



Canadian Arctic
Resources
Committee (CARC)



Environmental
Committee of
Sanikiluaq



Rawson Academy of
Aquatic Science
(RAAS)

**The Hudson Bay Programme
Final Report of Phase I**



HUDSON BAY PROGRAMME SUR LA BAI

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Final Report of Phase I**

**Hudson Bay Programme
June 1995**

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Table of Contents

Acknowledgements	iii
Foreword	iv
1 Introduction	1
The Hudson Bay Programme: Goals and Objectives	1
Cumulative Effects	2
Role of Science and Traditional Ecological Knowledge	2
The Science Study	2
The Traditional Ecological Knowledge and Management Study	3
Combining Science and Traditional Ecological Knowledge	4
Linkages to Phase II	5
2 History and Context	6
Biophysical Setting	6
Cultural Setting	8
Economic Development	11
3 The Hudson Bay Region: State of Scientific Knowledge	12
Availability of Information	12
Understandings	13
Marine and Terrestrial Ecosystems	14
Changes, Trends, and Consequences	17
Contaminants	17
Resource Availability	18
Climate Change	20
4 Hudson Bay Region: A Traditional Ecological Knowledge Perspective on Environmental Change	22
Introduction	22
Implications for the Bioregion	25
Rising Land Mass	25
Atmosphere	25
Weather	26
Altered Rivers	27
Weakening Currents	27
Lost Habitat	28
Animal Population Changes	28
Natural Fluctuations	29
Shifts in Response to Habitat Loss, Food Availability or Disturbance	29
Reproductive Responses	30

	Deteriorating Health and Body Condition	30
	Health and Well-Being	31
5	Some Reflections on Science and TEK	32
	Introduction	32
	Climate and Weather	33
	Weather, Currents, and Ice	34
	Isostatic Rebound	35
	River Diversions and Reservoirs	35
	Wildlife and the Traditional Economy	37
	Fisheries	37
	Geese	38
	Polar Bear	39
	Belugas	40
	Contaminants, Health and Well-Being	40
	Summary	42
6	Toward Sustainable Development in the Hudson Bay Region	43
	Introduction	43
	Sustainability and Preferred Futures	43
	Indicators of Environmental Stress	44
	Toward Cumulative Effects Assessment	45
	References	46
	Appendix	48
	Technical Reports of the Hudson Bay Programme	
	List of Figures	
1	Hudson Bay Basin: Major Watersheds and Rivers	7
2	Hudson Bay Basin: First Peoples	9
3	Hudson Bay: Communities	10
4	Summary of Environmental Changes in the Hudson Bay Bioregion Observed by Cree and Inuit	23

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The Hudson Bay Programme.

Foreword

Hudson Bay has a special place in our history. Much of the drama that personifies Canada has taken place in this huge watershed, but only recently has it attracted the attention of those who deal with environmental questions. The sheer size of Hudson Bay and its surrounding watershed is beguiling. Human activity is still so small, so insignificant within this whole. Or is it? It is possible, instead, that already we are approaching certain limits in the ability of the bay to withstand our uses of the rivers that debouch into it?

Motivated by these questions, the Canadian Arctic Resources Committee (CARC), the Rawson Academy of Aquatic Science, and the Environmental Committee of Sanikiluaq (an Inuit community on the Belcher Islands in south-east Hudson Bay), decided to jointly plan a research programme on existing and potential impacts in the bay of development occurring within the Hudson Bay watershed. Of particular interest and concern are the likely cumulative impacts of these developments. The programme formally began in 1992 and Phase I was completed early in 1995.

The Hudson Bay Programme, as this initiative has become known, is relying not only upon insights and conclusions provided by science, but also knowledge held by aboriginal people—Inuit and Cree—who live on the shore of the bay, and hunt and fish in its waters.

This is the last of a series of volumes published by the programme. A full list of programme publications is included in Appendix One. This report summarizes the conclusions of Phase I of the programme and looks forward to further work, to be conducted in Phase II.

In recent years, the federal and provincial governments have committed themselves to the principle of sustainable development. This is a principle in which we firmly believe. The Hudson Bay Programme represents our contribution to the goal of environmentally sustainable and equitable development in the Hudson Bay region.

The Hudson Bay Programme.

1 Introduction

The Hudson Bay Programme: Goals and Objectives

Hudson Bay is one of the world's largest inland seas; it includes James Bay, Hudson Strait and all interconnecting channels. The bay is bordered by Québec, Ontario, Manitoba, and the Northwest Territories but is under federal jurisdiction. However, upstream provinces and the Northwest Territories exert significant influence over the bay by virtue of the industrial activities and land and resource uses they allow.

The expansion of large scale development projects throughout the Hudson Bay bioregion—particularly over the last 50 years—has raised ecological, social, cultural, and economic concerns particularly by aboriginal peoples who live in the region. Large scale hydroelectric projects in northern Québec, Manitoba and Ontario have, for example, contributed to changes in the natural environment, the socio-cultural and economic conditions in aboriginal communities, and the erosion of traditional aboriginal practices in the bioregion.

In response to these concerns the Canadian Arctic Resources Committee (CARC), the Municipality of Sanikiluaq, and the Rawson Academy of Aquatic Science (RAAS), cooperatively developed the Hudson Bay Programme (HBP). This programme is divided into two phases, each with a specific, yet related, goal:

- Phase I: to identify key impacts of human activities, particularly hydroelectric developments, on the marine and freshwater ecosystems of the Hudson Bay and James Bay bioregion using scientific data and traditional ecological knowledge; and
- Phase II: to examine and propose cooperative processes for decision-making among governments, aboriginal peoples, developers, and other stakeholders to promote sustainable development in the bioregion.

More specific goals of Phase I include:

- to provide an overall description of the Hudson Bay/James Bay environment, and an understanding of the bioregion's ecosystem (the interactions among humans, biota, and environment);
- to assess the potential sensitivity of the region to cumulative impacts, induced by changes both within and external to it;
- to define conceptual and information deficiencies from traditional knowledge and scientific perspectives which limit our ability to assess problems associated with the region; and
- to discuss and present the findings as part of an iterative process of information sharing among all interested parties including government agencies, energy utility corporations and, in particular, Cree and Inuit.

Cumulative Effects

In recent years the concept of cumulative impacts and cumulative impact assessment (CIA) has attracted considerable interest in Canada, stimulated by debate on the recently proclaimed Canadian Environmental Assessment Act. Suggesting how to link cumulative impact assessment with other policy processes is a guiding principle of the HBP, and an objective of Phase II.

In the past, developments which affect Hudson Bay were conceived, planned, approved, built, and operated, on a project-by-project basis. This is most obviously the case with hydroelectric developments in the Churchill/Nelson, Moose and La Grande River basins. There is now a growing concern that the effects of one development in the bioregion could be compounded by, or act in concert with, the effects of others. Identifying and assessing cumulative impact is still in its infancy in Canada. In light of this we have adopted a broad definition of cumulative impacts—significant changes in the lives of people and or conditions which result from human disturbance of the environment. This definition encompasses both living and non-living things and the relations among and between bio-physical and socio-economic forms of impact.

Role of Science and Traditional Ecological Knowledge

The HBP relies on both scientific research and traditional ecological knowledge (TEK) in its examination of the Hudson Bay bioregion. We assume that TEK can and should be used in conjunction with science to identify ecosystem components or processes under stress or undergoing change.

The Science Study

The programme did not conduct scientific field research. Instead, the goal was to scan the published literature and consult with leading experts to identify biophysical factors likely to be significantly affected by the cumulative influence of hydroelectric and other developments within and outside the region.

The first step was to prepare an annotated bibliography on the Hudson Bay bioregion. This was completed through contributions from the provincial governments and public utilities in Manitoba, Ontario and Québec, several federal departments, and academic and private research institutions. This bibliography is available from the library of the Department of Indian and Northern Affairs in Ottawa, and is accessible electronically through regional offices of this department.

A science overview paper was prepared in 1993. A draft of this paper was used in a May 1993 HBP workshop on cumulative effects assessment. Experts were invited from all levels of government, the three electrical utilities, academic and private research institutions, aboriginal groups and non-government organizations. Participants received a status report on the early findings of the Traditional Ecological Knowledge and Management Systems (TEKMS) study, discussed the scientific data base available in Hudson Bay, developed hypotheses about potential

cumulative impacts, and identified topics upon which detailed technical papers should be commissioned.

Six technical papers were commissioned covering the following areas of interest:

- 1 Effects of stress on human health in the bioregion;
- 2 Relationship between selenium and mercury, and implications for the food-chain;
- 3 Climate variability, climatic change, and implications for the future of the bioregion;
- 4 Estuaries around the bay and the use of type examples to describe and integrate their physical and biological components and processes;
- 5 Shifts in subsistence economies and their significance in terms of the total economies of bay communities; and
- 6 The effects of hydro-electric development on sea ice, currents, and the marine environment in Hudson Bay.

The science paper, proceedings of the first workshop, and the technical papers provided the basis for a second meeting to discuss cumulative effects, held in the December of 1993. The results of the second scientific workshop aided in the development of the form and substance of the Phase I science report. The Appendix to this report lists the key publications of the Hudson Bay Programme.

The Traditional Ecological Knowledge and Management Study

Inuit and Cree have relied on the resources of Hudson Bay for thousands of years. During this time, a collective body of knowledge has been gathered from observation and experience and passed down through the generations. This oral tradition goes beyond simple documentation of events. It represents an understanding of the complex relationships of the natural environment that governs the behaviour of animals. This collective knowledge forms a data base for predictive modelling, forecasting, and selecting harvest areas.

A major goal of the programme is to help Inuit and Cree record and bring forward this rich knowledge base in such a way that it can be used in resource use planning and decision making. The focus is to record environmental changes that harvesters and elders have observed. This portion of the HBP goes beyond aboriginal land use and occupancy studies that have been published as a prelude to land claim negotiations.

TEK has several useful features as a data base. First, data can be independently verified by separate interviews with people who harvest in the same area. Second, changes over time can be established by collecting information about one area from several generations of users. Third, the collective memory offered through an oral tradition can provide insights for time prior to the birth of the oldest elder. When collecting TEK and using it in planning and assessment exercises it is important to avoid preconceived notions of what to expect. The reductionist approach of hypothesis testing commonly used by researchers is not appropriate to TEK collection or analysis; rather it is important to seek the information and let patterns of change

emerge through its compilation and organization.

The TEKMS study started with a workshop in Sanikiluaq in September 1992. People from Inuit and Cree communities in northern Québec, Cree communities in northern Manitoba, and Inuit communities from Keewatin, and Baffin Island attended. This was the first time that aboriginal people from around Hudson Bay and James Bay had met to discuss common issues including the environment. During 1993 HBP personnel visited communities around the bay, and talked to active harvesters and elders about their way of life on the land, and changes to the environment that they had noticed. This knowledge was recorded and mapped. A second round of meetings were held in the communities in Autumn 1993 to verify the information collected. In February 1994 a second workshop brought together thirty-five people including regional coordinators, community representatives, elders and the technical advisory committee to discuss information collected and to ponder how best it could be used.

TEK has been collected to:

- describe important biological, physical, and human processes influencing the behaviour of ecological communities in Hudson and James bays;
- identify ecological changes occurring in Hudson and James bays, and surrounding lands;
- assess the effects of human activities, including hydroelectric, mining, and forestry developments on economically and ecologically important species.

A two-volume TEKMS report with system-wide and selected regional maps was published by the programme in 1995. The Appendix to this report provides the full citations of these reports and their Table of Contents.

Combining Science and Traditional Ecological Knowledge

In May 1994, a meeting was held in Winnipeg to bring together key members of the scientific community with Inuit and Cree representatives to examine the information obtained from both the science and TEK components of the HBP. Participants examined ways in which science and TEK could be combined. The discussion on linkages between science and TEK focused on the attributes TEK and science bring to a combined knowledge base; areas of confirmation; areas of complementarity; and areas of omission. Issues that were addressed included:

- climate changes
- changing currents and ice regimes
- long term effects of flow diversions
- habitat change and loss
- animal population and migration changes
- changing land use patterns and values
- contamination of food webs
- human health and lifestyle (socio-cultural trends/cultural impacts)

Further meetings were held later in 1994 to scope the connections between science and TEK. Chapter five of this report summarizes the results of these meetings.

Linkages to Phase II

Phase II of the programme will seek to broaden debate about environmental assessment in the Hudson Bay bioregion from the present narrow, project-by-project approach. The aim is to encourage long-term protection of natural and human systems so as to promote sustainable use of resources. Phase II will refine the description of problems identified in Phase I and will address two additional goals. First, assess options and opportunities associated with sustainable development in the bioregion. Second, examine and propose co-operative approaches to more effective intergovernmental and community decision making based on the premise that sustainable development in the bioregion is the long-term goal of all.

2 HISTORY AND CONTEXT

Biophysical Setting

The Hudson Bay watershed covers well over one-third of Canada, as well as parts of North Dakota and Minnesota in the United States (Figure 1). Hudson and James Bay constitute a large, shallow inland sea connected to the Atlantic Ocean by Hudson Strait and the Labrador Sea, and to the Arctic Ocean by the Foxe Basin and Fury and Hecla Straits. Currents are affected by influxes of fresh water from rivers and, during the open water season, by wind. Cold saline water enters Hudson Bay and James Bay from the northwest. Less saline surface outflows occur along the eastern shores of James Bay and Hudson Bay north to Hudson Strait.

Hudson and James Bay are the largest bodies of water in the world that seasonally freeze and thaw (except for intermittent shore leads). Open water leads in the ice—known as polynyas—are found predominantly along the northwest and east coasts of Hudson Bay, both coasts of James Bay, and in the vicinity of the Belcher Islands. Polynyas are important for the marine wildlife that inhabit the bays and the Inuit who rely on the polynyas for hunting throughout the ice-cover period.

The Hudson Bay food web is comprised of Atlantic, arctic and freshwater animal and plant species. Ice algae and phytoplankton are found at the base of the food web, followed by copepods and amphipods. Ice algae—critical source of primary production—is also a very important component of the overall productivity of Hudson Bay. Sand lances, which feed on both amphipods and fish larvae, are a crucial food source for Arctic cod—one of the most important species of fish in the basin (Sly 1994). Arctic cod are fed on by beluga whales, ringed seals and thick billed murre. These organisms are, in turn, fed on by polar bears, killer whales and humans. Due to the relatively long food-chain in the Arctic, bioaccumulation of toxins is of particular concern.

Approximately 60 species of fish are known to inhabit the estuarine communities of Hudson Bay and James Bay. Fewer species are found toward the north where arctic species predominate. Key species in the Cree diet include Whitefish, Lake trout, and Northern pike, while for the Inuit, key species include Arctic char and Lake trout. Ringed seals are found on all coasts of James Bay and Hudson Bay. Bearded and Harp seals are also present in Hudson Bay, and Harbour seals occur in small numbers at isolated locations. The main concentration of walrus is at northeastern Coats Island, although they are also found in and around the Sleeper Islands, north of the Belcher Islands.

RIVERS

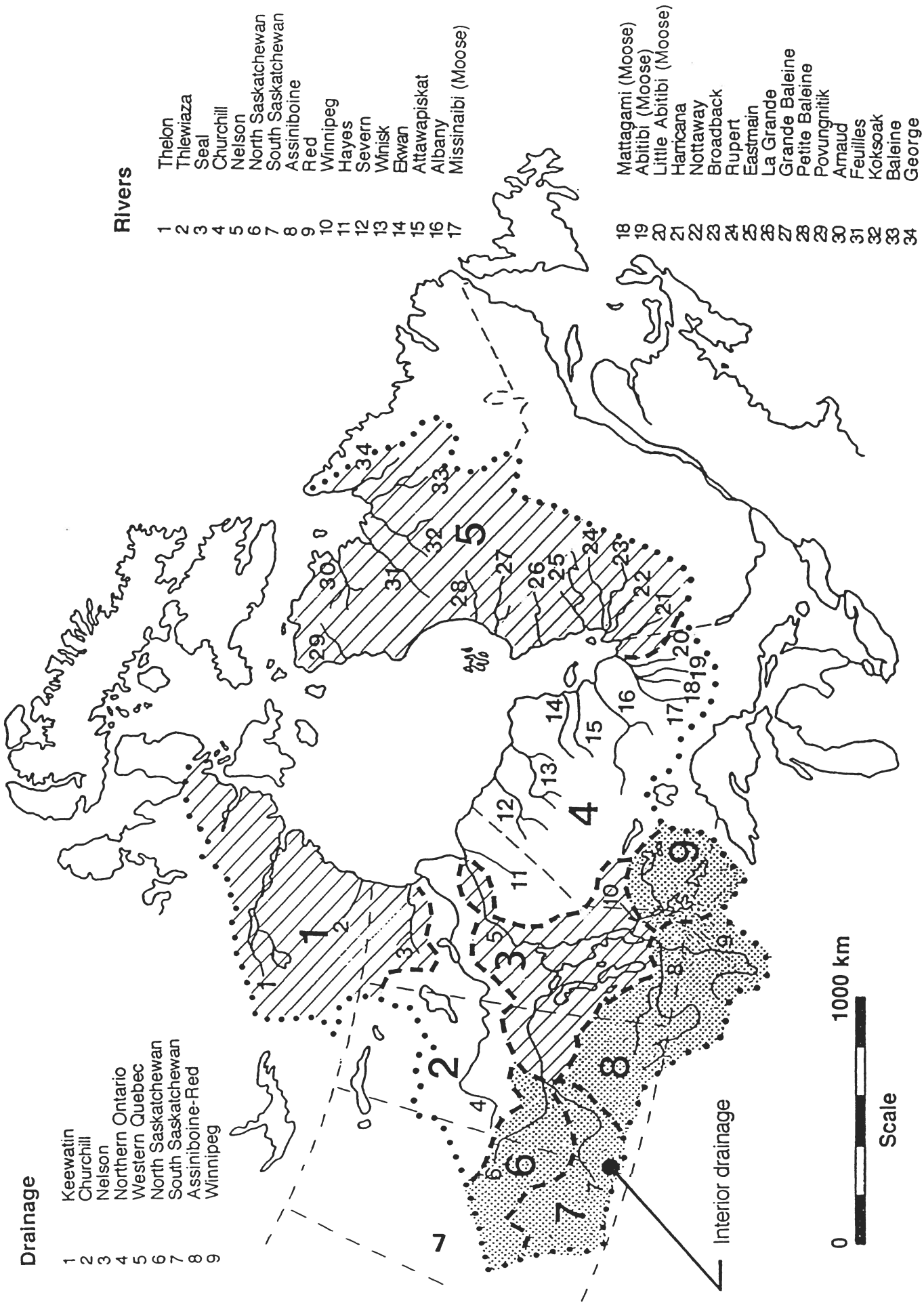


Figure 1

Beluga whales in the region are categorized into three "stocks"—according to their summer distribution—Western Hudson Bay, Northern Hudson Bay, and Eastern Hudson Bay. Rough estimates indicate the beluga population to be 23,000 in Western Hudson Bay, 1000 in Northern Hudson Bay, and 2,700 in Eastern Hudson Bay (Schneider-Vieira et al. 1994). Most beluga migrate in the winter northward along the east and west coasts of Hudson Bay to overwinter in the Hudson Strait region. Some belugas use the polynya of northwest Hudson Bay and Eastern Hudson/James Bay in Winter. Estuaries, including those affected by existing and proposed hydroelectric developments are important to belugas as feeding and calving grounds.

Polar bears inhabit the coast of Hudson Bay and northern James Bay during summer and fall, and the islands of northern James Bay year-round. Polar bears feed on ringed seals, bearded seals and walrus. When the ice breaks up in the summer in Hudson Bay and James Bay, Polar bears are forced to the shore. When ashore, Polar bears tend to eat less and rest to conserve energy.

The Hudson Bay and James Bay coasts provide a major migration pathway and a breeding ground to many species of geese and ducks. The Common Eider, which nests on offshore islands in Hudson Bay, is the most abundant breeding duck in the region. The Hudson Bay eider, located on islands off the shore of Eastern Hudson Bay, is of particular importance to the Inuit of the Belcher Islands. Three main species of geese use the basin as a staging and breeding area: Canada Geese, Lesser Snow Geese, and Atlantic Brant. The high fertility and productivity of the coastal zone support a wide range of food types which enable reproduction, growth of juveniles, and fattening of all ages prior to the fall migration.

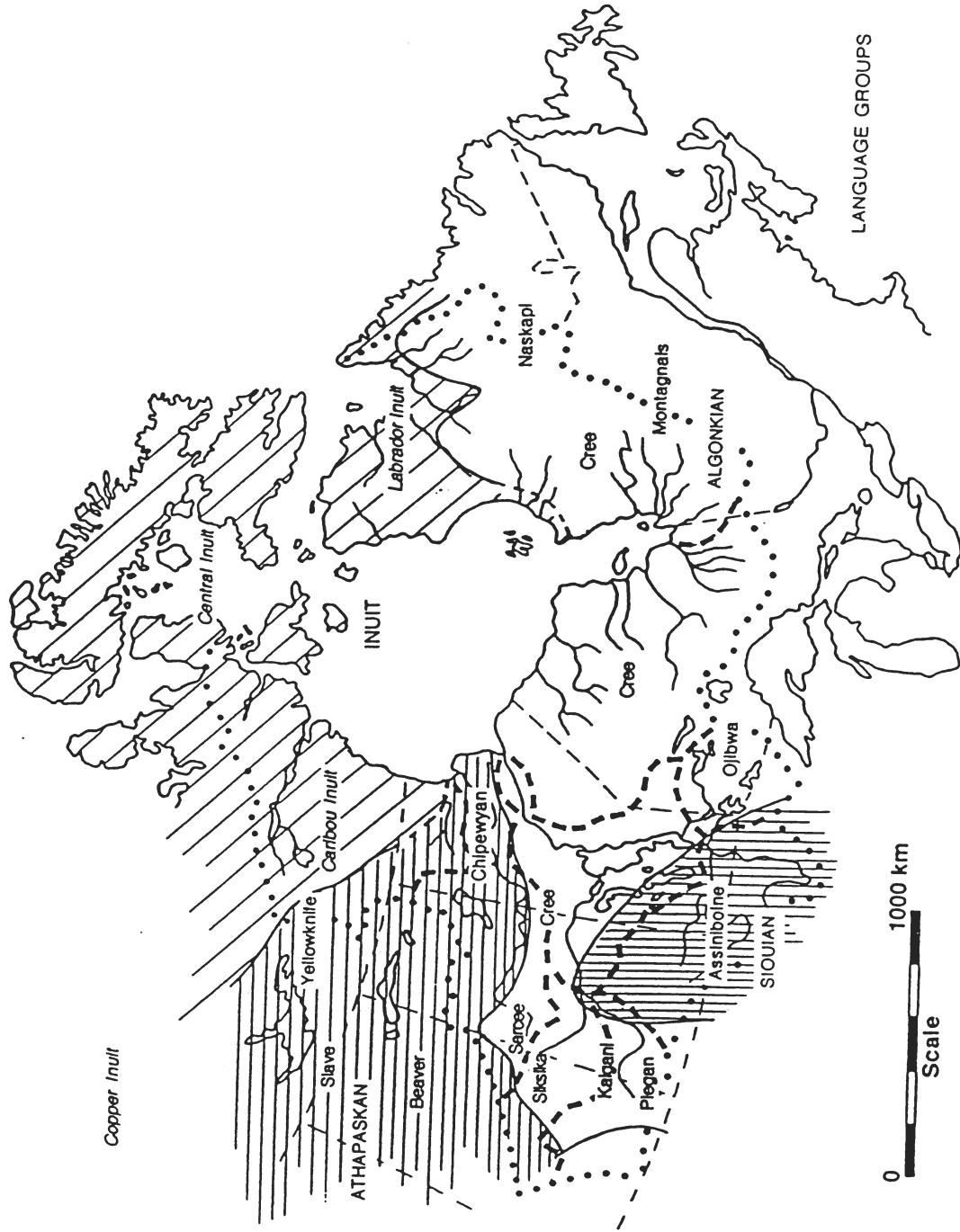
Cultural Setting

The Hudson Bay bioregion has been inhabited by Cree and Inuit for thousands of years (Figure 2). Forty-five communities are located in the region in four political jurisdictions—Manitoba, Ontario, Québec, and the Northwest Territories. Each of these communities, representing seven aboriginal nations, depend on the land for food. The Cree occupy parts of Manitoba, Ontario and northern Québec as far north as Whapmagootstui. Inuit communities are found along the eastern shores of Hudson Bay in Québec north from Kuujjuarapik to Ivujivik and Salluit. In the Northwest Territories, Inuit communities extend from Arviat on the western shore of Hudson Bay to Coral Harbour on Southampton Island. The Inuit community of Sanikiluaq on the Belcher Islands in southeastern Hudson Bay is approximately 100 kilometres from the mouth of the Great Whale River (Figure 3).

The economies of Aboriginal communities in the bay can be characterized as a combination of wage employment, traditional harvesting activities, and transfer payments (Fast and Berkes 1994). Harvesting wildlife is important economically for these communities, and is also vital for the social, cultural, and spiritual well-being of the people. The importance of wildlife, fish, and waterfowl in the local economies of the Hudson Bay and James Bay region cannot be overstated. Both coastal and inland subsistence fisheries are significant components of the aboriginal economy. Arctic char, whitefish, Arctic cod and other species contribute directly to the domestic fishery.

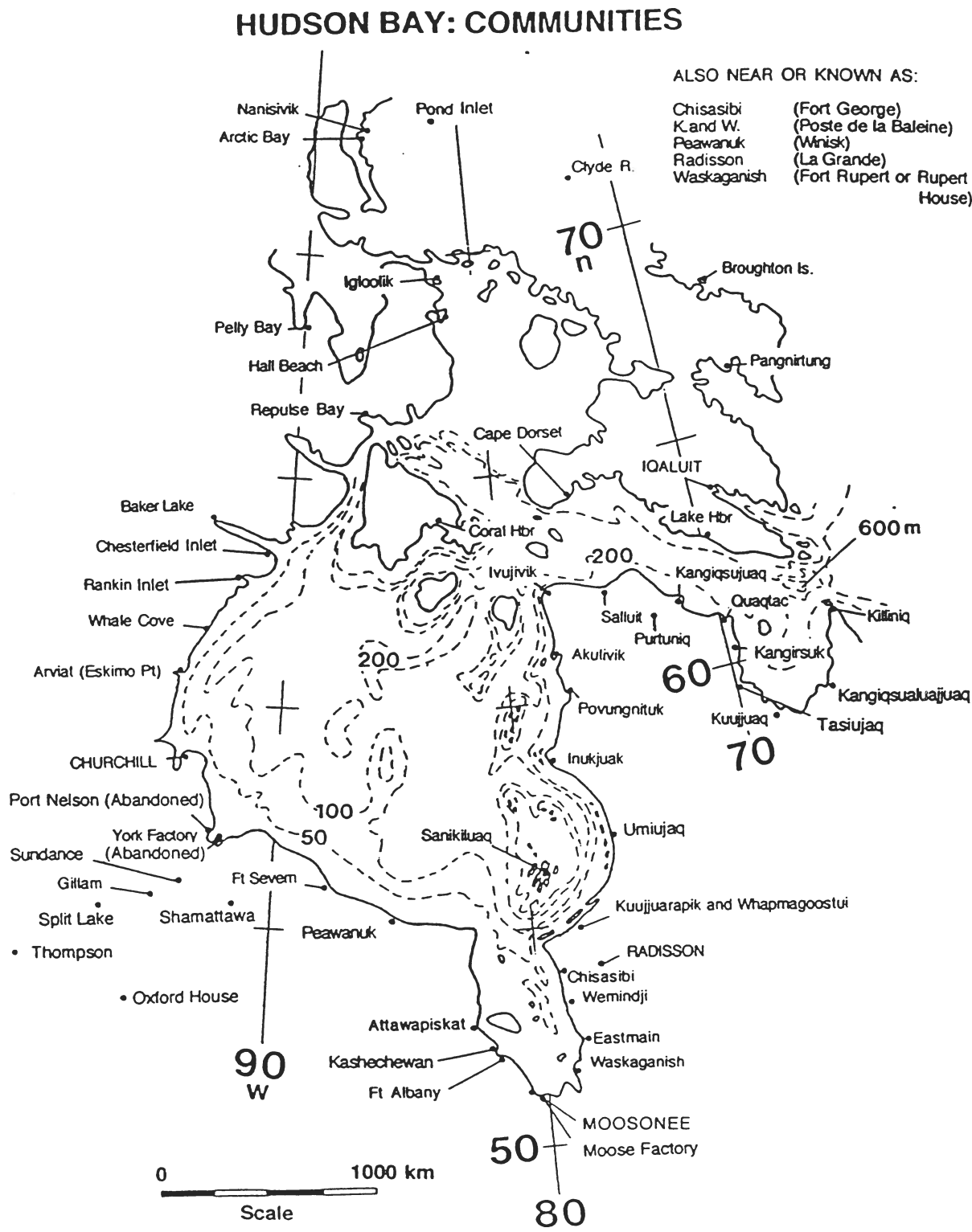
Figure 2

HUDSON BAY BASIN: FIRST PEOPLES



Source: Mowat (1970); Symington (1978); Dickason (1992).

Figure 3



The Cree hunt migratory birds including Snow Geese and Canada Geese, particularly in the spring, and terrestrial mammals such as moose. The Cree also fish the rivers in the region and trap fur-bearing mammals such as muskrat and beaver. Traditionally, Inuit have focused their harvesting efforts on fish and marine mammals including seals, walrus, and whales, but may also hunt polar bears and migratory birds. Some Inuit communities also depend heavily on caribou.

Economic Development

Government policy regarding economic development in the Hudson Bay bioregion has encouraged forestry, mining, hydro-electric development, and, to a lesser extent, oil and gas exploration. Forestry and mining in northern Manitoba, northern Ontario and Western Québec appear to have primarily indirect effects, such as the addition of pollutants and sediments to rivers leading into the bay. Clear cutting, the main harvesting technique in forestry, stresses the ecosystem through habitat change and loss, and through increased volume and decreased quality of surface water discharge. Persistent organic contaminants found in the effluent of pulp and paper industries are also of great concern.

Hydro-electric projects and particularly reservoir development, may cause significant effects on the bay. Reservoir developments likely lead to localized changes in hydraulic patterns in the bay, as well as nutrient and sediment loading, and increased levels of mercury and other contaminants. Altered hydraulic regimes may lead to delayed offshore ice break-up and earlier, thicker formation of ice.

Over the long term, impoundments may reduce the input of organic carbon to the bay, reducing nearshore and estuarine productivity. Changes in salinity, temperature, and freshwater flow as a result of impoundments may well alter the distribution of fish and dependent predators including birds particularly in estuaries. Attendant changes in ice-conditions and the time of break-up may affect marine mammals such as ringed and bearded seals and polar bears.

Environmental changes and loss of wildlife and wildlife habitat are of great concern to the region's residents. Many reasons account for these changes and losses, including: greater access by southerners to northern wilderness; population increase in northern communities; increased sport hunting and sport fishing; accelerated industrial development; and environmental contamination as a result of Long-Range Transport of Atmospheric Pollutants (LRTAP). Indeed, LRTAP is a principal source of organic contaminants to the bay, due mainly to atmospheric transport, but also through rivers flowing from northern Russia into the Arctic Ocean. LRTAP also distributes ozone-depleting gases. High altitude ozone depletion, which is greatest in high latitudes, may affect the health of terrestrial and aquatic species, and reduce primary production. LRTAP also redistributes greenhouse gases: the greatest effect of climate change is also expected at high altitudes. Increased levels of persistent organic contaminants pose a potential threat to the health of top predators in the region, including humans. This is particularly worrying to the Inuit and Cree, who eat substantial amounts of country foods.

3 THE HUDSON BAY REGION: STATE OF SCIENTIFIC KNOWLEDGE

Availability of Information

It is impossible to estimate the number of published articles and data records that contain useful material relevant to the understanding of effects of development on the Hudson Bay and James Bay bioregion. However, in the preparation of documents which now comprise the science-based publications of the Hudson Bay Programme, it is likely that about 2000 citations have been checked, used, or otherwise considered by the programme's authors. The programme reports referred to include (Cohen et al. 1993, Fast & Berkes 1994, Harder & Rousseaux 1993, Prinsenbergh 1993, RAAS 1993, Schneider-Vieira et al. 1993, Sly 1993, and Steib & Davies 1993). Using the science overview report (Sly 1993) which covers topics in both the natural and social sciences as an example, the frequency of citations by decade is as follows (zero omitted):

1911 - 20	< 1.0 (percent frequency)
1931 - 40	< 0.5
1951 - 60	1.5
1961 - 70	1.5
1971 - 80	3.5
1981 - 90	39
1991 - 2,000	53 (assuming the 1991-93 rate of publication is typical of the decade).

While the intent of the science overview has been to focus on the most recently available information and understandings, and this naturally places a bias on the use of recent references, there appears to be virtually no historical data base for most forms of information before the 1950s. This coincides with the period immediately prior to the impact of large scale changes in settlement and development, and reflects the depth in our lack of knowledge about the "near pristine" state of the region.

Most scientific data have been associated with project-driven research and the net result is that even where it might seem possible to tie different sets of information together, differences in space, time, period, and observational techniques usually preclude close correlation. Synoptic, regional observations (except for some climatic data) are virtually non-existent, even to-day. Seasonal observations of oceanographic conditions have been limited to a few nearshore sites and year-round observations are rare. The lack of synoptic and year-round observations, in particular, reflect both the difficulty of working in this harsh environment and the high cost of supporting such research. Probably, it will never be possible to develop densities of information such as are now available in southern Canada (especially those available for Great Lakes research), but it is clear that closer ties between TEK and the more usual means of research can be used to better understand this vast northern environment, and the probable effects of development on it and the people who live there.

Understandings

Many of the early publications and reports reflect government interest in the potential for commercial fishing in Hudson and James bays, particularly in the more accessible nearshore areas. Military flights during the 1940s confirmed that Hudson Bay became completely ice-covered during the winter, but it was not until the landmark publications of Dunbar (1958) and Grainger (1963) that understandings of the composition and structure of water masses within the Hudson Bay region became clear. Mineral exploration was accelerated by the development of aero-magnetic survey techniques (1950s and 1960s) and although the presence of many deposits has been established, most are likely to remain economically unattractive. Offshore oil and gas exploration was briefly important during the 1970s but ceased when the low probability of finding economically viable resources was established. However, the possibility of pipeline transportation across the bioregion (from the Arctic islands into central Canada) remains, and permafrost and soil stability have been key factors in many engineering studies since the 1950s.

Some hydroelectric power dams were built in the Moose River basin, northern Ontario, prior to 1940 and a large diversion was opened in the 1960s. Major impoundments and diversions in the Churchill and Nelson River basins of northern Manitoba were begun during the 1970s, but the need to prepare a solid pre-development environmental data base was not then recognised. It was not until the problems of societal disruption and mercury contamination in the Nelson-Churchill River system were brought to public attention that potential impacts of northern reservoir development became widely apparent. Early hydroelectric development in the James Bay region of Québec which also began in the 1970s advanced with a broader base of pre-impact environmental research; however, most was site-specific and did not address the effects of hydroelectric development throughout the bioregion.

On the other hand and despite some failings, the James Bay and Northern Québec Agreement (1975) marked the first time that Cree and Inuit had a major role in the decision making which resulted in large scale changes in their society, economy, and cultural activities. The effects of this agreement and other forms of devolution (transfer of federal, provincial, and territorial government authorities) to native people in the bioregion have also provided a catalyst for an increase in socio-economic research.

Both as a result of Antarctic and Great Lakes research, the effects of long range transport of atmospheric pollutants (LRTAP) became evident in the late 1960s and, recognising the potential for Arctic and sub-Arctic wildlife exposure to persistent organic contaminants, the Department of Fisheries and Oceans and the Canadian Wildlife Service began selected sampling during the mid 1970s. Previously stored tissue samples also made it possible to analyze contaminant concentrations in some biota from the 1960s. The potential for organochlorines to affect human health in Arctic and sub-Arctic communities was reported in the late 1980s. Most recently, the potential for climate change and possible effects of increased UV radiation have also drawn attention. Overview reports by Beals & Schenstone (1968), Martini (1986), and by Stewart et al. (1991) have each provided a milestone in our understanding of the Hudson Bay bioregion,

its environment and people.

The Hudson Bay bioregion is well described in terms of general landform, geological evolution, climate, and vegetation. Although the exact conditions which allowed an initial influx of relatively warm ("Atlantic") water and which later caused cold ("Arctic") water to dominate the bay, remain unclear (presumably, opening of the Fury and Hecla Strait was an important and controlling factor). The composition, structure, and circulation of ocean waters has been defined, and ice cover and the locations of polynya are generally known. The general characteristics of major land, marine, and avian faunas are established, as are their migrations which occur in response to seasonal climatic change. With improved research techniques population estimates of larger terrestrial and marine mammals and major species of ducks and geese have become more reliable. General climatic conditions are known and the potential for long-term change is recognized; and trends in the contaminant levels of many top predator species are also known. The distribution of settlements, much of the history of societal change, cultural and economic activities and many of the effects of development on native societies, especially those associated with hydroelectric power, have been studied and reported.

Undoubtedly there are large gaps among and between most data sets (across both the natural and social sciences) and the quantity of published literature may suggest much greater substance than is actually present. This is because many different articles essentially repeat the same information or attempt to reinterpret the limited amount of original data. But there is enough information to demonstrate and describe major changes in the state of the environment, and to explain or at least strongly suggest a number of cause and effect relationships. The focus on description and explanation which has been followed by each of the reports authored for the HBP closely reflects the availability of information. The quality of primary data is limited, but it is generally of high quality and has been widely used in the research community.

Partial sets of data for application at different scales in time and space are available from widely scattered locations throughout the bioregion and, probably, the most comprehensive data sets are those collected for the studies on James Bay hydroelectric development. At the other extreme, very little information is available about the mid-basin conditions of Hudson Bay needed to define its productivity and energy flows through the biota. To quote "Buster" Welch "as scientists we don't know what we don't know."

Marine and Terrestrial Ecosystems

The primary productions of Arctic and sub-Arctic ecosystems are much lower than those at lower latitudes and, in particular, they are light limited. Despite moderate nutrient concentrations, primary production in marine waters of the bioregion are typically only one-quarter or less of those in the shelf-waters of Atlantic and Pacific Canada (Welch, 1994). Light penetration is reduced by ice and snow cover, and light intensity is affected by its incidence and the length of the atmospheric pathway. The biological structure of the food-web is characterised by generally low diversity in both the terrestrial and marine ecosystems. The length of the marine food-chain is, however, much longer than that of the terrestrial food-chain.

In both fresh and salt water, phytoplankton forms the base of the food-chain, and because of ice and temperature effects, annual production is strongly pulsed and usually peaks towards mid-late summer. Small quantities of freshwater phytoplankton are present in shallow surface pools which form on melting sea-ice during spring and early summer, and ice-algae thrive at low light levels and make use of nutrient enriched and low salinity surface waters immediately beneath melting sea-ice. Ice-algae represent, perhaps, only 5% of the annual primary production but provide a critical early source of food to trigger zooplankton growth and reproduction. This, in turn, affects the survival of larval fish and predators higher in the food-chain. Nutrient concentrations in rivers flowing into Hudson Bay and James Bay are often very low, and nearshore and estuarine productivities are therefore much influenced by the coastal upwelling of marine waters. The discharge of freshwater into the coastal zone is often more important as a physical force contributing to the process of marine upwelling than as direct source of nutrients. The most important exception to this may be the contribution of detrital carbon which brought into nearshore flats and estuaries as partially decayed vegetation from the surrounding watershed. Most detrital materials enter the food-web through the benthic food-chain and may sustain large populations of wading birds and shallow diving ducks.

Complexity appears to be greatest at the base of the food-web but little is known about many of the mechanisms and efficiencies of energy transfer within it. Generally, energy is transferred up a food-chain as one trophic level of animal feeds on another and, in the bioregion, there are at least five trophic levels within the marine food-web. Because phytoplankton densities are generally low so, too, are the densities of zooplankton and the larval stages of other invertebrates which feed on them. These low densities greatly influence the food-web structure. The energy requirements of fish, for example, are such that minimum densities of biomass must be available for sufficient time and within a limited range to support their growth and reproduction. Primary production in some of the coastal regions of the bioregion and over large areas of the offshore is too small to support populations of fish. Consumption of primary production within the water column is also much more limited than at lower latitudes. About half of the primary production enters the marine food-web through pelagic species, and about half through benthic species. Filter feeders are efficient food collectors and clams are a particularly important component of the benthic community (especially Mya truncata and Serripes groenlandicus).

Throughout the bioregion, phytoplankton is grazed by copepods and the larval forms of other species. At the next trophic level, amphipods and Arctic cod are the dominant species throughout most of the northern part of the bioregion, and capelin and sand lance are of major importance in southern Hudson Bay and James Bay. Seals and whales dominate higher levels in the food-chain and at the top there are polar bears and man. Birds (especially thick-billed murre) are a key predator in northern Hudson Bay where they are heavily dependent on Arctic cod. Bottom feeding ducks (eg. eider ducks) are an important part of the benthic food-chain but, probably, the most important and largest member is the walrus which moves in groups from site to site as each bed of clam becomes temporarily exhausted.

Because primary production is strongly pulsed, energy storage is also extremely important to many species that exist through "feast and famine". Fat provides a means of energy storage for many species and, as insulation, it also conserves the body heat; this is particularly important for mammals. Some Arctic and sub-Arctic species have developed other strategies for dealing with pulsed food supplies and seasonal migration is a common characteristic of both aquatic and terrestrial animals. Likewise, several species have physiological adaptations which enable them to survive below 0°C water temperatures and substantially lower air temperatures. Slow growth and longevity are related characteristics of many species, and the large size of many land and marine mammals is related to greater efficiency in heat retention and the greater swimming efficiency.

The length of food-chains and the efficiency by which energy is transferred from one trophic level to the next is of major significance to humans as a top predator, and in particular to the Inuit who are most dependent on marine food supplies. Long food-chains mean that many other predators are dependent on the same food-base and that the human share is commensurately less; also, longevity and low rates of reproduction mean that stock recovery following over-harvesting may be very slow. Many stocks of Arctic char are harvested at or above sustainable levels. Although bowhead whales have not been commercially harvested in the eastern Arctic for more than 75 years the remaining stock is still only a few hundred animals and, similarly, the beluga population of eastern Hudson Bay is thought not to have recovered to its pre-whaling size.

Feeding strategies tend to apply the most efficient means that are possible. Arctic char move inland through shallow channels to over-winter in freshwater lakes where temperatures do not drop below 0°C, and return to the marine environment to feed particularly on amphipods and larval forms; bowhead whales follow the ice-edge as mobile filter-feeders that directly harvest the highest concentrations of small zooplankton; and many other species feed along current-induced shear zones within the water column or at polynyas where their food supplies are most available. These and related strategies leave many species particularly vulnerable to human predation which is targeted for commercial return rather than subsistence needs.

Most terrestrial food-chains in the bioregion are short, often with no more than three trophic levels. Primary production is provided mostly by low lying plants and shrubs. The plants are grazed by a wide variety of animals including geese, lemmings, ptarmigan, caribou and muskox. Top predators include a few species of birds, foxes, humans and wolves. Apart from the potentially greater share of production available to humans in the shorter terrestrial food-chains, there are important differences in the extent to which biomagnification renders top predators unavailable for human consumption because of high contaminant contents. Because the excretion of persistent contaminants is not complete, their concentrations increase up the food-chain. The effect of this biomagnification is to increase some contaminant concentrations in top marine predators by up to a million times or more, relative to ambient concentrations in the water. Since biomagnification increases by about 10-fold at each step in the food-chain, contaminant concentrations in terrestrial food-chains tend to be significantly less than in marine food supplies.

Some contaminants such as mercury (and other metals) are naturally present in the environment and, at very low concentrations, they do not present a hazard to health at any level in the food-chain. At artificially increased levels, however, health problems are likely to occur first at the top of the food-chain where the effects of biomagnification are greatest. Comparisons of present and historical concentrations of mercury in animal tissue and lake sediments, away from specific sources of contamination, indicate that present levels are three or more times greater than natural background levels. For most organic contaminants, of course, there are no natural background levels. Their presence is both an indicator of globally dispersed contamination and an indicator of the potential threat to human health at a higher level in the food-chain. Mercury contamination in the bioregion is derived from both site-specific and globally dispersed sources; almost all organic contaminants in the bioregion are derived from globally dispersed sources.

In addition, low diversity, the small size of some populations in the upper levels of the marine and terrestrial food-chains, and often a dependence on special habitat conditions or seasonal connectivity between different types of habitat, makes many species of birds, fish, and mammals particularly vulnerable to the effects of human development in the bioregion.

Changes, Trends, and Consequences

Contaminants (loadings and effects), resource availability (yield, habitat, and harvest), and climate change (emissions, atmospheric effects, weather) are considered in terms of available scientific information from the Hudson Bay bioregion. These topics highlight some of the critical gaps in knowledge.

Contaminants

At the bioregional level, there are two major contaminant concerns, 1) do existing concentrations of contaminants significantly affect the health and reproduction of fish and wildlife, and 2), as a result of the heavy dependence of native diets on country foods, is human health and reproduction at risk? The principal contaminants include mercury which is particularly associated with reservoirs and diversions, and a wide range of persistent organic contaminants introduced into the Arctic and sub-Arctic food-web by long range atmospheric transport (many of which are organochlorines).

At present, mercury is not thought to be a threat to the health and reproduction of fish and wildlife but, because global emissions are likely to increase, the possible beneficial effects of aging reservoirs and diversions may not result in significant future declines in mercury concentration. The use of mercury contaminated food is avoided, as far as possible, to prevent occurrence of human health problems, but this results in socio-economic hardship for many communities. Two follow-up questions can be posed, 1) what remedial actions might substantially decrease the concentrations of mercury in country foods, and 2) are there physiological mechanisms which would allow country foods with elevated levels of mercury to be safely consumed as part of the native diet? Information is not yet sufficient to answer either question.

At present concentrations, persistent organic contaminants are not thought to impair the health of fish and wildlife but, although there appear to be no obvious carcinogenic effects or reproductive failures, a lack of impact in the form of more subtle effects of contaminant stress is less certain. Consumption advisories have been used to limit human exposure to persistent organic chemicals but these have not been sufficient to protect all community groups from contaminant uptake. Not only are most health guidelines based on apparent cause and effect relations in southern white populations (as opposed to native groups) but, also, they have been based largely on the probability of inducing a carcinogenic response (other health effects may be induced at lower contaminant levels). Information is not sufficient to be sure that fish and wildlife are generally free from negative impacts on health and reproduction, and the potential for subtle human health effects (including those which might impose greater stress on native populations) is unclear. The relative contributions of contaminants from different sources remains unknown and it is difficult to target sources and to optimise the effect of available control strategies.

Because of global air mass circulation (including LRTAP), climate effects, and drainage into the region from large southern land areas, polar regions tend to act as a contaminant trap and, although the use and release of organic contaminants has greatly declined in North America over the past two decades, their use and emission globally continues to increase. At least for the immediate future it is unlikely that concentrations of persistent organic contaminants will decline much below present levels in the bioregion. It is possible that TEK may contribute to knowledge about contaminant effects, particularly the more subtle effects on humans and biota; cooperative studies with selected native groups offer potential to obtain considerably more information.

Resource Availability

It is possible to encompass perhaps the most complex of all issues to be faced in the bioregion, in terms of sustainable development and cumulative impact, with one seemingly simple question "What is the long term sustainable yield (harvest)?" In reality, the question should be addressed with a separate focus in each of the terrestrial, marine, and freshwater ecosystems. Further, within an area as large as the Hudson Bay bioregion, there are many different food web structures, and the spatial extent and structure and stability of each needs to be defined, and their energy flows quantified. It is known, for example (TEK 1994), that the diet of beluga whales varies within the bay: whitefish in James Bay, capelin at Churchill, Arctic cod and char in Chesterfield Inlet and Repulse Bay, and sculpins and other benthic species in north east Hudson Bay and Hudson Strait. Population dynamics are complex reactions to reproductive success and food availability, and the pressures of both natural and human predation. The availability and connectedness of habitat suitable for various life stages is an additional factor that is of particular importance to migratory species which typify many high latitude ecosystems.

Needless to say, most of the data required to quantify rates and processes do not now exist, nor may they ever. Even fundamental data such as the rates of primary production are available from only a few sites where they may indicate little more than "type conditions". While

site-specific studies such as those undertaken for the James Bay hydroelectric developments should provide detailed insights into a small number of food web structures, beyond these, empirical relations may be the only means by which it is possible to characterise larger ecosystem units.

Under natural conditions nutrient concentrations in the waters of Hudson and James bays remain relatively constant from year to year, and overall primary production is, likely, equally constant. At higher levels within the food web, variations in productivity tend to increase and these are often related to climatic variation. Postglacial isostatic rebound continues to slowly raise the coastal landmass (mostly at about 20-30cm/century) first creating marshlands and then dry land. Vegetation changes reflect the normal process of colonization and some animal populations may change more dramatically in response to the natural evolution of shoreline habitat.

Man-made changes which reduce the loading of detrital carbon (an effect of impoundment) are likely to influence shore and estuarine productivity, particularly that of shallow bottom feeders such as dabbling ducks, and shore birds. Variations in stocks of natural predators caused by intensive harvesting will also influence the structure and stability of local and regional food webs.

The rise and fall of owl and fox populations in response to cyclical changes in the lemming population are well known, but predator-prey relations and the importance of feedback mechanisms are poorly defined in many species; for example, the role of the wolf is substantially unquantified. Variations in polar bear populations may reflect changing sea ice conditions and their ability to catch ring-necked seals, in particular. Changes in caribou populations may reflect not only climatic variability but also predator control and the availability of grazing areas, particularly along migration routes. Populations may rise and fall over of several decades. Populations of walrus, on the other hand, may remain more constant while groups move between different feeding areas.

Without the use of TEK or cooperative studies with native communities, it may not be possible to differentiate between the effects of natural periodic population change, and changes occurring in response to excessive harvest or habitat loss and degradation.

Examples of TEK (HBP 1994, MKO 1994) that may be applied to enhance existing data include:

- Low flow conditions in northern Québec rivers (Kugak, Tankin, Saniku, and Niaquung) preclude fish migration and affect stock recruitment.
- Large-headed and small-bodied sturgeon have been observed in rivers where flow manipulation and impoundment have reduced their food supply. This body form is typical of the effects of starvation and has been observed in other species of fish, as well.
- Low rainfall has reduced summer/fall berry crops at Salliut and Ivujivik (south shore of Hudson Strait).
- Reduced ptarmigan and beaver populations occur where flow manipulation has

lowered the moisture content of river banks during the summer, and caused vegetation die-off.

- Moose populations have declined in areas of timber cutting.
- The quality of caribou meat is poor where herds are over-grazing. Hunters report evidence that these herbivores may become scavengers under conditions of extreme food shortage.
- Polar bears may be ranging farther afield for food, including the movement of bears into the Labrador coastal area where they prey on the rising population of seals.
- Changes in the timing and location of migration by some species of birds (particularly geese) have been noted by both Inuit and Cree but the significance of such changes has yet to be clearly related to environmental effects within the region or outside it.

Climate Change

Based on analysis of global network data, there has been a general rise in the average annual surface temperature over Canada by about 0.5°C, over the past century. The rise has not been evenly distributed, and cooling trends have occurred over the north Pacific and northwest Atlantic Ocean during the same period. Temperatures increased between about 1900 and the mid 1940s, declined into the 1970s, and increased further during the 1980s. Similar conditions occurred in the Hudson Bay bioregion where overall precipitation also increased. The bioregion lies in a transitional zone between the warmer western Arctic - Mackenzie region and the colder eastern Arctic Baffin - Greenland region. The transition zone reflects large scale pressure distributions in the upper atmosphere. In winters when the pressure wave lies west of its normal position (east shore of Hudson Bay), southerly flows increase and warmer temperatures occur. With the wave east of its normal position, northerly flows dominate and cool the region. The pressure wave is influenced by large scale ocean-atmosphere heat fluctuations elsewhere on the globe, such as the El Nino Southern Oscillation of the Pacific Ocean. As a temperature transition zone, it is difficult to discern either a warming or cooling trend in the region.

Nevertheless, models of global atmospheric change based on a doubling of CO₂ emissions, suggest major and continued warming over the next 50 to 100 years, with the effect being generally most pronounced over high latitude regions. More realistic models of atmospheric circulation are being developed to include the effects of ocean-atmosphere heat transfer, cloud formation, and the influence of other "greenhouse gases" (including SO₂, a major emission from the combustion of fossil fuels). All models assume increasing rates of greenhouse gas emission and varying degrees of feedback. There is considerable seasonal and year-to-year variability in the climate of the bioregion, and since long term variations still lie within this short term variability uncertainty persists about the validity of predictions. Periods of temporary cooling which may last as much as four to five years after an event can be associated with massive volcanic eruptions which inject fine dust and gas high into the atmosphere. Fine dust and water droplet/ice particle formation around SO₂ nuclei tend to reduce near ground air temperatures. Eruptions such as Mount St. Helens (1980) and Mount Pinatubo (1991) were large enough to cause short term cooling throughout the region and their signatures add to the natural variability of climate.

At a smaller scale, it is probable that large impoundments and the manipulation of seasonal freshwater discharge will influence local climatic conditions. The La Grande River, for example, does not freeze as early as it used to. Also, spring break-up may be delayed inland and there may be changes in sea ice formation.

Global releases of ozone-depleting gases are likely to continue for many years and even with significant reductions, due to international control, the natural but slow replacement of high level ozone by atmospheric processes will lag by several decades. As a result, increased or high levels of UV radiation are likely to be experienced throughout much of the bioregion for several decades to come. This could affect human health directly. As a result of reduced primary and secondary production, marine food supplies could also be affected (though this is not expected to be a large effect, Welch 1994).

In addition to the major indicators of climate (temperature and precipitation), freshwater ice, sea ice, permafrost, stream flow, and vegetation and faunal distributions provide key information about the effects of climate change. The monitoring network for climatological studies could be substantially improved with more local participation and TEK could be used to provide improved understanding, particularly of the effects of impoundments and flow manipulation (for example, relations between temperature, salinity, and current flow).

4 HUDSON BAY REGION: A TRADITIONAL ECOLOGICAL KNOWLEDGE PERSPECTIVE ON ENVIRONMENTAL CHANGE

Introduction

Indigenous knowledge, from the TEK perspective, is based on long-term experience and observation of processes and cycles occurring in natural systems over time. In the Hudson Bay region, many Inuit and Cree know how various parts of the ecosystem function and of changes that occur in the system over time. They have acquired this knowledge from collectively learning and following the advice of elders, and interacting in natural surroundings according to traditional beliefs and practices which recognize:

- 1 Cree and Inuit are part of the Hudson Bay bioregion which is part of a larger whole—our planet;
- 2 Everything, from the smallest insect to the stars has a purpose and must be respected for its part in the whole;
- 3 Natural and man-made systems function differently. Any part of a natural system altered by man does not function as it once did, and everything connected to the natural system changes as a result;
- 4 Inuit and Cree will survive for many generations to come if the natural system is followed and respected.

Cree and Inuit living in the Hudson Bay region regard change as natural. The correct interpretation of change has often meant the difference between life and death. Traditional Inuit and Cree are skilled in recognizing natural indicators of environmental change, and interpreting the consequences of those changes within or between naturally-occurring cycles. They know, for instance, that the way lakes, rivers and sea water freeze determines where fish, birds and sea mammals can be found during winter months and how the ice will break up in spring. They also know that animal fat content varies naturally on a seasonal basis. They are concerned, for example, when animals are thin when they are supposed to be fat.

Inuit and Cree in the Hudson Bay region have a long history of adapting to change. This enables them to discriminate between changes which are: (i) natural to time, (ii) sudden or unexpected and (iii) unnatural. If a change is natural to time, people see it coming and try to adapt by watching the animals, remembering, or listening to Elders explain how it happened before. If a change is sudden or unexpected, people and animals have a more difficult time adjusting to problems created. They also have difficulty adjusting to unnatural changes that introduce something new to the system. Through the TEKMS component of the HBP, we have documented changes in the environment observed by Inuit and Cree. A full description of these changes is included in the TEKMS reports of the HBP listed in Appendix One. Table One summarizes environmental changes observed by Inuit and Cree in the six regions that make-up the Hudson Bay bioregion.

Figure 4

Summary of Environmental Changes in the Hudson Bay Bioregion Observed by Cree and Inuit

	Eastern James Bay	Eastern Hudson Bay	Hudson Strait	Northwestern Hudson Bay	Western Hudson Bay	Western James Bay
weather	● colder winters in reservoir areas ● shorter fall & spring seasons ● greater variability in fall ● increased snowfall	● persistence of cold weather into spring ● snow melts later ● spring and summer cooling trend ● less rain; fewer thunderstorms	● greater variability; less predictable ● cooling trend ● new snowfall cycle ● longer winters; snow melts later ● less rainfall	● greater variability ● warmer and shorter winters ● snow fall and melts earlier ● cool summers in early 1990s	● longer winters ● colder springs ● snow melts faster	● shorter and warmer winters ● spring wind shifts several times a day
sea ice	● salinity changing along NE coast ● more freshwater forming in the Bay ● less solid in LG River area; freezes later, breaks earlier	● freezes faster ● solid ice cover is larger and thicker ● fewer polynyas ● floe edge melts before breaking up	● freezes faster ● poorer quality ● landfast ice extends further off-shore ● polynyas freeze ● floe edge melts before breaking up			
currents	● weaker in Eastmain area ● swifter and less predictable north of LG River	● weakening currents	● weakening currents	● weaker currents in Roes Welcome Sound		
rivers	● seasonal reversal in levels and flow ● decline in water quality ● unstable ice conditions on LG River: freezes later, breaks earlier ● vegetation dying along diverted rivers	● decreased water levels and river flow	● decreased water levels & river flow	● decreased water levels & river flow	● seasonal reversal in water levels and flow ● increased salinity, erosion and sediment in Nelson River ● decline in water quality	● decreased water levels and river flow in southern James Bay rivers ● increased erosion and mud slides
atmosphere	● change in sky colour	● change in sky colour ● sun's heat blocked by haze	● change in sky colour ● sun's heat blocked by haze	● change in sky colour	● change in sky colour	● change in sky colour

Figure 4

Summary of Environmental Changes in the Hudson Bay Bioregion Observed by Cree and Inuit

Canada and Snow geese	• coastal and inland habitat changes • coastal flyways have shifted east • fewer being harvested in spring and fall • large flocks of non-nesting/molting geese along coastal flyway	• Smaller flocks of Canada geese arrive in Belcher Islands since 1984 • increase in non-nesting/molting geese in Belcher and Long Islands	• new snow goose migration routes • increase in number of molting snow geese • Canada geese no longer nest in Soper River area	• more Canada geese in Repulse Bay area during summers of 1992 and 1993	• more snow geese migrating to and from the West • habitat changes at Marsh Point staging area • earlier and shorter fall migration	• habitat changes in Moose Factory area • more SG flying in from West • CG arrive from the North first part of June • change in fall migration patterns
beluga	• decrease in numbers	• decrease in numbers				
polar bears		• increase in numbers		• increase in numbers • appear leaner and more aggressive		
walrus		• shift away from Sleeper Islands & Belcher Islands	• increase in numbers around Nottingham Island	• decrease in numbers near Arviat and Whale Cove • increase in numbers near Coral harbour and Chesterfield Inlet	• decrease in numbers around Attawapiskat	
fish	• mercury contamination • loss of adequate habitat for several species, e.g. whitefish, sturgeon, pike, etc.	• decrease in Arctic char and Arctic cod in Inukjuak area		• Cod are no longer found near shores off of Cape Smith and Repulse Bay		
moose	• sharp decrease in numbers				• change in the taste of the meat	
caribou		• change in diet • very large herds • travelling closer to coast	• increase in abnormal livers, i.e. spots and lumps	• sharp increase in numbers • crossing to islands • change in diet	• migration route has shifted inland	

Implications for the Bioregion

Rising Land Mass

Rivers and in-shore coastal areas have been affected by the land rising throughout the Hudson Bay system. Rocks are exposed on sandy beaches, shallow areas have become shoals and shoals are now islands. New islands are forming in Arviat, York Factory and Belcher Island areas. Manitunik Sound is now shallow in places where it used to have deep water between the eastern Hudson Bay mainland and Nastapoka Islands; a change that has been particularly noticeable since the 1960s.

Receding shorelines in James Bay, and southwestern Hudson Bay have modified waterfowl habitat significantly over the past 50 years, and contributed to a major shift in migration routes in the past 20 years. An island which used to have a lot of walrus in southwestern Hudson Bay is disappearing as the shoreline recedes.

Water levels and rate of flow in rivers are decreasing in response to the land rising. Creeks and channels are drying up throughout the system. Grass and trees are growing in channels feeding into southern James Bay rivers, and rivers that have been altered for hydroelectric power generation. Whales can no longer use some of the estuaries in northeastern Hudson Bay for molting because they are too shallow. Other rivers in Hudson Strait, and eastern and northwestern Hudson Bay contain sufficient water for fish to migrate only in years when there is adequate rainfall.

Atmosphere

Changes in atmospheric conditions have been observed in all coastal areas of the Hudson Bay system. This includes a change in sky colour and the emergence of a high altitude haze.¹ Eastern Hudson Bay and Hudson Strait Inuit have found it has affected seasonal processes in winter and spring which have, in turn, affected summer weather. Elders in western James Bay and Hudson Strait have attributed this to the growing amount of pollution in the air:

"You can see very well that those haze-like things in the sky are the work of man-made problems. It's coming from air pollution like cars and airplanes. They are polluting our air like there was no tomorrow. Even those big planes are one of the polluters. In the old days, it was nice, warm and rained when it had to but, these days, you get falling snow instead of rain in the spring. The dirty smoke or smog affects the weather very much."²

¹ This observation was reported by community representatives in eastern Hudson Bay, Hudson Strait and northwestern Hudson Bay; also in western Hudson Bay, southwestern Hudson Bay and western James Bay. As previously noted, recent haze effects may have been related to the global spread of gas and particulates from the 1991 eruption of Mount Pinatubo.

² Hudson Strait Working Group Meeting 1. Lake Harbour: November, 1992

Eastern James Bay elders have also experienced the development of air pollution within their lifetime, and find the natural taste of land animals and plants changing in partial result of "strange smells in the air like gasoline".

Evidence of changing atmospheric conditions is also found in the snow which, as the people of western James Bay reported, has changed in colour, composition and taste. Community representatives in eastern Hudson Bay, Hudson Strait and northwestern Hudson Bay identified changes in snow composition as a result of changing weather systems. Both eastern James Bay Cree and Hudson Strait Inuit reported on the long-range transport of pollutants:

Two springs ago, we noticed the snow was covered with particles from a black substance that was visible to the eye. It was like a black powder. It started in early spring when there was a south wind, and it was snowing at the time. It was really noticeable out on the ice, where the snow was black after the snowfall. You could also see something black floating when the snow melted on top of the ice. I think it was like that all along the James Bay coast from Waskaganish up to Chisasibi, and it was probably like that in the wooded areas too. This stuff came from the air. They thought it came from the tire fire down in Montreal. It must have been in the atmosphere for a while before it came down with the snow.³

There was a dark smog that was not natural once. It was man-made smog that turned the sky dark in broad daylight. The sunlight was a reddish colour, and you could look directly at the sun because it was not bright anymore. That dark black smog affected our drinking water and the food animals eat. It also completely ruined our hunting tents because everything turned black with soot falling from the sky ... people in our community tried to find out what it was. At that time, they were told tires burning. It was an accident that happened down in Ontario. I think everyone knows there was a big tire fire, and those tires were burning for too long ... I have seen smaller ones falling with snow in winter, but it is usually not black soot.⁴

Weather

Traditional Inuit and Cree rely on their understanding of various seasonal and weather conditions to obtain food. They appreciate the complexity of weather and understand systematic changes in weather patterns. Elders in southern Hudson Strait say it takes about ten years for a systematic change to occur. They also say that clear, calm weather needs to be balanced with stormy weather in order for the sub-systems to function properly. Elders in northwestern Hudson Bay and eastern James Bay, find the weather has been changing so rapidly and erratically that they can no longer rely on their knowledge for weather predictions.

³ Eastern James Bay Working Group Meeting 1. Chisasibi: December, 1992

⁴ Hudson Strait Working Group Meeting 1. Lake Harbour: November, 1992

Cree and Inuit use environmental indicators to interpret weather patterns, forecast conditions and predict seasonal events. While individual indicators differ with respect to geographical locality and environmental orientations, people are discovering throughout the system that some of the indicators used for generations are not coinciding with weather of the early 1990s. In the past, for example, the spring arrival of migrating birds and animals was used to determine the time of warmer weather. In recent years the spring thaw is either too early or late and does not necessarily coincide with the arrival of some of these birds and animals.

Based on observations from southeast of Moose Factory on the Harrikanaw River to Hecla Strait at the tip of northwestern Hudson Bay in the early 1990s, we believe that ice and permafrost conditions may be key indicators for monitoring climatic change in the Hudson Bay system.

Altered Rivers

The combined effects of reversed water flow and fluctuating water levels is drastically affecting traditional Cree livelihood and negatively impacting the fish, birds, waterfowl and animals dependent on the Nelson, La Grande and Moose River systems. It has a particularly negative effect on trapping and hunting wildlife in flooded and downstream areas. Water levels fluctuate during the freezing seasons and the ice is continuously breaking up or shifting. This creates unpredictable conditions that have caused death, injury and suffering to fish, ptarmigan, muskrat, beaver, moose and Cree when they are "in the wrong place at the wrong time".

In summer, sturgeon get caught below the dam gates on the Moose and Nelson River systems, and cannot get back upriver unless assisted. Construction of the proposed Conawapa dam would push sturgeon into the saltwater zone where Cree question if they can survive. Sturgeon on the Abitibi River get caught below the gates and, when the water levels go down, die in small ponds from lack of oxygen.

The volume of sediment and debris entering Hudson and James bays has increased significantly since rivers in western Hudson Bay, southern James Bay and eastern James Bay have been dammed for hydroelectric generation. It has directly impacted domestic fisheries by interfering with net fishing at the river mouths.⁵ Inuit in eastern Hudson Bay, and Ivujivik are also seeing more anakluk; dirty, brownish pack ice coming from southern Hudson Bay and James Bay after break up in spring. This is undesirable, as seals tend to leave an area when there is a lot of anakluk around.

Weakening Currents

Currents give life to everything that lives in oceans. All the marine animals depend on the currents for travel and access to their food sources. Birds also depend on the currents for feeding, and Inuit rely on the currents for hunting. The observed weakening of currents is,

⁵ The nets become very heavy with mud, debris and slime and yield few fish.

therefore, of grave concern to all Inuit; particularly in eastern Hudson Bay, where the process has been occurring over a twenty year period and the effect is great in terms of extending sea ice cover and reducing habitat for ringed seal, bearded seal and common eider.

Although the weakening currents have been observed for a shorter period of time in Hudson Strait and northwestern Hudson Bay, they also are of concern due to the impacts on Inuit traditional foods such as ringed seal, walrus, belugas and polar bear. Walrus, for example used to feed in Roes Welcome Sound during fall but since currents have weakened they only come in September or October and stay for a shorter time. Similarly, more polar bears came to the Ivujivik area when stronger currents brought more ice packs into the area.

The exact cause for currents weakening is not known. Inuit who have been observing how the system functions know rivers are an important part of the Hudson Bay current system, and see the effects reduced river flow is having on currents in localized areas. They believe that significant alteration of water flowing to the bay as a result of hydro development on three of the system's largest rivers, may be contributing, over a 30 year time span, to currents weakening.

Lost Habitat

Animals, including birds and fish, are losing considerable habitat in the Hudson Bay region as a result of changes that are both naturally-occurring and human-induced. Receding shorelines around the coast from Wemindji to York Factory are resulting in structural changes in waterfowl coastal and riverine habitat; a natural process that is compounded by increased erosion and build-up of sediment from dammed rivers and the drying up of shoreline habitat in diverted rivers. The rising landmass is similarly reducing the number of rivers available for anadromous fish and seal populations in all the coastal areas of the arctic sub-system. Land-locked char and freshwater seals have adapted to reduced access to the marine environment.

Both the flooding and drying up of countless creeks and small rivers in the Nelson, Moose and La Grande River systems has reduced the habitat for over 15 species of animals, birds and fish. All the creeks and small rivers that used to grow wild rice in the Nelson River system have been flooded and, consequently, the duck population has declined. Beaver, muskrat, ptarmigan, grouse, rabbit and moose populations have also had to adjust to irrecoverable loss of food resources from river diversions and damming, logging and mining. The establishment of DewLine sites is now known as the "beginning to the end of lynx" in western Hudson Bay.

Sturgeon, whitefish, lake trout and dore are some of the fish species losing critical spawning sites in eastern James Bay, western Hudson Bay and southern James Bay rivers. Sturgeon may be considered a key indicator species for water quality based on Cree traditional knowledge of their sensitivity to water change and disturbance in pre-industrial times.

Loss of habitat has also contributed to the decrease in walrus that James Bay and southwestern Hudson Bay Cree have been observing during the past few decades. Receding shorelines and

changing habitat are the main factors. Willows, for example, now grow in the depressions walrus made on Cape Hope Island. Near Winisk, an island many walrus used to inhabit now has very few walrus as it became part of the receding shoreline ten years ago.

Animal Population Changes

When animal, bird and fish populations change in the Hudson Bay region, Inuit and Cree experience direct impact. In light of the many ways these populations change in response to environmental, atmospheric and intra-specific interactions through space and time, the question of whether specific populations are increasing or decreasing in number is complex. Moreover, whereas population numbers may decrease in a particular locality, the actual population number may be unaffected if the change involves an adaptive shift in migration routes and seasonal localities. The different ways populations in any given locality of the Hudson Bay system may change include (i) natural fluctuations within population cycles (ii) shifts to different locations in response to habitat loss, food availability and disturbance (iii) reproductive response to food availability, or unseasonable weather (iv) deteriorating health and body condition in response to disturbed habitat and (v) human interference in natural processes.

Natural Fluctuations

Rabbits, caribou, lemming and fox are some of the animals that naturally experience large population fluctuations. Both Inuit and Cree in northern Québec note several indicators that suggest caribou are peaking in their cycle. These indications suggest a sharp drop in numbers of caribou in coming years. These indicators include high population numbers, caribou moving into areas they don't normally inhabit, a greater reliance on secondary food resources, increased incidence of liver disease and deterioration of body conditions.

Shifts in Response to Habitat Loss, Food Availability or Disturbance

While lynx started declining when DewLine sites were established in western Hudson Bay, and there has hardly been any for the past 10 to 15 years, they have started appearing in the Arviat area. Similarly, moose are moving into the Kuujjuaraapik/ Whapmagoostui area in response to habitat loss and disturbance experienced in eastern James Bay.

Canada and snow goose migrations have changed considerably over the past 20 years in the James Bay and western Hudson Bay coastal areas. On the eastern side of the region, their main flyways have shifted from the coast to further inland as far east as the high mid-mountains of northern Québec. On the western side of the region more Canada and snow geese are entering and leaving the Hudson Bay system from the west, and fewer are taking the north-south coastal route. Such a significant change is recognized by Cree as the combined effect of several inter-relating factors including (i) weather system changes (ii) coastal habitat changes (iii) inland habitat changes i.e. creation of reservoirs in eastern Québec and waterfowl habitat on the prairies (iv) disturbance from inexperienced subsistence and sport hunters who "haven't learnt how to hunt and treat geese properly" and (v) wildlife management interference at critical times in the

goose reproductive cycle i.e. use of aircraft and handling of eggs for nesting surveys, leg and collar banding for population studies.

Migrating marine mammals have sensitive hearing mechanisms. Moreover, they are always moving in search of food and respond to marine environmental conditions which, like the waterfowl, influence their presence in a particular locality at a given time. A population decline in one area, therefore, may not signify an actual decrease in numbers but a shift to another area where environmental conditions are more favourable. Both beluga whales and walrus, for example, have become scarce in areas where they were more abundant, and more abundant in areas where they were scarce. Fewer beluga are seen in James Bay and along the eastern coast of Hudson Bay. More are seen in the off-shore areas of eastern Hudson Bay. Similarly, fewer whales are visiting the mouths of the Churchill and Nelson Rivers, but large numbers are reported in the vicinity of Winisk and Severn rivers where whitefish are abundant, and beluga hunting no longer occurs because residents do not require beluga meat for dog food.

Polar bear is another species whose population dynamics may be shifting significantly—both the Inuit of northwestern and eastern Hudson Bay report increasing numbers. Eastern Hudson Bay Inuit, for instance, have seen the numbers increase since the 1930s-40s, and particularly since the 1960s. They think the increase may be from polar bears shifting to eastern Hudson Bay in response to the combined effects of (i) an abundance of ringed seals (ii) extended floe edge and (iii) GNWT hunting quotas that have been in effect since the 1970s.

Reproductive Responses

Both Inuit and Cree have observed that without traditional hunting and trapping pressure, marine and terrestrial animals population numbers decrease over time. Although the numbers initially increase, the animals diminish their food supply over time, and either: (i) have to move to a new area causing localized numbers to decline due to a population shift or (ii) start dying from starvation which slows down reproduction. Snowy owls, for example, don't breed when the lemming population is low but begin breeding again as the lemming population increases. Walrus and beaver have similar responses when they diminish their food supply and have to move into new feeding areas.

Deteriorating Health and Body Condition

Natural indicators for animal health are seasonal fat thickness, liver condition, meat colour, fur colour and unusual behaviour. People also notice a difference in the taste, and behaviour of animals that feed in contaminated areas, or on human-generated waste.

Animals that have become dependent on feeding in garbage dumps are considered to have lost their natural hunting or foraging ability. Fox, sea gulls, crows and ravens are species that are now only part of the traditional Inuit diet when absolutely necessary because they are known to "eat anything" and that, today, includes human garbage and refuse. Polar bear, jaegers, falcons, and snowy owls are natural hunters but they also scavenge when there is opportunity. Polar

bears, for example, consume motor oil when foraging garbage dumps and hunting camps in western Hudson Bay which Inuit hunters in northwestern Hudson Bay have learnt blackens the stomach contents and which emits an offensive odour when in the stomach for too long. Inuit in northwestern Hudson Bay have also seen caribou and geese feeding in sewage lagoons. Eastern James Bay Cree report black bears have lost their sense of territoriality since they started feeding at work camp and community garbage sites.

Geese, ducks and fish are species which unknowingly feed in contaminated areas. Malnourished fish have been found in water systems contaminated from mining activity in northern Québec. Morphological changes are occurring in sturgeon affected by hydro activities in the La Grande, Nottaway, Moose and Nelson river systems.

Health and Well-Being

Inuit and Cree know that the contaminants damaging the Hudson Bay ecosystem are damaging them as well. They also know, and do not want to accept, that as more and more of their natural foods become damaged from industrial-based changes their own traditions and way of life have less chance of surviving. The Cree whose way of life has already changed from primary and secondary impacts of industrial activity occurring in their traditional lands say they need their natural foods to heal. Inuit, who are experiencing increasing pressure to change their traditional hunting way of life, say they need their natural foods to survive.

Young people in both societies have been born and are growing up in a period of tremendous cultural shock. Elders want to give them the self-respect, dignity, reverence and spirit that they, themselves, were given by their elders. To do so, they need a healthy natural environment that can provide younger generations with the nourishment they need to learn traditional ways.

5 SOME REFLECTIONS ON SCIENCE AND TEK

Introduction

The preceding chapters on scientific information and traditional ecological knowledge are founded on observations, in some cases, taken over long periods of time. Those observations are about changes in the environment and patterns of variability in a broad array of characteristics of the region. TEK holders come to know their environment from their intimate, daily activities on the land, the waters, and the ice, and through their relationships with wildlife. In addition, the oral traditions of information exchange in the community and the inter-generational transfer of knowledge continue to play significant roles in knowing. Scientists come to understand things about the Bays from field observations, and laboratory analysis, and the vetting of observations and explanations with peers. As we prepare to ask ourselves what we can say about cumulative effects and their evaluation, it may be helpful to ask first, how these two knowledge and information systems taken together help us to understand change and variability in the region.

We may want to know on what matters, and to what extent, the two knowledge systems consist of observations that are essentially in agreement with one another, i.e. where the observations and conclusions tend to converge and in doing so create areas of shared understanding between the two systems. We are also interested in the unique contributions of each perspective. Are there environmental features observed by one but not the other? Are there areas of greater and lesser attention? Are there observations about which the two bodies of knowledge disagree? Furthermore, are there aspects of these knowledge bases that complement each other so that when taken together, our understanding is greater than from one perspective alone?

On reading Chapters 3 and 4, of this report one is struck by the breadth and depth of the information that has been brought forward. Certainly there are "gaps" in knowledge, but the overall impression is one of a substantial set of observations whose scope is broad and whose level of detail is rich. In the analysis that follows we have selected patterns of knowledge and information that we suggest illustrate the overall character of the two knowledge systems. It is not an exhaustive analysis. Rather, by focusing on particular areas of knowledge we hope to illustrate more generally the character of the scientific information and traditional ecological knowledge that the HBP has gathered and, from this work attempt to identify directions for further analysis and discussion. As well, we will also raise questions about the implications of our findings and analysis for sustainable development and cumulative effects evaluation in the Hudson Bay Region, and more generally, for other northern areas.

It is important to note that in selecting various kinds of information and knowledge to examine and discuss, we run the risk of overlooking some of the interconnectedness among kinds of information and relationships among components of the ecosystems with the people who depend on it. For purposes of this report the intent is not to trace through all real and potential connections in the environment. That analysis must follow. Rather by focusing on some of the components of the two knowledge bases we hope to illustrate how our collective understanding

of the Hudson Bay Bioregion is enhanced through acknowledging the contributions of both systems of knowledge and noting,

- areas of shared understanding;
- unique areas of observation;
- areas of disagreement among observations; and
- the complementary aspects of both knowledge systems

Climate and Weather

Variability in climate and weather were featured in both the TEK and scientific perspectives. TEK observers reported colder temperatures, longer winters, shorter spring and fall seasons, and changing patterns of precipitation. By way of example, a cooling trend was reported in the Hudson Strait region. Observers there note that warmer weather arrives now in March or April, followed by much cooler weather in May, June and July. In a few instances elsewhere, notably Northwestern Hudson Bay and Western James Bay, warmer winters have been experienced. The overall impression from the two Bays is that, weather variability in the last 40 or so years has increased both in terms of seasonal and annual cycles.

From the scientific perspective the major conclusion on climate and weather is one of high levels of seasonal and year-to-year variability and thus, uncertainty in predictions about the future. As Chapter 3 notes:

"there is considerable seasonal and year-to-year variability in the climate of the bioregion, and since long term variations still lie within this short term variability, uncertainty persists about the validity of predictions".

Both knowledge systems also focus on "indicators" of weather and climate variation. The scientific approach has noted significant vegetation changes that are believed to correspond with changing climatic conditions. Similarly studies of multi-year ice systems are also known to yield information about climate change and variability. As well, the study of aquatic species provides evidence of relict forms whose presence is an important indicator of past climatic or regional habitat change.

On the TEK side, the evidence indicates that a number of key biological and physical indicators chronicle changing weather and climate conditions. The failure of the fruit of certain edible berry plants (e.g. Cloudberry) to ripen is observed to be correlated with changing weather conditions, notably cooler periods in late spring and summer. The presence or absence of certain insects also provides a sensitive indicator of climatic variation. Alterations in permafrost regimes along with changes in sea and freshwater ice are also taken by Inuit and Cree as evidence of weather and climatic variation. As well, TEK has observed changes in insect populations that correspond to changes in climate and weather. A further indication of weather changes comes from the Hudson Strait region. For many years the return of the Rough-legged Hawk in Spring to this area coincided with changes in the surface of snow due to alternate

freezing and thawing. More recently, though this hawk continues to return on or about the same dates, snow conditions are as they are in the winter, indicating the later arrival of spring weather.

Two points are worth noting here. The first is that both TEK and Science observe that weather and climate conditions over the last 40 or years have been highly variable and uncertain. The second is that in the Science and TEK data we note a rich and detailed set of observations about biological and physical indicators of changes in climate and weather. On both counts therefore, it appears that the two knowledge systems, each relying on very different modes of observation and information gathering, produce comparable results. Furthermore, while the two systems share certain indicators (eg., insects) they each make use of indicators not reported by the other. In this way the two information systems augment our overall knowledge, and thus create a wider frame of reference for future observations, perhaps environmental monitoring.

Weather, Currents, and Ice

Observations by Inuit, Cree, and scientists all point to variable weather conditions, changes in the patterns and strength of currents, and changes in the location, quality, and seasonality of ice regimes. Of particular significance are sea ice conditions that permit travel at earlier times in the Fall/Winter and for longer periods of time than in the past. Inuit from the Belcher Islands and Eastern Hudson Bay note that the "ice bridge" between the Belcher Islands and the Eastern Hudson Bay coast, "is more extensive and freezes faster than in the past". Travel is now possible where and when in the past, it was not. While an understanding of "cause and effect" relationships may not be entirely clear, (in some cases there are differing speculations), what is clear is that the observations of both the aboriginal people and the scientists are widely acknowledged and accepted. The evidence within and among Inuit communities in Eastern Hudson Bay consistently indicates;

- weakening offshore currents,
- the earlier formation of sea ice regimes,
- the formation of thicker ice in some places,
- longer periods of time through the winter in which ice persists,
- the freezing over of historically open water areas in the winter, i.e. polynyas,
- reduced effects of wave action on ice movements as the ice cover increases,
- the failure of "spring tides" (the tides of the full and new moon) to break up the ice at the floe edge during the winter months,
- while recent winter temperatures are observed to be declining, some elders report that temperatures in the 1940's were at least as cold as present winters, and at that time the "spring tides" consistently broke up the winter floe edge ice.

Scientific information on regional temperatures indicates a cooling trend in the past few winters. As well, rivers on which hydroelectric generating stations operate are now putting more freshwater into the Bay during the winter months which changes salinity, freezing potentials and ice patterns, possibly contributing to thicker and longer lasting ice regimes, and fewer polynyas

along that coast. Reduced precipitation in northern Québec may result in less freshwater moving from the rivers to the Bay and thus weaken nearshore currents that are influenced by river inflows. Increased ice cover itself may also reduce the effects of wind-driven currents, further complicating the unravelling of cause and effect.

The combination of the TEK and scientific observations provides a wealth of information about weather, currents and ice conditions. The knowledge in each system seems consistent, though the causal explanations appear at this time to differ somewhat. This is yet another instance where the power of both systems lies, in part, in their ability to inform the other and suggest approaches to future observations.

Isostatic Rebound

Both Science and TEK are consistent in their observations on rising shorelines and subsequent effects around many parts of the Hudson Bay ecosystem. The records of scientific studies measure, with some precision, the changing elevations of the land mass and the concomitant changes in vegetation, currents, and fish and wildlife. Similarly, TEK holders note in considerable detail, the changes in shoreline elevations and near shore conditions. Resultant changes in vegetation and wildlife patterns are also described in detail. Some speculate on the potential for wider effects of such changes including shifts in flyway patterns of geese and other waterfowl along with changes in the habitat selections of marine mammals as they seek more appropriate conditions for various parts of their annual cycles.

Both systems of knowledge converge in their descriptions of the physical changes of this phenomena and consequent changes in animals, birds, fish and marine species. Each system also specifies changes in ways the other does not and thus provides complementary information.

River Diversions and Reservoirs

Hydro-electric developments in the Hudson Bay bioregion and the associated environmental assessments in Québec, Manitoba, and Ontario prompted the gathering of scientific information and traditional ecological knowledge on the impacts of such projects. Reservoirs, diversions, transmission corridors and supporting infrastructure were all identified as significant contributors to cumulative environmental effects in the region.

On the science side, studies of marine and terrestrial ecosystems, contaminants, resource availability, and climate change examined a wide range of impacts from hydro-electric developments. While previous research and knowledge of such effects allowed a number of these impacts to be described with some confidence, the prediction of many impacts was couched in uncertainty. Little baseline data have been gathered over the past on which to gauge the magnitude of change or cumulative and interactive effects. The absence of comprehensive and sustained environmental monitoring of previous post-project impacts limits the kinds of conclusions that one can draw from the scientific literature. The lack of scientific conclusiveness

in these matters is also partly due to the lack of experience with mega-projects in the northern context.

As a result, not only are there limitations to identifying and predicting the nature of first order or direct impacts, the ability to do so for second, third and greater order effects is even more limited. For example, studies of fresh water plumes in northern marine ecosystems from both diverted rivers and those on which there are generating stations are fairly recent. The long term behaviour of plumes and their impacts on marine biota such as phytoplankton and zooplankton are therefore not well understood. It follows then, that much of the scientific perspective on the impacts of reservoirs and diversions is based on incomplete knowledge, and can be best characterized as "educated guesses". Thus, the contribution of science is in large measure focused on "hunches" and hypotheses.

Where science has made a definitive contribution to issues arising from the creation of reservoirs is in the case of mercury contamination. Tests on fish caught for both subsistence and commercial sale in the Southern Indian Lake reservoir on the Churchill-Nelson diversion revealed high levels of methylated mercury, and from this revelation came the beginnings of our understanding of the connection between reservoirs and mercury. Early studies of the La Grande reservoir in Québec showed similar results and established beyond doubt the significance of the issue for both people and the ecosystems.

From the TEK perspective on diversions and reservoirs a somewhat similar view emerges. Cree and Inuit have observed many changes in river conditions, ice regimes, the fisheries, migratory patterns of waterfowl, and animal populations, and furthermore, know with certainty that the hydro-electric projects have brought about profound changes. However, in some instances it is difficult to determine how much of the change is attributable to such projects and how much is due to other human activities or to natural fluctuations and oscillations. For example, while native hunters can point to visible changes in estuaries and coastal shallows, and to fish, waterfowl and animal behaviour in these areas, some of the effects of isostatic rebound and climatic variations are difficult to separate from those of hydro-electric development.

TEK observations on the Moose-Abitibi and Nelson River systems do provide a longer time frame than the Northern Québec rivers within which to observe and assess environmental change. Participants from these two river systems report prolonged accumulation of sediments in the lower reaches of the rivers, intrusion of saline waters up the rivers and decline in the fisheries to the point of the collapse of the sturgeon fisheries on the lower Nelson and Abitibi rivers.

It appears that both TEK and science agree on certain "facts of the matter" and at the same time are less specifically in agreement about the patterns of change and variability. When it comes to attributing "cause and effect" to observations both acknowledge that strong "hunches" characterize much of what they understand about the processes of environmental change. It is useful to note as well, that the scientific effort has been focused on particular impact sites and limited in time, usually to the immediate pre-project period. In contrast, the Cree and Inuit

observations have taken place over a much wider spatial area, the traditionally occupied and used lands. In this way the spatial comparisons of affected and non-affected areas serves to provide a frame of reference in which to assess the observed impacts of the various projects. While the time frame in which observations by aboriginal people of project impacts is similar to that of the scientific community, the fact that these observations are integrated into a longstanding base of traditional ecological knowledge means that change is being measured against a baseline, rarely found in the scientific literature. This suggests that TEK may prove particularly valuable in post project monitoring.

Wildlife and the Traditional Economy

Observations on the harvest or traditional economy, and of wildlife in particular, form an important part of both the scientific and TEK perspectives on cumulative environmental effects in the Hudson Bay bioregion. In a more general way we find agreement between the expressed views of the Cree and Inuit on the one hand and social scientists studying those economies and cultures. Aboriginal people from throughout the region affirm the viability and vitality of the traditional economy. While it is much different in its technologies and in the patterns of time spent on the land and in the communities, the harvests persist and with it the evolution of the economy and the culture. Many continue to derive the greater portion of their food from the land and the sea. Many attest to the strength of the people and their ways in spite of policies past and present, contaminants from afar, and protest lobbies that have taken away fur markets. While the people expect there will continue to be threats to their way of life and pressures to change, a sense of conviction about the fundamental ways of life and living and being able to sustain these ways in the future remains.

While the social scientific community includes some detractors about the capability of aboriginal lifestyles to endure, there is a more substantial and growing body of evidence that points to the economic, political, and cultural efficacy of indigenous management systems. Moreover, this literature suggests that native economies, as we understand them now, are at least indicative, in some ways exemplary, approaches to sustainable development. Scientific analysts also document the threats over time to native societies and the social and economic process that threaten to assimilate aboriginal people into the broader society. They point to the adaptiveness of native societies when faced with forces from both outside and within. Analyses also suggest that the traditional economy has been historically undervalued and under-reported. There is, then, a considerable measure of observational agreement between TEK holders and social scientists on the viability and significance of the traditional economy.

The traditional economy relies on the harvest of many species of mammals, fish, and birds. As we examine the reports of TEK holders and scientists we find both differences of view and agreements on changes in wildlife conditions. As well, we find some species for which there is little or no information from one or other of the knowledge systems. This may be due, in part, to the limitations of the study and, in part, to its focus on species people generally believe to be important.

Fisheries

Fisheries are a key resource to many Cree and Inuit throughout the Hudson Bay region. Their observations indicate that Char populations are in decline in many of the customary fishing areas. Similar observations are reported by scientists. While the aboriginal perception is that changing habitat (reduced flows in stream and river systems making passage impossible) accounts for an important part of the decline, the scientific analysis also suggests that harvest levels are in excess of sustainable limits at some sites especially those areas where both subsistence and commercial harvests are taken. From the scientific literature it is clear that very little attention has been given to sturgeon anywhere in the region. On the other hand, the Cree report significant population declines, to the point of the loss of the fishery, for the La Grande, Moose-Abitibi, and Nelson Rivers impacted by hydro-electric developments. Both scientists and the Eastern James Bay Cree observe that the whitefish populations in the La Grande estuary show signs of decline and may be endangered.

Geese

Waterfowl are particularly significant to the Cree and Inuit of the Hudson Bay region. Not surprisingly, TEK on waterfowl especially Canada and Snow Geese is comprehensive and detailed. Waterfowl population studies by resource managers constitute an important part of the scientific literature, in part because they are an economically significant species in the non-aboriginal hunt in Southern Canada and the United States. Additional areas of scientific interest include migration, breeding, rearing success, and habitat issues.

TEK observations indicate changes in localized population levels and migratory patterns. While Inuit and Cree observers note population declines in some areas, elsewhere notable increases have been observed. Similarly, migrating numbers appear to be in decline in some of the "usual" places, but significantly increased in others suggesting that flyway paths are shifting. These shifts in migratory routes are particularly noticeable in the Eastern James Bay region. Whereas previously the coastal zone served as the major pathway, residents of those communities report fewer Canada Geese, while for some twenty years hunters have observed them over the high ground of Northern Québec to the east of the hydroelectric reservoirs. In the Western Hudson Bay region geese are now observed to turn westward and head inland as they move south in the Fall instead of following the coast on their southward journey.

While the arrival of geese in the Spring has always been influenced by weather conditions, some TEK holders report new patterns. Strong winds out of the north in April and May can alter migrations. Under these conditions Canada Geese tend to travel in pairs, giving the appearance of fewer geese returning for the breeding season. Subsequent checks in the nesting areas however reveal that normal numbers of pairs are occupying the nesting areas. Large numbers of "moulting geese" arriving much later in the spring have been observed recently. Referred to as "city geese" by the residents of the Belcher Islands, they are less fearful of human beings. There are also observations to suggest that increasing levels of noise and human activity are causing geese to seek alternative habitat for feeding, breeding, rearing, etc.

From a TEK perspective then the evidence would suggest that overall population numbers remain steady and that local declines are offset by increases elsewhere, due in large part to shifting flyway and habitat preferences. The fact that TEK observations on these species are consistent across many hunters operating over a very large part of the region would indicate that the overall populations remain at sustainable levels rather than being in decline. Combining the evidence of Cree communities along the flyways and Inuit communities in the nesting areas adds weight to these conclusions.

Scientific information reaches beyond the Hudson Bay Bioregion to examine population estimates throughout much of the Canada-United States flyway. This additional information, particularly of wintering ground population estimates indicates both increases and reductions in numbers for different species and subspecies. A significant increase in the population of, for example, Canada Geese and Snow Geese over the past 20 to 30 years but, also, significant reductions in Harlequin ducks. Scientific evidence also suggests that hydro-electric diversions and reservoirs have, in part, affected local populations. Much of the scientific effort on these recent shifts and changes is in progress.

These above observations regarding geese, indicate broadly-based and detailed information on the TEK side. There is population, flyway, and nesting data from Science too, but in terms of recent changes more needs to be done to tie together the many separate sources of data to complement the geographic span of the TEK. What this suggests is an opportunity to consider ways in which the two systems might take cues from the other to make further observations and recordings to augment our current knowledge. One such area might be an examination of taste differences and flyway shifts reported in the TEKMS Study. What is particularly needed is an extension of both knowledge systems to pursue possible changes or overlaps in flyway patterns, stock composition, and related feeding behaviour and habitat selection.

Polar Bear

For some species there appear to be differences in the observations of the two knowledge systems. The Hudson Bay Program data indicate that observations on polar bears differ in some parts of the region. While the scientific evidence suggests that some populations are in decline the TEK holders' evidence suggests increasing populations are to be found in the Northwestern Hudson Bay region, parts of Eastern Hudson Bay, including the Belcher Islands and in the Western James Bay and Western Hudson Bay regions. In these latter two areas, populations are known to increase and decrease over time, but at present they seem to be on the upswing. Scientific analysts note that polar bear data are not well distributed spatially, i.e. relatively few locations and populations have been subjected to on-going study. On the other hand, TEK analysts argue that the large number of hunter/observers, over most of the Hudson Bay bioregion provides a broad spatial perspective and one that is sensitive to shifts and oscillations over substantial periods of time.

Belugas

Beluga whales are another species about which there appear to be differences in native and scientific observations. Scientists' observations, made mostly in the summer, suggest declining populations in various parts of the bioregion. Observations such as these have been the basis of new regulatory initiatives by governments to control harvests and thus, maintain stocks at self-sustaining levels. On the other hand, TEK holders continue to observe expected levels of local populations, but note that the whales appear to have abandoned some of their traditional summer areas in favour of sites that are less frequented by humans, particularly where boat traffic and noise are less.

The discussion on polar bears and belugas points to the importance of understanding more clearly the observational approaches and methods of the two information systems. What on the surface seem to be opposing sets of information, may be the result of very different kinds of observations, as well as ones taken at different times and places. As some have pointed out the scientific approach tends to be specific to species, population, or stock oriented. TEK approaches tend to be relational, where observations about a species or population are but a part of a large set of observations. When this totality of observations is integrated and assessed for its meaning the conclusions arrived at can be quite different, than if only species population data are used. For these cases then, it is important that care be taken on all sides to ensure that a clear understanding of the observational processes are known and understood.

Contaminants, Health and Well-Being

In recent years scientific studies have not only confirmed the presence of contaminants in the environment, but have shown that people in the North are exposed to them in greater degrees than most southern Canadians. Scientific inquiry has involved

- climatological processes and contaminant distribution,
- deposition and environmental uptake,
- pathways and effects in the ecosystem,
- human exposure and effects,
- monitoring environmental loadings and human uptake.

The research also confirms that the origins of the contaminants and pollutants are both distant and local. While observations from TEK holders has had little to say about the origins, pathways, deposition, and uptake of contaminants and pollutants, it nonetheless, has been instrumental in the development of the issue, and in focusing scientific research on contaminants. Participants in the Hudson Bay Program have reported, from time-to-time, observing contaminant residues from precipitation (snowfall). Hunters, and women who prepare foods, have observed changes in the appearance, condition, and colour of foods. As well, Cree and Inuit in the Hudson Bay region report that animals taste different than in the past, and that, in at least some of these cases, the animals have been observed eating in polluted and contaminated areas. Taste and food quality may also reflect animal conditions, and there are several instances

where cyclic fluctuations result in overpopulation or where changing habitat (and food supply) may have influenced taste and quality (e.g. char, sturgeon, caribou). Likely, food supply and contaminant effects influence animal condition both separately and together. As previously noted (ice and currents), cause and effect may not be quite as it first appears. TEK observations also note the dispersal of contaminants in the animals, birds and fish. The seasonal and annual travel patterns of wildlife are regarded by aboriginal people as one means by which contaminants are dispersed throughout the environment.

From these various observations a few key points emerge. First, TEK in its encounter with contaminants and pollutants, is a "new" sector of knowledge. In the face of uncertainty regarding the health effects of contaminants to humans and wildlife, the Inuit and Cree are developing a body of information on morphology, taste, colour, physical condition, and animal behaviour when considering the quality of wild foods for their use. That body of information could evolve into a valuable component in a basin-wide monitoring system for some contaminants. Furthermore, since the science of contaminant effects is still very much in its infancy, the search for TEK indicators of effects throughout the ecosystems may well aid scientists in their research. Not only might this be so for the presence or absence of certain effects, but it may prove to be the case that TEK could add sensitivity about levels of effects, and thus contribute in new ways to the documentation and understanding of cumulative impacts. What will be important in the long run is to relate TEK with not just scientific information, but the process of setting scientific priorities and agenda. This is not a call to "integrate" TEK and Science into some policy and administrative framework. Rather it is to suggest that the two parallel systems of knowledge can be mutually reinforcing in ways that we will come to ultimately know more things in more detail.

From a discussion of contaminants one is lead into a wider consideration of health and well being, issues that are clearly reflected in both the science and TEK streams of this study. In recent years we have begun to think differently about the science of "issues". Increasingly the view is being taken of the need to link several areas of study to ensure that complex problems require interdisciplinary, integrative, comprehensive, and ecosystem approaches. The linking of human, ecological, and policy sciences in the context of contaminants in the North is an example of this trend in science. Medical, ecological, socio-economic, cultural, and decision-making sciences are addressing questions related to contaminants. In addition to the science of exposure-effects referred to in the immediately preceding discussion, social sciences are accumulating evidence on economic, cultural, social and political "stress" among individuals, communities and societies. Some of that science also indicates that where traditions and customs, particularly those that relate to the traditional harvest economy are maintained, indices of social, economic, and political, and ecological sustainability suggest a sense of individual and community well-being. The TEK generated through the HBP also supports this view. Elders, hunters, and community leaders consistently observe that the well-being of their communities and individual residents is intimately linked to being sustained by the land. Terms such as "homelands", a "healthy environment", "control in our hands", making "a decent living" from the land and the waters, are dimensions of health and wellness in a land-based society. As the TEK evidence points out, this is not a static view of traditional native society, nor is it a retreat

to past times. Rather, it is a foundation upon which, given the opportunities, the people themselves will seek adaptations to the world around them. Part of adaptation is in recording their knowledge and sharing it with the "South". Part of it may also be in juxtaposing TEK and scientific information to gain a wider understanding of environmental change and variability.

Summary

From even these few examples of scientific information and TEK on the environments of the Hudson Bay bioregion, we are more aware of both the scope and detail of these systems of knowledge. Each has made observations on the same species or systems, finding concurrence in some cases and differences in others. Both approaches may be used to explore areas and events not examined by the other, thus bringing unique insights to bear on the issues of environmental change. As well, the ways in which the observations have been taken and accumulated over time vary in significant ways between TEK and science so as to make unique contributions to our overall understanding. Significant questions remain where, in both systems taken together, few observations exist, with even fewer explanations.

What these reflections now lead to is a consideration of the implications of the traditional ecological knowledge and scientific information that has been assembled in the project. As one looks to the future, questions of sustainability loom large. It is timely then to consider the roles of TEK and Science in directing our efforts towards those visions. It is also clear that the TEK and science initiatives in the Hudson Bay Program provide an important opportunity to think in new ways about the nature of ecological indicators in the bioregion.

6 Toward Sustainable Development in the Hudson Bay Region

Introduction

The HBP has generated and brought together considerable information from both TEK and science. This information shows that the region's natural environment is changing as a result of natural processes and that it is also under stress as a result of human activities within and outside the region.

Cree and Inuit societies too are changing in response to broad social and economic forces. While to the outside eye the region would seem to be isolated from and little influenced by the South, this is not the perception of aboriginal people who live in the region, particularly those who are most immediately affected by hydropower development in Manitoba and Québec.

In a very real sense the cultural, economic, and physical health of people in the region reflects the health of their natural environment. Both are sides of the same coin. While many Cree and Inuit lament environmental changes they observe and wonder how they are to pass on their ecological knowledge and time-proven values to coming generations, they appreciate that change will continue notwithstanding the apparent abandonment of the Great Whale and Conawapa hydropower projects. But realism in the face of powerful outside forces is tempered by their determination to continue their culture and economy, and to care for the environment upon which both are based.

Sustainability and Preferred Futures

Inuit and Cree suggest that TEK should be used in planning, assessment and political processes to make decisions about the future of the region. But TEK is not seen purely as a technical "fix". Rather, it is seen as a web of relations between people and land that need to be understood if both are to be sustained. Herein lies the possibility of ground that could be common to aboriginal peoples and agencies of government, industry and business.

Federal, territorial, and provincial governments have endorsed sustainable development—meeting the needs of the present without compromising the ability of future generations to meet their own needs—as a core public policy objective. Many industries have adopted this same goal. Aboriginal peoples too have endorsed this ideal and look to modern treaties with the Crown as vehicles to promote this end. Many participants in the HBP have suggested that prior to developing new approaches to assessing cumulative impacts in the region, all parties should create a shared vision of the region's preferred future. We believe that sustainability lies at the heart of that vision.

What do we need to do to ensure that future development in the region meets the test of sustainability? There are many potential answers to this question, but at a minimum we need:

- 1 Good baseline information on the environment;

- 2 Indicators of long-term environmental changes—the effects of environmental stresses;
- 3 Decision-making processes that use this information to assess cumulative effects of development;
- 4 Decision-making processes that treat the Hudson Bay region as an ecological entity.

Even with the good will of all parties concerned, giving effect to sustainability in Hudson Bay will prove difficult. Fragmented jurisdiction, differing environmental and procedural standards, sometimes competing institutions, information deficiencies, financial constraints, and other factors will have to be overcome if sustainability in the bioregion is to be achieved. These various and serious difficulties should not deter us from the task ahead. While Phase II of the HBP is to explore how development in the region can be sustainable, at this stage we suggest that cumulative effects assessment using science and TEK would help move us toward this end.

Indicators of Environmental Stress

Bunch and Reeves (1992) note that "little research has been done on many important aspects of the Hudson/James Bay ecosystem." They argue convincingly for additional research on "existing biological resources...and on processes that determine their composition and abundance" as a prelude to assessing effects. Sly (1994) suggests that Hudson Bay might be under stress from the following sources:

- nutrient stress—change in the balance of nutrients;
- thermal stress—change in temperature;
- radiation stress—increase in received UV radiation;
- toxic stress—contaminants in biologically available forms;
- habitat stress—loss of habitat;
- exploitation stress—disruption of the function and structure of the food web.

The HBP has documented stresses to and changes in the Hudson Bay environment, particularly those observed by the people who live there. These changes are expressed in terms that are easy to understand by dividing the bay into geographical regions, using animals of immediate economic importance to Cree and Inuit, and environmental factors that are of importance to everyone.

In volume 2 of the TEK report we suggest a number of "indicators" that people in the region use to express environmental changes. We conclude that human health and top predators in the food web, and sea-ice conditions are the most appropriate indicators of environmental change in the region. But clearly much work should now be done to assess whether and how systematic observations of the environment by aboriginal peoples, as reported in the TEK volumes, can expand the number of indicators available.

Toward Cumulative Effects Assessment

The recent passage of the Canadian Environmental Assessment Act requires cumulative assessment of the impacts of proposed development projects. This is all very well, but ties the concept of cumulative effects to specific project(s) under consideration at any given time. This approach is of limited use in the Hudson Bay region. What is required is a broader, ecosystem approach within which cumulative effects can be assessed. This requires that combined effects of multiple stresses be examined in a defined area over a specified time—a regional rather than project focus (Davies, K. in Sallenave 1994). It also presupposes some understanding of the carrying or assimilative capacity of the area in question—its ability to act as both a "source" and "sink". Finally it implies knowledge of the extent to which the environment is already under stress. Our knowledge base of Hudson Bay in all these areas is poor.

If human and community health, and behaviour or abundance of animal populations can be used to indicate stresses upon and changes to the environment, this brings the HBP to pose two questions for further work:

- 1 Can the many indicators that have been identified to express environmental and social change in the region be combined with other measures of human activity to indicate progress toward or away from sustainability? Very detailed work over many years has equipped Statistics Canada with indicators to express the health of our economy. What might similar, focused efforts achieve in the Hudson Bay region?
- 2 In light of deeply embedded jurisdictional differences, how can existing and/or future institutions work toward sustainability as the core policy objective in the region?

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Appendix

Technical Reports of the Hudson Bay Programme

***A TEKMS Overview for Assessment of Cumulative Impacts in Hudson Bay, Part I.**

***A TEKMS Overview for Assessment of Cumulative Impacts in Hudson Bay, Part II.**

Climate Variability, Climatic Change, and Implications for the Future of the Hudson Bay Bioregion.

Effects of Hydro-electric Projects on Hudson Bay's Marine and Ice Environments.

Health Effects of Development in the Hudson Bay/James Bay Region.

***Hudson Bay Programme: Final Science Report.**

***Human Impacts on the Hudson Bay Bioregion, its Present State and Future Environmental Concerns.**

Native Land Use, Traditional Knowledge and the Subsistence Economy in the Hudson Bay Bioregion.

The Estuaries of Hudson Bay: A Case Study of the Physical and Biological Characteristics of Selected Sites.

Towards the Assessment of Cumulative Impacts in Hudson Bay.

All reports of the Hudson Bay Programme are available from the Canadian Arctic Resources Committee at 1 Nicholas Street, suite 1100, Ottawa, Ontario, K1N 7B7, (613) 241-7379, fax (613) 241-2244, email ay385@freenet.carleton.ca.

***The table of contents of these reports is provided overleaf.**

Human Impacts on the Hudson Bay Bioregion, its Present State and Future Environmental Concerns

Table of Contents

Forward	iii
1 Introduction	1
2 The Watershed and its Drainage	3
General Characteristics	3
Population and Water Use	4
Agriculture	4
Mining	5
Thermal Power	5
Forestry	5
Manufacturing	6
Impoundments and Diversions	6
3 Settlement and Land Use	9
Early Cultures	9
Arrival of Europeans	11
Present Native Use of Resources	13
Recent Cultural Influences	14
Recent Economy	16
Resource Management	18
Parks and Sanctuaries	19
4 The Bay and its Ecosystem	21
Geological and Physical Setting	21
Climate and Oceanography	22
Nutrients and Primary Productions	26
Food Web Structure	28
Distributions of Fish and their Significance	30
Marine Mammals and Polar Bears	31
Birds of the Offshore and Coastal Areas	34
5 Environmental Stress and Possible Causes	37
6 Concerns	41
Identification of Concerns	41
Agriculture	41
Forestry	42
Mining	42

Oil and Gas	43
Pulp and Paper Manufacturing	43
Diversions	43
Hydroelectric Development	44
Transmission Corridors	45
Air, Shipping, Road, Rail, and Construction Site Activities	45
Off-Road Transport	46
Tourism and Recreation	46
Settlements	47
Long Range Transport of Atmospheric Pollutants	47
Global Warming	48
Understanding the Principal Concerns	48
Reservoir Development	49
Wildlife Use, Harvest, and Loss of Habitat	55
Long Range Transport of Atmospheric Pollutants	58
 7 Cumulative Impact Evaluation	 71
Cumulative Impact	71
Ecosystem, Environment, and Habitat	72
Sustainable Development	72
System Properties	73
Hierarchical Structures	73
Environmental Impact Assessment	74
State of the Environment	74
Vision	75
 Acknowledgements	 77
 References	 79
 Glossary	 101
 Figures	
 Tables	

Hudson Bay Programme: Final Science Report

Table of Contents

Introduction	1
General Thoughts	1
Settlement and Cultural Impact	2
Development	4
The Natural Environment	6
Land	6
Sea	6
Climate and Vegetation	8
Food Web	9
Issues and Concerns	12
Contamination of the Food Web	13
Settlement and Land Use	16
Transport and Travel	17
Wildlife Resource Depletion	18
Climate Change	20
Lifestyle and Health	22
Cumulative Impacts: Priorities	24
"Now" Priorities	24
Future Priorities	25
Bibliography	26
Credits	26

A TEKMS Overview for Assessment of Cumulative Impacts in Hudson Bay, Part I

Table of Contents

1	Introduction	1
1.1	Geographical Scope	3
1.2	Study Focus	5
1.3	Report Organization	6
2	Environmental Views and Values	8
2.1	Traditional Respect	8
2.2	Natural Environment	8
2.3	Environmental Responsibility	13
3	Traditional Knowledge of Ecosystem Components	14
3.1	Seasonal Cycles	14
3.2	Currents	14
3.3	Sea Ice	17
3.4	Hudson Bay Food Web	25
3.5	Seasonal Foods	25
4	Observed Changes in Hudson Bay Environment	31
4.1	Atmosphere	31
4.2	Weather	32
4.3	Currents, Polynyas and Sea Ice	34
4.4	Salinity	35
4.5	Shorelines	36
4.6	Rivers and Settlements	37
4.7	Fish and Wildlife	42
5	Significance of Changes from a TEK Perspective	45
5.1	Rising Land Mass	46
5.2	Changing Atmosphere	46
5.3	Changing Weather	47
5.4	River Systems	48
5.5	Currents	49
5.6	Loss of Habitat	50
5.7	Wildlife Population Numbers	51
5.8	Health and Well-Being	53
6	Indigenous Perspectives on Development	54
6.1	Socio-Cultural Considerations	55
6.2	Hydroelectric Development	58
6.3	Grand Canal Project	62

6.4 Mining	63
6.5 Forestry	64
6.6 Shipping and Off-shore Exploration	65
6.7 Contaminants and Pollutants	66
6.8 Wildlife Management	69
7 Future Needs	72
7.1 Recognition	72
7.2 A Healthy Environment	73
7.3 Traditional Foods	74
7.4 Traditional Ecological Knowledge	75
7.5 Cultural Education	75
7.6 Development Planning	77
7.7 Conservation	78
7.8 Working Together	81
8 Comments of TEKMS Study	82

Figures

A TEKMS Overview for Assessment of Cumulative Impacts in Hudson Bay, Part II

Table of Contents

1	Research Process and Schedule	1
1.1	Study Methods	4
1.2	Database Development and Processing	5
1.3	Intellectual Property Rights	9
2	Seasonal Characteristics in Hudson Bay	11
3	Environmental Indicators	18
4	Currents	22
5	Rivers and Settlements	24
5.1	Western Foxe Basin and Northwestern Hudson Bay	25
5.2	Northwestern Hudson Bay	26
5.3	Western Hudson Bay	27
5.4	James Bay	28
5.5	Eastern Hudson Bay	30
5.6	Hudson Strait	32
6	Sea Ice	34
6.1	Sea Ice Dynamics	35
6.2	Inuit Sea Ice Typology	38
7	Animal and Plant Types in Hudson Bay Ecosystem	42
8	Beluga Whale	46
9	Polar Bear	49
10	Snow Geese	53
11	Canada Geese	59

Tables

Figures

Maps

Appendices