deal at the crucial Climate Change convention meeting in Copenhagen this December.

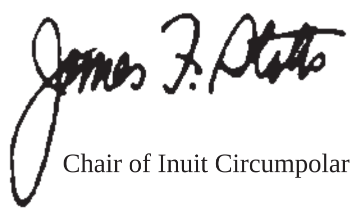
Achim Steiner
UN Under-Secretary General
Executive Director of UNEP

Message from ICC

If I was forced to use one word to describe Inuit culture I would use the word 'adaptable'. Inuit lore and legend are replete with incredible stories of survival through adaptation to our ever changing hostile environment. Every culture is a product of its environment and our culture is no different from other cultures in this respect. The long, cold, harsh winters molded our culture to be highly adaptable. It was a matter of survival.

Inuit didn't ask for global warming, it came as a gift from the outside world. We have received many of these gifts during the last century and a half, some good and some bad. We kept those gifts that were beneficial and discarded those that were useless, always adapting. Despite having its roots in prehistoric times, present day Inuit culture is quite modern. Inuit have no desire to end up as an exhibit of just another extinct culture in a museum. We intend to be a player in everything that goes on in our homeland. As the first inhabitants and stewards of the Arctic we have the responsibility and right to ensure the protection of our environment and culture. We accept this responsibility for the benefit of all mankind.

The problem with global warming is the fact that it is changing the environment that Inuit have mastered. Our traditional knowledge is not as reliable as it used to be. The long-term potential is there to turn our world upside down. Global warming with a resulting loss of sea ice and milder temperatures has the outside world salivating at the prospect of exploiting previously inaccessible Arctic resources. Inuit insist that study and assessment must be undertaken leading to standards for development. Any development in the Arctic must be carried out on a sustainable basis. This includes cultural sustainability.



James Stotts
Chair of Inuit Circumpolar Council (ICC)

Message from ICSU

The International Polar Year (IPY) 2007-2008, which was planned by the International Council for Science (ICSU) and cosponsored with the World Meteorological Organization (WMO), has invigorated polar research and education to a new level of action and global attention at a critical time in human-environment interaction.

Science conducted during IPY has exposed the startling changes that are occurring at both poles – among the most significant of which is the stunning decline of Arctic sea ice extent in summer and its impact on every facet of the Arctic system, including humans and our activities.

The success of IPY in provoking and enabling a huge range of science for society rests primarily on the energy invested by thousands of scientists, teachers, and other partners, including those authors who contributed to this volume. But to help ensure this success, ICSU insisted early in the planning of IPY that the programme should (I) be truly interdisciplinary, including a strong component of biological and social science, (II) have a balanced portfolio of work in both the Arctic and Antarctica, (III) involve 'non-traditional' polar nations (indeed, 63 nations are involved in this IPY), and (IV) emphasise education and outreach.

With the observance period of IPY now behind us, I look optimistically toward the future contributions of polar science to societal action. IPY has built a strong foundation of new international research and education partnerships, a new appreciation for the challenges and importance of polar observations and managing polar data, a new appreciation for open access to polar data and areas, and a new generation of polar researchers. But future societal action will require not only the creativity and energy of individual scientists, educators, and their partners. It will rely on the public's appreciation for science that will help politicians commit to long-term international action. An early impact of the effective education and outreach efforts of IPY is the joint statement by the parties to the Antarctic Treaty and the members of the Arctic Council in April 2009.

For its part, ICSU will continue to work on the fundamentals of the conduct of scientific research implemented in the polar areas such as free and open access to data and areas. And with our partners, including UNESCO, we will continue to stimulate and promote the IPY legacy of international, interdisciplinary polar science that will underpin societal choices about our shared future.

Catherine Bréchignac

Catherine Bréchignac
President of the International Council for Science (ICSU)

Message from UNESCO Goodwill Ambassador

The world is facing a major threat: climate disorder. Deglaciation is a reality, and despite all the controversies this warming is partly the result of human activity. If the oil and gas exploitation that is projected after the melting of sea ice is not regulated, these industrial and naval activities can only worsen the effects of climate change. Sovereign nations are faced with these dangers, as are the circumpolar peoples who have lived in these territories from time immemorial. We must recognise that these people of the Far North are the holders, not only of a unique culture, but also of a precious and fragile civilization with a unique philosophy, wherein lie treasures of thought, art and sources of reflection on the future of our greatly threatened Western civilization. Credit goes to UNESCO for having instigated since its inception such a vast reflection on the intangible and the invisible world.

One of the most serious problems that threaten these indigenous peoples is probably what makes these spaces so powerful: their oil and gas wealth that has created a massive immigration from the south. They also lie on major future shipping routes. The potential massive immigration of workers could overwhelm indigenous peoples. This might be, together with global warming, one of the fundamental problems facing the North. A second problem is the political tensions between sovereign states. Such preoccupations can and do overrule concern for the rights and welfare of the indigenous peoples residing in the territories in question.

UNESCO has the enormous merit of being informed by the greatest scientists, bringing together representatives of natural, social and political sciences in a single mandate. However, it is also informed by indigenous peoples, themselves represented by their own experts who seek by all means to convey the wishes of the one million men and women in the circumpolar north. With this in mind, UNESCO organised an international meeting on 'Climate Change and Arctic Sustainable Development' at my personal request as UNESCO Goodwill Ambassador in charge of Arctic polar issues. This meeting, generously hosted by the principality of Monaco from 3-6 March 2009, addressed the urgent need to put human beings at the centre of reflections on the Arctic and climate change. This book represents just one outcome of this process.

Jean Malaurie
UNESCO Goodwill Ambassador for Arctic Polar Issues
Director, Centre of Arctic Studies,
École des Hautes Études en Sciences Sociales (EHESS) and
Centre National de Recherche Scientifique (CNRS)

Acknowledgements

This book and the meeting on which it is based were made possible by funding generously provided by the Principality of Monaco.

HSH Prince Albert II personally attended the meeting's opening event, made a speech during the first session, and attended the closing session. This commitment and vision was essential to the meeting's success.

HSH's dedication was mirrored by the people in Monaco who worked tirelessly on the development and execution of the meeting. Of particular note are the efforts of Monaco's Minister of External Affairs Franck Biancheri; Ambassador Jean Pastorelli; Mr Patrick Van Klaveren, Ms Geneviève Berti, Ms Marina Ceyssac and Ms Anne Médecin from the Ministry of External Affairs; Ms Corinne Magail from the Permanent Delegation of Monaco to UNESCO; and Ms Marie-Catherine Caruso-Ravera and Ms Nelly Gastaud of Monaco's Tourism and Convention Authority.

Also to be commended are the support staff from Monaco for their excellent facilitation of the meeting, the staff of Novotel Monte Carlo for providing an exceptionally professional and personable venue, and the interpreters for their tireless efforts throughout.

The meeting was held at the request of Professor Jean Malaurie, UNESCO Goodwill Ambassador in charge of Arctic polar issues, and many concepts and themes were developed thanks to his active collaboration and enthusiasm.

Invaluable support was provided by Jonathan Baker, Mireille Jardin, Fuad Pashayev and Mercedes Ruiz Molero from UNESCO's Office of the Director-General.

INTRODUCTION

The Arctic is undergoing rapid and dramatic environmental and social transformations due to climate change. This has ramifications for the entire planet, as change spreads through interconnected global networks that are environmental, cultural, economic and political. The changes currently seen in the Arctic also serve as a warning of what may occur elsewhere as climate change advances. Lessons learned now in the Arctic about the complexity and unpredictability of change, as well as the ways and means to collaborate in monitoring, mobilising and adapting, may therefore be of crucial importance for other world regions. Understanding and responding to this challenge requires the unified efforts of the scientific community, civil society, governments and national and international organisations from across the globe.

Now that the anthropogenic origin of climate change has been ascertained, it is increasingly recognised that the major thrust of research efforts must shift from deciphering causes and monitoring trends, to exploring strategies for response and adaptation. The development of these strategies has therefore emerged as a central preoccupation of all actors, including the UN system.

Adaptation strategies require a broad interdisciplinary response. They must be rooted firmly in the knowledge base of scientific monitoring and assessment, which provides data on changes in climate and their direct impacts on the physical environment. It is also essential to understand how these changes will affect the network of biological systems that sustain life on the planet. Furthermore, adaptation adds a crucial social, economic and cultural problematic as it encompasses the ability of different societies to respond to the challenges they face. UNESCO is unique in the UN system in that it brings together the domains of natural sciences, social sciences, culture, education and environmental ethics. Given this broad mandate, the Organization is uniquely placed to foster integrated approaches for monitoring and adapting to climate change, and UNESCO is convinced that adopting an interdisciplinary approach is essential for true sustainable development.

In the domain of the physical environment, over the past 30 years the Organization has mobilized efforts to build a global knowledge base on climate change, with contributions particularly in the areas of oceanography, hydrology, biodiversity and the Earth sciences. Today, alongside the World Meteorological Organization (WMO), UNESCO has been assigned the role of convener for science, assessment, monitoring and early warning in the climate change domain. UNESCO's Intergovernmental Oceanographic Commission (IOC) fulfils an expanding role with respect to the production of authoritative scientific and technical information on global climate observation and on systems of prediction. In this manner, IOC reinforces global cooperation in the study of oceans, which are key climate drivers. Working jointly with WMO, IOC today coordinates an ocean observing system that supports both the Global Ocean Observing System (GOOS) and the Global Climate Observing System (GCOS).

Better understanding of the biological environment is the goal of UNESCO's Man and the Biosphere (MAB) Programme. This programme has a global network of 531 Biosphere Reserves in 105 countries, five of which are in the Arctic region: North East Greenland Biosphere Reserve in Denmark, Laplandskiy and Taimyrsky in the Russian Federation, Lake Torne in Sweden, and Noatak in the United States. These reserves represent excellent laboratories for the study of climate change effects on biodiversity and ecosystem services. Similarly, climate change has been mainstreamed into the various operational mechanisms and processes of UNESCO's World Heritage Convention. Six Arctic sites are inscribed on the World Heritage List: in Canada, Greenland, Norway, the Russian Federation, Sweden and a trans-boundary site shared by the United States and Canada. In October 2007, the General Assembly of State Parties to the World Heritage Convention adopted a 'Policy Document on Impacts of Climate Change on World Heritage Sites', which addresses the use of World Heritage sites as laboratories for long-term climate monitoring and the testing of innovative solutions for adaptation.

It is equally important to recognise the cultural repercussions of climate change, as the impacts of this phenomenon on ways of life, identities and systems of meaning are enormous. In this perspective, the 2003 Convention for the Safeguarding of the Intangible Cultural Heritage emerges as particularly relevant for putting in place safeguarding measures for the oral traditions, social practices and knowledge and know-how of Arctic indigenous communities. UNESCO's Local and Indigenous Knowledge Systems (LINKS) Programme also joins in this effort, by placing a necessary emphasis on the key contribution of indigenous knowledge to better understanding the impacts of climate change on both human societies and the environment, and for mobilising local adaptation capacities.

Similarly, we must continue to improve our observation and understanding of the social transformations that are underway, in particular with respect to human habitat, migration and the management of natural resources. These preoccupations are key concerns of UNESCO's intergovernmental programme on the Management of Social Transformations (MOST). In the context of climate change, the issue of environmental ethics is also unquestionably important, as neither global causes nor global impacts are distributed equitably. UNESCO, through its independent World Commission on the Ethics of Scientific Knowledge and Technology (COMEST), aims to ensure that this fundamental issue becomes central to the climate change debate.

Finally, there is the education dimension, which should constitute the core of any policy on sustainable development. As has been forcefully underlined by the United Nations Decade of Education for Sustainable Development (2005 to 2014), we must mobilise both formal and non-formal education systems in order to further values and behaviours tied to sustainable development of the Arctic and Subarctic regions. Such a commitment is indispensable, especially if we wish to identify educational processes that can support the efforts of indigenous and local communities to maintain their knowledge, lifestyles and languages.

Through this book, UNESCO seeks to stimulate debate on how to ensure a sustained, comprehensive, interdisciplinary and multi-actor approach to monitoring, managing and responding to change in the Arctic.

Structure of the book

The book is divided into eight sections, each of which seeks to address a different facet of change in the Arctic, whilst also maintaining the interdisciplinary dynamic achieved during the 2009 UNESCO meeting in Monaco from which the book originates. This is no small challenge, as is demonstrated by the wealth of views, perspectives and approaches offered by the authors. However, it is only through this spirit of interdisciplinary collaboration, and its effective practice, that the challenges of climate change and sustainable development will eventually be met. The sections of the book therefore address distinct themes, while harbouring numerous points of convergence. The book's eight sections are as follows:

Ice, Oceans and Atmosphere documents recent trends with respect to climate change impacts on the physical environment of the Arctic. It bridges from climate science to locally-based knowledge and experience, and describes efforts to merge these understandings through innovative research.

Biodiversity and Ecosystem Services turns to the biological and ecosystem impacts of Arctic climate change, and the ways that these can be monitored and managed, again with a focus on both scientific monitoring and indigenous experience and response strategies.

Community-Level Impacts and Adaptation highlights the direct affects of climate change on the tangible and intangible heritage of local and indigenous communities throughout the circumpolar North, and explores strategies that can help to manage and respond to these impacts.

Health and Well-Being focuses on key health issues for Arctic communities, as they play out in relation to already existing challenges that may be exacerbated by climate change.

Economic Development and Social Transformations examines the ways that industry and shipping, and thus Arctic and global society as a whole, will respond to a dramatic reduction in sea ice cover and the growing accessibility of the Arctic and its resources.

Education places the crucial need for accessible and culturally appropriate education at the forefront of efforts to generate sustainable development in the Arctic, and discusses mechanisms by which this can be achieved.

Ethics, Responsibility and Sustainability turns our attention to urgent questions about climate change and sustainable development, asking where the weight of responsibility should lie for climate change impacts and response, and examining different perspectives of what it means to be 'sustainable'.

Monitoring Systems examines in detail the interdisciplinary strategies that need to be put into place in order to monitor and manage the rapidly evolving environmental, biological and socio-cultural landscapes of the Arctic. Such considerations are a recurrent theme throughout this book, as a well-informed and coordinated interdisciplinary multi-actor response, which bridges scientific and indigenous knowledge, must be at the heart of efforts to attain sustainable development in the Arctic in the face of climate change.

Introduction by:

Keith Alverson,
Chief, Ocean Observations and Services Section,
Intergovernmental Oceanographic Commission

Bernard Combes,
Education for Sustainable Development Coordination Section,
Education Sector

John Crowley,
Chief, Ethics of Science and Technology Section,
Social and Human Sciences Sector

Peter Dogsé,
Ecological Sciences and Biodiversity Section,
Natural Sciences Sector

Cécile Duvelle,
Chief, Section of Intangible Cultural Heritage,
Culture Sector

Douglas Nakashima,
Chief, Small Islands and Indigenous Knowledge Section,
Natural Sciences Sector

Mechtild Rössler,
Chief, Europe and North America Section,
World Heritage Centre

Section 1

ICE, OCEANS AND ATMOSPHERE

Overview of Changes in Arctic Sea Ice Cover

Julienne C. Stroeve
National Snow and Ice Data Center (NSIDC)
Cooperative Institute for Research in Environmental Sciences (CIRES)
University of Colorado (CU), USA

Abstract

The sequence of extreme September sea ice extent minima observed since 2002 points to an acceleration in the response of the Arctic sea ice cover to anthropogenic warming, hastening the transition towards a seasonally open Arctic Ocean. This acceleration results from several mutually supporting processes. First, because there is more open water in a given September than there used to be, more solar radiation is absorbed by the exposed open water areas during summer, leading to a thinner ice cover the following spring that is vulnerable to melting out during the next summer. Thinner ice in spring in turn fosters a stronger summer ice-albedo feedback, through earlier formation of open water areas in summer that further accentuate summer ice loss. Finally, warming of the Arctic has reduced the likelihood of cold years that could bring about temporary recovery of the ice cover. Continued decline of Arctic sea ice will have widespread socio-economic, ecological and climatic impacts.

Changes in the Arctic sea ice cover

Arctic sea ice extent has declined over the past several decades, showing downward trends in all months, with the smallest trends in winter and the largest trends at the end of the melt season in September (Serreze et al. 2007). However, the rate of decline is accelerating. In 2001, the linear trend in September monthly mean extent over the available satellite (1979 to present) record stood at -7.0 per cent per decade. By 2006, it had increased to -8.9 per cent per decade. Then, in September 2007, Arctic sea ice extent fell to the lowest value ever recorded, 23 per cent below the previous record minimum set in 2005, boosting the downward trend further to

-10.7 per cent per decade (Stroeve et al. 2008). Including September 2008, which ended up as second lowest in the satellite record, the trend stands at -11.8 per cent per decade (Figure 1).

All coupled global climate models used in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) show declining September ice extent over the period of observations (Stroeve et al. 2007; Zhang

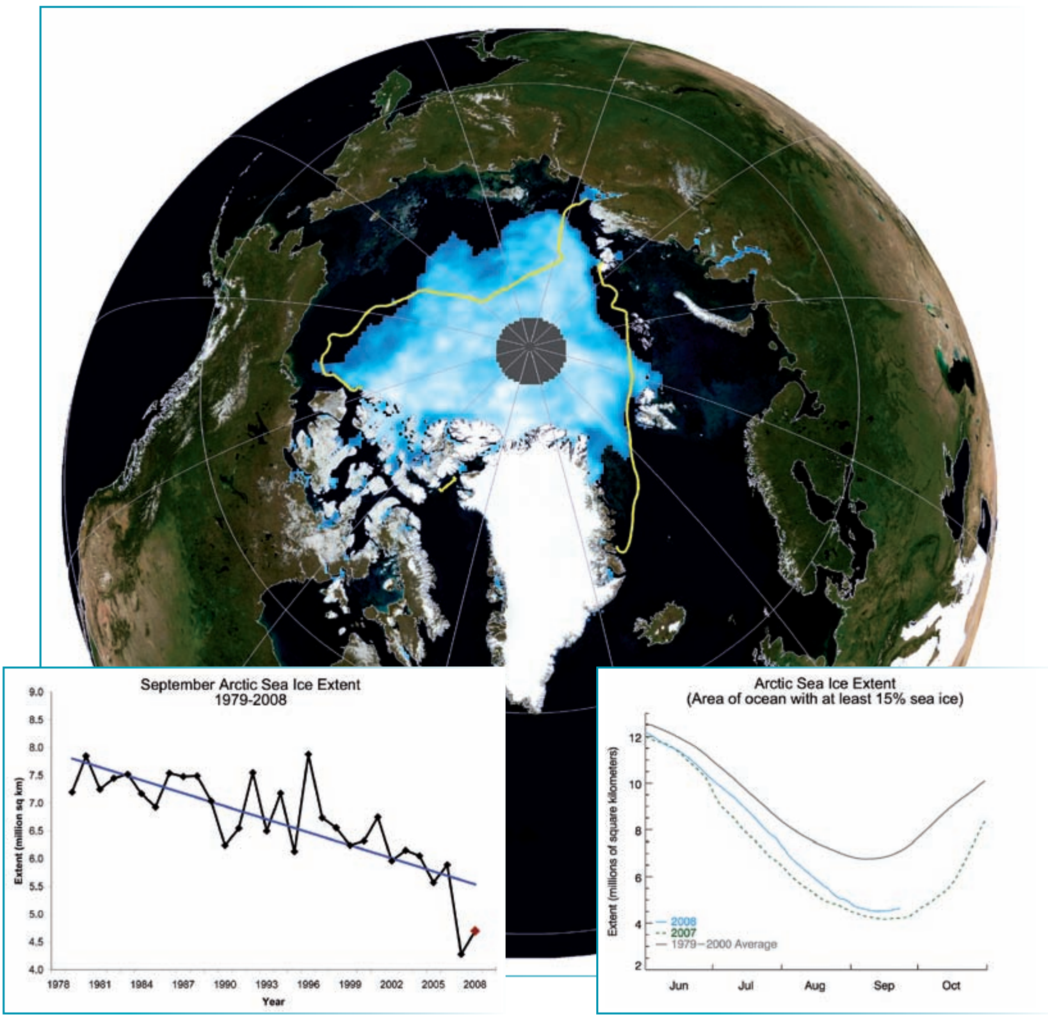


Figure 1. Colour map: Sea ice extent on 14 September 2008, the date of the minimum, when ice extent was 4.52 million km^2. The yellow line marks the extent for September 16, 2007. Right inset: Time-series of ice extent from June 1 through 24 September for 2008, and through end of October for 2007 and climatology (1979-2000). Left inset: Time-series of monthly averaged September sea ice extent. (National Snow & Ice Data Center)

and Walsh 2006). Although this is strong evidence for a role of greenhouse gas (GHG) forcing on the observed trend, the simulated trends, as a group, are smaller than observed. This finding has raised concern that ice free summers might be realised as early as 2030 (Stroeve et al. 2007). Some of the IPCC simulations also show that the September trend becomes steeper with time, but only later into the twenty-first century.

Why has the observed downward trend steepened? While natural variability in the coupled ice-ocean-atmosphere system has certainly been a player (see Stroeve et al. 2007 and papers cited therein), the rate of decline of sea ice extent in response to external GHG forcing is now being enhanced by three inter-connected processes. First, because of the extensive open water in recent Septembers, ice cover in the following spring is increasingly dominated by thin, first-year ice (ice formed during the previous autumn and winter) that is vulnerable to melting out in summer, especially under the influence of anomalous atmospheric circulation patterns that favour summer melt. Thus, back in the early 1980s when the Arctic Ocean in winter was dominated by old, thick ice, an unusually warm summer, such as occurred in 2007, could promote a strong negative anomaly in summer ice volume, but only a modest negative anomaly in ice extent. However, at the same time that the overall spatial extent of sea ice has been declining, the winter ice pack has correspondingly become much younger and therefore much thinner (Maslanik et al. 2007), leaving little of the old, thick ice that can help stabilise the summer ice cover. Today a given summer decline in ice volume translates into even larger declines in ice extent simply because more of the ice pack is so thin.

Second, the existence of more thin ice in spring allows open water areas to develop earlier in the melt season, leading to a stronger ice albedo feedback. Ice albedo feedback has always been part of the sea ice system – as the melt season commences, bare ice is exposed by melting snow, melt ponds form and areas of dark open water are exposed, which readily absorb solar radiation, fostering further melt. However, with the trend towards more thin ice in spring, open water areas form earlier and are present longer in the melt season so that the ice albedo feedback has grown in importance, accentuating summer ice melt and steepening the downward trend of September ice extent. It is this ‘boosting’ of the ice-albedo feedback mechanism that has been implicated in rapid transitions towards a seasonally ice free Arctic in climate model simulations (Holland et al. 2006).

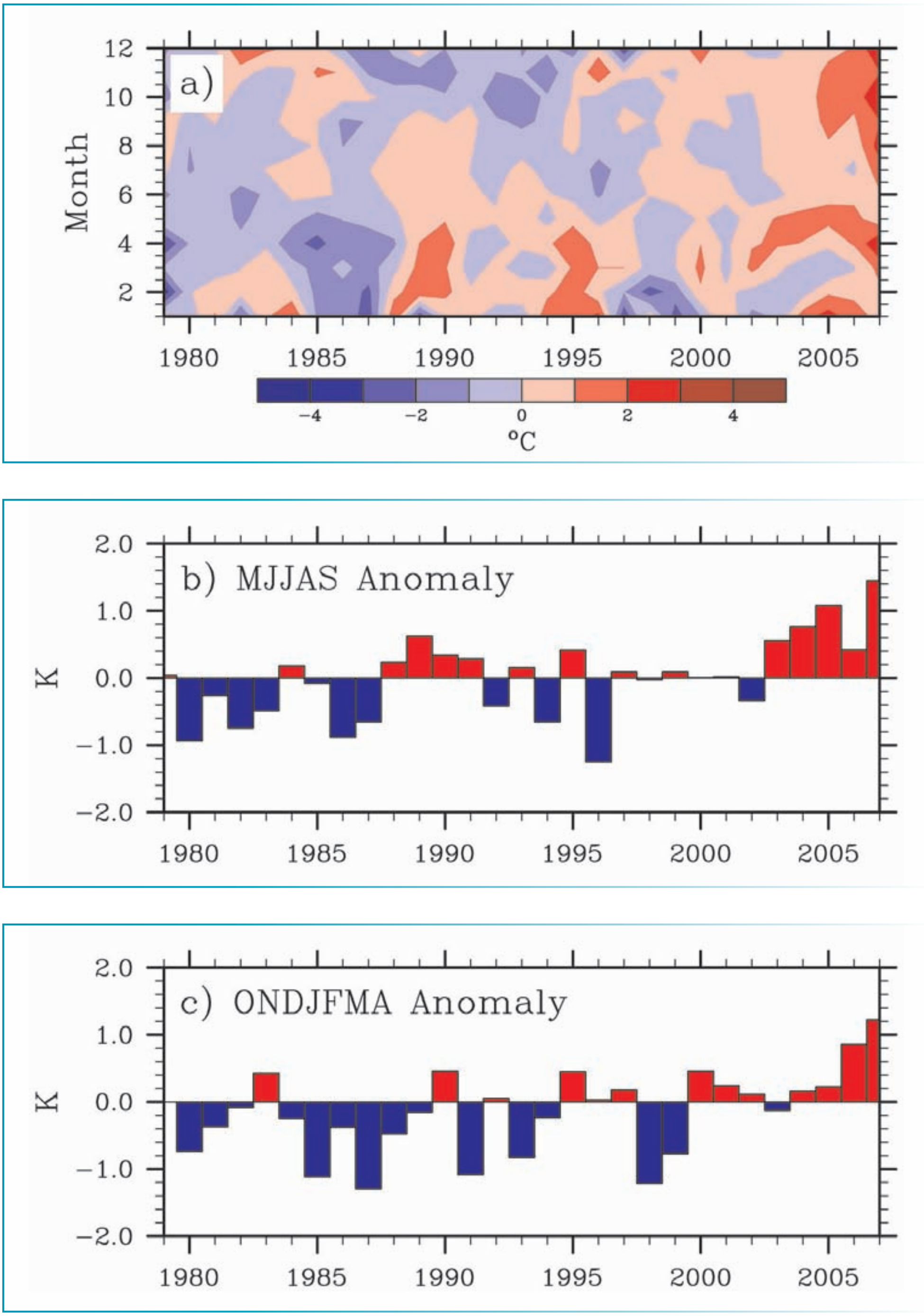


Figure 2. JRA-25 925 hPa temperature anomalies by year and month (top) and averaged for extended summer (MJJAS, middle) and extended winter (ONDJFMA, bottom) seasons. Results are for an Arctic Ocean domain. Anomalies are computed with respect to the period 1979-2007 (from Stroeve, unpublished).

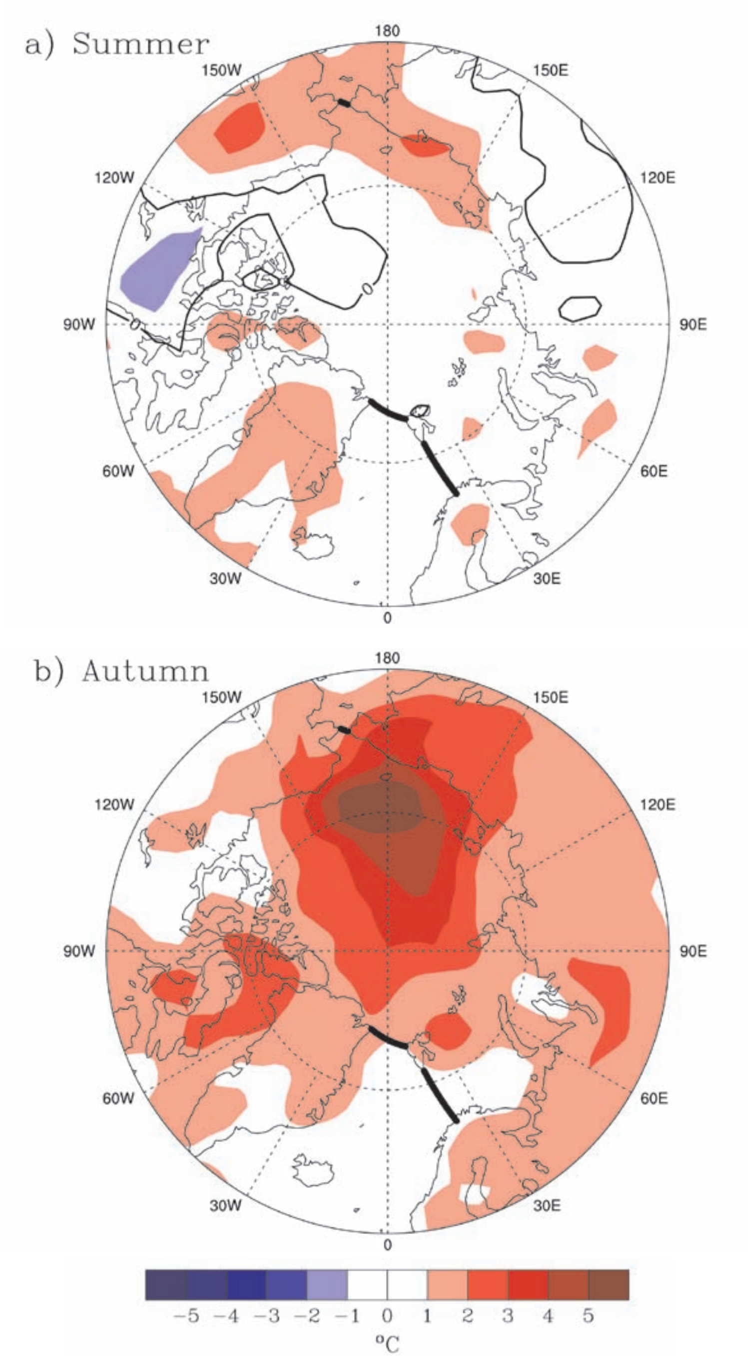


Figure 3. Surface air temperature anomalies from NCEP/NCAR reanalysis from 2002 to 2007, relative to 1979-2007 for (a) summer (JJA) and (b) autumn (OND) (from Serreze et al. 2009).

Anomalies of monthly mean absorbed solar radiation fields from JRA-25 Reanalysis,[(1)] a product of the Japan Meteorological Agency (Onogi et al. 2007) averaged for the last six years (2002-2007, corresponding to the advent of extreme September sea ice minima, see Figure 1, and derived with respect to the 1979-2007 climatology) show positive anomalies in absorbed solar in the Barents Sea, along the east coast of Greenland, Baffin Bay and Bering Strait. These positive anomalies in absorbed solar radiation correspond to negative anomalies in ice extent and concentration for the six-year period. Positive anomalies grow in magnitude and spatial extent through the melt season. Cumulative anomalies in absorbed solar radiation for August locally exceed 150 MJ m-2, representing an equivalent melt of ice thickness of 49 cm. This will impact on the survivability of the summer sea ice. On average about 40 per cent of first-year ice survives the summer melt season and about 80 per cent of the older ice types survive. However, in the last two years, less and less of the older ice is surviving the summer melt and 2007 had the record low survivability of first-year ice.

Anomalies for the year 2007, the year of the record September ice minimum, point to a more prominent feedback than that seen by the 2002-2007 average as more than 60 per cent of the Arctic Ocean was exposed to incoming solar radiation during summer. Perovich et al. (2008) used similar techniques to estimate anomalies in absorbed shortwave radiation over the Beaufort and Chukchi accumulated through the 2007 melt season (use was made of operational fields from the European Centre for Medium Range Weather Forecasts). Compared to averages for 1979-2005, anomalies of 500 per cent characterised much of the region in 2007. This retention of heat in the Arctic Ocean must be released back to the atmosphere before sea ice can once again form in the autumn and winter, leading to warmer autumn temperatures and a shorter growing winter season for ice growth.

Third, the Arctic has warmed in all seasons, meaning that the likelihood of unusually cold conditions that could bring about temporary recovery through natural climate variability has declined. For example, Figure 2 shows 925 hPa temperature anomalies for an Arctic Ocean domain (the same as used in the Arctic energy budget analysis of Serreze et al. (2007) from JRA-25 by year and month (top) and averaged for extended summer (May-Sept [MJJAS], middle) and extended winter (October-April [ONDJFMA], bottom) seasons. Anomalies are computed with respect to the period 1979-2007. In the earlier part of the record, it was

(1) JRA-25 Reanalysis is an atmospheric reanalysis data product. These are retrospective forms of numerical weather prediction, the data for which start in 1979 when the satellite record begins.

common for an anomalously warm summer, contributing to a negative anomaly in September ice extent, to be followed by an anomalously cold winter or cold summer, helping to bring about recovery of the ice cover. Since about the year 2000, there has been warming in all months.

Positive anomalies are especially strong in the last few years and for October, a month after the seasonal sea ice minimum. This growing 'Arctic amplification' is linked to anomalous open water areas in September, from which there is rapid transfer of heat from the ocean mixed layer (the top 25-50 m of the ocean) to the atmosphere, cooling the former and warming the latter. Atmospheric circulation then spreads the positive atmospheric temperature anomalies horizontally to influence adjacent areas (Serreze et al. 2009). This amplified autumn warming can impact on ice growth, resulting in a thinner spring ice cover, which in turn would lead to less ice at summer's end and more warming. The major point however, is that with rising air temperatures in all seasons, prospects for the ice to recover through a sequence of cold years have dimmed.

Climatic implications of loss of sea ice

A seasonally ice free Arctic Ocean is expected to have widespread socio-economic, ecological and climatic impacts. One climatic impact already being observed is amplified warming during autumn. The concept of Arctic amplification is a near universal feature of climate model simulations (Holland and Bitz 2003). Arctic amplification refers to the idea that rises in surface air temperature (SAT) in response to increasing concentrations of atmospheric GHGs will be larger in the Arctic compared to the Northern Hemisphere as a whole. This is because as larger expanses of open water areas develop in summer, the oceans absorb the incoming solar radiation that would normally be reflected back out to space by the sea ice cover. The sensible heat content of the ocean increases, and ice formation in autumn and winter is delayed. However, before the ocean can once again refreeze in winter, it must first lose the heat it gained in summer. This promotes enhanced upward heat fluxes, seen as strong warming at the surface and in the lower troposphere. This vertical structure of temperature change is enhanced by strong low-level stability which inhibits vertical mixing. Arctic amplification is not prominent in summer itself, when energy is used to melt remaining sea ice and increase the sensible heat content of the upper ocean, limiting changes in surface and lower troposphere temperatures. Loss of snow cover contributes to an amplified temperature response over northern land areas, but this temperature change is not as pronounced as over the ocean.

Coinciding with the large ice losses observed since 2002, Arctic amplification has emerged in autumn (Serreze et al. 2009). Evaluation of surface air temperatures from atmospheric reanalysis products show that Arctic Ocean SATs were 3 °C to 5 °C warmer in autumn (Oct-Dec [OND]) for 2002 to 2007, compared to the long-term 1979-2007 mean (Figure 3b). The warming is centred directly over the areas of ice loss, but is also spread out over the adjacent land through atmospheric circulation. This warming associated with the loss of the summer Arctic sea ice cover may hasten permafrost degradation (e.g. Lawrence et al. 2008), leading to even more release of carbon to the atmosphere in the form of methane. With the expectation of continued summer ice loss, fostering more sensible heat gain in the upper ocean, autumn freeze-up will be further delayed, such that Arctic amplification should start to be seen in winter. Eventually, ice extent and thickness will be sufficiently reduced so that low-level warming will emerge in spring.

We also expect that warming associated with the loss of the summer ice cover will alter atmospheric circulation and precipitation patterns, not only in the Arctic, but also at lower latitudes. In a recent study by Deser et al. (submitted), climate model simulations were used to investigate the atmospheric response of a seasonally ice free Arctic Ocean. Results from the study reveal large impacts on atmospheric temperature, precipitation and snow cover in autumn and winter. Over Siberia and Canada, the largest temperature and precipitation responses are seen in November and December. Although the model experiments only addressed the direct impact of Arctic sea ice loss on atmospheric circulation and climate, the study serves as a guide. Oceanic feedbacks, in particular warming of the Arctic Ocean due to enhanced absorption of solar energy, may provide additional forcing to the atmosphere. In addition, warming of the high latitude Pacific and Atlantic Oceans may also alter the atmospheric circulation response through feedbacks with the mid latitude storm tracks (e.g. Peng et al. 1997).

Considering the potentially significant impacts that the continued reductions in Arctic sea ice will have on Northern Hemisphere climate during this century, scientific research needs to continue to focus on better understanding of the role of the Arctic in the global climate system.

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The Sea Ice is Our Highway: The Importance of Sea Ice to the Inuit Way of Life

Duane Smith
President, Inuit Circumpolar Council (ICC) Canada

Abstract

Interviews conducted for an Inuit Circumpolar Council (ICC) Canada study on the role of sea ice in contemporary Inuit life indicate that despite the increased difficulty in finding and harvesting big game and sea mammals due to thinning and less predictable sea ice, Inuit communities are persistent in maintaining their traditional diets. When asked whether changes in ice conditions were affecting their traditional diets, respondents spoke of having to travel further or in a different month than usual; they spoke of dietary substitutions such as hunting more musk-oxen when the caribou migration shifted away from their area, or they explained how melting permafrost has made the natural ice cellars used to age and store meat less effective. Not one of them said anything to suggest they were giving up on hunting despite the considerable challenges some were facing in getting out on the ice and land.

Introduction – Giving voice to Inuit

It has become common knowledge around the world that the Arctic climate is rapidly changing. Every summer new reports detail how much sea ice melted in that year, comparing the extent of the sea ice cover to previous years, and estimating when certain passages may be ice free. Many of these reports feature images of polar bears, as they have come to symbolise the idea of ‘Arctic’, just as penguins do for the people-less Antarctic.

For Inuit, the sea ice is our highway. Though some of our equipment is now more modern, Inuit are still out on the ice, travelling to find game (photo: ICC Canada).

Amongst the many statistics about sea ice listed in these reports and the subsequent outpouring of concern for the health of polar bears, Inuit sometimes wonder if the world realises that there are also people in the Arctic – people whose daily lives are personally affected by the sea ice conditions.

In order to give voice to Inuit and attempt to make these voices heard by international decision-makers, Inuit Circumpolar Council (ICC) Canada conducted a study on the role of sea ice in the lives of Inuit today. ICC Canada reviewed historical Inuit land claims and occupancy studies and updated them by interviewing twenty Inuit hunters and elders to ask about their use of sea ice.

The historical Inuit use of sea ice

Throughout our history, Inuit have been using the sea ice. We are a marine people. Our identity and way of life is closely connected with the sea, the ice and the snow of the Arctic. One clear indication of this is the location of our communities: both historical and current maps of the Inuit regions in Russia, Alaska, Canada, and Greenland show that virtually all Inuit communities are located on the coast.

Those few communities that are not directly on the coast are situated on major waterways with easy access to the sea.

Historical data, including the research led by Milton Freeman in the 'Inuit Land Use and Occupancy Project' done in the 1970s, shows that sea ice has always been used as an extension of Inuit land. Freeman led a large team of researchers who travelled to every Inuit community in what was then called the Northwest Territories, in Canada. They met with hundreds of hunters and together drew maps of all the places where each individual hunter had travelled in search of game. The result was a large compilation map showing all the land and sea occupied by Inuit, along with regional and individual maps indicating where Inuit were hunting for each species. A similar study titled 'Our Footprints are Everywhere' was conducted in Labrador, Canada.

The maps indicate on paper what Inuit already knew – that we Inuit travel extensively along the coasts near our communities, and frequently venture one hundred kilometres from the coast, or even more, when hunting seals, whales, polar bears and other sea mammals. The maps show that for Inuit, the sea ice is our highway.

Continued importance of the traditional diet

In order to study what may have changed in the way Inuit use sea ice now as compared to the 1970s when these land use and occupancy studies were done, ICC Canada interviewed twenty Inuit hunters, most of whom were also elders, from thirteen different communities across the Canadian Arctic. One of the questions we asked was whether they continue to eat a traditional diet, meaning food that comes from subsistence hunting, fishing, whaling, birding, berries and so on. The answer was a resounding yes.

The individuals we interviewed told us that they are having increased difficulty finding and harvesting big game and sea mammals due to thinning sea ice and less predictable sea ice, but that they are doing their best to maintain their traditional diets.

They told us that changes in ice conditions were affecting their traditional diets because they often have to travel further or in a different month than they used to. Some of them have also been forced to make dietary substitutions. Inuit in the community of Sachs Harbour reported hunting more musk-oxen because the caribou migration has shifted away from their area, for example.

Several of the hunters and elders also mentioned that melting permafrost has made the natural ice cellars used to age and store meat much less effective. This greatly heightens the risk of food spoilage during the ageing process. It also increases the need for large community freezers. Such freezers can perform the same function as the natural permafrost freezers, but running them requires energy that must be acquired and paid for whereas the natural freezers did not cost anything.

Despite these new challenges, however, not one of the people interviewed said they were giving up on hunting. The answer given by Frank Pokiak from the Hunters and Trappers Association of the Inuvialuit Settlement Region expresses this determination well. He said:

> *I'm still going to depend on harvesting, different species if it has to be. The majority of my food I still get from the land, I still depend on all the fish that we get and different ways to prepare it. Whale meat and seal meat, geese. You just change with the changes, I guess. I'll still be here. As long as I'm alive I'll keep doing what I'm doing (28 March 2008, quoted in ICC Canada 2008:12).*

Moving to follow the game

Life in the Arctic – the lives of people, but also of wildlife, birds, fish, sea mammals and so on – is dependent on movement. Many of the species in the Arctic are highly migratory. Take seals, whales, polar bears, walrus and geese, to name a few. These species travel hundreds or thousands of kilometres during their annual migrations, and many of them depend on sea ice to do so. When ice conditions change, their migratory patterns must change as well. In some cases the changes are so extreme that they can no longer access their usual feeding or nesting areas, forcing them to adapt if possible or else face starvation and population loss. Because Inuit rely on these highly migratory species for our subsistence, our way of life requires a great deal of movement. We follow the animals as far as needed in each season, depending on the conditions of that particular year.

Though many Inuit now use snowmobiles instead of dog teams, we are still out on the land and sea just as our ancestors were, travelling as far as necessary in order to seek out the wildlife we rely on for subsistence. The hunters interviewed in the ICC Canada study reported that in some cases, they do not need to travel as far as they did years ago in order to find enough game, but in other cases they have to travel much further than they used to. This depends on the particular conditions surrounding their communities. For example, the floe

Inuit are still out on the land and sea just as our ancestors were (photo: ICC Canada).

edge – the place where the sea ice ends and the open water begins, which is a prime location for harvesting seals and bears – may be closer to or further from their coastal community than it used to be, or the route of the annual caribou migration may have shifted.

A hunter from Kangiqsujuaq, a community in the Nunavik region on the shores of Hudson Bay, described the effect of shifting migrations this way:

> *This past year we had a really hard time finding caribou. We travelled all over and didn't find any. We ended up going over to the island, which we never do, but finally there we managed to catch a caribou. It was really affecting our community already (Panguartuq, 15 March 2008, quoted in ICC Canada 2008:14).*

Looking at the overall changes in hunting areas, with some having decreased and others increased, the ICC Canada study suggests that on average Inuit are still occupying a similar amount of land and sea as we did in past generations.

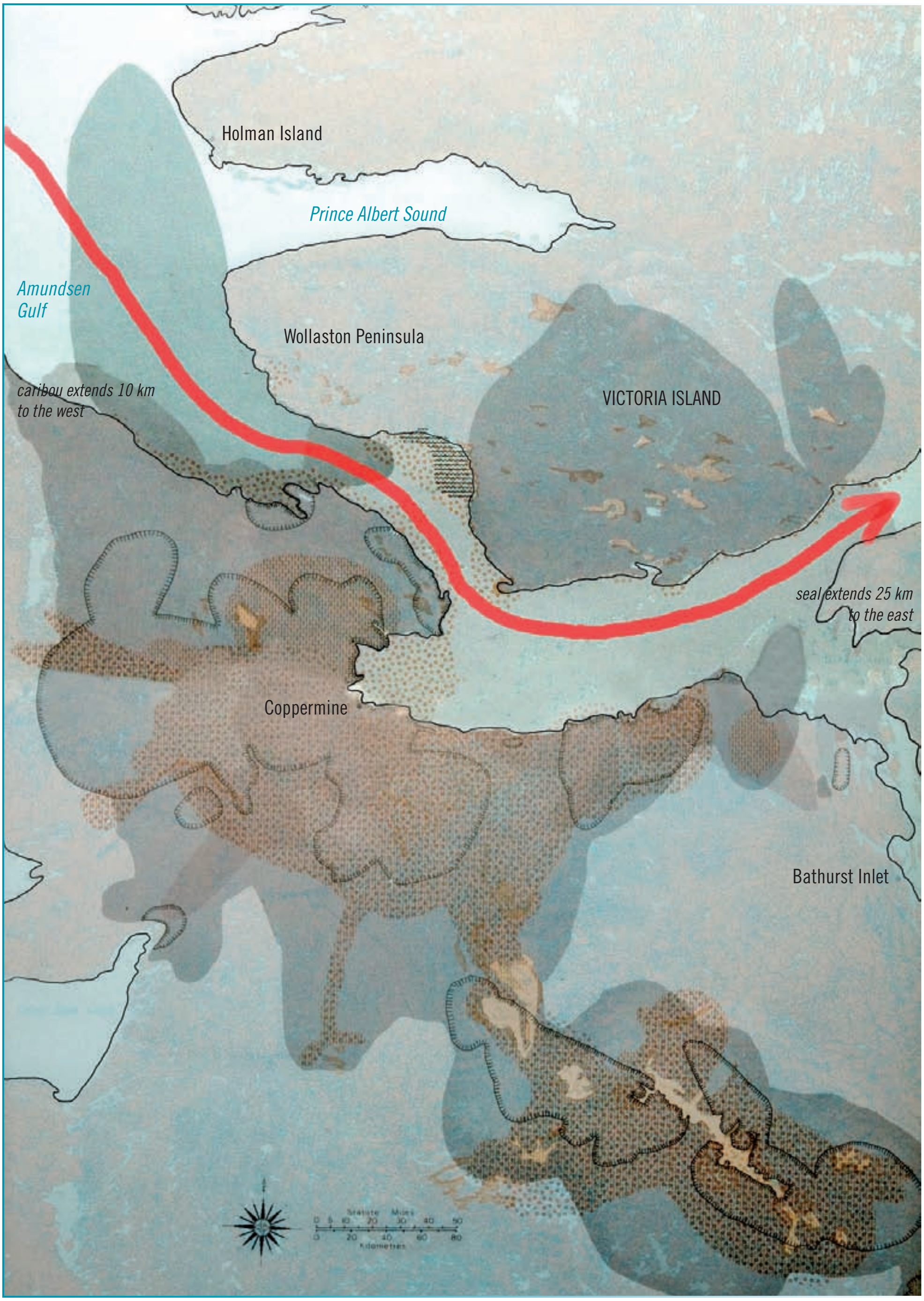

Figure 1. This Northwest Passage shipping route through the hunting regions (shaded) of the Inuit community of Kugluktuk, Nunavut illustrates colliding interests between Inuit land use and shipping (Freeman 1976, modified).

Recommendations

The ICC Canada study on the role of sea ice in Inuit life underscores the fact that Inuit continue to rely on traditional foods and continue to practise subsistence harvesting in the same regions as we have for hundreds of years by using the sea ice as our highway. Following from this conclusion come three major recommendations.

1. Regulate Arctic shipping

The first major recommendation put forward is that Arctic shipping must be strictly and effectively regulated. Because Inuit continue to rely on a traditional, subsistence-based food supply, and because this food supply comes from highly migratory species of wildlife, Inuit health and the health of the Arctic ecosystem depend on strict regulations to protect the water, land and air from pollution due to shipping.

Inuit have observed, and Western scientists have corroborated, that small amounts of contaminants can cause serious damage to Arctic flora and fauna. With the new opportunities for exploration and development opening up due to climate change and the subsequent reduction in sea ice, the risk of contamination is growing exponentially. While the risk of pollution caused by land-based exploration and development is serious, Inuit as a marine people are most concerned about the risks associated with increased shipping traffic. We are afraid that a large oil spill, the dumping of on-board wastes, or simply the cumulative effect of exhaust from many ships will wreak havoc on our fragile Arctic marine ecosystem.

Inuit in Canada are especially concerned because each of the routes that make up the Northwest Passage cuts through Inuit hunting regions. In order to reduce the risk of irrevocable damage to the Inuit way of life, we are urging the international community and the Arctic states in particular to: adopt stringent regulations that permit travel only for ships constructed for Arctic conditions and only for ships that are navigated by specially trained crews; rapidly develop technology to clean up oil spills and seepage in the unique conditions of the Arctic; improve their capacity to respond immediately to spills, or train Inuit to do it; and enact laws that prohibit all forms of marine waste dumping.

It will also be necessary to regulate when and where ships are allowed to travel in order to be certain they are not disrupting the particularly sensitive areas where animals feed and nest, or disrupting migration cycles by cutting through with ice breakers at inopportune times.

For the sake of our children, let us continue our efforts to keep climate change from progressing (photo: ICC Canada).

2. Support Inuit adaptation

The second major recommendation that follows from the recent hunter and elder interviews is that more support for Inuit-specific adaptation to climate change is necessary. Inuit are creative, courageous and determined to adapt to the changing climate, just as our ancestors have adapted for millennia. This is obvious in the following selection of quotes from Inuit hunters:

> *I'm still going to depend on harvesting, different species if it has to be… You just change with the changes, I guess… As long as I'm alive I'll keep doing what I'm doing (Pokiak, 28 March 2008, quoted in ICC Canada 2008:12).*
>
> *Then we'll use other equipment. People will still hunt. It's part of our life. When things change, you just have to go with it (Qaqqasiq, 14 March 2008, quoted in ICC Canada 2008:11).*
>
> *A buddy of mine is into making little sleds out of aluminum, which you can use as a little kayak or boat. If you're out on the ice and you have to cross an open lead or something you can use that. It's one of the things that can help. I'm going to get one of those. It's combined as a little sleigh and, if you have to, you can use it as a boat. That's one way I can adapt (Keogak, 13 March 2008, quoted in ICC Canada 2008:12).*

We as Inuit will do our best to adapt to climate change, but because this change is happening so quickly, we need support to deal with it. For example, we need more creative, Inuit-specific inventions like the sled-kayak hybrid described above. In order to foster innovative ideas like that one, and especially in order to distribute such innovations to all Inuit who need them, we will need outside support to undergird the efforts we are making ourselves.

3. Continue climate change mitigation efforts

Lastly, the third major recommendation is to continue working to halt climate change. Although the challenge of halting or even slowing climate change often seems overwhelming, we as Inuit urge the international community to press on toward this ambitious, but necessary, goal. Now that the United States appears to be exercising more leadership on the climate change issue, and is using its influence to bring other countries like Canada and China on board, there is a glimmer of hope that there may be a breakthrough at the UNFCCC COP15 Copenhagen climate change summit at the end of this year. For the sake of our children, let us all remain hopeful and tirelessly continue our efforts to keep climate change from progressing any further than it already has.

Conclusion

In conclusion, ICC Canada's interviews with Inuit hunters and elders indicate that changing sea ice conditions are already having a significant effect on Inuit communities. Inuit are working hard to adapt to the challenges this poses to food security and subsequently to Inuit health, culture and economic security.

Arctic states, the international community, advocates for the environment and for the rights and concerns of indigenous peoples, along with concerned citizens everywhere, can do their part to help by pushing for strict Arctic shipping regulations, providing support for Inuit-specific adaptation, and redoubling their efforts to reach a breakthrough in global efforts to stop human-induced climate change. For the sake of generations to come, we must work together now.

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What Have We Found in the Polar Oceans During the International Polar Year?

Jean-Claude Gascard
Coordinator, EU DAMOCLES Project, France

Abstract

Due to global warming and its polar amplification related to positive feedback such as albedo, the polar regions are experiencing unpredicted and unprecedented changes. The Arctic sea ice has retreated in summer by almost 50 per cent during the last 20 years. This ice is also much thinner, younger and moves faster. All the models predict a disappearance of Arctic sea ice during this century. But all the models appear to lag current observations by several decades and the disappearance of Arctic sea ice could occur much sooner than models have predicted. We have also observed an amplification of global warming affecting ice shelves along the Antarctica peninsula and in western Antarctica. In the Arctic, sea ice retreat seems to accelerate the melting of the Greenland ice cap, responsible for a sea level rise of about 1 mm to 2 mm per year. Arctic sea ice retreat seems also to affect permafrost and methane releases aggravating greenhouse gas concentration in the atmosphere. The international scientific community was mobilised during IPY to study climate changes affecting polar regions. But this community needs to continue operating in these regions according to an international agreement (e.g. a Memorandum of Understanding).

What have we found in both polar oceans, the Arctic and Antarctic, during the International Polar Year?

Firstly we should remember a few differences between these two oceans, and a few similarities. The Arctic is an ocean surrounded by land; a Mediterranean Arctic. It receives and drains a large amount of freshwater coming from Siberia and the Mackenzie Delta (10 per cent of the freshwater on the planet). The Southern

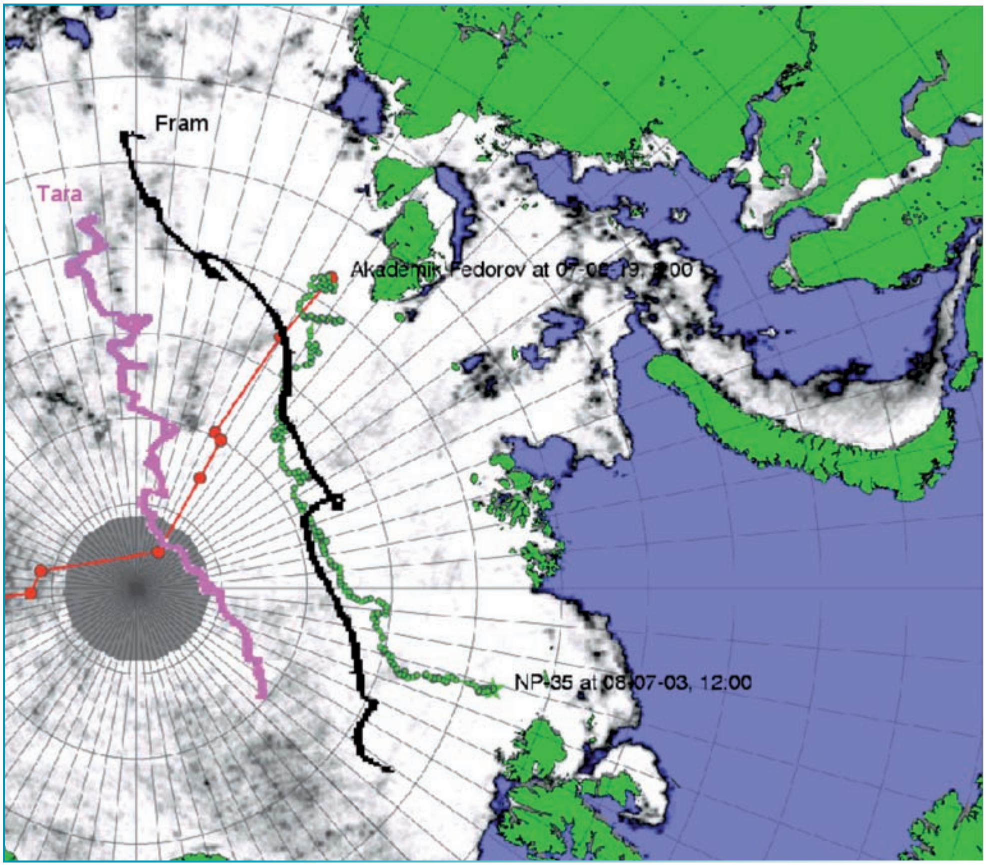

Figure 1. The transpolar drift of the Norwegian vessel Fram led by the explorer Fridtjof Nansen in 1893-1896 compared to the transpolar drift of the French schooner Tara between September 2006 and September 2007 (1 year) and the Russian drifting Station NP35 between September 2007 and July 2008 (10 months). This demonstrates the acceleration of the transpolar drift during recent years.

Ocean is surrounded only by the Antarctic Circumpolar Current, which defines its borders. Both oceans are covered with sea ice in winter: 20 million km^2 in Antarctica and 14 million km^2 in the Arctic, of a thickness of around 2m and 3m on average respectively. The big difference is that Arctic sea ice is largely resistant to summer melting (half of the Arctic Ocean used to remain ice covered in summer) in contrast to the Antarctic sea ice, which melts almost entirely every year.

Both oceans are also regions where the deep waters of the world are formed, where the waters regenerate and become dense and oxygenised. They are the lungs of our planet, i.e. where the salt water, like the blood circulating in our veins, is purified and oxygenised and then circulates through the deep arteries of the Earth.

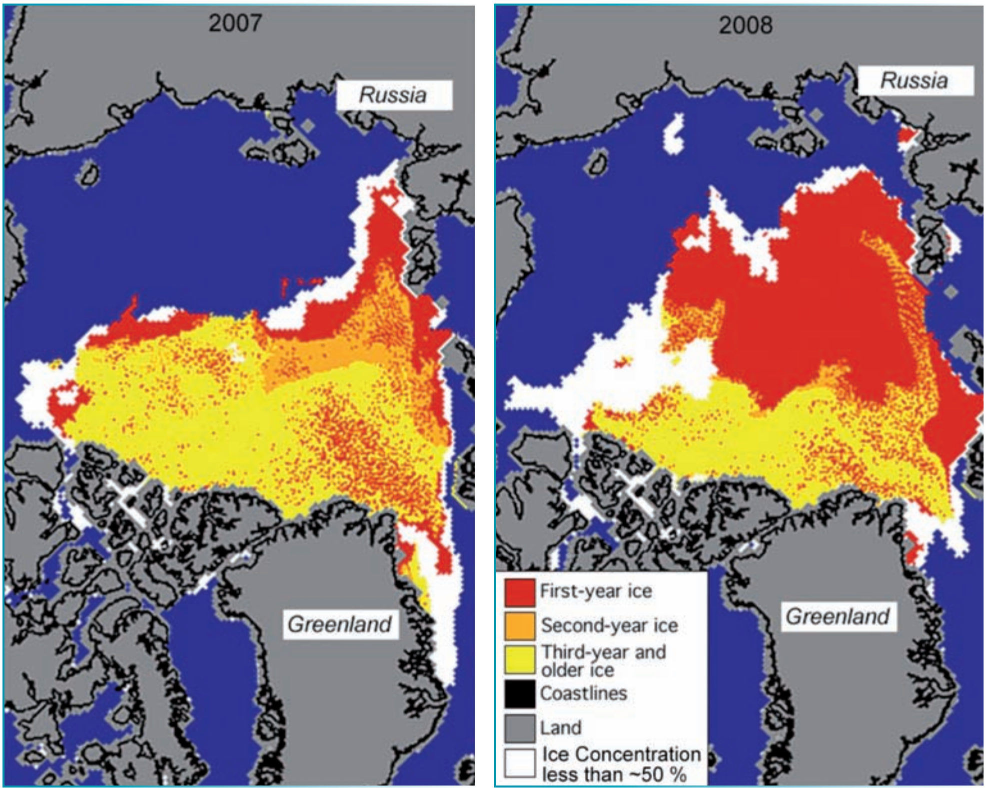

Figure 2. Intercomparison of sea ice summer minimum extent in September 2007 and September 2008. Both years reached a record minimum extent. The main difference comes from the fact that in September 2008 half of the perennial ice disappeared compared to September 2007, and was replaced by first year ice which became second year ice after resisting summer melting. In September 2007 almost all the first year ice disappeared either by melting and/or exiting the Arctic Ocean through Fram Strait. In terms of sea ice mass and volume the 2008 situation corresponds to a great reduction in sea ice remaining at the end of the summer than in 2007 (NSIDC; Courtesy of C. Fowler, J. Maslanik and S. Drobot, CU Boulder).

Thermohaline circulation is a highly important element in the Earth's climate machine, and it works like a central heating system by enabling the transport of bodies of water heated at the equator to the poles, where they are cooled. The Earth's climate is not determined solely by the greenhouse effect, it is also substantially influenced by this transport of oceanic heat from the equator to the poles.

The atmosphere of the two polar oceans is characterised by two polar vortices that maintain masses of cold air above the ice. These two vortices are not isolated, however, and the Arctic especially has become very sensitive to low pressure systems that draw more and more heat to medium and high latitudes. Poleward transport of heat by the atmosphere is highly comparable to that of the ocean.

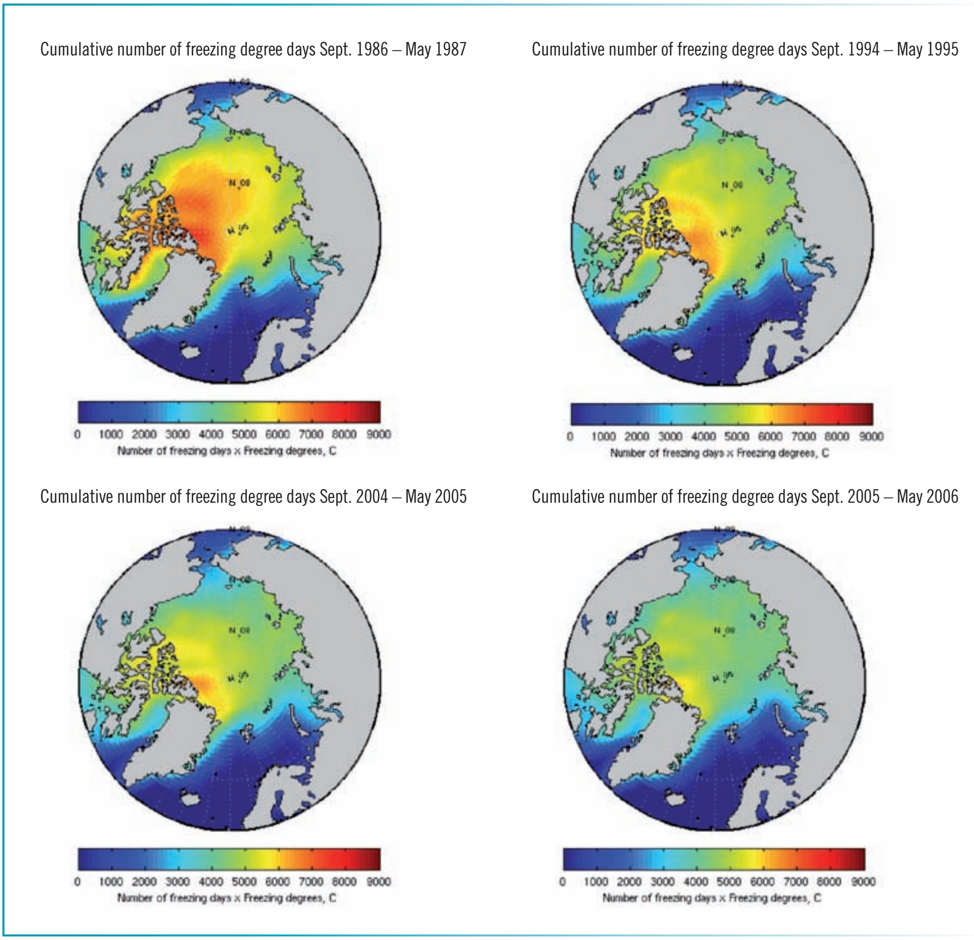

Figure 3. Number of cumulated freezing degree days between September and May for different periods over the past 20 years, showing a reduction of cumulated freezing degree days of about 1,500 °C between 1986 and 2006.

The Arctic ice drastically changed over the last 10 years. 2007 and 2008, albeit exceptional, were of course not accidents. The scientific literature has reported on exceptional events each year over the last 10 years. This can be summarised briefly. The extent of sea ice at the end of the summer has regularly been the subject of press releases, especially during the two years when the autumn polar sea ice registered record figures. From 8 million km^2 30 years ago, the extent of ice in 2007 and 2008 was nearly 4 million km^2 in late summer. The average thickness of sea ice has decreased from more than 3 m in the 1970s, to about 1.5 m now. A sea ice extent that has been halved, coupled with an ice thickness that has been halved, amounts to a loss of 75 per cent of late summer sea ice volume and mass.

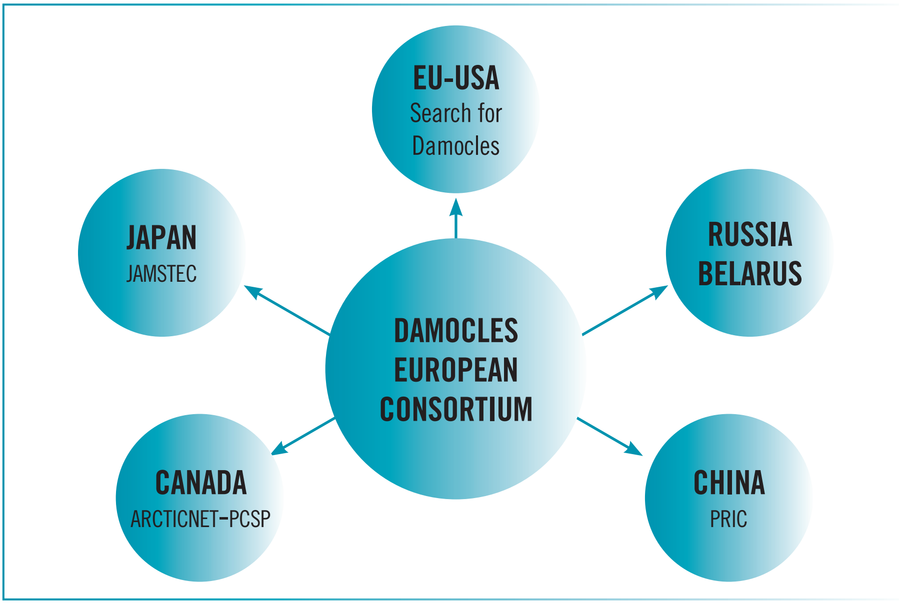

Figure 4. International cooperation during the 4th International Polar Year and the European integrated project DAMOCLES of the EU 6th Framework Program.

This is monumental. But that is not all, for we have also observed that the drift of sea ice has recently increased significantly. The transpolar drift of the ship *Tara* in 2007 and of the Russian drifting station NP35 in 2008 were twice as fast as the drift of the ship the *Fram*, with the explorer Fridtjof Nansen, more than 100 years ago (12 years after the first International Polar Year) (Figure 1).

Finally and perhaps most importantly, sea ice in the Arctic has shown it can rejuvenate considerably, but unfortunately in this case it is longevity that is a sign of good health. Indeed, it is the perennial ice in the Arctic that can prevent a loss of sea ice in late summer, while the young ice formed that year is less thick and salty, and is thus more vulnerable. With the loss of the perennial ice in the Arctic, which guaranteed high stability of the ice, we expose the Earth's climate system to major changes in the coming years. A total retreat of Arctic sea ice in summer would cause a radical change in the radiative balance of the entire northern hemisphere. Indeed a frozen surface of 4 million km^2 (albedo 0.8) that disappears to leave an ocean free of ice (albedo 0.2) exposed constantly to solar radiation, corresponds to four times more energy entering the ocean during the summer months. This would further delay the formation of ice during the winter and thereby reduce the Arctic sea ice mass balance at the end of winter.

We found that between November 2007 and March 2008 the perennial ice declined by half. This is considerable. A comparison between September 2007 and September 2008 at the time of the minimum ice extent reveals a massive reduction in perennial ice in 2008 that had been compensated by an equal amount of first year ice that resisted the summer melting (Figure 2). In contrast, we can highlight significant anomalies in the summers of 2005 and 2007, in which unlike in the summer of 2008, the first year ice did not make up for the loss in perennial ice because this young ice had either completely melted, or it had left the Arctic via the Fram Strait without the possibility of returning. In September 2008 we saw a very significant decrease in the mass balance of Arctic sea ice compared to September 2007, although the ice extent had not decreased significantly between these two years at the end of the melt period.

It is very clear that the prediction models are lagging far behind in their representation of the evolution of sea ice in the Arctic. This is mainly because phenomena of non-linear positive feedback which greatly amplify the greenhouse effect, such as albedo for example, are poorly reflected in the models. The albedo effect, which acts directly on radiation balance, requires consideration of poorly known parameters such as cloud cover, transparency of the atmosphere and snow cover on the surface of the ice. We see a gradual warming of the lower atmosphere, which corresponds to a loss in 20 years of 1,500 °C freezing degree days during the entire period of freezing, which lasts from September to May (Figure 3) (freezing degree days are a cumulative sum of average degrees below freezing per day, over a given period of time). This loss is largely due to warmer autumns causing the freeze-up to come later, as the ice free ocean that has captured a lot of solar energy releases this heat in the autumn. It is also due to an early onset of the melting period. Dramatic changes are also being observed in Antarctica, on the Antarctic Peninsula and in the western Antarctic (Bellinghausen Sea), where major collapses of the ice shelf due to the early withdrawal of the Antarctic sea ice have been reported.

The impacts of these changes on marine ecosystems are very important, for example the migration of species such as diatom *Neodenticula seminae* from the North Pacific to the North Atlantic have been reported. This is probably related to the reduction of sea ice in summer leading to more North Pacific water circulating through the Canadian Archipelago, but this has not been proven yet. Of note also in the Arctic (Chukchi Sea) is that the partial pressures of CO_2 in the waters are well below the partial pressure of CO_2 in the atmosphere, causing an increase of CO_2 uptake by the Arctic Ocean and a risk of acidification.

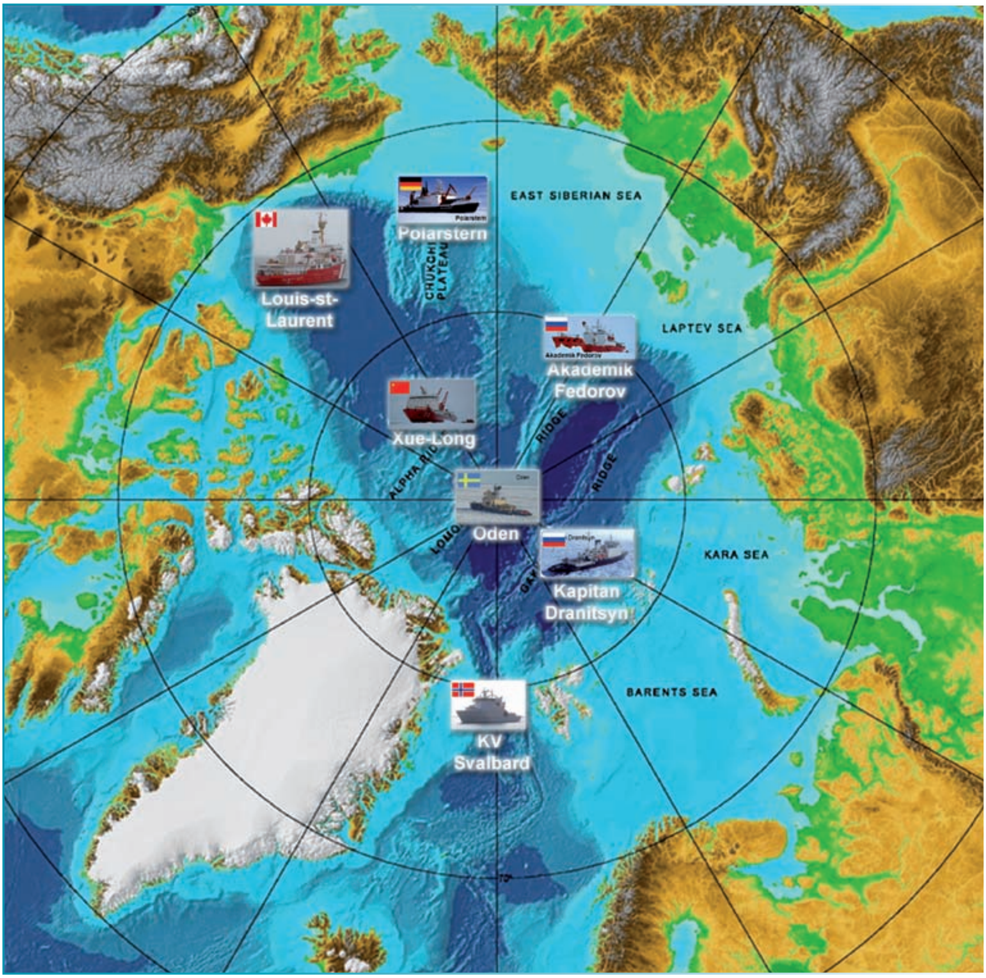

Figure 5. Seven ice breakers operating in the Arctic Ocean during the summer 2008 from Canada (Louis Saint Laurent), from Sweden (Oden), from Russia (Akademik Fedorov and Kapitan Dranitsyn), from Norway (KV Svalbard), from China (Xuelong) and from Germany (Polarstern). The icebreaker Healy from the USA also operated in the Arctic in the summer 2008.

The Arctic sea ice is certainly the part of the cryosphere that is currently showing the greatest changes. This is in close interaction with the continental ice and permafrost. We are currently witnessing a major change in the Arctic climate system, which has most visibly led to the dramatic withdrawal of ice at the end of the summer. This can have consequences and impacts on the reservoirs of carbon, which is either stored on the continents in and under the vast expanses of frozen soils of eastern Siberia, or that is being transported and sequestered by the sea and buried under the ice of the Arctic Ocean, which acts as a major carbon sink for the planet. It is clear in both cases that the rapid changes of Arctic sea ice now observed suggest that we should worry about what could happen to these two major reservoirs of carbon, and consider the impact on our climate of a partial or total withdrawal of Arctic sea ice by the end of this century.

The polar meteorological front has retreated towards the north by approximately 1000 km across the whole width of Siberia, which seems to be well connected to the decline of sea ice in the Arctic according to Lawrence et al. (submitted). The melting of permafrost could lead to a massive release of methane, a powerful greenhouse gas. There are also gas hydrates which are stored in the ocean and which could be released if the deep ocean starts to warm up.

Greenland ice melt is undergoing acceleration mainly on the continental margin. It seems that this is the result of an interaction between glacial fronts and the coastal ocean. These interactions present in the fjords, where tongues of glaciers come to drop ice into the ocean, are very important.

Review of the International Polar Year

This International Polar Year is very different from previous ones. With regard to research on climate change in particular, the polar regions play a key role for us in anticipating major, dangerous climate shifts. They are our crystal balls for seeing the future. How can it be possible in such circumstances that the observations made during these two years might be put to sleep for 25 or 50 years until the next International Polar Year? It makes no sense at a time when we are observing the first important signs of climate change on our planet in polar regions. This is a change of which we know the origins, but which surprises us by its suddenness, leaving many questions unanswered for the future of humanity. This is not strictly speaking a danger to the Earth, which has gone through many other far more dramatic changes, but it is a challenge to humanity as a whole. On what kind of Earth would we hope to live? How can we live on an Earth with 7 billion people today, soon to be 10 billion, with finite resources which are very poorly shared? We know that the Earth is subject to significant climatic variations, which are in general slow, but some can be very rapid and can generate enormous difficulties and major conflicts worldwide.

What to do?

We must maintain a highly rapid pace of work that can be sustained, of the same intensity as that successfully generated during the International Polar Year. We know that the stakes are global. The challenges go far beyond the capacity of any one country, even the most powerful. The effort required is universal and international, multidisciplinary and multiethnic. We need men and women from all countries, scientists and engineers, students and professors, journalists and writers. We need research vessels (icebreakers in the Arctic and Antarctica) and submarines, satellites and computers, and other innovative technologies.

Regarding the remarkable efforts developed during the International Polar Year, we should highlight the European Integrated Project 'Damocles' (Developing Arctic Modelling and Observing Capabilities for Long-term Environment Studies) of the 6th Framework Program, of which the University Pierre et Marie Curie (France) leads the coordination. Independent experts who evaluated the results of the Damocles project every year repeatedly awarded the title of 'flagship of Europe for the IPY' to this specific project. The project coordinates and brings together the efforts of all Arctic experts: from North America, with the USA and the Search programme (Search for Damocles) and Canada with the ArcticNet network; from Asia (Japan, South Korea and China); from Russia (full member of the Damocles consortium); and from the core of ten European countries representing forty-five laboratories in Europe, all of whom are Damocles partners (Figure 4). A sure sign of the project's importance: there were seven icebreakers operating in the Arctic during the summer of 2008 (Figure 5). The unique link between these vessels was Damocles and the IPY. The international community has paved the road, and it will thus be able to continue its efforts. An international symposium on the Arctic will take place in Brussels a month before the COP15 meeting in Copenhagen. Damocles, with Europe and all our partners in the USA and Canada, Asia and Russia, will be sending a clear message to COP15 (a Declaration) regarding the importance of the phenomena observed during the IPY in the Arctic and the urgency of continuing research on the impacts that these phenomena might have on our environment. We will also highlight the difficulties these impacts could create for international cohesion and for plans for demographic development worldwide and for developing robust sustainable development. In the case of the Arctic it is essential to establish a Memorandum of Understanding to allow the international scientific community open access to the Arctic Ocean, which will inevitably be different from the Antarctic Treaty.

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Cryosphere and Climate: The Arctic Challenge

Barry Goodison
Visiting Expert,
World Meteorological Organization, Switzerland

Abstract

The cryosphere is arguably the most visible and informative indicator of climate change over the Arctic. Monitoring and modelling of the elements of the cryosphere and assessing cryospheric change and associated impacts in an integrated manner in high latitude areas are essential in the study of climate change and Arctic sustainability. This short paper notes some of the changes in the Arctic cryosphere and associated key gaps in our knowledge. Recent science and observing plans and assessments that focus on climate-cryosphere issues are available upon which to build future research initiatives. The IPY 2007-2008 was a great success and provides the impetus to continue polar science needed to support sustainable development in the Arctic in a changing environment. Four recommendations are suggested to build this science basis: an International Polar Decade, sustaining Arctic observing networks, integrated monitoring, and user focused climate services for adaptation and sustainable development. Action on these should start now.

Introduction

The cryosphere collectively describes elements of the Earth system containing water in its frozen state on land and sea, and includes: snow cover and solid precipitation, sea ice, lake and river ice, glaciers, ice caps, ice sheets, permafrost and seasonally frozen ground. The cryosphere is arguably the most visible and informative indicator of climate change over the Arctic region, as dramatically seen during the last decade, as is noted by Stroeve (2009). Through its influence on surface energy, moisture fluxes, clouds, precipitation, hydrology and atmospheric and oceanic circulation, the cryosphere plays a significant role in not only the regional climate of the Arctic, but also in global climate. Yet monitoring and modelling of the elements of the cryosphere and assessing cryospheric change and associated impacts in an integrated manner in high latitude areas are complex and remain a major challenge. Major pan-Arctic changes to bio-geophysical and socio-economic systems are of special importance to northern residents and a key element of these changes is the changing cryosphere and the associated processes within the Arctic system. Figure 1 provides a very useful perspective for understanding the Arctic cryosphere and some of the major associated climate feedbacks and bio-geophysical and socio-economic impacts (Prowse et al. 2005).

Changes in the Arctic cryosphere

Stroeve (2009) provides discussion of changes in one of the key Arctic elements of the cryosphere – sea ice. Changes have been dramatic, but likewise there have been notable changes in the other elements of the cryosphere which are having significant impact on the bio-geophysical and human dimensions of the Arctic. Changes in the cryosphere have been well documented through ongoing assessments, from the Arctic Climate Impact Assessment (ACIA 2005) through to the recent IPCC report (Lemke et al. 2007) and the current assessment 'Snow, Water, Ice and Permafrost in the Arctic' being conducted by the Arctic Council and others. UNEP (2007) provides not only a summary of the changes in the elements of the cryosphere, but notes impacts of these changes on ecosystems, societies and economies. These documents should be consulted for the current assessment of changes in the Arctic cryosphere. However, it is important to remember that changes are not uniform across the Arctic. Changes in the cryosphere vary locally and regionally as well as seasonally and annually. The impacts of these changes can vary from community to community, and these communities are adjusting constantly to such environmental changes. Changes, which now seem to be reported almost daily, include:

¬ Declining Arctic sea ice extent over the last several decades, with an accelerating rate of decline over recent years, affecting transportation, energy exploration and development, marine ecosystems and indigenous hunting practices;

¬ Increasing mass loss from Greenland, especially over the last decade, through both glacier calving and surface melting, resulting in a positive contribution to sea level rise;

¬ Increasing ice loss from high latitude glaciers and ice caps, especially since the mid 1990s, with the Arctic and Alaskan glaciers making large contributions to sea level rise because of their large area;

¬ Decreasing spring snow cover, affecting ecosystems and transportation, such as by snowmobile to hunt;

¬ Changing snowpack structure, with snow often packed harder than normal by changing winds, affecting wildlife grazing and herding practices;

Figure 1. Examples of major climate feedbacks and bio-geophysical impacts resulting from major changes to cryospheric and hydrologic processes and systems in the Arctic (Courtesy of Terry Prowse; from Prowse et al. 2007).

¬ Increasing temperatures at the top of the permafrost layer in the Arctic, by up to 3 °C since the 1980s. When permafrost starts to thaw, the changes may impact ecosystems, infrastructure, hydrology and the carbon cycle, with the largest impacts in areas where permafrost is rich in ground ice;

¬ Shortening of the freshwater ice season in northern Canada, with the reduction being mainly attributable to earlier break ups, with such ice loss reducing ice transportation access to northern communities.

There are continuing interactions between the different elements of the cryosphere and with weather and climate. To look at Arctic sustainability, we must understand what, why, when and where the cryosphere is changing. We must continue to observe and analyse changes, conduct field process studies to understand the changes, and improve our modelling of weather and climate and the cryosphere in the Arctic region to improve prediction of future changes which are needed to develop adaptation strategies. Results from investigations conducted during the International Polar Year 2007-2008 are expected to provide new knowledge about the Arctic cryosphere and provide a baseline for assessing environmental change in the Arctic (Goodison et al. 2007).

Gaps in cryosphere-climate knowledge

Gaps in our knowledge on cryosphere-climate interactions and the impacts of the changing cryosphere on physical and socio-economic systems have been identified in recent years through national and international initiatives. Science plans or assessments produced by WCRP's CliC Project (Allison et al. 2001; CliC 2005), the Arctic Climate Impact Assessment (ACIA 2005), the Second International Conference on Arctic Research Planning (ICARP II 2007), UNEP's Global Outlook for Snow and Ice (UNEP 2007), the IPCC WG1 chapter on Observations: Changes in Snow, Ice and Frozen Ground (Lemke et al. 2007), and currently, the Arctic Council's SWIPA initiative, all articulate scientific gaps in knowledge and identify needed actions. Reports of the IGOS Cryosphere Theme (IGOS 2007) and SAON (SAON Initiating Group 2008) focus on observational gaps and needs, complementing the reports noted above. The most recent, ambitious collaborative initiative addressing several of the gaps in our knowledge has come through the International Polar Year 2007-2008 (IPY) projects (Allison et al. 2007). Yet challenges remain to improving our understanding and prediction of the past, present and future of the Arctic and the Earth systems. Some knowledge gaps in cryospheric studies, as identified through the WCRP Climate and Cryosphere Project (Allison et al. 2001; CliC 2005), ICARP II (Bengtsson et al. 2007; Prowse et al. 2007), and the initial IPY statement on the state of polar research (Allison et al. 2009), include:

- Determination of the mass balance of ice sheets and glaciers and their contribution to sea-level change through improved/enhanced observation and modelling;
- Accurate determination of sea ice extent and thickness and improved representation of sea ice in climate models to improve future prediction of changes;

¬ Improved understanding and quantification of the role of permafrost and frozen ground in the carbon cycle through a coordinated measurement and modelling framework for the northern high latitudes;
¬ Significantly improved accuracy of observation and model prediction of precipitation, especially snowfall, over the Arctic land and ocean;
¬ Determination of the present and future freshwater balance of the Arctic and assessment of the impact of changes on bio-geophysical and socio-economic systems;
¬ Improved prediction of the cryosphere using regional climate models leading to improved prediction on monthly to seasonal or longer timescales;
¬ Identification of climate and cryosphere information needs of people and groups living and working at high latitudes and provision of cryosphere products to users, along with information on their interpretation and use.

The challenge now is to sustain the momentum that IPY generated. IPY Legacy initiatives, which would address gaps in cryosphere-climate knowledge and contribute to a comprehensive, integrated observing system of the Arctic include: Sustaining Arctic Observing Networks (SAON) (SAON 2008), with an Integrated Arctic Ocean Observing System (iAOOS) (Dickson 2009), Arctic-HYCOS (runoff), and *Integrated* AON (Atmospheric Observing Network); Global Cryosphere Watch (GCW) (Goodison 2009); Polar Satellite Constellation based on the IPY GIIPSY project (Jezek and Drinkwater 2008); and Polar Regional Climate Outlook Forum (PCOF) (WMO 2008).

An integrated observation and data management system is essential, incorporating *in situ* and satellite observations from operational and research networks and platforms and proposed polar reference stations or 'supersites' following established standards and guidelines (Allison et al. 2001; Goodison 2009; Prowse et al. 2007). For the cryosphere, WMO's Global Cryosphere Watch initiative (Goodison 2009) is being designed to provide reliable, comprehensive observations of the elements of the cryosphere through an integrated observing approach, in collaboration with relevant national and international programmes and agencies, and to provide authoritative products and information on the current and projected future state of the cryosphere to support decision-making and environmental policy development. It will be a focus for implementing the IGOS Cryosphere Theme (CryOS) and will build on the work already being done by the cryosphere community. Strong cooperation is therefore needed among all partners to establish a functional Global Cryosphere Watch. The concept of GCW is based on the premise that agreed-upon standards and recommended practices and procedures will apply to the cryospheric observing systems. Where these do not currently exist, GCW would work with WMO and partners to develop appropriate best practices. This should include homogeneity, interoperability and compatibility of observations from all GCW constituent observing and monitoring systems. GCW will respect partnership, ownership and data-sharing policies of all observing components and partner organisations. It should have an organisational, programmatic, procedural and governance structure that will significantly improve the availability of, and access to, authoritative cryospheric information. Targeted pilot and demonstration projects over the next two years are being planned to demonstrate the feasibility of GCW. Such an initiative will contribute to our ability to address climate change and Arctic sustainable development.

IPY has not only advanced scientific knowledge, provided a snapshot of the current state of the Arctic system, and shown the benefit of comprehensive, integrated Arctic observing systems. It has also engaged young scientists, who are ready to carry the research to an even higher level, and engaged northerners, especially indigenous peoples, in science projects in which they contribute their knowledge to an improved understanding of the Arctic environment. Now the challenge is to engage national and international support for maintaining and expanding a multi-disciplinary Arctic research programme that will support sustainable development of the Arctic in a rapidly changing environment.

Recommended actions for Arctic research

The IPY 2007-2008 has been a success. It was timely, provided a focus on the polar regions and their people, advanced our scientific knowledge of these regions, built our scientific capacity and raised the public's awareness of the rapidly changing polar environment. To continue this progress, to build on our collaborative efforts in these challenging regions, and to ensure that we have the knowledge base needed to address sustainable development in the Arctic, broad collaborative action and commitment among countries, organisations and agencies at the national and international level will be essential. Four recommended actions are given below that would contribute to this goal. They are broader in scope than just cryosphere-climate, and are intended to foster initiatives that are collaborative, pan-Arctic, multidisciplinary, integrative and sustainable over the longer term. They all require international collaboration, but national commitment is essential if they are to be successful in the long-term.

International Polar Decade

WMO and ICSU were the co-sponsors of International Polar Year 2007-2008. Over sixty nations invested human and capital resources to make IPY a success. Yet, it is recognised that there are continuing and growing requirements for information on environmental change in northern high latitudes by scientists, communities, northern peoples, decision-makers and policy-makers. There is a need to build upon the surge of operational and research programmes conducted during IPY and the need to convert these into sustainable long-term research and monitoring capabilities. This view was expressed in the declaration from the Monaco Conference on ‘The Arctic: Observing the Environmental Changes and Facing their Challenges’ which stated the need to ‘uphold the impetus launched by International Polar Year 2007-2008 and capitalise on the momentum created by consolidating and sustaining the mobilisation of scientific research and monitoring initiatives’. In addition, it is noted that the WMO Executive Council LX (2008) invited other international organisations to consider the launch of an International Polar Decade. Following this WMO suggestion, it is recommended that ICSU and other international organisations, such as UNESCO, consider the idea of an International Polar Decade as a long-term process of research and observations in Polar Regions to meet the requirements for climate change studies, assessments and prediction to benefit society.

Sustaining Arctic Observing Networks (SAON)

It is acknowledged that observing systems are essential for monitoring the current state and changes in the Arctic environment, and for validating and improving climate predictions over the Arctic. It is recognised that data and information for assessing climate variability and change and environmental sustainability are dependent on operational and research networks, on *in situ* and satellite systems, and on effective data and information exchange. IPY provided an expansion of observations and stimulated international cooperation on data management and access. Yet there remains a need for pan-Arctic coordination. Following on from ICARP II outcomes (ICARP II 2007), the Arctic Council/AMAP and IASC, with other international organisations, initiated discussion on Sustaining Arctic Observing Networks (SAON), a process to further multinational engagement in developing sustained and coordinated pan-Arctic observing and data sharing systems and social, economic and cultural change. Based on these discussions, and their recommendations for concerted action on sustaining Arctic observing systems, it is recommended that a mechanism be established to facilitate international collaboration among operators, funding bodies and users of observational systems and data over the Arctic region.

Integrated monitoring

a specific recommendation of ICARP II (2007) was that 'an integrated observation and data management system, incorporating all relevant disciplines, scales and observing platforms, is paramount and will make use of polar reference stations, so called "supersites"'. ICARP II also recommended that integrated observing plans require coordination of observations and modelling to ensure the same domains for modelling and observation work, which would lead to production of high-quality data sets representing the variability of essential parameters at dominant temporal and spatial scales. An integrated approach has been used in other programmes. Noteworthy is the success of the approach of integrated observation by the WCRP Co-ordinated Enhanced Observing Period (CEOP) in creating a global reference network of observatories for water cycle studies, by collecting atmospheric and surface data from *in situ* and satellite observations and output from atmospheric models over a reference area. The supersite/reference network concept would provide a pan-Arctic framework for building on IPY observing initiatives and proposed legacy observing initiatives, including WMO's Global Cryosphere Watch (GCW), the IPY International Arctic Systems for Observing the Atmosphere (IASOA), and iAOOS (Dickson 2009) for ocean areas, and it would contribute directly to the SAON initiative. Such an approach would require international multi-disciplinary cooperation, and should be seen as a key component in a pan-Arctic environmental monitoring and prediction system. Hence, it is recommended that an integrated polar reference observing network of 'supersites' be established, building on existing infrastructure and facilities, where feasible, where *in situ*, satellite and model data can provide long-term, multidisciplinary datasets suitable for environmental monitoring and prediction.

User focused climate services for adaptation and sustainable development

a fundamental step in assessing the impact of climate change on sustainable development in the Arctic is to identify clearly the climate information needs of people and groups living and working at high latitudes. Meeting those needs presents further challenges. It must be recognised that the predictive skill of global and regional models for high-latitude areas, on all timescales, need to continue to improve. There will be a need to assist the users in interpretation and application of climate information and products in real life decision-making. This, in turn, produces the need for capacity building, including technical training for climate scientists and product developers, and also for combined provider and user groups. Hence, it is recommended that a viable operational mechanism be established to facilitate effective interactions between climate professionals and users/stakeholders, such as a Polar Climate Outlook Forum (PCOF), a WMO IPY legacy project.

There have been many successful efforts to define the gaps in knowledge and the needs for Arctic research. The four initiatives above would build on these efforts and should build on the science and co-ordination plans, assessments and associated recommendations noted earlier, as well as the achievements of IPY 2007-2008. These initiatives will take resources, collaboration, co-ordination and commitment, but now is the time to act.

Acknowledgements

The author wishes to thank the World Climate Research Programme, which was his host while he was on secondment from Environment Canada to work on the Global Cryosphere Watch. Discussions with Ed Sarukhanian (WMO) and Vladimir Ryabinin (WCRP) on the paper and its recommendations are gratefully acknowledged.

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Siku-Inuit-Hila ‘The Dynamics of Human-Sea Ice Relationships: Comparing Changing Environments in Alaska, Nunavut and Greenland’

Lene Kielsen Holm
Director of International Sustainable Development,
Inuit Circumpolar Council (ICC) Greenland

With:
Shari Gearheard, Henry P. Huntington, Andy Mahoney, Yvon Csonka,
Ilkoo Angutikjuak, Toku Oshima, Warren Matumeak, Joelie Sanguya,
Igah Sanguya, Geela Tigullaraq, Mamarut Kristiansen, Qaerngaaq Nielsen,
Joe Leavitt, Nancy Leavitt and Roger Barry

Abstract

The Siku-Inuit-Hila (Sea Ice-People-Weather) project involves local people from Kangiqtugaapik in Nunavut, Qaanaaq in Greenland and Utqiagvik in Alaska, along with academic researchers from these three countries. The project has three major components: sea ice knowledge exchanges, regular meetings of sea ice experts in each community and the establishment of a sea ice monitoring network in the three communities. Throughout this innovative research, we have found that the best way to ensure interdisciplinary understanding and collaboration is to ensure that all actors share mutual experiences in the field during the research process, so that scientists and indigenous peoples connect on a personal level.

Introduction

The Siku-Inuit-Hila (Sea Ice-People-Weather) project involves Inuit from Kangiqtugaapik, Nunavut, Inughuit from Qaanaaq, Greenland and Iñupiat from Utqiagvik, Alaska, along with academic researchers from several institutions in these three countries. The project has three major components.

The first component includes a series of 'sea ice knowledge exchanges', visits by all participants (residents of all three communities plus the visiting researchers) to each of the study locations for participant observation. During these trips, the emphasis is on travelling on the sea ice together. The sea ice itself acts as the common denominator for the participating hunters and elders from different communities and scientists from different disciplines. The host community leads each visit, allowing the visiting team members to experience local hunting and travelling techniques and to exchange knowledge about diverse issues such as tools, clothing, food and navigation used in relation to sea ice.

The second component involves regular meetings of sea ice experts in each community. Led by local team members of Siku-Inuit-Hila, these working groups provide an opportunity to assess current sea ice conditions throughout the sea ice season and to document local knowledge of sea ice, ranging from traditional stories and mythology of sea ice, to sea ice terminology, to extreme events, to strategies for hunting and travelling in different sea ice environments.

The last component involves the establishment of a sea ice monitoring network in the three communities. Trained by the project's sea ice physicist and supported by a handbook created especially for the local monitoring teams, local technicians measure physical properties of sea ice and snow on a weekly basis at two to four stations installed at each community. Local sea ice experts chose the location of the stations according to key areas of importance for sea ice use. In combination with local historical records, available climate data and local knowledge, the data from the observing network provides detailed information about local and regional sea ice processes.

The different components of the project are tied together in a number of ways. Team members from the different regions have held workshops with elders and other knowledgeable persons in their respective areas. In these workshops they have been discussing sea ice and climate change issues, mapping changes, documenting related language/terminology, and talking about how recent climate and environmental changes have influenced their everyday lives. The data collected from these meetings are being incorporated into the work of Siku-Inuit-Hila, as is data collected from sea ice measurement instruments in these three Arctic regions. Sea ice monitoring is part of the project and the instruments are maintained by local people in the partner communities. The outcome of Siku-Inuit-Hila is first and foremost the meetings and exchanges between and among the hunters and scientists, and a book that is projected to be launched in 2010.

The diversity and breadth of knowledge, experiences and viewpoints about the Arctic and climate change

At the core of the Siku-Inuit-Hila project is our team spending time together, and as much time as possible on the sea ice. Through a series of exchanges, our team has travelled together and visited each of our partner communities. As a group, we are diverse – from Alaska we have whalers, from Baffin and Greenland expert hunters. We have a glaciologist, a climatologist, two anthropologists, and a geographer. We also work closely with local experts like hunters and elders and

Clockwise from top: Mamarut Kristiansen, Joellie Sanguya, Ilkoo Angutikjuak and Toku Oshima studying a map for Qaanaaq (photo: Lene Kielsen Holm).

Lene Kielsen Holm and Ilkoo Angutikjuak on their way to Siorapaluk by dogsledge (photo: Lene Kielsen Holm).

resident scientists. Together, we possess different knowledge and perspectives, but the sea ice, no matter what our background is, ties us together through our common interests and experiences. Travelling, living and working together, especially on the sea ice, has been intense. It has given us insight into life with ice that we could never have gained otherwise and there are many examples.

In Greenland, we travelled by dog team from Qaanaaq to Siorapaluk, the most northerly community in the world. On the way there, in March 2007, we travelled on ice so thin that the dogs' legs were punching through. For team members Mamarut, Toku, Rasmus, Mikili and Ilannguaq, and the local Inughuit who are part of our team and our guides on the trip, these conditions had become a regular spring experience, and they have already been adjusting their travel routes. For the team scientists, it was the first time that they had *directly* experienced the impacts of changing sea ice conditions – that is, they *felt* what it was like to come across dangerously thin ice. As researchers we know about these impacts, we use words like 'vulnerability', 'resilience' and 'adaptation', but what do those words really mean to the person on the ground? For us, experiencing the direct *feelings* as a result of environmental changes gave everything a whole new meaning.

In Qaanaaq we were doing workshops with the team members and elders, e.g. collecting terminology on sea ice and working with maps of the environment that the Qaanaaq hunters are travelling on. From the terminology exchange we learned that the Inuit languages on sea ice are very much the same wherever you go in the Inuit regions, and that the language and terminology on sea ice are very detailed in comparison with scientific terminology. In that way we found out that the two knowledge bases can complement each other so that gaps in knowledge can be filled. To showcase how the surrounding environments have changed, maps were used. The hunters could tell us what kind of changes have happened within their lifetimes and sometimes longer. For example the maps show that the forming and breaking up of the sea ice has not been as uniform as it used to be in former times and it showed that the surrounding glaciers are also changing rapidly, so that the hunters have been forced to use other travel routes. Satellite images are telling the same story.

In Utqiagvik/Barrow, Alaska, where our second exchange was held, our team was honoured and privileged to participate in the spring bowhead whale hunt. Because of our collaborative approach and the fact that we are a mostly Inuit research team, the local whaling captains made a special exception for us to participate and we were able to be at the floe edge for the hunt. We were welcomed and hosted by the Leavitt Crew, as Joe and Nancy Leavitt are part of our team. We had an opportunity to learn about the traditional whaling boats that are still used, like the one that Nancy sewed with other Iñupiat women, about the tools that the whalers use for whaling and working with ice, and about the fascinating traditions and rituals that are at the heart of Iñupiat whaling. Then, we were there when a whale was caught. In a stroke of amazing fortune, we were able to witness a successful catch – from the chase in the skin boats, to the first strike of the harpoon, to pulling up the whale onto the ice, to watching the captain's wife orchestrate the distribution of muktuk and meat, to sharing in the feast. Emotions ran high for everyone. For Mamarut Kristiansen from our team, a renowned narwhal hunter from Qaanaaq, it was an experience of a lifetime, for the successful whaling crew invited him to throw the last harpoon that would secure the catch to the ice. Mamarut did not hesitate to accept. With skill and strength Mamarut threw the harpoon for his first bowhead whale. As you might have guessed, his throw was right on target and the whale was safely secured. Everyone at the floe edge erupted into cheers.

In Utqiagvik/Barrow it really hit home that these personal stories, and the personal connections that were growing in our team through our travels and experiences, were becoming the real foundation of our project. As the relationships and trust built, we were all more willing and open to try new activities, discuss new topics, and most importantly, work harder for each other.

We were also learning that there was some 'Zen-ness' to what we were doing in terms of researching ice. It was becoming very clear that 'to study sea ice, is to not study sea ice'. While people who live with ice do understand it and know it in a direct way, they primarily understand it indirectly, through use. We all realised that in our project about sea ice, the conversation and the activities always ended up on topics like food, tools, clothing, family relationships, dogs, gender roles and travel.

Looking at the sea ice itself is still important and in our project we work on aspects like mapping, collecting terminology and creating seasonal and historical calendars. However, as we continue through this project we are learning more and more that in order for us to truly understand sea ice, from its characteristics and dynamics to its importance in Inuit culture, we have to almost turn the focus away from the ice. For as our local partners have told us, and more so shown us, the ice is simply a means to go where you want to go, or catch what you want to catch. But along the way, you can not help but intimately know ice. For our sea ice scientists

The team of Siku-Inuit-Hila leaving Siorapaluk (photo: Lene Kielsen Holm).

The teams stops en-route to exchange sea ice knowledge (photo: Lene Kielsen Holm).

in the project, this approach has been a bit of a learning curve, but the results on their science have been insightful – for example learning how to assess changes in sea currents and salinity while seal hunting.

Scientists are not the only ones learning new ways in our project. The Inuit are learning to see from different perspectives as well. In one way, they are learning through interactions with our project scientists. For example, during our exchange in Kangiqtugaapik/Clyde River, Nunavut, the team spent time working with the sea ice monitoring stations that are part of our project and operated by local people in all three communities. Our project glaciologist, Andy Mahoney, helped to teach all of us how our monitoring programme was detecting the ways that local sea ice formed and broke up over the course of the year, including processes that were occurring at both the top and bottom of the ice. Combined with local knowledge, the scientific monitoring helps give us great insight into the patterns and processes of local sea ice characteristics and change.

Andy also helped our team with many other science questions and concepts as well – including an interesting dance that is supposed to help demonstrate how the Earth moves around the sun. This revealed that there will always be barriers to knowledge exchange, bad dancing included. But Andy became a trusted member to the team not because he is a talented scientist, which he is, but because of his human qualities. Ilkoo in particular warmed to Andy after hearing about his childhood in England and his passion for rock climbing and skiing – pursuits Ilkoo found fascinating. These two became fast friends and bonded even more when Andy took a special interest in Inuit string games. Ilkoo, and all of us, got great enjoyment out of watching Andy practice the games for hours and hours, with the type of detailed obsession that can only come from a scientific mind. And when Andy came to perform for us after practice, after being convinced he had finally 'got it', Ilkoo would laugh the hardest when the string that was supposed to turn into an igloo, a caribou, or a tidy loop, ended up a knot in his hands.

Some of the most interesting human connections happened between the different community members in our project. During our exchange in Kangiqtugaapik/Clyde River, we spent five days camping and fishing at a traditional campsite some 200 km from the community. Team member Qaerngaaq Nielsen, an elder from Savissivik, Greenland, shared a tent with Jacopie Panipak, an elder from Clyde River. On our last day in Clyde, at our wrap-up meeting before everyone left, Qaerngaaq expressed to the group how grateful he was to have shared a tent with Jacopie; he had had an opportunity to get to know an elder just like himself, but who was from a different place and had some different knowledge than he had. If there was anything he had learned about sea ice it was not so much from us looking at it, photographing it, mapping it, or talking about it, it was from making a new friend and talking about *life with it.* They exchanged stories of their families, skills for making various tools, and stories of travel and hunting. This is how they exchanged sea ice knowledge.

Conclusion

By taking time to honour the individual people we all work with, explore a little bit of who they are, whether Inuit hunters or scientific researchers, we remember that our greatest chance for truly sharing knowledge and accepting diverse perspectives, is to connect as humans, through our experiences as humans. By being open to the relationships that can happen through research, we open ourselves to the opportunity for true understanding. No matter who we are, or where we come from, that is something we all strive for.

Arctic Change in the Flow of Global Warming: Need for Long-Term Monitoring Observations

Takashi Yamanouchi
National Institute of Polar Research and Department of Polar Science,
The Graduate University for Advanced Studies, Japan

Abstract
The Arctic, confronted by climate change, has shown an abrupt warming in the 30 years since the 1980s. The warming in the Arctic is seen in a number of climate processes such as air temperature rise, ground temperature rise, decrease of sea ice extent and so on. In terms of Arctic change, many atmospheric processes are important as driving forces and feedback agents; however, atmospheric changes are not well investigated within studies. A large warming event between the 1920s and 1940s in the Arctic, comparable to the recent 30-year warming, is known. This was only concentrated on the high latitudes. Several explanations have been made, but no single source could explain these changes. Observing systems for monitoring change are essential for validating and improving predictions, especially of future global warming and its impacts. At the end of our International Polar Year (IPY) 2007-2008, we should start to rebuild our solid network in the Arctic as a legacy of IPY.

Introduction
The Arctic, confronted by global warming, has shown an abrupt warming in the 30 years since the 1980s. The warming in the Arctic is seen in a number of climate processes such as air temperature rise, ground temperature rise, decrease of sea ice extent and so on. The Arctic sea ice extent shows a drastic decrease and reached a record minimum in summer 2007. The rate of reduction in ice cover exceeds

twice that predicted by climate models, and has already reached the level simulated for 2040. Permafrost on land has melted in a wide area of the Arctic and is expected to release greenhouse gases such as methane. Outflow of large rivers to the Arctic Ocean has greatly increased. Retreat and melting of glaciers and ice caps surrounding the Arctic and Greenland ice sheet are contributing to sea level rise. Following these impacts, the ecosystem will be changed and this will alter the exchange of greenhouse gases and surface albedo, and then in turn feed back to the climate and environment. Accompanying this are many extreme changes such as the decrease in the area and term of snow fall, reduction of snow surface albedo by anthropogenic black carbon (BC) and acidification of surface sea water due to the increase of atmospheric CO_2 concentration. We are anxious about their impacts on human life and the natural ecosystem.

Atmosphere change

Black carbon and Arctic haze

It is well known that aerosols that absorb solar radiation, such as black carbon (BC) are liable to warm the atmospheric layer, and that their warming effect would be amplified over snow and ice covered surfaces (Myhre et al. 1998). Once this BC is deposited on snow or ice surfaces, it decreases the surface albedo and contributes to warming (Aoki 2007; Hansen et al. 2005; IPCC 2007). McConnell et al. (2007) determined the yearly variations of BC concentration in the snow layers from 1788 through to 2002 from ice core analysis of the Greenland D4 core. They demonstrated that the maximum concentration was found in the early 1900s, which might have contributed to the Arctic warming at that time.

'Arctic haze', which refers to the visibility-reduction events that occur during the Arctic spring due to aerosols in the atmosphere, is increasingly being studied due to its various possible environmental impacts (e.g. Heintzenberg 1989). The highest aerosol concentrations were recorded in the Arctic spring and a strong seasonal variability of the aerosol burden was observed (Herber et al. 2002). However, few datasets exist that give a complete picture of the temporal, vertical and horizontal variation of the Arctic; thus, more data is needed for modelling and radiative transfer calculations. Recently, several airborne projects were conducted around the international research site Ny-Ålesund, Svalbard by the National Institute of Polar Research and the Alfred-Wegener Institute for Polar and Marine Research (AAMP 2002; ASTAR 2000, 2004; Matuski et al. 2008; Yamagata et al. 2009; Yamanouchi et al. 2005).

International Research Site, Ny-Ålesund, Svalbard (photo: H. Kanda).

Methane and greenhouse gases

Among several kinds of greenhouse gases, methane is one of the most highly impacting and uncertain species. Methane in the atmosphere has an extremely strong warming potential. At one point its concentration had an extremely large rate of increase. However, its increase rate slowed down in the 1990s and then almost stopped in the early part of the first decade of the twenty-first century, but then seems to have recovered again in 2007! From the analysis of stable isotope of methane ($\delta^{13}C$) in the air samples obtained at Ny-Ålesund, the contribution of each source, such as wetlands and biomass burning, on the variation of the methane increase rate was estimated, and the highest contribution was found to be from wetland variation (Morimoto et al. 2006). In the Arctic terrestrial environment, methane release from wetlands and permafrost melting dependent on climatic warming might be one of the most important issues to be monitored (Sugimoto and Fujita 2006).

Arctic sea ice melting in the spring (photo: Peter Bates).

Carbon dioxide has already been discussed in many studies, and still shows a great influence on the carbon cycle. CO_2 uptake and release by the terrestrial biosphere are still being discussed in relation to global warming, especially in the high Arctic (Nakatsubo et al. 2005). The direction of the feedback loop is also a sensitive issue. The Greenland and Barents seas have been found to be highly significant sink areas among global seas (Nakaoka et al. 2006). Enlarged open water areas due to the recent sea ice retreat can increase an area's potential as a sink or source of CO_2. Also, increased atmospheric CO_2 concentration influences acidification of sea water, which is especially serious in high latitude regions such as the Arctic (Orr et al. 2005).

Cloud and radiation

The role of cloud cover and radiation in the polar climate system has been examined in detail (Curry et al. 1996; Yamanouchi and Charlock 1997), and cloud has a large effect on the radiation budget, comparable to the effect of sea ice. Cloud cover masks the radiative effect of sea ice. On the other hand, sea ice reduces the radiative effect of cloud. If the cloud distribution was determined by the sea ice, then ice-albedo feedback – the most pronounced process of the climate system in the cryosphere – might be different from what we see now (Yamanouchi and Charlock 1997).

Satellite remote sensing of cloud distribution was expected to settle the deficiencies of sparse observation stations and the long polar night. However, it was discovered that it is difficult to discriminate between clouds and snow and ice surfaces, due to their similarity in physical and optical properties. A number of efforts have been devoted to confronting this difficulty; however, large uncertainties still remain in cloud climatologies in the Arctic and Antarctic. Increasing trends in the amount of cloud in spring and summer and decreasing trends in winter during the last 20 to 30 years are reported in several recent studies of the Arctic (Hori 2007; Schweiger 2004; Wang and Key 2003, 2005). Some reports from surface observations (Yamanouchi 2007) and satellite observations (Kato et al. 2006) show an increasing trend in annual amount of cloud. In the summer of the notable year of 2007, when sea ice extent reduced to its minimum, the amount of cloud was reported to be rather smaller than usual (Hori 2007). The relationship between cloud amount and sea ice extent is one of the most interesting and urgent issues to be resolved. Liu et al. (2008) discuss the relationship between temperature and change in cloud amount and conclude that temperature decrease and cloud amount decrease were parallel in winter for the greater part of the Arctic, while the relationship was not clear in other seasons.

Early twentieth century warming

It is known that there was a large warming event in the Arctic during the 1920s and 1940s, comparable to the recent 30-year warming (e.g. Polyakov et al. 2003). This was only concentrated on the high latitudes. Climate models well represent both observed warming events in the global average during the twentieth century, in the early mid century and at the end of the century. The models show that the later warming is due to anthropogenic greenhouse gas increase, while the former warming was due to natural variation (IPCC 2001). The cause of this natural variation is explained by the clean up of stratospheric aerosols due to a reduction in volcanic activity (Sato et al. 1993) and an increase in solar radiation due to high solar activity (Lean et al. 1995) in the early twentieth century (Nozawa et al. 2005; Shiogama et al. 2006). However, actual warming was seen only within the high latitudes (Johannessen et al. 2004; Overland et al. 2004; Serreze and Francis 2006).

Several explanations were suggested for this localisation, but external forcing from solar and volcanic activity, which was once considered able to explain the global climate, failed to provide an explanation.

One of the new possible explanations is internal atmospheric variability with low frequency, which sometimes appeared through long-term integration of the control climate model (Johannessen et al. 2004; Wang et al. 2007). This internal variability with a decadal scale was similar to that obtained by Tanaka and Ohashi (2007) using the barotropic S-model to explain variations in the Arctic Oscillation. The Pacific Decadal Oscillation (PDO) also resembles the temperature variation curve (Turner et al. 2007). Another candidate for the explanation was black carbon deposited on snow and ice surfaces, as mentioned above. We have to continue our study by exploring historical meteorological, aerological and radiation data (Ohmura 2008); by ice core analysis (Motoyama 2008); and by Arctic system reanalysis together with long-term reanalysis back to the 1880s (Compo et al. 2008). It is indispensable to recover historical data and to study this early twentieth century warming if we are to understand the recent abrupt warming and predict future change in the Arctic.

Future directions, observation network and platforms

Observing systems for monitoring change are essential for validating and improving predictions, especially of future global warming and its impacts. Starting from the first International Polar Year (IPY) in 1882/83 and through the second IPY 1932/33 up to the International Geophysical Year (IGY) 1957/58, most of the observation station network was established in the Arctic. However, a large number of stations, especially in the Russian Arctic, have been closed since then, possibly due to a lack of financial support. Now, just at the end of our IPY 2007-2008, we should start to rebuild our strong network in the Arctic as a legacy of IPY, following the State of Polar Research (the statement from the ICSU/WMO Joint Committee for the IPY 2007-2008 [WMO 2009]). In the future, a new Arctic network, the Sustaining Arctic Observing Networks (SAON), should be created, together with several international initiatives (e.g. IASOA – International Arctic Systems for Observing the Atmosphere). Also discussed should be a drifting sea ice station, such as the Russian North Pole Stations, airborne observations and ship cruises – not only as new observing stations, but also as points to contribute to Arctic system reanalysis (ASR).

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Section 2

BIODIVERSITY AND ECOSYSTEM SERVICES

Coordinating for Arctic Conservation: Towards Integrated Arctic Biodiversity Monitoring, Data Management and Reporting

Michael J. Gill
Chair, Circumpolar Biodiversity Monitoring Program,
Environment Canada

Christoph Zöckler
Senior Adviser Arctic Biodiversity,
UNEP-World Conservation Monitoring Centre, UK

Risa B. Smith
Manager, Biodiversity Assessments and Reporting,
Environment Canada

Abstract

Arctic ecosystems and the biodiversity they support are experiencing growing pressure from climate change and resource development, yet established research and monitoring programmes remain largely uncoordinated, lacking the ability to effectively monitor, understand and report on biodiversity trends at the circumpolar scale. The maintenance of healthy Arctic ecosystems is a global imperative as the Arctic plays a critical role in the Earth's physical, chemical and biological balance (ACIA 2005). A coordinated and comprehensive effort for monitoring Arctic ecosystems is needed to facilitate effective and timely conservation and adaptation actions. The Circumpolar Biodiversity Monitoring Program (CBMP) was launched with this aim.

Introduction

The Arctic's size and complexity represents a significant challenge to detecting and attributing important biodiversity trends. This demands a scaled, pan-Arctic, ecosystem-based approach that not only identifies trends in biodiversity, but also identifies underlying causes. It is critical that this information be made available to generate effective strategies for adapting to changes now taking place in the Arctic – a process that ultimately depends on rigorous, integrated and efficient monitoring programmes that have the power to detect change within a 'management' time frame.

To meet these challenges and in response to the Arctic Climate Impact Assessment's recommendation to expand and enhance Arctic biodiversity monitoring, the Conservation of Arctic Flora and Fauna (CAFF) Working Group of the Arctic Council launched the Circumpolar Biodiversity Monitoring Program (CBMP). The CBMP is working with over 60 global partners and 600 members to expand, integrate and enhance existing Arctic biodiversity monitoring efforts to facilitate more rapid detection, communication and response to significant trends and pressures.

Towards this end, the CBMP is establishing five Expert Monitoring Groups representing major Arctic themes (Marine, Coastal, Freshwater, Terrestrial Vegetation and Terrestrial Fauna). Each group, representing a diversity of expertise including both community-based and scientific-based monitoring capabilities, is tasked with developing pan-Arctic, comprehensive and integrated biodiversity monitoring plans for these systems. To facilitate effective reporting, the CBMP is developing a suite of indices and indicators and a web-based data portal that will be used to report on the current state of Arctic biodiversity at various scales and levels of detail to suit a wide range of audiences. The current and planned CBMP biodiversity monitoring underpins these indices and indicators.

Global significance of Arctic biodiversity

The Arctic's contribution to global biodiversity is substantial. Its brief summers are intensely productive and attract hundreds of migratory species. Two hundred and seventy-nine species of migratory birds breed in significant numbers in the Arctic: of these, thirty reach southern Africa, twenty-six reach Australia and New Zealand, twenty-two reach southern South America, and several pelagic species reach the southern oceans. Several species of land and marine mammals, including gray and humpback whales, also participate in the global migration, travelling long distances to the Arctic each year.

While the Arctic has relatively few species compared to the mega-diverse tropics, Arctic biodiversity is notable for its genetic diversity, reflecting the many unique adaptations species have developed in response to extreme environmental conditions. The Arctic and Subarctic also support globally significant populations, including more than half of the world's shorebird species (Zöckler et al. 2003), 80 per cent of the global goose population (Zöckler 2008), and several million reindeer and caribou.

The circumpolar Arctic, as defined by the Arctic Council's Conservation of Arctic Flora and Fauna (CAFF) Working Group, covers 14.8 million km^2 of land and 13 million km^2 of ocean. The emerging economic importance of Arctic ecosystems often conflicts directly with conservation values, as the region has some of the world's few remaining pristine, undeveloped environments where indigenous peoples operate in concert with their natural surroundings. Vast wilderness areas where ecosystem processes continue to function in a largely natural state play a key role in the physical, chemical and biological balance of the planet. Seven of the world's ten largest wilderness areas are located in the Arctic region, comprising an important contribution to the conservation of the Arctic's unique biological diversity and providing an opportunity to monitor global climate and other changes in a comparatively undisturbed environment. Together with the Antarctic, the Arctic contains the largest freshwater resources on Earth. The Arctic is also home to diverse, vibrant and unique societies whose indigenous cultures depend on and maintain close ties to the land and sustain hundreds of distinct languages.

Arctic biodiversity under pressure

Dramatic changes now underway in the Arctic are threatening the integrity and sustainability of its living resources, directly challenging the resilience of Arctic residents – particularly indigenous peoples – dependent upon these resources. Of greatest concern is climate change, with its impacts on Arctic biodiversity already being witnessed and much larger impacts (with significant regional variation) expected over this century. By 2100, the Arctic is expected to warm 3 °C to 5 °C over land and 7 °C over the oceans, contributing to dramatic changes in its ecosystems (ACIA 2005). Predicted impacts include a more than 50 per cent decline in the extent of summer sea ice and the displacement of existing Arctic species and ecosystems (e.g. polar deserts and tundra) as southern species and ecosystems expand northward. Much of the recent observed change (e.g. the 34 per cent reduction in summer sea ice extent in 2008) has outpaced climate model predictions, suggesting that these models are conservative in their estimates.

Although climate change is placing increasing pressure on the resilience and sustainability of Arctic biodiversity, it is not the only stressor. Others include environmental contaminants, habitat fragmentation, invasive species, increased shipping and air traffic, and regional development such as oil and gas exploration and production, forestry, hydroelectric projects and urbanisation. Oil and gas development is expected to play a particularly important role in the future, as the Arctic is estimated to contain 13 per cent of the world's undiscovered oil and 30 per cent of its undiscovered natural gas (Gautier et al. 2009). Already, 10 per cent of the world's oil and 25 per cent of the world's natural gas is produced in the Arctic, with the majority coming from the Russian Arctic (Ahlbrandt and Whitney 2000).

Our current understanding

Information on Arctic biodiversity, human stressors and natural changes is currently available in a piecemeal fashion and on an irregular basis. An integrated picture of the status of and trends in key species, habitats, processes, services and ecosystem integrity in the Arctic and along related migratory routes is not fully developed. Although numerous monitoring efforts are currently underway, a lack of coordination, long-term commitment, integration and involvement of local people has resulted in weak linkages between monitoring results and decision-making, and a corresponding inability to detect and understand change. The communication of results in a manner that dovetails with policy-making is a prerequisite to the successful management and conservation of Arctic biodiversity and prompt adaptation to inevitable changes. An integrated, interdisciplinary and collaborative Arctic biodiversity monitoring programme that enhances our ability to detect important trends on a timely basis, attribute these trends to causal factors, and disseminate this information in both the public and policy arena is urgently needed.

Opportunities

The significant environmental challenges facing the Arctic present a unique opportunity for the development of a world-class, integrated and sustained Arctic biodiversity network. The recent, unprecedented changes witnessed in the polar regions have prompted increased demand for accurate, timely and unbiased information on the Arctic. These demands have coincided with renewed support for polar research and monitoring (e.g. International Polar Year (IPY)). Indeed, many of the monitoring networks that underpin the CBMP (e.g. the Circum-Arctic *Rangifer* Monitoring and Assessment Network) have been activated as a result of IPY funding.

Little auks in Disko Bay, Greenland (photo: Carsten Egevang ©).

Although largely uncoordinated at the current time, there are a great number of research and monitoring networks already observing the Arctic at various scales, from on-the-ground to satellite. There is an opportunity to enhance coordination and output from these existing programmes in order to improve our ability to detect, understand, report on and respond to significant trends in Arctic biodiversity.

There is considerable existing information (time-series data, paleo-ecological, local and traditional knowledge-based) on environmental change in the Arctic, much of it representing valuable long-term records and perspectives. However, these resources are often overlooked. This information can often be accessed, analysed and repurposed for relatively little cost in order to establish historical baselines, identify previous trends and better understand ecological relationships.

Purpose and function of the Circumpolar Biodiversity Monitoring Program

The CBMP is, first and foremost, a coordinating entity for:

- existing Arctic biodiversity monitoring programmes;
- addressing gaps in knowledge through the identification of new programmes;
- gathering, integrating, and analysing data;
- communicating results.

This coordinating function presents an opportunity to add significant value to the ongoing efforts of independently operating local, national and regional programmes. The standardisation of data collection methodologies, coordination of data analyses and presentation of results through a common web-based portal will benefit all stakeholders. The collaborative approach enabled by this coordinating function will provide answers not previously attainable on a circumpolar scale and lead to a broader understanding of the Arctic environment and the effects of its multiple stressors on biodiversity and ecosystem integrity.

The CBMP is serving as a mechanism for harmonising and enhancing monitoring efforts across the Arctic in order to improve our predictive and reporting capabilities. The resulting information is being made accessible in a broad range of formats geared towards specific target audiences such as northern communities, scientists, governments and the global community.

Information on Arctic species responses to environmental and development pressures is widely scattered amongst scientists, government institutions and northern communities. Through its Expert Monitoring Groups (EMGs), the CBMP is identifying gaps in data coverage, integrating information and efforts aimed at monitoring and communication, and encouraging the development of new monitoring efforts to overcome gaps in knowledge. A major focus is on the organisms, services and processes of primary importance to the integrity of Arctic ecosystems and the culture and livelihood of indigenous cultures. Special attention is being paid to community-based observations and citizen science in recognition of the valuable and significant contributions that Arctic residents can make to biodiversity monitoring.

The CBMP serves as an international forum of key scientists, conservation experts and local resource users from all eight Arctic countries, the six international indigenous organisations of the Arctic Council, and various global conservation organisations. It is strategically linked to other international conservation programmes and initiatives such as the Sustaining Arctic Observing Networks Initiative (SAON), International Polar Year (IPY), the Arctic Biodiversity Assessment (ABA), State of the Arctic Reporting, and the 2010 Biodiversity Indicators Partnership, thereby ensuring effective coordination and integration with related Arctic and global initiatives.

The CBMP's results will be translated via the Arctic Council into effective conservation, mitigation and adaptation policies that promote the sustainability of the Arctic's living resources. To do this, information is needed not only on the status of and trends in Arctic biodiversity at the circumpolar level, but also on the natural and anthropogenic stressors driving trends in Arctic biodiversity at all geographic scales. Understanding how and why biodiversity is changing at various scales will enable local communities and decision-making bodies to develop informed policies and responses focused on adaptation, mitigation and conservation. This information will be provided by the CBMP in a timely fashion using diverse formats.

Programme clients: users of Arctic biodiversity information

The demand for accessible, current and accurate information on Arctic biodiversity is increasing. This demand is coming from a broad set of stakeholders, including the general public both within and outside of the Arctic and northern communities, in addition to local, regional, national, global and aboriginal institutions and governing bodies.

Northern communities are a key target recipient of the CBMP's output, as changes to Arctic biodiversity have a direct and often significant impact on the livelihood of these communities. Products sought out by northern communities include biodiversity indicators that depict regionally relevant status and trends information, summary reports and regional level predictive ecosystem maps, and models that identify anticipated changes to ecosystems in a specific region.

Decision-makers and policy-makers (e.g. environmental assessment bodies, co-management boards, land-use planning agencies) operating at multiple geographic scales require accurate and current information on the status of and trends in Arctic biodiversity – as well as their underlying causes – in order to make informed and effective decisions. The CBMP products designed to meet the needs of decision and policy makers include the biodiversity indices and indicators (at various scales), ecosystem vulnerability assessments, policy recommendations, conservation plans and predictive models.

Industry also requires accurate and timely information on Arctic biodiversity in order to continually update best management practices and reduce its impact on the environment. Products anticipated to meet industry needs include regional biodiversity indicators, best management practices, regional habitat and species maps and ecosystem vulnerability assessments that identify those areas that are most vulnerable or sensitive.

The scientific community is most likely to be interested in comprehensive, detailed data. Scientists are expected to want a full range of information products, from the CBMP indicators and indices (at various scales) to multi-disciplinary data to predictive models.

Finally, the public at large, both within and outside of the Arctic, has a significant need for Arctic biodiversity information. The public's fluctuating interest levels and limited technical underpinnings necessitate the creation of products that are easy to understand, quick to view, high impact and broad in scope. CBMP products intended for the public, media and politicians include the indices, public reports and general assessments and newsletters that are written in non-technical language.

Due to the diversity of languages in use around the Arctic, it is expected that many of the CBMP's products will be translated into Russian and other languages to facilitate access for a broader group of users. Also, multiple delivery formats will be used to engage a diverse audience, including the CBMP's internet-based web data portal, website and print-based products such as newsletters and reports.

Circumpolar Biodiversity Monitoring Program and the Arctic Climate Impact Assessment

In 2004, the Arctic Council released the Arctic Climate Impact Assessment (ACIA), which recommended that long-term Arctic biodiversity monitoring be expanded and enhanced. In its acceptance of the ACIA findings and projections, the Arctic Council directed two of its working groups, the Conservation of Arctic Flora and Fauna (CAFF) Working Group and the Arctic Monitoring and Assessment Program (AMAP), to examine these findings and develop follow-up programmes and activities to address key projections for the future of the Arctic.

A primary response of the CAFF Working Group was the implementation of the CBMP. The development of the CBMP as CAFF's cornerstone programme received ministerial endorsement in both 2004 (Reykjavik Declaration) and 2006 (Salekhard Declaration). Iceland led the programme before Canada assumed the role of chair in April 2005.

The CBMP is the primary vehicle through which CAFF will follow up on ACIA's recommendations. It can also be used to promote Arctic biodiversity information in global fora and reports, such as the United Nations Convention on Biological Diversity, the Ramsar Convention on Wetlands, the United Nations Millennium Development Goals, the International Polar Year and the International Arctic Science Committee.

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Connections Between Arctic Peoples and Their Environment

Henry P. Huntington
Huntington Consulting,
Eagle River, Alaska, USA

Abstract

The natural world provides materially and spiritually for the peoples of the Arctic. The relationship between humans and their environment is deep and multi-faceted. In the worldviews of indigenous people, it is a two-way relationship, with obligations and expectations for all beings that are part of the system. Most often in scientific work, we focus on the material connections between people and their environment. Those connections are vital, deep and fascinating. But the spiritual connections are also vital, deep and fascinating, even if they are harder to discover, assess and address.

Indigenous knowledge can contribute greatly to monitoring biodiversity, ecosystem services and the host of social and cultural implications they have. There are many examples around the Arctic demonstrating the detailed knowledge that local residents have and the depth of cultural traditions that inform that knowledge. In Savoonga, Alaska, for example, one family resumed bowhead whaling after several decades, using knowledge that had been handed down for generations even though no one still living had participated in whaling at their traditional site. In addition to providing the know-how and skills to sustain Arctic communities and peoples, indigenous knowledge has contributed greatly to scientific efforts around the Arctic. It is important that we maintain and increase our efforts to engage the holders of indigenous knowledge, involving Arctic residents not just as the subjects of study, but as full collaborators in joint research, monitoring, analysis and action.

Inupiaq residents of Barrow, Alaska pull together to bring a bowhead whale up on the ice in May 2007. This communal activity and the sharing of the whale reflect the connections between people, their environment, and one another (photo: Henry Huntington).

In doing so, we will inevitably also touch on the spiritual connections that are so important for Arctic peoples. At times, the spiritual dimension of understanding may seem at odds with scientific understanding. For example, Athabascan people in Alaska have a powerful relationship with the moose. Moose are taken for funeral potlatches, a rare instance of a spiritual practice that is recognised in state law, as people can take moose for potlatches when they need them rather than waiting for the usual hunting season. Athabascans believe that the number of moose in the world is constant, with moose only offering themselves to worthy hunters and then coming back to the world again after their death. Scientific counts of moose make little sense in this worldview, because the moose can choose not to be visible to the counters. Discussions about moose abundance, a key 'ecosystem service' in one worldview, have a large cultural gap to cross before they can make sense to both groups participating in those discussions.

Indigenous approaches to knowledge typically incorporate many sources of information, from the emotional, intuitive and spiritual realms as well as from direct observation and analysis. Indigenous cultures around the world place great importance on dreams and visions, on following one's feelings, guided by wisdom as well as observation. The goal can be entirely material and pragmatic, such as providing food for one's family. Nonetheless, the actions involved are often considered as part of a much wider system of belief and practice, with many ramifications for the present and future. In this view, a successful hunt not only produces food, but also sustains the set of relationships that connect the hunter with the animal, thus providing for future hunts as well. In the context of natural resource management, human intention and the intention of the animal or other part of the natural world are both as important as, if not more important than, the direct physical interaction that takes place. Failure to take the emotional aspects of a situation into account will lead to problems.

Among indigenous peoples, these factors are taken into account in everyday practice and action. The way a hunt is conducted may be every bit as important as whether an animal is taken. The state of mind of the hunter, the health of his or her relationships with others in the community, and other aspects of the individual often have a large influence on decisions about whether to hunt and so on. Actions are more than a mechanical response to various stimuli. They are instead a matter of seeking the right way to be a part of the world, to fulfill one's role and uphold one's duties with respect to others, human and otherwise. Failure to do so can have lasting consequences. For example, mistreating the meat from an animal can cause others of that species to withdraw, to withhold giving themselves to hunters, leading to want and suffering for other people. Speaking ill of an animal or a force such as fire can have consequences as well.

It is important to remember that few people act without reasons for their actions. Instead, most people act in accordance with their beliefs and understanding. Thus, individuals from different belief systems may agree on the nature of a natural resources issue, but not on the actions that should be taken. Or, individuals may disagree on the nature of the problem because they have differing views of the causal relationships that govern the world. A hunter may see the absence of animals as the result of poor behavior by members of his or her community, whereas a population biologist may see the absence as the result of shifts in distribution or a decline in abundance. Both agree that there are few animals to be seen, but one may recommend ceremonial or other actions to atone for misbehavior, whereas the other may recommend restricting hunting or modification of habitat. A focus on action without an understanding of the underlying belief system is unlikely to result in effective communication or form a foundation for cooperation. Awareness of the underlying basis for another point of view, on the other hand, is a good step towards mutual understanding.

Travelling by dog sled on the sea ice near Clyde River, Nunavut, towards an iceberg (photo: Henry Huntington).

With this in mind, it is important to remember that natural resource management is a social process, in which interpersonal relations may matter as much as or more than environmental conditions. Agreement on the question – for example whether there are enough fish to allow a harvest – is only one step in management. Knowledge from different sources may be used together to address that part of a management issue, but determining how to use different types of information, particularly if they do not match, involves social relations among those involved. If one group feels that they do not have an effective voice in the discussion, they may withdraw or fail to support a course of action that others have developed. If a course of action is developed cooperatively, however, with all sides feeling that they have been heard and understood, broad support is more likely. Transmission of knowledge can be done in many ways, but requires willingness on both sides as well as sufficient common understanding of the belief systems involved and the means by which information is conveyed, evaluated and understood.

Setting management goals is more than simply agreeing on a target population level or land status designation. Such goals are really proximate goals, reflecting values that derive from ultimate goals that in turn come from the underlying belief system. For example, a management goal of a certain density of bull moose may stem from a larger goal of providing maximum trophy hunting opportunities. Such a goal may conflict with the values of another belief system, in which moose provide sustenance to people who in turn respect the spirit of the moose by remaining humble about hunting skills, sharing the meat from the animal and other actions. If one group believes that moose numbers are constant but availability is determined by people's actions, and the other group believes that moose numbers can be manipulated to maximise certain hunting opportunities, it may be difficult to develop a common management strategy.

Focusing on differences in beliefs and values can emphasise conflicting views, but on the other hand there may be much common ground as well. In January 2006, Chester Noongwook, a Siberian Yupik whaling captain from Savoonga, Alaska, explained Yupik values:

> *Yupik values concern many aspects of the environment…* Yaayasitkegpenaan *is a term describing the appropriate treatment of animals and all life surrounding the Yupik. Proper behavior includes harvesting no more than one needs, not killing an animal that cannot be retrieved, and keeping the environment clean both for the animals and for future generations of islanders.*

Eddie Hopson, then chairman of the Alaska Eskimo Whaling Commission (AEWC), provided a different but largely consistent view in 1990 when he spoke about the role of management agencies:

> *Management agencies like the AEWC, the Alaska Department of Fish and Game, the National Marine Fisheries Service, the International Whaling Commission – they are all doing the job given to us by the Creator, so I do not object to them.*

The whalers had plenty of disagreements with management agencies over other matters, and indeed the AEWC itself was not always regarded with universal approval by the whaling captains who were its members, but they were able to create an effective management system through compromise and learning rather than contention and conflict.

It is important to distinguish between real differences and apparent ones. In the moose example above, the issue may not be trophy hunting itself or even competition for resources between different user groups, but instead whether lasting damage will be done to the moose-human relationship. While that relationship is likely to be outside the usual considerations of science-based management, the intersection of belief systems is a critical element of the overall management situation. Discussing moose as something to be 'managed' solely for human goals may be offensive to those who regard them as equal partners in a mutually beneficial relationship. But if the discussion shifts ground to address the ways in which moose can be hunted to sustain hunting opportunities while also sustaining the moose, then differences in perception can perhaps be sidestepped and other aspects of moose hunting can be addressed. This does not remove the differences in understanding or belief, but simply recognises that it may not be necessary to agree on all things in order to agree on some things. The same actions need not be interpreted the same way.

Designing appropriate actions can thus become a crucial step in developing a collaborative approach to management. 'Appropriate' in this instance means that the action in question is consistent with (or at least acceptable to) the belief systems involved and that it is considered likely by one or more of those belief systems to achieve the desired goal. Again, not everything can be accomplished in this way, and there will inevitably be cases of fundamental disagreement. But unnecessary disagreement can be reduced or avoided. For example, a ceremony that offers thanks to the animals may serve no function in a science-based belief system, but it also causes no harm. In many traditional belief systems, on the other hand, such ceremonies are essential. In one case from the Northwest Territories, caribou biologists inadvertently impressed local elders because they knocked the dirt from their shoes before boarding a helicopter during research flights. The biologists may just have been trying to keep dirt out of the helicopter, but the elders thought they were showing respect for the caribou by keeping caribou habitat clean. Small gestures such as these, if done on purpose, can have great value in fostering good relationships.

More complex are those cases where actions may be appropriate in one system but inappropriate in another. Some of these reflect different development of hunting practices. For example, in the European-derived tradition of sport hunting, birds should only be shot when flying. In many indigenous societies, making hunting harder by imposing such a restriction makes no sense. Hunting regulations that stem from the former system, however, may outlaw common practices in the latter. Neither approach, however, is by itself incompatible with the idea of keeping bird populations healthy. In another example, the use of radio and satellite collars and tags is widespread in scientific studies of wildlife. That practice, however, is regarded in many belief systems as animal cruelty and thus a violation of human-animal relationships.

The distinction that collaring an animal is cruel whereas hunting one is acceptable can be confusing to those outside the belief system in question. The difference becomes clearer when one reconsiders the matter. If animals are not to be bothered without good reason, hunting for food and clothing is acceptable. Capturing an animal, perhaps with the use of drugs that may render the meat unsuitable for human consumption, is not likely to be acceptable unless what is to be learned is important and cannot be learned in another way. Conflicts of this kind in Alaska have often involved concerns by Natives that the study in question was only going to show what the Natives already knew. In other cases, Native hunters have actively supported and participated in capturing and collaring or tagging animals because they regard the information that will be gained as important and thus worth any suffering caused to the animals that are captured. An essential difference in these cases has been the cooperative development of research plans and information needs, the production of 'our' knowledge rather than knowledge belonging (or appearing to belong) to one group or another.

It is important to recognise differences in viewpoint, not to sweep them aside and hope they do not reappear. Collaborative approaches can help find common ground for discussions about past, present and future, and a chance to learn other ways of seeing and knowing the Arctic. Much has been made lately of the difficulties faced by traditional people in applying their knowledge to a changing world where the patterns and lessons of the past no longer hold true. But there are also values and traits that endure, such as patience, humility and adaptability. These values are closely tied to a deeper view of how people can and should relate to their environment. A good starting point to learning about and caring for the Arctic environment is first to learn from and about one another.

Wetlands – Threatened Arctic Ecosystems: Vulnerability to Climate Change and Adaptation Options

Tatiana Minayeva
Wetlands International, Russian Federation

Andrey Sirin
Institute of Forest Science, Russian Academy of Sciences

Abstract

The latest reviews indicate that Arctic wetlands are undergoing active degradation induced by human impacts and climate change. According to the Ramsar Convention, terrestrial and freshwater wetlands may cover up to 60 per cent of the total area of the Arctic region. They are amongst the most widespread and varied of its ecosystems, and at the same time the most vulnerable and threatened. This is due to their characteristically high integrity, their complex hydrological and energy cycles reflected in gas and mass exchange, their dependence on permafrost and water, their strong influence on adjacent landscapes, their specific biodiversity, their irreversible successions and their low restoration capacity. Arctic wetlands, and especially Arctic peatlands, are not specifically recognised as valuable ecosystems, and many uncertainties remain regarding their responses to climate change. The adaptation strategy for these wetlands should focus on minimising human impacts, filling gaps in our basic knowledge of their ecosystem functions and values, and monitoring.

Introduction

The problem addressed here is the underestimated functional role and high vulnerability of wetland ecosystems in the Arctic. Both the Third and Fourth IPCC Assessment Reports (IPCC 2001; IPCC 2007) stated with high confidence that polar regions are extremely vulnerable to current and projected climate change. Moreover, recent scientific investigations (ACIA 2005) clearly demonstrate dramatic degradation of Arctic ecosystems and rapid changes in Arctic biodiversity due to climate change exacerbated by anthropic impacts. Wetlands are one of the key vulnerable Arctic ecosystem types.

Diversity and distribution of wetlands

Wetlands, as defined by the Ramsar Convention, are widely distributed in the Arctic and cover 60 per cent of the total ecosystem area. The Ramsar wetland types that occur in this region are shallow lakes, rivers and deltas, coastal marshes, shallow sea waters, and non-forested and forested peatlands (Ramsar Recommendation IV.7 and Resolutions VI.5 and VII.11). Peatlands are represented by permafrost systems such as polygonal mires, palsa mires and kettle-hole mires in thermokarst depressions; and by other types such as valley fens and shallow peat tundra. The Ramsar Convention recognises peatland as a wetland type for which a specific management approach is required, which is under-represented in conservation strategies (Ramsar Recommendation VI.6, Ramsar Resolution VIII.17); whilst the Convention on Biological Diversity has stressed the role of peatlands in relation to biodiversity and climate change by adopting the policy recommendations of the 'Assessment on Peatlands, Biodiversity and Climate Change' (Parish et al. 2008; CBD SBSTTA July 2007 Recommendations No XII/5). The 'Assessment' includes consideration of the situation in the Arctic, where peatland ecosystems have a unique role for biodiversity and climate change but are hardly recognised as specific targets for management including conservation, even though they are widely distributed. Indeed, the areal extent of peatland and land covered by shallow peat may comprise up to 70 per cent of the Arctic wetland area.

Wetlands specific natural features in Arctic

Arctic wetlands are extremely fragile on account of their specific natural features at ecosystem, population and individual levels. Permafrost, which is itself extremely vulnerable to climate change, is the main ecosystem factor governing the genesis, features, characteristics and functions of Arctic wetlands. Phase transitions of water

Peatland dwarf shrubs (photo: Andrey Sirin).

(freeze-thaw processes) play a key role in their development and maintenance by shaping the surface of the landscape. Cracking, swelling and mound formation due to freezing, together with the thermokarst effect, are important. Specific peatland types such as polygonal, palsa and thermokarst kettle-hole mires are exclusively associated with permafrost. The singular hydrophysical properties of peat mean that it conducts heat and thus promotes melting of permafrost when wet, but acts as an insulating layer when dry. As a result, palsa mires can still be found well south of the modern permafrost zone in Siberia (to 55° N), their ice cores, formed thousands of years ago, having persisted through subsequent warm paleoclimatic periods due to their protective coverings of slowly degrading dry peatland. Other wetland types with shallow, flowing or stagnant fresh, brackish or saline water that have developed under specific severe Arctic conditions are also highly dependent on freeze-thaw processes.

The short growing season and uneven rate of metabolism (intensive for a very short period in summer) mean that the ecological niche capacity of Arctic wetland species is limited and annual production relatively low, so that communities have low resistance to disturbance and restricted potential for restoration. Arctic ecosystems are characterised by low diversity at species, population and ecosystem levels (ACIA 2005). Typical Arctic species, although few in number, are highly specialised and intimately linked to their habitats, so that habitat changes will lead to losses amongst these species. The large group of boreal species, on the other hand, will be readily integrated into the new ecosystem types that are expected to establish as a consequence of changes in climate and environment followed by tree line changes (IPCC 2007).

Arctic wetlands provide habitats for many migratory species, and are often referred to as 'the source of all flyways' (Boere et al. 2006). Thus, the biodiversity status of the entire world is linked to that of Arctic habitats through bird migration routes. In just the European part of the Arctic, there are more than sixty bird species with conservation priority, 75 per cent of which are strongly associated with tundra and mire habitats. Almost all of these birds are threatened.

Whilst some wetland ecosystems are strictly confined within the Arctic region, others receive water from more southerly river and lake systems, including five of the world's largest river catchments. These act as major conduits transporting water, heat, sediment, nutrients, contaminants and biota into the Arctic, so that any changes across the entire basins of these river systems will have consequences for Arctic ecosystems (Lewis et al. 2000).

Therefore, Arctic wetlands are highly integrated ecosystems depending on water and permafrost with balanced production processes provided by their own characteristic biodiversity; they have a significantly broader impact on the whole landscape than 'dryland' ecosystems; they maintain very specific biodiversity; and impacts on wetlands are caused mainly by hydrological changes which are usually irreversible. Special features of Arctic wetlands are: dependence on permafrost, low resistance to disturbance, restricted restoration potential, vulnerability to basin-wide changes in non-Arctic river systems, and potential to impact on the status of species and populations worldwide.

Wetland ecosystem services, uses and threats

Arctic wetlands provide significant natural ecosystem services as well as goods required by people. They play a crucial role in permafrost protection, water regulation, greenhouse gas exchange, primary production and accumulation of biomass. On the other hand, human requirements affecting Arctic wetlands include water supply, fishing, grazing, oil and gas exploitation, settlement and transport development. Traditional use was sustainable for many years, and in the recent past was still largely in harmony with natural ecosystem capacity. Now, however, new technologies have provided the means to overcome challenges presented by the harsh Arctic environment, leading to rapid and widespread industrial development. Apart from expansion of the oil and gas industry, even traditional land uses such as reindeer herding are being industrialised. The impact of transport infrastructure increases substantially every year, and there is a danger that the pursuit of Arctic resources will result in unsustainable development ignoring environmental needs.

Climate change alone is likely to seriously affect the hydrology of Arctic wetlands, leading to the disappearance of permafrost and changes in the flood regimes, hydrochemistry and dissolved and particulate matter loadings of rivers that will impact on the extent of permanent sea ice. The growing interest in Arctic resources means that the effects of climate change are increasingly combined with active ecosystem transformation, landscape fragmentation and species losses due to human activities. Thus, the effects of climate change are being significantly exacerbated by human impacts.

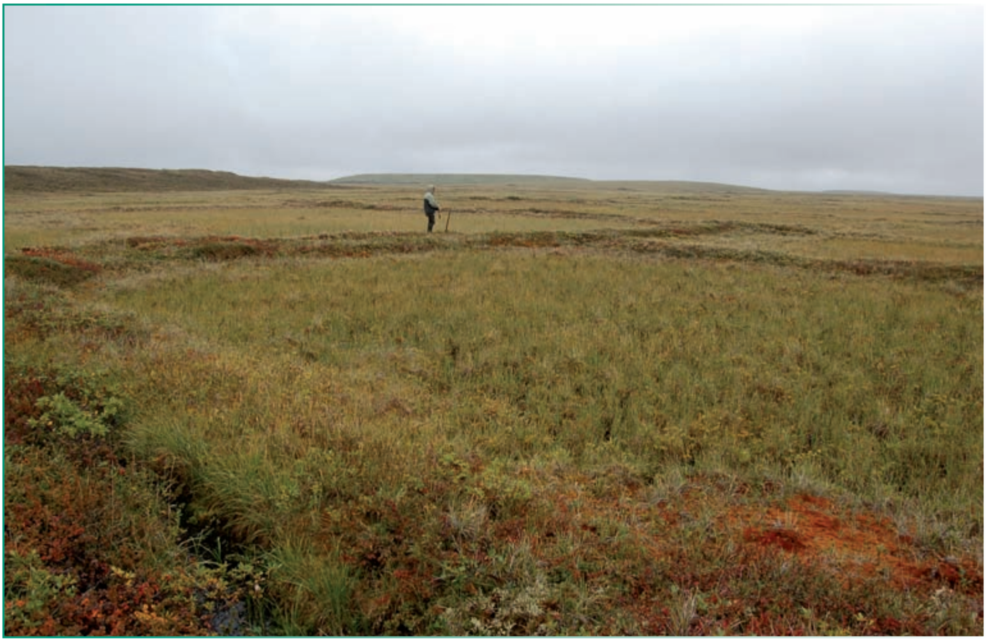
The transformations of wetlands resulting from climate change will cause them to release the greenhouse gas methane, and thus create a positive feedback for climate change. The volume of modern and relic methane involved is comparable with present-day industrial fluxes, and will have a global impact (Parish et al. 2008).

Adaptive wetland management

To mitigate the changes described here and provide adaptation to climate change, a number of management steps should be undertaken as soon as possible.

Assessment of knowledge gaps

Wetlands, and especially peatlands, are not yet clearly recognised as specific and valuable ecosystems which need special management approaches. As a result, the currently available information on Arctic wetlands is insufficient to provide an adequate basis for planning of land use and wetland conservation. More data are needed on the natural functions of wetlands, and on the threats arising from changes in climate and land use. Furthermore, there are still many uncertainties and gaps in knowledge about the responses of wetlands to climate change. For example, there is little knowledge or predictive capability for the water and energy balance, or for mechanisms of mass and gas exchange.



Polygonal mire (photo: Tatiana Minayeva).

Integrated planning

Our experience in regional wetland conservation has shown that a good knowledge of the ecosystem features, natural processes and mechanisms of wetlands combined with precise evaluation of the socio-economic situation could provide a basis for successful wetland conservation and wise use strategies, even in the complicated circumstances of the Arctic region. Integrated spatial planning of development and nature conservation, combined with implementation of the wise use concept, could provide an effective mechanism if comprehensively applied. For the wetlands which are most vulnerable and valuable for their ecosystem services, so-called 'no-go' zones should be defined.

Monitoring

Activities that still need to be organised are monitoring of wetlands, the development of a specific approach to EIA, and good geographical analyses based on a comprehensive wetland inventory. There is a large field of experts available for cooperation and knowledge exchange within and between relevant disciplines, including remote sensing (EO) techniques.

Ridge-pool complex within palsa mires (photo: Andrey Sirin).

Environment-friendly technologies

The rapid industrial development within fragile Arctic ecosystems demands new approaches and technical decisions to minimise impacts. Mitigation of impacts arising from the Arctic oil and gas industry is currently the subject of investigations and information exchange amongst the largest companies within the OGP (The International Association of Oil & Gas Producers) and other cooperation processes. The national regulations of Arctic countries should impose requirements for developers to invest in environmentally friendly technologies in order to avoid ecosystem degradation; and the development of this principle should be placed high on the agendas of international conventions such as UNFCC, CBD, Ramsar, CCD and the Arctic Council.

Restoration technologies

Because they have low restoration capacity, the restoration of Arctic wetland ecosystems requires the development of special technologies which should be based on an evaluation of existing restoration practices combined with an understanding of the integrative character of wetlands. The success of restoration initiatives should be judged in terms of criteria based on a wide range of natural, social and economic ecosystem services.

Awareness and understanding

The poor information background and consequent low level of understanding of wetland values, diversity, distribution and ecosystem services has led to low awareness of wetland conservation needs. This should be remedied as soon as possible. Otherwise, we shall lose Arctic wetlands before we recognise their value and our urgent need to avail ourselves of the services that they provide.

International cooperation

During the last five years, the Arctic Council (CAFF, AMAP and related initiatives) and EuroBarents groups (Barents Habitat Forum etc.) have been especially active in this area. But there is still a significant gap in that Arctic wetlands have received little attention from international conventions focusing on biodiversity. The working plans of these processes should include chapters on wetlands.

Conclusion

Arctic wetlands are hardly recognised and extremely valuable, fragile, vulnerable and threatened ecosystems which demand a specific management approach and a much higher level of attention from stakeholders than they enjoy at present.

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Norwegian Fisheries and Adaptation to Climate Change

Gunn-Britt Retter
Head of the Arctic and Environmental Unit,
Saami Council, Norway

Abstract

There has been continuous settlement along the northeast coast of Norway for more than 10,000 years. The local people in the fjords and at the coast have developed knowledge for generations that has allowed them to adapt to changing environmental conditions, in part by utilising a range of fish species. Small-scale fisheries based on this knowledge are thus less vulnerable to climate change. The challenge in the fjords today is limitations to this local adaptation capacity due to centralised management of marine resources and inflexible regulations on the fisheries, which are not based on local traditional knowledge. Nonetheless, climate change itself remains a greater threat to the Norwegian national economy, which relies heavily on a single species, the Barents cod, which may migrate out of the Norwegian economic zone due to climate change.

Unjárga/Nesseby is a municipality in the innermost part of the Varangerfjord in Finnmark County, northeast of Norway. The Saami culture and identity is still very central in Unjárga today. The Saami language is spoken by most of the inhabitants and quite a number of people are still occupied with subsistence livelihoods.

At the cultural historic site of Ceavccageadgi/Mortensnes, in Unjárga/Nesseby municipality, archaeological investigations prove that the site has been continuously settled from about 11,000 years ago until the present. The Varanger Peninsula became ice free 13,000 years ago, and the land has been rising ever since the downward pressure of the ice was removed, in a process known as ‘post glacial rebound'. Today, this land rise can be seen with the human eye, as natural terraces in the landscape. People traditionally settled at the sea shore, on the terraces. Today we can read the history of the settlements by walking from the highest hill down towards today's sea level – one step being a step in 100 years of history.

The Ceavccageadgi site, which is interesting for historical reasons, is in fact also a walk through a history of climate adaptation and resilience. Archaeologists are able to tell a story of how house construction and lifestyles have changed with changing climatic conditions, and conversely it may also be possible to learn how the climate has changed, based on how people were living at the time. During warmer periods, around 7,000 to 3,500 years BC, communities were more stable and had only a summer and a winter settlement and solid constructions of pine wood. During colder periods up to around the birth of Christ, the constructions were simple and people became more mobile. The aim was always to find a place with living resources they could utilise, and with shelter and firewood for the colder parts of the year. Various kinds of settlements can be spotted at the site in Ceavccageadgi, and they are more recent the closer they get to the present sea level.

Archaeologists can tell a lot about the diet at a certain time in history by investigating domestic waste. Remains of fish, sea mammals and birds tell us what kind of species our ancestors depended on during various periods. Their diet mainly consisted of cod, seal and whale, as well as birds, mostly migratory birds such as kittiwake, red knot, common redshank and European widgeon. Investigation of domestic waste from settlements from a warmer period also reveals fish species normally found in warmer water than we have today, which are thus no longer found in the fjord, such as whiting and moonfish or cusk (a member of the cod family). People of course utilised what was available for them at the time. As with the contemporary fjord fisheries, the past taught us not to simply rely on one species for survival, but rather to depend on the diversity of species available throughout the year. In Varangerfjord today that means cod in the winter, salmon in the spring, pollock/coalfish and haddock in the summer, and flatfish and halibut in the autumn, all of which are equally essential and valuable to our culture.

After 1600 AD the coastal Saami (Sea Saami) culture developed into a combination of small-scale farming and fishing combined with hunting and gathering. The seasonal migration and combination of subsistence livelihoods continued until the Second World War. From the nineteenth century various acts to regulate the fisheries were established, followed by a number of guidelines, all different for each region of Norway. These acts concerned mainly the ocean fisheries and not the fjords, which traditionally have been understood to be used by the local people. However, in 1955 an act on fisheries in salt waters revised all the existing regulations into one act for salt water fisheries for the whole of Norway, including the fjords that so far had in practice been reserved for the local people. As I see it, from then on the main objective of the fisheries regulations was increasingly to strengthen the big fisheries and weaken the small-scale fjord fisheries. In 1951 there were 1,512 inhabitants in the Unjárga/Nesseby municipality. Today there are 878 (as of 1 January 2009) – the population has been almost halved during the last 60 years – perhaps largely due to the fisheries regulations reducing livelihood options.

The fisheries in Finnmark totally collapsed in the late 1980s, due to overfishing and bottom trawling in which spawning grounds and capelin stocks were damaged. In January 2009 a new act came into force, the Marine Resource Act, which changed the management approach from single fish stock management to ecosystem-based management. This is however what was practiced in the fjords in the first place by the traditional fishermen, albeit perhaps not with such efficient equipment as is available today.

In January 2009 the research director at the Institute of Marine Research in Norway, Mr Einar Svendsen, gave a presentation at the Arctic Frontiers Conference in Tromsø, Norway (see http://arcticfrontiers.com/). The Institute of Marine Research develops research and provides fishery management advice for policy-makers in Norway. In his presentation he pointed out that the cod fish is very vulnerable to water temperature: when it gets warmer the spawning of Barents cod moves northwards, when it gets colder the spawning area moves southwards (Svendsen 2009).

Svendsen (2009) showed that so far in the northern waters of Norway, there has been an increase in the fish stock: climate change has been positive for the cod. This is in line with what the local fishermen in Varangerfjord have experienced since 2007 – that the cod fishing during winter was exceptional.

However, if climate change goes beyond what has been experienced previously, and the waters become even warmer, science cannot predict what will happen. There is thus a need to improve on current models. For example, the capelin, the main source of food for the Barents cod, migrate between the coast of Norway and the ice edge. In summer, the capelin graze on dense swarms of plankton at the edge of the ice shelf. This plankton is extremely rich in the fat known as omega 3. Thus fish is a major source of this much needed fat, and this is a main reason that

In recent years we have seen fish on the scaffolding again, the catch is better than in many years, but also the price for dried fish has been increasing (photo: Gunn-Britt Retter).

people today aim to have fish in their diet. If the ice edge is disappearing, it is not know what will happen with the capelin.

It is thus difficult to make predictions of what might be expected if the waters continue to become warmer. It is likely that the cod will move even further north or even eastwards, seeking colder waters. That might put the cod outside the Norwegian economic zone. In 2009 Norway is the world's second largest exporter of fish, and if the important cod fish moves out of the Norwegian economic zone, this will have a huge impact on the country's economy.

The Norwegian economy is thus vulnerable to climate change. Conversely, the traditional Saami fishing economy is not vulnerable to climate change, as locally people depend on the entire ecosystem and the diversity of fish stocks, giving them the flexibility to adapt to changing conditions. The Saami culture is more vulnerable to mismanagement and centralisation of power and research than to climate change, as these issues may limit the freedom the Saami need to respond

Ceavccageadgi cultural heritage site, Unjárga gielda / Nesseby Municipality, Norway (photo: Gunn-Britt Retter).

effectively to what may come. For example, inflexible quotas on catches of certain species may limit avenues to adapt to shifting fish populations. So too might regulation of the fishing season (starting and closing dates) and limitation of the hours in which we are allowed to fish, as is already in place for salmon fishing in salt water. Strict hunting regulations on seal, which prey heavily on fish, also interfere with the Saami's ability to adapt to changing ecosystems.

It has been suggested that fish farming might be a solution, as 'there is a lot of "farmland" out there' (Svendsen 2009). However, fish farming may not be a suitable adaptation solution to climate change – putting a fence around the fish to keep the economy going. Farmed fish may bring diseases to the wild fish populations. Furthermore, farmed fish may not be as healthy as wild fish, as they will not have access to the natural wildlife in the ocean like the fatty plankton via capelin, thus reducing their levels of omega 3. However, worryingly, Norway's policy seems only rooted in concern for the national economy.

If we manage to keep the waters clean, our past has shown that food is also available during warmer periods, but that this may be different food. Is the aim of good management to keep ecosystems the same as they were 60 years ago? Is that why we put money into monitoring and seed banks on Svalbard? Or is it more appropriate to attempt to adapt to the changes as they arrive?

The main future challenge will be adapting to rapid change, but I believe more regionalised management for the fisheries in Finnmark, as proposed by the Smith committee (NOU 2008:5), would be of benefit. However, this issue is controversial. The huge and influential industrialised fishing companies mainly based on the southwest coast of Norway are worried that with regionalised management they might lose their quotas and access. Also local Norwegian fishermen are wary of the proposal because it is based on Saami rights, even though the rights to fjord fisheries are not based on ethnic background or 'belongingness'. Some coastal Norwegian fishermen do see the benefits, however. Undoubtedly strong political leadership is needed to manage the fisheries through the changes predicted due to climate change. My suggestion would be that it is also crucial to involve the local people who depend on the ecosystems in question in the management already taking place today.

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Arctic Biodiversity and Ecosystem Services: How the *Conservation of Arctic Flora and Fauna Program* Can Help

Aevar Petersen
Icelandic Institute of Natural History
Chair of the Arctic Council CAFF Working Group

Abstract

The Arctic Council's Conservation of Arctic Flora and Fauna (CAFF) Program is designed to establish a more coordinated effort to the conservation of Arctic biodiversity. With the increasing pressure on Arctic biodiversity through climate change and other stressors, the monitoring of trends and impacts becomes more and more crucial. CAFF uses several approaches of which there are two main but related programmes, the Circumpolar Biodiversity Monitoring Programme (CBMP) and the Arctic Biodiversity Assessment (ABA). Arctic biodiversity monitoring through the CBMP is recognised as a component of the developing Sustaining Arctic Observing System (SAON).

Introduction

The Arctic covers 14.8 million km² of land and 13 million km² of ocean, including vast wilderness areas. Together with the Antarctic the Arctic holds the largest freshwater reserves on the globe, and also has a globally significant array of biodiversity and unique, diverse indigenous cultures. The Arctic's ecosystems are critical to the biological, chemical and physical balance of the globe.

The natural resources in the Arctic have been used for millennia for hunting, grazing, fishing and other resource use, more recently for commercial fisheries and tourism. Dramatic changes in biodiversity and ecosystem services are underway. These changes can be both negative and positive for the economy of the region. Changes generate threats to resilience and sustainability, and can have global repercussions for biodiversity.

Various stressors are placing pressure on the Arctic environment, and more are imminent. Climate change is predicted to cause greater warming in the Arctic than elsewhere, and will be double over oceans than over land. Resource development is on the increase, such as oil and gas explorations, with increasing infrastructures, and increased shipping and air traffic, leading to more extensive habitat destruction and fragmentation. Invasive species pose a threat to indigenous biota, and potential overexploitation is a continuing challenge.

Climate change as a stressor on biodiversity

The Arctic Climate Impact Assessment (ACIA) report (2005) predicted rapid warming with worldwide implications. As a result there will be geographical and numerical shifts in Arctic biota. Coastal communities will experience increasing physical exposure, and increased transport and resource access will follow from reduced sea ice. Thawing damages infrastructures and important feeding areas for mammals and birds shift geographically. These changes will have economic and cultural impacts for indigenous and other local peoples, and elevated ultra-violet (UV) radiation will affect people and biota. Climate change, increased resource development, and other stressors will place greater pressures on Arctic biodiversity in the future. The results are multiple interactions impacting people and ecosystems. Increased challenges for Arctic people are inevitable as a result, in terms of both their economic use of and general relationship with the environment.

The CAFF Program

The Conservation of Arctic Flora and Fauna (CAFF) Program is designed to establish a more coordinated effort to the conservation of Arctic biodiversity. CAFF is one of the six working groups of the Arctic Council, with a focus on biodiversity conservation. Board members come from eight Arctic countries and six indigenous organisations. Observers are from international organisations and non-Arctic states. The CAFF mandate is *inter alia:*

- *to address the conservation of Arctic biodiversity, and to communicate the findings to the governments and residents of the Arctic, helping to promote practices which ensure the sustainability of the Arctic's living resources…*
- *to monitor, assess, report on and protect biodiversity in the Circumpolar Arctic.*

What is urgently needed now for conservation of Arctic biodiversity is evaluation of status and trends, establishment of baseline data on status, and improved, enhanced capacity to monitor and understand changes. Much monitoring already takes place on Arctic biota, but we need a more integrated approach to biodiversity monitoring on a circumpolar rather than a national scale. Such an approach allows for more coordinated gap analyses and answers to regional and global, rather than local, pressures. Such an approach also allows for greater awareness of Arctic responsibilities to global challenges.

How is CAFF responding to these needs? CAFF uses several approaches of which there are two main but related programmes, the Circumpolar Biodiversity Monitoring Programme (CBMP) and the Arctic Biodiversity Assessment (ABA). Besides expert groups on seabirds and flora, there are individual projects such as ECORA (An Integrated Ecosystem Management Approach to Conserve Biodiversity and Minimise Habitat Fragmentation in Three Selected Model Areas in the Russian Arctic). Furthermore CAFF endorses Arctic projects that are considered important to Arctic biodiversity conservation but are supervised by other stakeholders and actors.

Arctic Biodiversity Assessment (ABA)

The purpose of ABA is: *to synthesise and assess the status and trends of biological diversity in the Arctic.*

Baseline information is gathered of the most recent scientific data and traditional ecological knowledge (TEK), gaps in data records are identified, the main stressors and key mechanisms driving change are analysed, and recommendations are produced. Co-leads are Greenland/Denmark, Finland and the US. ABA has three components or publications under consideration; the Arctic Biodiversity Trends Report (planned for 2010), the Scientific Report (2013), and lastly the Overview & Policy Recommendations (2013). The Arctic Biodiversity Trends 2010 Report is looked upon as an Arctic Council contribution to the UN International Biodiversity Year 2010, and as a measure of progress towards the 2010 CBD target to reduce the rate of biodiversity loss. ABA will form a baseline for future assessments of Arctic biodiversity.

Circumpolar Biodiversity Monitoring Program (CBMP)

The CBMP has a direct link to the ACIA recommendation to: *expand & enhance long-term Arctic biodiversity monitoring.*

The CBMP is an international network for improving detection, understanding and reporting on biodiversity trends. CBMP uses an ecosystem-based management approach, and currently has over sixty global partners, thirty-three of which are Arctic networks. The CBMP is led by Canada, with current funding from Canada, the United States, Finland, Sweden, Norway and the European Union. It is a coordinating body of monitoring networks, and is recognised as an IPY legacy and as a component of the Sustaining Arctic Observing Networks (SAON), which is under development.

The CBMP approaches monitoring through expert monitoring groups, representing the five major Arctic ecosystems, i.e. marine, coastal, freshwater, terrestrial vegetation and terrestrial fauna. Each group consists of site-based and network-based monitoring programmes, both scientific-based and community-based, using to begin with existing monitoring capacity. Research on various pressures is intrinsically linked to these networks. Each monitoring group develops comprehensive, multi-disciplinary and integrated biodiversity monitoring information for responding to identified science questions and decision-making needs. Each group needs to identify appropriate sampling schemes and standardised components.

Interactions with abiotic (physical) factors will be developed through linking with the appropriate monitoring groups. Gap analyses on current monitoring coverage are an important part of the present exercise.

Seabirds as an example of activity

One example of CAFF activities in focus is work on seabirds. The Seabird Expert Group (CBird) has main thrusts as follows:

- Identify principal conservation issues;
- Develop conservation strategies and action plans;
- Develop and implement an Arctic monitoring network;
- Map seabird sites and analyse population trends;
- Compile identified conservation issues and reporting;
- Bi- or multilateral research on identified issues;
- Contribute to other AC projects, e.g. oil and gas assessment.

CBird has so far developed three conservation strategies, on eiders, murres, and Ivory Gull *Pagophila eburnea.* The group attends to new, urgent conservation issues which arise and compiles reports on various issues, such as seabird harvest,

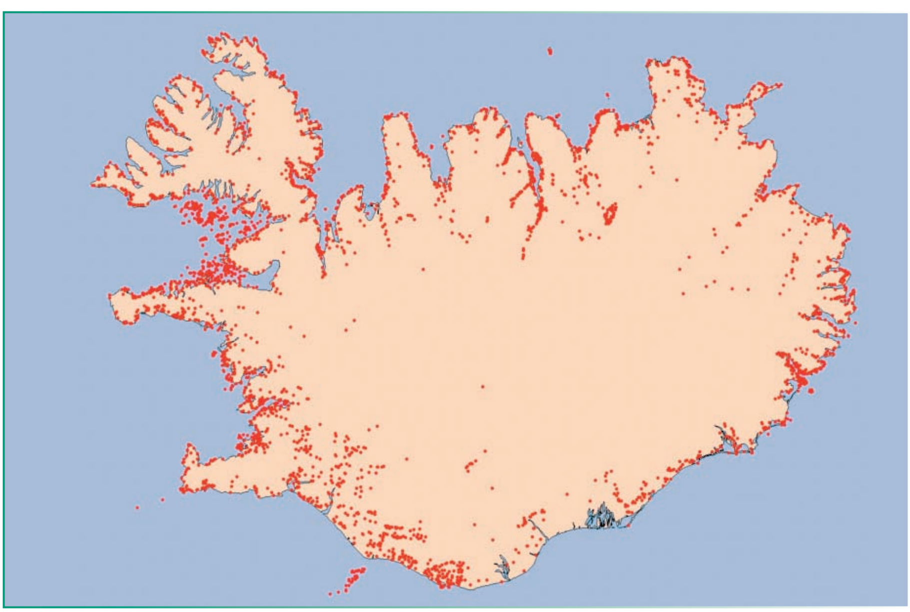

Figure 1. Distribution of Icelandic seabird colonies (from Bakken et al. 2006).

bycatch and disturbance at colonies. The status of some individual species is currently under scrutiny, e.g. Glaucous Gulls *Larus hyperboreus* and Arctic Terns *Sterna paradisaea*. As part of national seabird work breeding colonies are constantly being mapped (see Figure 1) and Arctic data are compiled for trend analyses in relation to stressors, e.g. climate change (see e.g. Irons et al. 2008).

CBird has developed a framework for an Arctic Seabird Monitoring Network, with the following main components:

- Colony monitoring;
- At-sea surveys;
- Harvest statistics;
- Breeders/non-breeders lists;
- Red lists.

Physical and biological data needed for interpretation of results will be sought from other sources and partners outside CAFF, as needed. One example relating to population trends includes the Ivory Gull (see Figure 2), which is an entirely High-Arctic breeding species for which the Arctic countries have special, and practically complete, responsibility. Its distribution is closely linked with Polar Bears *Ursus maritimus*, which Ivory Gulls follow for scraps, and the species is

Figure 2. Ivory Gull on Russian breeding grounds (photo: Maria Gavrilo).

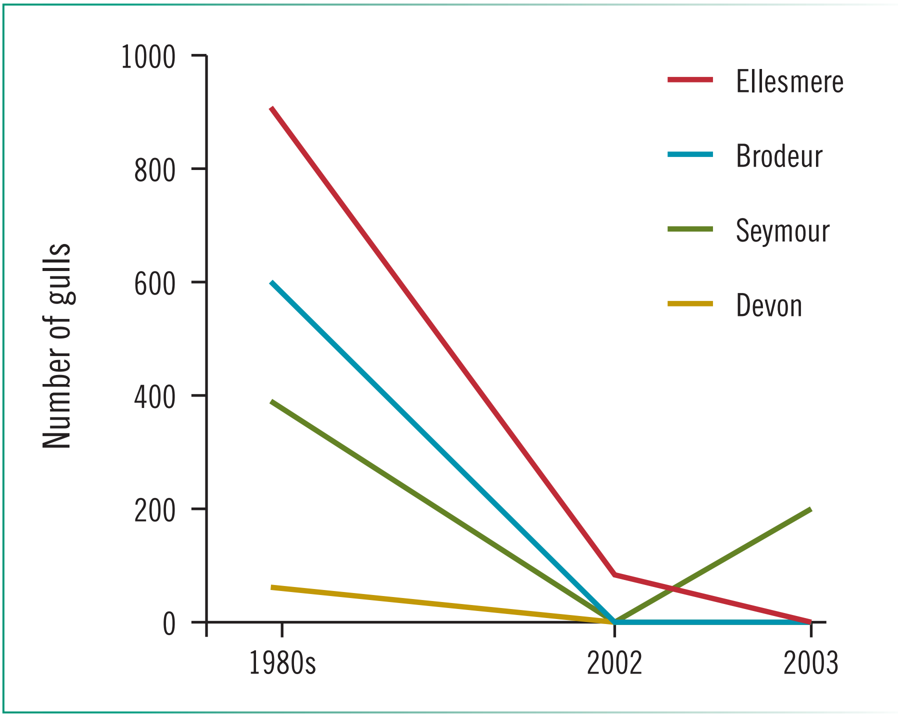

Figure 3. Population trends of Ivory Gulls in Canada (from Gilchrist et al. 2008).

listed nationally as an endangered species, also by the International Union for Conservation of Nature (IUCN). Dramatic decline has been observed in Canada (Figure 3) while Russia holds the bulk of the world population. The Ivory Gull is a CAFF-priority species and an International Conservation Strategy and Action Plan (Gilchrist et al. 2008) has been developed for its conservation.

Epilogue

CAFF faces a number of challenges in its work. Perhaps the main ones are to ensure sustained funding, Arctic-wide participation and access to scientific and traditional ecological knowledge (TEK) information. Management and dissemination of data to stakeholders is also challenging, as is continued political commitment. Evaluation of the effects of stressors on biodiversity is ongoing, as is the research needed for interpretation of monitoring results. Lastly, identification and filling of obvious gaps in the knowledge base is an integral part of the work.

Conclusion

A number of lines of action are needed to ensure the monitoring and conservation of Arctic biodiversity. It is important to acknowledge challenges to biodiversity caused by climate change and other stressors. It is also crucial to recognise the dependence of Arctic peoples on biodiversity, and the importance of traditional ecological knowledge (TEK). Further monitoring and research should be supported, aimed at linking biodiversity to climate change impacts, including the full range of ecosystem services and social systems as highlighted in the ACIA report. The Arctic Biodiversity Assessment (ABA) Arctic Biodiversity Trends 2010 Report should be endorsed as a contribution to UN International Year of Biodiversity 2010. Arctic biodiversity monitoring through the CBMP should continue to be recognised as a component of the developing Sustaining Arctic Observing System (SAON). The CBMP will be a true IPY legacy.

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Section 3

COMMUNITY-LEVEL IMPACTS AND ADAPTATION

Facing the Impact of Global Climate Change: Recommendations from the Arctic

Aqqaluk Lynge
President, Inuit Circumpolar Council (ICC) Greenland

Abstract

In the coming decades, the effects of climate change in the Arctic will include faster rises in sea levels, more frequent and extreme storm winds and flooding, a decrease in the extent of the sea ice, higher temperatures, and increased erosion due to higher waves, melting sea ice and thawing permafrost. Already, Inuit villages are being destroyed by erosion. The Inuit Circumpolar Council has done much lobbying internationally, especially through the Arctic Council, to try to limit climate change and lessen its impact on indigenous peoples and their lands. Notwithstanding such involvements, Inuit recognise that their capacity to achieve sustainable development in the face of climate change is dependent on their progress toward autonomy and self-government. In acknowledgement of the right of indigenous peoples to self-determination, we believe that Inuit must be included, as active partners, in all future international and domestic policy-making for the Arctic.

Our current state of knowledge

The challenge of sustainable development of the Arctic in the face of global climate change is central to every single issue currently being faced by indigenous peoples throughout the circumpolar region. It is probably the greatest challenge they have ever faced in a long history of formidable challenges. It is, in fact, absolutely crucial for the survival of circumpolar peoples and their cultures that we all find ways of meeting this challenge and that we find them quickly. My own experience of the impact of climate change is immediate and personal.

Inuit Circumpolar Council (ICC) Greenland President Aqqaluk Lynge near his birthplace in the Disko Bay region of Greenland (photo: ICC Greenland).

I come from a spectacularly beautiful place on this planet – a place known as the Disko Bay area of western Greenland, about 250 km north of the Arctic Circle. It is the home of the Ilulissat Ice Fjord with its thousands of floating icebergs – a unique location that has been named a UNESCO World Heritage Site. Emptying into the Ilulissat Ice Fjord is *Sermeq Kujalleq*, a glacier through which the Greenland ice cap reaches the sea. This is where most of the North Atlantic's icebergs originate and where more calf ice is produced than anywhere else outside Antarctica. The ice breaks off this enormous glacier and crashes thunderously into the sea below. It is quite a breathtaking sight, even for those of us who grew up nearby.

It is hard for me to believe that this mighty glacier, *Sermeq Kujalleq*, may someday disappear. But it may. *Sermeq Kujalleq* is now melting at an unprecedented rate. Not only do large icebergs break off its edge, but now water pours over its edge as well. In the past 15 years, winter temperatures on Greenland's ice cap have risen by about 5 °C, expanding the ice cap's melt zone at a faster rate than glaciologists predicted. Greenland's ice cap, which accounts for a tenth of the world's supply of fresh water, now loses annually more ice than is found in the Alps.

There is no longer any doubt that climate change is upon us. And Inuit traditions, the traditions of my people, established over thousands of years of living in the Arctic, are being severely tested by dramatic changes in our climate and environment. My people live cross the vast Arctic region that crosses the political boundaries of Canada, Russia, Alaska and Greenland. Inuit are one people: we speak the same language, eat the same whale muktaq and subsist on the same Arctic Ocean. And we are all dealing with the impact of climate change.

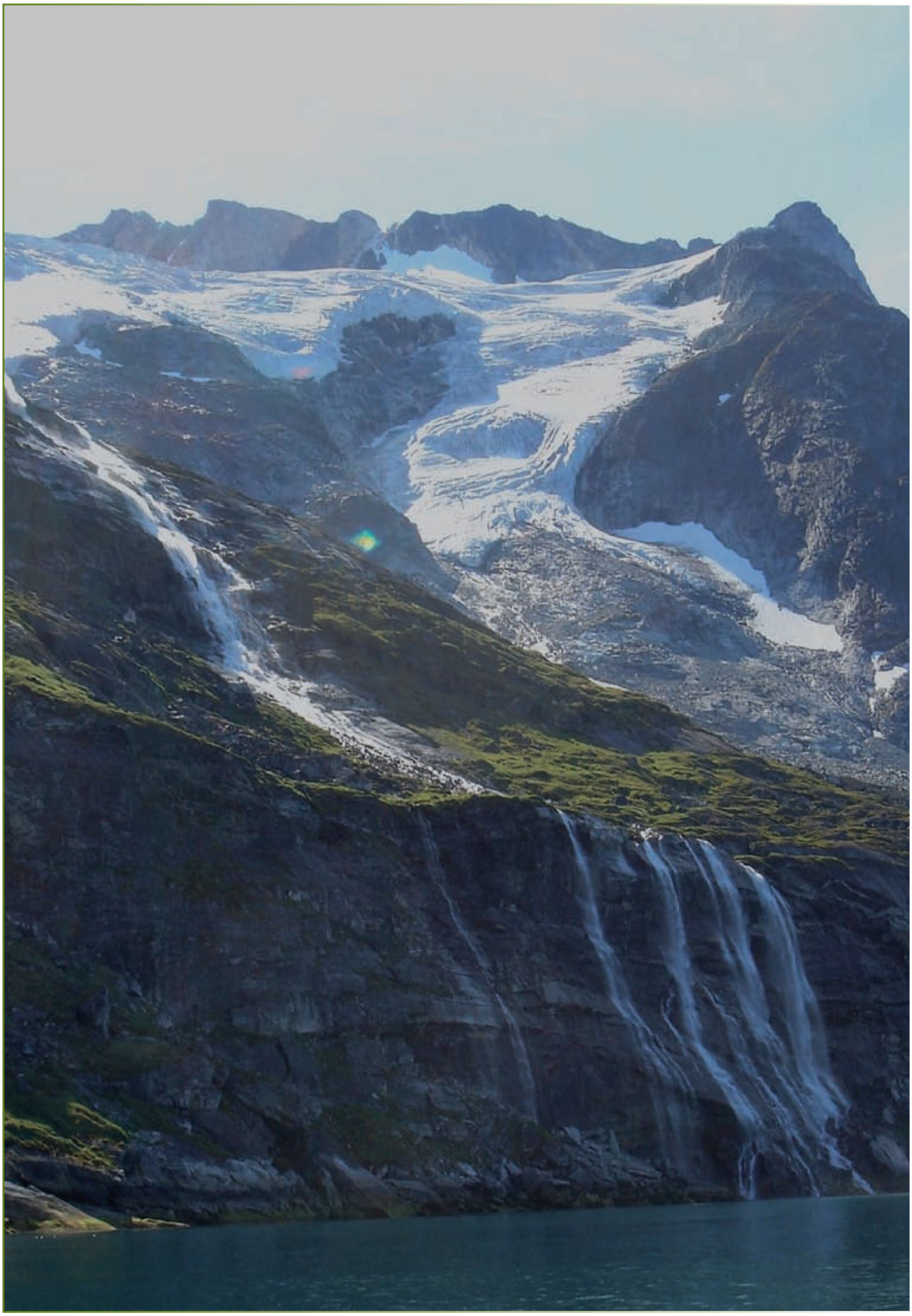
In Greenland, our *Sila Inuk* project focuses on Inuit hunters, asking them to document what climate change effects they have seen over their lives and what information they have gleaned from their grandparents (Kielsen Holm 2007, and this volume). Hunters speak of thinning sea ice that makes hunting much more dangerous, changes to permafrost that alter spring run-off patterns, a northward shift in seal and fish species, and rising sea levels with more extreme tidal fluctuations. One hunter told us, ‘The sea must be getting warmer because it doesn’t freeze where it used to, even when the air is very cold.’ Another said that the snow melts so quickly in the spring now that ‘it is as if the earth just swallowed it!’ Many say their traditional knowledge is not as reliable as it was in the past for predicting safe ice conditions. This is a great source of anxiety for Inuit hunters.

Just one example from Canada – The Inuit village of Tuktoyaktuk on the Beaufort Sea is experiencing rapid changes and a great deal of stress and uncertainty due to the effects of climate change. The sea ice at the edge of the village, which normally forms a protective barrier against erosion, is melting. Erosion of the shoreline is therefore increasing, and this erosion has created a new channel of water between two sides of the town. When there is no protection from sea ice, a storm can erode the shoreline up to a depth of 10 metres. This erosion, along with the thawing of the region’s permafrost, is destroying buildings and threatening the village cemetery. In Alaska, several Inuit villages face relocation because of damage brought about by melting sea ice and thawing permafrost. Their infrastructure is crumbling, their drinking water is contaminated, and the natural ice cellars they use for food storage have melted (See McClintock, this volume). We hear similar stories from Inuit in Chukotka.

There are many other examples like these, and scientists tell us that things will only get worse in the coming decades. The effects of climate change in the Arctic will include faster rises in sea levels, more frequent and extreme storm winds and flooding, a decrease in the extent of the sea ice, higher temperatures, and increased erosion due to higher waves, melting sea ice and thawing permafrost. All across the Arctic, Inuit are studying the effects of climate change and proposing strategies for adaptation. We recognise the importance of teaching young people the skills they will need in a changing environment, working with politicians, business leaders and scientists on problems facing Arctic communities, researching the impact of climate change on wildlife populations and their food sources, investigating new commercial and employment opportunities, learning different hunting techniques, translating climate change information into indigenous languages, making research results quickly available to decision-makers, identifying barriers to adaptation, locating financial resources, and so on.

The organisation that represents all 155,000 Inuit – from Russia to Greenland – on matters of international concern, environment and human rights is the Inuit Circumpolar Council (ICC). I was the Chair of ICC for six years, and for the past seven years, I have been the president of the Greenland chapter. ICC takes climate change very seriously and has done much lobbying internationally to try to limit it. We are active within many international bodies, including the eight-nation

Inuit hunters participating in ICC Greenland's Sila Inuk climate change study report that increased humidity is making it more difficult to dry fish and waterfowl (photo: ICC Greenland).



Greenland's glaciers are melting at an alarming pace (photo: ICC Greenland).

Arctic Council, where we and five other indigenous peoples' organisations have *permanent participant* status, which means we sit at the same table as ministers and senior Arctic officials and contribute at all levels.

The Inuit Circumpolar Council has been active in the various working groups and programme areas of the Arctic Council, including the Arctic Monitoring and Assessment Programme, the working group on the Conservation of Arctic Flora and Fauna, the Arctic Climate Impact Assessment, the working group on Protection of the Arctic Marine Environment, the Sustainable Development Working Group, and the Arctic Marine Shipping Assessment. The ICC and other indigenous peoples have also been very active within the United Nations and its various subsidiary bodies, including the UN Framework Convention on Climate Change.

Recent developments

As worldwide interest in the Arctic and the effects of global warming on the Arctic has skyrocketed in recent years, Inuit communities and organisations have become increasingly involved in national and international initiatives to address the issue of sustainable Arctic development in light of global climate change. Let me touch on only a few recent developments.

In the spring of 2008, Victoria Tauli-Corpuz and I, as special rapporteurs of the UN Permanent Forum on Indigenous Issues, prepared a paper for the Permanent Forum's Seventh Session that made many specific recommendations to states and multilateral bodies with regard to lessening the impact of climate change on indigenous peoples and their lands (Tauli-Corpuz and Lynge 2008). We recommended that policy-makers consider the long-term sustainability of any climate change mitigation policy they choose; that financial institutions increase their support for restructuring and reorientation towards low-carbon, national energy policies; that the full participation of indigenous peoples in post-Kyoto negotiations should be ensured; that scientists and policy-makers should consult with indigenous peoples so that their studies and decisions will be informed by indigenous peoples' knowledge and experience; that indigenous peoples should be given support to develop their traditional knowledge, their environment-friendly technologies, their cultural diversity and the biodiversity in their territories; and many other measures. We also noted from our research and from what science is telling us, that the Arctic is an area of special urgency.

In October 2008, under the auspices of the Sustainable Development Working Group of the Arctic Council, ICC organised the Arctic Indigenous Languages Symposium in acknowledgement of the importance of language, culture and traditional knowledge to sustainable development. Hugues Sicard of UNESCO made an interesting presentation, reminding us that when it comes to protecting and promoting indigenous languages, the most important work is being done in local communities, in schools and within families as they sit around the kitchen table. But he went on to explain that international instruments are essential elements too (Sicard 2008). In the same vein, we must remember that the language of climate change has both village level and international forum level dimensions. As we speak the new international language of climate change, let us not forget that the most important climate change language is what we find at home, in hunters's camps, and in eroding village coastlines. We need to look more closely at how we use language in describing what is happening both at home and internationally.

While most of our learning begins in the family, Inuit communities are increasingly aware of the need for higher education and awareness-raising, among our own people and among the global community, about sustainable development and climate change. In collaboration with our university in Greenland, Ilisimatusarfik, ICC Greenland is currently coordinating the establishment of a new 'Centre for Indigenous Studies'. This centre would create opportunities for students and professionals to examine global issues from the perspective of indigenous peoples and their own history and traditional knowledge. Canadian Inuit have proposed the establishment of an Inuit Knowledge Centre, which will foster the next generation of Inuit scholars and serve to boost the legitimacy and value of Inuit knowledge in research initiatives. They are also proposing the establishment of an Inuit Language Development Institute to serve as a Centre of Excellence, linking language revitalisation efforts across the Arctic. All of these types of centres are important to fully understand and address the numerous variables affecting climate change and other impacts we are facing.

As the 2012 deadline looms for the greenhouse gas emission reductions agreed to in the 2005 Kyoto Protocol, ICC has called for the avoidance of climate change impacts on the Arctic to be one of the key benchmarks for determining the effectiveness of the post-Kyoto process. ICC is also seeking a post-Kyoto-2012 process that includes international cooperation to support urgent action on adaptation to climate change, and the engagement of Inuit in the development of a circumpolar Arctic science and research infrastructure.

Inuit are hopeful that effective partnerships between indigenous peoples and science, industry and government will enable us to create solutions to the grave problem of climate change (photo: ICC Greenland).

In April 2009, ICC hosted a Global Summit on Climate Change in Anchorage, Alaska that brought together indigenous delegates and observers from around the world to exchange their knowledge and experience in adapting to the impacts of climate change; delegates also developed key recommendations to be shared at the December climate change summit in Copenhagen.

Notwithstanding these involvements, Inuit recognise that their capacity to achieve sustainable development in the face of climate change is dependent on their progress toward autonomy and self-government. Following a self-government referendum in November 2008, in which Greenlanders voted overwhelmingly in favour of greater autonomy, this major change in how we govern ourselves came into force in June 2009. We are all celebrating. In contrast, Nunavut Tunngavik Inc. has launched a lawsuit against the Government of Canada, asserting that the Canadian state stands in violation of its legal obligations arising from the Nunavut Land Claims Agreement. The Alaska Native Claims Settlement Act does not allow for true self-determination at all, and Russian Inuit have virtually no rights as an indigenous people. As for the recent talk of 'Arctic sovereignty', where many

Arctic countries – as well as non-Arctic states – are claiming the Arctic as theirs: this has largely been bought on by climate change. And Inuit have been left out of much of this sovereignty diologue, maybe because the melting ice has uncovered significant resource riches. Through ICC, Inuit have been advocating to be included in the bi-lateral and multi-lateral talks that have been taking place.

Future trends

What about the future? Indigenous peoples are looking forward with courage and hope to a future filled with effective partnerships that will allow us to make our own contributions to the solutions of world problems and at the same time to protect our ways of life as unique peoples. How should we work together, as partners, to solve the world's problems?

First, in order to deal with the challenges of the present and the future, we need to forge meaningful and mutually respectful relationships among scientists, policymakers, business leaders, funders and indigenous peoples. Second, we need to consult each other at the early stages of our research. Third, we need to share our knowledge and the results of our research with each other. Fourth, we need to make a commitment to each other as partners, recognising that we all have knowledge and skills that we can bring to our joint enterprises. A true partnership is about sharing, and a good partnership is about sharing equitably.

To adapt to rapidly changing circumstances, while at the same time preserving important elements of our culture, we as indigenous peoples need to find a balance between old and new ways, between scientific and experience-based knowledge, between change and stability. And I dare to suggest that our global partners in science, industry and government need to find a balance too between the excitement that accompanies new knowledge and the implementation of new policies and the respect they need to have for the ancient wisdom and experience of Inuit and other indigenous peoples around the world. In this way, we can form effective partnerships and walk confidently into the future to solve the world's problems *together.*

In conclusion, let us return to the Ilulissat Ice Fjord in Greenland I described earlier, to a 2007 symposium that started in Ilulissat and was held down the coast of Greenland. It was a symposium that was attended by nearly 200 scientists, theologians and government officials, hosted by His All Holiness Bartholomew, Archbishop of Constantinople. Pope Benedict XVI delivered a statement from the Vatican by video to those of us who were gathered there, in which he noted that how we address climate change is a matter of human dignity and human rights. The Roman Catholic pope reminded us that there are ethical dimensions to dealing with the impact of climate change on indigenous peoples (Pope Benedict XVI 2007).

Given the overwhelming extent to which the Earth, and certainly the Arctic, has already changed, and the seemingly desperate situation in which we find ourselves, I dare say that something very strong and spiritual must happen if we are to survive. I think we need, individually and collectively, to dig deep into our inner sanctums, find the ethical principles at the core of our humanity, and create solutions to this very grave problem of climate change. Without these solutions, sustainable development in the Arctic will be impossible.

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Arctic Peoples in a Changing Environment: A Humanist's Vision

Jean Malaurie
UNESCO Goodwill Ambassador for Arctic Polar Issues
Director, Centre of Arctic Studies CNRS/EHESS

Abstract

The melting of the sea ice, a sharp increase in economic activity and political tensions over sovereignty of the Arctic Ocean are all set to transform the Arctic both environmentally and culturally in the coming years. History tells us that in times of change and tension, indigenous peoples are often ignored or exploited. It is essential to ensure that this is not the case as we strive for sustainable development of the Arctic. It thus becomes useful to reflect on what we can learn from past experiences, and determine both the disadvantages and opportunities for indigenous peoples that arose during the Arctic's colonial history.

The world is facing a major threat: climate disorder. Global warming and deglaciation in the North are a reality, and despite all the controversies it is now recognised that this warming is at least in part the result of human activity. If the oil and gas exploitation that is predicted in the Arctic after the melting of the sea ice is not regulated, these industrial and naval activities can only worsen the effects of global warming: accelerated melting of glaciers and universal rise of sea waters. As sovereign nations struggle to face these dangers it is essential that the circumpolar indigenous peoples who have lived in these territories from time immemorial are not pushed aside.

There are many examples from the past when this has not been the case, when indigenous peoples have been ignored. For a first example: we are in a democracy under the sway of liberalism and we all believe, after the disastrous experiences of state socialism, that free competition and laissez faire allow those in the strongest positions to act in the interest of all, and lead the people of the world on a path of progress: a social Darwinism. I recall the terrible statement uttered by Louis St. Laurent, Prime Minister of Canada, 8 December 1953, at the Senate, Ottawa: ‘Apparently, ladies and gentlemen, we have managed these vast spaces of the North since 1877, in a state of almost continuous distraction.’ This continuous distraction resulted in the laissez faire being granted to a monopolistic fur industry, the powerful Hudson Bay Company. Its price dictatorship in some sectors led to the bankruptcy of companies that for whatever reason did not take part in its commercial administration and in its economic control. This laissez faire also resulted in a lack of management in the large Northwest Territories. There were no public schools and education was restricted to Catholic and Anglican schools that were not at all inclined to pave the way for indigenous animist spirits to create or maintain an independent philosophy. These huge errors add up to decades of suffering during hunting and fishing crises caused by unpredictable environmental changes, a procession of deprivation and even famine in the postwar years until 1958, with fatal consequences for the Inuit people, in a Canada that was so rich and powerful.

As a second example: in a place like Canada, which claims to be multicultural and federal, it became clear to the northern authorities that the young ‘illiterate’ students of the far North should be rapidly ‘Canadianised’. It was considered appropriate in a modern spirit of immersion, to gather the children in boarding schools in the south, far away from their families. The government relied mostly on the church to carry this out. I shall not dwell on the personal tragedies that were experienced. Protests against this treatment have never ceased since that time, and that is why on 11 June 2008, the Prime Minister made this painful statement: ‘In over a century, Indian boarding schools have torn over 150,000 indigenous children apart from their families and their communities. (...) On behalf of the Government of Canada and of all Canadians, I stand before you to offer our apology to indigenous peoples for Canada’s involvement in Indian boarding schools.’

In the colonial history of Great Britain, France and Holland, encounters with indigenous peoples have often been unfortunate and ill-considered. I myself have no willingly unpleasant thoughts towards these sovereign nations. We are fully aware of the prompt reactions of the great democratic nation that is Canada and we do recognise their generosity and determination when the promising self-governing territories of Nunavut and Nunavik were established by Ottawa.

As a third example it must be remembered that there are legal and military tensions that continue to worsen at the top of the world. They derive from concerns over the Law of the Sea in the Arctic Ocean. Nothing would be more damaging than a Cold War in these days of a major climate crisis, and we should remember that the first victims of such conflicts are indigenous peoples. In 1951, during the Cold War, serious tensions occurred in Korea, opposing the free world and the Soviet world. Under the aegis of the United Nations, it became necessary to organise the protection of the free world at a high level. This led to the development of the DEW Line (Distant Early Warning Line) operations, a series of radar stations built above the Arctic Circle. I was the only foreigner to witness one of these operations in Thule, which took place with an absolute contempt towards the peoples of the far North of Greenland; the Inughuit who have lived in these territories for centuries. In June 1951, after having spent a year with the Inuit, I was in North Star Bay, northwest of Greenland, during this powerful air operation. This was followed by a naval action consisting of 100 ships, which resulted in the creation of a base for planes carrying nuclear bombs. The creation of such a base had not been permitted by the Inuit people of Thule, who never received any request for authorisation. Still, a fifth of the land was imperatively appropriated. The ramifications were terrible: on 29 January 1968, during a period of very low temperatures, a B52 crashed in the middle of the polar night. It carried four H-bombs, three of which were sprayed into the waters, contaminating these pristine seas forever, and one of which remains unaccounted for below the ice.

It is thus necessary to identify the weaknesses and the mistakes resulting from colonialism. We cannot ignore the high rate of suicide that the Arctic continues to experience - one of the highest in the world - and that this shows how much teenagers crave for another form of society in the framework of development. It is both a philosophical and political response: a categorical no. Teens in the Arctic cities are often out of control, and alcoholism and drugs are scourges. We are now in a position to better appreciate what threatens major emerging indigenous nations. The experience of Indian reserves remains in our memories. And we know also, with reference to other parts of the world, the dangers of the drifts of financial capitalism.

We should nevertheless also emphasise the advantages resulting from the West, which offer these societies and civilisations avenues for development, advanced technology, medicine and all the benefits that science may provide. We must identify what has proved positive for indigenous peoples and reflect on what could be applied more widely.

In this huge Arctic theatre, undoubtedly the main polar island is Greenland. Five times as large as France, it has a particular geopolitical destiny. Thanks to a wise Danish administration, over two and a half centuries Greenland was built for Greenlanders, the language has been preserved and heritage protected, and executives are well trained within a consistent administration with modern means. Greenland is likely to become the first Inuit nation, and further to a recent referendum in favour of 'enhanced self-governance', Greenland is clearly moving towards some form of independence. Nuuk, the capital city of Greenland, happens to be the crossroads of circumpolar peoples in terms of geography and history. Of particular note is the policy followed by this young nation of adopting a cautious and peaceful postcolonial stance over the last fifty years.

In the Arctic desert of ice and tundra, it becomes clear that some hope must be granted to the creative imagination of technologists, who may invent a green economy with advanced technologies and futuristic architectures, in short, an economy that is useful not only for the peoples of the North but for the entire universe. Undoubtedly, the sustainable development of the Arctic is one of the greatest challenges given to the United Nations, to all its partner organisations, to all the academies of sciences and major universities of sovereign Arctic countries such as the United States of America, Canada, the Scandinavian nations and Russia. Also the other great nations of the world, such as the European Union, Japan and China, should contribute to reflecting on how to allow science and technology to serve Arctic sustainable development. Such is the challenge: develop nature, but also protect it, never forgetting the indigenous peoples who live in this nature, as well as the ever-increasing groups of immigrants that constitute a new people of the North.

Noteworthy is the innovative Uummannaq Polar Institute (UPI) recently established in Uummannaq, Greenland by the Greenlanders themselves. The institute seeks to associate traditional hunting and fishing with the most modern technologies - computers, plant and animal biology, economics, law and film - within the training of the young elite of Greenland. It also seeks to launch a mentoring programme that aims to complete the education of this young elite for six months to one year in major European countries and North America. The Greenlandic leaders of the UPI requested that I serve as an honorary president of the institute. I have agreed to fulfill this function through my work with the Centre d'Etudes Arctiques (CNRS/EHESS) and the new French Institute of Arctic Studies, whose director is Professor Jan Borm, at the University of Versailles-Saint-Quentin-en-Yvelines.

I also commend the Polar State Academy in St. Petersburg, established on the initiative of the academic Dimitry Likhachev, scientific and cultural adviser of President Mikhaïl Gorbatchev. I am one of the founders and the Honorary President for Life of 1,600 students, both indigenous and Russian. While certainly not perfect, its existence provides a foundation on which to build. Everywhere initiatives are increasing. Examples include Arctic universities in Rovaniemi, in Norway, in Greenland, in Canada, in Alaska and in Siberia. I must mention the intense work of the ICC commissions, the advanced investigations conducted by the Saami, and the work of the Subarctic indigenous peoples of North America, including the Dene and the Cree of northern Quebec, all of which teach us valuable lessons. I would also highlight the US Arctic Research Commission in Anchorage, and the excellent work of the Native organisations in Siberia, especially the Native Languages Institute in Yakoutsk directed by Professor Vassilii Robbek.

The history of men is tragic and it is our responsibility to ensure it is not lethal, not only for these peoples, but for all of us as we move faster towards the destruction of nature. Yet, while biodiversity loss is a crucial issue, and managing the climate is an overriding obligation, multiculturalism is a greater emergency. Everything in this modern world must therefore contribute to an intercultural dialogue. Our museums must not only be cemeteries of so called ‘past civilisations’, but living spaces where one reflects on the philosophies and conceptions that lie at the heart of traditional art. These million men and women, these fifty groups of people are alive and well. They want to design their move into the next century, at their own pace and with their own conception of ‘development’. Moreover, they want to remind Western societies that wisdom should prevail, and that they are highly concerned by the orientations of modern industry, which they often see as highly incongruent with nature’s balance.

The Arctic is no longer the scene of exploration. There was a time when scientists travelled to the Pole to discover it and to study it. Today, their aim is to conquer, exploit and colonise. One of the most serious problems that currently threaten circumpolar indigenous peoples and their lands is probably what makes these spaces so powerful: their oil and gas wealth. They also lie on major future shipping routes: thanks to global warming, the northern Siberian route reduces the distance between major ports of Western Europe such as Hamburg, Le Havre or London and Yokohama, Shanghai or Hong Kong. The same applies to the route through northwest Canada, which shortens the connection between the Atlantic and the Pacific oceans. Resultant economic development has the potential for attracting a massive immigration to the Arctic from the south. This immigration, already significant in Alaska, northern Scandinavia and Russia, could submerge indigenous peoples, even if they are protected by law as is the case in Nunavut and Nunavik.

It is important to recall that a third force exists among the tensions between sovereign nations vying for control of this resource rich area: Mother Earth, and consequently indigenous peoples who have always been connected to nature through environment and spirituality. It is important that throughout the coming years, we fully realise the dramatic dangers that Mother Earth is experiencing. The arrogance of science can blind us to the impacts of development on the terrestrial and marine balance. Yet nature is the supreme arbiter. It is crucial to remember that nature is our master.

Coastal and Riverine Erosion Challenges: Alaskan Villages' Sustainability

Sharon E. McClintock
President, McClintock Land Associates, Inc., Alaska

Abstract

Coastal and interior riverine villages in Alaska are reeling from the unprecedented warming trends due to climate change on many fronts, and they face challenges in combating the problem of erosion and flooding while struggling to adapt. Tremendous changes have occurred in the last 40 years when Alaska's land claims were settled and new land ownership patterns and a focus on economic viability thrust indigenous people into the twenty-first century. Concurrently, climate change is affecting the people most dependent upon the land for their livelihood; perhaps nowhere as dramatically as Shishmaref and Kivalina, two large Inupiat villages in the Bering Straits and Arctic Slope. Late formation of sea ice combined with melting permafrost onshore causes substantial erosion of the land base when extreme sea storms undercut the permafrost. Open water and less ice also means warmer temperatures which in turn affects subsistence hunting on land and sea, a vital factor in the preservation of the culture and traditional economy of Arctic people.

Erosion in key Alaska villages

Alaska is the largest state in the USA, with a land area consisting of 378 million acres. It holds over 220 indigenous villages, which rely on subsistence from the land and sea for their livelihood. Alaska has approximately 6,600 miles of coastline and four major rivers; the Yukon River, Kuskokwim River, Colville River and Copper River. Even today, many areas are only accessible by air or boat, and the cost of groceries, oil for heating, and gas for snow machines and boats makes residents more dependent upon what the land can provide. The basic amenities of life that many of us take for granted, such as basic sanitation and indoor plumbing, are lacking.

Through their intricate relationship with the land, environment, territories and resources, Alaskan indigenous communities are highly dependent upon the land and ice for their sustenance and livelihood. Depending upon the land for survival requires detailed ecological knowledge which has been passed down for generations and creates a distinct identity of strong, resilient and adaptable people. Their traditional livelihoods include subsistence hunting and gathering, trapping and fishing. They used and occupied large areas of land seasonally and travelled to known areas rich with edible plants and animals. They often established camps in settings along the shoreline, which were in strategic locations near the abundant hunting grounds of the ice pack. The sea ice is vitally important because it protects the land from the onslaught of coastal storms and provides an important habitat for the seals, walrus and polar bears that these communities depend upon for their subsistence.

Many villages that are now located along the coast and rivers grew out of traditional subsistence camps. When schools and churches were built and children were required to attend these schools, hunting camps became permanent communities. Over time, infrastructure was developed, at great expense due to the remote location of the villages. In the past, when erosion occurred, villagers could move back to higher ground or construct subterranean dwellings out of the tundra in new locations. In recent times, seawalls and revetment projects are built in erosion prone areas to protect homes and public buildings in imminent danger from erosion.

The US Army Corps of Engineers (COE) completed a Baseline Erosion Assessment study in March 2009 which calls twenty-six Alaska communities 'priority-action communities' (Figure 1). This means that they need immediate and substantial help. The congressionally funded study was intended to help federal, state and tribal entities and local stakeholders develop strategies and plans to address erosion issues. Small and remote Alaska Native villages have generally not received federal assistance under federal flooding and erosion programmes because they do not meet programme eligibility criteria. Even villages that do meet the eligibility criteria may still not receive assistance if they cannot meet the cost-share requirements for the project. Of the nine villages that the Government Accountability Office (GAO) reviewed, four – Kivalina, Koyukuk, Newtok and Shishmaref – are in imminent danger from flooding and erosion and are planning to relocate, while the remaining five are in various stages of responding to these problems.

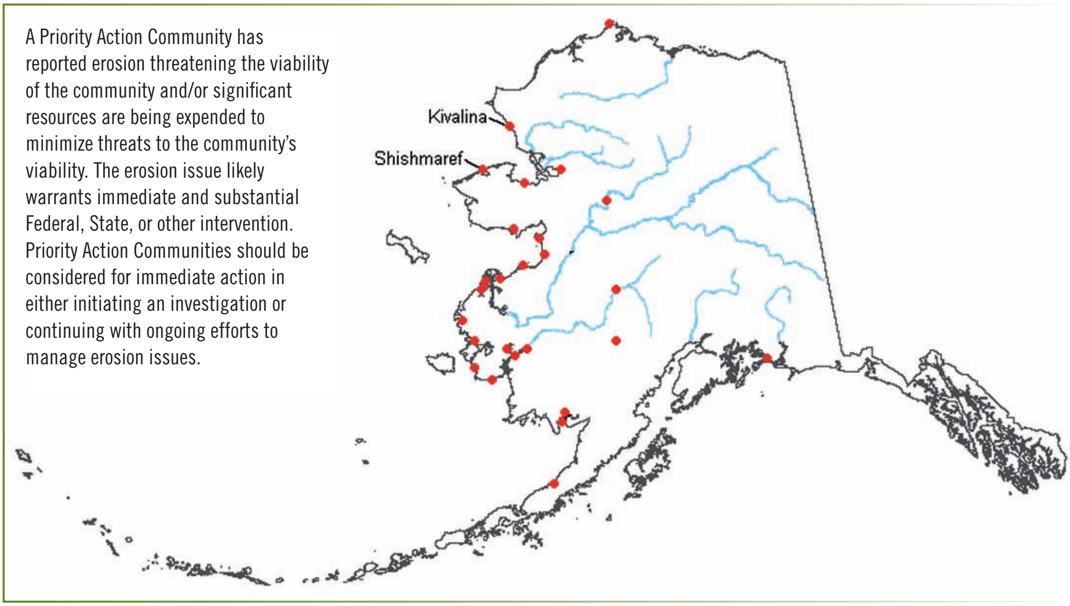

Figure 1. The COE Alaska Baseline Erosion Report's Priority Action Communities (from COE 2009).

Several of the villages located on barrier islands or low areas on rivers that experienced the greatest erosion have no room to move due to a lack of unencumbered or useable land. In such villages, state and federal agencies realise that there are no cost-effective erosion prevention measures that will save the villages, so they must relocate entire communities at enormous cost. Funding new community projects is considered risky by state and federal agencies in light of relocation efforts. Recent repeal of Section 117 of the Energy and Water Development Appropriations Act (Omnibus Appropriations Act 2009, PL 11-8) which provided flooding and erosion funding to villages through the COE has struck a hard blow to village erosion prevention efforts. The act took away the COE's authority to fully pay for erosion or relocation projects with federal dollars. At stake is the means to combat erosion because villages will have difficulty coming up with 35 per cent of the funding for erosion projects upfront. Funding from other sources is counted toward the percentage, but the recent budget cuts by the US Congress failed to fund the COE to adequately combat erosion. At this time, revetment construction projects already started in Shishmaref and Kivalina have been funded for additional phases to protect community property. A Community Site Selection Feasibility Study for Shishmaref to study the feasibility of at least three alternative community sites for long-term habitation is also funded.

Climate changes and erosion are a serious matter because they threaten homes, subsistence sites, schools, airports, roads, fuel tanks, graveyards, other infrastructure and even the lives of hunters and travellers in communities. The difficulties of living in eroding villages also create the impetus for families to move to larger cities resulting in the further dilution of the fabric of village culture. The villages of Shishmaref and Kivalina in the Arctic and Newtok in southwestern Alaska are seriously threatened and must relocate. A number of villages along the Yukon, Kuskokwim and Tanana rivers have been hard hit during 2009 spring flooding as a result of higher than average spring temperatures and thick ice jams. The village of Eagle near the Canadian border was totally destroyed in severe flooding in early May 2009.

Shishmaref

Shishmaref is a traditional Inupiat village in the Bering Straits with a population of over 600 people. The village is located on Sarichef Island, a barrier island with the Chukchi Sea located to the northwest. *'Kikiktuq'* is the traditional Inupiat name of Shishmaref. In 1973 during a massive storm, 30 feet of land was lost. In 1974, the village experienced a storm of major proportions and high water flooded a third of the only airport, prompting a federal disaster declaration. In October 1997 a severe storm eroded 30 feet to 150 feet of the north shore, forcing the relocation of fourteen homes. Five additional homes were relocated in 2002. In 2009, the village is struggling to find space for seven homes that are funded by the local Regional Housing Authority. Yearly storms continue to erode the shoreline, at an average retreat of 3 to 5 feet per year.

The former Shishmaref Relocation Coordinator reports that winters are shorter, the sea level is rising, freeze up is later, ice is thinner, the permafrost is melting and summer temperatures are warmer with more rain (Weyiouanna 2009). In the past, the sea ice would freeze in the fall and provide a blockade of ice along the shore which acted as a protective barrier along the beach. The ice barrier is critical to protecting the land from the onslaught of sea storms that come in October and November. The protective sea ice on the shore's banks no longer forms solidly by October and November. Its absence allows powerful waves to undercut the banks already weakened by melting permafrost. The resulting erosion forces houses to be continually evacuated. The teacher housing is in a precarious location near the bluff and the fear that the next storm will leave them homeless convinced long time and well-liked teachers to leave Shishmaref; a huge loss to the community. More than half the land area of centuries old subsistence sites where 80 per cent of the subsistence foods harvested in Shishmaref were

Storm in Shishmaref (photo: NOAA).

processed have been lost to the sea. The National Guard moved their armoury in the 1980s to high ground near the new airport. The sewage lagoon, roads, water supply, laundromat, community store, fuel tanks and teacher housing are at risk of damage or loss. The main road to the airport and landfill has eroded in several areas places and the road is now dangerously close to the sea. In July 2002, residents voted to relocate the community but learned in 2008 that the site chosen for relocation was not suitable so efforts have begun anew. Their short-term predicament is dire but the planning efforts are underway with exciting options for alternative energy such as geothermal and wind power and room for a well designed community, if funding is available.

It is evident that the later freezing of the sea ice is an indication of warmer temperatures in the ocean. Local people describe conditions of the Chukchi Sea: 'it doesn't freeze right, or fast, anymore…We go out a couple of miles, and you have this creamy-looking ice, and dark-looking, which is very thin and unstable.' Stanley Tocktoo recalls learning as a youth that 'blue ice and white ice were thick and solid. In winter, when solid ice extended down from the northern Arctic Ocean, seals and walrus could come in close to shore. Hunting was good' (Lempinen 2006).

After the massive storm in October 1973, the community worked with government agencies and made their initial decision to move to a site called *Nunataq* six miles south of the village. When the serious storm hit in 1974, the federal disaster that was declared prompted the reconstruction of a seawall in front of the village and a seawall to protect the school. In 1988, a state disaster declaration was made as two storms damaged the seawall in July and August. In 1997 a federal disaster was declared after the sea storm of monstrous proportions hit in mid-October eroding up to 150 feet of land and endangered thirteen homes. A state disaster team arrived to move the homes to higher ground. I was present to assist the village with site control and to determine where unencumbered land was available for homes, as ancient valid claims were off limits. The Alaska Native Claims Settlement Act had preserved the rights of occupants in 1971 but these claims had not yet been surveyed or deeded. Five thousand sand bags were placed in the weak spots along the base of the bluff. Gabions were placed in other locations over the years, but all were a temporary fix. In 2002, the community voted again to relocate and in 2004 chose a site at Tin Creek. In 2006, the COE reported that 3,400 feet of beach needed protection; otherwise the village would be jeopardised

Shishmaref Revetment Project (photo: Sharon McClintock).

Kivalina today (Photo: NoEnergyTomorrow).

by erosion and flooding. In 2009 Shishmaref was listed among the twenty-six ‘Priority Action Communities’ which reported erosion that threatened the viability of their community (COE Alaska Baseline Assessment Report 2009:ES-1).

Kivalina

In Kivalina, a predominately Inupiat village located on a shrinking barrier island in the Chukchi Sea 120 miles above the Arctic Circle, the Northwest Arctic Borough funded a $2.5 million protective ten-foot-tall seawall consisting of fabric-lined baskets filled with sand and reinforced with wire. Within a month of its completion in 2006, powerful undertows pulled the sand under the barrier and dismantled the seawall. Erosion in Kivalina is reaching a critical rate. The island has shrunk from 54 acres in 1953 to 27 acres in 2009. The community has lost teacher housing and sewage drain fields for the school and the washerteria (COE 2009:4-6). In 2007, the year when the village evacuated during a storm, water seeped into ice cellars and spoiled caribou and seal meat that typically stays frozen in permafrost 10 to 12 feet down. An interim shoreline revetment project is currently underway using rip-rap (rock rubble used to protect shorelines) cut from the face of Cape Nome. Four hundred feet of revetment has been completed. The final 1,200 foot segment constructed by the corps in 2009 cost approximately $8.5

million. Another segment, 400 feet in length, is needed. This project was authorised at full federal expense (GAO 2009). Extreme damage is expected within the next 10 years. Relocation planning is underway. The US Army Corps of Engineers estimate the cost of moving to be between $95 and $400 million.

Historically, the Chukchi Sea turns solid by early winter. Slush usually forms along the shore in the fall, creating protection from autumn storms. Over the past half century, average annual temperature here has risen more than 3 °C. Rain is extremely uncommon in the winter but occurred in January 2006 for the first time in memory, and in summer 2007 the thermometer approached 26 °C. The result of the warming trends, as in Shishmaref, is the late forming of sea ice and earlier and more severe storms.

In February 2008, the village of Kivalina filed a lawsuit (Native Village of Kivalina v. ExxonMobil Corp. et al.) in federal court against twenty-four oil, electricity and coal companies, including Exxon Mobil, Conoco Phillips, British Petroleum, Chevron and Shell. They demanded up to $400 million in damages, which is the estimated cost of moving the village out of reach of the rising sea. The lawsuit accuses the companies of contributing to global warming and creating a public nuisance that has harmed property in the town (Readers Digest 2008). The lawsuit also goes further, charging that some of the corporations 'conspired to create a false scientific debate about global warming in order to deceive the public'.

How is erosion being combated?

State and federal agencies have programmes to provide assistance for flooding and erosion. The Corps of Engineers and the Natural Resources Conservation Service are the key agencies tasked with administering flooding and erosion control projects. The COE Baseline Assessment Team identified key criteria for determining priority risk ratings. They include critical infrastructure, human health and safety, community siting/geographic location, housing and population affected, housing in parallel, environmental hazard, cultural importance, and commercial/non-residential (COE 2009:3-10 to 3-11).

Erosion of the land-base is very serious in Shishmaref, Kivalina and Newtok because these villages must relocate their entire community or risk losing homes and lives. Every coastal village experiences some erosion but many villages have enough of a land-base to move further back to higher ground, but villages that live on barrier islands or unstable land along rivers are forced to relocate elsewhere. Accomplishing the relocation process first involves consensus from the community to move. State and federal funding requirements require coordination among the consortium of organisations in the community, and years of planning where to move, seeking financial resources to fund the move, and compliance with the bureaucratic processes make it difficult to make any noticeable progress. 'We have no economic development. We have no fisheries, no mining and no oil development,' said Tony Weyiouanna, who headed the Shishmaref Relocation efforts for years.

In Shishmaref, seawalls of various designs have been used as erosion protectors for years with limited success. The COE, Bureau of Indian Affairs, State of Alaska and the City of Shishmaref coordinated to build a rip-rap revetment along the shoreline of a third of the community, protecting the residential and commercial and public buildings and infrastructure. Phases I and II of the project consisted of adding 1,325 feet of rock to 1,000 feet of existing seawall. During the summer of 2009, Phase III added an additional 550 feet of rock to protect the northeastern portion of the community. Phase IV, if funded, will protect the southwestern side of the community. The airport and the lagoon are still unprotected. A residential subdivision that was created for homes has ten lots of low undesirable ground and six lots close to shore that would endanger any home that is built. The COE expects severe damage to occur within 10 years so relocation is critical (COE 2009:4-8).

Shishmaref organised a coalition of three local entities to help address erosion. They included the Native Village of Shishmaref (tribal government), City of Shishmaref (state municipal government) and the Shishmaref Native Corporation (ANCSA Village Corporation) who worked in coordination with Kawerak, Inc., the regional non-profit corporation for the Bering Straits villages. The village coalition worked for ten years hosting numerous public meetings, submitted funding requests, selected potential relocation sites, obtained consensus of the community to move, and found a site that was near subsistence activities on their own land. Kawerak provided staff and assisted the coalition. Among the problems that the community encountered were the reluctance of the state and federal governments to fund infrastructure for water and sewage services, improvements to the public health facility, bulk fuel facilities and landfill, or to give monetary support for relocation of administration and planning or to act as the lead for the relocation project (Weyiouanna 2009:2). When the site was discovered to have permafrost issues, the efforts to start over with relocation planning began in 2009. Almost $23 million has been spent to construct seawalls that will provide temporary protection to what is left of Shishmaref. The community values its culture and has no interest in moving to Nome or Kotzebue as some agencies have suggested

Kivalina Revetment Project 2008-9 (photo: Ron Cothran, MLA).

as an option for relocation. Their culture has been strong for over 4,000 years and it is their hope that the next generations will follow in their cultural footprints in a new community.

Conclusion

Obviously, state and federal agencies will need to spend significant time and effort to assist communities in relocation. The effort to plan, design, permit and implement solutions to combat erosion and help with relocation is costly and time consuming. However, communities must relocate and their efforts to help manage erosion and work toward a permanent solution will have to succeed.

It is evident that Alaskan communities fare worst in dealing with federal and state assistance compared to other states and countries. When a hurricane destroys towns, an entire nation comes to their aid. When a tsunami destroys international communities, the world comes to their aid. When natural disasters strike, the Red Cross is there and the nation opens up their pocket books to help. But when Alaskan communities, many of whom live under third world conditions, are impacted by erosion and are forced to move, the process to relocate is delayed by lack of funds and a long drawn-out planning process. In the interim, mitigation measures fall short as millions of dollars worth of various seawall erosion projects fail within a few years. The prognosis is bleak as villages that choose to move lose funding eligibility for needed infrastructure. Second and third generations must live in one house because there is no funding for new homes. Many villages lack adequate sanitation facilities and running water, and the cost of gas is $8.00 a gallon, fuel oil cost $7.00 a gallon, and milk is $12.00 a gallon. In Shishmaref, the poster child of Arctic erosion, homes, airports, roads, teacher housing, fuel storage and subsistence processing sites are in danger of falling into the sea. The cost to relocate entire villages is enormous; funding needs can cost into the hundreds of millions of dollars.

When financial and technical aid is needed the most, the US Congress passes an Omnibus Bill which bails out failing companies, but in the same breath repeals an important section of law which gave the US Corps of Engineers (COE) broad authority to assist communities hard hit by erosion and flooding. We are however hopeful that the state and federal agencies will continue to provide long-term funding so that Shishmaref's motto, 'Shishmaref, we are worth saving', is realised.

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Perspective of Saami Reindeer Herders on the Impact of Climate Change and Related Research

Juvvá Lemet – Klemetti Näkkäläjärvi
Licentiate in Philosophy
President of the Saami Parliament in Finland

Abstract

Climate change will cause all Arctic indigenous peoples similar problems. They will be less able to ply their livelihoods and live in their traditional territories. Such changes will not only affect the material culture but also the cultural foundation, and the entire sphere of social life, of indigenous people. Consequently, research on climate change cannot simply focus on analysing the effects of these changes on material culture, it must also examine the impact on the foundations of entire cultural systems. Climate change will undoubtedly have significant environmental, economic, cultural and linguistic impacts on Saami reindeer husbandry. In order to find ways to adapt to climate change, we must combine the cultural knowledge of indigenous people with new scientific data. However, this approach is viable only if more training is provided for scientists studying indigenous people, if the higher education system is developed in the traditional territories of indigenous people, and if resources for research are increased. The most efficient solution to minimising negative impacts and ensuring indigenous peoples' ability to adapt to climate change lies in securing their autonomy at national and international levels.

Introduction

Research and discussions on climate change have focused on atmospheric and environmental impacts. In recent years, however, the effects of climate change on humans have been highlighted to an increasing degree (e.g. Arctic Human Development Report). From indigenous peoples' perspective, the effects of climate change on human life are critical, since these peoples depend on the environment, and their cultural foundations are based on its sustainable use. Consequently, climate change may rob Arctic indigenous peoples of their living environment, livelihoods and cultural foundations. For them, climate change is a question of justice. Indigenous peoples have survived colonialism but if nothing is done, climate change may be more effective at destroying their cultures than colonialism ever was.

Representatives of the dominant culture have commonly regarded the Arctic regions as being sparsely populated. It should be understood that the Arctic regions are, in fact, densely populated places, since the people living there have fully inhabited their territories in order to secure sufficient and ecologically sustainable livelihoods for both animals and themselves (Anderson 2004:2). The view of the Arctic regions as infertile and barren is misleading. In reality, some of the most dense seasonal biomass concentrations can be found there, although their exploitation is not as simple as in other areas, such as at the equator (Kankaanpää 1997:104). Arctic indigenous peoples have populated their regions in a way that is purposeful and economically sustainable. Now, climate change is about to alter this balance.

The Arctic region is also attracting increasing interest from world politics and energy policy. From the perspective of many indigenous peoples, such interest is unwelcome. The sensitive nature of the Arctic environment cannot sustain large numbers of people or the wide-scale exploitation of energy resources. Climate change will therefore have an impact on the resource base of the entire Arctic region, preventing the traditional, sustainable use of the environment by indigenous people. Changes in the flora, fauna and climate, combined with the loss of entire living territories, will force indigenous people to seek new ways of adapting. Meanwhile, these changes are obliging national states to seek opportunities for securing the Arctic region and its indigenous cultures for future generations.

In the Arctic region, climate change will cause all indigenous peoples similar problems. Reindeer grazing will become more difficult with the increase in snow cover and crusts on the snow. People will be less able to ply their livelihoods

In this picture a small reindeer herd (čora) is being gathered to the main herd (eallu) in the Stálovárri area of Eastern-Eanodat in northernmost Finland. The reindeer were startled and started to canter (ruvgalit) because there are wolverine (geatki) tracks nearby. It is spring time and the snow has a hard crust (ceavvi), which allows reindeer to travel a great distance rapidly. Herders have to keep the herd together because of the predators, and consequently the herd has to be circled by snowmobiles many times a day (photo: Klemetti Näkkäläjärvi).

and live in their traditional territories. Such changes will not only affect material culture but also the cultural foundation, and the entire sphere of social life, of indigenous people. Forced relocation from traditional living territories will erode the foundation of indigenous peoples' culture and compel them to adapt to a new environment. Climate change will affect cultural and social life, as the survival skills learned by the previous generations may cease to matter and the social hierarchy of the community will erode. Consequently, research on climate change cannot simply focus on analysing the effects of these changes on material culture, but must also examine the impact on the foundations of entire cultural systems.

Indigenous peoples live within national states, where their views and suggestions for adapting to climate change, minimising its negative impacts and conducting relevant research are almost invariably left without support. Securing opportunities for Arctic indigenous peoples to influence decisions and wield decision-making power is of vital importance. Partnerships between Arctic indigenous peoples and scientists can produce new ways of adapting to climate change.

Research on indigenous peoples

In the past twenty years or so, knowledge accumulated by indigenous people has attracted growing interest within the study of developing countries and indigenous peoples. This knowledge has been termed traditional ecological knowledge (TEK)[(1)] (see e.g. Borchgrevink 2002:223-225). TEK attempts to describe indigenous peoples' special knowledge in relation to the dominant culture, the distinctive nature of such knowledge and, in particular, its intrinsic ecological knowledge. TEK is related to a wider theoretical discussion, which attempts to demonstrate the similarities and equality between the knowledge of indigenous people and so-called Western science. The purpose of TEK is laudable as such – valuing the knowledge of indigenous peoples to the same degree as Western theories. While this is a very worthwhile political objective, the concept raises some questions when viewed in the light of science. Scientists applying the concept of TEK cannot ignore the fact that, as they review the cultural knowledge found in indigenous communities, their object of study must remain at the local level. TEK cannot be defined as applying to an entire people, sometimes living in a very large geographical area. Certainly, it cannot be thought to apply to all indigenous people. TEK studies mainly focus on terminological questions and terms, as indicators of environmental relationships and understanding. Such taxonomies are informative but reveal only a little about the ways in which terminology is used and taught, and about the environmental relationship behind the terminology (Näkkäläjärvi 2008:61). In climate change studies, TEK alone will not suffice in explaining the impacts of climate change on indigenous cultures and cultural knowledge. Research on climate change involves impacts on livelihoods, the environment, cultural behaviour, language and the cultural transfer of knowledge from one generation to the next. In short, political objectives and scientific theories should be kept separate.

In the future, indigenous knowledge is expected to provide more help in monitoring climate change. For that reason, it is important that indigenous peoples, the scientists studying them and scientists from other fields can work together to develop theories and concepts, which will assist in the accurate description of

(1) The concept is based on a political definition. The United Nations has defined TEK as: the knowledge, innovation and customs of indigenous and local communities around the world. TEK has developed over centuries through accumulated experiences and has been transferred from one generation to another. TEK refers to collective information in the form of songs, narrative traditions, sayings, cultural values, beliefs, rituals, community laws, local language, agricultural practices, the breeding of animals and cultivation of plants. Traditional knowledge is mainly practical in nature, particularly in the areas of agriculture, fishing, health, farming, forestry and environmental management in general (UN Convention on Biological Diversity 1992).

indigenous peoples' knowledge and relationship with nature. Instead of TEK, I prefer to use the term 'landscape memory'. This is a theoretical concept covering the entire scope of professional knowledge required of a reindeer herder. Landscape memory brings together the culture, learning and professional knowledge of reindeer husbandry in a single theoretical model. Although reindeer herders' professional competence and knowledge are largely practical in nature, landscape memory also contains more theoretical aspects, such as perception models, cultural ways of seeing, and detailed classifications of natural phenomena, land forms, terminology and identification models, thus forming a cultural knowledge system (Näkkäläjärvi 2008:43-46).

Indigenous people have frequently appeared as both subjects and informants of research. In order to find ways of adapting to climate change, we must combine the cultural knowledge of indigenous people with new scientific data. However, this approach will be viable only if more training is provided for scientists studying indigenous people, if the higher education system is developed in the traditional territories of indigenous people, and if research resources are increased. The promotion of scientists and research training related to indigenous people is crucial if the cultural knowledge of indigenous people is to have a genuine impact on research.

The impacts of climate change on indigenous cultures and languages

Understanding the special terminology through which landscape is identified, classified and defined is a crucial aspect of plying and managing indigenous peoples' livelihoods. Language transfers knowledge from one generation to the next. Thus, it represents continuity and helps people perceive and experience their environment. Consequently, any breakdown in the language structure signals a breakdown of their conception of the environment, affecting the nature of knowledge and the worldview passed on from the previous generation. Describing human responsibility for the environment, language works to maintain the ecological balance, which is crucial to sustaining life (Sara 1977:72-73).

The Saami language and reindeer terminology are largely congruent in the speaking area of North Saami.[2] Nevertheless, regional variations both in language and

(2) The North Saami speaking area covers northern areas of Finland, Sweden and Norway. The number of North Saami speakers is estimated at 30,000-50,000 depending on the source.

A Saami reindeer herder at the end of the 1960s. When the first motor vehicles, such as mopeds, came to the Saami area these new forms of transport could not be trusted. That is why this herder has skis and, the most important help in herding work, a reindeer dog with him as he goes to the herd. He also has a lasso (suohpan) and binoculars with him (photo: Eanodága Sámiid Searvi Archives).

reindeer husbandry models can be observed, explained by the resource base and cultural contacts of the local culture. For example, differences have been observed in the terminology and models of reindeer husbandry between Utsjoki and Enontekiö.(3) In climate change research and in the search for adaptation models, no single model can be found that might work throughout the Arctic region. Adaptation methods and measures must be modified to suit local cultural models and landscapes.

Language lies at the core of indigenous cultures; it is a tool which enables people to gain their livelihoods and maintain the community's memory. Gaining a livelihood from reindeer husbandry is possible only if reindeer herders have a classification system of language that can be learned. Language should be studied as part of a culture and its development. In linguistic research, it is commonly held that language influences culture and vice versa. Researchers speak about the Sapir-Whorf hypothesis or about linguistic relativity. Language influences the ways in which we think and is a tool for thinking (Sapir 1968). Consequently, we should always bear in mind that languages are a very important issue when preserving indigenous cultures.

Saamis are experts in reading nature and have a very special and distinct terminology for environmental conditions and phenomena. The Saami language has a vast store of terminology and appellatives for snow, which creates certainty when navigating and moving through the landscape. Although linguistic knowledge is largely of a practical nature, it also holds more theoretical aspects in perception models, cultural ways of seeing and in precise classification systems for natural phenomena, land forms, terminology and identification models.

Several indigenous peoples have no written history, their culture and cultural history being preserved and developed through language and stories. For example, the reindeer terminology of the Saami language is connected to deer hunting, which preceded reindeer husbandry. As the culture changed from deer hunting towards reindeer herding, deer terminology was considered appropriate for reindeer husbandry and, in many cases, no changes were necessary. A portion of the know-how required in deer hunting, such as the names and understanding of ages and the gender of deer, transferred to reindeer husbandry largely without modification. The linguistic heritage of specific names and concepts describing the biological identification marks and characteristics of reindeer also dates back

(3) Enontekiö is located in West Lapland, where the western variant of North Saami is spoken. Utsjoki is located in East Lapland by the Norwegian border. In this region, the eastern variant of North Saami is spoken and the influence of the fishing culture, in particular, can be observed in the local culture (see Näkkäläjärvi 2007).

a long way. The same terms are used to describe the age of reindeer and beaver. Consequently, terms describing the age and gender of reindeer are shared by the Saami languages, indicating that the terminology dates back to the Stone Age and the Uralian period (Itkonen 1984:74; Sammallahti 1982. Uralian period until 4000 BCE, see Korhonen 1981:27). This know-how, accumulated over thousands of years and expressed through language, is in danger of becoming obsolete and/or may disappear with climate change. The death of an indigenous language is a cultural loss for mankind and especially to indigenous culture. The relationship between language and culture disappears and this results in changes in the cultural core itself. Possibilities for using lingual know-how disappear and new lingual knowledge needs to be developed. Maintaining indigenous languages and their vitality as part of living indigenous cultures must be taken into consideration in minimising the impact of climate change. The preservation and development of indigenous languages requires the protection of traditional livelihoods and livelihood models, the maintenance of a sufficient natural resource base and the encouragement of modern research and education.

Climate change and actions by national states are endangering lingual knowledge. More efforts are required to teach indigenous languages and encourage the transfer of language from one generation to the next. The link between language, livelihoods and the environment can disappear for several reasons, such as the increasing use of indigenous peoples' traditional territories for the livelihoods of the dominant culture, fewer opportunities to engage in traditional trades, and the spread of the dominant culture's social structures. Indigenous languages must be recognised in the law as indigenous, not only as minority languages, as has often occurred. They can survive only when they are spoken and developed. New technology and research require new terminology and simultaneous language development. From the perspective of indigenous languages, the prevailing view that English is the only language of science is wrong. Indigenous languages must also be languages of science; otherwise they are in danger of remaining business and home languages.

Although forming part of the Finnish population throughout history, the Saami in Finland differ from the dominant Finnish culture in terms of their livelihoods, languages and cultures. The environmental relationship of the Saami is not constructed on the economic (agriculture and forestry) or political and artistic[4]

(4) Political and artistic exploitation refers to the ways in which Lapland has been presented in arts and politics in order to advance the building of a nation state. With its unique natural beauty, Lapland has signified an exploitable area both economically and artistically, depending on the person's perspective.

exploitation of landscape, but on a concept which sees human beings as forming part of nature. The Saami perception of landscape has been largely built on fishing, foraging, reindeer husbandry and the earlier deer hunting. These livelihoods are evident in their language, fishing and reindeer husbandry practices, and lifestyles (see e.g. Näkkäläjärvi 2007). Climate change may lead to a change in their traditional relationship with nature.

The Saami culture of reindeer husbandry relies on distinctive ecological structures. Their livelihood is based on detailed knowledge of the territory and nature, as well as the close and mutually beneficial relationship between reindeer and the herders, sharing the same living environment. Reindeer-herding Saami adapt directly to their natural environment, live in the real time of nature and migrate according to the seasons. Mobility and social flexibility form their basic social structures, enabling Reindeer Saami to exploit their living environment extensively and in diverse ways, while eliminating the ecological crises caused by changes in plant and animal life. The Reindeer Saami community continues to rely on kinship rights in the organisation of its society. These aspects of the social and ecological system guarantee the community's safety and continuity.

In economic studies, the livelihoods of indigenous people have often been reviewed as mechanical trades, the purpose of which is to secure income. Consequently, research has focused on distribution, exchange and trading, and the resource environment. From this perspective, nature is considered purely as an exploitable resource; precisely the kind of thinking that has led to climate change. The unique nature of indigenous peoples' livelihoods lies in their engagement in culture, the transfer of culture to future generations, and the connection with previous generations, all of which is inherent in the livelihood. Above all, reindeer husbandry is based on the knowledge of reindeer and the natural environment. Climate change is already affecting snow levels. The period of snow cover begins later and snow depth has increased. Following the change of seasons, Reindeer Saami register information on the formation, consistency and characteristics of snow cover, particularly on the places where snow melts and vegetation is uncovered for reindeer to feed on, and the effects of snow depth on snowmobile movement. In particular, such registration has been performed using snow terminology within its context of application.

Climate change will have an impact on indigenous peoples' resource base and, consequently, on the methods of land use, as areas previously reserved for reindeer pasture become unusable and reindeer find it increasingly difficult to find food. In addition to climate change, indigenous peoples must accommodate other competing land uses, such as oil fields, forest felling, tourism and mining. The cumulative impact of these may critically reduce the indigenous culture's chances of survival. In reindeer husbandry, it may lead to a reduction in herd sizes, the need to acquire additional food for the animals, and changes in reindeer husbandry models and cultures. Continuous feeding will transform nomadic reindeer herding, bringing it closer to domestic animal husbandry. For reindeer herders, these changes would not be restricted to economic matters but would also involve significant cultural aspects. If reindeer herders have fewer reasons to travel within their environment, the use of environmental, snow and climate terminology will become less important, along with the ability to navigate within and read the environment. The knowledge and terminology necessary for identifying reindeer will also deteriorate if reindeer are not out in the pasture, but are instead fed regularly. Earmarking[(5)] may be discontinued, as plastic ear tags could also be used to identify not only cattle but reindeer. When reindeer no longer have some 300 plants in their diet, the taste and fat content of reindeer meat will change and the fat will become unhealthy. Due to climate change, the terminology and practical knowledge of nature and reindeer husbandry will decline and partly disappear, unless we make the political decisions necessary for the prevention of climate change. According to my database, North Saami has no fewer than 2,000 terms describing the environment, weather and snow (Näkkäläjärvi 2009). When the system of reindeer husbandry changes, most of these will become obsolete.

Climate change decision-making

The Saami have gained little cultural autonomy in Finland, Sweden and Norway, the latter of which has ratified the ILO 169 convention concerning the rights of indigenous and tribal peoples. The ILO convention is the most important convention for indigenous people because it grants indigenous people the right to their own homelands, resources, land, culture and language. The United Nations Declaration on the rights of indigenous peoples is important, but remains a declaration only. For the Arctic peoples, ratification of the ILO convention would be particularly

(5) The most important identification mark of reindeer is the earmark, which shows ownership. Other features used to identify reindeer include gender, age, body shape, hair colour, shape of antlers, lack of antlers and character (Näkkäläjärvi 2002). According to Eira, there are around a thousand terms for describing reindeer in his Kaunokeino dialect of North Saami (Eira 1984:59). The earmarking system of reindeer, *mearkaoalli* in North Saami, displays ownership of reindeer and the transfer of earmarks. The earmarks of nuclear families and extended families resemble each other, helping herders remember the earmark and identifying the reindeer herders as part of a family, kin and community (Näkkäläjärvi 2002).

crucial due to climate change. Establishing representative bodies for indigenous people and granting them autonomy to govern and own their lands and to promote their language, culture and livelihoods, would provide the most effective solutions for fighting against, and adapting to, climate change at the local level.

In addition to national state bodies, matters involving indigenous peoples and climate change are often decided in a number of international forums. Among others, the European Union, the Arctic Council, the Barents Euro-Arctic Council and the United Nations agree on preventative action on climate change that affects indigenous peoples. While the rights of indigenous people to attend and speak at meetings vary, no indigenous group has been granted decision-making rights. Increasing the representation and decision-making powers of indigenous people on international platforms is vital in the fight against climate change. While climate change is widely discussed in the international political arena, the debate often focuses on the objectives of energy policy and world politics (such as the dispute over the continental shelves).

Indigenous peoples are frequently viewed as objects of decision-making. They are expected to adapt to the changes brought about by the industrial and post-industrial world, climate change and other competing forms of land use. From indigenous peoples' point of view, this unending requirement to adapt is an extension of colonialism, disguised in fine words. From this perspective, indigenous people can develop and adapt only under the conditions set by the dominant culture. Securing the rights and autonomy of indigenous peoples would provide a solution to this. However, the reluctance of states to recognise increased autonomy as a solution to adapting to climate change is a common problem. Instead, research and the increased participation of indigenous people are continuously cited as the preferred methods. The most efficient solution would be to secure indigenous peoples' autonomy at both national and international levels.

Climate change poses a significant threat to the future of Arctic indigenous peoples. Thus far, its effects have remained small but they will accumulate in the near future. Simultaneously, indigenous peoples are not only seeking new ways to adapt their cultures, livelihoods and languages to the changes brought upon them by climate change, but are also fighting for the existence and future of their cultures. The common denominator for Arctic indigenous peoples is the complete lack of solutions to questions concerning land rights. Attempts are still being made to assimilate indigenous cultures into the dominant culture's education system and the prevalent power politics. Indigenous peoples do not have sufficient rights to make decisions on their own issues, and in the main lack adequate funding for preserving their cultures and languages. They are engaged in a struggle against massive social pressures. The global economic crisis will not help their position but will make it even more difficult to meet demands for increased autonomy and for resources to promote their languages and culture. For indigenous peoples, climate change forms part of a large tangle of problems, caused by industrialised nations and the assimilation policies of nation states. As has often been said, the Arctic peoples will face their most difficult situation so far through climate change.

Securing the future of indigenous cultures in the Arctic regions will require significant reductions in emissions, wide-scale research into the effects of climate change on indigenous peoples, and methods of minimising the negative impacts of climate change. First and foremost, we need to find ways to secure the existence of their cultures.

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Protecting Cultural Heritage and Community Roots

Susan Barr
Senior Advisor in Polar Matters
Directorate for Cultural Heritage, Oslo, Norway

Abstract

Climate change is happening faster in the Arctic than in other regions of the world. This has a great impact on the tangible cultural heritage of the region, both directly and through the more indirect effect of greater accessibility to areas previously protected by sea ice hindrance. As a result concrete manifestations of international history can be lost and local communities can lose their tangible roots.

The cultural heritage sites of the Arctic are being rapidly degraded and destroyed through increased coastal erosion, melting of permafrost, increasing rot, rusting, fungal growth and mould. They are in addition at risk from the impacts of steadily increasing tourism. Thorough documentation of sites together with assessment of the threat level to each site is recommended. In addition an overview of Arctic sites of particular international value that will need special attention for their future management and protection should be prepared for UNESCO and the Arctic Council.

Introduction

It is a documented fact that the changes to the climate in the Arctic are more rapid and deep than in most other regions of the world. Several large international research programmes address this complex issue and have already presented results that show serious implications. For example, the project 'International Study of Arctic Change' (ISAC) takes its starting point in changes that already affect the lives of native populations and others who live in the circumpolar Arctic, including changes in fishery patterns, in vegetation growth and in shipping and transport (Arctic Ocean Sciences Board 2009).

A relatively spacious trappers' cabin from 1930 in northeast Greenland. It was totally destroyed c. 1995 by an unprecedented winter melt with resulting landslide (photo: Susan Barr in 1991).

Direct effects of climate change on cultural heritage

The changes that will affect cultural heritage are milder temperatures, increased and wetter precipitation, melting permafrost, more stormy weather and less sea ice. All these changes have great effects on the cultural heritage of the Arctic, both directly and through the more indirect effect of greater accessibility to areas previously protected by sea ice hindrance. International history can lose its concrete manifestations and local communities can lose their tangible roots (see International Polar Heritage Committee 2009).

The fixed (i.e. objects that cannot be removed to museums) cultural heritage of the Arctic consists of many types of remains of earlier human activities, both from indigenous populations and from other visiting cultures. Examples include various types of early Inuit dwellings, explorers' campsites, graves and memorials, wooden huts, early mining installations and shipwrecks. While previously often described as 'frozen in time', we now see that the milder, wetter climate is accelerating rotting, mould growth, rusting and disintegration of heritage sites.

Coastal erosion

The warmer ocean and the colder land meet at the coastal zone, and it is in the coastal zone in the Arctic that most human activity and settlement has occurred and still takes place. Cultural heritage and current activities are therefore deeply affected by major changes in the coastal zone, whether it be erosion or land gain. The lack of sea ice – in particular the ice foot attached to the shoreline – together with increased wind and wave effects, is seriously accelerating the erosion of shorelines with resulting loss of heritage sites. In fact it is erosion that is the main problem for cultural heritage protection around the entire Arctic region, as can be seen from such examples as the 1,200 year old native cemeteries at Nuvuk, Barrow, Alaska, and the late nineteenth century whaling stations at Herschel Island, Yukon, and early twentieth century explorers' sites in the Russian Arctic (e.g. Mys Flora, Franz Josef Land). During the ice free summer season, wave action can erode coastal zones up to several metres a year (in the area around Barrow, Alaska up to 30 m/year has been recorded), while the water-land interface during this period warms the newly exposed permafrost surfaces, thus accelerating the erosion process (see the Arctic Coastal Dynamics Project, Arctic Portal 2009). With summer and whole-year ice melting in the Arctic Basin, the coastal erosion will increase.

A tiny cabin in Svalbard slides down the erosion edge (photo: Urban Wråkberg).

Even the remotest sites are now on the tourist itinerary. Here in Franz Josef Land (photo: P.J. Capelotti).

No longer 'frozen in time'

In the early 1980s in the Norwegian Arctic archipelago of Svalbard, seventeenth century corpses were exhumed which still had skin and hair intact. Similarly from a graveyard in Alaska in the 1990s it was possible to extract lung tissue for virus analysis from victims of the huge 'Spanish 'flu' pandemic in 1918-19 which killed around 20 million people worldwide. The corpses had in effect in part been freeze-dried by the cold and dry climate, and in part preserved in the permafrost. A warmer, moister climate and a deeper 'active layer' which thaws each summer and freezes again each winter, will affect such burials as well as other historic organic matter.

More rust, rot, fungal growth and mould

These are also results of the diminishing natural freeze-dried conservation that was such an advantage of the traditional high Arctic climate. Wooden structures such as the small trappers' huts in Svalbard and Northeast Greenland were erected directly on the ground without, for example, stone foundations. Rotting has always occurred, but is now happening at a much faster rate. Discarded mining machinery from the beginning of the twentieth century in Svalbard and Alaska is rusting away at a previously unknown speed, and the spread of fungal growth and mould is making the occasional use of historic buildings unhealthy.

A bad case of mould and fungal growth in a protected building from 1957 in northeast Svalbard (photo: Susan Barr).

Indirect effects of climate change on cultural heritage

The Arctic has received much publicity in recent years, and together with the fact of retreating sea ice, this has led to an extremely rapid increase in the tourist industry. Heritage sites which were previously preserved by their inaccessibility are now being exploited, for better and for worse. Considering the attraction of heritage sites, local communities can and do use them as a source of new income. While this can greatly benefit a community, it can also compromise both the community and the heritage sites. Heritage sites lying far from any settlements can be seriously damaged by increased visitation.

There is a worry that increased summer temperatures in more southern regions will negatively affect tourism to heritage sites in areas that are dependent on the income from tourism for adequate site maintenance. In the polar regions the effect is the opposite, but may be negative in another way. Less sea ice opens the way for more tourism access, and cruise tourism to the Arctic can be said to have exploded during the past years. In Svalbard the number of persons put ashore at nature and cultural heritage sites from cruise ships during the short summer season increased from 25,000 in 1996 to 60,000 in 2008. This may not sound much compared to more accessible and warmer regions, but in the polar regions the effect can be that delicate sites with at best marginal, but still crucial, vegetation cover may be trampled by well-meaning, but still damaging, feet. Erosion may be accelerated and loose objects that have been protected for decades and centuries by snow and ice may be damaged or removed. Protection of these delicate sites demands great care and understanding from the cruise operators and local guides.

Knowledge gaps and action needs

In both the Arctic and Antarctic scientists are working to address the challenges mentioned above, which require multi-disciplinary research from both science and the humanities. Methods to save sites from destruction by erosion are sorely needed.

The effects on and mitigation of increased visitation on sites, including general wear and tear and the disturbance or removal of objects, needs to be better researched. Information concerning positive and negative effects of the exploitation of community heritage should be spread to potential new tourism areas. Management plans for particularly valuable sites must be developed and enforced. Tourist guides and communities must cooperate to the advantage of both tourists

One of the industrial monuments in Svalbard which will be affected by increasing rust and rot (photo: Susan Barr).

and communities. Methods to stagger erosion and climate degradation of heritage sites must be developed and applied. Heritage sites generally should be well documented in case of unavoidable loss.

Facing the challenges

So is the future only dark for cultural heritage in the Arctic, or is it possible with mitigation to prevent or alleviate the loss of cultural heritage?

The first step is obviously to recognise the challenges. Although we do not know whether the gloomiest scenarios will ever be fulfilled, we do see certain climate change effects happening right now. We can also imagine that certain effects might increase before the climate trend may turn again and lead us happily back to more 'normal' conditions. So, being better safe than sorry, there is no harm in taking mitigating actions right now against the worst-case scenarios of the future. Such actions may mean the difference between saving and losing important aspects of the cultural heritage through negative climate change impacts or – if the climate actually does not follow the doomsday prophecies – the actions will anyway greatly benefit cultural heritage in the future, climate change or not.

The testing of a new geosynthetic material for sandbagging coastal sites in danger of erosion (photo: SINTEF, Trondheim).

Some sites have to be given up, hopefully after thorough documentation. Barrow, Alaska (photo: Susan Barr).

A first important step is the documentation of sites of all types, large and small, together with a grading of the importance of the site and the potential danger of degradation and destruction. In cases where it seems fairly certain that climate change effects such as erosion will destroy the site within a limited time period, the inventory must conclude with either a complete documentation (with or without an archaeological survey as appropriate) of the site which ultimately will be lost, or measures to prevent or alleviate the erosion threat. Of the latter can be mentioned breakwater or erosion barriers of stone, wood or other materials, or even moving the heritage structure further inland where this may be feasible. Unfortunately some important sites will be impossible to save, but the information from a thorough documentation will still allow the heritage to live on for research, education and in some cases reconstruction purposes. This is a problem and solution challenge which applies to many other regions of the world too and where information exchange on mitigation ideas can be beneficial.

Increased fungal and bacterial growth on organic materials at heritage sites is not a new phenomenon for Arctic sites, but is a phenomenon which is increasing from a relatively marginal conservation issue to become a major challenge. Happily, innovative scientific work is addressing this issue now, and scientists familiar with

A locomotive used for coal transport in Ny-Ålesund, Svalbard from the 1920s. It was restored in the 1980s and is now suddenly rusting dangerously (photo: Susan Barr).

the problem either in the Arctic or the Antarctic are getting together to compare the problems in both regions and discuss solutions. The cooperation on research and mitigation between Arctic and Antarctic scientists is increasing and producing results applicable for both regions. The same applies to research on increased chemical reactions caused by chlorines and other salts in the wind-blown spray and increasing rainfall at Arctic (and Antarctic) heritage sites.

Over climate boundaries

Because of the early-warning effect the more pronounced climate changes in the Arctic can give to the rest of the world, a large amount of research and data collection is already available on the subject. Similarly, because the climate changes are already affecting heritage sites in both the Arctic and Antarctic, scientists have been addressing the challenges for the past few years. Many of the increasing problems are common for other regions of the world too, and it should therefore be fruitful for scientists involved in climate change and heritage projects to work together over regional and climatic zones.

Conclusions

Authorities in all the Arctic areas should work to ensure the development of a comprehensive inventory of all cultural heritage sites in their region, together with an assessment of the current condition, maintenance needs and the level of degradation or destruction threat to each site (immediate, mid-term and long-term).

An international assessment of significant heritage sites around the Arctic should be prepared in order to present an overview to UNESCO and the Arctic Council of sites of particular international value that need special attention paid in the future to management and protection. This would be a cultural heritage equivalent to CAFF's (Conservation of Arctic Flora and Fauna) Arctic Biodiversity Assessment project.

A concentrated, international and multi-disciplinary programme should be initiated to address the challenge of the increasing erosion of coastal cultural heritage sites.

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Section 4

HEALTH AND WELL-BEING

Sustainable Development, Climate Change and Human Health in the Arctic

Alan J. Parkinson
US Centers for Disease Control & Prevention (CDC),
Arctic Investigations Program, Anchorage, Alaska

Abstract

Indigenous populations resident in the Arctic are uniquely vulnerable to climate change because of their close relationship with, and dependence on, the land, sea and natural resources for their cultural, social, economic and physical well-being. Climate change will affect sustainable development of Arctic communities through its impact on sanitation and water infrastructure, food supply, transportation infrastructures and the prevalence of infectious diseases. Without addressing these basic public health needs, Arctic communities are not sustainable. Given the importance of human health to the maintenance and advancement of sustainable development in the Arctic and the threat of climate change to human health, it is recommended that UNESCO encourage the Arctic Council and the World Health Organization to take action on the human health recommendations put forward by Chapter 15 of the Arctic Climate Impact Assessment, and the United Nations recommendations in the Russian Federation report on Climate Change Impact on Human Health in the Russian Arctic.

The statements and positions contained in this report represent the proceedings of the UNESCO meeting and are those of the author and do not necessarily represent the official position of CDC.

Several coastal villages of western Alaska are facing evacuation due to rising temperatures, which are causing a reduction in protective shoreline sea ice, and increased thawing of permafrost along the coast. This has dramatic health impacts for the population (photo: Nome Nugget Newspaper).

The Arctic, like most other parts of the world, has warmed substantially over the last few decades. The warming trend is projected to continue and may lead to significant economic and cultural upheaval particularly for the indigenous peoples of the Arctic (ACIA 2005). Resident indigenous populations of the Arctic are uniquely vulnerable to climate change because of their close relationship with, and dependence on, the land, sea and natural resources for their cultural, social, economic and physical well-being. Climate change will affect sustainable development of these communities through its impact on the sanitation and water infrastructure, food supply, transportation infrastructures and the prevalence of infectious diseases. Without addressing these basic public health needs, Arctic communities are not sustainable.

While the health of Arctic populations has greatly improved over the last 50 years, life expectancy and infant mortality are higher in indigenous Arctic residents in the US Arctic, northern Canada, Greenland and the Russian Federation than in Arctic residents of Nordic countries (Hild 2004). The rapid pace of change within the Arctic also presents new challenges to the health and well-being of Arctic residents that will require additional health research (Curtis et al. 2005). For example,

On the coast of western Alaska, village homes, ice cellars, water systems and infrastructures are being undermined by the sea, threatening the health of village residents (photo: Nome Nugget Newspaper).

in many Arctic regions living conditions changed and continue to change from an economy based on subsistence hunting and gathering to a cash-based economy. Across the circumpolar north there is increasing activity towards sustainable development via local resource development and widening involvement in the global economy. Such changes have had many positive influences on the physical health of Arctic residents, including improved housing conditions, stable supply of food, increased access to Western goods and decreases in morbidity and mortality from infectious diseases. But these changes in lifestyle have also led to an increase in the prevalence of chronic diseases such as diabetes, hypertension, obesity and cardiovascular diseases. In addition, increasing rates of child abuse, alcohol abuse, drug abuse, domestic violence, suicide and unintentional injury are also associated with the rapid cultural change, loss of cultural identity and low self esteem in these populations (Bjerregaard 2004; Curtis et al. 2004; Hild 2004).

Similarly, globalisation of the Arctic economy was accompanied by improvements in the Arctic's transportation infrastructure. Many communities that were once isolated are now linked to major cities by air transportation. Consequently, these communities are now vulnerable to many infectious diseases (influenza, SARS-like infectious diseases, antibiotic resistant pathogens such as multi-drug resistant tuberculosis) commonly found in more densely populated urban centres (Butler et al. 1999).

Environmental contaminants are a global problem. Contaminants such as mercury, other heavy metals, PCBs, DDT, dioxins and other organochlorines originate primarily in the mid latitude industrial and agricultural areas of the globe but are concentrated in the Arctic via atmospheric, river and ocean transport. Their subsequent bio-magnification in the Arctic food webs and appearance in subsistence food, and the indigenous people who rely on these foods, is of great concern to Arctic residents. Potential human health effects include damage to the developing brain, endocrine and immune system. A new concern is the role of mercury on cardiovascular diseases. Research is needed to identify the levels and human health effects of these contaminants in Arctic residents, particularly the very young, and to provide guidance on both the risks and benefits of consuming traditional food (AMAP 2002).

Climate change is already affecting many Arctic rural communities, and is bringing economic and health threats, as well as possible opportunities. The impacts of climate change on the health of Arctic residents will vary depending on factors such as age, socioeconomic status, lifestyle, culture, location and capacity of the local health infrastructure systems to adapt. It is likely that the most vulnerable will be those living close to the land in remote communities, those already facing health related changes (Berner 2005).

Direct health threats from climate change include morbidity and mortality resulting from increasing extreme events (storms, floods, increased heat and cold) and an increased incidence of injury and mortality associated with unpredictable ice and storm conditions. Indirect effects include increased mental and social stress related to changes in environment and loss of traditional lifestyle, changes in bacterial and viral diseases, and altered access to quality water sources. Some regions will be at risk from increasing illness due to failing sanitation infrastructure resulting from changes in permafrost and storm surges. Some regions will also experience changes in diet resulting from changes in subsistence species distribution and accessibility. This may have negative impacts on health as diet shifts from a traditional diet to a more Western diet associated with increases in 'modern diseases' such as obesity, diabetes, cardiovascular disease and cancer. Projected warming will affect the transport, distribution and behavior of contaminants, impacting human exposure in northern regions and further threatening the safety of the traditional food supply. These changes are taking place in the context of ongoing cultural and socioeconomic changes. Climate change represents another of many sources of stress on these northern societies and cultures as it affects the relationship between the people and the land and environment, which will further stress community and individual psychosocial health.

The potential impact of climate change on human health will differ from place to place depending on regional differences in climate alterations as well as variations in health status and adaptive capacity of different populations. Rural Arctic residents in small isolated communities, with fragile support systems, little infrastructure and marginal to non-existent public health systems may be the most vulnerable. People who depend on subsistence hunting and fishing will be vulnerable to changes that affect targeted species. Climate stress and shifting animal populations may create conditions for the spread of certain infectious diseases from animals to humans.

The Arctic Climate Impact Assessment (ACIA) was published in 2005 and was the first comprehensive scientific assessment of climate change in the Arctic (ACIA 2005). The ACIA provides recommendations for communities, researchers and policy makers to begin to address human health challenges posed by climate change (Berner 2005). The main conclusions of the assessment on health impacts of climate change were that: 1) much research remains to be done on the relationship between climate change and individual and community health, 2) climate will continue to influence public health in small and remote communities of the Arctic and 3) there is an urgent need for adopting community-based monitoring strategies that would identify both emerging threats and opportunities, for example there may be increased availability of funding for infrastructure improvements.

Further, the ACIA outlines a number of gaps in knowledge and need for action. For example there is a lack of comparability in health status data between countries. This calls for the creation of a core set of health indicators that can be gathered and defined similarly. There is a need for a carefully planned strategy at the community and regional levels to monitor and document environmental change. There is a lack of organised effort to collect and utilise indigenous knowledge regarding climate and climate changes. There are few data on climate change and its impact on regional biota. There is a need to monitor wildlife diseases and human-animal interactions. There are few data on climate induced changes in the diets of subsistence species, which affect their nutritional value in traditional diets.

There is no systematic monitoring in all regions for snow and ice conditions for local and regional travel necessary for subsistence activities. Monitoring is critical in regions of the Arctic where physical infrastructure depends on permafrost or where a village site depends on sea ice protection from storm erosion. Data on contaminant transport into and out of the Arctic is critical for projecting impacts and risks for Arctic wildlife and residents. A changing climate makes monitoring essential.

An international workshop was held in Anchorage, Alaska (13-15 February 2008), to 1) update current knowledge on the impact of climate change on human health, 2) reexamine the principal conclusions and recommendations of the ACIA on human health to determine potential items for action, and 3) examine the feasibility of implementing community-based monitoring strategies within and across regions to measure a common set of climate, health status, environmental infrastructure and ecosystem indicators (Parkinson 2009). The workshop reaffirmed the principal conclusions of the ACIA report on actions required to address the impact of climate change and human health, and outlined the essential elements needed to establish a community-based monitoring strategy. These included:

1. The identification of communities and segments of the population at greatest risk. These should be targeted for assessment of existing or potential health risks, vulnerabilities, and engagement in the design of community-based monitoring and formulation of intervention and adaptation strategies.
2. Identification of community leaders or project managers. In Alaska, communities have access to training in emergency preparedness and implementation of the Incident Command System for managing community emergencies. This system could be utilised for the management of incidents related to climate change (e.g. village evacuation, unsafe ice conditions, threats to the sanitation infrastructure).
3. Evaluation of existing capacity, resources, motivation and infrastructure needed to establish a community-based monitoring system.
4. Identification and creation of regional partnerships. Linkage with and engagement of appropriate tribal, public health and wildlife agencies, non-governmental organisations and universities engaged in climate change activities and research are important as potential funding sources and to ensure local, regional, national and international coordination of monitoring, research and prevention and control activities.
5. Identification, selection and monitoring of basic indicators for climate change and community health. The selection of indicators specific to sites or villages should be guided by local concerns.

6. Expansion of community-based monitoring systems to include other communities both regionally and internationally. Linkage of community-based monitoring systems to include other communities is important for the detection of trends in climate and health impacts over larger geographic regions. This should include sharing standardised protocols for monitoring climate change community health indicators.
7. Develop contingency plans, communication networks, education programmes and early warning systems. These would include, for example, village evacuation contingencies, posting of dangerous ice or weather conditions, alternate travel routes, alternate food sources, food storage/preservation methods and alternate water sources.

An international workshop sponsored by the United Nations in the Russian Federation, was held in Moscow, 23-24 April 2008, to assess the 'Impact of Global Climate Change on Human Health in the Russian Arctic' (United Nations in Russia 2008). The workshop proposed the following major goals to reduce the impact of climate change on human health in the Russian Arctic:

1. Support and enhance assessments of regional climate change in the Russian Arctic, including environmental and social community monitoring involving indigenous peoples;
2. Develop regional scenarios for the Russian Arctic based on global models of climate change;
3. Enhance efforts to determine the health status of the inhabitants of the Russian Arctic including indigenous peoples;
4. Develop preventive programmes to minimise the adverse consequences of climate change;
5. Strengthen government health surveillance systems in Arctic communities that are vulnerable to climate change;
6. Develop recommendations and action plans to protect the population against the consequences of emergencies associated with climate change (natural disasters, extreme weather, infectious disease outbreaks);
7. Train health care experts in various fields (including universities and regional institutes) concerning the impacts of climate change on human health;
8. Raise awareness among federal and regional officials about the impacts of climate change;
9. Expand basic and applied research on the impact of climate change on human health in the Arctic;
10. Expand international cooperation to assess the impact of climate change on human health in the Arctic using the capacity of individual countries,

the Arctic Council, the Arctic Forum, The European Commission, United Nations programmes and agencies of the World Bank;

11. Assess the effectiveness and adequacy of existing federal and regional systems of sanitary epidemiological monitoring and epidemiological emergency response in the context of climate change, and develop recommendations for their improvement.

Given the importance of human health to the maintenance and advancement of sustainable development in the Arctic, and the threat of climate change to human health, it is recommended that UNESCO encourage the Arctic Council and the World Health Organisation to take action on the human health recommendations put forward by Chapter 15 of the ACIA, and the United Nations in the Russian Federation report 'Impact of Global Climate Change on Human Health in the Russian Arctic'.

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Indigenous Peoples of the Russian North: Social and Climatic Changes

Larisa Abryutina
Vice-President on Health Issues,
Russian Association of Indigenous Peoples of the North (RAIPON)

Abstract

The Russian North is home to forty small ethnic groups of peoples who have maintained the traditional lifestyle. Many different kinds of external impacts have brought positive and negative transformations to these aboriginal communities. Among other issues, the Russian market reforms worsened the existing problems of aboriginal peoples, traditional lifestyles have decreased, aboriginal peoples have migrated from their traditional areas to urban centres, and there is high unemployment. Industrial pollution of the environment and climate change represent additional threats. To escape from these threats by migrating to other territories or by practicing other forms of livelihood, as used to be done in the past, is not possible anymore. The result of these complex issues is the deterioration of physical, psychological and spiritual health.

Forty ethnic groups, who are officially classed as 'small indigenous groups of the North, Siberia and the Far East', live in the Russian North, in twenty-eight regions of the federation. The total population of these peoples is estimated to be around 200,000. The populations of these groups vary, from eight Kereks to 42,000 Nenets. Eleven of these aboriginal groups live in the Russian Arctic. Eighty per cent of Arctic aboriginal people are village inhabitants, living in very small communities on the tundra. The aboriginal peoples of the North have different origins, but they also have many similarities, which are defined by the extreme environment, long

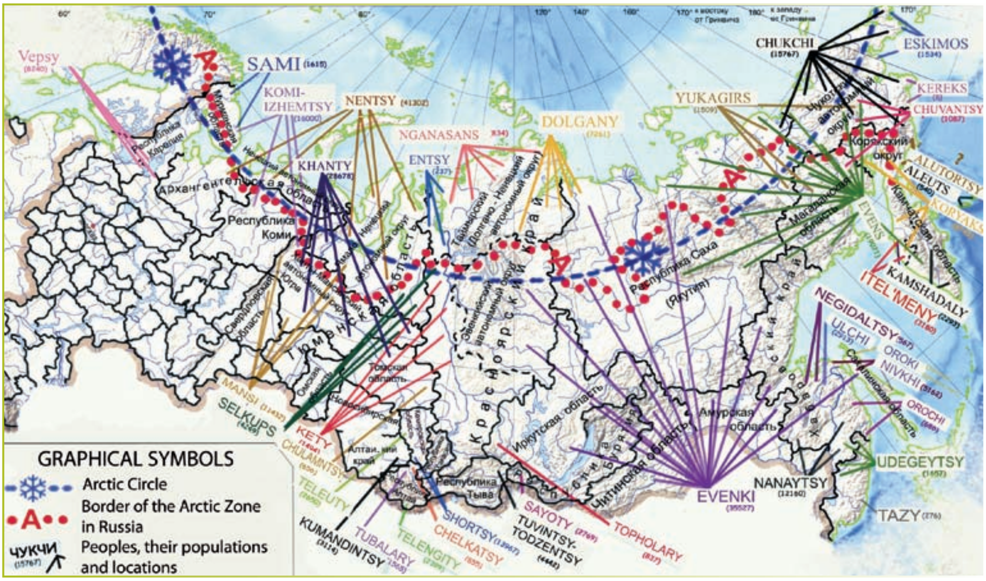

Figure 1. The Arctic zone and indigenous peoples of the North in Russia.

isolation from other peoples, the complexities of integration into other cultures, migratory mobility and specific forms of worldview and economic activities.

It is widely known that the encounters of indigenous peoples with more powerful cultures are not painless. The situation with indigenous peoples of the Russian North is no exception. The particular Russian and Soviet approach was to consider aboriginal peoples as the most archaic and vulnerable population groups, and the measures that were taken against them by the state were the most radical and totalitarian due to the state's ideology. Progressive human measures (education development, improved health system, improved living conditions, etc.) were combined with badly formed and repressive measures (transformation of way of life and land use, expropriation of property, isolation of children in boarding schools, etc). These measures overcame the adaptive capabilities of indigenous peoples of the North and resulted in ambiguous outcomes: the destruction of cultural continuity between generations, the loss of cultural values and the decrease of traditional activities, which were combined with full employment in *sovkhoz* (state-owned farms) and the improvement of the health system. However, the market reforms of the 1990s weakened the successes of the Soviet Period and thus worsened a latent crisis. Economic activity collapsed, and yet reindeer breeding – the basis of traditional activity – had been reduced.

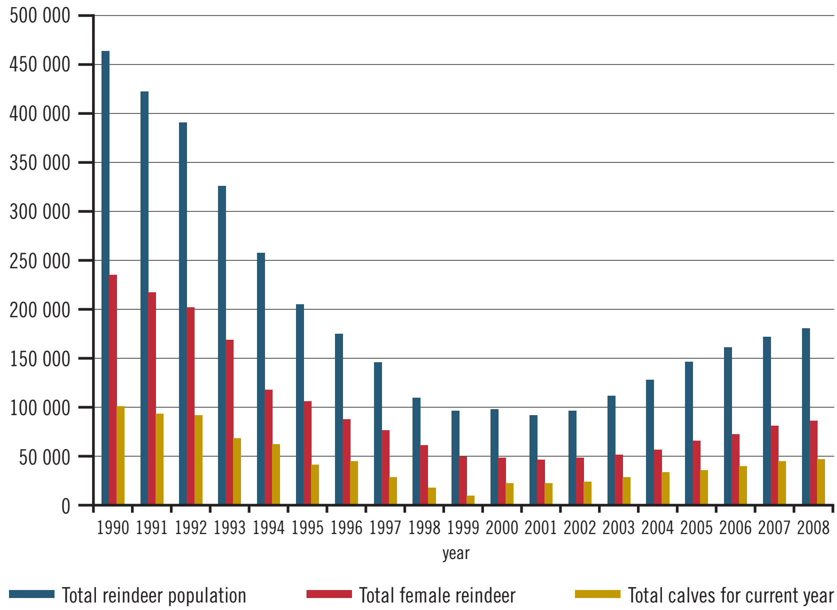

Figure 2a. Reindeer population dynamics in Chukotka, Russian Federation (Courtesy of Government of Chukotka 2009).

In certain northern regions reindeer breeding was greatly weakened. For example, in the Ayano-Maysky area of the Khabarovsk Region the number of reindeer livestock became twenty-three times smaller during the period between 1990 and 2002 (Independent Institute of Social Politics 2009). The actual crisis of reindeer breeding is more serious and more long-term than the crisis which happened after the soviet collectivisation, and the support measures for reindeer breeding are smaller. This is due not to the systemic problems of the country's economy, but to the changes in state politics and strategy for exploring the North (Klokov 2004:11-12). With the exception of the marine hunting industry, the decline also happened in other branches of the economy – hunting, fisheries, breeding animals for furs and fur processing.

Significant harm is caused to indigenous peoples of the North by industrial companies as they exploit natural resources, the location of which often coincides with the areas used for the traditional lifestyles and economic activities of aboriginal peoples. According to official data, of 332.1 million hectares of reindeer pastures, 40 per cent are degraded and out of use due to industrial impacts (Novikova 2008:283). The consequence of the reindeer herding crisis, and crises in other

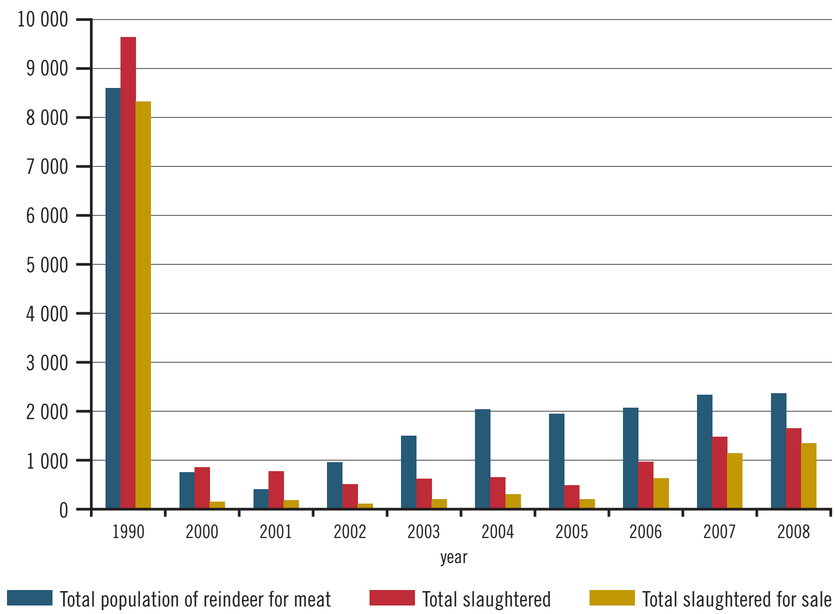

Figure 2b. Reindeer production dynamics in Chukotka, Russian Federation (Courtesy of Government of Chukotka 2009).

branches of the economy, is massive unemployment, in general within the male population, who normally financially support the well-being of the family. A rapid and radical shift of gender roles has thus occurred, and one of the consequences of that shift is an increase in alcoholism (Pelyasov 2006).

Another negative influence of industrial activity in the North is pollution of the environment, and therefore of traditional food, which remains vital for survival and for the preservation of unique cultural identities. The contamination of the environment, in particular by high concentrations of artificial radionuclides, positively correlates with the incidence of stillbirths, and the frequency of cataracts, psychological disturbances and mental problems (Naroditskiy 1995).

A project on persistent toxic substances, food security and indigenous peoples of the Russian North revealed that in certain regions of the Arctic, the environment, habitat and traditional food have become dangerous for aboriginal peoples, in particular for those groups living in the coastal regions who practice fishing and marine mammal hunting. In many cases the concentration of certain highly toxic substances exceeds the recommended WHO limits, causing human reproduction

Ethnic group	Percentage unemployed	Ethnic group	Percentage unemployed
Chuvancy	7.5	Nanaicy	15.4
Kety	8.5	Eskimos	15.5
Yukagiry	8.5	Nivkhy	15.8
Nenets	8.9	Tuvin-Todjin	15.9
Aleut	9.2	Ul'ta (Orok)	16.4
Dolgan	10.0	Shortsy	16.4
Teleut	10.3	Selkup	17.1
Tubolar	10.3	Ulchi	17.1
Orochi	12.0	Udege	17.5
Khanty	12.4	Sami	18.3
Evenk	12.5	Tofolar	19.0
Kumandincy	12.8	Entsy	19.9
Even	13.0	Nganasan	21.3
Chelkancy	13.3	Koryak	24.3
Chukchi	15.0	Itelmen	25.2
Mansi	15.2	**Average for 32 groups**	**14.7**
Negidalcy	15.2	**Average for Russia**	**7.4**

Table 1. Percentage of population unemployed by ethnic group (using data from the All-Russian census of 2002).

and foetus development to be compromised. In the women's group under observation in the study four cases of births with serious abnormalities and six cases of stillbirths were noted. The blood of these women held concentrations of polychlorinated biphenyl (PCB) and dichloro-diphenyl-trichloroethane (DDT) that were twice as high as concentrations in the blood of other women under observation (AMAP 2004:58-59).

It is known that the main causes of pollution are both long-distance and local sources of toxic elements. In the local context the pollutants take the form of thousands of empty metal drums, pesticides, radioisotope thermoelectric generators from lighthouses, and scrap metals abandoned by industry and the military. Waste burial sites remain in the permafrost, and with the permafrost thawing, the danger from this waste increases.

Consequently, the aboriginal peoples of the North are torn between two dangers. On one hand there is the threat from traditional food contaminated by persistent toxic substances, and on the other, the threat of imported food products, which often are of bad quality, are past their expiry dates and do not correspond to the genetically determined biochemical nutritional requirements of Arctic and Subarctic aboriginal peoples. Unfortunately, the medical, educational and administrative staff in the regions are poorly informed of these locally specific issues, and in practice do not attend to them. In particular, while determining the nutritional content of diets in childcare institutions, there is no account taken of the congenital alactasia (lack of the enzyme needed to digest the milk sugar lactose) that is inherent to the aboriginal peoples of the North (Kozlov and Vershubskaya 1999:157-161).

The main result of all these problems is the depopulation of the North by the aborigines, with the loss of the unique northern gene pool and circumpolar indigenous culture. One of the most important aspects of that issue is the decrease in the levels of health among aboriginal peoples due to disturbances in ethnic norms – biological, functional and cultural (Manchuk 2008:131-132). The biggest medical and demographic problem is the high death rate of northern aboriginal peoples and their low life expectancy.

	Peoples of the North			Entire population of Russia		
	1978-79	1988-89	1998-2002	1978-79	1988-89	1998-2002
Both genders	49.1	59.4	54.8	67.7	69.3	65.7
Males	44.3	54.0	49.1	61.7	64.5	59.6
Females	54.1	65.0	60.5	73.1	74.4	72.4

Table 2. Life expectancy (years) (from Bogoyavlenskiy 2008).

	Livebirths	Deaths	Nat. incr.	Infant mort.*
1984-1988	30.2	10.5	19.7	41.1
1989-1993	25.7	10.8	14.8	30.4
1994-1998	19.8	12.6	7.2	32.5
1999-2002	17.6	11.7	5.9	27.6

Table 3. Demography of peoples of the Russian North (as per population of 1000) (from Bogoyavlenskiy 2008). * (per 1000 live births)

The suicide rate within small northern indigenous groups during the period from 1998 to 2002 was more than 100 per 100,000 people (in Russia as a whole it was 38 per 100,000), and the homicide rate was 70 per 100,000 (in Russia it was 27). The death rate from infectious diseases, in particular from tuberculosis, among aboriginal peoples was 60 per 100,000 (in Russia it was 23). This is a shocking indicator of aboriginal health at the beginning of twentieth century (Bogoyavlenskiy 2008:14-16).

The state constantly engages with northern aboriginal issues, but nevertheless, the measures undertaken do not give tangible effects in regulating socio-economic problems for various reasons. This inefficiency is also characteristic of the health system for northern peoples – the levels of poor health do not indicate that adequate practical measures have been taken. This is due to vertical and horizontal compartmentalisation of the health system, which does not allow single coordinated actions to take place on a scale covering the entire North. Other flaws of the health system include the decrease in primary health care, and the cultural distance between healthcare workers (in general non-aboriginal peoples) and the local population's specific cultural nuances and traditional knowledge.

It is clear that the declarations of intentions, significant financial outlay and practical steps so far taken are inadequate for solving the problems of Russia's northern aboriginal peoples. Meanwhile, northern aboriginal peoples, along with rest of the world, face the issue of climate change, which will have dramatic consequences in the Arctic region.

Many northern aboriginal peoples have experienced changes in the environment and they do express their concerns. However, these are not loud declarations and they are not 'scientific' statements. Often they take the form of the exchange of observations and testimonies of the effects which impact daily life and livelihoods.

Often these testimonies are the following:

¬ An increase in ice covered ground, which negatively impacts the reindeer herd, in particular during the calving period;

¬ Frequent changes in wind; blizzards and rain storms occurring at 'unusual' times;

¬ Disturbances in the usual periods and quantity of precipitation, in particular snow falls, which affect the depth of snow cover. The depth of snow affects opportunities for moving across the tundra, and feeding for reindeer. Deep snow also impacts on opportunities for hunting wild animals;

¬ In the northern regions bushes and trees are growing more intensely. The reindeer herders are concerned by the forestation of the tundra.

¬ Appearance of new animals, birds and insects species. Last autumn during my visit to the reindeer herd in the Magadan Region, I was told by the reindeer herders of the appearance of caterpillars on bushes which were not seen before. They represent a threat of new diseases for the reindeer;

¬ Timings and patterns of bird migrations have changed;

¬ Thickness of ice on lakes has changed. Last winter I visited reindeer herders in the Murmansk Region. During the crossing of the lake our snowmobile fell through the ice and sank. During a visit to reindeer herders of the Republic of Komi, I was told that the spring nomadic route on the coast of the Arctic Ocean, along river ice, is becoming more dangerous every year, as the ice breaks and the reindeer die. In Chukotka the marine mammal hunters told me that hunting pinnipeds has become dangerous, as the edge of the ice is thinner and fragile;

¬ The walrus rookery had decreased and has moved, their migration has changed, and the number of marine animals has decreased, as has their fat content. According to indigenous peoples the meat of marine mammals, including whales, tastes and smells bad;

¬ Reindeer herders and hunters complain about the increased frequency of fires;

¬ Coasts have begun to erode, which threatens to displace some of the population.

Notwithstanding the facts above highlighted by aboriginal peoples, other issues exacerbate the consequences of climate change. Some of these will be given here:

¬ During the post-Soviet transformations, the number of meteorological and observational stations decreased, in particular at outposts in far northern regions. It is clear that this damaged the observation and monitoring system for weather and climate changes and hindered early warning of the population;

¬ Similar damage was done by the decrease in the forest guard's aviation service, reducing their ability to detect and extinguish fires in the forest and tundra;

¬ In northern village areas medical assistance, local ambulances and mobile medical groups were reduced. These could have provided the medical care to combat the early health effects of climate change;

¬ The knowledge and information held by aboriginal communities (traditional and modern) do not receive proper attention and research;

¬ The results of research investigations are not taken into account during the elaboration of development programmes for northern aboriginal peoples;

¬ In the sustainable development programmes aimed at aboriginal peoples, little attention is given to climate change, or the possible extinction of traditional occupations;

¬ Predictive scenarios of climate change are needed that take into account human behaviour. Aboriginal peoples, especially those who lead a traditional way of life, are not informed of anything, including recommendations and instructions for adaptation plans, information on already ongoing environmental and climate changes, threats from new diseases, etc;

¬ Relationships between state related institutions and local populations are not built on a basis of real partnership.

Climate changes have occurred in the past in the Arctic, and aboriginal peoples have overcome them and adapted to new conditions. They had to learn new types of traditional activities or migrate to new territories. Apparently, historic climate change was one of the drivers behind the migrations of the ancestors of Arctic aboriginal peoples (Burykin and Sharina 2001). Under current conditions, however, regarding industrial pollutants and climate change, aboriginal peoples are not able to adapt in the same ways as their ancestors. The Arctic is vast, yet there are no options for escaping to new territories. Why?

First of all, many aboriginal peoples now remain in a state of hopelessness and confusion. Secondly, there is nowhere to go: the lands and lakes have been destroyed and contaminated by industrial and household wastes, and the populations of animals and birds have catastrophically decreased, in particular due to massive poaching. Thirdly, fishing, hunting, reindeer herding and other possibilities for self-sufficiency are complicated by laws and other administrative impediments.

The most convenient 'solution' supported by the government is the displacement of aboriginal peoples from traditional spheres of life and economic activity, moving them into inhabited areas, and thus giving them the opportunity to receive unemployment benefits or to become workers in modern industries. This is a painful process for northern aboriginal peoples. For the material and spiritual culture of the West the dynamics of constantly increasing economic activity are a normal feature. However, for northern indigenous peoples the appropriative economic activity is characteristically subsistence, without aiming for profit or increased productivity. In traditional economic activities reside the life and the future of the peoples of the North (Burykin and Sharina 2001). With the destruction of this way of life certain aboriginal peoples will disappear. This is already a reality.

The conclusion is that the indigenous population of the Russian Arctic is not protected from the physical impacts of climate change. They are already confronting economic, social and domestic problems, and will be impacted by the worsening of these existing crises.

How can these threats be mitigated? Clearly, measures are needed to decrease the destruction and pollution of the Arctic environment, to regulate the use of northern marine space, to detect early signs of climate change, and to revitalise meteorological observing stations and aviation surveys. It is essential in sustainable development programmes for northern aboriginal peoples that all causes of the current crisis, including climate threats, are taken into account. Adequate measures are needed in health care, particularly in terms of access (i.e. medical services should be located directly in the actual areas of traditional residence), and health care should take into account traditional knowledge.

Our organisation aims to implement the realisation of these goals. Nevertheless, there is a need for projects and the implementation of these can occur through community organisations. With partnerships with scientific organisations we could instigate a project on aboriginal health and its relationship to climate change. Based on the information collected, there would be the opportunity for various scientific analyses and the elaboration of informative materials and recommendations.

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The Socio-Economic Impacts of Climate Change and Sustainable Development in Canada's Northern Communities

Chris Southcott
Professor, Lakehead University, Canada
Research Associate, Yukon College, Canada
Chair, Research Outreach Program Team, University of the Arctic, Canada

Abstract

Climate change is currently having an impact on the socio-economic development of Canada's northern communities and impacts are likely to increase in the future. Compared to research in the natural sciences, the current level of social science research does not allow us to be very specific about what these impacts will be. Reasons for this relative lack of knowledge vary but one of the most important is that effects introduced by climate change are part of a large number of transformations that are occurring in these communities. Researchers and communities are often forced to devote limited resources to other social and economic problems. This does not mean that social scientists cannot be useful in assisting these communities to ensure their sustainable development in the face of climate change. A consensus exists that greater community empowerment and capacity-building is the most sensible long-term solution to potential climate change impacts.

Introduction

There is a widely accepted belief that climate change will have important socio-economic impacts on the sustainable development of Arctic communities. At the same time if we examine the specific situation of communities in Canada's North, the current level of research on the issue does not allow us to be very specific or very confident about what these impacts will be. What research that does exist notes effects such as increased access to natural resources and transportation routes, deterioration of communities' infrastructure and regional transportation routes, negative effects on traditional food harvesting and its cultural and health implications, and the increased occurrence of extreme events. While research on this topic has been increasing over the past few years, it remains true that knowledge about the socio-economic impacts of climate change is less developed than that of the physical sciences.

There are a variety of reasons for this, such as fewer research projects on the issue being funded, and the great deal of complexity surrounding the issue due to a large degree of local variation in climate change impacts and the adaptive response of communities. One of the most important reasons however, is that the effects introduced by climate change are part of a large number of changes that are occurring in these communities. When forced to prioritise due to limited resources both researchers and communities often devote their attentions to other more pressing social and economic problems. Few societies have undergone social and economic transformations with the rapidity that communities in Canada's North have over the past fifty years. These changes have introduced a great deal of stress accompanied by a range of social and economic problems. Climate change is adding to these challenges but its impacts are often hidden behind other issues.

This does not mean that the social sciences cannot be of assistance in developing answers to the potential negative impacts of climate change on northern communities. While more precise solutions will emerge as further social research is done in the region, given the current relative lack of knowledge about the social impacts of climate change the most effective solution available to us is to give northern communities more control over their social and economic development. For thousands of years these communities have shown they have the ability to deal with change. The increased variability that accompanies climate change means these communities require increased capacity to deal with these changes. This is especially important since impacts will vary by region. The best way to prepare northern communities for the impacts of climate change is to increase their ability to access human, social and physical capital.

Socio-economic impacts of climate change in northern Canada

There is no official definition of northern Canada. Some definitions include large northern areas of the Canadian provinces while others restrict the region to the three northern territories of Nunavut, the Northwest Territories and the Yukon. For the purposes of this paper we will refer to the Canadian North as including the three territories as well as Labrador and the Nunavik region of Quebec. This region is made up of 114 communities.(1) Of these communities only two have a population exceeding 15,000 (Statistics Canada 2006). Whitehorse is the largest community, with 20,461, followed by Yellowknife with 18,700. All of the remaining communities have less than 10,000 people. Over 34 per cent of the inhabitants of the region live in communities of less than 1,000. Of the 114 communities, 90 have populations where over 50 per cent have identified themselves as being aboriginal. A total of 78 have over 80 per cent of their population listing themselves as aboriginal. The non-aboriginal population tends to be clustered in the larger communities. The region tends to have lower levels of formal education. The population of northern Canada is the youngest in the country. In the three territories one person in four is under 15 years of age and one person in twenty is over 65 (Statistics Canada 2007:27).

Historically the North has been characterised by two types of communities: resource-dependent communities dominated by settler societies and indigenous communities characterised by a mixed economy where traditional harvesting remains important (Southcott 2003). Increasingly however a third type of community is developing based on a service sector economy (Bone 2009). These are typically the largest communities in the region. The region has experienced extensive socio-economic change over the past 50 years. Communities have moved from an economy based almost entirely on subsistence hunting and fishing, to an economy dominated by the industrial exploitation of natural resources, to an uncertain future in a world increasingly dominated by a knowledge-based post-industrial culture. As we will see later on, the stress introduced by these changes has had a profound influence on the relative importance placed on climate change by these communities.

Most research looking at the socio-economic impacts of climate change has noted that knowledge about these issues is less developed than knowledge about the impacts of climate change on the physical environment. One of the first reviews

(1) This number comes from Statistics Canada's division of the region into 'census sub-divisions' for the 2006 Census based on concentrated population centres. This total excludes general 'unorganised areas'.

Boats near Inuvik, Northwest Territories, Canada (photo: Chris Southcott).

of the subject was done in a report for the Northern Climate Exchange in 2000. At that time it was noted that 'There is fairly good information on the impacts of climate change on physical processes (such as permafrost); fair information for biological systems (i.e. community ecology) and less information for socio-economic systems…' (Northern Climate Exchange 2000:10). In 2004 Duerden noted that while physical evidence of climate change at high latitudes is now overwhelming, 'uncertainty best characterises our current level of knowledge about its impact on human activities' (Duerden 2004:204).

Ford et al. (2007) note that while the importance of climate changes are well recognised, research on how to help communities adapt to these changes is surprisingly absent. The Arctic Climate Impact Assessment (ACIA 2005:150), '…highlights our limited understanding of the vulnerability of Arctic communities and contains little substantive discussion of adaptation policy'. The recent update of the ACIA commissioned by the WWF International Arctic Programme underlines that in regards to the human dimensions of climate change impacts 'profound uncertainties remain' (Loring 2008:91).

While research on the socio-economic impacts of climate change on northern communities is limited, it has been growing over the past 10 years. The literature review done by the Northern Climate Exchange in 2000 noted research dealing

Landscape near Iqaluit, Nunavut (photo: Chris Southcott).

with impacts on the structural integrity of buildings, changes in the economic bases of communities, impacts on traditional harvesting and transportation, and increased extreme events such as flooding, erosion in coastal communities, forest fires and landslides. Duerden (2004) notes a series of studies on specific sectors of the regional economy which point to increased access to oil and gas reserves, the expansion of northern agriculture, and changes in forest resources. In Canada a great deal of writing has been devoted to the potential impacts of climate change on increased shipping and the fact that the possible opening up of the Northwest Passage to commercial traffic has the potential to transform these communities in a variety of ways.[2]

While the extent of research on many of the above potential impacts is largely limited to conjecture, there has been an increasingly reliable amount of research done in recent years indicating that climate change is having a significant impact on traditional harvesting activities. This was noted in the 'Inuit Observation of Climate Change' Project undertaken in 1999 and 2000 at Sachs Harbour in the Northwest Territories. Local inhabitants stated that climate change was having its greatest impact on traditional activities such as hunting, fishing, travelling on

(2) While most discussions of this issue highlight Canadian national security issues, some studies have started to discuss the potential impact of increased shipping on northern communities. See Coates et al. (2008).

traditional lands, and other types of subsistence activities (Riedlinger 2001:96). Climate change was making conditions unpredictable and as such making it more difficult to travel on the land or sea ice. Safety was becoming an important factor in restricting access to food and cultural resources. Wildlife patterns were also shifting making it harder to predict where the resources could be harvested. According to Riedlinger, while the community was currently able to cope with these changes, the restriction of these activities could have important detrimental effects on the 'physical and cultural health' of the community (Riedlinger 2001:97). Subsequent research has resulted in similar findings (Ford et al. 2007; Furgal and Seguin 2006).

Barriers to social research on climate change in the Canadian Arctic

While these research projects have added much to our knowledge of the socio-economic impacts of climate change, they are, as pointed out earlier, much more limited in scope than studies conducted by the physical and biological sciences. The reasons for the relative absence of social science research on the issue are many and difficult to summarise. Below is an attempt to outline several of these reasons.

One reason is the difficulty that northern social science projects have getting funding. It is difficult for social science researchers in Canada to find research funds. Funding application success rates for social science and humanities research projects are much lower than those of the natural sciences. Those researchers looking at social change in the region have the added problem of the additional costs of doing research in the North. As the 'Final Report to SSHRC and NSERC of the Task Force on Northern Research' noted, Canadian northern research is extremely costly (2000:2). These funding constraints mean that generally speaking there are fewer social science projects studying the region.

Duerden (2004) has pointed out that it is extremely difficult for social scientists to study the impacts of climate change for two reasons. The first is that impacts will vary widely by locality. It is extremely difficult to talk about general system-wide changes since the changes introduced by climate change will be experienced differently by communities in varying environmental zones. As well, these experiences will have different impacts even within communities depending on one's age, culture and economic position. Indeed, for some in the community climate change may present new opportunities to resolve current problems that communities are experiencing.

The second reason highlighted by Duerden (2004) is that climate change impacts depend upon a community's ability to respond to changes brought on by climate change. Humans are not passive actors. Climate change will bring about responses to deal with any issues that are created. It is extremely difficult to determine what these responses will be. Duerden (2004:206) underlines that an important aspect of social research on climate change in the Arctic will be investigating the 'determinants of community responses'.

Another important factor in explaining the relative absence of social research on climate change in northern Canada is that it is not as high a priority for communities as other social and economic issues. The rapid pace of change that the region has experienced over the past fifty years means that there are a whole range of concerns and stressors affecting Canada's northern communities. Limited socio-economic research resources have been devoted to studying how to deal with other more clearly discernable problems. Fox notes that while 'climate change is clearly a concern for the Inuit… it is important to recognise that there are other, often more pressing problems, facing communities' (2002:45). As noted in the final report of the Arctic Climate Impact Assessment, any attempt to understand the potential socio-economic impact of climate change must also understand the other forces that these communities are dealing with: '… indigenous peoples are multiply exposed – to climate change, to changes caused by the global processes affecting markets, technologies, and public policies, and to local and regional political and economic situations' (ACIA 2005:658). The report goes on to state that it is important to 'contextualise climate change impacts with reference to other changes experienced by Arctic residents'.

Much of the current research relating to the changing socio-economic situation in northern Canada, and in particular that dealing with sustainable development, can be summarised by four main themes: resource dependence, mega-project development, increasing power of aboriginal peoples, and environmental issues as a source of change.(3) Resource dependence and mega-project development reflect conditions that have long existed in the Canadian North and continue to be some of the main drivers of change. The increasing power of aboriginal peoples and the increasing importance of environmental issues are more recent trends.

Since the Second World War, resource exploitation has dominated the economy of northern Canada and it continues to be the situation today. Resource dependence leaves communities in the northern regions vulnerable to the boom and bust cycles

(3) While this summary will not refer to specific sources, an excellent summary of these can be found in Bone (2009).

of world commodity pricing and the periodic exhaustion of resources. The impact of globalisation in northern Canada has intensified boom and bust cycles as fluctuations in commodity prices have escalated to become more intense, numerous and rapid (Duhaime 2004; Delaney et al. 2001). Technological advancements have led to the loss of jobs in resource industries, contributing to the depopulation of northern regions as a result of economic change (Southcott 2006). In the 1970s the introduction of government services associated with the welfare state model countered the loss of employment in resource industries; however, beginning in the 1980s, government cutbacks across northern Canada slowed growth in this sector (Gardiner 1994). Attempts to diversify the northern economic base have often failed (Duerden 1992). Most explanations of failure blame geographic constraints or the regions' inability to access capital. This lack of capital mobilisation is often explained by the fact that northern regions are resource hinterlands which exist to supply raw materials to industries located elsewhere.

Resource development in the North has largely occurred through mega-projects (Bone 2009). Resources developed in remote regions face enormous expense. The cost of development in northern regions is high because of the lack of available inputs, ranging from housing and transport, to utility infrastructure and labour. As a result of the high cost of transporting inputs, resource development is largely implemented through large-scale projects to ensure economies of scale (Huskey and Morehouse 1992). Other than the involvement of provincial crown corporations in hydro-electric development, most projects are led by large multinational corporations with both the capital and capacity to develop large-scale operations. Mega-project development brings many positive impacts to northern regions. Historically this has come primarily in the form of well-paid jobs and the introduction of new services. Unfortunately, there are many negative social and economic impacts associated with mega-projects. The labour demand of the construction phase means large numbers of transient workers are brought into the region, introducing a host of social problems.

Recent mega-project developments in the North are somewhat different from those in previous decades because of new political structures. One of the most important trends to have occurred in the Canadian North over the past thirty years is the political and economic empowerment of indigenous peoples. This is largely the result of a political shift that began in the years following the end of the Second World War. The end of colonial empires and the rise of transnational civil rights movements were all signs of a political shift supporting human rights in democratic societies. This shift did not occur without considerable conflict between northern aboriginal peoples and southern interests. Conflict over the Baie-James Hydro project and the initial Mackenzie Valley Pipeline project forced governments and industry to change their relationships with aboriginal peoples. In addition to these conflicts, a series of court decisions on aboriginal title forced governments to recognise aboriginal rights.

These changes resulted in federal and territorial governments working to ensure the negotiation and resolution of long-standing land claims and other issues of contention. New comprehensive land claim agreements significantly increased the political and economic power of northern aboriginal peoples. Not only do they now have recognised aboriginal title to land, but these treaties also included innovative forms of self-government and cash settlements. New aboriginal economic development organisations, such as the Inuvialuit Regional Corporation and the Makivik Corporation, were developed to increase the participation of aboriginal peoples in regional economies. These aboriginal organisations often became the first real regionally-based economic power to ever exist in the Canadian North. They are quickly becoming key business partners in many development projects. In addition to the new treaties, new mechanisms such as impact benefit agreements and socio-economic agreements were introduced to ensure greater benefits to regional aboriginal communities. Perhaps the most politically empowering event to occur for aboriginals in the region was the creation of Nunavut in 1999, followed by the recent agreement to establish a new form of regional government for Nunavik. While these changes have given northern communities some of the tools they need to ensure their sustainable development, many questions remain that social scientists, in partnership with these communities, could help address.

Finally, while there has been an increasing amount of research looking at the impact of environmental issues on change in northern communities, not all of it is linked to climate change. The negative effects of industrial development on the northern environment first emerged in the media during the 1970s. Changing values meant that industry practices that negatively affected the region's environment were criticised. The destructive impacts of resource development on aboriginal communities such as Grassy Narrows and Whitedog in northern Ontario became widely known and governments were required to act quickly to constrain the worst of these activities (see Shkilnyk 1985; and also Hobart 1984).

The shifting political power in the Canadian North has meant an increased degree of co-management of renewable resources. Many social scientists have been engaged in developing a relatively rich amount of research on the environmental and cultural aspects of resource co-management in northern communities in an attempt to assist these communities in their sustainable development (Berkes et al. 2005). This work sometimes includes climate change impacts but it tends to be more all-encompassing, dealing with impacts of other non-climate change related environmental impacts. Related to this research is the involvement of social scientists in attempts to find ways of partnering traditional environmental knowledge about the land and its renewable resources with that of scientific knowledge (Wenzel 1999).

Dealing with climate change impacts in communities in Canada's North

While there have been barriers to social science's ability to contribute to an assessment of the impacts of climate change on the sustainable development of Canada's northern communities, this does not mean that the existing research cannot help communities deal with these changes. The one issue around which a consensus seems to be developing is that greater community involvement and empowerment is the most sensible long-term solution to assisting these communities deal with these impacts. Any strategy regarding the sustainability of communities in the Canadian Arctic needs to discuss ways of increasing human, social and physical capital.

As was pointed out above, much of the existing research on climate change impacts on communities underlines that these impacts will vary greatly by community. Northern communities need to have the capacity to deal with the local variant of these impacts. Enabling these communities to deal with these issues themselves would be a much more effective solution than a uniform top-down centralised approach.

Many of these communities do not yet have the all the tools necessary to allow them to deal with these impacts. While the political empowerment of Canada's northern communities has increased lately there are still capacity issues that need to be addressed. Davidson et al. (2003) note that northern communities are the most vulnerable to climate change impacts not only because of the degree of physical impacts but because their lower levels of human and social capital means that they have less capacity to deal with the changes. Ford et al. (2007) note that the adaptive capacity of northern communities needs to be increased in order for them to better deal with the changes brought about by climate change. Referring to Inuit communities in Canada's North they note the importance of increasing Inuit knowledge and land-based skills, increasing support for social networks based on the economy of sharing, increased flexibility in resource use through local control of resource management, increased monetary transfers, and increased institutional capacity.

Furgal and Sequin's (2006) research also highlights the importance of increasing the capacity of northern communities as a solution to dealing with the impacts of climate change:

> *The ability to overcome changes in access to or availability of country food resources, which are important for nutritional and sociocultural well-being, is significantly influenced by an individual's access to economic resources and technology. The ability to invest more in the required tools and equipment for hunting and traveling, or the access to other forms of transportation (e.g., snow machine, four-wheel all terrain vehicle, flat bottom or larger boat) allows individuals to adapt more easily to changing environmental conditions… (Furgal and Sequin 2006:1968).*

They also stress the importance of the generation and sharing of various forms of knowledge as key to increasing the ability of these communities to adapt (Furgal and Sequin 2006:1968).

While social science research on climate change impacts in northern communities is limited at this point and while additional research will enable us to be more precise in discussions of solutions to these impacts, the existing research does allow us to state that any assistance that helps these communities increase their local political, social, cultural and economic empowerment is likely to increase their ability to deal with these impacts. In particular, increasing the human capital of these communities through education and training programmes that are appropriate to the traditional cultures and knowledge of these communities is likely to enhance the ability of these communities to meet the future challenges imposed by climate change in their region.

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Section 5

ECONOMIC DEVELOPMENT AND SOCIAL TRANSFORMATIONS

From the Arctic: Partners Needed

Mead Treadwell
Chair, US Arctic Research Commission

Abstract

The Arctic is becoming increasingly accessible to the rest of the world, in part through climate change. With this access comes growing social change, in the form of increased shipping, health impacts on local populations, and exploration for and exploitation of hydrocarbon reserves. In order to manage change in all its forms in the Arctic region, it is essential that we continue to research and gain knowledge of the Arctic. International cooperation on issues affecting the Arctic region also becomes increasingly important.

Introduction: Why the Arctic matters…

The importance of the Arctic region to the world is often overlooked. It is overlooked despite its strategic significance in the security of Europe, Asia, and North America. It is often overlooked despite its major contribution to the global economy, through its significant contributions of food and fuel. It is often overlooked despite its major contribution to biodiversity from the lowest end of the food chain to the highest. It is often overlooked despite its rich and enduring 'ethnosphere' tying us to our past, and the contribution the Bering land bridge made as a venue linking the continents for prehistoric global human migration. It is often overlooked despite its major role today in global aviation, and its potential role tomorrow in global shipping. It is often overlooked despite the fact that natural processes in the cryosphere govern sea level, and regulate the climate of the Earth itself, as the world's major storehouse of terrestrial carbon, and, with the southern polar region, as the reflector of major solar radiation through the high albedo of the polar ice cap. The Arctic is overlooked even for the contribution it makes to allow life on Earth itself to exist, for it is the deflecting power of the magnetosphere, manifested at the North and South magnetic poles, which protects us from deadly solar radiation.

Dramatic change in the Arctic may mean our region is overlooked no more. People of the world increasingly understand that change in the Arctic affects them no matter where they live. With change, the Arctic now matters. People further understand that without global action, many of the attributes of the Arctic we all hold dear may disappear in our time.

In this paper, I want to suggest four major forces of change occurring in the North and two forces now promoting further political cooperation in this region. Second, I offer two avenues for future action.

US action and the Arctic

In the United States, a Presidential decision document was released 9 January 2009, which revised US comprehensive Arctic policy for the first time since 1994. The policy is focused on international objectives in the Arctic, and gave us a list of major work that needs to be done – from ratification of the UN Law of the Sea Treaty to increasing both bilateral and multilateral scientific cooperation. As a result of the policy, the US will seek search and rescue arrangements in the Arctic. A regional fisheries agreement will be discussed. Our nation is now directed to work with others to see that shipping in the Arctic, as it increases, is 'safe, secure, and reliable'. Mandatory ship standards, vessel traffic systems in areas such as the Bering Strait, and other agreements will be sought through the International Maritime Organization. Arctic-wide monitoring, referred to as the 'Sustaining Arctic Observing Networks', to support a number of scientific research objectives, is another goal adopted by the policy. And seeking guarantees of access throughout the Arctic Ocean for scientific research – something enjoyed now in Antarctica, but not in the Arctic – is now an official objective.

An 'accessible Arctic'

We are witnessing four forces making the Arctic region far more accessible to the people of the world. They are:

- Dramatic change in the climate of the Arctic region;
- Dramatic changes in transport, satellite communication, navigation and remote sensing technologies;
- Increasing global demand for Arctic resources, including food, energy and the convenience of its location between global population centres. Global demand for experiencing the Arctic's dramatic landscape and culture is also bringing more tourists to the region;

¬ The interest of Arctic residents to involve the outside world in improving living conditions in the North.

An 'accessible Arctic' is accompanied by growing local and global political cooperation. In response to these forces of change, listed above, two forces are helping to knit political cooperation in the North into a fabric which is stronger than ever, and is, in many ways, a model for the world in regional cooperation:

¬ Circumpolar proximity: the end of the Cold War allowed the governments of the eight Arctic nations, its regional governments, indigenous, business, academic and professional groups to take advantage of their proximity to work on common problems and opportunities. These efforts are resulting in increasingly stronger institutions. Sharing knowledge brings sustainability.

¬ Other nations besides the 'Arctic 8' are recognising national interests in the Arctic region. The observer list to the Arctic Council is growing. While most of the Arctic region will soon find itself within the sovereign boundaries of Arctic nations, global interest in the high seas region of the north, and in the global contribution of Arctic resources, has brought the question of global cooperation on Arctic issues to the forefront.

Keep exploring: research in the Arctic

Research in the Arctic is vital to understand Arctic change and Arctic change requires us to keep exploring. New features underwater are being added to the charts, and new territory, uncovered by ice melt, is being added to the map. Understanding Arctic processes is essential to predicting the threats to the planet caused by tundra thaw, methane gas release, sea ice retreat, glacial ice sheet melting, and changes to habitat, ocean currents and ocean salinity. I single out ocean acidification as one phenomenon caused by rising greenhouse gases. It is dangerous to shellfish stocks, and perhaps other species. More needs to be understood, and short-term mitigation options appear to be limited.

Within the United States, the US Arctic Research Commission will soon publish a report establishing goals for federal agencies conducting Arctic research. Already, detailed research plans are being formed, across the US government, for each of the five research themes the commission has set out:

¬ Climate change and understanding of the Bering Sea and Arctic Ocean ecosystems

¬ Arctic human health

¬ Arctic civil infrastructure

¬ Arctic resource assessment and Earth science

¬ Preservation of indigenous languages, identities and cultures. (The commission is concerned that in the Arctic, we are losing indigenous languages in the space of a generation. Much human knowledge is lost when a language disappears.)

Each of these research themes listed above would be better fulfilled with international cooperation.

The US Arctic Research Commission is also putting special attention to several areas:

Shipping: The Arctic Marine Shipping Assessment, completed this April by the Protection of the Arctic Marine Environment (PAME), a working group of the Arctic Council, has been funded and directed in large part with resources from our agency. That assessment will show that regular Arctic shipping is not just a 'future' thing, but is a 'now' thing. Several global action items are included in recommendations submitted to ministers, primarily focused on proposals that would forward through the UN's International Maritime Organization. Business and government entities from around the Arctic cooperate now on improving oil spill prevention and response in the Arctic through a 'Joint Industry Program' being conducted in Norway. We are urging the US, which increasingly relies on oil and gas produced and/or shipped in Arctic waters, to expand its contributions to this, and to domestic spill research programmes with similar objectives.

Health: As we work to improve Arctic Human Health research in the US, the alarming epidemic of youth suicides in rural Alaska, primarily among indigenous youth, is of great concern. With the US National Institutes of Health, we co-sponsored a meeting on behavioral and mental health research issues in the Arctic in Anchorage in early June 2009. An Arctic-wide health research conference was also held in Yellowknife, NWT, in July 2009. The potential death rate for Alaska's indigenous peoples is among the highest in the US, and we do not face this problem alone. International support for this effort would be welcomed.

Fishing: The United States is finalising a moratorium on almost all commercial fishing inside its 200 mile exclusive economic zone in the Arctic Ocean. It is doing so even as preliminary research tells us that valuable fishing stocks are moving north. The United States will host an international conference in October 2009, in Anchorage, Alaska to discuss fishing with others interested in the fate of fish stocks and wildlife in the Arctic Ocean. One outcome of this initiative must be a stronger commitment to joint marine science in the Arctic Ocean and Bering Sea region. We have much to do, even with our closest neighbours, Canada and Russia. A second outcome might be a concerted effort toward a regional fisheries regime, recognised under international law. Appropriate proposals for marine protected areas should also be discussed.

Climate change mitigation: As the nations from across the globe convene in Copenhagen in December to again attempt to establish an effective mitigation regime to stem climate change, the Arctic should get special attention. We are a resilient species living on a resilient planet, but it is not well-understood by residents of the temperate zone that a slight change in global average temperature is magnified, greatly, in the polar regions. With temperature magnification comes the potential destruction of many Arctic attributes we hold dear, and indeed rely upon. The commission is urging a special assessment of the timing and level of greenhouse gas targets set on a global scale to understand how the range of options will affect the Arctic region. Some research we have seen suggests one course could return sea ice to a 'normal cold' condition, with extensive multi-year ice, and that another course might see that ice gone for centuries. As well, our call for extensive Arctic monitoring comes because the contribution our region makes to the greenhouse gas and heat budget of the globe is not just from tailpipes, but increasingly from a reduced albedo effect resulting from declining sea ice. Warming causes greater carbon dioxide and methane releases from melting permafrost. A successful Copenhagen meeting is vital to a sustainable Arctic.

Monitoring and research platforms: On Wednesday 25 February, a ceremony in Geneva marked the completion of the International Polar Year, 2007-2009, where the world's science community came together to dramatically improve our knowledge of the polar regions. The commission is working to ensure that whatever the scientific legacy is of this IPY, the first in 50 years, that we leave the Arctic 'wired for sound' with an extensive monitoring system. The pan-Arctic science community is addressing this with plans for SAON: the Sustaining Arctic Observing Networks. It is tied to global observing initiatives, such as the Global Earth Observing System of Systems (GEOSS). We face the problem of better 'scaling' in climate prediction. Local observations must be used to support global decisions, and vice-versa. I urge strong support to this observing initiative. We also need support for other individual and mutual investments nations are making in Arctic research infrastructure – icebreaking ships, satellites, laboratories, cabled observatories, ocean buoys, and training for researchers to work with these assets.

Access to the Arctic Ocean for research: There is a contrast between the access enjoyed by scientists in the Arctic and the Antarctic. The Antarctic continent and adjacent seas are open for research while access to the continental shelf of the Arctic Ocean is not guaranteed. Ocean science cannot deliver the results the world expects of it if national rules bar access to science. This shortcoming of the Law of the Sea needs to be addressed.

Energy: Hydrocarbon production is a major source of revenue to several countries in the Arctic. Nations outside the Arctic depend on this energy, and all should work to ensure its safe development. We are working to expand renewable energy research and demonstration projects in the Arctic region. Hundreds, if not thousands, of Arctic settlements and villages are off national road systems and power grids, and energy is thus much more expensive. There is no better place to test newer, more costly technologies than where people are spending more money already for power and propulsion. An Arctic Energy Summit held in 2007 showed this is true across the Arctic region. Alaska is rich in tidal energy, hydrothermal, wind and hydro potential, and has plans to use these sources for power generation, transportation fuels and ultimately export.

Keep cooperating: global support for Arctic sustainability, with accompanying investment, is necessary

The world should recognise and help strengthen the work of the many cooperative arrangements that focus on the Arctic. The Arctic Council convenes nations, and brings indigenous representatives as Permanent Participants to sit at the table. The Northern Forum convenes governors, and helps regional leaders find solutions to common problems. International cooperation in science and research is carried out by a number of bilateral and multilateral efforts, notably the International Arctic Science Committee, the International Union of Circumpolar Health, the Northern Research Forum, and the Pacific Arctic Group.

The fascinating situation of the Arctic is this: nations can dictate what happens inside their borders. Soon, those borders will expand with extended continental shelf claims allowed by the Law of the Sea (UNCLOS). Article 234 of UNCLOS allows other rules to be made in traditional ice covered waters outside national boundaries. Nations in the region can act in concert, and issue harmonious rules or make joint investments, as the US and Canada have in the St. Lawrence Seaway/ Great Lakes region to facilitate safe shipping. Even then, some parts of the Arctic Ocean will be extra-jurisdictional to any nation. In such a case, if rules are needed, they can be set only at the global level.

The United Nations has important work ahead on sustaining the Arctic. When it comes to protecting the Arctic from further abrupt climate change caused by humans, or allowing rules to ensure safety of Arctic shipping, or reducing trans-boundary contaminants, sustaining trans-boundary populations of wildlife, or establishing extraterritorial marine protected areas, it is to the world diplomatic community that we have to turn to get the best results. Non-Arctic nations France, Germany, Poland, the Netherlands and the United Kingdom serve as Permanent Observers to the Arctic Council, and may be joined soon by China, Italy, South Korea and Japan whose applications are pending. In the future, these and many other nations might best take on the role of 'Arctic Partners.' The best partners, in my view, will support the quest of Arctic residents for greater self-determination, and will work with us to protect the resources of the Arctic as we all enjoy them.

In the last year, the five Arctic Ocean nations have rejected the need for an Arctic treaty. Arctic treaty or not, our rulemaking must be comprehensive. Our common investments – in research and monitoring, in aids to navigation, in technologies and techniques to reduce greenhouse gas emissions – must also be robust.

Greenland's Path to Overcome Global Warming

Jonathan Motzfeldt
Former Premier and former chairman,
Greenland Home Rule Government

Abstract

The melting of the Greenland ice cap generously adding to rising sea levels, and the melting of the pack ice off the northernmost and eastern shores of Greenland leaving polar bears with diminishing habitats, provide for vivid images for the campaign to halt global warming. Those concerned with the human dimension of climate change also see images of the rapid decline of the ancient Inuit hunting civilisation. In this submission I will argue that the reality of climate change for us in Greenland is much more nuanced than the images projected to the global audience. By balancing mitigation and adaptation efforts, we will survive global warming. As a resilient and self-determining people we refuse to be mere victims of global warming.

Greenland and its history

The opportunities and challenges that we in Greenland are facing at this time, in the age of global warming, are defined from our experiences as a people who have inhabited the island of Greenland for more than a thousand years. For people new to the Greenland experience it is therefore important to start off with an introduction to Greenland and its history.

A quick glance at Greenland's natural environment

Greenland is the world's largest island and is geographically part of the North American continent. Greenland stretches from a latitude of 59°46' N to a latitude of 83°39' N, in total 2670 km. At its broadest Greenland spans 1050 km. The island comprises 21,756,000 km^2, about 85 per cent of which is covered by the Greenland ice cap, which rises from sea level to a height of 3000 m. The coastline of Greenland is 40,000 km long and consists of an archipelago of many small and larger islands as well as deep fjords with mountains as high as 3700 m towering above.

The climate is classified as ‘Arctic’, defined by the average temperature of the warmest month not exceeding 10 °C. It is a climate characterised broadly by long, cold and dark winters and short, cool and sun-filled summers, and low humidity. Due to the length of Greenland, climate within Greenland varies greatly from north to south. However nowhere has the climate ever been ideal for agriculture, whereas hunting, in particular for marine mammals, was the natural livelihood choice for our ancestors who excelled at seal hunting and whaling.

Marine mammals such as seals and whales provided for all our needs: meat and blubber gave vital food and nutrients, the oils from the blubber gave heating and cooking fire, and the skins and furs gave shelter, clothes and skins for the kayaks and *umiaqs* (women’s boat) that were vital for reaching the hunting grounds at sea and for transportation. Such was our adaptation to our natural environment and our livelihood choices that the famous Scottish medical researcher David F. Horrobin, after studying the fatty acid metabolism in Inuit and other peoples in the early 2000s, categorised Inuit as ‘obligate carnivores’ (Horrobin et al. 2003) and implied serious consequences from a switch to a Europeanised diet.

Though biochemical science may indicate that our ancestors’ adaptation to the natural environment was near perfect, the realities of our ancestors’ lives were neither perfect nor romantic. The myths and histories that have been handed down for generations testify that periods of hunger and even starvation were not unknown due to natural and inherent ecological and climatic fluctuations, which periodically changed migration patterns and the availability of various game species, thereby leading to diminishing returns of catch.

A quick glance at our political history

The year 1721 marked the beginning of the Danish colonisation of Greenland. Although the colonisation of Greenland was bloodless compared to colonial experiences elsewhere, it did have some disastrous consequences. Some of these disastrous effects were caused by the missionaries’ policy of promoting a more sedentary lifestyle conducive to regular religious instructions and education in literacy. The sedentary lifestyle resulted in a reduction in the catch around the

Hosting of research, innovation and development in hydrogen technology could become an important source of income for Greenland (photo: Kevin O´Hara).

colonial settlements. When Denmark had achieved absolute trading monopoly in Greenland and had thus sealed the island off completely from the influence of other Europeans, the cash economy was introduced to Greenland. The introduction of cash into trade with Greenland also had serious impacts:

> *From ancient times, Greenlanders had to make sure they had provisions for the coming winter. But the implementation of the cash economy began to create a whole new relationship… People developed new consumer tastes. They didn't think of money as something that corresponded to a winter's provisions. On the contrary they developed the impression that money was simply to use here and now (Petersen 1997).*

Until the Second World War, Greenland was still a closed colony with an economy that was self-sufficient, though the standard of living was low. Furthermore, with the change from a colder to a warmer climate in the 1920s and the 1930s, sealing as a livelihood came under stress, concurring with the decline in world market prices for train oils from seal and whale. Climate change and the warming of our oceans suddenly led to an abundance of cod fish – an attractive commodity in Europe – and the transformation from a seal hunting economy to a fisheries economy saw its

View of Qooroq Fjord. Greenland as a tourist destination has an offer for every temperament (photo: Ellen Fjellanger).

early beginnings. It should however be noted that despite this transformation, we as Greenlanders continued to be heavily dependent on seals and whales in our meat consumption and in the utilisation of the skins, including for exports.

In 1954 a new constitutional arrangement for Greenland meant that Greenland was integrated into Denmark and taken off the UN's list of non-self governing territories. Greenland now had a status comparable to an ordinary Danish county. In order to bring development and the economic living conditions on par with the rest of the Danish kingdom, a massive modernisation of Greenland process was put in motion.

This modernisation process was vital in fighting poverty. But the downside to this development was that it was a social engineering project controlled by Copenhagen. We as Greenlanders became passive onlookers to what was happening in our country and the social discontent emanating from the rapid modernisation process became more and more acute. This was when my peers and I started to advocate for development in Greenland to be on Greenlandic terms, and for political autonomy in Greenland. We succeeded in 1973 in the establishment of bilateral Danish/Greenlandic Home Rule Commission, which produced a draft bill on Home Rule. Three years later the Home Rule Act was adopted by the Danish Parliament and came into force in 1979.

Home Rule

With Home Rule we were able to gradually, field by field, assume legislative and executive power regarding Greenland's internal administration, direct and indirect taxes, fishing within the Exclusive Economic Zone (EEZ) (within 200 nautical miles of the Greenland coastline), hunting, agriculture and reindeer breeding, social welfare, labour market affairs, education and cultural affairs, vocational education, other matters relating to trade, health services, and the housing area, as well as the protection of the environment. In our ambitions to gain control of our own resources, we opted out of what was then called the EEC (today's EU) in order to maintain independent management and control of our own fisheries resources. The fields remaining with the Danish authorities are the foreign and security policies, the justice and law enforcement sector, constitutional law and monetary policies. The sovereignty of mineral and oil resources remains with the Danish realm, however the administration of the exploration and exploitation is based on a so-called co-management regime between Danish and Greenlandic authorities. The financial arrangement for the Home Rule in Greenland is such that the Danish purse provides an annual block grant to the Greenland purse amounting to the level of expenditure that Denmark used for these fields at the time that the jurisdiction of these fields were transferred to the Home Rule Government.

The Greenland Home Rule has been an enormous success. The most important criteria for success are that it has brought governance closer to the people of Greenland. Ordinary Greenlanders no longer feel that that their everyday lives are controlled from Copenhagen, and when they are dissatisfied with their government their reproaches and their political demands are directed to Nuuk, which is the capital of Greenland.

Self Government in Greenland

As of 21 June of this year (2009) we moved one step further in the enhancement of our autonomy as we inaugurated Self Government for Greenland. Self Government means that it will be possible for us to take over the competences in areas such as the justice sector and the management and control of the oil and minerals sector, when we have the financial means to finance these areas.

Thus for us in Greenland, there is a great incentive to expand and develop our economy. Economic self-reliance means the financing of a well functioning welfare society and the extension of our political autonomy. But how does a small Arctic nation, with a population of around 56,000 persons scattered in more than sixty small insular towns and communities living under extreme climatic conditions, generate the surplus to provide social and health services and education opportunities which match the same welfare level as other Nordic countries?

The answer was obvious: we have to pursue and develop a multi-tiered strategy to make best use of *all* our country's resources. As a people with the right to self-determination, we also enjoy the rights enshrined in the international bill of human rights as well as in the UN GA resolution 1803 to the permanent sovereignty over our natural wealth and resources. And in Greenland these resources are both living and non-living, tangible and intangible. These are the resources that we need to harvest by applying the human resources, creativity and skills of the entire Greenlandic population.

An innovative, creative and well-educated population is key to the succesfull transformation of material riches into genuine and humane welfare: A woman pilot flying by the UNESCO World Heritage Site Ilulissat Icefjord (photo: Sigurd Schjøtt).

Our resource base

The first tier is the reliance on our living natural resources and thus the continuance of the livelihoods we have always known, most importantly hunting, whaling and fisheries. Fisheries are the most important source of our exports – up to 87 per cent of our income from exports is derived from fish (halibut and cod) and shellfish (shrimps, scallops and crabs), which thus provide an important contribution to our economy. However, we have also learned that dependence on the living resources of the sea is a rocky affair. Fish and marine mammals belong to the same food chain, that of the vast ocean ecosystems. The species belonging to this food chain are interdependent and the delicate and dynamic balances between them are influenced by factors such as fluctuations in ocean temperature, as well as the degree of utilisation of these resources from fisheries, sealing and hunting.

Exploitation of fisheries also requires heavy investments in vessels, technologies, knowledge and fish processing, whenever there is a shift in the availability of the various species. In the 30 year span of experience with Home Rule in Greenland, we have learned that these shifts in the availability of fish stocks can be extremely burdensome. One such example was the shift from cod to shrimp fisheries in the late 1980s. And now it seems that global warming may cause the return of the cod fisheries and we would again be forced to restructure and reequip our fisheries fleet. The question is whether this would be a sustainable investment. This question becomes even more acute given the potentially negative impact of global warming induced acidification on the abundance of fish stocks.

Seal hunting and whaling provide food for more than 50 per cent of the Greenlandic population, either totally or partially. Hunting and whaling provide food and important nutrients and fatty acids for people and for sledge dogs. The sale of the sealskins and meats to wage-dependent families is the only cash income opportunity for those families who rely on hunting. However, our sealing and whaling are under ever-increasing pressure from the Western world. Since the establishment of the International Whaling Commission (IWC) in 1947, we have been allowed a certain quota of the great whales under the aboriginal whaling scheme. Increasingly these quotas have been more and more difficult to obtain, despite the advice of the scientific committee of the IWC, due to the increasing influence of the Western animal rights movement. And when it comes to sealing, the widespread opinion that it is unethical to wear furs of sealskin, generated by the campaigns of the same animal rights movements in Europe and North Anglo America, has made it increasingly impossible for Greenlandic hunters to sell the skins, thus depriving them of an important supplement of cash income. The latest important blow to Greenlandic sealing is the pending ban of seal products by the EU. Although European nations sympathetic to the Inuit and our sealing might be able to make an exemption for products hunted by Inuit, the ban will further cement the general public sentiments in North America and Europe that seal hunting is barbaric and unethical.

Global warming is not the only environmental threat to the livelihoods of our hunters. Transboundary pollutants such as the POPs (Persistent Organic Pollutants) travel long distances from the industrialised south and from tropical plantations. The POPs enter the food chains of the Arctic ecosystems forcing we who are obligate carnivores to put dietary restrictions on how big an intake we Greenlanders, and especially pregnant and breastfeeding mothers and young children, can have of seal and whale meat, in order to avoid the build-up of chemical compounds that have serious effects on our immune, enzyme, hormone and reproductive systems. And thus we are locked in a true dilemma: if we as obligate carnivores, whose entire metabolism has evolved on a diet of marine mammals, switch to a more Europeanised diet in the belief that we can thereby avoid these dangerous organic pollutants, we will, as Horrobin says '"become completely depleted" (of vital fatty acids popularly know as omega 3 and 6) and it will lead to the development of… well-recognised health problems, including sudden cardiac death, diabetes and psychiatric disturbances' (Horrobin et al. 2003). The most recent study on the living conditions of the Greenlandic population showed an upsurge in cardiac diseases and diabetes coinciding with the decrease in intake of traditional foods such as seal and whale meats.

The second tier is based on our non-living resources. Greenland has mining potential for minerals such as lead, zinc, gold, molybdenum, niobium and diamonds, as well as gemstones such as rubies. Since 2001, we have had two mines operating, one for gold and the other for olivine. The export value of these minerals reached a level of 100 million Danish kroner in 2007. Our Bureau of Minerals and Petroleum expect that within the next 10 years Greenland will be exploiting seven mineral sites. Besides the minerals, Greenland also has an enormous potential for the exploitation of hydrocarbons e.g. oil and gas. According to the mean estimates of the US Geological Survey, offshore Greenland oil reserves lie in the area of 50 billion barrels of oil.

To a world that is eager to reduce its dependency on fossil fuels, it might not seem sensible that Greenland aspires to become an oil-producing nation. However, here it is worth taking note of the fact that despite all our efforts in shifting to renewable

How does a small Arctic nation generate the surplus that ensures welfare levels of Nordic standards? (photo: Royal Greenland).

resources, the world will continue to be dependent on fossil fuels for generations to come. Thus energy security is a major concern for European and many other Western nations. Henceforth, Greenland has the potential for becoming a reliable supplier of energy.

Although we in Greenland are thinking in terms of exploring for oil, this does not mean that we are not concerned with reducing greenhouse gas emissions. Therefore, we insist that the best available technologies be used in the future exploitation of oil and gas to minimise the production-related emissions. Likewise, we are eager to use our water resources, most of which are the melt waters coming off the Greenland ice cap, to build hydroelectric plants for our own energy needs as well as for developing energy intensive industries. Since 1992 we have invested heavily in building these hydroelectric plants, with the result that today the capital of Nuuk as well as two other major towns draw all their electricity from renewable

Eqi glacier, to the North of Ilulissat (photo: Ellen Fjellanger).

energy. In the next few years, we expect that still three more towns will follow suit in switching their energy source from diesel to water. Another interesting proposal is to build an aluminium smelter in Greenland. Smelting aluminium is a highly energy intensive process. Other possible income generating activities could be the hosting of research, innovation and development in hydrogen technology.

A third tier is tourism. For people living in congested cities and densely populated countries with hardly any natural spaces left, Greenland is an attractive choice with its enormous expanses of pristine nature and its small population with a unique culture. For many recent years, we have made investments to promote tourism and to develop knowledge, service and skills among local entrepreneurs who offer anything from individual hunting or nature-watching trips on dog sledges and kayaks to cruise ship adventures. There is an offer for every temperament from extreme sports such as heli-skiing and high mountain climbing, through to contemplative hiking in the wilderness, and to congenial culture oriented community visits, all of this in a clean and beautiful environment.

Conclusion

In conclusion it should be underlined that abundance in resources is no guarantee for prosperity and human well-being. An innovative, creative and well-educated population is key to the successful transformation of material riches into genuine and humane welfare. This is why in Greenland we spend ca. 25 per cent of our annual budget on education and capacity building. By combining our material resource base with our human resources we will avoid becoming mere victims of global warming.

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Uses of the Arctic Ocean and the Future of Indigenous Cultures

Edward Saggan Itta
Mayor of the North Slope Borough, Alaska
President of the Inuit Circumpolar Council (ICC) Alaska
Whaling Captain and a member of the Barrow Whaling Captains Association

Abstract

Ever since oil was discovered on the Arctic coast 40 years ago, we have lived with this development. Oil brought a lot of changes – some good and some bad – but most of our people believe the benefits have outweighed the challenges. However, we are opposed to offshore oil and gas activity, as we do not believe it can be done safely. Yet, we recognise that we cannot just say no, as that will not leave us in a very good position if leasing and exploration continue to move forward. We are therefore currently assembling our own offshore policy statement that will very clearly outline our greatest concerns and what steps, if any, would minimise our fears. This policy will amount to our estimation of what it takes to achieve sustainable development in the waters of the Arctic Ocean.

Introduction

I do not have scientific credentials, but my own expertise is the result of a lifetime spent in the Arctic, learning about the workings of nature in that remote and relatively unknown corner of the world, under the guidance of elders and expert hunters whose vast knowledge was accumulated through generations of keen observation.

Their knowledge was tested on a daily basis, and the reward for their study was not an advanced degree, but one day of survival after another. It was a high-stakes education. They lived on the edge in many respects, inhabiting a world that was both unforgiving and highly productive, and they became intimately familiar with the ice and the ocean and the tundra. These were their subsistence hunting grounds, and they were experts in the characteristics and seasonal changes of each, as well as the habits of the animals they pursued.

Observations of climate change

I learned at the foot of my father, who in English was called Noah. He was like the Arctic itself – patient and quiet, but demanding at the same time. In his later years, my father noticed how the climate seemed to be changing, and he would comment on how spring came earlier and warmed up faster, making our whaling activities more hazardous. We hunt from the edge of the shorefast ice in the spring, and changes in the ice pack have a big impact on our ability to participate in this traditional hunt. As time went on, even us young folks could see the changes. The ice pack was shrinking, and shorefast ice was rotting earlier in the year, and the ice retreated farther out during the summer and stayed out longer. It was almost like a rug was being pulled from under us.

Now these changes seem to be occurring faster and faster, and frankly we are very concerned about this accelerating pace of change in our environment and how it will affect the whale migration and the ability of other marine mammals and shore-based animals to survive. We are inextricably tied to these subsistence species, and their fate is our fate. We recognise this, and we lose sleep over it. We do not know what steps can be taken to repair this damage and preserve the biological basis of our cultural survival.

Oil and gas development

However, we do have some ideas about how to keep things from getting worse. Ever since 10 billion barrels of oil were discovered on the Arctic coast 40 years ago, we have lived with development in our back yard. Oil brought a lot of changes – some good and some bad – but most of our people believe the benefits have outweighed the challenges. Oil provided us with a tax base, which in turn gave us the foundation for a regional economy. The North Slope Borough is able to provide jobs for 800 of our residents because of oil, and our private-sector Native corporations are among the largest economic engines in the state.

So we do not reject oil development. We welcome it if it is conducted onshore with adequate safeguards and local participation in all phases, from environmental planning to production to restoration after the field is played out. On the other hand, we are philosophically opposed to offshore oil and gas activity. We do not believe it can be done safely, and we do not believe that a spill can be contained or cleaned up in our waters – because of the ice and the difficult operating conditions.

Our federal government has a different opinion about that, and it has allowed offshore leasing in the Beaufort Sea and the Chukchi Sea for decades. A few near-shore projects have gone into production, but for the most part, the cost of development in the most promising offshore areas has prevented widespread activity. Of course, in recent years we have learned that there is no limit as to how high the price of oil can go, and as the ice retreats, valuable new areas will be exposed.

Shell Oil has not been active in Alaska for many years, but in the past few years, they have shown renewed interest in the Arctic offshore. They spent $2.6 billion dollars on leases, and they ramped up for the largest offshore exploration project ever in the Beaufort Sea. We challenged the federal government's planning process in allowing that exploration, and we were able to get it stopped in court, at least for three years. Shell plans to try again with a scaled-down project, and they hope to be exploring in the Beaufort next year.

Indigenous voices in environmental policy

Shell's aggressive move offshore has forced us to take a much harder look at what it will take for us to come to terms with offshore development, if the government is going to allow it in the long run. I do not believe we can just stamp our feet and say, 'no, no, no.' That would not leave us in a very good position if leasing and exploration continue to move forward, however slowly. So we are therefore in the midst of assembling our own offshore policy statement that will very clearly outline our greatest concerns and what steps, if any, would minimise our fears. This policy will amount to our estimation of what it takes to achieve sustainable development in the waters of the Arctic Ocean. Once this policy statement is completed, we will promote it in Washington with just as much vigour as we promoted *onshore* development in the Arctic National Wildlife Refuge earlier in this decade when that issue looked like it might move.

One of the core items in this policy will be our insistence that development must be preceded by extensive baseline studies to collect the data that can give us a snapshot of the ocean environment *before* activity gets underway. This should be obvious, but the policy world seems to be full of people whose faith in technology trumps any concern for the remote and fragile world that may be disrupted in the course of doing business out there.

There is only one Arctic species that is relatively well understood from a scientific perspective, and that is the bowhead whale. More time, effort and money has been invested in bowhead whale research than any other whale species. This is because in 1977, the International Whaling Commission (IWC) told us we could no longer hunt bowheads because their population had declined too far. Our whalers and elders thought the IWC's population estimate was way too low, but nobody paid much attention to traditional environmental knowledge in those days. So over the past 30 years, we have spent millions of dollars to collect and analyse biological data on the bowhead.

Our traditional bowhead whale harvest was severely restricted for many years, and as the science gradually proved that our elders knew what they were talking about, our whale harvest quota was increased by the IWC. There are two lessons here. One is that the scientific community needs to take traditional environmental knowledge more seriously, as will be discussed below. The other lesson is that, although the IWC ban on whaling was misplaced, the underlying caution was commendable. And if a traditional whaling culture can be asked to prove that its activity is sustainable, then we should be demanding the same of oil and gas multinational corporations who could pay for all the science in the world without the slightest ripple in their bottom line.

This is what we are asking of the government and the industry: to do the baseline science before they go out in the Arctic Ocean. Paint a data-driven picture of each major species and of their habitat, so we have a starting point against which we can measure changes in that fragile ecosystem.

We are also asking that projects be evaluated for their individual impacts on wildlife and habitat, as well as for their cumulative impacts in conjunction with other projects underway in the area. We have seen the long-term process of oil and gas development onshore, and it has been very instructive. It starts with one project here and one project there. Then as fields are delineated, you see additional projects extending the area of impact both beyond and within the original field of work. Each of these projects gets a separate permit, and each is judged for its discreet environmental impacts. But we have seen how projects can also have collective impacts that are separate from their individual effects. For example, any one project by itself may not harm a certain species of fish, but when considered collectively they could have a significant impact on the health of that species. This kind of cumulative environmental impact must be monitored and analysed in the course of development, because most Arctic wildlife species migrate over vast distances and are susceptible to these cumulative impacts.

Another piece of our ocean policy speaks to the need for ever-greater collaboration and communication among nations on questions of science. Resource development companies want to limit costs, especially in expensive frontiers like the Arctic. Expectations are established early in the development process, and they respond to political realities in the host country. As a result, companies use different technologies and varying technical approaches in different parts of the Arctic.

Our goal is to make sure that companies doing business in the Arctic Ocean use the world's best technologies and adhere to the strictest operational guidelines. So we need to know what Canada, Norway and Russia and other countries require. We need to know if zero-volume discharge is achievable, and if it is being used in another nation, for then it is probably practical as well. Our scientific and policy communities need to share information as widely as possible. I urge that international mechanisms for the sharing of data be encouraged and pursued.

I also want to urge the scientific community to continue working with policy-makers toward international standards and protocols for industrial operations in the Arctic. The Arctic is a single ecosystem that is under increasing stress from global climate change. Its future cannot be assured by varying responses and policies in eight different nations. I think we can all contribute to the effort for clear standards that respond to the best available science throughout the Arctic.

Conclusion

The Inuit and other Arctic indigenous peoples have the most to lose from mistakes that are made in Arctic waters. We are the people who cannot just relocate if things go wrong, because the Arctic is our home. It defines us as it sustains us with its bounty of marine mammals and other wildlife. This is why indigenous people must have guaranteed participation in the policy-making process at all levels. It is a matter of simple justice. We are the primary stakeholder in the Arctic world based on millennia of our presence there. Nations have grown up around us and pushed us around. But we have stayed, and we will stay. I believe that it is a moral imperative for the nations of the world to guarantee our ability to remain and survive in the Arctic, because it is the only place where we really fit in this world.

And I think this guarantee can be achieved, first of all, by active and meaningful participation in the decision-making process – or what we call ‘a seat at the table’ in the formulation of Arctic policies.

Also, protection of traditional subsistence hunting and fishing practices must have a top priority. Other uses should be allowed only after subsistence uses are guaranteed.

Greater emphasis should also be placed on incorporating the traditional ecological knowledge of indigenous peoples in mainstream scientific research. Our people have a lot to offer in terms of understanding the nature and processes of the Arctic world. Nobody knows the Arctic better, and nobody has studied it as carefully and continuously. We may not be schooled in Western scientific methods (although some of our young people are learning those skills), but we are keen observers of the world that has always surrounded us. The International Whaling Commission and the prevailing experts of the time could have learned a lot from our people in 1977. Even before our researchers began their defining bowhead whale census work, our hunters came up with what turned out to be a much more accurate population estimate than the scientists who were advising the IWC. It was a lesson in the potential advantage of using people who live in the field, not just putting people out in the field who have never lived there. The Arctic needs all the knowledge that can be brought to bear in its behalf, and it would benefit scientists and indigenous people to forge a closer working relationship.

Sustainable Development and Climate Change: Challenges and Opportunities in the Case of Greenland

Marianne Lykke Thomsen
Senior Policy Advisor, Department of Foreign Affairs,
Government of Greenland

Abstract

Climate change and its potential impacts on society is considered important, but this issue was slow to reach the very top of the political agenda in Greenland. This is despite the fact that Greenland tends to be at the centre of the international climate change debate. Over the past 30 years, the overall political goal of the Greenland Home Rule Government has been to establish an economic sustainable society. This effort continues today and has been the most important driver towards greater political self-determination. As a result, on 21 June 2009 the Greenland Home Rule Government – with the clear consent and approval of the Greenland people – transformed into Greenland Self-Government (Government of Greenland), whereby its powers have been extended even further. This major and historic achievement, combined with the attention and many activities generated by the process to renew the Kyoto protocol, gives new momentum to climate change issues as they clearly impact on political and economic development in Greenland. In this context, it is important to note that there are many challenges ahead but also some potentially rewarding opportunities.

Solar panels at a hill-top relay station in West Greenland (photo: Tele Greenland Ltd.).

Introduction

This paper aims to highlight some of the challenges and opportunities that relate to both sustainable development and climate change and to the responsibilities resulting from Greenland's assumption of additional political decision-making power. These factors put pressure on Greenland to continuously adjust its economic development strategies in order to maximise benefits and minimise disadvantages. Recent developments, which have culminated with the introduction of the new self-government, seem to boost political and industrial self-esteem. Greenland may be able to make significant contributions to sustainability of the Arctic in the face of climate change.

Challenges and opportunities

I begin by highlighting some of the challenges and opportunities as they relate to both sustainable development and climate change and to the responsibilities following Greenland's assumption of additional powers – not to forget the

Iced over hill-top relay station in West Greenland (photo: Tele Greenland Ltd.).

economic responsibility, which is an important part of the package. When elaborating on observations concerning the ongoing climate change in the Arctic, it becomes obvious that there are both advantages and disadvantages, which must be taken into account when assessing the impacts.

Resources

Increasing sea temperatures may have dramatic consequences for traditional occupations such as small-scale hunting and fishing in which stable sea ice is essential for the hunters and fishermen to be able to get to the hunting and fishing grounds. It is impossible to predict exactly how changes in sea currents will impact on the biodiversity and thereby on both small-scale hunting and fishing and industrial fisheries. Fisheries currently constitute 86 per cent of Greenland's export revenues making the national economy very vulnerable to sudden changes in fish stocks – and market conditions.

A potential benefit may be the increased access to previously ice covered areas with oil and gas deposits, which may thus be extracted more easily. This triggers calls for regulation and determination of ownership of the seabed. These developments are particularly important as Greenland is, at the same time, aiming at making non-renewable resources extraction one of its main industries. This would provide much needed revenues and greater economic self-reliance, which again are important factors in relation to the future development of the Greenland Self-Government. The downside of such activities, of course, is the potential negative impact on the environment unless appropriate environmental protection measures are taken.

Warmer temperatures in South Greenland may also aid the farmers in their attempts to increase agricultural production and the breeding of livestock. The overall dominating sheep farming has, over the past few years, been supplemented by cattle, and the variety and distribution of local agricultural products have been on the increase.

New shipping routes

Under the headline 'Northwest Passage navigable', one of the nationwide Greenland newspapers last spring held an article quoting one of Denmark's leading scientific experts on sea ice (Leif Toudal Pedersen of the Technical University of Denmark), who stated that global warming has melted so much ice in the polar regions that the long sought-after sailing route through the Northwest Passage is now navigable.

The opening of the Northwest Passage clearly brings Greenland and the Arctic Region into a new geostrategic position, which may provide opportunities for servicing the ships passing through, but, at the same time, brings risks of pollution as well as potential interruption of the traditional migration routes of marine mammals. In other words, this is a threat to the industrial fisheries, which rely on the clean, cold, Arctic waters, and a threat to the traditional hunting and fishing, dependent on reliable sea ice.

Sovereignty issues

The melting of the sea ice also brings about the question of sovereignty, not only in relation to resource extraction. According to the Danish news agency, Ritzau, the draft report of the Defence Commission states that increase of cruise ships, illegal fisheries and smuggling activities moving further north will require increased military presence and surveillance.

Hydro as the way forward

The ongoing and projected development of the Greenland economy will impact both positively and negatively on global CO_2. Massive investments in hydro are reducing the country's dependence on fossil fuels. According to the national power company, Nukissiorfiit, hydroelectric power plants provided 42 per cent of the company's total production of energy for heating and electricity in 2007.

The national goal is to utilise hydro everywhere possible. Hence in 2010, an additional hydroelectric power plant will be in operation supplying electricity to the second largest town in Greenland, Sisimiut. To put these figures into perspective, however, oil and gas consumption today constitutes approximately 77 per cent of the total energy consumption in Greenland, whereas hydro so far only accounts for 7 per cent, and gasoline and kerosene accounts for 15 per cent (according to Atuagagdlit-Grønlandsposten, the national Greenlandic newspaper, February 24, 2009).

Hydro will also be the major energy source of the aluminum smelter that ALCOA has proposed to build in Central West Greenland. As in other countries with a limited manufacturing industry, increased economic activity instantly means an increase in carbon dioxide emissions. This has to be handled within the limits set out in the Kyoto agreement by which Greenland is bound today.

Submarine fibre cable

According to certain estimates, the global information and communication technology (ICT) industry accounts for approximately 2 per cent of global carbon dioxide emissions or a level equivalent to the aviation industry. There is an increasing awareness that – despite the overall environmental value of IT – this is currently not sustainable.

In that respect, Tele Greenland Ltd.'s new submarine fibre cable ('Greenland Connect'), which was inaugurated in early 2009, now connects Greenland to Europe via Iceland, and Greenland to North America via Newfoundland. According to experts this represents a new industrial potential, in combination with further exploitation of renewable energy such as hydro power. In addition to the sustainability of using hydro power for data storage, the cold Arctic climate would reduce the costs associated with the cooling of large data centres. Therefore, Greenland could be the right location for new zero carbon data centres, thus providing valuable 'green IT' to consumers in North America and Europe. This would of course be of interest to Greenland and to Tele Greenland, who are already sporting the slogan 'Greenland at the centre of the world'. Overall, this new development represents a very important opportunity for Greenland to contribute to Arctic and global sustainability, which should be explored further.

Hill-top relay station in West Greenland, with solar panels (photo: Tele Greenland Ltd.).

Self-Determination

So how do all these examples of climate change impacts relate to self-government? The Premier of Greenland, in his New Year reception of representatives of the Danish Government and Parliament, and the Diplomatic Core in Denmark, clearly emphasised the importance of political development with respect to self-government. The Premier described the happiness and pride that the Greenland people had shown when the Self-Government Commission handed over its report to the Danish Prime Minister and himself. The Premier also underscored the fact that 75 per cent of the Greenland people had voted in favour of the introduction of self-government. A self-government where, as he stated, 'we finally are being recognised as a people in accordance with international law, a self-government where we will be able to reap all revenues from our sub-soil resources and through that eventually also reduce the annual block grant we receive from the Danish state'.

The Premier talked at great length about self-government being a first step in an ongoing process towards independence, but he also recognised the evident impacts

A kayaker hauling ashore the submarine fibre cable at Nuuk, connecting Greenland with Iceland/Europe and Canada/North America. Tele Greenland Ltd.'s cable project is called 'Greenland Connect' (photo: Jørgen Chemnitz/Tele Greenland Ltd.).

of climate change, indicating that climate change will now assume an increasing importance on the political agenda. After elaborating on Greenland's participation in the Kyoto process, the message to the distinguished audience was that 'we are of the opinion that Greenland's potential for the production of CO_2-free and clean energy shall and must be tapped in full by the establishment of hydroelectric power plants and that it must be possible for Greenland to utilise this clean CO_2-free energy for industrial development, for instance in the establishment of highly energy demanding smelters or other such plants'. In other words, yes, we support the efforts to mitigate the impacts of climate change. However, we must also be allowed to develop our own economy in order to fully implement our right of self-determination.

Similar observations have been made by other members of the Greenland Government over the past few years, stressing the overall dilemma concerning – on one hand – the common responsibility in the fight against climate change and the ambition to protect and maintain biodiversity, and on the other hand, the urgent need for economic development – for instance in the non-renewable resources industry. This dilemma is not an isolated Greenlandic phenomenon. In relation to the recent Nordic conference in Iceland, observers raised the question whether the global financial crisis will mean lower priority to climate change or alternative environmentally sound solutions.

Adaptation and mitigation

So, what are we doing about climate change in Greenland? Firstly, although climate change has been slow to reach the very top of the political agenda, we are making an effort. The heavy investment in hydro is one example. The submarine cable and related potential benefits is another. But first and foremost, we are concentrating on the development of a sustainable society.

To refer once again to the New Year's greeting, the Premier also assured the distinguished audience of his government's commitment to mitigate climate change, explaining that Greenland participates actively in the Kyoto process. The minister responsible for the area, however, publicly announced in November 2008 that Greenland will not be able to live up to the Kyoto Protocol requirements and that a new climate strategy is underway.

The international process

The Government of Greenland is participating actively in the preparations for COP15 which will be hosted by Denmark in December 2009, where a major Greenlandic presence is planned (for more information, please visit www.climategreenland.gl). Greenland has additionally been pushing for full and equal participation in the Kyoto process for the world's indigenous peoples. Meetings and letters of support at the ministerial level have prompted the Danish Government to set aside funds for their participation. At the NGO or Indigenous Peoples' Organisation level, ICC-Greenland was an active partner to the Indigenous People's Global Summit on Climate Change, which represents a global preparation and coordination initiative which was hosted by ICC-Alaska in Anchorage in April 2009.

Generally speaking, Greenland is engaging at many levels of sustainable development and climate change focused activities around the world. This is because the Arctic region serves as an indicator of climate change, as has many times been demonstrated, and Greenland seems to be particularly susceptible. Climate impact assessments and observations at the community level in the Arctic point to the urgent need for capacity-building with regard to making strategies for adaptation. In this regard, the sharing of experiences and best practices is a key issue.

The Government of Greenland participates actively in the Arctic Council together with Arctic indigenous peoples' organisations, Arctic States and relevant observers. The monitoring and assessment of impacts of climate change on the peoples of the Arctic, the environment, and the flora and fauna has been the focus for some years, and an important body of information has been gathered and shared with interested international agencies and organisations.

Local efforts

At the local, practical and research levels it should be mentioned that the Government of Greenland, in cooperation with the Danish Government, recently established the Center of Marine Ecology and Climate Impact under the Greenland Institute of Natural Resources, which draws on both Greenlandic, Danish and foreign institutions and research. The centre provides an enhanced framework to monitor and assess climate changes and to ensure the necessary capacity building and local ownership of adaptation strategies in response to these changes. The main task will be to monitor and document climate changes and to evaluate their impact on Arctic society and living resources.

The institute, and now the centre, is engaged in a number of science-based, cross-disciplinary, ecological monitoring and research programmes. One is the 'MarineBasic Nuuk', which collects long-term data observing the effect of climate change and variability on the terrestrial and marine compartments in a low Arctic ecosystem in Kobbefjord near Nuuk. These data will be related to local, regional and global climate change variability and change (see: www.natur.gl; www.nuuk-basic.dk).

MarineBasic Nuuk is one of the more locally founded research projects. Much climate research is taking place in remote areas such as the drilling and studies of ice cores on the Greenland ice cap mostly undertaken by teams of Danish and foreign scientists. Results are presented via the media, often after it has been presented to the rest of the world, and in a way which is not easily understood or applied locally. Efforts to communicate and educate the public on the effects of climate change and the need to engage actively in the development and implementation of mitigation and adaptation strategies have so far been limited.

Having said this, the Government of Greenland supports projects and innovation in the area of sustainable energy sources, which, of course, is an important contribution to these adaptation and mitigation measures. Funds are being administered by the Climate and Energy Unit, and a register of thirty-six projects on alternative energy

A skilled and respected hunter dog sledging en route to the hunting grounds in Uummannaq, Greenland (photo: Paulus Nikolajsen).

Youth representative addressing the 2009 Youth Parliament in Nuuk, Greenland (photo: Greenland Parliament Bureau).

sources was listed in one of the nationwide newspapers at the end of February 2009. The Arctic Technology Centre, ARTEK, which is an innovation, education and training centre based in Sisimiut, accounts for many of these projects and is also offering local training in application and operation of the technologies – for example solar panels – to local construction workers and technicians. Other ongoing projects include Tele Greenland's testing of windmills at remote hilltop sites on the radio link connecting the towns and settlements along the west coast of Greenland. Windmills are supplementing the well-known solar technology on the sites with the purpose of reducing the use of kerosene burning engines.

Sustainable development

Global challenges – albeit being an important part of the news broadcasts – generally count little in the daily struggle to make ends meet. Notably, in comparison, sustainable use of the living resources has been the target of more intense scrutiny than climate change issues in the former Tulugaq (raven) campaign and travel show, which focused on engaging local users and the general public in discussions on sustainable development via town hall meetings, TV and radio broadcasts and school campaigns. The same methodology was applied in the information campaign concerning self-government. The idea is that the people concerned have to take ownership of proposed reforms or adaptations. This message also clearly came across at the annual Youth Parliament, 16-19 February 2009. This year's theme was specifically the opportunities and challenges of globalisation, and interestingly, in the final document, a number of the twenty-two recommendations address climate change or related issues. While there is an overall agreement that Greenland needs to exploit its non-renewable resources, there is also a clear message of precaution and the importance of accountability in a globalised world. To give you an example, one of the central recommendations reads more or less as follows:

> *It is fair, that consideration is given to Greenland's special energy needs and the need to develop the country's economy and employment. However, Greenland must take responsibility in the global efforts to mitigate man-made climate change. A modern, legally binding environment and climate strategy is urgently needed.*

Concluding remarks

Even though the effects of climate change may vary from place to place, they pose significant challenges for indigenous peoples and their rights all over the world, including the Arctic. Climate change threatens traditional lifestyles and culture, and puts pressure on biodiversity conservation and sustainable development in the broader sense of the word, even though some areas may also experience advantages.

As mentioned in the introduction, Greenland has for some time been the focus of many international climate change research activities. The climate change research was further intensified during the International Polar Year and will, together with Denmark's hosting of the UNFCCC, provide an excellent opportunity to demonstrate the urgent need for action, both in terms of developing adaptation strategies and concrete measures to mitigate negative impacts.

The question is, however, how to assert our rights in a world where global activities and agreements put increasing pressure on all nations to conform to the same rules, even though the preconditions may vary significantly. As stated by the youth and future leaders of Greenland in the final document of the Youth Parliament, 'We have to prepare ourselves to comply with the new environmental challenges that globalisation and Self-Government command'.

The Arctic in the New Creative Age: The Arctic Dimension of the Knowledge Economy

Alexander Pelyasov
Director of Center of Arctic and Northern Economies,
Council for Reproductive Forces,
Russian Federation

Abstract

This paper deals with several points of discussion. First, the necessity for Arctic scientists to be highly receptive to the toolbox elaborated by modern social science, that is, concepts of creativity, networks, post-industrial society and knowledge economy. Second, I suggest the framework of four distinct models of the Arctic economy and characterise only one feature of each model critical for the success of the knowledge economy – positive intellectual externalities connected with the agglomeration effect. Third, the idea is elaborated that in the conditions of the Arctic the network effect can sometimes be an approximate substitution for the agglomeration effect. Finally I try to convince the reader that due to the unique features of the Arctic, northern communities are universally more successful in building the knowledge economy than their southern colleagues.

It is crucial for Arctic science to utilise the latest achievements of global social science. For the Arctic this is a real challenge as it usually takes time for ideas to travel from the intellectual centres to remote regions. As a member of the European Regional Science Association (chairman of the Russian section) I know that the most powerful contemporary ideas among European scholars in social and regional science are those of the knowledge economy, knowledge spillovers and positive externalities connected with the agglomeration effect in metropolitan areas where talented individuals can easily communicate face to face with other talented people. There are dozens of articles or papers on this topic at the annual European Regional Science Congresses (ERSA Congresses) easily accessed at the ERSA website or at the websites of ERSA Annual Congresses (Amsterdam 2005; Cergy 2007; Jyväskylä 2004; Liverpool 2008; Volos 2006; etc.).

In such an intellectual environment it is clear that the global Arctic definitely needs the rapid implementation of these models and achievements from our colleagues from the neighbouring sciences and neighbouring regions to the Arctic. Let me first mention these frameworks before moving on to contemporary Arctic realities. They are R. Florida's (2002, 2007) ideas on the creative age and creative class; M. Castells' (2004) ideas on the network society; P. Drucker's (1994) ideas on post-capitalist (post-industrial, knowledge, service) economy and society; and F. Fukuyama's (1995) ideas on the economic role of trust in contemporary societies. This list surely can be continued, for example, we are obliged to mention works of D. North, M. Olson and many other social scientists on the institutions. However, my task is not to share with you the list of obligatory reading for the Arctic social scientist. Instead I wish to persuade you that all these concepts and frameworks can really help the Arctic under the challenges of global economic instability and climate change. Arctic social scientists should utilise them as their toolkit or toolbox.

Let us start with the agglomeration effect. I am one of the contributors to the Arctic Human Development Report (2004). Based on the Arctic demographic and economic data available before this report was launched (and then reading chapters of this report I saw that my conclusions were correct) I postulated that there are four distinct models of the Arctic economy: American (Alaskan Arctic), Canadian (Nunavut, NW Territories, Yukon), European (two versions – 'Regional' Nordic Arctic – Norway, Sweden, Faroe Islands; and 'State' Arctic – Greenland and Iceland); and Russian.

The Arctic Human Development Report very clearly differentiated Arctic territories by the proportion of their population in big urban settlements. For the knowledge economy this 'agglomeration effect' is a critical factor, as it generates favourable conditions for positive knowledge externalities. The agglomeration effect is greatest in the Russian Arctic (the majority, more then 80 per cent of residents, are living in urban settlements). We can thus suggest that the knowledge potential of the Russian Arctic and northern regions is high. I made an evaluation of the global creativity index for the Russian regions using Richard Florida's methodology described in his recent book *The Flight of Creative Class* (Florida 2007), and the Russian North and Arctic regions obtained a high position in this ranking (Pelyasov 2008).

Next in order of agglomeration come the Alaskan Arctic and Iceland. Here more than 60 per cent of residents live in urban (big) settlements. This means that the agglomeration effect critical for the production of new knowledge, creativity of the residents and innovative development is a bit weaker here. The Canadian Arctic, Greenland and the European Arctic (Norway, Sweden, Finland) are the last in this list as only 30 to 50 per cent of the residents of these regions live in big urban settlements. People live instead in small settlements dispersed across millions of square kilometres. So the challenges of being creative in the era of the knowledge economy are the strongest here, as face to face communication and regular personal exchange of ideas are very expensive, and there is the biggest risk of being isolated from the world knowledge 'pipelines'.

So the question is what can be done for these marginal Arctic regions to overcome intellectual remoteness in an age when fresh knowledge is critical for innovative development and competitiveness? The network effect and network externalities now become important for the Arctic regions where the agglomeration effect does not function efficiently. Indeed, one of the clear distinctions between Arctic regions and the 'mainland' regions is the strength of the network effect in regional economies. By the network effect I mean the possibility of using irregular personal contacts between bearers of different knowledge and traditions, who are as a rule residents of settlements and regions located very far from each other (and therefore these places are very different in their cultural traditions, level of economic development, etc.). One of the good examples of the network effect in the Arctic was the tradition of the annual fair between Chukchee reindeer herders and Inuit marine hunters in Chukotka at the beginning of the twentieth century (see e.g. Krupnik 1995). The importance of such fairs went much further than the simple exchange of food. They were an exchange of news, ideas and technologies between very distantly located groups of people, and in some cases even involved the search for a marriage partner. My hypothesis is the following: the weaker the manifestation of the agglomeration effect in the Arctic, the stronger the manifestation of the network effect.

Arctic regions are very successful in creating networks, for example the open learning networks such as the University of the Arctic and the Northern Research Forum, and also SAON – Sustaining Arctic Observing Networks – which is a collective effort of 350 researchers. Arctic social networks include connections between recent Arctic emigrants to more southerly cities and the Arctic communities they came from, as well as between southern immigrants to the Arctic and their social milieu of origin. This is a good example that Arctic regions can share with the rest of the world. Under the risky and unpredictable social and climatic environment, creating new and maintaining old networks (joint ventures, councils, partnerships of different kinds, etc.) can be a successful strategy for sustainable development. Climate change will influence network-building in the Arctic and we should use new possibilities to enrich and enlarge contemporary Arctic networks.

We should use network solutions to attract talented people to the Arctic – the key economic factor for successful development under the conditions of the knowledge economy. Arctic labour contracts should be adjusted to better correspond to the needs and values of talented people from outside. It is critical to strengthen the Arctic's image as a land of discovery, an adventure territory and a magnet for researchers. Climate change could make the Arctic more attractive for talented people.

We next turn to Arctic achievements in the development of the knowledge economy. In this period of global economic crisis it is critical to look for positive examples of human creativity and successful adaptations to the challenges of climatic and economic change in the Arctic, which may be important and encouraging for the rest of the world. At present we know that the countries of northern Europe are more successful than southern Europe according to all officially elaborated indicators of the information society, human capital and innovation activity. Norway, Iceland, Sweden and Finland are European champions in many innovative rankings in the general creativity index elaborated by R. Florida (2007) (Figure 1).

Denmark, Ireland and Great Britain are located close to the leaders. Our critics can say that the success of Nordic countries can be explained by their model of the welfare state which they have developed successfully for the last decades. It must however be noted that it is not by chance that this model was elaborated in the north of Europe and not in the south.

The EU project AsPire, in which the behaviour related to contracts between industrial firms of the northern and southern European periphery was compared, revealed a principal difference (Copus et al. 2003). 'Northern' firms have more subcontractors outside of their region than 'southern' firms, and the market for their final products is more often located outside of their region. The extensive links of the 'northern' firms carry more innovative potential for new knowledge

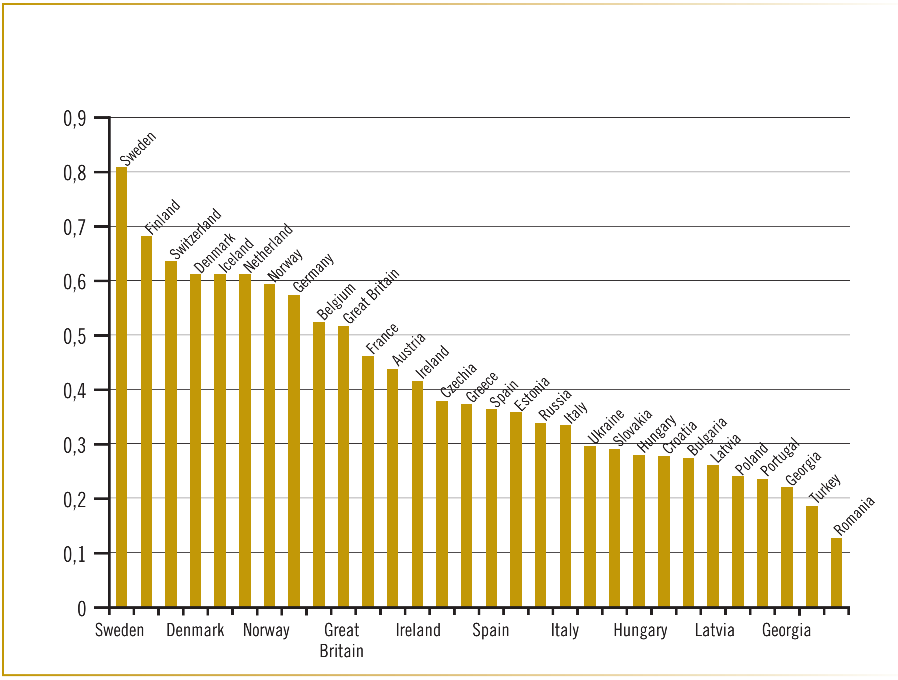

Figure 1. General creativity index for 30 European countries. The major indicators of innovative activity in northern Europe are better than in southern Europe.

than the closer links of the 'southern' firms. As distant subcontractors are located in regions with a different economic atmosphere and other cultural traditions, they therefore enhance the injection of new knowledge and new perceptions much more than subcontractors located in the same region as the industrial firm, and cultural and intellectual plurality is critical for the success of innovative activity.

A study by my colleagues from the Institute of Social and Economic Research, University of Alaska, Anchorage has revealed that the density of non-profit organisations in the State of Alaska is 25 per cent higher in comparison with the average level in the US (Goldsmith 2006). Their share of the total employment figure is also higher in Alaska than in the US. These facts suggest that voluntary work is more developed in the north of the US in comparison with the rest of the country.

But how can we generalise these numerous examples characterising unique peculiarities of different northern and Arctic territories of the world from the point of view of the challenges of the knowledge economy? In Arctic and northern communities we do see some fundamental features which help them to be more successful in the knowledge economy and be more dynamic in their movement to the information society, in comparison to southern communities.

First of all is their openness, for example the involvement of the majority of economic actors and households from the European Arctic regions in extended links and face to face communication with partners from the rest of Europe. In the case of Alaska this is with partners from the 'lower 48' states, and in the case of the Russian Arctic with contacts from the 'mainland' regions. Inconceivable for the 'southerners', the openness of Arctic actors helps them to be receptive to new knowledge and to constantly learn. The openness of the Arctic and northern communities is connected directly to their mobility, with active migrations not only inside the borders of their own region, but further – inside their country and even across the world. This is also a particularity of the northern regions and countries. Communities in the south of Europe and Russia are in general more stable.

Another fundamental peculiarity of the northern communities is their cooperativeness. By this term I mean their capacity to build networks, associations and unions on an unallied (not connected to relations with relatives) basis. American political scientist F. Fukuyama (1995) called this feature 'spontaneous sociality'. He considered the economic role of trust and spontaneous sociality at the national level (for Japan, South Korea, China, France and Germany), but ignored zonal factors totally. This is unfortunate as zonal and geographic factors are critical in the development of human behaviour, and of course trust is one of the most visible features of human behaviour. Therefore we cannot ignore them. The Arctic, as the territory where zonal factors play such an outstanding role, is a remarkable example of the influence of geographic and natural factors in defining human behaviour.

Because of this disagreement with F. Fukuyama I prefer to use the term 'cooperativeness' and not 'trust'. The term cooperativeness by my definition does have clear zonal (zone-dependent) meaning. In this approach I follow the traditions of P. Kropotkin who in his famous work *Mutual aid: a factor of evolution* (2006) revealed fundamentally different principles in the organisation of life among biological species of North-East Asia in comparison with the temperate zone. Scrupulous study of the oral histories of the indigenous groups of northern Russia reveals the absolute value of generosity and sharing, with greed under a taboo. These values (like voluntary work) can also be taken as features of cooperativeness. This is natural, for in a world of huge unpopulated areas and extreme natural conditions, values of cooperativeness rather than of competition are of high priority. The whole necessity of everyday survival demands such values.

Another feature of northern and Arctic communities that differs from the 'southerners' is their tolerance and great ability to include outsiders in their community, which may be unthinkable for the much more clear-cut communities of the southern countries and regions. Indeed, according to the proportion of migrants from outside regions and countries, northern and Arctic territories are universally far ahead of southern communities. This means that 'strangers' are included in the new community with ease.

It is interesting that comparison of Arctic communities and creative communities from other intellectual territories of the world, for instance Silicon Valley, can reveal similar features. For both, openness, mobility, cooperativeness (generosity in information sharing) and tolerance are characteristic features of behaviour. These features help them to easily form networks like partnerships, joint ventures, unions and associations. These networks are places where bearers of different knowledge can meet, which is helpful for radical innovations. To put it shortly, Arctic indigenous groups have long traditions of sharing subsistence food and the communities of Silicon Valley have traditions of sharing new knowledge. The very features that have been developed in the Arctic communities during their survival for centuries in a difficult environment are much in demand in the knowledge economy. Not surprisingly these will now help them to move surely on the route to the knowledge economy.

Technological factors and conditions are also very important in the knowledge economy. However, the fundamental peculiarity of the new age is that the human dimension of innovative development is of higher importance. To put it another way, the community values and individual experiences of a person simplify economic transformation for the knowledge society or conversely, reduce possibilities to learn. The knowledge economy and information society are in reality very social and highly community-dependent phenomenon. The household was the dominant institution of the pre-industrial era, the factory of the industrial era, and the community is the principal institution of the post-industrial (service, knowledge economy) era. It is not by chance that the penetration of information technology into each household and into the social services (education, health and culture), which involves every member of the society, has provided the real success of the new knowledge economy, rather than the digitalisation of industrial enterprises.

The idea that the Arctic and the North are successful in innovative modernisation in the building of the new knowledge economy, compared to the rest of the globe, is often at first met with disbelief. Certainly we can find examples in which separate countries from central or southern Europe are more successful in the indicators of the information society and innovation activity. But we would like to draw a general picture, and this does give us basis for optimism of the possibility that the Arctic and northern regions can fulfil effective economic modernisation for the challenges of the knowledge economy.

I think it will be very helpful to go beyond the initial idea of the Arctic Social Indicators (ASI) project which is a follow-up to the AHDR and elaborate an Arctic creativity index for the Arctic regions using not only general (by R. Florida 2007) but also Arctic-specific indicators (see Pelyasov 2009).

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Section 6

EDUCATION

Education for Arctic Sustainable Development

Lars Kullerud
President, University of the Arctic, Norway

Abstract

Education is an essential component of sustainable development. However, for the Arctic there is a history of education systems that tried to force central school models on local people, including different degrees of suppression of local language. This has been improved today to various degrees in the Arctic states. However, lack of skilled teachers with local roots is a circumpolar challenge. Arctic higher educational institutions also face many challenges when attempting to be innovative and competitive due to their small size and geographic isolation. The model of the University of the Arctic allows for a dynamic development of shared education systems through mutual cooperation. This network can be a very efficient tool to for delivering a relevant curriculum for a changing North.

The Arctic and the World(1)

Today's world is more dependent on the North(2) than ever – a dependency that will only grow in the future. The North represents invaluable resources, globally vital ecosystems, an important platform to conduct research and understand our dynamic planet, as well as a dream of a different land: a pristine part of the earth for the mind to explore. Seen from the south, the Arctic may be a frontier or a

(1) This article is partly based on Uarctic Shared Voices, IPY legacy, 2008, authored by Kullerud and Snellman.

(2) The term 'the North' is here synonymous with the wider definition of the word 'Arctic', as it is used in the Arctic Council, Barents Euro Arctic Council, by the University of the Arctic as well as by Arctic Indigenous Peoples (Permanent Participants of the Arctic Council). In this case Arctic is not limited to the high Arctic i.e. Arctic Ocean with its archipelagos. Many discussions and articles often confuse those two possible understandings of what is the Arctic.

modestly relevant periphery, but the Arctic also represents a fifth of the Earth's surface,[3] and is similarly important for the services that its environment provides to humankind. Sustainable development of this region is thus critical to the rest of the world.

The North has been a homeland for people for thousands of years. For a few centuries it has been an arena for exploration, exploitation and land claims by national states. The last decades have given us a melting of the political ice but also melting of sea ice from rapid climate change. The Rovaniemi Process, which started in 1991, led to a unique partnership between governments and indigenous peoples to safeguard the Arctic environment and ensure the sustainable development of the region through what is now the Arctic Council. Now, 18 years later, it is more imperative than ever that indigenous and state political leaders work in cooperation with local communities, academic institutions and the private sector to build a resilient and strong North.

Challenges for the North

As a source of vital resources, the North for centuries has been managed as a distant 'colony' within each nation state. It has been a place where one sends experts, soldiers, doctors, managers, workers and teachers, while resources and young northerners are sent to the south. The new international cooperation, different types of local governance, and the establishment of new higher education and research institutions all show hope for a new future. The North can become a region which is empowered to provide goods and services globally on equal terms with other regions in the world.

The norths of the different Arctic States face many similar challenges. They need to build capacity for daily governance, develop human as well as natural resources in a sustainable way, create jobs and develop opportunities for their populations. Furthermore, they need to provide the world with vital resources like lumber, metals, fish, oil and gas, and services like transportation routes, pristine nature for recreation and local knowledge about the North, as well as opportunities for research vital to understanding the Earth system. These developments need to be done in a region with an extremely low population density, and a history of 'colonial style' management by the national capitals.

(3) Depending on the definition, the Arctic may be between 14-20 per cent of the Earth's surface.

Unfortunately the North has generally been perceived as a periphery, and investments in education have historically been done from a 'help' and 'frontiers' perspective, even if there are shining exceptions in several countries. The governments of the Arctic countries have met the challenges of the north with school systems that are often identical to the systems provided in large towns in the south. Rarely have these education systems been adapted to local needs. Different kinds of higher education institutions in the North have been established, ranging from those focusing on training students for the local job market through professional education, to science-based universities, often modelled on higher education institutions in the southern parts of the country.

Primary and secondary education

The UNESCO led 'Education for All' movement has led to a Canadian and Norwegian Arctic initiative which produced a preliminary overview report on the state of education in the Arctic (Rønning and Wiborg 2008). This report confirms the general picture described above, and also the similar findings expressed in the 2004 Arctic Human Development Report and by indigenous leaders of the Arctic.

There is a clear correlation between the level of education and income in the Arctic. An important observation is that both those completing an ordinary school system and those who receive good training in traditional skills through non-formal education have better economy than those who drop out from traditional or ordinary forms of education. Not surprisingly, those who have higher education have the highest income in the communities (Krause et al. 2008).

Arctic communities, and in particular rural areas, face high drop-out rates in primary and secondary school. For all of the Arctic there is a history of education systems that tried to force central school models on local people, including different degrees of suppression of local language. This has been improved today to various degrees in the Arctic states. However, lack of skilled teachers with local roots, in particular in rural areas, is a circumpolar challenge.

Even if there are exceptions, the school systems provide an education modelled on Western values and content. Local and traditional knowledge is only valued in good-will speeches and is normally not valued in admission to further education, jobs, or in evaluations of education systems. Education is normally driven by central norms that poorly fit the local needs, and does not provide education and training relevant for local job markets. This leads to a continuation of the old system, with a high degree of unemployment, import of experts (often only short-term), and out-migration of youth. It is normally the females that leave and males who stay behind, leading to many social problems.

It is time for a shift from viewing knowledge as a standardised commodity to seeing it as a distributed resource. Decentralisation of control and decision-making in education is needed, as are local adaptations of curriculum, and increased use of alternative approaches to access knowledge from any place at any time (Rønning and Wiborg 2008).

Higher education

There is a global trend towards bigger units and more centralisation both in the private and public sectors. This is a general challenge when one aims for sustainable development of the sparsely populated Arctic region. This trend is also evident in higher education: larger universities provide the benefit of more comprehensive programming, the ability to develop world class research in some areas, and the capability to promote themselves in a competitive research and education market. This strategy, based on the need to be robust, dynamic and well-known in one's own right, is resource demanding and therefore a driver towards larger entities.

The less populated North cannot easily host comprehensive universities and professional education institutions of a size that can match this development. It is, however, not the total size of a university which determines its excellence in a specific area at a given time, as good research groups tend to be modest in size. Many of the same challenges can be solved by smaller institutions if they cooperate in networks, share resources, and divide roles in an efficient manner. The circumpolar network of smaller and larger institutions can form the critical mass for expertise in any field by their collective size. Through a well organised network, partnered universities will be better equipped than any single institution, even if it is large, to develop and maintain world class excellence in several disciplines as well as foster education, research and training that is relevant to sustainable development of the Arctic region.

To address this, the higher education institutions in the circumpolar North have formed the University of the Arctic (UArctic). UArctic allows for a dynamic development of the shared education systems through this kind of cooperation. Smaller learning centres can provide relevant quality education for people who seek higher education within their community or region, based on curriculum developed through circumpolar cooperation. The same learning centres may be developed to serve the infrastructure needs of shared research projects and thus benefit universities that do not have access to such infrastructure. A complete network in the Arctic region can be a very efficient tool for delivering a relevant curriculum for a changing North.

Practically all northern universities, colleges and organisations engaged in higher education have come together in the University of the Arctic, currently a network of 121 members. The leaders of UArctic higher education institutions have signed a declaration, the UArctic Charter, which demonstrates an unparalleled will to share resources and goals across national and institutional boundaries to ensure research, education and training in and about the North. The ambition is for a dynamic UArctic that uses its members' resources and capacity in a flexible and adaptive manner to meet the needs of the North as it changes over time.

UArctic members are ready to take a collective responsibility as leaders of research and education relevant to northern communities both to serve the North's internal needs as well as to equip the North with the capacity to serve the rest of the planet. In UArctic, through its members, the North has the higher education opportunities needed to ensure leadership and competence to develop its own relevant strategies for knowledge generation and sharing, as well as for education to ensure sustainable development of the North.

Research

The global academic community has practiced international cooperation in Arctic research since the first Polar Year 125 years ago. It laid the groundwork for a century in which the Arctic has become an increasingly attractive arena for scientific research. The International Polar Year (IPY), now ending, represents hope for a future with intensified research and increased attention to the polar regions, including on human perspectives. The people of the North are no longer only an object of study; instead, indigenous peoples and other northerners together take active part in the development and governance of the region, and in defining the research agenda for the North, with 'shared voices'. After this IPY the global research community, in particular that located in southern latitudes, who seek to study in the North will benefit from partnering with a growing well-educated northern population and with the Arctic higher education and research structure.

The University of the Arctic is ready to take the lead in providing stewardship for a sustainable long-term legacy of the Polar Year in higher education and research cooperation in the Circumpolar North, which promotes both Western academic traditions as well as traditional and indigenous knowledge in the northern knowledge base. It is a goal we hope we share with the whole science community; that future leaders of polar science are just as likely to be recruited from youth from the North as from today's southern-based research communities. UArctic will provide this leadership in close cooperation with the global polar research community, in particular the major polar science organisations, such as the International Arctic Science Committee (IASC) and the Scientific Committee on Antarctic Research (SCAR), as well as the International Arctic Social Sciences Association (IASSA). We hope that UNESCO and other global organisations will support this endeavor.

Further, UArctic is committed to ensuring that the northern universities and colleges become key players in the development and sharing of knowledge in and about the North and that such knowledge is based on indigenous and local traditional approaches as well as modern science approaches to knowledge generation and sharing.

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People on Thin Ice: The Need for Education and Research in Greenland

Ann Andreasen
Leader, Uummannaq Children's Home, Greenland
Director, Uummannaq Polar Institute (UPI), Greenland

Abstract

The Uummannaq Children's Home/Børnehjemmet, works with disadvantaged Greenlandic children, bringing together knowledge of traditional Greenlandic ways of the land, hunting, gathering and homemaking with the Western traditions of art, music, science and economics. Such education, combining traditional and Western aspects, is essential for the sustainable development of Greenland. Linked to the children's home is the recently created Uummannaq Polar Institute (UPI), where foreign experts work closely with knowledgeable members of the local community to identify and address gaps in scientific knowledge. Through such collaboration, the pressing environmental and social challenges facing the Arctic, including climate change, may be better resolved.

Genesis of the children's home and the Uummannaq Polar Institute

For the past twenty-five years, my work in northern Greenland has been dedicated to healing and educating children and young people from all over Greenland. These are Greenlanders who have been adversely affected by social changes from the outside world. These outside changes have not only proved to be cumulative; the rate of those changes has dramatically increased.

As US Secretary of State Hillary Clinton wrote a few years ago, quoting what is considered to be an ancient Igbo proverb from Nigeria, 'it takes a village to successfully raise a child' (Clinton 1996). Where the settlements and villages of the District of Uummannaq fail to raise their young, the Children's Home/*Børnehjemmet* serves that function. With

Ann Andreasen with hunters and children on ice in Uummannaq (photo: Jean-Michel Huctin).

the objective of healing these children, who are often struggling in one or more ways, we build a surrogate community. It is nevertheless a very real community. Here, we bring together the elders, women, hunters and fishers who are knowledgeable of traditional Greenlandic ways of the land, hunting, gathering and homemaking, and we also teach the Western traditions of art, music, science and economics. With teachers, social workers and psychologists, we bring together these two worlds. Collectively, with the resources of the children's home, we create a 'village' residential home.

The curriculum includes hunting, fishing, music, art, science and culture. Practical activities are designed to be educational, for example travel to Europe for two months or the purchase of old homes and their restoration by staff and children. Through these activities, children also learn how to read and write. Satellite homes in the district which are administered and staffed by the Uummannaq Children's Home can be found in settlements like Ikerasak, Ukkusissat and Qaarsut, and in the hunter's camp located in the abandoned village Uummannatsiaq. The annual staff complement is fifty to sixty per year which includes teachers, environmental therapists, cooks, maintenance, household workers, hunters and fishers.

A recent activity which traces its genesis to the work of the Children's Home is the Uummannaq Polar Institute (UPI). Because of a half-century of association in the

Arctic with scientists and researchers and given the occurrence of the International Polar Year 2007–2009, the Uummannaq Polar Institute (UPI) was created. By design the UPI serves as a needed workshop in which the knowledge gaps in science and research can be identified and subsequently addressed. Occupying its own building and facilities, the institute is adjacent to the children's home complex. Through the work of the home and now through the UPI, a close association with scientists, researchers, artists and communication specialists continues to develop. These foreign experts work closely with issues which closely relate to environmental change and cultural impacts (biological, social and economic), as well as to strategies for remediation. However, many gaps exist in the knowledge within each scientific paradigm as well as between paradigms. As a solution Wilson (1998) offers his model of 'consilience', which is 'literally a jumping together of facts and fact-based theory across disciplines to create a common ground for exploration' (Wilson 1998:8). Included are the social sciences, physical sciences and humanities, as well as history and traditional knowledge. The complex nature of environmental and ecological problems and analysis requires this melding of many disciplines.

It is at the UPI that foreign experts can assemble and avail themselves of the valuable skills and traditional knowledge of local hunters and fishers as well as that of the older wards of the children's home. These Greenlanders, through year-round residence in the north, can help research through monitoring changes in the Arctic. The world of science depends upon the collection of these field data. Without a continuing record of spatial and temporal information, scientific models are devoid of value.

For many years, we of the North have witnessed the often adverse effects that climate change has had on the daily life of Arctic peoples. The UPI serves as a channel for people with first-hand knowledge of this change to study, discuss and offer suggestions as to how Arctic culture can continue to sustain itself – as it has done for four thousand years in Greenland (McGhee 1992; Scheldermann 1990).

Pollution and climate change – effects on life in the Arctic

As educators our traditional focus in the Arctic has been on changes in culture and technology and on the synthesis of the Western cultural world with the traditional Greenlandic/Inuit world. Increasingly, the primary focus of attention is now on climate change, with the Arctic regions proving to be those latitudes on planet Earth that have been most impacted. With climate change, there is a mélange of more frequent winds, erratic ice conditions, enhanced rainfall and fog, and changes in sea currents and the fauna dependent upon those currents, such as the polar bear, seal and cod (Royal Embassy of Denmark 2008).

Of additional and particular concern is the pollution borne north by air and sea currents. Through ingestion and bioaccumulation in the food chain, the traditional Inuit diet of seal and whale has become hazardous to human health as indicated, for instance, by increased incidence of cancer and brain embolism. This forces Arctic people to buy imported foods which are expensive and often of questionable nutritional value. To make these purchases, Arctic people of the land must enter the wage economy (Wenzel 1991). However, the wage economy is next to non-existent – particularly in small settlements. Recently, in collaboration with a Dutch film crew, we produced a film to focus on these problems, *Silent Snow* (2007).

For many people in Greenland – especially in small villages and settlements in the outer regions, the subsistence economy still prevails. Due to changes in the climate, this way of life has increased in difficulty. Both the lack of sea ice in winter and spring and the generally more unstable weather, with heavy unpredictable storms that often last days, have made work as a hunter and fisher hard and dangerous. On the sea, there is often too little ice for dogsleds and skidoos but still too much ice for using boats. During these hiatuses, Royal Greenland fish plants often close down. Valuable days that would otherwise be used to gather protein from the sea for either the subsistence or market economy are lost, as Inuit wait at home for improved weather conditions.

If families stay in the outlying settlements, they are likely to endure extended periods of deprivation without access to food. This insecurity largely explains high rates of stress and anxiety which can – and do – lead to a variety of social problems. A particular manifestation of this is the victimisation of children.

Due to a generally low level of school education, it is hard for family members to get jobs in the more wage-oriented economies of Greenland in, for example, Nuuk, Uummannaq, Ilulissat and Qaqortoq. If these families choose to move voluntarily or if they are forcibly displaced as a result of a state policy of closing down communities, there is often no housing available. For example, according to the Greenlandic newspaper *Atuagagdliutit* (2009:6), the waiting time for rental housing in Nuuk is now twenty-nine years. Families or individuals who seek housing often end up in ghettos with exposure to substance abuse and with children falling through the cracks and into a life of social alienation. The dilemma for these people is easy to see but not as easy to deal with. Pride and traditional culture keep many alive but it is an everyday struggle for them.

UNESCO visit by the Uummannaq Children's Home in 2007 (photo: Jean-Michel Huctin).

Better education for the Arctic Peoples, more information to the public worldwide

Remediation of pollution and climate change will take decades. Through the forthcoming UNFCCC COP15 scheduled for December 2009 in Copenhagen, at least a foundation is being laid for addressing a reduction in CO_2, as the major global pollutant. However, it will take decades to achieve a measurable change even with this one strategic objective which underlies much of the Earth's pollution.

With pollution in mind, it is important not to just sit back and wait for these changes to come. Here in the Arctic we must take action as soon as possible to ensure an acceptable quality of life. As the quality of Arctic life continues to be compromised by climate change, we need to help the Arctic peoples to live under improved conditions. For them, the task is often beyond their limited resources. As programme managers and opinion leaders, it is our responsibility.

The paramount way to help these at risk peoples is through the promise of employment. Job careers which do show promise in Greenland include the IT and tourism sectors with their need for programmers, computer operators, graphic design and animation specialists, cross-trained educational specialists, technicians and repairmen. Solid working knowledge of Danish and English are needed for jobs in


Uummannaq Children's Home and Uummannaq Polar Institute (photo: Jens Ole Josenius).

the field of IT technology, as well as – with an eye to the European community – French and German. It is important to note that English is the language of travel and tourism throughout that entire sector. These are all skills which are readily transferable and where distances, for example, between Nuuk, Uummannaq, or Ilulissat and Iqaluit, Copenhagen, London, Berlin or New York are of little relevance. Yet another plus is an enhanced sense of self-worth which can carry the individual through future hard times that may occur.

However, it can be difficult for a student to acquire sufficient educational support from either family or the government. Without financial resources from these social safety nets, students often give up and return to their small settlement and a life which is contingent upon the whims of nature.

Sharing knowledge

It is our hope that knowledge gathered by scientists and researchers under the umbrella of the Uummannaq Polar Institute will be available to the world. It is our expectation that through coordination with the UPI these Greenland-trained IT and language specialists will find work opportunities with these scientists and researchers.

Furthermore, there is a need to make the general public – particularly the Arctic peoples – more aware of the impending catastrophe of climatic change. Scientific research is important, yet because of the gaps caused by the complexities of feedback loops and climatic factors yet to be discovered, scientific projections may fall short of the desired level of statistical accuracy. People of the land are becoming fewer. Barry Lopez (1998:135) writes of these people who possess traditional knowledge that '…something strange, if not dangerous is afoot. Year by year, the number of people with firsthand experience on the land dwindles'. However, by combining the traditional knowledge of Arctic peoples with the research paradigms of the scientific community, we may be able to enhance the accuracy of these projections, as well as provide further clues to the causes of climate change.

Upon leaving Greenland, Gretel Ehrlich (2001:277) wrote:

> *It's too bad for you when you visit Greenland, because then you have to keep going back. When you have been with those people – with the Inuit – you know that you have been with human beings.*

The people of Greenland stand ready to serve the global community and help them to understand climate change.

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The Role of Nomadic Schools in the Revival and Preservation of the Cultural Heritage of Indigenous Peoples of the North and Arctic

Anastasia Lebedeva
Deputy Head, Center of Nomadic Educational Institutions Development,
Russian Federation

Abstract

Nomadic schools provide innovative and culturally appropriate forms of schooling for nomadic reindeer herders in the Russian North. By combining traditional skills and knowledge with national curricula, children are better equipped for modern challenges within a northern context. This form of schooling also supports the preservation of traditional nomadic subsistence livelihoods, as children are able to remain with their parents during the educational process, and parents are free to move while their children are being educated.

Nomadic schools have been created due to a series of critical social problems: disappearance of traditional ways of life, disturbances to the ecological milieu in which indigenous peoples live, and poor social conditions.

Pupils of nomadic schools (photo: Anastasia Lebedeva).

The first nomadic schools were created in our country in the 1920s and 1930s. Some were later closed and stopped their activities over a long period, but today, many of these nomadic schools have reopened. The nomadic schools in the Republic of Sakha (Yakutia) were opened in the beginning of the 1990s. With the active support of the Ministry of Education of the Republic of Sakha (Yakutia), they have appeared in the Aldansky, the Olensky and the Momsky ulus (areas), for the schooling of Evenk children. Unfortunately, one of those schools was closed during its first year, and the others have experienced problems related to material and financial costs (Neustroev et al. 2006:5).

Today in the Republic of the Sakha (Yakutia) ten nomadic schools are functioning, nine of which are UNESCO's pilot schools. All of these schools are subsidiaries of support schools (village schools), although each is different and has a specific character. This specificity is needed due to many factors, such as the type of activity that the parents are engaged in (reindeer herding, hunting, fishing), the diversity of culture and language (five different nationalities of northern indigenous peoples live in the republic: Even, Evenk, Yukagir, Dolgan and Chukchi), population size in communities, children's age, etc.

Nomadic family in Tomponsky ulus district (photo: Anastasia Lebedeva).

Nowadays, there is a process of growing self-consciousness and outside recognition of indigenous peoples' cultures. Recently, among scientists, researchers and representatives of indigenous people of the North, worries have arisen about the loss of native language, culture and traditions. As was noted in the 2003 Egorov and Neustroev monograph: 'The foremost worry is about the loss by northern indigenous people of their traditions, valuable forms of national culture and native languages, with concern for their complete extinction in certain places. All this leads to the destruction of national psychology and culture' (Egorov and Neustroev 2003:14).

The modern nomadic schools are different from previous ones. 'The specific importance of school for the children of the North is that they should here form an awareness and respect for their culture and territory. The school takes the role of an ethno-consolidating centre and becomes an ethno-cultural focal point, cultivating the intellectual, spiritual, creative and moral potential of future bearers of national culture' (Egorov and Neustroev 2003:99).

In northern conditions, depending on the specific character of the natural and climatic zone and the type of economic activity, the nomadic school is a mobile form of education, in which in general two types prevail, nomadic and stationary-nomadic. Accordingly, we have developed seven educational models:

Model 1. Nomadic school – kindergarten

This type of school, with a structure and content adapted to the nomadic lifestyle, creates conditions for the children to familiarise themselves with the culture, customs and traditions of their own people, and to be educated while maintaining daily contact with their parents. This nomadic school nurtures strong bonding within families, the continuity of knowledge and culture between generations, and the preservation and the revival of traditional economic activities and lifestyles of small indigenous groups.

Model 2. Community school

This type of school, through its structure and content, fills the same function as would a stationary school for a small number of children up to 14 years old. It is unique and is part and parcel of the social medium of the small territories of small indigenous groups. The main difference is that the school – pupils and teachers – may all be one extended family, which has an impact on the organisation of the educational process.

Model 3. Tutor school

This is a type of school in which the teacher comes to the area where herding is taking place, and teaches in nomadic conditions, and lives with the family and pupils. The first Even tutor worked at the beginning of the 1990s in the area of Burkatymnakh Momskiy ulus in the territory of a skilled and licensed hunter.

Model 4. Taiga school

This is a school where children who are taiga dwellers receive education from their parents as consultant tutors. The taiga units of schooling are combined with lessons taken at a support school elsewhere.

Model 5. Stationary-nomadic school

This is a type of school in which pupils go for a specified time to the herding area, where they study subjects related to ethno-cultural themes, and take general lessons with national-regional components.

Model 6. Network nomadic school

In this type of school, teachers circulate among several herds. The teaching is thus a combination of full time tuition and tuition by correspondence. The structure of the teaching process comprises full-time meetings with teachers *in situ*, teaching *in situ* with parental consultant tutors, and full time teaching in support schools.

Model 7. Summer nomadic school

This is designed for the emersion of pupils who do not speak their own language into a native speaking environment and culture.

An analysis of educational work in these schools demonstrates a rise of conscious motivation to learn native languages and traditional culture and to engage in education as a whole (Neustroev et al. 2006:5-6).

An example of a nomadic school is the nomadic Evenk school kindergarten 'Kuonelekeen', which has been functioning since 1991 and is linked to herd Number 5. It is a subsidiary of the Khar'yalakhasky secondary school. The distance from the main school is 50 km. Transport is complicated; during winter skidoos are needed to make the journey, and in spring and summer the main means of transport is helicopter or all terrain vehicle. The facilities and equipment for the children's education are situated in a specially sewn tent with an iron stove, and radio communication is established with the inhabited area of Khar'yalakh. The school has two teachers of elementary classes and seven pupils, five of whom are of school-going age, and two of whom are of preschool age. The school runs from January to May. Meanwhile, secondary basic school runs from October until January. Under arctic tundra conditions the school successfully fulfills the tasks of education and training for the children without loss of contact with the family, and allows familiarisation with traditional activities, and the preservation of the cultural heritage of nomadic Evenks. Besides the subjects that are obligatory federal components, the pupils study subjects of regional relevance, such as 'basics of reindeer herding' with field studies, 'applied arts and sewing' and local sports. Over the years the teacher, Kirillova Klara Vasil'evna, has been roaming the land with her husband and children. She has developed the concept of a nomadic community within a modern context. Being the mother of the clan, she fulfils the important task of educating children to be in harmony with nature, allowing the child to choose their way of life and their own individual educational strategy (Golomareva 2004:43).

Regional gathering of reindeer herders (photo: Anastasia Lebedeva).

Under the conditions generated by the modernisation of the Russian education system, nomadic schools are in some ways seen as a dilemma, and there are supporters and adversaries of this form of education. Many call it 'golden', because of the large financial investments and costs involved. Others think that for nomadic reindeer herders, these schools are vital. People who do not know the nomadic peoples and their culture may be puzzled: why have these people decided to restore what would seem to be an old form of teaching in modern times, when the stationary schools are equipped with new equipment and teaching aids, and when innovative technologies are utilised everywhere?

The Ministry of Education of Republic of Sakha (Yakutia) also leads an active programme for the education of indigenous peoples, and supports the nomadic schools:

> *With the aim to satisfy the educational needs of peoples of the North, the strengthening of family, the preservation and the renewal of traditional activities and lifestyles of indigenous peoples, the Ministry of Education of the republic supports the development of mobile forms of nomadic (community) school*

Verkhoyansk Ridge in Tomponsky ulus district (photo: Anastasia Lebedeva).

> *networks in the areas that are densely populated by northern indigenous peoples. Projects have been created on 'the status of community (stationary) schools and of community kindergarten', and 'the state development programme for nomadic schools in the Republic of Sakha (Yakutia), for the period from 2004 to 2006'. The nomadic school is a new type of school, which suits the nomadic lifestyle of reindeer herders and hunters and, besides the teaching of school subjects, directly accustoms children to the culture, customs and traditions of their own people, developing their working skills in the process of shared daily communication with parents (Vinokurova and Borisov 2006:52).*

The essence of the nomadic school is access to education. Thanks to nomadic schools, people of the North can now move without constraints along with the reindeer from pasture to pasture, and the children can go to the school and receive a basic education in this environment, living with their parents in the family home. Thereby, the reindeer herd grows and parents maintain this traditional and vital activity.

The Director of UNESCO's office in Moscow, Dendev Badarch, noted:

> *The nomadic lifestyle has often been seen as a barrier to receiving education, because children move along with their families and cannot spend most of their time at school. Nevertheless, under the conditions of the modern world there is a wealth of possibilities for providing access to education and preserving the cultural and historical heritage of indigenous peoples. UNESCO truly welcomes the advanced research of Yakut scientists and teachers who created the system of nomadic education, which provides teaching of the school programme in accordance to state standards, and the integration of the child's own culture and language (Gavysheva et al. 2007:7).*

The specificities and advantages of the nomadic schools are shown under the working conditions of reindeer and fishing brigades who follow migrations, in which the most effective form of management comes from families all working together on tasks. In this way the children have the opportunity from an early age to experience their parents' skills and knowledge, and the spiritual culture of their own people.

In the process of education it is easy to use the advantages of the traditional education systems of northern indigenous people, in which the positive example of the father and mother is invaluable. In particular, reindeer breeding and herding is a profession transmitted through generations from father to son, from mother to daughter. Children are constantly in close contact with the environment, which influences and educates them to treat the vulnerable ecosystems of the North with care.

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Section 7

ETHICS, RESPONSI-BILITY AND SUSTAINA-BILITY

Sustainable Development in the Arctic: A View from Environmental Ethics

Johan Hattingh
Professor of Philosophy, Stellenbosch University, South Africa
Member of COMEST (UNESCO)

Abstract

In this paper I will argue that the principles of environmental ethics can make a substantive contribution towards sustainable development in the Arctic in the face of global climate change, but only if we are prepared to put some work into it, and take seriously considerations from a variety of angles from within this newly established field of applied ethics. I will argue that it is not a single principle, but rather a network of values and ideas working together that can create this positive contribution, and that a thorough, critical understanding of this network can provide a platform on the basis of which we could at least start a rational conversation among the key stakeholders who have a direct and critical interest in establishing what it would entail to ensure sustainable development in the Arctic. Thus, I will argue in this paper that the complexity of the challenge will require a complex environmental ethics.

Introduction

Environmental ethics is that field of applied ethics in which critical questions are asked and theories formulated about the values that drive the interaction of humanity with nature. In its more critical-analytical manifestations, environmental ethics asks serious questions about practices and strategies of decision-making that have negative impacts on humans and nature, both in the short and the longer term. In its more creative-constructive manifestations, environmental ethics strives to articulate a value theory that is robust enough to promote meaningful and sustainable lives that can overcome the destruction of nature by human activities. In both of these formats, environmental ethics is a theoretical, reflective enterprise that strives to support the practical task of environmental ethics, which is to conserve life on earth (Rolston 1991). Accordingly, in theory as well as in practice, environmental ethics promotes values such as the inherent value of non-human entities, the beauty of nature, the ruggedness of wilderness, the flourishing of biodiversity, the resilience of ecosystems, respect for the community of life, the constitutive function of relations and differences, the transformation of society, the limitations of our knowledge, and the power of the precautionary principle, to mention a few (see Ten Have 2006).

However, the meaning and application of values such as these to the challenges of sustainable development in the Arctic in the face of global climate change is not obvious, and need to be interpreted within the context of the complexities of the problematique at hand. Accordingly, this paper will be devoted to an overview of considerations that can help us to better understand the complexities of sustainable development in the Arctic, as well as some of the ethical challenges that these complexities point to. Central to these considerations are the history of the emergence of environmental ethics and the central themes discussed in it; challenges related to the dominant decision-making model informing economic thinking the world over, namely cost-benefit analysis; environmental justice issues and how they can emerge in the Arctic; fault lines in the notion of sustainable development; and the characteristics of climate change that make it very difficult to develop an ethics of responsible action with regards to the effects of global climate change.

The history of the emergence of environmental ethics

Environmental ethics emerged in the 1970s in response to concerns about industrialisation, pollution, nuclear war, the depletion of natural resources, the destruction of nature and ecosystems, the unjust distribution of the benefits and burdens of industrialised society, a continuously growing population and the ability of future generations to meet their needs. Since that time environmental ethics has gone through various stages of development, exploring a wide variety of intellectual avenues and value orientations. However, in all of its diversity, environmental ethics has one central and very concrete practical message: that current patterns of production and consumption in the world has put the flourishing, as well as the survival, of all life on earth under serious threat, and that something seriously should be done to reverse this trend. In its theoretical form all contributions to environmental ethics entail, each in their own way, a search for a language or a value theory that is profound enough to articulate this message and support the practical task it alludes to (Attfield 1994; Rolston 1991).

Since its inception, one of the defining characteristics of environmental ethics is its suspicion and critique of instrumental value theory in which intrinsic (or inherent) value is reserved only for humans (or only for some humans, for that matter), leaving everything else with nothing but resource value – that is, some kind of use value to humans. This view is challenged by many environmental ethicists who argue that humans cannot be the only morally valuable entities on Earth, and that some intrinsic or inherent value can be discovered and appreciated in non-human entities – which not only include non-human living entities such as individual animals and plants, but also larger units or spheres of value such as species, communities of life, ecosystems, and even non-living phenomena such as land, landscapes, regions, geographical formations, water cycles, carbon cycles etc.

From this perspective, different forms of animal, nature, wilderness, life or ecosystem oriented ethics were articulated, each emphasising the meaning, significance and implications of acknowledging some inherent (non-use) value of parts or the whole of nature. This generated still ongoing debates about the basis or source of this inherent value: does it exist objectively, independently of all human valuing, or is this inherent value anthropogenically constituted by the very act of human valuing itself? This ontological-epistemological debate about anthropocentrism and intrinsic value dominated much of the debates in environmental ethics during the 1970s and 1980s. The emphasis however started to shift to a set of socio-ecological questions that are still hotly discussed to this day: should we at all accept the notion of an isolated and decontextualised nature 'out there' that should be conserved, or rather work with the idea of interconnectedness in which entities become what they are because of their relationships with others – which implies, among other things, that humans and natural entities are not atoms interacting externally with one another, but mutually constituting one another, as nodal points in a web of life (Brennan 2009:373; Naess 1973).

This last set of questions paved the way for a wide variety of concerns that currently preoccupy environmental ethicists, such as the restoration of damaged land, urban environments, pollution and resource depletion and their connections with poverty, dispossession, housing, environmental and economic policy, social justice (Brennan 2009: 376), and learning again how to live sustainably in a place. Similarly, more and more emphasis has been placed in recent developments in environmental ethics on participative decision-making procedures in which interest groups in local communities work together with authorities to find solutions to socio-environmental challenges within the contexts and timescales that they will be experienced – not only by humans, but also by other members of the community of life. Since these participative decision-making procedures are never politically or ideologically neutral, and since their success is never guaranteed because of asymmetrical power relations, some streams in environmental ethics also focus on radical ideology critique, as well as strategies to translate that into a fundamental transformation of society, including organisational forms, thinking patterns and processes of identity formation and self-realisation. Within the latter context, the 'environmental crisis' is seen as an opportunity to free humanity from the burden of a destructive praxis, and to start moving towards a cultural, political, social and economic revolution that may move us beyond our current predicaments.

From this point of view, it is evident that the impact of climate change on the Arctic is of great concern to environmental ethics for at least three reasons. Firstly, if, for instance, Arctic ice melts away completely in a short space of time as is expected by many scientists, a lot of intrinsic value stands to be destroyed: a whole community of life consisting of animals and humans interacting with one another will lose the prerequisite for and basis of their very existence: ice. In such an event, individual animals, species and a whole ecosystem will either cease to exist or will be severely disrupted. Similarly, the traditional way of life of people indigenous to the Arctic will be lost, and moreover, a humanitarian crisis will result as indigenous people become displaced and are confronted with the reality of adapting to radically changed living conditions. Secondly, if Arctic ice melts away rapidly, thus literally opening up the way for the exploitation of the natural resources underneath a blue Arctic Ocean, many environmental ethicists will ask the question whether such exploitation will merely be a continuation, and even an intensification, of the instrumental approach to valuing that currently dominates the world, or whether a new, different approach to resource extraction and its valuation should be followed that takes into account and pays respect to the ecosystem and humanitarian disruptions that have taken place to 'make room' as it were, for such exploitation. This last question already points to a third observation I would like to make in this regard, namely that from a radical point of view, any rapid changes in the Arctic could be seen as an opportunity to deeply question and fundamentally transform any practices that are merely extensions of an instrumental approach to valuing and resource extraction.

Challenges related to the dominant decision-making model informing resource extraction

Much of the intellectual effort in environmental ethics is devoted to an analysis and critique of the dominant decision-making model informing economic thinking the world over: cost-benefit analysis. The cruder forms of cost-benefit analysis are easy targets for the critique that its internal logic opens the way to any and all forms of environmental pollution and destruction, as long as this is offset by an aggregate of more gains than losses. However, cost-benefit analysis in its more sophisticated and refined versions is also not exempted from criticism, even if it is moderately successful in internalising externalities in various forms of full-cost accounting. The difficulties that many environmental ethicists have with this model of decision-making is that it allows for only one kind of value to be accounted for – resource or use value – while there are many other kinds of values that need to be taken into account when decisions are made about resource extraction and its transformation into commodities.

One such value is respect for people, and another broader value is respect for life in general. As has been alluded to in the section above, one of the serious value questions that should be faced is whether resource extraction in the Arctic in the event of complete ice melt can take place without making provision for the continued well-being of those people and animals displaced by the melting of the ice. The converse of this question is whether business as usual with regards to resource extraction in a blue Arctic Ocean would not amount to a severe and unprecedented disrespect for persons, and life in general, if nothing is done to take care of the immediate and longer term needs and interests of those people (and other non-human living entities) displaced from the Arctic because of its loss of ice. Generally speaking, the challenge is therefore how to make provision for these other kinds of values in economic policy and decision-making, if the dominant model precludes their articulation from the start.

Environmental justice issues in the Arctic

Environmental justice issues emerge when the benefits and burdens of resource use, or of conservation, are distributed unequally within or between societies, regions, nations or generations. Examples of such unequal distribution are often fairly easy to point out, and the excruciating details of many instances of such injustices are well-documented. However, the ethically vexing question that begs to be answered is why it is at all possible that cases of environmental injustice continue to emerge in an apparently never-ending stream; and when they have been exposed and made public, why it is apparently so difficult to address and overcome these injustices – for instance to claim compensation for harm suffered, or restitution for past unequal treatment.

For the purposes of our discussion on the prospects of sustainable development in the Arctic in the face of global climate change, it seems as if a special kind of analysis is called for – one that focuses on the one hand on the social, political and economic processes and structures through which victims of environmental injustice are created; and on the other hand, the linguistic and symbolic strategies through which these injustices are legitimised, glossed over, and removed from the realm of public scrutiny, discussion and critique, and thereby reinforced and perpetuated (Thompson 1990). One task of such an analysis will surely be to expose these processes, structures and strategies, and to show the way towards effectively resisting them and subsequently moving on from what is exposed. Another task will entail devising strategies of assisting and supporting the victims of environmental injustices in the different phases of their exposure and resistance to it, as well as in the different stages of 'rehabilitation' – which are tasks that in fact fall squarely within the realm of advocacy, or, if you will, environmental ethics in practice.

For the purposes of a debate on the prospects and requirements of sustainable development in the Arctic in the face of climate change, this perspective from the point of view of environmental justice calls for serious questions to be asked: whether and to what extent people indigenous to the Arctic are already the victims of injustice, whether this injustice will intensify in the future, through which strategies these injustices are established, justified and perpetuated, and whether these strategies can be unmasked so that something can be done to effectively address them.

Fault lines in the notion of sustainable development

The very serious problem of human induced climate change underscores that the main characteristic of the world's economic system seems to be that of unsustainable development, and given that the term sustainable development can mean anything to anyone, it is important to ask serious questions about the concept of sustainable development itself, and how it can be related to the notion of development in the Arctic. One of these questions that needs to be asked, is how the notion of sustainable development can regain its critical, normative edge. This in turn can be done by recognising the fields of tension that emerge between different possible interpretations of sustainable development. These fields of tension are captured in the differences between weak and strong interpretations of sustainable development, egalitarian and non-egalitarian interpretations of it, bottom-up and top-down models of implementing sustainable development, and narrower or wider interpretation of its scope, where narrower interpretations focus on nature conservation only, while wider interpretations view nature conservation as but one of many goals that should be pursued in sustainable development (Jacobs 1999). Accordingly, a number of test questions can be formulated with a view to distinguishing between notions of sustainable development that leave the world pretty much as it is, and notions of it that strive to make a difference. The questions include the following: What is so important that it should be sustained indefinitely? For the sake of whom or what should we sustain this valuable something? How should we do so? By making use of which kinds of knowledge and utilising which kinds of decision-making structures and procedures? And what are the appropriate indicators so that we can know if we move towards sustainable development or further away from it?

Restrictions on space do not allow me to venture any answers to these questions, except to point out that if climate change will inevitably result in a rapid and complete melt-down of Arctic ice, that valuable something that needs to be sustained will have to be something other than the culture and traditions of people indigenous to the Arctic, or the ecosystem sustaining life in the Arctic. In all probability it may not even be the co-evolution of human culture and nature at the very margins of the possibility of life itself that needs to be protected indefinitely. The facts of climate change rather point to the tragic reality that life, cultures, traditions, ecosystems and the creative interaction between nature and culture in the Arctic will at the least be severely disrupted by steadily increasing trends in warming, and will at worst be totally destroyed. The critical questions listed above thus acquire a radical edge when they are applied to the prospects and requirements of sustainable development in the Arctic in the face of climate change: they challenge us to ask serious questions about the global impacts of development taking place in other parts of the world, and also what exactly it is that we need to sustain in the event of a massive displacement of indigenous people from the Arctic. What immediately comes to mind, are livelihoods, justice, and the dignity of individuals and societies. What this would entail under conditions of severe disruption and displacement is something that calls for serious further investigation and debate.

The characteristics of global climate change

The characteristics of global climate change make it very difficult to develop an ethics of responsible action with regards to the mitigation of its causes and thus its intensity, and adaptation to its unavoidable effects. Gardiner (2004, 2006) argues that these characteristics include a dispersion of causes and effects, the fragmentation of agency, and institutional inadequacy that plays itself out in both the global and intergenerational contexts. Gardiner further argues that in their mutual interaction, these characteristics can place us in the untenable positions of resignation and inaction in the face of global climate change, or of having to make tragic choices in the process of defending ourselves against the negative effects of climate change. As such, these characteristics challenge our conventional modes of moral decision-making, and compel us to rethink our notions of responsibility, accountability, harm, justice, human rights, etc. In this manner, Gardiner reminds us that conventional approaches to moral and economic decision-making may not be enough to tackle the challenges of global climate change. He rather calls for a radical re-thinking of the meaning of our ethical vocabulary, and a radical rethinking of our strategies of moral and economic decision-making – taking into account the radically changed and rapidly changing context in which we currently have to make moral decisions. The rapid changes that are expected in the Arctic because of an accelerated trend in warming underlines the urgency of this re-evaluation of our ethical vocabulary and decision-making strategies.

Conclusion

Having said this, and taking into account that life in the Arctic, like life in Antarctica, is lived at the margins of its very possibility (Rolston 2009), I conclude that the conventional values emphasised in environmental ethics (such as the inherent value of non-human entities, the beauty of nature, the ruggedness of wilderness, the flourishing of biodiversity, the resilience of ecosystems, respect for the community of life, the constitutive function of relations and differences, the transformation of society, the limitations of our knowledge, and the power of the precautionary principle, to mention a few (see Ten Have 2006)) can acquire radically new meanings and connotations if related to the challenges of sustainable development in the Arctic in the face of global climate change. We could choose to ignore these new meanings (or not even try to look for them) and leave the world pretty much as it is. But we could also choose to articulate and explore these meanings with a view to acknowledging the scope and limitations of our knowledge, to sharpening our abilities to determine what the morally right things to do are, and to determining what we can legitimately hope for, thus contributing to changing things in the world, transforming what has already gone wrong in our world, and moving beyond what we as humans have become in this world.

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Continuing Ethical Livelihoods for Arctic Peoples Despite Change

Ilan Kelman
Center for International Climate and Environmental Research, Oslo, Norway

Abstract

This paper explores directions for continuing ethical livelihoods in the Arctic for Arctic peoples within the context of the social and environmental changes that the region and globe are experiencing. First, the meaning and relevance of livelihoods are discussed followed by a brief indication of why a specific ethical framework is not adopted here. Then, four provisional guidelines are provided and critiqued as a starting point for considering Arctic ethical livelihoods: 1) Adopt the sustainable livelihoods approach; 2) Factor in intangible values for livelihoods; 3) Respect land rights, with some qualifications; 4) Consider all timescales for livelihoods. For moving forward, an emphasis is placed on the sustainable livelihoods approach, despite its limitations. Increased understanding would be useful on the flexibility of Arctic subsistence-related livelihoods; on working across, without ignoring, political boundaries; and on instilling a better balance of Arctic livelihoods needs over different timescales.

Livelihoods and ethics

Given the social and environmental changes being experienced globally as well as around the Arctic, consideration needs to be given to how Arctic peoples will continue to develop and maintain livelihoods. The notion of livelihoods refers to ways of living and working for acquiring the necessities of life, such as food and water, and for generating further cash and non-cash income. Examples of Arctic livelihoods are reindeer herding (e.g. Turi 2008), extracting oil and gas (e.g. Mikkelsen and Langhelle 2008), being a religious or spiritual leader (e.g. Porter 2003), and computer programming for clients around the world.

Dog sled tourist tours on Svalbard/Spitsbergen, in Norway's Arctic (photo: Ilan Kelman).

As certain forms of livelihoods continue to expand around the Arctic, notably industrial development including mining, land use patterns change. Examples are building or decommissioning airports and harbours, plus redesigning settlements and urban development patterns. Industrial development also brings social change, which is frequently in the form of increased reliance on cash-based purchases for goods and services; less reliance on one's own skills for food and shelter; immigration into the Arctic to pursue new, often opportunistic and short-term livelihoods or to seek a different lifestyle; and emigration from the Arctic to seek different livelihoods or lifestyles.

Conflicts and trade-offs can occur amongst different livelihoods. Mineral resources including oil, gems and metals might be sought or found on prime hunting and herding land, whilst different interests, such as restoring ecosystems compared to commercial timber exploitation, might desire different species or management regimes. Increased use of shipping lanes for transporting goods might interfere with nature-based or culture-based tourist cruises. Tourism also illustrates the challenge of livelihood scales. Increasing tourism can increase income, but can then harm the ambience, natural heritage and cultural heritage that many tourists seek in the Arctic.

Consequently, ethical approaches can assist in developing and maintaining long-term livelihoods, although different ethical approaches can yield different decision-making criteria and different decisions. An example of an ethical framework for decision-making is 'do no harm' (e.g. Anderson 1999) which refers to assessing possible outcomes from livelihoods choices and avoiding as much social and environmental harm as feasible, including harm resulting from inaction. The main challenge with 'do no harm' is trying to understand and avoid all possible facets of all possible harms (e.g. Fox 2001).

Another ethical framework is risk/benefit analyses which seek to balance risks and benefits from livelihoods. That is accomplished first by ensuring that any risks taken are justified in comparison to the expected benefits and second by managing and mitigating all risks as much as feasible (e.g. Wilson and Crouch 2001). One drawback with risk/benefit analyses for livelihoods is that trust in the authorities by the public affects risk/benefit perception and can limit acceptance and applicability of the analysis (e.g. Siegrist and Cvetkovich 2000).

The third ethical framework illustrated here is utilitarianism, which tries to achieve the greatest happiness or greatest good for the greatest number of people or tries to achieve maximum total benefit (e.g. Smart and Williams 1973). The main critique of utilitarianism is that the majority rules, often sidelining or actively suppressing minorities (e.g. Williams 1999).

These three examples of ethical frameworks are effectively explored from one cultural paradigm, namely modern Western philosophy, although aspects do emerge from other paradigms too. Different cultures have different base ethics and different ways of implementing (operationalising) ethics. As demonstrated for the three frameworks given, ethical approaches are continually critiqued and have limitations in areas such as consistency and practicality of implementation.

Despite the lack of one solid, universal approach to ethics, asking ethical questions about livelihoods from varying perspectives helps to develop and maintain livelihoods that meet a large set of ethical criteria. Even without explicitly selecting a culture or approach for an ethics framework, guidelines can be developed for making 'ethical livelihoods' realistic and for assisting the analysis of livelihoods choices.

Four potential operational guidelines are suggested here as starting points for discussion, without claiming that they are perfect or must apply in all circumstances – and guidelines should not be implemented without the full and effective participation of, and full acceptance by, the people involved. Many aspects overlap amongst the guidelines, but they are sufficiently distinctive to be separated.

Operational guidelines for ethical livelihoods

Guideline 1: Adopt the sustainable livelihoods approach

Livelihoods choices should be selected on the basis of criteria from the sustainable livelihoods approach, without relying on macro-economic indicators or economic growth rates. The sustainable livelihoods approach is about building and maintaining between generations means of individual and community living that are flexible, safe and healthy (based on Chambers and Conway 1992; see also Chambers 1995; Kelman 2007; Kelman and Mather 2008). This approach has numerous limitations, especially in trying to define and interpret 'flexible', 'safe' and 'healthy' and to provide consistent indicators for those criteria.

As one example, the World Health Organization defines 'health' as a 'state of complete physical, mental and social well-being and not merely the absence of disease or infirmity' (WHO 1948), which is entirely appropriate for sustainable livelihoods. Yet the Millennium Development Goals (UN 2000) are dominated by physical health characteristics that can be quantified, focusing on disease or infirmity. As well, an intense ethical and philosophical debate rages regarding what the current generation owes to future generations and how to balance different generational needs and desires (Glantz and Jamieson 2000; WCED 1987). One challenge is that we do not know exactly the social or technological characteristics of future generations. Yet the principal advantage of the sustainable livelihoods approach, despite its difficulties, is that it is as encompassing as possible of multiple needs, criteria and cultures.

In contrast, macro-economic indicators and current economic approaches tend to be too artificial, too financially orientated, and too focused on short-term desire for profit to fully factor in and enhance the livelihoods options adopted by many Arctic peoples. Examples are bartering, subsistence contributions to food and preferring quality of life, culture and heritage as wealth, rather than focusing on money as wealth. The 2008-2009 international financial crisis further demonstrates how devastating a unilateral focus on economic growth rates can be and how society's well-being is often neglected as a consequence. Finally, resources are by definition finite, meaning that growth forever is impossible, so it would be preferable to choose one's own non-growth related livelihoods rather than

Longyearbyen on Svalbard/Spitsbergen, in Norway's Arctic, where cultural and natural heritage might be threatened by tourism livelihoods (photo: Ilan Kelman).

being forced into them (see especially Bartlett et al.'s 2004 analyses of this point including his critiques of Simon 1981).

The sustainable livelihoods approach is imperfect, but it can explicitly recognise and accept the limitations of dominating economic approaches while exploring alternatives. That leads directly to the second proposed guideline.

Guideline 2: Factor in intangible values for livelihoods

Cultures and natural environments have non-quantifiable, non-financial, non-monetary values for Arctic peoples that must be considered when making livelihoods decisions. An example of intangible values from culture are pride in knowing one's own language, ancestry and history. Some cultures have sacred artefacts, from the original copy of a country's constitution to the bones or ashes of one's ancestors, the presence and respect of which are far more important to the people from those cultures than any money that could be exchanged for it.

Similarly, while some schools of thought advocate that ecosystems have intrinsic value in their own right simply by existing (e.g. Naess 1973), promoting that view

Tourism above the Arctic Circle: Senja, Norway (photo: Ilan Kelman).

is not necessary to accept the importance of intangible values for the environment. Instead, many people feel integrated with and connected to their environments in such a way that they attain livelihoods and quality of life partly through being able to use their environment for livelihoods without destroying either the environment or future prospects for those livelihoods.

Common recreational examples are hiking through a forest and kayaking in the sea. Common livelihoods examples, for subsistence as well as for generating income by selling the surplus or by deriving products that are sold, are hunting, fishing, farming and food gathering. That could be not just for saving money on groceries or for generating income, but also for enjoying the quality of life and the cultural and environmental connections of gaining one's own food through one's own skills; of knowing where that food came from; and of knowing and understanding one's environment. The third guideline is an important element in that.

Guideline 3: Respect land rights with qualifications

Land rights and subsistence components of livelihoods deserve full consideration, and often priority, when balancing conflicting Arctic livelihoods. Full, unqualified priority for land rights is not suggested for two reasons. First, different groups might have different, conflicting and potentially valid claims to the same land and they might desire different uses for that land. Dispute resolution mechanisms are needed, even if some rights are infringed irrespective of the final outcome. Second, prioritising land rights could supersede the other guidelines.

The possibility exists in which a small Arctic community – indigenous, non-indigenous or mixed – decides democratically that they wish to exploit the nearby mineral resources, irrespective of the long-term social and environmental impacts. Methods exist for mineral extraction without causing long-term social or environmental impacts but, again, a community might decide otherwise.

One argument states that it is the community's land, so they decide how to use it. Yet it is rare that everyone in a community agrees, plus democratic processes must factor in minority views. Due to the lack of homogeneity within many communities, ample evidence exists to show that 'community' is an idealistic notion with communities rarely displaying unblemished community characteristics in reality (Cannon 2007). Meanwhile, when poorly implemented, community consultation and participation processes can be as exploitive and as damaging as lack of consultation and lack of participation (Cooke and Kothari 2001).

Furthermore, despite past histories of exploiting people and land, tenets are being considered and applied for entrenching global, common ownership of certain land and resources, for protecting areas for cultural or environmental reasons, or for implementing the often ill-defined and badly interpreted 'common good'. The legality and effectiveness of such management regimes are, though, disputed. Finally, it is possible that communities employing democratic processes can err or might not be aware of essential information, leading to decision-making based on unrobust environmental knowledge (e.g. Tibby et al. 2007). In accepting these provisos to community-based decision-making, it is also essential to avoid control of or top-down imposition on communities' or peoples' ways of thinking and their decision-making processes (e.g. Kennedy et al. 2008).

This guideline is neither easy nor straightforward and it is unclear whether or not an acceptable and successful balance could be achieved. In fact, any form of qualification might undermine land rights principles – even though concepts of 'rights' are as culturally constructed (e.g. Preis 1996) as concepts of 'ethics'. Nevertheless, respecting land rights, with or without qualification, supports the fourth guideline.

Guideline 4: Consider all timescales for livelihoods

When making livelihoods choices, all timescales must be considered, including many generations into the future. Short-term gains are currently an important factor in livelihoods-related decision-making, but diminishing that influence should be encouraged. Long-termism that leaves livelihoods opportunities for future generations, irrespective of social or environmental changes, must be an important consideration. This attitude might overturn principles of current common ownership or of current democracy, but more than current desires and needs are prominent in many ethical frameworks and should be factored into livelihoods-related decision-making.

Next steps

These four guidelines are, to a large degree, already practiced by many Arctic peoples and have been for a long time. New livelihoods, particularly related to industrial development, might be less willing to adopt them and could potentially induce changes amongst current livelihoods and attitudes. To establish a baseline for Arctic livelihoods for Arctic peoples, the guidelines suggest a starting point for further discussion and then modification of the guidelines, because numerous gaps exist in knowledge and action to create and support ethical livelihoods in the Arctic.

In particular, more understanding would be useful regarding the flexibility of Arctic subsistence-related livelihoods, given the expected social and environmental changes. Non-subsistence livelihoods are frequently flexible. Tourism can offer new services or attractions, whilst businesses catering to remote clients can find new regional or international clients. For more traditional approaches, much is articulated regarding livelihood vulnerability along with some actions for addressing that vulnerability (e.g. Ford et al. 2008), but not enough is known about what actions to take to adjust to these changes while retaining traditional cultural approaches (although see e.g. Hovelsrud et al. 2008).

For action, a better balance of Arctic livelihoods needs over different timescales should be instilled amongst people interested in the Arctic – as distinct from Arctic peoples, who do tend to understand livelihoods that are viable over all timescales. Considering timescales especially applies to subsistence living, to ensure that subsistence methods can continue over the long-term, even if that means curtailing non-subsistence Arctic livelihoods. As well, distinctions must be made between mass commercial exploitation of natural resources and Arctic peoples using resources in small but sustainable amounts, even if for their own commercial gain.

Reindeer herding is a traditional livelihood in the Arctic. This reindeer is in Longyearbyen on Svalbard/Spitsbergen, in Norway's Arctic (photo: Ilan Kelman).

That connects directly to the predominant action-related gap of overcoming the current focus on short-termism, especially regarding short-term profit. Current economic paradigms usually promote the exploitation of resources as fast as feasible. Alternative economic approaches need to be explored to determine how subsistence and non-subsistence livelihoods could overlap to support Arctic peoples now without compromising future livelihoods, in the context of ongoing and expected social and environmental changes.

One approach to examine further is thinking beyond, without ignoring, political boundaries. Livelihoods choices are needed that support the Arctic and the world rather than those choices being geared towards the interests of sovereign states. The latter often means supporting the most powerful interests of Arctic states, as defined and dominated by the most powerful interests in the capital cities of the Arctic states, with Arctic peoples often marginalised or ignored.

To explore these topics, to achieve improved understanding and action, and to continue working towards maintaining ethical livelihoods in the Arctic, a sustainable livelihoods approach is a helpful basis. It is not a panacea and ethical limitations emerge from it too. Nevertheless, it provides a suitable baseline for understanding the nebulous and culturally constructed terms such as 'livelihoods', 'sustainable', 'development', 'ethical' and 'risk'. It also achieves a better balance of criteria for livelihoods related decision-making, for example by not relying on macro-economic indicators and by not seeking continual or maximal economic growth as a livelihood outcome. Instead, Arctic livelihoods become about and for Arctic peoples over all timescales.

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Sustainable Development of the Arctic: The Challenges of Reconciling Homeland, Laboratory, Frontier and Wilderness

Bernard Funston
Executive Secretary, Arctic Council Sustainable Development Working Group
President, Northern Canada Consulting, Canada

Abstract

There is much uncertainty as to what is meant by the 'sustainable development of the Arctic'. Will Arctic sustainable development be understood as an environmental doctrine or a developmental doctrine? Do we intend this to mean development or non-development of the Arctic primarily for the benefit of non-Arctic interests, or for Arctic peoples? The future of the Arctic will be determined by how various values and goals are reconciled in regional, national and international law and policy. This reconciliation may well hinge on the ability of state and non-state actors to achieve sustainability and balance. It is not enough to simply advance scientific knowledge of the Arctic. The translation of Arctic knowledge (scientific and indigenous/local) into policy development and policy implementation is slow and poorly executed in some Arctic states and in most non-Arctic states. The focus of many Arctic policy-makers, Arctic residents, Arctic scientists and NGOs active in the region appears to be inward towards the Arctic region, despite a commonly acknowledged understanding that many of the major drivers of change have their origins outside the region. A coordinated global approach is needed.

The views expressed here are personal and do not necessarily represent the Arctic Council or any of its working groups.

A plane prepares to leave the airport in Cambridge Bay, Nunavut (photo: Peter Bates)

Understanding the Arctic

The Arctic can be analysed under four broad and often competing conceptualisations: homeland, laboratory, frontier and wilderness.

Homeland: Depending on how it is delimited, the Arctic is home to between 4 and 9 million people, including indigenous peoples. Hunting, herding, fishing, trapping, gathering and other renewable resource activities remain important components of indigenous cultures and economies.

Laboratory: For the past few decades in particular, the Arctic has been a laboratory for increasing scientific research and cooperation, particularly during the recent International Polar Year.

Frontier: For many nation-state governments and multinational corporations the Arctic is a 'frontier' with the potential for exploitation of important natural resources to feed national and global demands for energy, fresh water and other renewable and non-renewable resources.

Wilderness: Alternatively, many environmental and conservation organisations rooted in towns and cities outside the Arctic see the northern circumpolar region and its flora and fauna as 'wilderness' to be preserved in parks and protected areas.

While this way of characterising the Arctic is an over-simplification, juxtaposing homeland, laboratory, frontier and wilderness helps clarify some of the values and goals of various stakeholders. The future of the Arctic will be determined by how these various values and goals are reconciled in regional, national and international law and policy. This reconciliation may well hinge on the ability of state and non-state actors to achieve sustainability and balance. However, there is much uncertainty as to what is meant by the 'sustainable development of the Arctic'. Will sustainable development be understood as an environmental doctrine or a developmental doctrine? The Brundtland Commission noted that:

> *The environment does not exist as a sphere separate from human actions, ambitions and needs, and attempts to defend it in isolation from human concerns have given the very word 'environment' a connotation of naivety in some political circles… But the 'environment' is where we all live, and development is what we all do in attempting to improve our lot within that abode. The two are inseparable (World Commission on Environment and Development 1987:xi cited in Mikkelsen and Langhelle 2008:19).*

In other words, sustainable development is perhaps best understood as a socio-economic concept directed at 'sustained increase in the level of societal and individual welfare' (a process of need satisfaction and the creation of equal opportunities). In this paradigm the process of development is sustained rather than a particular resource, institution or activity; however, the integrity of the environment is a precondition of sustainable development.

When we speak of 'Arctic sustainable development' do we intend this to mean development or non-development of the Arctic primarily for the benefit of non-Arctic interests? Or do we mean development or non-development as determined primarily by, and for the benefit of, Arctic peoples?

In the Arctic, sustainability is often characterised as a blend of the best of the old with the best of the new. Balance is important because the values expressed through each of the conceptualisations of the Arctic (homeland, laboratory, frontier and wilderness) are politically legitimate and have to be taken into account in policy-making processes. However, as Dryzek (1997:129 quoted in Mikkelsen and Langhelle 2008:23) notes:

> *The core story line of sustainable development begins with a recognition that the legitimate developmental aspirations of the world's peoples cannot be met by all countries following the growth path already taken by the industrialised countries, for such action would over-burden the world's ecosystems… sustainable development is not just a strategy for the future of developing societies, but also for industrialised societies, which must reduce the excessive stress their past economic growth has imposed on the earth.*

The Inuit community of Umingmaktok/Bay Chimo in Bathhurst Inlet, Nunavut (photo: Peter Bates).

Two environmental problems in particular will be crucial constraints to Arctic sustainable development: climate change and loss of biodiversity.

The challenges of climate change

The Arctic is extremely vulnerable to observed and projected climate change and its impacts. The Arctic is now experiencing some of the most rapid and severe climate change on Earth. Over the next 100 years, climate change is expected to accelerate, contributing to major physical, ecological, social and economic changes, many of which have already begun. Changes in Arctic climate will also affect the rest of the world through increased global warming and rising sea levels.

The Arctic Council released its Arctic Climate Impact Assessment report in Reykjavik in November 2004. The report's ten key findings were:

1. Arctic climate is now warming rapidly and much larger changes are projected.
2. Arctic warming and its consequences have worldwide implications.
3. Arctic vegetation zones are projected to shift, bringing wide-ranging impacts.
4. Animal species diversity, ranges and distribution will change.
5. Many coastal communities and facilities face increasing exposure to storms.
6. Reduced sea ice is very likely to increase marine transport and access to resources.
7. Thawing ground will disrupt transportation, buildings and other infrastructure.

8. Indigenous communities are facing major economic and cultural impacts.
9. Elevated ultraviolet radiation levels will affect people, plants and animals.
10. Multiple influences interact to cause impacts to people and ecosystems.

Therefore, the Arctic should be viewed as a barometer that is highly responsive to global processes. It may also be a trigger for a cascade of globally-important processes relating to ocean circulation and weather systems. In other words, the Arctic today is a tightly-coupled component of highly dynamic global biophysical, geopolitical and socio-economic systems. Such systems can involve shifts that may be both non-linear and abrupt. Even under normal conditions it is difficult to forecast or project their trajectories beyond the immediate future. We cannot say when dramatic changes will occur or what particular form they will take. Climate change could produce impacts in the Arctic that overwhelm existing adaptive capacity, not only in the Arctic, but in other regions of the globe (Fenge et al. 2008:11).

Devising governance systems and management practices that are both resilient in the face of change and nimble in their ability to adapt quickly and effectively to new challenges is essential in situations of this kind. Soft and hard law tools will be required to deepen and broaden cooperation among Arctic states, but also to provide meaningful roles for non-Arctic states and non-state actors.

Relationships among Arctic and non-Arctic interests

In other words, the Arctic is not a closed system. The presence of some sort of 'Arctic Circle' demarcating the southern-most limit of the Arctic has tended to 'ghetto-ise' the region even within the Arctic states, setting it aside as a boutique issue that is often viewed in isolation, apart from mainstream national and international affairs.

Are we looking in the right places for solutions?

Are we looking in the right place for solutions? Are we diffusing the need for urgent action by indulging in a monitoring posture that makes us seek more knowledge without a solid strategy to deploy what we already know?

It is not surprising that the policy and scientific communities have turned their attention to issues of the climate change challenge in the Arctic. However, it is not enough to simply advance scientific knowledge of the Arctic. Efforts to seek synergies amongst scientific disciplines (natural and social), and between scientific and indigenous knowledge, although well-intentioned and useful at some levels, do not at the present seem well-placed to attack the problems at their roots. The translation of Arctic knowledge (scientific and indigenous/local) into policy development and policy implementation is slow and poorly executed in some Arctic states and in most non-Arctic states.

This is not to say that worthwhile initiatives are not proceeding. Any effort to better understand the dynamics of Arctic human and natural systems has a potential to better inform policy responses. All efforts to generate cooperation have the potential to empower collaborative actions which will be necessary to move towards a lighter human footprint on Earth systems.

Addressing these issues, however, is a far more complex matter. The tendency has been to look for solutions within the Arctic region. The focus of many Arctic policy makers, Arctic residents, Arctic scientists and NGOs active in the region appears to be inward towards the Arctic region. This seems to be the case despite a commonly acknowledged understanding that many of the major drivers of change in the Arctic, whether in relation to climate, transboundary pollutants, development pressures or increased accessibility to Arctic lands and oceans, have their origins outside the region.

Arctic state and Arctic non-state actors must not simply talk among themselves. Non-Arctic actors can no longer ignore their connection to changes in the Arctic. Both Arctic and non-Arctic interests must accelerate their efforts to find processes and mechanisms to improve dialogue and take actions. Even with immediate reductions in greenhouse gas emissions, the impacts of climate change on the Arctic, and on global systems generally, will continue.

Quite simply, the solutions for many Arctic problems cannot be implemented by actions in the Arctic alone. While climate change and developmental pressures have potentially profound impacts on the ecosystems and peoples of the Arctic, changes in the Arctic also have significant implications for non-Arctic regions which are poorly understood and often overlooked by non-Arctic states. The primary search for mitigative solutions needs to be *outside* the Arctic. The search for solutions in the Arctic needs to be directed primarily at adaptation. A coordinated global approach is needed.

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Many Strong Voices from Arctic and Island Peoples

John Crump
UNEP/GRID-Arendal, Norway

Ilan Kelman
Center for International Climate and Environmental Research, Oslo, Norway

Abstract

Climate change presents humanity with a profound challenge that is increasingly being seen as a matter of ethics and human rights. With that context, the Many Strong Voices Programme (http://www.manystrongvoices.org) brings together the peoples of the Arctic and Small Island Developing States (SIDS) to address climate change. The programme's vision is to ensure the well-being, security and sustainability of communities in the Arctic and SIDS in the face of climate change. The programme facilitates collaboration between peoples and organisations on climate change mitigation and adaptation at the local, national, regional and international levels. Activities cover three areas: educating policy-makers and decision-makers, supporting communications and outreach, and developing actions based on innovative research.

Climate change ethics and 'global barometers'

The Intergovernmental Panel on Climate Change (IPCC 2007) was unequivocal in its 4th assessment report: unless there are deep cuts in greenhouse gas emissions, there will be dramatic effects on water, ecosystems, food supplies, coastal areas and human health. There is little equity in climate change impacts. They adversely affect the regions that have produced the fewest emissions. These regions are usually the least able to deal with such change and are thus the most vulnerable. It is imperative that there be equity in how the world responds (e.g. Crump 2008a,b; Glantz 2003).

Societies and livelihoods in both the Arctic and Small Island Developing States (SIDS; see http://www.sidsnet.org) are particularly vulnerable to climate change because of their close ties to land and sea environments (ACIA 2005; IPCC 2007;

Sea ice at Point Barrow, August 2008 (photo: John Crump).

UN 2005). While communities in both regions have proven adept at adapting to changing conditions in the past (e.g. Nunn et al. 2007; Nuttall and Callaghan 2000), it is unclear whether or not those experiences and abilities will suffice to deal with ongoing social and environmental changes including climate change.

The impact of climate change on coastal zones is a common denominator between the two regions. It provides a context for comparing vulnerability and adaptation processes and for developing adaptation strategies that contribute to sustainable development in both regions by meeting the needs of present and future generations (see also http://www.climatefrontlines.org). The Arctic and SIDS are barometers of global change and in this context are considered critical testing grounds for applied processes and programmes that will strengthen human societies confronting climate change (see also UNEP 2007; UNFCCC 2005). The magnitude of present and forecasted climate change in the Arctic and SIDS means that these regions can be considered harbingers of what may be in store for the rest of the planet. The rest of the world therefore has an interest in the responses and solutions to climate change being generated in both regions.

Archaeologists working to save artifacts from rapid erosion at Point Barrow, Alaska, summer 2008 (photo: John Crump).

The ethical question of imbalance between regional contributions to greenhouse gas emissions and regional effects is supposed to be addressed in the United Nations Framework Convention on Climate Change (UNFCCC 1992), Article 3, which states that '[t]he Parties should protect the climate systems for the benefit of the present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities'. Because developing countries (and the Arctic) have historically had the lowest emissions, the fewest resources available to tackle the problems created by climate change, and are most vulnerable to impacts, Article 3 of the UNFCCC (1992) contains another important principle to guide global decision-making: 'specific needs and special circumstances of developing country Parties, especially those that are particularly vulnerable to the adverse effects of climate change…should be given full consideration'.

Questions of equity are involved not only in the discussion of how the effects of climate change are distributed, but also in how responses and solutions will be developed. Not everyone will be affected equally, not everyone has the same resources to manage effects and adapt, and not everyone has an equal voice (Crump 2008a,b).

Consequently, climate change is increasingly being seen as a human rights issue. In 2005, sixty-two Inuit in the Canadian and Alaskan Arctic regions filed a petition with the Organization of American States Inter-American Commission on Human Rights. Led by Inuit leader and Nobel Peace Prize nominee Sheila Watt-Cloutier, the petition requested ‘relief from human rights violations resulting from the impacts of global warming and climate change caused by acts and omissions of the United States’ (Watt-Cloutier 2005). Additionally, the Male Declaration on the Human Dimensions of Climate Change calls for the UNFCCC to assess the human rights implications of climate change, asks the UN High Commissioner for Human Rights to ‘conduct a detailed study into the effects of climate change on the full enjoyment of human rights, which includes relevant conclusions and recommendations’, and requests the UN Human Rights Council to hold a special debate on climate change and human rights (AOSIS 2007).

The human rights implications of climate change have been explored in numerous fora outside the Arctic and SIDS, including an African Union declaration that called on the international community to meet its obligations to cut greenhouse gases and to strengthen African institutions to help them address impacts and adaptation (African Union 2007). In March 2008, the UN Human Rights Council unanimously passed a motion declaring climate change a threat to the human rights of people living in Small Island Developing States.

The Many Strong Voices Programme

These ethical and human rights considerations are the philosophical foundation of the Many Strong Voices (MSV; http://www.manystrongvoices.org) Programme which was launched by UNEP/GRID-Arendal at the UNFCCC COP XI meeting in Montréal in December 2005. The MSV Programme is coordinated by GRID-Arendal and the Center for International Climate and Environmental Research – Oslo (CICERO). It supports a consortium of Indigenous Peoples Organisations, researchers, policy-makers and community organisations in the Arctic and SIDS to collaboratively design solutions to the climate change challenges facing them. Key partners include the Caribbean Community Climate Change Centre (CCCCC); the Pacific Regional Environment Programme (SPREP); the Pacific Islands Applied Geoscience Commission (SOPAC); the Inuit Circumpolar Council; the Arctic Athabaskan Council; Aleut International Association; Organization of American States (Department of Sustainable Development); the International Institute for Environment and Development (IIED); Climate Change & Energy Programme, Foundation for International Environmental Law and Development (FIELD); Conservation Society

Snowmobile pulling a sled across melting sea ice near Uummannaq, Greenland (photo: Lawrence Hislop).

of Ponipeh, Federated States of Micronesia; the New Zealand Tourism Research Institute (NZTRI); and the Sea Level Rise Foundation. Several SIDS governments participate in the programme, including Seychelles, Micronesia and Niue.

Lessons learned through MSV are feeding into policy processes at local, regional and international levels, and are providing decision-makers in the two regions with the knowledge to proactively safeguard and strengthen vulnerable regions.

The first MSV Stakeholders' Planning Workshop was held in Belmopan, Belize in late May 2007 funded by the Norwegian government. Co-hosted by the CARICOM Climate Change Centre in Belize, it was attended by more than fifty people from the Arctic, Pacific, Caribbean, North America and Europe. The participants discussed the latest research and assessments on climate change vulnerability and adaptation in the Arctic and SIDS and began developing a Five-Year MSV Action Plan.

Workshop participants highlighted similar climate change effects in both regions, including the relocation of communities away from coastal areas due to sea level rise and frequent storm surges (e.g. GAO 2003 and Kelman 2006), and the human

An Inuk preparing his dogs for a sled ride across the frozen sea near Uummannaq, Greenland (photo: Lawrence Hislop).

and economic impacts of changes to the marine resources upon which Arctic and SIDS communities depend (e.g. Shea 2003; Smit et al. 2008). Given the great distances in geography, culture and language, participants might have been forgiven for wondering why they were in the same room. However, they responded enthusiastically to each other's stories and a new alliance was formed that decided to press for significant reductions in greenhouse gas emissions globally while working to ensure that resources are allocated regionally to assist those that need to adapt now to climate change.

The second MSV Workshop was held in Washington, DC at the beginning of April 2009, funded by the Norwegian government. The meeting was co-hosted by the Organization of American States, the Climate Law and Policy Project, the World Bank Institute, and the North American office of the United Nations Environment Programme. It involved more than fifty people from Alaska, Nunavut in the Canadian Arctic, northern Norway, the Russian Arctic, the Cook Islands, Seychelles, Fiji, Samoa, Niue and Micronesia and representatives of several international organisations based in Washington, DC.

The workshop focused on specific communications and outreach activities leading up to and following the UNFCCC COP15 in December 2009 in Copenhagen, Denmark. Participants looked at existing and potential projects, including continuing to pursue action-oriented research. The purpose of these projects will be to identify areas of collaboration between the Arctic and SIDS, potential partners, and sources of funding.

These continuing activities and the support given from the Arctic, the SIDS and other groups involved provided a strong mandate to continue MSV work through capacity building and action-related research. In both, communication, education, networking and outreach are continual activities, representing cross-cutting and linking actions, especially to ensure that both capacity building and research lead to and support effective action.

Capacity building

Building alliances between the Arctic and SIDS regions, developing common approaches to problem solving, and ensuring that information reaches both decision-makers from developed countries and the peoples most directly affected by climate change will aid in the broader goals outlined in international documents and processes dealing with climate change. UNFCCC (1992) specifically identifies 'Education, Training and Public Awareness' as important activities (Article 6). MSV seeks to build and develop capacity for Arctic and SIDS communities in this regard.

Linking the two regions in the context of climate change stimulates regional and cross-regional initiatives in education, training and public awareness raising. Partnerships have developed, allowing information exchange and methods for raising awareness regarding reducing greenhouse gases and dealing with the consequences of climate change at all levels. Arctic and SIDS representatives have also learned how to influence the debate on, and participate in, decisions on local climate change action, along with facilitating regional and global efforts.

For the UNFCCC negotiations, Many Strong Voices provided logistical, communications and other support for MSV participants at the UNFCCC COP13 in Bali, Indonesia in December 2007 and at the UNFCCC COP14 in Poznan, Poland in December 2008. That ensured support for programme partners to build networks, to get involved in COP activities, and to highlight to decision makers and negotiators topics of interest to them. At COP14, MSV was involved in a side event at the Development and Climate Days, highlighting the links between action on development and action on climate change (IISD 2008). Bringing people together in that manner helps to share information on negotiations, strategies and positions related to climate change.

MSV Ambassadors and Champions are also an ongoing endeavour. As people living in the regions affected, they become the voice and face of MSV, emphasising that dealing with climate change is about people and their communities, which includes the surrounding environments. With these ambassadors and champions speaking, writing and promoting MSV and the concerns of the Arctic and SIDS peoples, powerful messages can be conveyed regarding action.

To be most effective, climate change adaptation activities must be incorporated into larger planning initiatives related to sustainable development, such as integrated coastal management, disaster risk reduction, health care and education planning (e.g. Lewis 1999; Wisner et al. 2004). Policies that lessen pressures on resources, improve the management of environmental risks and increase the welfare of the poorest members of society can simultaneously advance sustainable development and equity, and reduce vulnerability to climate change and other stressors while supporting adaptation to them (Beg et al. 2002; Hewitt 2007). MSV supports knowledge exchange and application in these areas.

An especially important task is incorporating local perspectives into national, regional and local adaptation plans (e.g. Mahiri 1998; Mercer et al. 2009; Wisner 1995). The cultures of both the Arctic and SIDS regions are closely linked to the environment, covering both the land and sea, in terms of creating and sustaining communities and using the natural resources without ruining them for future generations (Einarsson et al. 2004; Howorth 2005). Exchanging that knowledge, and particularly indicating how local knowledge could and should be used for action, has given many Arctic and SIDS communities the impetus to start on adaptation actions on their own terms in their own way, without awaiting external direction or support that might be a long time in coming and that might not understand or accept the local contexts. MSV supports and facilitates sustained collaboration, from story telling to cooperative adaptation on the ground, between and within Arctic and SIDS regions.

Action-oriented research and implementation

MSV work indicates a need for assessments of vulnerability and adaptation to climate change that are community-based, rather than national or regional. These

Sea ice off the coast of Barrow, Alaska (photo: John Crump).

should use a scientific approach, while ensuring that local knowledge is prominent. It should also be ensured that action results from the research (CICERO and UNEP/GRID-Arendal 2008). These assessments should contain strong links to the Arctic and should lead to community-relevant adaptation strategies, strengthening local and national adaptation planning and supporting vulnerable regions in their call for strong action globally (Kelman and West 2009). Any such work should go beyond providing a 'snapshot' of impacts and vulnerability in these regions, to produce results that can guide adaptation actions and appropriate policy measures over time, while factoring in a deep understanding of a location's history.

The assessment would be a collaborative effort with the following results:

1. Capacity built and developed in the participating institutions and among individuals to understand and tackle climate change.
2. Networks developed and solidified across the SIDS and between SIDS, Arctic partners and non-SIDS institutions regarding climate change impacts, vulnerability and adaptation.
3. Cutting-edge scientific publications in international peer-reviewed journals written in cooperation with local and community partners.

4. Communication of the scientific work underway and the results achieved to the general public, policy makers and other researchers, especially those in SIDS.
5. Timely and relevant policy recommendations and policy briefs for interested parties, including governments, which are based on sound science.

With this solid methodological basis, implementation of the assessment is the next step. Selecting case studies and carrying out research must be in collaboration with local partners, factoring in their interests and needs. That will ensure that the continuing MSV work for the vulnerability and adaptation assessment produces original, useable and useful research on the terms of the people most affected by climate change.

Steps taken since the assessment report include starting an international network of Masters and PhD students who are interested in working on the assessment for their dissertations, liaising with researchers and practitioners in order to avoid overlap and duplication and to tap into unpublished material, and submitting funding applications. In this work, consultations continue with communities to ensure that assessment work is on their terms and serves their needs. In particular, it was clearly highlighted that further national and regional assessments were not needed. Instead, a local, community-based focus is essential, and this research must lead to action.

Conclusions

United Nations Secretary General Ban Ki-moon has called climate change 'the moral challenge of our generation'. At the plenary session of UNFCCC COP13 in Bali, Ban told assembled delegates that 'the situation is so desperately serious that any delay could push us past the tipping point, beyond which the ecological, financial, and human costs would increase dramatically' (Fuller and Gelling 2007).

Unless the world embraces this moral challenge, the burden of climate change will fall on the most vulnerable regions, areas like the Arctic and SIDS. That echoes what people in some of the world's most vulnerable regions have been saying for some time. MSV provides the inspiration, impetus and opportunity to build and maintain processes for people in these regions to deal with climate change based on sustainability principles, policies and practices. With such comprehensiveness, cooperation and exchange, Many Strong Voices will be heard, leading to action locally and globally for positive change.

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Section 8

MONITORING SYSTEMS

The Need for Arctic Data: Sustaining Arctic Observing Networks (SAON)

Odd Rogne
Senior Advisor, Arctic Monitoring and Assessment Programme
IPY International Programme Office, Norway

Abstract
There is a need for well coordinated and sustained Arctic observations that meet scientific and societal needs. In an initiative that has become known as the 'SAON process', the Arctic Council and twelve other international organisations have made a joint effort to identify a strategy for 'Sustaining Arctic Observing Networks', to maintain and extend long-term monitoring of change in the Arctic, with a view to building a lasting legacy of the International Polar Year.

Introduction
The Arctic is undergoing considerable changes due to climate change, contamination, biodiversity loss and alterations to the physical environment, which have serious impacts both inside and outside the Arctic. Trends indicate that the severity of the impacts is projected to increase in the near future. Natural capital and prospects for human development may be undermined.

Arctic countries and their people are faced with new environmental, economic and social challenges. Global activities affect the Arctic environment while changes in the Arctic environment have global consequences. Hence, the broader global community must be engaged in improved monitoring of the Arctic to better understand the changes and their affects and must address the social and human dimension in Arctic observations.

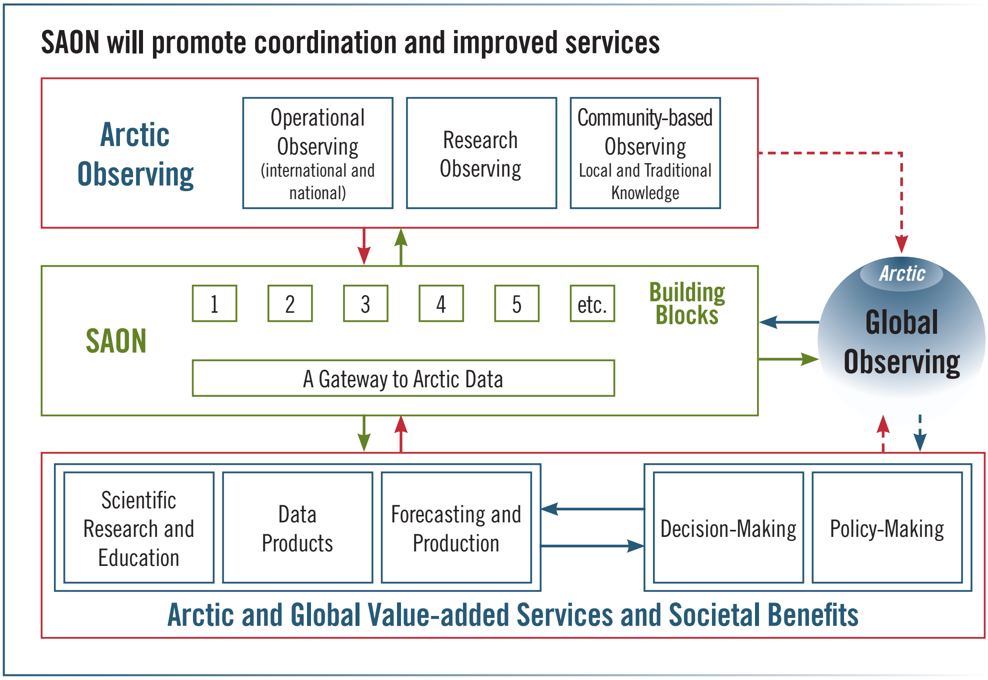

Figure 1. Conceptual diagram showing the three Arctic observing categories and data and information management collectively contributing to value-added services and societal benefits, and to global observing. The SAON promotes coordination, collaboration and communication among all the parties, i.e. long-term Arctic observing activities and data and information management that contribute to circum-Arctic and global services and benefits (Courtesy of the SAON Initiating Group).

SAON: Sustaining Arctic Observing Networks

The need for well coordinated and sustained Arctic observations that meet scientific and societal needs has been identified in numerous high profile reports and at a variety of workshops and conferences (e.g. ACIA 2005; ICARP II 2006; NRC 2006). The International Polar Year 2007-2008 (IPY) provided an opportunity to initiate new observing activities in the Arctic. However, we do not know which of these projects will survive in the long-term.

In November 2006, the Arctic Council (AC) urged all member nations to maintain and extend long-term monitoring of change in the Arctic, with a view to building a lasting legacy of the International Polar Year. Further, the AC requested that the Arctic Monitoring and Assessment Programme (AMAP, an AC Working Group) work with other AC working groups, the International Arctic Science Committee (IASC) and other partners in efforts to create a coordinated Arctic Observing Network that meets identified societal needs (Arctic Council 2006). The goal of developing an Arctic Observing Network as a legacy of IPY (WMO/ICSU 2007) was endorsed by the WMO XV Congress in May 2007. AMAP initiated shortly after the AC Ministerial Meeting a dialogue with a number of international organisations involved in Arctic observing with a view to forming an initiating group for responding to the Arctic Council request. This initiative has become known as the 'SAON process' in which the Arctic Council and twelve other international organisations have made a joint effort to identify a strategy for 'Sustaining Arctic Observing Networks', as well as actions to be taken.

The SAON process has so far consisted of three major international workshops, two regional meetings and numerous consultations. About 350 experts, scientists and northern residents have taken part in the SAON process. A special effort has been made to have all observing communities (governmental agencies, scientists and local/indigenous communities) well represented, as well as participation of all sorts of users and stakeholders. Comprehensive material has been collected during these workshops and meetings ranging from users' needs, ongoing (and planned) observing networks, identification of gaps and views on how gaps should be filled, and sustaining observations and data and information management. This material, as well as the SAON Initiating Group (IG) document and the SAON Report, is available at: www.arcticobserving.org. The SAON Report ('Observing the Arctic') was finalised in December 2008 (SAON 2009), and is now under consideration by the Arctic Council and the other organisations involved. The final discussion of the SAON Report, including actions to be taken, is expected at the Arctic Council Ministerial Meeting in April 2009.

The SAON recommendations include advice to national governments on actions to be taken on sustaining and increasing current levels of observing activities; creating a data dissemination protocol to make data and information freely, openly and easily accessible; establishing a national inter-agency group to coordinate and integrate their Arctic observing activities; and finally welcoming non-Arctic states and international organisations as partners.

The basic SAON strategy is to build on existing or developing networks (governmental agencies, research, community-based), aiming to cover the entire Arctic, meeting all societal needs and collecting data long-term. SAON would also focus on sustaining networks through long-term funding, and will address a number of key issues that transcend individual networks or national capabilities.

The need for Arctic data

Notwithstanding the many and frequent reports of Arctic change, our knowledge of the Arctic system is limited in many respects; for example, there are temporal, spatial and disciplinary gaps in observing records, and data are often difficult to obtain or even unavailable. While current observing systems have been adequate to detect a variety of physical, biological and socio-economic changes in the Arctic, observing capabilities are less than adequate to document either the full suite of changes that are underway, or any changes that will occur in the future.

Sub-optimal observing and data management hamper our ability to monitor and study (by assessment, synthesis and modelling) Arctic environmental and socio-economic change and their regional and global consequences. Understanding the causes of Arctic change, and the development of adaptive responses to change, require increased national and international commitment to sustained, coordinated and improved observing sites, systems and networks in the circumpolar Arctic.

Concluding remarks

All observing and data networks being presented in this volume are or will fit under the SAON umbrella, and will benefit from the SAON initiative. Consequently, UNESCO (like Arctic Parliamentarians, the EU Arctic Monaco meeting etc.) is strongly encouraged to:

- Support and encourage the Arctic Council and their partners to sustain and increase Arctic observations, and related data and information management services.
- Take concrete actions for ensuring long-term national as well as trans-national funding for observing platforms, data archives and information management services.
- Assist in filling current gaps (temporal, spatial and disciplinary) in Arctic observing and data services.

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Predicting Arctic Climate: Knowledge Gaps and Uncertainties

Alexander V. Frolov
Vladimir M. Kattsov
Federal Service for Hydrometeorology and Environmental Monitoring
(Roshydromet), Russian Federation

Abstract

Complex and still insufficiently understood climate processes and feedbacks, specific for the northern high latitudes, contribute significantly to the challenge that the Arctic poses from the viewpoint of physically-based climate prediction. This challenge makes itself particularly evident in the range of climate change projections for the Arctic by state-of-the-art global climate models, even for the same scenarios of anthropogenic radiative forcing. Arctic climate prediction is further complicated by the vigorous unforced natural variability inherent to the climate system in high latitudes. Hopes for decreasing Arctic climate prediction uncertainties, as well as for better quantifying regional and global impacts of climate changes in the Arctic, are pinned on enhancing and synthesising remote and in situ *observational networks and high performance computing. The latter is necessary for refining spatial resolution of climate models, developing their components, and improving computational strategies. This should be facilitated by increasing governmental investments in and international cooperation within the framework of major observational and research programmes.*

Arctic climate change as observed, attributed and projected

Global mean surface air temperature in 2008 was the tenth highest during the past 100 years (Figure 1a), 1998 being the warmest year during that period. Average surface air temperature in the Arctic appears to have increased over the twentieth century, however against the background of pronounced low frequency variability with two major prolonged warming events – in the first half and by the end of the

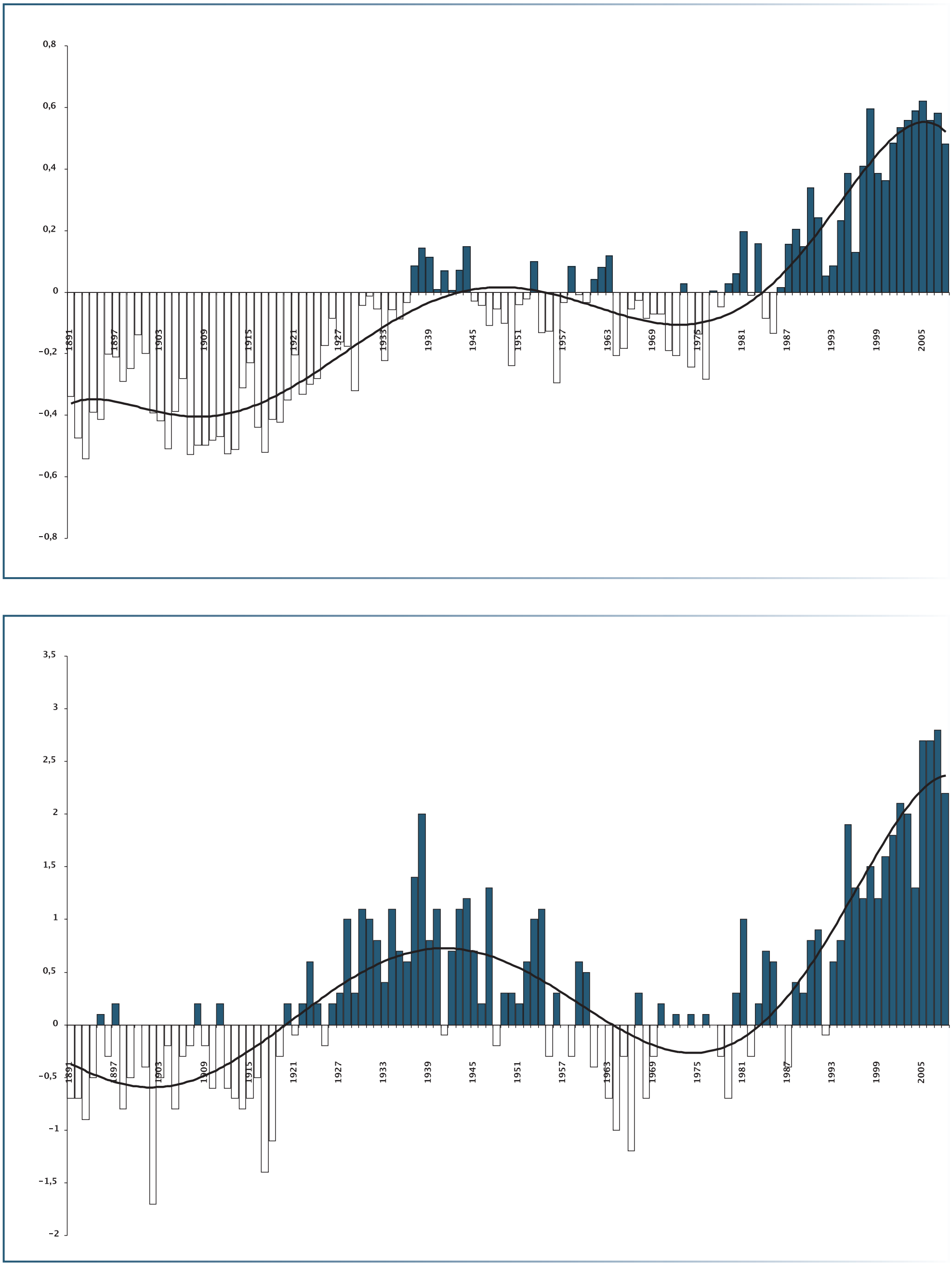

Figure 1. Observed evolution of (a) annual/global mean surface air temperature (as anomalies relative to the 1979-2000 mean) and (b) annual surface air temperature in the Arctic (as anomalies relative to the 1979-2000 mean) (Birman and Berezhnaya 2009).

century (Figure 1b). It is very likely that the Arctic has been warming faster than any other region of the planet since 1966 and has by now exceeded the temperature increase in the 1930s and 1940s.

Over past decades, observed climate changes in the Arctic have been demonstrating impressive consistency (ACIA 2005; IPCC 2007): the warming in the Arctic has been accompanied by dramatic shrinking of sea ice (with the largest trend in September – at the end of the melt season), thawing permafrost, glacier mass loss, melting of the Greenland ice sheet, increasing river discharge into the Arctic Ocean (along with changes in runoff seasonality), etc.

On the other hand, the Arctic remains among the regions notorious for the poor coverage of their observational network, as well as insufficient representation and lengths of observational time series. This in particular limits possibilities for climate model evaluation and development. The well-known observational problems in the Arctic include sea ice thickness, cloudiness, solid precipitation and permafrost characteristics.

For the above reasons, but also due to the vigorous natural variability that may amplify or mask the anthropogenic signal, detection and attribution of the observed climate change in the Arctic is a much more challenging scientific problem than in many other regions of the Earth. In this context, recent discussions around possible causes of the two above-mentioned major Arctic warming events are particularly notable (e.g. Bengtsson et al. 2004; Johannessen et al. 2004; Overland et al. 2004; Polyakov et al. 2003). While climate sceptics believe that both warming events are nothing but natural variability, arguments in favour of the dominating anthropogenic nature of the later event have become more convincing (e.g. Wang et al. 2007).

Several generations of climate models, which during the past two decades have been demonstrating encouraging advancement and promise, show significant polar amplification of global warming in projections for the twenty-first century climate. A number of positive feedbacks operating in the climate system are likely to be responsible for this feature (Bony et al. 2006). However, some of them are poorly quantified and insufficiently understood. Especially revealing in this context are large differences between the Arctic climate changes projected for the twenty-first century by different state-of-the-art climate models forced by the same anthropogenic greenhouse gas (GHG) emission scenario (e.g. Figure 2) (Chapman and Walsh 2007; Kattsov et al. 2007a,b; Sorteberg et al. 2007; Zhang and Walsh 2006).

Arctic climate change: knowledge gaps and uncertainties

Components, processes and feedbacks

Along with the terrestrial and marine cryosphere, with all the complexities of its dynamics and thermodynamics, there are many other specific features that contribute to the challenge that the Arctic poses from the viewpoint of physically-based climate prediction. These include stable stratification in the lower troposphere, low water vapour content in the atmosphere, multi-layer clouds, specific features of the Arctic Ocean thermohaline structure, and specific interactions (for example between snow and vegetation).

Major uncertainties associated with climate change in the Arctic relate to quantification of its future impacts on the global climate system, e.g. on global oceanic thermohaline circulation through the increased export of fresh water into the North Atlantic, or on global sea level rise through melting glaciers and particularly the Greenland ice sheet, or on global atmosphere GHG content through carbon emissions by thawing permafrost, etc.

On the other hand, climate models are probably unjustifiably blamed for having failed to 'predict' the rate of accelerated decrease of the annual minimum sea ice extent in the Northern Hemisphere observed over past decades (Figure 3). However, attribution of that acceleration remains to be carried out, because besides the suspected insufficient sensitivity of climate models' sea ice components, possible causes of the model-observation discrepancy may include the neglect of some processes (e.g. decreased reflectivity of the sea ice surface polluted by black carbon) or the manifestation of unforced decadal scale variability (see below), for the timing of the corresponding extremes of this are not supposed to be reproduced by climate models (Kattsov et al. 2007a; Wang et al. 2007).

Timescales and the rate of sea level rise associated with expected melting of the Greenland ice sheet fall within the most significant uncertainties of the IPCC Fourth Assessment Report (AR4) projections (IPCC 2007). Including the dynamics of ice sheets (which are currently not represented in the climate models) in projections is expected to improve this situation.

Resolution

Local and regional climate features, such as enhanced precipitation close to steep mountains, are not well represented in global climate models due to their limited horizontal resolution. Much higher resolution – both horizontal and vertical – than that provided by the state-of-the-art global climate models is crucial for proper representation of many processes in the Arctic (Kattsov et al. 2005), some of which are important for the entire Earth system.

A local change in climate can more easily be translated into impacts than a direct use of global model results. To describe local climate, high-resolution limited area models customised to the Arctic domain are used (Dethloff et al. 2005). However, application of regionalisation techniques introduces another greater level of uncertainty which can significantly affect climate change simulation (Kattsov et al. 2005).

Unforced variability

A single model simulation provides only one possible climate scenario. Clearly, this is not a prediction of future climate, as one can only calculate change in climate based on a prescribed, artificial change in atmospheric GHGs (see below).

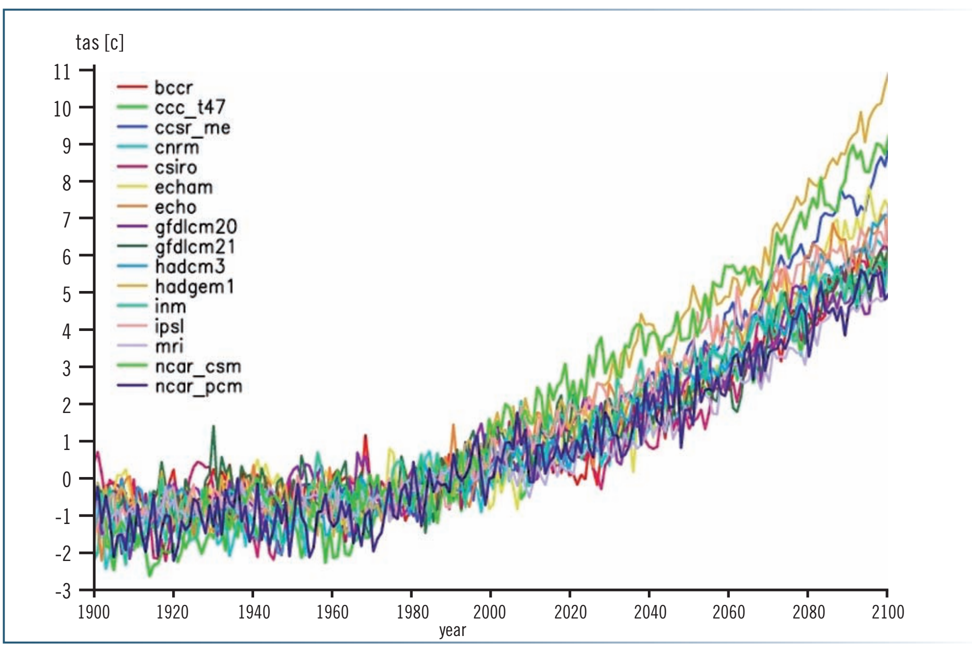

Figure 2. Surface air temperature evolution through the twentieth and twenty-first centuries (as anomalies relative to the 1980-1999 mean) as simulated by an ensemble of global climate models used in the IPCC Fourth Assessment Report (2007).

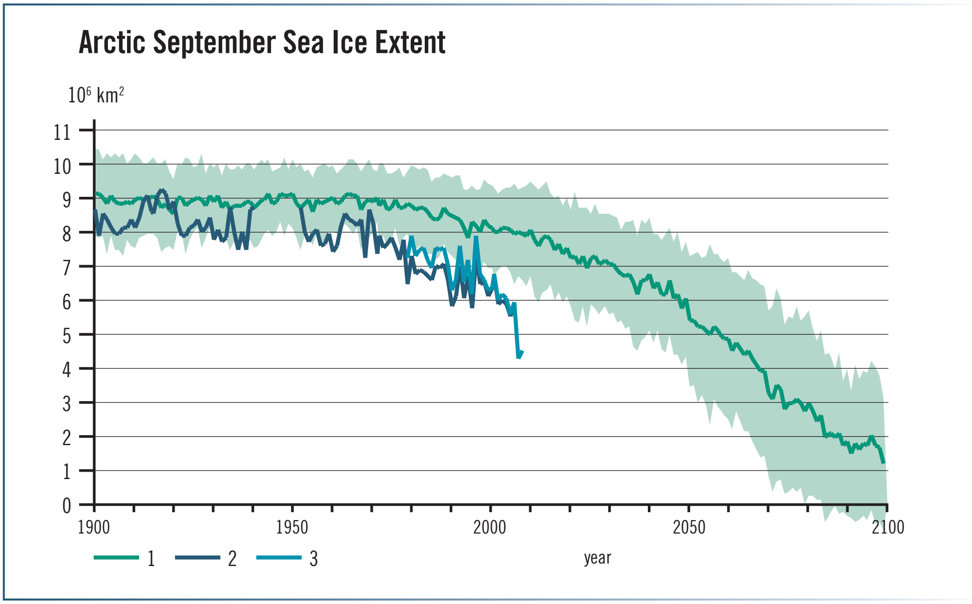

Figure 3. Seasonal minimum (September) sea ice extent in the northern hemisphere as simulated by an ensemble of state-of-the-art global climate models (1) and observed (2, 3) (Adopted from Meleshko et al. 2008).

A climate shift can be due to natural variability as well as a GHG induced change. This effect could be larger or smaller depending on the region, the climate parametre (temperature, precipitation, snow cover, etc.) and the time and space scales. To assess the relative importance of natural variability versus a prescribed climate forcing, ensemble simulations from different initial conditions, as well as ensembles of differently formulated climate models, should be used.

Ensembles containing in the order of a hundred simulations would give a better estimate of climate change probability distributions. Ensemble simulations would also provide a possibility to estimate changes in the frequency of storms, temperature extremes and other high impact weather events. Noteworthy is another challenge which arises with this – adequately utilising the probabilistic prediction information in socio-economic decision-making.

Radiative forcing

Prediction of changes in radiative forcing – both anthropogenic (e.g. anthropogenic GHG emissions) and natural (e.g. volcano eruptions) – is at least very difficult, if not impossible. Emission scenarios converted into radiative forcing are not assigned any probability, while natural emissions are stochastic. Climate change may feed back on concentrations of atmospheric constituents through for example biogeochemical processes, which further dramatically complicates projecting climate.

For example, the magnitude of the positive feedback between the warming climate and additional emission of GHGs into the atmosphere from natural sources and particularly from thawing permafrost (Figure 4) is unknown. Some scientists believe the effect may be catastrophic, while others are sceptical about its significance. The picture is complicated by limited information on the quantity and form of carbon sequestered in permafrost, by inadequate knowledge of Arctic biogeochemistry, and by insufficient understanding of the interactions between the terrestrial cryosphere, hydrology and vegetation in northern high latitudes in the warming climate.

Outlook for predicting Arctic climate

Sustainable pan-Arctic observing network

There is an urgent need for integrated remote sensing and *in situ* observational systems that combine good coverage with sufficient accuracy and numbers of observed climate characteristics in the Arctic (and globally).

Several satellite missions are planned that hopefully will provide observational datasets for the Arctic region with a much better coverage than at present. These efforts must accompany the restoration and development (on a new technological basis) of the land and marine observing network in the Arctic, accounting for spatio-temporal variability and employing comprehensive models and simulation experiments of observing networks to optimise the site distribution (through testing the impacts of different observational sites). The network should include new observing platforms for deploying *in situ* sensors (rocketsondes that launch instruments that can make weather observations, stratospheric balloons, unmanned and piloted aircrafts, ocean robotic floats, ice drifting buoys, etc.) allowing an increase in density where especially necessary, as well as in the number of measured parameters (humidity, ice and snow depth, ocean vertical temperature and salinity profiles). Special attention should be given to the unification of methods, requirements and data analyses.

A pan-Arctic sustainable observing system is essential, which allows the incorporation of *in situ* and satellite observations from operational and research networks

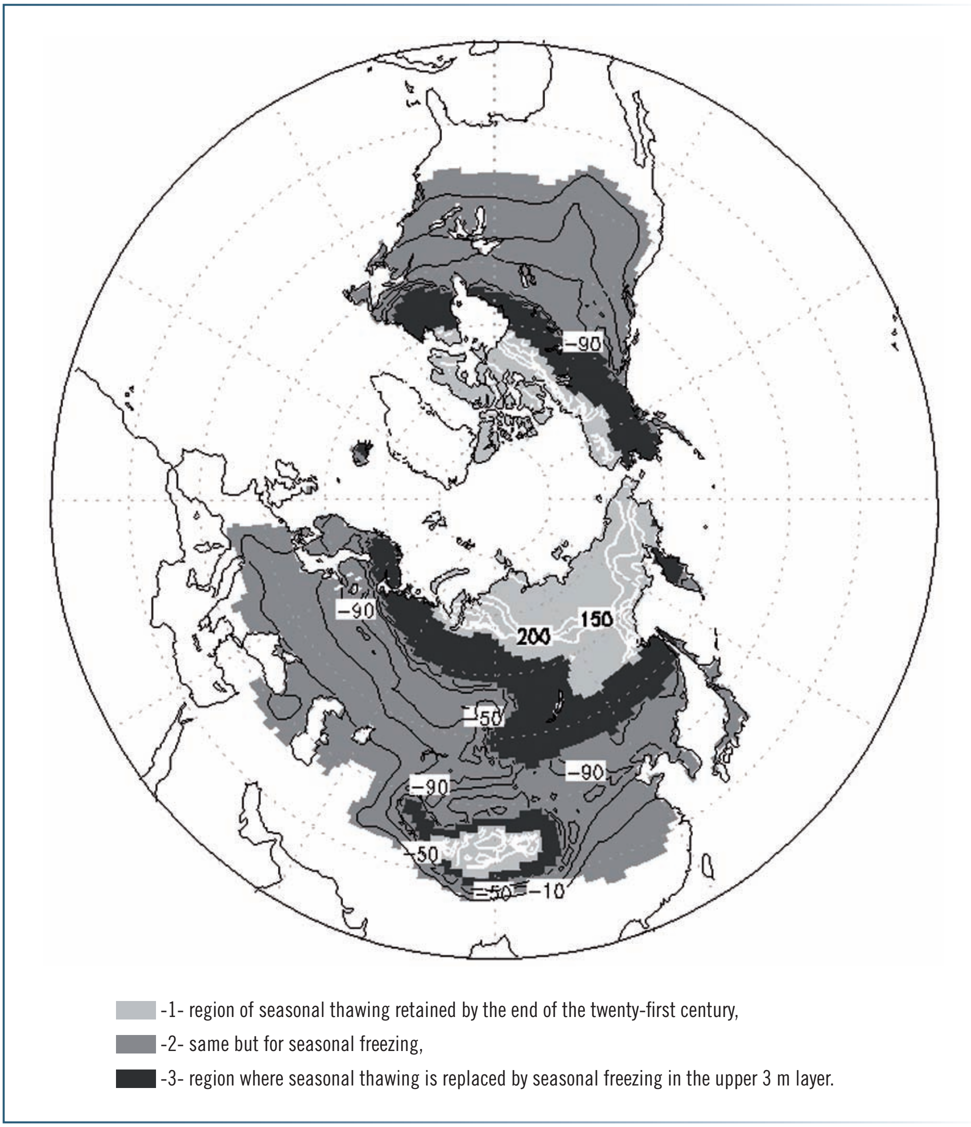

Figure 4. Depth changes of seasonally thawing layer (white lines, cm) and seasonally frozen layer (black lines, cm) over 2080-2099 (A2) relative to 1980-1999 (Pavlova et al. 2007).

and platforms. Coupled with modelling, the observational data allow the development of (re)analysis products crucial for evaluating and improving climate (Earth system) models used in predictions.

Enhancement in high performance computing

Obviously, a better quantification of future changes in the Arctic climate will require further big efforts in climate (Earth system) modelling, which is among the most computationally demanding problems in science. Such efforts should include not only enhancing different components of Earth system models or refining the spatial resolution. Computational strategies, e.g. large ensembles of simulations, have started (and will undoubtedly continue) to play an increasingly important role in addressing climate predictability, unforced variability and extreme events. All these will require very significant further enhancements in high performance computing (Shukla et al. 2009).

Advancing the science of climate change

After the impressive and encouraging achievements of climate science, confirmed by the evident success of the IPCC assessments, which culminated in 2007 in the IPCC receiving the Nobel Peace Prize, some policy-makers have the impression that the science of climate change has generally finished developing its physical basis and has thus fulfilled its main task, so that all that remains is to clarify details of minor importance for the decision-making process. As a matter of fact, our knowledge of the mechanisms of climate change still suffers from significant gaps, associated in particular with insufficient observational data and the status of climate modelling. Those gaps to some extent challenge the credibility of climate change predictions, particularly for the Arctic. Moreover, in spite of any improvements in observation and modelling, the chaotic nature of the climate system will always introduce uncertainty into predictions, thus predetermining their probabilistic character.

In such conditions, it is necessary to learn to take the best possible decisions on adaptation and the mitigation of climate change's negative impacts. Having in mind the very high cost of erroneous decisions, it is necessary to invest in enhancing observations and scientific research in the Arctic aimed at minimising the uncertainties of regional climate predictions and therefore of climate change impacts on natural systems and humans. This enhancement should be facilitated by intensification of international cooperation within the framework of major observational and research programmes, including the Sustaining Arctic Observing Networks (SAON) initiated by the Arctic Council, the World Climate Research Programme (WCRP) which is jointly sponsored by the World Meteorological Organization, the International Council for Science, and the Intergovernmental Oceanographic Commission of UNESCO, among others.

Acknowledgements

Some results presented in this paper were obtained within research projects supported by the Russian Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet), by the Russian Foundation for Basic Research and by the US National Science Foundation via the International Arctic Research Center, University of Alaska, Fairbanks. Modelling groups are acknowledged for making their simulations available for analysis, the Program for Climate Model Diagnosis and Intercomparison (PCMDI) for collecting and archiving the Coupled Model Intercomparison Project, Phase 3 (CMIP3) model output, and the World Climate Research Programme's (WCRP) Working Group on Coupled Modelling (WGCM) for organising the model data analysis activity. The WCRP CMIP3 multi-model dataset is supported by the Office of Science, US Department of Energy.

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Observatories for Understanding Arctic Change

Peter M. Haugan
Geophysical Institute, University of Bergen, Norway

Abstract

Rapid changes in the extent, thickness and characteristics of the Arctic sea ice cover are already occurring. Several recent analyses suggest that a state change has occurred in response to atmospheric forcing and that a return to ice-ocean conditions of previous decades is unlikely. The ventilation of the deep ocean, ocean circulation and physical conditions for marine life are expected to change significantly with changes in the ice cover. The Arctic and Subarctic region will be the first to experience ocean acidification in deep waters as well as surface waters. In order to document and understand the ramifications and implications of this development, there is a need for dedicated observatories which not only monitor the evolution over time and produce consistent data sets, but also which allow in-depth studies and understanding to underpin governance for the common good.

Introduction

The Arctic Ocean is probably the least explored ocean basin in the world. Recent measurements and process studies allow improved understanding of several features, such as vertical mixing in the Arctic Ocean and the role of ocean heat transport and sea ice melt water in the future evolution of the ice cover. However incomplete understanding of how air, ice and water interact is still limiting our ability to make future projections. Complexities not only in the ocean circulation and ice-ocean interaction, but also concerning the stable atmospheric boundary layer, are not well described. The cold surface of ice and snow separates the atmospheric surface layer from the upper atmosphere, particularly in winter, and this sharp layering is difficult to represent in numerical models. Climate models do particularly poorly in the Arctic, partly because there has been such a scarcity of observations of Arctic conditions to test various aspects of the models. Poorly known cloud cover (both its areal fraction, height and characteristics), low sun angle and other factors including subtle properties of seawater at low temperatures, imply that estimates of the surface heat balance even in the climatological mean are notoriously difficult to establish. The shortness of available time series means that climatology and natural variability are poorly defined.

When climate models are so poorly constrained in the Arctic, one might say that it comes as no surprise that none of the model scenarios in the latest Intergovernmental Panel on Climate Change (IPCC) projections were able to match the recent observed rapid decline in sea ice extent. The physical explanations offered, which are being borne out by an increasing number of scientific publications, involve a potential run-away mechanism associated with weaker and more mobile ice cover. This ice can respond much more rapidly to changing winds. Heavy multiyear ice, which was much more prevalent until a decade or two ago, has been exported from the Arctic and replaced by a diminishing and increasingly seasonal ice cover. The coupled dynamics of this system, including the response in the reflection of solar radiation and indirect cloud effects, have not been well represented in models.

It is therefore primarily through physical reasoning aided by incomplete measurements and illustrative calculations with simplified mechanistic models that we arrive at the present understanding and analysis of the situation. This involves a real possibility for an essentially seasonally ice free Arctic within a decade or two, and an increasingly reduced likelihood of a wind pattern or event that would lock the ice in place and allow it to grow back to its previous extent and thickness. Thus, we can expect increased human activity in the region, with growing transportation, natural resource exploration and exploitation, and changes of lifestyle for Arctic inhabitants. What does this mean for the natural environment and how can we monitor and understand the rapid changes that are expected in this environment?

Monitoring and understanding the environment and impacts in the Arctic

During the International Polar Year (IPY) 2007-2009, a number of research projects were carried out. During the data analysis phase, which will still continue for several years, some projects will make use of observations made during the previous International Geophysical Year (IGY) 1957-1958. For some variables

A pressure ridge in the straits of the Northwest Passage (photo: Peter Bates).

there are time series over this period and longer, but these are very few and far between. Observations with reasonable spatial resolution are generally only available from satellites, i.e. for a maximum of three decades and not covering anything below the ocean surface. It is therefore very hard to ascertain what the natural climate variability would be, and also the accompanying natural variability in biological species, particularly in the marine environment.

There is therefore a great need for long-term continuous observations of the oceanic subsurface environment, including its physics, biology and chemistry. Concerning the latter, ocean acidification due to uptake by the ocean of CO_2 emissions to the atmosphere is of prime importance. Within this century, corals and many other species will experience severe problems due to this ongoing change in the chemical environment. Reduced availability of calcium carbonate from the water column makes corals and other organisms suffer something akin to osteoporosis (i.e. weakening of their skeleton), but also a host of other potential effects may occur in a wide range of organisms. The penetration of anthropogenic CO_2

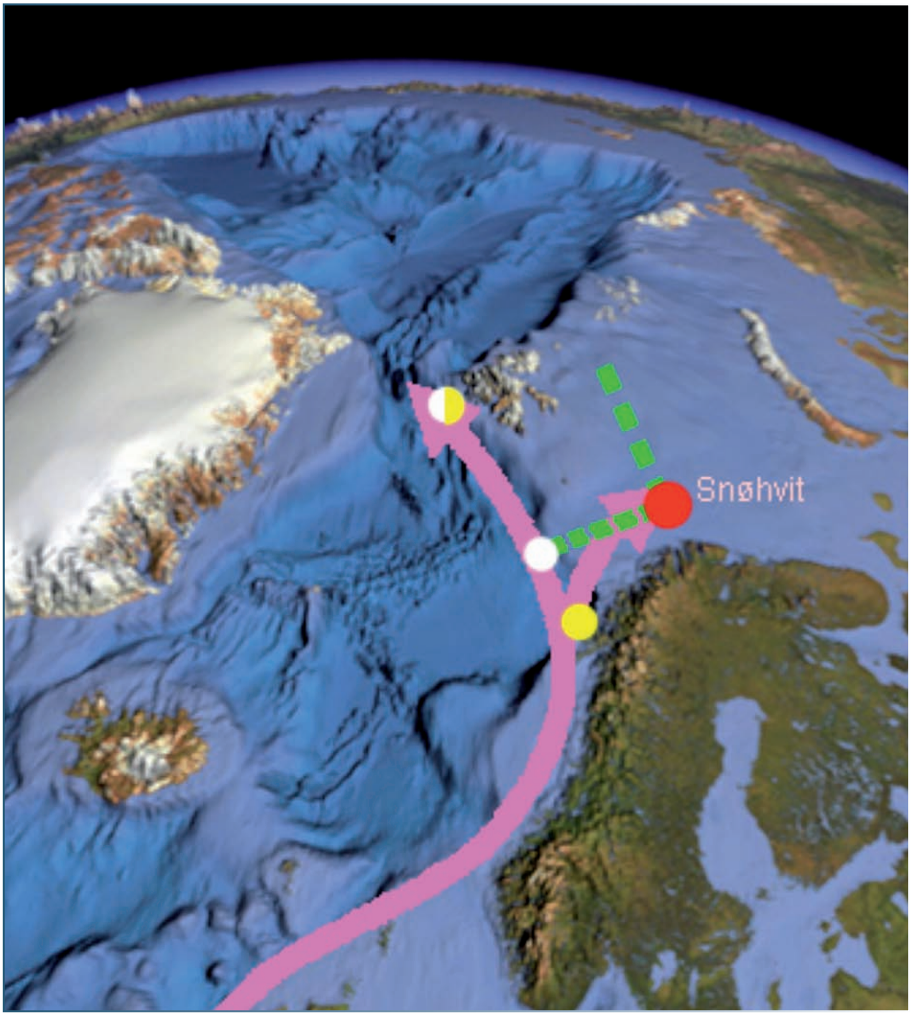

Figure 1. ESONET Demo Missions (white dots), StatoilHydro financed Demo Missions (yellow dots), and NOON-planned Cabled Ocean Observatory in the Barents Sea (Courtesy of Juergen Mienert and Benedicte Ferre, University of Tromsø, and Anne Hageberg, Christian Michelsen Research AS).

into the deep ocean occurs particularly early and rapidly in high latitude areas with deep vertical mixing like the Greenland Sea, but may also follow slope currents and downflows to the central Arctic from areas like the Barents Sea.

With warming of the water and eventually the seafloor, anthropogenic effects may be felt even in the subsoil. Considerable amounts of methane are locked up in methane hydrates just below the seafloor in the Arctic. Methane is a potent greenhouse gas, so if some of these reserves are destabilised due to warming, the greenhouse effect will be strengthened. Also natural geological processes at the seafloor, including circulation and release of fluids to the water column, occur in the Arctic. These processes may be influenced by global warming and play a role in natural hazards by initiating submarine landslides which may lead to tsunamis. Can we document and understand the ongoing changes?

Observatories of environmental change

Unprecedented technological opportunities for continuous monitoring even of the deep sea environment now exist. Underwater communication by acoustic means is efficient for transfer of low bit rate data streams with simple information from single instruments over long distances using very low acoustic frequencies, and is used also for higher bit rate higher frequency local data transmission and monitoring. Mobile autonomous and pre-programmed vehicles are beginning to be used under the sea ice. However, for the most demanding multidisciplinary monitoring requirements (e.g. using undersea video cameras and for provision of sufficient power for demanding instruments), the scientific community is increasingly calling for fiber optic cabled observatories providing much greater power (kWatts) and more powerful (Mbit/s) two-way data transmission bandwidth between offices/research stations and instruments on the seafloor.

No such cabled observatories currently exist in the high Arctic. However, highly significant achievements have been made in projects such as Neptune-Canada off Vancouver Island(1) and pilot projects like MARS in Monterey Bay. In Europe, the coordinated projects Esonet(2) and European Multidisciplinary Sea Observatories (EMSO) are planning research infrastructure of this nature along the Norwegian margin and west of Svalbard. The Norwegian Ocean Observatory Network (NOON)(3) is working with StatoilHydro to develop a facility in the Barents Sea in connection with the Snøhvit gas field (Figure 1).

It is urgent that environmental monitoring commences in the high Arctic well before development and local changes in human activities begin to take effect, and it is important to do this in several locations with differing local human pressures and other conditions. Only then can we properly understand and differentiate between natural variability, impacts of global climate changes and impacts of

(1) http://www.neptunecanada.ca/ and http://www.neptune.washington.edu/
(2) http://www.oceanlab.abdn.ac.uk/research/esonet.php
(3) http://www.oceanobservatory.com/

local activities. This is particularly pressing in the least observed compartment, which is the marine realm (Dickson 2009), where also many localised activities, as well as local and global impacts, are expected. Multidisciplinary observatories also covering the terrestrial and atmospheric compartments and all aspects of the cryosphere should also however clearly be included.

Conclusion

It is necessary to establish Arctic ocean-ice-atmosphere observatories which combine long-term reference measurements of core variables in combination with in-depth studies of geophysical and biogeochemical processes, particularly through cabled seafloor observatories. It is also important that we begin to integrate long-term observatories with satellite data, and that this data is assimilated into models through regional mechanisms which are tightly linked to global counterparts, like the Arctic Regional Ocean Observing System (Arctic ROOS),[4] a component of the Global Ocean Observing System (GOOS), and the Global Earth Observation System of Systems (GEOSS).[5] We should also integrate studies of present day physical climate system processes with studies of past climate evolution, and with biogeochemistry, emphasising urgent topics like ocean acidification and seafloor gas exchange.

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(4) http://arctic-roos.org/
(5) http://www.earthobservations.org/

Arctic Monitoring Systems: The Challenge for the Social Sciences

Joan Nymand Larsen
Stefansson Arctic Institute and University of Akureyri, Iceland

Abstract

There is an urgent need for close and long-term monitoring of Arctic change, including the need for observations and data management. Improved monitoring of the Arctic is needed to gain a full understanding of the processes of change and their impacts. This is a particular challenge for the social sciences, where there is no established tradition of monitoring. A long-term and sustained approach to addressing sustainable development in the Arctic requires appropriate indicators, data, coordination and monitoring systems to provide us with information on the rapidly evolving social systems of the Arctic.

The Arctic Human Development Report (AHDR), the Arctic Climate Impact Assessment (ACIA), the International Conference on Arctic Research Planning (ICARP II), projects of the International Polar Year (IPY), and others, have documented in detail the changes occurring in the Arctic and the need for monitoring to assess the impacts of change. Arctic societies and cultures are faced with multiple stressors and challenges related to the ongoing and combined effects of environmental processes, industrial development, cultural development and economic changes. The AHDR – the priority project of the Icelandic chairmanship of the Arctic Council – presented the first overview of human development in the Arctic. The goal of the report was to identify and synthesise existing knowledge in the interests of presenting an integrated picture of human development in the Arctic. It details the challenges faced by Arctic societies, and shows that Arctic peoples are susceptible to changing environmental conditions. It concludes that Arctic societies have a 'well-deserved reputation for resilience' in the face of change, while today they are facing an unprecedented combination of rapid and stressful changes (AHDR 2004).

The ICARP II process also identified critical research needs and outlined practical steps and organisation to be considered. One such proposal was the establishment of coordinated and integrated Arctic observation systems that focus on social, biophysical and ecological dimensions and include local to global scale monitoring, as well as the build up of a meta-database of case studies on socio-ecological change and with it, a standardised format and common set of key variables. ICARP II, ACIA, projects of the IPY such as SAON (Sustaining Arctic Observing Networks), the Arctic Social Indicators (ASI) project, and many others, have pointed to the need for close and long-term monitoring of Arctic change, including the need for observations and data management. Improved monitoring of the Arctic is needed to gain a full understanding of these processes and their impacts.

To help facilitate the analyses of the impacts of climate change, to make comparative assessment of vulnerability to climate change, and to facilitate decision-making on the reallocation of resources in response to change, it is necessary to undertake in-depth analyses of living conditions in Arctic communities across the circumpolar region. A critical element in research and assessment is community participation and community-based monitoring. The critical role of Arctic communities and indigenous people in the collection, management and storing of data in remote regions for on-going monitoring is increasingly being recognised. The integration of local knowledge and the inclusion of Arctic residents as partners in research projects is a critical link to successful interdisciplinary research. Significant bodies of data including local indigenous knowledge on the Arctic environment, ecosystem change and living conditions are being accumulated by local inhabitants of the north, and help provide the basis for community-based monitoring of Arctic change. The IPY project 'Exchange for Local Observations and Knowledge of the Arctic' (ELOKA) is an example of a project that seeks to 'provide data management and user support to facilitate the collection, preservation, exchange and use of local observations and knowledge of the Arctic' (ELOKA 2008). It seeks to support community-based research with accessible and usable data management to facilitate the sharing of research results more broadly, and to maintain local control of data.

The IPY project on Community Adaptation and Vulnerability in Arctic Regions (CAVIAR) is a programme of interdisciplinary research to identify insights essential for the development of adaptive responses to changing conditions in the Arctic (CAVIAR 2008). The purpose of CAVIAR is to further the understanding of how Arctic communities are affected by environmental changes in order to contribute to the development of adaptive strategies and policies. Data collection or

The town of Akureyri, Northern Iceland (photo: Joan Nymand Larsen).

monitoring of change is an essential part of the CAVIAR programme. The programme seeks to characterise vulnerabilities or risks, to document the processes and forces that facilitate adaptation or management of risks, and to identify and evaluate means to improve the capacity of communities to adapt to changing conditions. This involves interdisciplinary integration and collaboration with Arctic community partners (CAVIAR 2008:2-3).

Among gaps in knowledge and action with respect to the challenge climate change poses for Arctic sustainable development are the lack of Arctic monitoring systems, coordination of Arctic observing, access to timely and reliable data, and a long-term commitment to funding of observing networks. The amount of research on climate change and its impacts is growing, but significant gaps in knowledge concerning the nature of global change risks and ways to deal with them persist. Environmental and societal changes and other processes occurring at a rapid pace, combined with limited observational infrastructure, and a lack of timely, appropriate and reliable data and information networks, present Arctic stakeholders, governments and the research community with new challenges. Natural sciences have a long established tradition for monitoring, but this is not

Nuuk, Greenland. Old colonial houses in the foreground with modern apartment buildings in the background (photo: Joan Nymand Larsen).

the case in the social sciences. However, despite the natural sciences having this monitoring tradition, these challenges are experienced across the sciences. New demands are placed on access to data for the study and modelling of these processes, and for understanding, measuring and predicting the impacts of change on social systems at various scales, and understanding the links with the rest of the world and their feedback mechanisms. The integration of knowledge across disciplinary boundaries adds to data and information requirements. The task of measuring and predicting requires better access to relevant, reliable, accurate and timely data and information, and in particular access to data which is appropriate and relevant to the Arctic context. Much data is currently based on southern or national data protocols, where models are often designed and legitimated in institutional contexts outside the Arctic. There is an urgent need for more complete data sets that can enable more comprehensive and accurate research and analysis at various scales, across disciplines and across the circumpolar Arctic, and that can facilitate comparisons and contrasts, modelling, evaluation, assessment and monitoring of changes and their impacts. As well, there is a growing demand for timely and more conclusive data and information from the natural sciences to help facilitate studies of the socio-economic impacts of climate change. A more complete understanding of the current and future environment requires access to year-round data, including improved and disaggregated data series.

SAON is one of the most recent developments in Arctic observing and monitoring. An IPY and Arctic Council project, SAON's work on monitoring and observing across interdisciplinary boundaries has contributed significantly to moving us closer to a pan-Arctic observing system. It is a process for furthering multinational engagement in developing sustained and coordinated pan-Arctic observing and data sharing systems. The foundations of SAON are the existing networks and programmes that already provide high quality Arctic observations. The goal of such a system is to serve societal needs, particularly related to environmental, social, economic and cultural issues (SAON 2008).

Increased emphasis is placed on achieving better coordination within and among existing networks. There currently exist several observing systems, observatory networks, evaluation and assessment programmes, monitoring programmes, indicator projects and Arctic databases. A range of problems and limitations related to data and observing sites were identified during the SAON process: Arctic observing sites do not adequately cover the Arctic region, observing data are fragmentary and not easily available, and only a part of the Arctic observing is funded on a long-term basis (SAON 2008). The work of SAON is an important new development in the effort to achieve better coordination within and among existing observing networks and the broad range of existing programmes. To meet the goal of pan-Arctic observing and data sharing systems, a key SAON recommendation is to create the Arctic Observing Forum (Ibid.).

The Arctic Social Indicators (ASI) project

The AHDR identified several gaps in knowledge that have relevance for Arctic data and monitoring activities relating to the human dimension. The report recommended a series of follow-up activities including the construction of a small set of indicators to be used in monitoring changes in human development in the Arctic over time. The Arctic Social Indicators (ASI) project – a follow-up to the AHDR – is working toward filling this critical gap in user needs in Arctic research and data information. It aims to devise a limited set of indicators that reflect key aspects of human development in the Arctic, that are tractable in terms of measurement, and that can be monitored over time at a reasonable cost in terms of labour and material resources. The development of ASI indicators falls within six domains, all of which

Sheep farming in Northern Iceland. Agriculture in the region could potentially benefit from climate change (photo: Joan Nymand Larsen).

seek to address key aspects of human development that have been identified as being particularly prominent in the Arctic. They are: fate control and/or the ability to guide one's own destiny; cultural integrity or belonging to a viable local culture; contact with nature or interacting closely with the natural world; material well-being; education; and health/demography. Such a database with unique long-term series of data could be immensely useful to decision-makers, planners and others concerned with the future of the Arctic. The work on constructing Arctic-specific social indicators is directed at a broad audience, including the science community, inhabitants of the Arctic, policymakers at all levels, and in particular the Arctic Council and its Sustainable Development Working Group (SDWG). ASI seeks to leave a long-term IPY legacy, and this includes also its potential future contribution to SAON, where it has been identified as one of the potential human dimensions building blocks within the Arctic Observing Forum recommended by SAON.

The construction of valid and useful Arctic social indicators is a challenge. Indeed, several of the indicators suggested by the ASI working group have weaknesses related to one or more selection criteria, including availability of data, afford-

Two cruise ships in Akureyri harbour. Cruise ship tourism is on the rise in the North (photo: Joan Nymand Larsen).

ability in terms of labour and material resources, and their level and applicability to both indigenous and non-indigenous inhabitants of the Arctic. To be valid for tracking and monitoring, an indicator should be the most accurate statistic for measuring both the level and extent of change in the social outcome of interest. It should adequately reflect what it is intended to measure, and ideally there should be wide support for the indicators chosen so they will not be changed regularly. It is critical that the chosen social indicators are consistent over time and across places, as their usefulness is related directly to the ability to track trends over time and compare the well-being of regions. Ideally, the chosen ASI indicators should do well in terms of a broad range of selection criteria such as data availability, ease of measurement, internal validity, affordability, robustness, applicability at various levels (household, local, regional), and applicability to indigenous as well as non-indigenous populations. To advance beyond the AHDR baseline report, ASI seeks indicators that can be compared for geographies more specific than the general Arctic regions (ASI 2009). A main limitation is data availability, and statistical agencies do not provide breakdowns below certain minimum thresholds of population counts for example. Although specific thresholds vary from country to country, they sometimes preclude the release of accurate data on small Arctic communities,

Whale watching in Husavik. Whale watching tourism is on the rise in Iceland (photo: Joan Nymand Larsen).

or make the released data a patchwork of true and artificially rounded or suppressed numbers (Hamilton et al. 2009). The work to address these data challenges is part of the second phase of ASI.

ASI recommendations deal with data issues and the need for an Arctic Social Indicator monitoring system. The Arctic Social Indicator monitoring system would meet the following objectives: data are available at a regional level; data are available separately for indigenous and non-indigenous populations; data are available on at least a five-year reporting period. Depending on the indicator and the nation, one of three levels of effort are required to meet these monitoring objectives: data are collected by a national agency and published in hard copy or electronic form; data are collected by a national agency and require special tabulations to be made available; data require primary data collection (Larsen and Schweitzer 2009).

ASI phase II is now underway, which aims to test, refine and implement the ASI indicators, with the overall goal of facilitating the monitoring of change in human development in the Arctic. The first phase of the ASI project developed a social indicator system, having identified a set of Arctic-specific indicators to monitor human development and quality of life in the Arctic. The next phase of ASI aims to implement the constructed indicators, by testing, validating and refining the indicators across the Arctic, and then to measure and perform analyses of select cases, with the ultimate goal of moving toward adoption by Arctic governments and the Arctic Council of the indicators for the purpose of long-term monitoring of human development. Creating and refining suitable indicators of human development in the Arctic will take time. It involves a step-wise process in which initial proposals are vetted empirically and refined or replaced over time as our ability to capture the essential features of human development under the specific conditions arising in the Arctic rises. Viewed in this light, the work of the ASI constitutes a significant step forward in moving us toward an ability to track trends in key elements of human development in the Arctic and, as a result, guiding discussions regarding questions of policy (ASI 2009).

Arctic societies and cultures are faced with multiple challenges related to environmental processes, industrial development, cultural development and economic changes. A long-term and sustained approach to addressing sustainable development in the Arctic requires appropriate indicators, data, coordination and monitoring systems, to provide us with the information about the presence or absence of sustainability, or threats to sustainability in the various systems that surround us.

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CONTRIBUTORS

Larisa Abryutina was born in 1955 in Chukotka in Omolonsky tundra in an extended family of reindeer herders. In 1980 she obtained a degree from Khabarovsk Medical Institute. She worked as the head doctor in a mobile medical unit in the Bilibinsky region of Chukotka until 1996. She has also set up and directed a health centre. Meanwhile, she worked as a representative in the government bodies of Chukotka and led social work in local communities. She has a PhD in political sciences from the Academy of Public Service under the authority of the President of the Russian Federation. She wrote the book *Peoples of the Russian North: The Right for Health*. From 1999 to the present, she has been the vice-president in charge of health issues in the Russian Association of Indigenous Peoples of the North, Siberia and Far East of Russia (RAIPON). She is a regular participant in the work of the Arctic Council.

Ann Andreasen was born in Faroe Islands in 1960. She has been leader of the Uummannaq Children's Home in Greenland for more than 20 years. Social educator and family therapist, she created original educational activities including dogsled expeditions, hunting and fishing schools, international summer holiday camps, music therapy and filmmaking workshops including the making of the coming international feature film 'Inuk'. She is co-founder and director of the Uummannaq Polar Institute, inaugurated by HSH the Prince of Monaco and Professor Jean Malaurie in April 2009. In September 2009 in Denmark, she was awarded the prestigious 'Gerda Price' for her involvement in giving children opportunities for a good life.

Susan Barr has worked in Norway with polar history and cultural heritage since 1979, starting as the first full-time cultural heritage officer for the Norwegian Arctic (Svalbard and Jan Mayen). She is currently senior advisor in polar matters at the Norwegian Directorate for Cultural Heritage. Susan has a BA Honours degree from University College London and Mag.art. (PhD) in Ethnology (Historical Archaeology) from Oslo University. She has had extensive fieldwork over many years in the Arctic and two seasons in the Antarctic. She is founding president of the ICOMOS International Polar Heritage Committee, devoted to promoting cultural heritage protection in both the Arctic and Antarctic.

John Crump is currently the Polar Issues Coordinator of UNEP/GRID-Arendal. His academic background is in journalism, communications and political economy. He has a Master's Degree in Northern and Native Studies from Carleton University. His practical northern experience began when he migrated to the Yukon Territory in the early 1980s and got hooked on all things northern. After working with

CBC Radio in the Yukon, he was Cabinet Communications Advisor to Tony Penikett's NDP government. Currently residing in Ottawa, John has worked on policy issues for the Royal Commission on Aboriginal Peoples, been government relations manager for the Nunavut Planning Commission, and Executive Director of the Canadian Arctic Resources Committee (CARC). He was also Executive Secretary of the Indigenous Peoples' Secretariat in Copenhagen, Denmark. He has taught graduate and undergraduate courses in journalism, public administration and geography at Yukon College in Whitehorse, Carleton University and the University of Trier in the beautiful Mosel Valley in Germany.

Alexander Frolov holds a diploma in oceanography from the Moscow State University named after M.V. Lomonosov in 1974 and a Ph.D. degree in Mathematical and Physical sciences (ocean physics) from the Hydrometeorological Research Centre of the USSR in 1980. Frolov spent 29 years in the Russian Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet), capping his career as a research scientist of the Hydrometcenter of Russia, where he worked and led scientific research in the field of atmosphere and ocean fluid dynamics, numerical weather prediction and data assimilation. Since 2001 Frolov has been Deputy Head of Roshydromet, responsible for the development of nationwide, reliable, comprehensive and sustained observation and forecasting systems, including in the Arctic. Alexander Frolov is the Vice-president of the WMO Commission for Atmospheric Sciences and author of more then sixty scientific publications.

Bernard Funston has extensive experience pertaining to the Canadian North and the northern circumpolar region, including systems of governance, international and intergovernmental relations, aboriginal land claims and self-government processes, resource development issues, scientific research and cooperation, and a range of fields relating to economic and community development. He served as Director of Constitutional Law (1986-92) and Special Advisor on Constitutional Affairs (1992 to 1997) with the Government of the Northwest Territories. In his international work, Mr Funston was directly involved in the negotiations leading to the creation of the Arctic Council in 1996 and has participated in the work of the Council since its inception. He chaired the committee which drafted the Arctic Council Rules of Procedure. Since 2002 Mr Funston has been the Executive Secretary to the Arctic Council's Sustainable Development Working Group Secretariat. He is president of Northern Canada Consulting which provides strategic, analytical, consultative and facilitation services respecting the Canadian North and the northern circumpolar region.

Jean-Claude Gascard began to study oceanography (physics and geophysical fluid dynamics) after graduating in physics and applied mathematics at the University of Paris in 1966. His PhD examination in 1977 concerned deep convection and deep water formation in the ocean. During a sabbatical year (1990) at the Naval Postgraduate School in Monterey, California, he organised an international symposium dedicated to ocean deep convection and edited a book published by Elsevier in 1991. As deep convection is a process typical to the polar oceans, this led him naturally to start investigating sea ice and its role in climate. Since then he has been engaged in European projects dedicated to Arctic and Subarctic seas. During the 4th IPY, he coordinated a major EU project, the so called Damocles (Developing Arctic Modelling and Observing Capabilities for Long-term Environment Studies) Integrated Project (2005-2010).

Mike Gill is currently Chairman of the Circumpolar Biodiversity Monitoring Programme (CBMP), an Arctic Council Conservation of Arctic Flora and Fauna (CAFF) working group programme led by Canada. Over the past 15 years, Mike has been designing and implementing Arctic research and monitoring programmes across the Arctic. The CBMP is an international network of scientists and local resource users working together to improve detection, understanding, reporting and response to important trends and pressures on the Arctic's living resources. The CBMP has over sixty global partners to date.

Barry Goodison has just retired after 36 years with Environment Canada where he most recently served as the IPY coordinator for Environment Canada. He was a member of the Canadian National IPY Steering Committee since its inception. He was Chair of the World Climate Research Program's Climate and Cryosphere Project (WCRP/CliC) until December 2008, and CliC was a leading organisation for coordinating IPY initiatives on the cryosphere. Dr. Goodison serves on the World Meteorological Organization's Intercommission Task Force for IPY. He proposed an IPY legacy project which is being developed within WMO – 'Global Cryosphere Watch'. From September 2008 until March 2009 he was a seconded visiting expert with WMO leading the ad-hoc expert team scoping the feasibility of WMO's Global Cryosphere Watch initiative. He has authored/co-authored over 100 papers and contributed to, and edited, numerous books, chapters and agency reports. He has been a member or chair of many Canadian and international committees and working groups, including the ICARPII Steering Committee, the SAON Implementation Group, and the Arctic Council/AMAP SWIPA Integration Team.

Johan Hattingh is Professor of Philosophy and Vice Dean of Social Sciences at the University of Stellenbosch, South Africa. Based at this university since 1980 he has extensive experience in the teaching of a variety of subject fields, including Practical Logic and Critical Thinking Skills, Philosophy of Culture, and Poststructuralist Thought. In the last fifteen years he specialised in Applied Ethics, Ideology Critique, Development Ethics, and particularly in Environmental Ethics. He is a member of three research ethics committees, and since 2004 is also a member of the World Commission on the Ethics of Scientific Knowledge and Technology (COMEST) of UNESCO where he serves on the Executive Board as Rapporteur.

Peter M. Haugan is Professor of Oceanography and Director of the Geophysical Institute at the University of Bergen in Norway. He is also affiliated with the Bjerknes Centre for Climate Research and is leading the Bergen Marine Research Cluster. Starting from a degree in applied mathematics, Haugan obtained several years of experience from research and development within the petroleum industry before returning to academia. He has special expertise in polar oceanography including physical climate processes and carbon cycling. In later years he has become much involved in interdisciplinary, international and intergovernmental ocean and climate research and related management.

Lene Kielsen Holm received her Master's degree in social and cultural history from Ilisisimatusarfik in 2002. She is employed as Director for Research and Sustainable Development at the Inuit Circumpolar Council Greenland. She has been doing several research projects within the Arctic Council's Working Group for Sustainable Development, on gender and resource issues. She is currently working with a project called Sila-Inuk, which is an interview project on the hunters and fishermen's observations of changes related to climate change in Greenland. She is also collaborating on an interdisciplinary and intercultural Sea Ice Knowledge and Use project, called Siku-Inuit-Hila, with partners in Alaska Canada and Greenland, both hunters and scientists. She is currently chair of the board for the Institute of Natural Resources in Greenland.

Henry Huntington is a researcher in Eagle River, Alaska, where he lives with his wife and two sons. He studies human-environment interactions in the Arctic, particularly among indigenous peoples. He has worked throughout Alaska and also in Canada, Greenland, Russia and Scandinavia. Recently he conducted an exploratory project in Nepal, examining the prospects of high altitude-high latitude comparisons of climate change impacts. He has published scientific papers and popular articles on indigenous knowledge, the impacts of climate change, traditional hunting practices and other topics.

Edward S. Itta is an Inupiat whaler and hunter. He is committed to protecting the Inupiat subsistence heritage and ensuring the long-term social and economic viability of all the communities of Alaska's North Slope. Edward was elected Mayor of the North Slope Borough in 2005 and re-elected in 2008. He is president of the Inuit Circumpolar Council Alaska, a member of the federal Outer Continental Shelf Policy Committee, a member of the Barrow Whaling Captains Association, and a past commissioner of the Alaska Eskimo Whaling Commission. Edward also served as president of the North Slope Borough School Board and was vice-chairman of the federal subsistence advisory council for northern Alaska. He and his wife, Elsie, have two children and four grandchildren.

Vladimir Kattsov holds a PhD in the physics of the atmosphere and hydrosphere. He is in his twenty-first year as a research scientist and third year as the director at the Voeikov Main Geophysical Observatory (MGO, St.Petersburg) of Roshydromet. His research includes global climate 3D modelling with a focus on polar climate dynamics (about sixty papers in peer-reviewed journals, books and reports). He was a lead author of the IPCC WG1 Third (2001) and Fourth (2007) Assessment Reports, as well as of the Arctic Climate Impact Assessment (ACIA 2005). From 2000, Dr Kattsov was with the World Climate Research Programme (WCRP) as a member of the Working Group on Numerical Experimentation (WGNE) and he then worked on the Climate and Cryosphere Project's Scientific Steering Group (CliC SSG). He has been on the Joint Steering Committee (WCRP JSC) since 2009. He is also a Member at Large of the International Association of Meteorology and Atmospheric Sciences (IAMAS); and a member of the Scientific Advisory Committee, Asia-Pacific Economic Cooperation Climate Center (APCC SAC).

Ilan Kelman is a Senior Research Fellow at the Center for International Climate and Environmental Research - Oslo (CICERO). His main research and advocacy work relates to two areas. The first is island sustainability, about creating and maintaining safer and healthier communities on islands and in other isolated areas. The second is disaster diplomacy, covering how and why disaster-related activities do and do not reduce conflict and create peace. Other areas of interest are ethical research and practice for disasters, the poverty-disaster links, school safety, disaster deaths, refugee settlement and shelter, and connecting disaster research and disaster risk reduction practice. More details are available at http://www.ilankelman.org.

Lars Kullerud is the President of the University of the Arctic, UArctic. His office is based at UNEP-GRID/Arendal in Arendal, Norway. Lars has held the position of President of UArctic since May 2002. Before joining the UArctic team, he was the Polar Programme Manager for UNEP/GRID-Arendal (United Nations Environment Program/Global Research Information Database - Arendal), and worked extensively with Arctic information and assessment, including Arctic inputs to UNEP's Global Environmental Outlook designed to help governmental and non-governmental organisations protect the Arctic environment. Throughout his UArctic presidency, Lars has continued to foster an academic interest in northern environment and development issues and has also been actively engaged in building up the UNEP Shelf program at GRID-Arendal which has assisted some 50 developing countries and small island states to document their extended continental shelf according to the UN Law of the Seas. His academic background is in Precambrian Geology and Isotope Geochemistry.

Joan Nymand Larsen received her PhD in economics in 2002 from the University of Manitoba, Canada, specialising in development and northern economies. She is senior scientist with the Stefansson Arctic Institute in Iceland, teaches economics and development in the Social and Economic Development and Polar Law programmes of the University of Akureyri, and is president of the International Arctic Social Sciences Association (IASSA), 2008-2011. Her research interests include northern economies, and the issues and challenges of global change and socio-economic development in the North. She was project manager and co-editor of the Arctic Human Development Report (AHDR) 2004 and now leads the work of the international working group on Arctic Social Indicators (ASI) as well as the University of the Arctic curriculum work on Arctic Economies and Livelihoods in a Changing World.

Anastasia Lebedeva is Even from the Kukuyin village in the Allaykhovskiy region of the Republic of Sakha. She has been working since 2006 as assistant to the director of the Center for the Development of Educational Institutions of the Republic of Sakha, which is under the authority of the Institute for National Schools of Republic of Sakha, a federal state scientific institution. One of her main areas of work is the education of nomadic children.

Aqqaluk Lynge represented the Inuit of Alaska, Canada, Greenland and the Far East of Russia as Chair of the Inuit Circumpolar Conference (ICC) from 1997 to 2002. In 2006, Mr Lynge was re-appointed President of ICC Greenland and ICC Vice-Chair. A founding member of the Greenlandic political party *Inuit Ataqatigiit*, Mr Lynge was first elected to the Greenland Parliament in 1983 and has served both as a Member of Parliament and as a Minister of various portfolios. He has promoted the rights of indigenous peoples both in his home country of Greenland and globally since his youth. He is an accomplished author and past chair of the Greenland Writers' Association.

Jean Malaurie, director of the Centre d'Etudes Arctiques (Centre of Arctic Studies) at the Ecole des Hautes Etudes en Sciences Sociales (EHESS) and the Centre National de Recherche Scientifique (CNRS) in Paris and director emeritus for research at the Centre National de Recherche Scientifique (CNRS), is a leading Arctic ethnohistorian and geomorphologist. Born in 1922 in Mainz (Germany), on 29 May 1951 he was the first man to reach the geomagnetic North Pole by two dog sledges, accompanied by the Inuk Koutsikitsoq. Professor Malaurie has led more than thirty scientific expeditions that have taken him throughout the North from Greenland to Siberia. The author of numerous books, including *The Last Kings of Thule*, translated in 23 languages, *Call of the North*, *Hummocks*, *Ultima Thulé* and *The Whale Alley* (Tchoukotka) he founded the Terre Humaine publishing house to make ethnology accessible to a wider public. In July 2007, Professor Malaurie was designated a UNESCO Goodwill Ambassador, in charge of Arctic polar issues. His designation as Goodwill Ambassador recognises his 'personal commitment to promoting environmental issues and to safeguarding the culture and knowledge of the peoples of the Great North'.

Sharon McClintock is an Inupiat Eskimo whose ancestral roots come from Wales in the Bering Straits and Point Barrow on the Arctic Slope. She was born in Buckland, Alaska where her principal school teacher father taught in a one room school. Her paternal grandfather was the first full Inupiat school teacher in Alaska. She received her A.A. Degree at the University of Alaska, Anchorage. She is president and senior planner of her own company, McClintock Land Associates, Inc., an Alaska Native firm that provides land survey, land planning and aerial photography mapping services primarily to rural Alaskan villages. Ms. McClintock is a specialist in land and right-of-way research and management and is a well known authority on Alaska Native Land Claims. She has been involved in land claims issues since 1973 and works extensively on all issues dealing with Native land rights and projects with ANCSA corporations, municipalities, tribal governments, state and federal agencies.

Tatiana Minayeva is a specialist in mire biodiversity, and has been Senior Technical Arctic Officer of Wetlands International since 2008. She graduated from the Department of Geobotany of Moscow State University, and holds a PhD on mire sciences from Komarov Botanical Institute. She has worked in Taymyr, Norilsk Institute of Agriculture of the Far North, in the Central Forest Biosphere Nature Reserve as a researcher and later as Deputy Director for Sciences. Since 1997 she has worked with Wetlands International as coordinator of projects on peatland conservation and wise-use. In 2005-2008 she worked for the Ministry of Natural Resources and Ecology of the Russian Federation among others, coordinating scientific support for international cooperation in the Arctic.

Jonathan Motzfeldt is the Former Premier of the Greenland Government and Former Chairman of the Greenland Parliament. He was born 25 September 1938 in Qassimiut, South Greenland and married Icelandic born Kristjana Gudrun Gudmundsdottir in 1992. He holds an honorary LL.D from the University of Fairbanks, Alaska. He was a member of both the Commissions charged with preparing Home Rule (established 1979) and Self-Governance (established 2009) respectively. He has also held several important posts as a CEO in the business sector.

Klemetti Näkkäläjärvi (Juvvá Lemet) is currently finishing his doctoral dissertation in cultural anthropology, focusing on the cultural knowledge system of the reindeer herding Saami and concentrating particularly on the professional skill and cultural acculturation of the reindeer herding Saami culture. Currently Näkkäläjärvi is working as full-time president of the Finnish Saami parliament, which is the highest political organ of the Saami people in Finland. Näkkäläjärvi has held various posts connected with Saami culture and the Saami language. He played a central role in the planning of the permanent exhibit at the Siida Sámi Museum. Lic. Phil Klemetti Näkkäläjärvi has been studying reindeer herding and Saami culture since the 1990s.

Alan Parkinson is currently the Deputy Director of the Arctic Investigation Program of the US Centers for Disease Control & Prevention located in Anchorage, Alaska. Dr Parkinson's research interests include laboratory and epidemiological aspects of infectious disease detection, prevention and control in Arctic and Subarctic populations and is currently the chair of the International Union for Circumpolar Health's Infectious Disease Working Group, the coordinator of the Arctic Council's Sustainable Development Working Group's International Circumpolar Surveillance of Infectious Diseases project, and Arctic Council's International Polar Year's Arctic Human Health Initiative.

Alexander Pelyasov holds a doctorate in economic geography and worked at the North-East Interdisciplinary Research Institute, Russian Academy of Sciences, Magadan from 1987 to 1997. From 1997 to 2000 he worked at the Federal Committee Responsible for Northern Development (Goskomsever), Moscow, as the head of the Economic Department. He then moved to become a senior research associate at the Council for Research of Productive Forces (SOPS), working with regional authorities on the issues of interregional equalisation and links between the organisation of regional authorities and the rate of economic development. From 2004 to the present he has been the Director of the Center of Arctic and Northern Economies under the Council for Research of Productive Forces (SOPS), dealing with strategies and programmes for the Russian regions.

Aevar Petersen graduated with BSc Honours degree in zoology from Aberdeen University in Scotland 1973 and he took a DPhil. degree in ornithology from the University of Oxford in England in 1981. Aevar has been employed at the Icelandic Institute of Natural History, Reykjavik, Iceland since 1978. He was Director of Reykjavik Division from 1992 to 2005. Presently he is a holder of a research post as chief scientist. He has been the national representative for Iceland in the Arctic Council´s CAFF (Conservation of Arctic Flora and Fauna) Working Group since its inauguration 1993, and he is currently the chair.

Gunn-Britt Retter is a Saami from Unjrga/Nesseby in Varanger, northeast Norway. Retter is chair of the local Saami association, vice-chair to the Norwegian Saami Association, and a Member of Saami Parliament, Norway. In her position as head of the Arctic and Environmental Unit in the Saami Council, Retter has been involved in issues related to indigenous peoples and climate change, biodiversity, language, pollution and management of natural resources.

Odd Rogne is in part-time retirement, and is also a Senior Advisor to the Arctic Monitoring and Assessment Programme (AMAP), as well as the International Programme Office of the International Polar Year. He graduated as a business economist and naval officer followed by PhD studies, and came into polar research in 1979 as Deputy Director of the Norwegian Polar Institute and became its director in 1983. He has been one of the founders of several international polar organisations, and became in 1991 the first executive secretary of one of them - the International Arctic Science Committee (IASC), a position he held until 2006. He has served on several national, Nordic, regional and international organisations and is ‘Chevalier de l’Ordre National du Mérite’ (Knight of the French Order of Merits).

Andrey Sirin is a specialist in mire hydrology and ecology. He is director of the Institute of Forest Sciences RAS, and holds a PhD in geography. He graduated from the Department of Geography of Moscow State University where for many years he has been teaching mire hydrology. As an expert on mire hydrology he has been working in different northern regions. He cooperates with different international organisations and conventions. He is also editor-chief of the Assessment on Peatlands, Biodiversity and Climate Change, adopted by the CBD in 2008.

Duane Smith has served as President of the Inuit Circumpolar Council (ICC) Canada since 2002. He was born and raised in the community of Inuvik, Northwest Territories, Canada which is now the centre for the Inuvialuit Settlement Region. Duane continues his close attachment to the land, annually harvesting marine mammals and caribou much as his ancestors did. He has represented Inuit locally, regionally and internationally for many years on matters regarding the environment, indigenous rights and co-management. Duane is presently on a multi-year, Canada-led international research body coordinating and documenting data on the Arctic through traditional knowledge and Western science. Duane was also a past co-chair of the World Conservation Union (IUCN) Arctic Specialist Group Sustainable Use Initiative.

Risa B. Smith graduated with a PhD in ecology from the University of British Columbia, Canada. She has 16 years of experience leading the development of biodiversity assessments and state of the environment indicator reports for the Canadian government and the province of British Columbia. She has been engaged in the development and/or review of several domestic and international assessments, including the Global Environment Outlook, Climate Change Indicators reports, Children's Health and the Environment, and the second and third Global Biodiversity Outlook. Since 2006 Risa has been Canada's national representative to the Conservation of Arctic Flora and Fauna (CAFF) working group of the Arctic Council. In this capacity she sits on the steering committee for the Arctic Biodiversity Assessment, currently in preparation, and has been involved as an advisor in the development of the Circumpolar Biodiversity Monitoring Program (CBMP).

Chris Southcott holds a PhD from EHESS, Paris and is a professor of sociology at Lakehead University and Research Associate at Yukon College. Raised in Northern Canada, he has been involved in community-based research in the region for over 20 years and has written numerous publications dealing with social and economic change in Northern Canada and the rest of the circumpolar world. Over the past 10 years Southcott has led several Canadian and international research network initiatives dealing with sustainable development and global change in the Arctic. Since 2005 he has served as Chair of the University of the Arctic's Research Outreach Program.

Julienne Stroeve holds a PhD in Geography from the University of Colorado where she focused on surface energy balance studies of the Greenland ice sheet using satellite imagery. She has extensive experience in remote sensing of the polar regions using satellite imagery that spans the optical to the microwave spectral region. She is employed as a research scientist at the University of Colorado's National Snow and Ice Data Center. Stroeve has participated in several field campaigns in Greenland and the Arctic for the purpose of validating various geophysical parameters retrieved from spacecraft, such as sea ice concentration, surface temperature and surface reflectivity. Current research projects include monitoring and explaining the causes behind the rapid decline of the Arctic sea ice cover, and investigations into how the transition towards a seasonally ice free Arctic will impact climate in the Northern Hemisphere. Stroeve has been lead author on more than seventeen papers related to Arctic climate change, and co-author on more than twenty papers. Stroeve's work has been featured in several Discovery Science and History Channel documentaries.

Marianne Lykke Thomsen has a background in Inuit studies and has been living in Nuuk, Greenland, since 1987. She has been advising the Government of Greenland on foreign policy issues since 2004. Prior to this, she held the position of environmental coordinator with the Inuit Circumpolar Council. She is coordinating the Government of Greenland's engagement with the United Nations, in particular with respect to the promotion and protection of the rights of indigenous peoples. Marianne Lykke Thomsen has also been part of the Arctic Council process for many years and is currently serving as the Chair of the Sustainable Development Working Group of the Arctic Council.

Mead Treadwell chairs the US Arctic Research Commission, appointed by the President of the United States, to set goals for the US Arctic research program. He is a Senior Fellow of the Institute of the North in Anchorage, Alaska and is Chair of the publicly listed Immersive Media Corporation, based in Calgary, and a private technology venture development firm, Venture Ad Astra, LLC, based in Anchorage and Portland, OR. He served as Deputy Commissioner of Environmental Conservation during Walter J. Hickel's 1990-1994 term as Governor of Alaska and has played an active role in building Arctic cooperation, including the Northern Forum and the Arctic Council, since that time.

Takashi Yamanouchi is a professor in atmospheric science and polar climatology at the National Institute of Polar Research and also a professor at the Department of Polar Science, the Graduate University for Advanced Studies. He received a Doctor of Science from Tohoku University in1978. He has wintered in the Antarctic three times, in 1979, 1987 and 1997, as a member of the Japanese Antarctic Research Expedition, and was a leader of the 38th Expedition in 1996-98. He also coordinated Arctic research observation projects, such as the Arctic Study of Tropospheric Aerosol and Radiation (ASTAR) 2000. His research interest is in radiation budget, material cycle with atmospheric circulation, and cloud and sea ice climatology with satellite remote sensing. He is currently a Chairman of the SCAR National Committee of Japan and a member of the IPY ICSU/WMO Joint Committee.

Christoph Zöckler holds a PhD in biology, having studied biology in Kiel, Germany and Aberdeen, UK. His 25 years work experience includes 11 years with WWF Germany in nature conservation and site management, two years in a research project at the University in Bremen, and more than 12 years with the United Nations Environmental Programme (UNEP) in Cambridge at their Centre for Biodiversity (UNEP-WCMC). Apart from wet grassland management, agriculture and river restoration in Northern Europe he has been increasingly involved in the conservation of Arctic migratory water birds. He has been working with UNEP-WCMC and CAFF on Arctic issues since 1996 and helped to built CAFF's Circumpolar Biodiversity Monitoring Programme (CBMP). He worked and managed various international research projects and participated in as many as thirteen expeditions to Greenland and the Russian Arctic and led four research expeditions to South and South-East Asia. Over the last 10 years he has been increasingly engaged on the assessment of climate change and other threats to Arctic biodiversity.

ANNEX
International Expert Meeting
3-6 March 2009, Monaco

REPORT AND RECOMMENDATIONS

Climate Change and Arctic Sustainable Development
scientific, social, cultural and educational challenges

I. MEETING RATIONALE AND STRUCTURE

Climate change will have multiple and complex repercussions on the natural, social and cultural landscapes of the Arctic and Subarctic. The implications of these changes, including their global impact, have yet to be comprehensively monitored, evaluated, understood and communicated. To comprehensively analyse the multilayered and multiform interactions connecting global and Arctic processes, an international and interdisciplinary approach is required.

The International Expert Meeting 'Climate Change and Arctic Sustainable Development: scientific, social, cultural and educational challenges' was generously supported and hosted by the Principality of Monaco. The event was opened by HSH Prince Albert II of Monaco, the Director General of UNESCO, Koïchiro Matsuura, and Professor Jean Malaurie, UNESCO Goodwill Ambassador in charge of Arctic polar issues. The meeting was also addressed by the Executive Director of UNEP, Mr Achim Steiner. HSH Prince Albert II of Monaco also attended the closing session.

The expert meeting brought together 42 participants from 13 countries, including all Arctic states and Greenland. Participants were experts in the fields of the natural and social sciences, education, ethics, law, health and international affairs. These experts included representatives from UNEP and the Arctic Council, and circumpolar indigenous peoples working with the Russian Association of Indigenous Peoples of the North (RAIPON), the Inuit Circumpolar Council (ICC) and the Sami Parliament. Secretariat from UNESCO's Natural Science Sector, International Oceanographic Commission (IOC), Culture Sector and Social and Human Sciences Sector oversaw the meeting.

The meeting assessed the scientific, social, cultural and educational challenges to be met in order to ensure the sustainable development of the Arctic within a global context. A combination of discussions at the plenary and working group levels generated an interdisciplinary dynamic for the meeting. Four interdisciplinary working groups deliberated on the following facets of change in the Arctic:

1. Oceans, ice and atmosphere
2. Biodiversity and ecosystem services
3. Circumpolar indigenous peoples and intangible heritage
4. Economic development and social transformations

Four cross-cutting themes were also explored in these same working groups:

1. Education for sustainable development
2. Environmental ethics
3. Monitoring and observing systems
4. Global connections to change in the Arctic

Plenary sessions focused on further building dynamic interlinkages between disciplines and themes.

The participants identified key challenges and knowledge gaps and addressed recommendations to the Director General, for follow-up action by UNESCO and transmission to appropriate institutions, member states and intergovernmental committees. These are given below.

II. KEY CHALLENGES

There is a clear sense of urgency in our discussions of the Arctic. Rapid changes are currently underway in the cryospheric (water in its frozen state on land and sea), terrestrial, oceanic and atmospheric systems of the Arctic and many of these changes are currently outpacing climate model predictions. Arctic sea ice is declining in all regions and in all months, with the smallest trends in winter and the largest at the end of the melt season in September. Since about 2002, the satellite data record has indicated that the downward trends in summer ice cover have accelerated, with the implication that a seasonally ice free Arctic Ocean may be realised sooner than projected by our most advanced climate models. Meanwhile, local communities have been noticing profound changes in the Arctic sea ice environment for several decades. During the same period, the Greenland ice sheet has shown enhanced surface melting and increased discharge rates from its outlet glaciers, impacting on global sea level rise. Almost all Arctic glaciers are currently losing mass and snow cover over Arctic land areas is declining. Permafrost is warming and its southern limits are thawing. Temperature rises in the Arctic are twice as large as those for the planet as a whole. Model projected Arctic amplification has recently emerged in autumn as the Arctic Ocean is covered by larger expanses of open water at the end of the summer melt season, which absorb more solar radiation than an ice covered ocean, with the potential to impact further on land surface temperatures. An ice free 'blue' Arctic Ocean will lead to profound changes in the marine ecosystem, the culture and livelihood of indigenous peoples, and economic activities in general.

The rapid rate of climatic change in the Arctic, coupled with the potential increased transmission of invasive species, greater industrialisation and rapid social change, makes understanding and conserving Arctic biodiversity an ever greater challenge. This is especially important in recognition of the 2010 Convention on Biological Diversity's target to reduce the rate of loss of biodiversity. The maintenance of healthy Arctic ecosystems is a global imperative as the Arctic plays a critical role in the Earth's physical, chemical and biological balance, providing ecosystem services that are vital to human well-being.

Circumpolar indigenous peoples live under the flags of many countries but share, with northern communities, many similarities in aspects of land use, culture, subsistence, environment, educational needs, language, social and resource development pressures, and traditional knowledge. In our discussions we shared our unique cultural perspectives and described the challenges we face, and addressed the ways we adapt to these changes. We also acknowledge that there are gaps in our knowledge base and response systems that can benefit from the expertise and collaborations with experts in many fields from all over world. It is a fact that our communities are experiencing dramatic changes to our environment due to climate change and that the repercussions of those changes fuel already existing problems. Yet it is not only people living in the Arctic that will be impacted by the profound changes in the Arctic environment. Melting ice in the Arctic will have implications for the rest of the world in terms of its impact on global sea level, atmospheric and oceanic circulation. We believe that by sharing our experiences and knowledge of the Arctic, where climate change is more advanced than in other regions, we can play a vital role in better preparing the world for what is to come.

Action formulated to address Arctic issues must begin from an understanding that peoples of the Arctic have self-governing institutions at various levels of development. Indigenous peoples and their institutions have immense creativity and seek to advance the self-determination, prosperity and aspirations of their communities and their regions. The challenges of maintaining and enhancing the prosperity and cultural well-being of the people of the Arctic are often complicated by drivers of change which have non-Arctic origins. In addition, scientific, developmental and conservation efforts are often driven by interests outside the Arctic. Arctic governments and Arctic residents welcome the growing global interest in this important region. Efforts to advance Arctic knowledge through scientific, traditional and local means will be critically important to formulating responses to major challenges such as climate change and variability. As work advances on all fronts, it will be important to acknowledge the people of the Arctic and their institutions as actors with valid interests and not simply treat the Arctic as a project area to be researched.

III. KNOWLEDGE GAPS

In relation to work on physical Earth systems, several reports have been written in the last five to ten years regarding gaps in knowledge and observations of the Arctic's ice, ocean and atmospheric systems. These include key observational gaps, gaps in infrastructure and gaps in data sharing (see for example the Sustained Arctic Observing Network (SAON), International Conference on Arctic Research Planning (ICARP), and Arctic Climate Impact Assessment (ACIA) reports). Our efforts here should not repeat those exercises, but rather should focus on action. That said, we acknowledge that this analysis of gaps will need to be updated over time, as some of these gaps will be filled, and new knowledge, including local and indigenous knowledge, may help us to identify new gaps.

Science challenges remain and it is recommended that UNESCO promote work on science aspects such as those listed below in order to achieve the possibility for regional predictions and interactions:

- The Arctic Ocean remains poorly understood both in its current state and its future state, including the influence of ocean circulation, inflow of Atlantic and Pacific waters into the Arctic, ocean bathymetry, ocean salinity and effects of ocean acidification.

- Atmospheric circulation requires further attention.
- Processes contributing to ice formation and ice melt, ice thickness and snow depth remain poorly known.
- The role of permafrost and frozen ground in the carbon cycle remains unclear.
- Many feedbacks remain poorly understood, i.e. methane released from thawing permafrost, cloud-radiation interactions, cloud-atmospheric aerosol interactions, and black carbon on albedo.
- Inconsistencies remain in modelling results and temperature data sets.
- Determination is needed of ice sheet and glacier mass balance and their contribution to sea level change.
- There is a need to improve prediction ability because present day global climate models are limited in their capacity to provide reliable projections of climate change in the Arctic.
- Observation networks for the Arctic are still quite limited, with only a few long-term stations, making it difficult to distinguish with confidence between the signals of natural variability and long-term climate change.

In terms of our understanding and protection of the Arctic's biodiversity, numerous gaps remain in knowledge and action:

- The critical role that Arctic ecosystems play in the Earth's physical, chemical and biological balance, providing ecosystem services that are vital to human well-being, are only somewhat understood by the public and policy-makers.
- Arctic states and Greenland also need to more proactively address and influence processes occurring outside of the Arctic which are negatively impacting Arctic biodiversity.
- The Arctic's size and complexity represents a significant challenge towards detecting and attributing important biodiversity trends, thereby demanding a coordinated, integrated, multi-disciplinary and ecosystem-based approach, yet established research and monitoring programmes remain largely uncoordinated and limited in coverage, lacking the ability to effectively monitor, understand and report on biodiversity trends at the circumpolar scale.
- Arctic residents are often forgotten or excluded from full and effective participation when discussing biodiversity despite their integral role in these ecosystems and the importance of Arctic biodiversity in supporting not only ecosystem services, but also cultural and spiritual values.
- While efforts have been made to include local and indigenous peoples and communities in monitoring and understanding change in the Arctic, more work is needed and successful projects need to be built upon.
- More timely and accessible information is needed to generate effective strategies for mitigating and adapting to changes in the Arctic - a process that ultimately depends on rigorous, integrated, and efficient research and monitoring programmes that have the power to detect change within a 'management' time frame.

- Existing information, be it historical accounts, indigenous/traditional knowledge or long-term scientific datasets, is of high potential value in determining past trends and identifying potential drivers of trends. Yet, this information is often forgotten or not easily accessed.
- Much of the information generated in the Arctic is fragmentary, disconnected across disciplines, and does not reach the public or policy makers or is not delivered in a proactive or appropriate format that facilitates communication and understanding.

There are also numerous gaps in our knowledge of the socio-cultural systems of the North, and the ways that these will be impacted by the rapid changes currently occurring.

- Gaps exist on connections and cross-disciplinarity between the sciences. Integration across disciplines is needed to help further our understanding of global change impacts, and to create solutions.
- Gaps in knowledge exist regarding non-Arctic drivers of Arctic change.
- Communication of research results between the physical sciences and the social sciences on the impacts of climate change has been slow.
- Much research on the impacts of climate change is conducted on a large scale whereas human activity is highly localised, and impacts and responses will be conditioned by the local context. More needs to be done to reconcile the research on impacts of change with the need to understand and predict local consequences and adaptation.
- Gaps in knowledge exist in how indigenous and Arctic communities can deal with climate change on their own terms.
- Knowledge gaps exist in the flexibility of subsistence living approaches. Much research has been done on the problems that subsistence living will face due to climate change, but gaps exist in how those problems could be overcome by the people themselves.
- Arctic community characteristics need further study. Community structures matter with respect to climate challenges (according to some research, diverse communities are more able to adapt than more homogenous communities).
- Indigenous and Arctic communities need to be provided with a better predictive understanding of global and local climate, social, biological and economic trends. This includes building upon current pan-Arctic efforts to develop analytical frameworks and appropriate indicators useful for Arctic communities. Indicators should assist with the long-term monitoring of human development in the Arctic.
- There is insufficient integration and dissemination of the knowledge generated by research and conferences on issues such as Arctic tourism and Arctic energy systems.
- Considerable gaps exist between knowledge on Arctic change and actual action. There is a vast amount of knowledge on change and global change impacts, whereas action is lacking. Also, there has been little analysis of activities that have been successful, be they adaptation or mitigation.
- There are gaps in dialogue and communication, both between the sciences, and between science and Arctic residents and other stakeholders. There are crucial gaps in the dialogue necessary

to move from science to action. There is as yet little understanding of the extent to which Arctic communities and indigenous peoples influence decisions on science funding in the Arctic.

- Effective and legitimate policies need to take account of the interests, values and knowledge of the people directly affected by them. Often, although not invariably, the people most directly affected are local communities at relevant geographical scales. Yet there are major gaps in institutional design and policy processes. Local communities are sometimes not consulted at all; when they are, their contribution may be neglected. Furthermore, opportunities to be heard through non-institutional processes such as political mobilisation may be restricted. As a result, policies are commonly adopted that may be unacceptable to local communities or, because local knowledge is neglected, do not work.

IV. RECOMMENDATIONS

The recommendations below reflect the breadth and depth of the participants' expertise and experience and are addressed to a variety of audiences, including UNESCO but also other international organisations, national governments, NGOs, indigenous peoples and Arctic communities, and others involved in Arctic matters. They are organised according to the organic flow of discussions in the working groups and plenary. This ordering does not imply priority, and nor does it necessarily follow the structure of the themes and cross-cutting issues of the original meeting plan. For example, ethical issues are an integral part of many recommendations and thus are not separated into their own section. A rewarding and important characteristic of the discussions was that both indigenous and scientific knowledge and concerns were fully and equally considered. Several participants highlighted that they had valued the discussions precisely for this reason. The collective set of recommendations was compiled with this sense of shared purpose, and should be read with the understanding that they are intended to promote collaborative action.

Education, communication and outreach

1 Given the critical and high importance of education in terms of socio-economic development in the Arctic, UNESCO should expand its role as a promoter of education at all levels in the Arctic. In this connection UNESCO should:
   a. Create an overview of best practices in primary and secondary education, to promote education that is relevant and adapted to the North;
   b. Promote and enhance integrated northern education systems that include traditional and scientific knowledge to facilitate better adaptation strategies in the Arctic;
   c. Create a review of education evaluation systems so that in future they also promote local and traditional knowledge systems and local cultures and languages;
   d. Support teacher training covering local cultures and languages;
   e. Encourage formal and non-formal education efforts suited to the requirements of indigenous

and northern communities, such as nomadic schools which bring quality education to children of families that must migrate for their livelihoods and thus are unable to attend regular schools;

f. Support universities in indigenous peoples' homelands and postgraduate study programmes for indigenous peoples;
g. Promote and support the work of the University of the Arctic (UArctic), which is innovative, directly beneficial to and adapted to the needs of indigenous peoples and northern communities;
h. Collaborate with officials of the University of the Arctic as a starting point for further development of educational strategies and practices for sustainable development in the Arctic, as well as to prepare a new generation of polar researchers.

2. Scientists should be trained to communicate science effectively to indigenous and Arctic communities, and to have cultural sensitivity towards northern communities. Encourage journals, journal editors and reviewers to ensure that, where relevant, Arctic science papers demonstrate communication with, and cultural sensitivity towards, indigenous and Arctic communities.
3. UNESCO should support the continuation of the IPY APECS (International Polar Year Association of Polar Early Career Scientists) program.
4. UNESCO, the Arctic Council and other relevant organisations should disseminate information to the global community about the pressures facing Arctic ecosystems and peoples. This could include the Arctic Council supporting and adopting a regular 'State of the Arctic' report that meets international, national and local reporting needs.
5. UNESCO should take a lead in building on the International Polar Year (IPY) outreach committee in cooperation with Arctic indigenous peoples' organisations, the Arctic Council and other organisations, as global communication via the media, schools etc about Arctic culture, science and key issues is essential.
6. UNESCO should make 'lessons learned' from Arctic education and the UArctic model available to education networks in other regions of the world.

Cultural heritage

7. UNESCO should encourage national governments, corporations, NGOs, and local communities in the Arctic to support and promote indigenous cultural traditions.
8. UNESCO should document, safeguard and promote the dynamism of the intangible cultural heritage of indigenous peoples such as language, oral history, folklore, knowledge and traditions. UNESCO, through its programmes on language retention, should also assist Arctic states and peoples in their efforts to preserve languages.
9. UNESCO should work to raise awareness among Arctic groups of the 2003 Convention for the Safeguarding of the Intangible Cultural Heritage.

10. It should be recognised that indigenous communities in the Arctic are modern societies and use modern technologies, and that use of such technologies is not incompatible with the maintenance of traditions or indigenous identity. Cultural programmes should affirm this, or risk undermining sustainable development.
11. A study should be produced on the trends of human migration, including the causes of immigration to and emigration from the Arctic, as well as internal migration within the Arctic region. Measures should be devised to reverse and/or reduce the consequent risks to Arctic cultures.
12. An international assessment should present an overview to UNESCO and the Arctic Council of heritage sites around the Arctic of particular international value that need special attention in the future in terms of management and protection.
13. Archaeological work should be prioritised to document and preserve tangible evidence of ancient coastal and inland heritage and sacred sites that are in danger of loss due to the impact of climate change and exploitation.

Well-being and health

14. The Arctic Council and the World Health Organisation (WHO) should take action on the human health recommendations put forward by chapter 15 of the Arctic Climate Impact Assessment and the report by the United Nations in the Russian Federation report, 'Climate Change Impact on Human Heath in the Russian Arctic'.
15. WHO and other relevant authorities should continue to raise awareness of the problems of contaminants and other threats to human health.
16. UNESCO and WHO should work with other agencies to ensure the provision of adequate primary and other medical services to Arctic communities.
17. The United Nations Environment Programme (UNEP) and UNESCO should organise a 'food security' conference focusing on the Arctic, in collaboration with the Arctic Council.

Economic development and resource management

18. The renewal, conservation, and development of traditional forms of activities that will help to create employment and social and economic well-being of the indigenous peoples of the North should be promoted. All forms of local economics should be integrated into development plans in wide consultation with indigenous people.
19. A review should be made of policy options related to protection of the non-market subsistence sector in connection with the emergence of the mixed and industrial economy in the North.
20. The sustainable use of renewable resources, including for commercial purposes, should be recognised, supported and promoted throughout the circumpolar Arctic.
21. Sustainable use of renewable resources and sustaining ecosystems should be promoted in regards to exploration, development of oil and gas, mineral resources and shipping, through

the application of the most stringent environmental standards, which should exceed today's standards, and through land-use planning that includes development thresholds to ensure that cumulative impacts are limited.

22. International investment, including from states outside the Arctic, should be mobilised to ensure safe, secure and reliable marine transportation in the Arctic.
23. National governments and corporations should take into account ecosystem services values during development planning, including spatial integrative planning and recognition of no-go zones.
24. Governments should be called on to establish new legislation, where needed, to ensure that industry operating in the Arctic supports and participates in integrated research and monitoring following set standards.
25. Assessments should be produced of the impacts of different-scales of resource and industrial development in the North. This should include alternate governance models to address resource conflicts related to the increased role and presence of multinational corporations in the North.
26. It should be ensured that indigenous peoples and Arctic communities are fully involved in decisions concerning development, are fully and effectively consulted, and have free prior and informed consent.
27. Best practices should be investigated and disseminated in the management of industrial development controlled by indigenous peoples, to ensure that local communities benefit as much as possible from the positive aspects of industrial development.
28. National governments and corporations should be stimulated to compensate any net negative impacts caused to indigenous peoples and Arctic communities by industrial development and climate change, through affirmative plans, education and support programmes.

Arctic governance

29. Governance initiatives should consider values beyond macroeconomic indicators and economic growth rates.
30. The United Nations Framework Convention on Climate Change (UNFCCC) should address land-use changes as an important driver of climate change.
31. UNESCO should work closely with the Arctic Council, which provides a forum for cooperation between Arctic and non-Arctic states, indigenous peoples and observer organisations, to promote sustainable development.
32. The full and effective participation of indigenous peoples in international climate change negotiations and debates should be ensured.
33. A working/advisory group should be established to develop dialogue and strategy on the challenges of climate change for circumpolar indigenous peoples, including safeguarding intangible heritage and building synergies between indigenous and scientific knowledge.

34. UNESCO and other international bodies should support efforts by Arctic indigenous peoples and peoples of the Small Island Developing States and other vulnerable regions to achieve an effective climate change treaty that will reduce risks and vulnerabilities, in particular to peoples living in low lying areas, small islands and the Arctic.
35. Support should be encouraged for the recognition of human rights and the United Nations Declaration of the Rights of Indigenous Peoples, and the ratification and implementation of relevant Conventions including the 1989 International Labour Organization (ILO) Convention 169 concerning Indigenous and Tribal Peoples in Independent Countries, the 1992 Convention on Biological Diversity, and UNESCO's cultural conventions, in particular the 1972 World Heritage Convention and the 2003 Convention for the Safeguarding of the Intangible Cultural Heritage, as well as the 2001 Stockholm Convention on Persistent Organic Pollutants and the United Nations Framework Convention on Climate Change (UNFCCC). Self-determination should be supported on national and international levels.
36. Arctic peoples should be involved, formally and informally, in collaborative management of biodiversity at all levels of planning and decision-making concerning the Arctic and its future.
37. Sustainable use by indigenous peoples should be acknowledged when any proposals are made to place animals on endangered species lists. It should be recognised that indigenous peoples have depended upon this resource for their traditional diet, which has an impact on their health, and that sustainable use of the surplus of nature (sea mammals, deer, birds etc) is legitimate and is an important part of Arctic culture. Indigenous peoples should be fully and effectively consulted prior to any restrictive measures being considered.
38. Arctic wetlands and other underrepresented ecosystems should be properly represented in existing conventions and other international fora by stressing the important services that Arctic wetlands provide (regulating climate and hydrology).
39. UNESCO should support the efforts underway to improve international governance of the Arctic, such as broadening stakeholder participation. This should, in part, support improved outcomes for Arctic biodiversity such as the analysis of Multilateral Environmental Agreements being conducted by UNEP.
40. Arctic states and Greenland should be encouraged to recognise the importance and value of efforts by non-Arctic stakeholders, including international organisations and NGOs, to sustain the region's unique biological, social, and cultural heritage and reduce the effects of climate change, and they should collaborate with these efforts.
41. Both Arctic and non-Arctic states should be encouraged to work together to develop coordinated programmes to mitigate environmental deterioration in the Arctic.
42. All necessary efforts should be made to enable research to thrive by ensuring free and open scientific access to the Arctic. In view of the gaps in the application of Article 247 of the United Nations Convention on the Law of the Sea (UNCLOS), UNESCO is requested to act through the mechanisms of the IOC to develop related procedures which would improve access of researchers to the exclusive economic zones of Arctic states.

Establishing, sustaining and strengthening research and monitoring systems

43. Given the limited number of observation networks in the Arctic, sustaining, strengthening and further developing long-term comprehensive multidisciplinary integrated pan-Arctic observing systems is recommended.
44. A mechanism should be established to facilitate international collaboration among operators, funding agencies, indigenous peoples' organisations and users of multidisciplinary observational systems and data over the Arctic region. The efforts of SAON (Sustained Arctic Observing Networks) and CBMP (Circumpolar Biodiversity Monitoring Program) to do this should be acknowledged and supported. UNESCO and its IOC should request that member countries support these observation and monitoring systems.
45. It is recommended the cryosphere aspects of this pan-Arctic system be linked to the Global Climate Observing System (GCOS) in the Arctic, building on its main existing components currently in place such as the Global Ocean Observing System (GOOS), Global Terrestrial Observing System (GTOS) and new mechanisms such as Global Cryospheric Watch (GCW).
46. It is recommended that the core components of these observation systems that need to be developed, strengthened and sustained include at least the following:
    a. A full gap analysis to determine where we can strategically fill priority gaps in research, monitoring and protected area coverage (geographic, thematic), including through indigenous knowledge;
    b. Further development of satellite observations and ground truthing focused on the polar regions;
    c. Continuation of existing polar observatories, other research and monitoring networks (regionally based/theme-based) and community-based monitoring networks and enhanced coordination among these observatories (networks of networks);
    d. Maintenance of existing drifting ice and ship stations in the central Arctic Ocean;
    e. Continuation and further deployment of autonomous observation platforms;
    f. Continuation of data rescue efforts to enhance our understanding of long-term Arctic environmental change;
    g. Full and effective participation of local communities and their institutions in community monitoring of variables such as snow, precipitation, ice, ocean and weather conditions, as well as larger operational and research programs;
    h. Development of an overall status report on Arctic communities that reviews impacts on social, economic and cultural issues due to climate change. Include updates on the progress made by communities which are forced to move due to severe erosion;
    i. Design and implementation of the Arctic Social Indicator monitoring system for long-term monitoring of human development and quality of life in the Arctic;
    j. Development of guidelines and best practices for a standardised observing programme at all the observing stations, including community monitoring programmes;
    k. Global tsunami warning systems should be extended to the Arctic (where appropriate).

47. UNESCO should work with Arctic states and Greenland to expand the network of Arctic biosphere reserves and World Heritage Sites and they should reactivate the Man and Biosphere (MAB) Northern Science Network.
48. UNESCO should support the work of the ongoing Arctic Biodiversity Assessment, aimed at international efforts to halt the loss of biodiversity.
49. UNESCO should promote coordinated and streamlined activities and processes as well as reporting on Arctic related issues such as biodiversity, climate change, land degradation, economic and social development, human rights and indigenous peoples in all its existing relevant international conventions and their liaison groups.
50. UNESCO should encourage comparative and multi-disciplinary research and monitoring approaches (both within and outside the Arctic) to facilitate the identification of drivers of change and to inform effective adaptation and management strategies.
51. UNESCO, the Arctic Council and other international bodies should support further monitoring and research aimed at linking climate change impacts on physical systems to biodiversity (including the full range of ecosystem services), and social systems, as highlighted in the ACIA report.
52. UNESCO should produce reports to examine how actions in non-Arctic states affect the Arctic, and how change in the Arctic will affect non-Arctic states. Already, recognising the connection, some distant large population states have become observers to the Arctic Council. Such reports would help bring attention to the enormity of the problems faced by the globe.
53. UNESCO could help perform assessments on information and communications technology, sustainable and stable cost energy, World Heritage, resources, and food security in the Arctic.
54. An integrated pan Arctic network of 'supersites' should be established, building on existing infrastructure and facilities, where *in situ*, satellite, local knowledge and model data can be integrated to provide long-term, multidisciplinary data sets suitable for environmental monitoring and prediction.
55. In order to promote implementation of research and monitoring activities into operational services, it is recommended that:
    a. Groups such as SAON, CBMP and/or Global Cryosphere Watch should be utilised by UNESCO as a means of addressing several of the above research and observational recommendations;
    b. UNESCO should further encourage scientific research of Arctic climate in the framework of the World Climate Research Programme (WCRP), including creation of a new generation of climate models that would be able to address the above mentioned uncertainties;
    c. UNESCO should support efforts started during IPY, including collaborations and cooperations already in place within programmes like DAMOCLES (Developing Arctic Modelling and Observing Capabilities for Long-term Environmental Studies);
    d. UNESCO should use its potential as the organisation having the mandate for interdisciplinary research to create through its existing programmes (i.e. IOC, MAB and the International Hydrological Programme (IHP)) and by other mechanisms, new information

and knowledge which could be improved by the study of these science knowledge gaps;

e. A viable operational mechanism should be established, such as the Polar Climate Outlook Forum (PCOF), an IPY legacy project led by WMO, to facilitate effective interactions between climate professionals and users/stakeholders.

56. In line with changes in the IPY that have included human dimensions in the polar science agenda for the first time, UNESCO, in cooperation with relevant bodies, should initiate a study on how research questions are formed in the Arctic, whether these get addressed, and where gaps appear in research agendas and activities.

57. WMO and UNESCO, as designated conveners by the UN for enhanced UN collaboration on climate knowledge: science, assessment, monitoring and early warning, are invited to promote UN collaboration for establishing, sustaining and strengthening research and monitoring systems in the Arctic.

Information access and data sharing

58. Research and monitoring systems, programmes and processes in the Arctic and elsewhere should:
    a. Ensure a two way dialogue and exchange of information between indigenous and scientific knowledge. Ensure that indigenous and Arctic peoples are full and effective participants in the design and implementation of research and monitoring programmes, and that they receive the results from these programmes using formats both appropriate and comprehensible, e.g. using local languages;
    b. Recognise and encourage parallel, collaborative processes between scientific methods and indigenous knowledge in setting regulations, laws and policies on the environment and natural resource management;
    c. Place a greater emphasis on local and indigenous knowledge in mainstream science. Acknowledge Arctic Peoples' dependence on and stewardship of biodiversity, and the important contribution that indigenous knowledge can make to detecting and understanding change in Arctic ecosystems;
    d. Support studies into how Arctic peoples have adapted to changing environmental conditions in the past to assist the development of adaptation strategies;
    e. Encourage research cooperation and coordinate efforts between Arctic peoples' organisations, UNESCO and other bodies with regard to climate change impacts and adaptations. Adopt policies and programmes to address this relationship;
    f. Identify the vulnerability of users in the Arctic and their needs for climate and cryosphere information;
    g. Reinforce collaboration amongst the practitioners of natural science, social sciences and cultural issues;
    h. Incorporate northern higher education institutions as infrastructure and platforms.

59. Data and information (including local and traditional knowledge, where appropriate) collected through polar research should be made available freely, openly and easily accessible in a timely fashion at minimal cost to users. This must take into account relevant international agreements and national legislation, as well as critical information needs of people and nations vulnerable to the effects of Arctic climate change. Furthermore, in order for the data collected to be useful, best practices (standardisation) for data collection and data format need to be provided and enforced.
60. UNESCO, WMO, the International Council for Science (ICSU) and other relevant international organisations should consider the idea of an International Polar Decade as a long-term process of research and observations in polar regions to meet the requirements for climate change studies, assessments and prediction to benefit society.
61. Arctic and non-Arctic governments should support and encourage efforts to rescue existing relevant information, including that on climate change, biodiversity trends and the drivers of these trends, and ethnographies of Arctic circumpolar indigenous peoples, as these information sources may have crucial relevance to trends seen in the contemporary Arctic.

Policy and decision support

62. UNESCO, together with WMO, UNEP and other relevant bodies, should fully evaluate adaptation potential for the whole of the Arctic and its individual regions. Special attention should also be given to the development of models and techniques for prediction of high impact climate events leading to serious socio-economical and ecological consequences. The organisations should serve as a clearinghouse of knowledge (collect, examine, disseminate), including but not limited to climate change, its impacts, its challenges and best practices.
63. The best available knowledge, including indigenous knowledge, scientific research and monitoring, should be utilised in the development of adaptation and mitigation strategies.
64. The UNFCCC Conference of the Parties 15 (COP15) should seek to mobilise sufficient resources to allow the world's vulnerable regions to adapt to rapid climate change.
65. It should be ensured that mitigation and adaptation strategies are in conflict neither with each other nor with other biodiversity values.
66. UNESCO is encouraged to address the Arctic research-policy linkage within the framework of the MOST (Management of Social Transformations) Programme.
67. UNESCO should participate in the organisation and conduct of the World Climate Conference-3 (WCC-3), and UNESCO should continue to expand its productive collaboration with WMO and other relevant agencies as a key partner in implementation of the WCC-3 outcomes.

The Arctic is undergoing rapid and dramatic environmental and social transformations due to climate change. This has ramifications for the entire planet, as change spreads through interconnected global networks that are environmental, cultural, economic and political. Today, with the major thrust of research shifting away from deciphering causes and monitoring trends, the central preoccupation of a growing circle of actors has become the exploration of strategies for responding and adapting to climate change.

But to understand the far-reaching nature of climate change impacts and the complexities of adaptation, a truly interdisciplinary approach is required. Unique in the UN system, UNESCO brings together the domains of natural sciences, social sciences, culture, education and communication. Given this broad mandate, UNESCO favours integrated approaches for monitoring and adapting to climate change in the Arctic, fostering dialogue among scientists, circumpolar communities and decision-makers.

This book brings together the knowledge, concerns and visions of leading Arctic scientists in the natural and social sciences, prominent Chukchi, Even, Inuit and Saami leaders from across the circumpolar North, and international experts in education, health and ethics. They highlight the urgent need for a sustained interdisciplinary and multi-actor approach to monitoring, managing and responding to climate change in the Arctic, and explore avenues by which this can be achieved.

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United Nations
Educational, Scientific and
Cultural Organization

Culture Sector
Education Sector
Natural Sciences Sector
Social and Human Sciences Sector

ISBN 978-92-3-104139-6
9 789231 041396