

**Community-based assessments of change: Contributions
of Inuvialuit knowledge to understanding climate change in the
Canadian Arctic**

By

Dyanna Riedlinger

**A Thesis submitted to the Faculty of Graduate Studies
of the University of Manitoba in partial fulfillment of the requirements
of the degree of Masters of Natural Resource Management Degree**

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**Community-based Assessments of Change:
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Climate Change in the Canadian Arctic**

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Abstract

Inuit and Inuvialuit in the Canadian Arctic possess a substantial body of knowledge and expertise related to climate and climate change. The weather, and the relationship between weather and other environmental phenomena, is closely monitored in northern communities. Variability and fluctuation are expected elements of local environmental patterns and processes. However, in the past 10 years communities have begun to experience changes that they consider to be beyond the range of normal variability. Community assessments of change are based on cumulative knowledge of local trends, patterns and processes, derived from generations of experience.

The Arctic is considered by many to be the “canary” of climate change; an early warning sign of the impacts of change. Thus, high latitude regions have become a focal point for climate change research. However, there is significant difficulty associated with discerning regional differences and predicting impacts at the local scale. Climate science in northern regions is often complicated by insufficient observational data, seasonal limitations and a lack of baseline data against which to compare change.

An emerging theme in climate research is bridging the gap between Western science and Inuit knowledge of climate change to better understand Arctic climate change. This thesis is encouragement for this theme. Based in part on the collaborative research project *Inuit Observations of Climate Change* (1999-2000) in Sachs Harbour, Western Canadian Arctic, I describe how local, land-based expertise and community-based assessments can provide observations, predictions and explanations of climate change at scales and in contexts currently underrepresented in climate change research.

Firsthand experience working with local experts and scientists is used as a basis for a conceptual framework that explains how to find common ground between Inuvialuit traditional knowledge and Western science. This framework includes five areas of convergence in which traditional knowledge can complement scientific approaches to

understanding climate change in the Canadian Arctic. These areas are: the contributions of traditional knowledge (i) as local scale expertise; (ii) as a source of climate history and baseline data; (iii) in formulating research questions and hypotheses; (iv) as insight into impacts and adaptation in Arctic communities; and (v) for long term, community-based monitoring.

Preamble

This thesis is a reflection of the generosity and support of the people of Sachs Harbour. It is a result of people sharing their knowledge and experience of climate change. One of the most important aspects of working with a community and learning about traditional knowledge is the responsibility of the researcher to present what was learned in the best possible way; and this is what I have tried to do here.

It is my hope that this research will be used to encourage and support future efforts to understand climate change, from both Inuvialuit and scientific perspectives. In doing so, I ask that when the thesis is used by those other than the community of Sachs Harbour, the project team or the author, that it be used in the spirit of respect, for the knowledge that the people of Sachs Harbour have shared, and of reciprocity, as research that gives back to communities.

Dedication

To all of my grandparents.
It is through them that I know who I am.

Acknowledgements

Thank you

To my family for their on-going love and support while I worked towards a graduate degree, especially my mom, for helping me to understand that research is relationship-based. Quana too, Duane, for all of your help and encouragement along the way. This degree means so much to me, and I could not have done without each one of you.

Quyanainni

To the people of Sachs Harbour for making me feel so welcome in their community and making this project happen. I will never forget the kindness and generosity, food and tea that came my way. Quana especially to my nanuk, Mrs. Sarah Kuptana, for her love, kindness, and patience. You taught me so much.

Quana

To the Inuit Observations of Climate Change project team – Neil Ford, Graham Ashford, Jennifer Castledon, Bonnie Dickie, Terry Woolf, Lawrence Rogers, Norm Snow, John Nagy, Stephen Robinson, Theresa Nichols and Rosemarie Kuptana. I am honored to have had the opportunity to work on such a unique project with an equally unique and exceptional project team. Additional thanks to John Nagy for providing the map in Chapter 2.

Quana

To my advisor, Dr. Fikret Berkes for his patience, good advice and support. We've come a long ways! Thanks also to the rest of my committee, Norm Snow, Micheline Manseau, Chris Trott and Tim Papakyriakou for the quality time and advice that was put into making this thesis happen.

Quyanainni

I am grateful to the Walter and Duncan Gordon Foundation who saw the promise in this kind of research and provided such generous funding. Thanks also to support from my advisor through his SHRCC grant, the Arctic Institute of North America (Lorraine Allison Scholarship), the Arctic Institute of North America Grant-in-Aid award, and the Northern Scientific and Training Program. Finally, this research could not have been possible without the in-kind support from the International Institute of Sustainable Development, the Sachs Harbour HTC and Parks Canada (Sachs Harbour).

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Chapter One

Introduction: Arctic climate change, Arctic communities

1.0 Introduction: Arctic climate change, Arctic communities

There is growing evidence that the Arctic climate may be changing. Observed temperature trends indicate that polar regions have experienced noticeable warming in recent decades. Current assessments show marked surface air temperature increases over northwest North America and the Eurasian land masses from 1966-1995, with local trends exceeding 0.5° C per decade (Serreze et al. 2000). Researchers using proxy data such as ice cores and lake sediments suggest that Arctic temperatures in the 20th century may be the highest in the past 400 years (Overpeck et al. 1997). Rising temperatures in the Arctic are considered part of a larger trend of global warming of the Earth's surface, a trend expected to be noticed earliest and most keenly in polar latitudes. The Arctic, for many, is the "canary" that indicates the early warning signs of global change.

Many climate change forecasts, using global circulation models (GCMs), suggest that regions of northwest Canada and Alaska will experience above average increases (Cohen 1997, Kattenberg et al. 1996). Environmental changes observed in the last decade such as melting sea ice (Rothrock et al. 1999, Johannessen et al. 1999, Maslanik et al. 1999, Vinnikov et al. 1999), rising sea levels and coastal erosion (Shaw et al. 1998), permafrost thaw (Woo et al. 1992, Weller and Lange 1999) and the range extension of some fish species (Babaluk et al. 2000) suggest that the effects of climate change in these regions are already recognizable. However, while there is increasing scientific observational evidence of climate change in polar regions (see Serreze et al. 2000), a considerable uncertainty remains concerning the rate and extent of change, and its impacts on northern ecosystems. Climate science in the North is often hindered by inadequate observational data, seasonal limitations and a general lack of historical baseline data against which to measure change. Compared to other regions of the world, scientific knowledge of Arctic physical, biological and ecological processes is often inadequate for predicting impacts.

In recent years, some Inuit communities in the Canadian Arctic have begun to notice environmental changes they consider different from normal variability. Observed differences in the seasonal extent and distribution of sea ice, fish and wildlife abundance and health, permafrost thaw and soil erosion are considered to be without precedent (Fox

1998, Kuptana 1996, Riedlinger 1999, Thorpe 2000). Inuit Elders say the years and the seasons are 'getting crazy now' and that the weather has become unpredictable.

Community assessments of change are based on cumulative knowledge of local trends, patterns and processes, derived from generations of experience. Can these community assessments, based on local observations and traditional knowledge, enrich and expand understandings of Arctic climate change?

1.1 Issue Statement

Bridging the gap between scientific research and traditional knowledge is a prominent theme in northern resource and environmental management. Contributions of traditional knowledge have been well documented in several areas, including biological information and ecological insights, protected areas, biodiversity conservation, environmental assessment, social development and environmental ethics (Berkes 1999). Traditional knowledge and local observation are increasingly recognized as a promising means to help understand the Arctic environment (Duerden and Kuhn 1998). However, very little research has been done to explore the value of such knowledge to climate and climate change research.

There is a clear role for northern communities in investigating the impacts of climate change in the Canadian Arctic. Inuit possess a substantial body of knowledge and expertise relating to climate and climate change. The weather is a principal factor influencing community life, and thus is one of the most closely monitored of natural phenomena (Fox 2000). Community-based knowledge, often termed traditional or Inuit knowledge, can broaden the scope of how climate change is understood in the North, through rich understandings of local conditions and variability. Such knowledge enables local scale understanding of impacts for global processes such as climate change. The wisdom and skills of local experts can complement other approaches used to understand the impacts of climate change on northern ecosystems.

In this thesis I address the contributions of Inuvialuit (Inuit of the Western Arctic) knowledge to understanding climate change. By documenting one community's

observations, perceptions and explanations of recent environmental changes, I demonstrate that Inuvialuit knowledge is a valuable source of local expertise that can complement existing understandings of change, as well as guide future research. Through an exploration of five “convergence areas” for linking traditional and scientific knowledge of climate change, I describe how climate change research can provide a rich setting for collaboration between scientists who study such change and communities who are experiencing it.

The research and ideas presented here are based on firsthand experience working with a community that is experiencing environmental changes they relate to climate, and a project that is documenting these changes. The thesis addresses the *how to* question: how to facilitate communication between two different groups of experts. While the discussion is specific to climate change research, much of what is presented here is applicable to a broader range of resource and environmental management issues. It is my hope that this thesis will contribute to the larger body of theory, research and practice that is working towards an Arctic science guided by both communities and scientists.

1.2 Objectives

This study was guided by two objectives. The objectives were designed to support participatory research and partnership with the community of Sachs Harbour, NWT.

1. To document the changes people in Sachs Harbour are seeing and explore the extent and scope of Inuvialuit knowledge of climate-related change.
2. To provide a conceptual framework to facilitate the use of traditional knowledge and western scientific approaches together for understanding climate change in the Canadian Arctic.

1.3 Research Context

The achievement of this study's objectives was possible through my participation in the project *Inuit Observations on Climate Change (IOCC)*. The project is a shared research effort between the International Institute of Sustainable Development (IISD) and the Inuvialuit community of Sachs Harbour, NWT. It was initiated by Rosemarie Kuptana, an IISD Board member and from Sachs Harbour, in response to community concerns about recent environmental changes that they have experienced. The project has several goals (based on Ford 2000):

- ❑ To understand how the community of Sachs Harbour uses traditional knowledge and local observation to perceive and explain climate change.
- ❑ To show Canadian audiences, interest groups and decision-making fora that climate change is making an impact on the traditional lifestyle and livelihood system of Inuit on Banks Island in the Beaufort Sea.
- ❑ To evaluate the potential contribution of traditional knowledge, local observations and adaptive strategies can make to scientific research on climate change.

The project has both a video and a science component. One of the main objectives was to produce a video that shows climate change phenomena through the eyes of local people and explains it according to traditional knowledge. The science component of the project was designed to create an opportunity for a group of invited scientists to work with community members to document and learn about Inuvialuit knowledge of climate change. Participatory methodologies such as community workshops and semi-directed interviews were conducted during a series of four community visits, at times during the year as determined by the community, in order to document climate change phenomena on a seasonal basis.

This thesis is a product of my experience from May 1999 to October 2000 working with the *Inuit Observations of Climate Change* project team. This experience allowed me to address the question of how to bridge the gap between western science and traditional knowledge, an ongoing challenge for many researchers working in environment and resource management. The quality and character of the research presented in this thesis is a reflection of the community's support for the IOCC project, and perhaps more importantly, their concern over the changes they have been experiencing in recent years. Finally, it is reflective of my own experience in the community; the time I spent visiting, travelling, and learning from the people of Sachs Harbour.

1.4 A note on terminology

In this thesis I use the terms 'traditional knowledge' and 'western science' to reflect different ways of knowing climate change in the North. I use these terms to indicate *how* and *why* knowledge was acquired (after Ferguson and Messier 1997), and also where the knowledge comes from and who acquires it. The distinction between traditional knowledge and western science is not intended to support a dichotomy or to commodify ways of knowing, but rather to recognize the *contexts* in which each way of knowing occurs.

1.5 Organization of the thesis

This thesis is organized into six chapters, including this introduction. Chapter two provides background and context for this study through a brief introduction to the community of Sachs Harbour as research partner. It also describes the role of weather in community life, and how and why Inuvialuit know so much about the weather and climate change. Chapter three outlines the methods used by both the *Inuit Observations of Climate Change* project and my own independent research. The methods are described

in the context of current debates concerning the problems and prospects associated with community based traditional knowledge research. Chapter four and five specifically address the two main objectives of my thesis. Chapter four addresses objective one, documenting the changes the people of Sachs Harbour are experiencing and discussing the extent and scope of Inuvialuit knowledge of climate change. Objective two is addressed in chapter five, by presenting a conceptual framework for linking scientific based research and traditional knowledge. Last, chapter six summarizes the main themes that have come out of the research, with concluding comments as to directions for future research.

Chapter Two

Background: The community of Sachs Harbour

2.0 Introduction

In this thesis, I document examples of one community's observations and knowledge of climate change, and explore the contributions of this knowledge to understandings of climate change in the Canadian Arctic. However, it is not sufficient to record a community's knowledge of change without giving that knowledge context. Inuvialuit knowledge of climate change needs to be addressed in the context of where the knowledge comes from and the way of life it exists within. Understanding the historical experience of the people and the places from where the knowledge originates is key to understanding community assessments of climate change. As Fox's (1998) research found, Inuit perceptions and understanding of climate and weather need to be addressed in the context of Inuit culture.

This chapter is intended to provide background and context for the thesis through a description of the physical landscape of Banks Island and an overview of Inuvialuit land use and occupancy of the region. In addition, the role and importance of weather to the Inuvialuit is introduced. The history presented here is brief and not exhaustive. Its purpose is to give the thesis a *setting* – a place and space in which it occurs. In acknowledging where this research comes from, I acknowledge that this work would not have been possible without the support and commitment of the people of Sachs Harbour. This thesis represents a shared effort, and a shared outcome.

2.1 Banks Island: Physical background

The physical landscape of Banks Island is representative of the Northern Arctic Ecozone, and is one of the coldest and driest regions in Canada (CNEF 1999). Canadian climate normals for 1961-1990 (Environment Canada 1998) put total yearly precipitation for the Sachs Harbour station at 126.5 mm (compared to 504.4 mm in Winnipeg). Yearly rainfall is calculated to 49.7 mm (Winnipeg – 404.4 mm) and yearly snowfall at 83.8 cm (Winnipeg at 114.8 cm). Snowfall can occur in any month, and rain occurs in the summer and fall, with July and August having the highest amounts of precipitation. The mean

annual temperature for the given time period is – 13.7 °C. As a coastal community, temperatures are moderated by open water during the late summer and early fall.

The community is located in a small bay known as Sachs Harbour, which is part of the larger Thesiger Bay in the Amundsen Gulf and Beaufort Sea. Banks Island is surrounded by a multiyear ice pack (summer ice) to the west and north, and by winter ice on the south between the Island and the mainland. The permanent polar pack ice begins northwest of the community, and there is a recurrent polynya and leads off the west and southwest coasts of the Island.

The Island is a periglacial tundra landscape, characterized by the freezing and thawing of the ground and the presence of perennially frozen ground, or permafrost. Permafrost on the Island is deep and continuous with a high ice content, and abundant ice wedges. Unconsolidated sands and gravels underlie most of the Island. The presence of permafrost dominates the landforms and geomorphic processes that occur in the region (French 1996).

Wetlands are abundant, covering 25-50% of the coastal plain region. Vegetation is characterized by mosses, with low-growing herbs and shrubs such as arctic willow, purple saxifrage, sedge and arctic poppy. Banks Island supports the world's largest muskoxen population, as well as the largest nesting population of snow geese in the Western Arctic (Sachs Harbour Community Conservation Plan 1992). Other wildlife include Peary caribou (*Rangifer tarandus pearyi*), which number less than a thousand and are considered an endangered population. The region also supports arctic hare, arctic wolf, white fox, ground squirrels, snowy owl, raptors, polar bear, seal, seabirds and waterfowl.

2.2 The community of Sachs Harbour

Sachs Harbour (*Ikaahuk*) is the only community on Banks Island – or Banksland, the most westerly island of the Canadian Arctic Archipelago. It is one of six communities in the Inuvialuit Settlement Region (ISR) under the Inuvialuit Final Agreement (IFA), or

Western Arctic landclaim of the North West Territories (Figure 1). It is geographically located at 71° 59' N, 125° 14' W.

Sachs Harbour became a permanent community in 1956, when seasonal trappers began to spend their entire year on the Island instead of returning to the mainland each summer to resupply their outfit. However, the history of land use and occupancy on Banks Island extends much beyond the 1950s, to the times of early Pre-Dorset and Thule occupants, more recent Copper Inuit (*Inuinnait*), whaling ships, arctic expeditions and the development of the Western Arctic fur trade.

Understanding the history of the community is central to understanding the community today. This section provides a brief account of the early history of the Island and the families that now settle in the community of Sachs Harbour. Historical material is drawn from Usher's (1965, 1970, 1971) series on the economy and ecology of Sachs Harbour as a frontier trapping community; the *Banksland Story* (1969) written for the Sachs Harbour school by Father Lemer O.M.I. and community Elders; Stefansson's (1923) writings on the Canadian Arctic Expedition; the Aulavik oral history project (Nagy 1999), and other background documents written for Parks Canada preceding the formation of Aulavik National Park (e.g. Stevenson 1993). Last but not least, background for this section comes from the people of Sachs Harbour, who retain their unique history as Bankslanders.

The use and occupancy of Banks Island by Copper Inuit is one aspect of the history of Sachs Harbour. Many families in the community of Sachs Harbour are of Copper Inuit descent, and speak of how their ancestors have always known this place, spending winters on the sea ice and summers on Banks Island long ago. These were the *Kangiryuarjatmiut* from Minto Inlet and the *Kangiryuarmit* from Prince Albert Sound, both on Victoria Island to the east. Elders such as Edith Haogak and Sarah Kuptana tell stories of how the lakes and rivers of Banks Island all had names before people from the mainland began to arrive (pers. comm. February 2000).

Another aspect of Sachs Harbour's history is the development of the fur trade in the Western Arctic, which followed the decline of whaling in the region. As Usher (1970:26) describes, the Western Arctic fur trade was unlike any other area of Canada, characterized by "individual enterprise, competitive trade, and an abundance of material

goods; an economic milieu already familiar to the Eskimos of that region from the whaling days". It is the fur trade, beginning in the 1920s, which is most commonly associated with the history of Banksland.

A group of mainland trappers became known as "Bankslanders". These were trappers who traveled to the Island by schooner each fall to spend the winter trapping white fox. Trappers were both Mackenzie Inuit and Alaskan immigrants, but also what was known as a new generation of trappers – men whose mothers were Mackenzie Inuit and fathers were whalers. The shortage of white fox on the mainland and increased competition from white trappers in the 1920s provided additional impetus to go to Banksland. However, it was only an elite group of trappers who were able to go; the trip required the purchase of a schooner and an outfit for the entire winter. In 1920 the Banks Island game sanctuary was created, protecting trapping rights of the native trappers and preventing competition from non-native outfits.

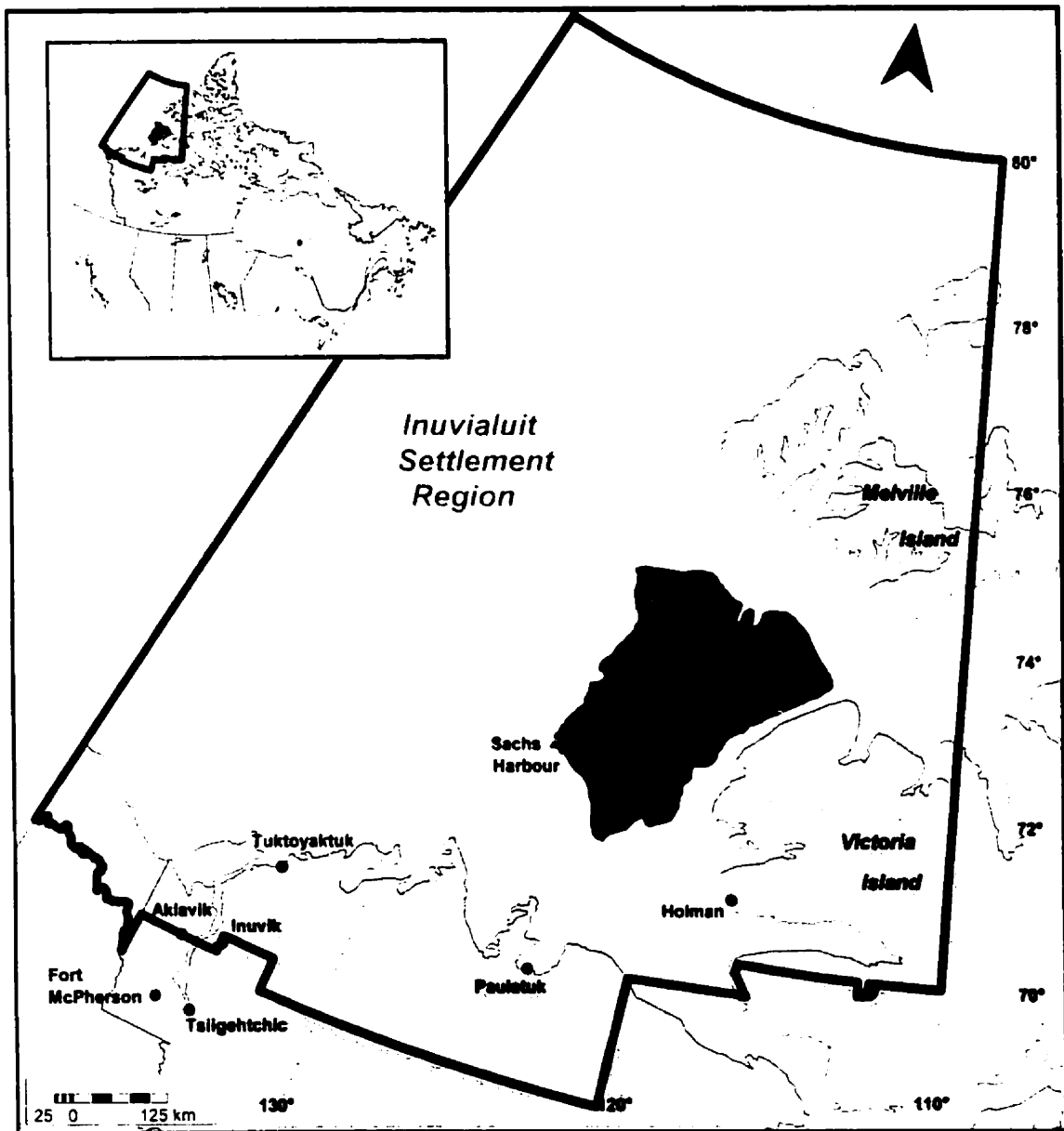
In the period 1928-36, Inuit trappers had familiarized themselves with the resources and topography of much of Banks Island (Usher 1970). Thus, long before there was an established community, there was a distinctive group of families known as Bankslanders who traveled to the Island in the fall and returned to the mainland when the ice cleared in the spring. Many of these families remain on the Island today.

The schooner had become symbolic of the special identity of the Bankslanders, especially in the 1940s and 1950s. The arrival of the Banksland fleet at Aklavik was an exciting and awesome event to both natives and whites alike (Usher 1970:72).

Sachs Harbour today

As with other Arctic communities, the last 50 years have seen Sachs Harbour undergo significant socioeconomic changes, from trapping to the DEW lines, to oil development and more recently, co-management agreements. The community now has a school from kindergarten to grade eight, a nursing station, arena, guesthouse and the Ikaahuk co-op. There is a small airport, and two flights a week come into the

Figure 1: Map of the Inuvialuit Settlement Region, NWT, showing Banks Island the community of Sachs Harbour.



community from the mainland center of Inuvik. Trapping is no longer the economic basis of the community, as a result of the collapse of the fur market in the 1980s, however land based activities remain a central component of community life. Following the settlement of the Inuvialuit Final Agreement (IFA) in 1984, management of fish and wildlife resources became a shared responsibility between Inuvialuit and the federal and territorial governments under five new co-management bodies.

As of 2000, the population of Sachs Harbour is approximately 120 people. The Island remains rich in wildlife and fish resources. The economy is based on a mix of subsistence hunting and trapping, administrative jobs (i.e. Hamlet, community corporation), other wage labour, private business, arts and crafts, government jobs (Parks Canada), small-scale tourism, sport hunting and guiding, and transfer payments. The Hunter and Trapper's committee, Hamlet Office and Community Corporation are responsible for community affairs. Most families in the community still make some part of their living from the land. Hunting and fishing are still the primary sources of food, and sport hunting and some trapping provide additional cash income. These land-based activities also are a source of Inuvialuit identity (see also Stairs and Wenzel 1992).

2.3 Seasonal harvest activity

The community of Sachs Harbour harvests some 20 species of wildlife including fish, marine mammals, and terrestrial mammals and birds (SHCCP 1992; Fabijan (Inuvialuit Harvest Study) 1989, 1996, 1998, 2000). Caribou (*tuktu*) and muskox (*umingmak*) are the primary sources of meat for the community, although currently caribou populations are very low and only a few are harvested each year. Arctic hare (*ukalliq*), wolf (*amaruq*) and white fox (*tiriganniaq*) are harvested in winter months, with wolf and fox harvested for fur. Several fish species are harvested, from gill nets, ice fishing, and rod and reel. Ringed seal (*natchiq*), bearded seal (*ugyuk*), and polar bear (*nanuq*) are the primary marine mammals harvested. More ringed seal are taken than bearded. Polar bears are harvested both for community use and for sport hunts. Walrus (*aiviq*) are only seen occasionally in the area, and one or two may be taken each year.

The lesser snow goose (*kanguq*) and its blue phase, white fronted goose (*tingmiaq*), Canada goose (*uluagullik*), brant, eider duck (*qaugaq*), swan (*qugyuk*), sandhill crane (*tatidjgaq*) and ptarmigan are the most common bird species to be harvested.

Table 1 describes the primary species and quantities harvested by the community in 1998, based on Inuvialuit Harvest Study data. It also illustrates the annual cycle of harvesting activity in the community of Sachs Harbour. During the winter, roughly from November to the end of February, harvesting activity includes some sealing, hunting of arctic hares, muskox and caribou, as well as any white fox trapping that may still be done and the occasional wolf that may be harvested. In the past, this would have been the main white fox trapping season. Subsistence hunting of muskox is highest in the winter months, from September to March. Polar bears are also harvested at this time, however most bears are taken in late winter and early spring for both sport hunting and local use. Many hunters will spend up to two weeks at a time on the ice hunting polar bears. As the weather begins to warm in March and April, people head out to numerous inland lakes for ice fishing for both lake trout and landlocked Arctic char.

In May fishing slows for the goose-hunting season, along with egg collecting. Banks Island supports the largest nesting population of snow geese in the Western Arctic, and the goose-hunting season is one of the most important times of the year for the community. Families camp near numerous rivers and inland lakes during the goose-hunting season, although Middle Lake (east of the community) is the most popular spot. Eggs are collected in early June, mostly at Egg River. Geese are traded to friends and family on the mainland in exchange for *muktuk*. The entire community is busy for the spring, plucking, cleaning, freezing and drying geese.

By mid June when goose hunting is over, if there is still ice, people return to the lakes to fish. They will also fish for cod on the sea ice in the harbour, often through natural holes in the ice. June and July are also the primary months for seal hunting. With the summer and the break up of the ice, people hunt seals off the ice floes, or from boats in the open water. Most seals are ringed seal, but some bearded seals are taken as well. By July gill net fishing has begun, with nets set along the mouth of the Sachs River for cod, least cisco and char. All through August and into early September, families will check their nets each day. Many families spend weeks on end at their camps, some as far

Table 1. Sachs Harbour hunter reported and estimated fish and wildlife harvest for 1998. Source: Inuvialuit Harvest Study Final Data Report (after Fabijan 2000).

ANIMAL NAME	Total reported harvest	1998 Monthly reported harvest											
		Jan	Feb	Ma	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
FISH													
Arctic charr	254				5	8	58	154				29	
Lake Trout	150				5	22	59	49		5		10	
MAMMALS													
Ringed seal	61			15	6		10	29	1				
Bearded seal	7						1	4				2	
Polar bear	4		1	1	2								
Caribou	6									2		4	
Muskox	95				1	31	5	10		3	10	28	7
Wolf	23	1			18						2	2	
Arctic Fox													
White	84											41	43
Red	1											1	
Rabbit	6				3					1		2	
BIRDS													
Snow goose	1648					1636	12						
Snow goose (blue)	1					1							
Swan	2					2							
Ptarmigan	212									11	61	140	
Eider	5									5			

Note: On average, monthly harvesting information was obtained from 77% of the known hunter population.

as 60 km away from town, at inland lakes use rod and reel to catch fish. Many of the fish at this time of year are dried for the winter months. Muskox are also hunted in the summer months, and drymeat (*mipku*) is put away.

By early September, gill net fishing has declined. Falltime is when caribou may be taken, although due to low numbers, a quota of one caribou per family is currently in effect. People continue to hunt muskox for food until the fall rut begins. With freeze up and the beginning of winter, the community begins preparing for the muskox harvest. This is a commercial harvest which does not happen every year. It employs almost the entire community, as well as people from other communities, for much of November.

2.4 Inuvialuit knowledge of the weather and climate

Observations and assessments of climate change in the community of Sachs Harbour are based on peoples' knowledge of the weather, or *sila*. While my research focused on *change* rather than Inuvialuit knowledge of the weather and climate itself, I recognize that the community's knowledge of change is rooted in a rich tradition of understanding, interpreting and predicting the weather. Thus, it is necessary to provide a brief background of the role of weather in Inuvialuit culture and daily life, and how accumulated knowledge of the weather contributes to community assessments of change.

Inuvialuit in Sachs Harbour know a lot about the weather, and its relationship to other parts of the environment. Weather is experienced on a daily basis; knowing about the weather is an integral part of community life. People most often relate to weather in terms of overall environmental conditions rather than as something measured numerically (see also Brody 1975). It is one aspect of the knowledge Inuvialuit possess; part of the larger body of traditional and local knowledge relating to the land, seasonal cycles, processes and relationships between the elements of the environment (Box 1). The weather is perhaps the most closely observed of all natural phenomena (Aodla Freeman 1994); understood through such phenomena as the sky, clouds, temperature, winds and animal behavior (Fox 1998, Nelson 1969). People watch the weather, because the weather tells when it is a good time to go out on the land, leave for a camp or plan a

hunting trip. The weather dictates if a plane will come that day, bringing mail and supplies. It influences when the geese will arrive, when the sea ice will begin to break, if the fish will bite, or a storm will come.

Box 1

What is Inuit Qaujimajatuqangit?

The question itself is like asking how many grains of sand there are on Baffin Island. We can never hope to count each and every grain of sand, but we can describe what a grain of sand generally looks like.

IQ as an epistemology or theory of knowledge can be outlined as follows:

- ❑ It is a set of teachings on practical truisms about society, human nature and experience that is passed on from one generation to the next.
- ❑ It is knowledge of the land that covers weather patterns, seasonal cycles, ecology, wildlife, resource use and the inter-relationships of these elements.
- ❑ It is holistic, dynamic and cumulative approach to knowledge, teaching and learning; an approach best learned by observing, doing and experience.

Source: J. Arnakak (2000), Nunavut Social Development Council

Inuvialuit knowledge of climate change comes from experience and observations of the weather over time. This knowledge captures a sense of “normal”, or expected variability and fluctuation in the Arctic environment. This sense of *normal* conditions is fluid and changing. Assessments of change are derived from this sense of normal, as it provides a baseline against which to compare change. Inuvialuit knowledge can identify a window of expected variability relating to such phenomena as sea ice conditions, the timing of freeze up and break up, seasonal temperatures and precipitation, wind strength and direction at a given time of year, or rates of erosion. Thus, community-based assessments of climate change have the capacity to capture changes in *situations* and

conditions that may not be possible to the same extent using techniques such as weather station records and 30-year climate normals.

Different people in the community know different things about the weather and climate change. The extent and scope of Inuvialuit knowledge of the weather and climate change varies between generations, genders, and livelihoods. For example, a forty-year-old man may compare the changes he is currently observing to his own life experience. In some cases, these observations may be compared to knowledge passed on to him by parents and grandparents. An Elder may have a different sense of normal, one that is a product of a long remembered past. When Elders in Sachs Harbour explain to me that the weather, *it is not the same now*, I know that this assessment is coming from a different place than the younger community members. It is coming from a keen understanding of expected variability that is based on many years of experience.

A story told by one Elder in Sachs Harbour describes how long ago the weather was always good on Banks Island. Shamans used to bring the good weather from Banks Island to the people when they were on Victoria Island. Now the weather is not the same anymore. Things are happening at the wrong time. The years are getting crazy and the seasons are unpredictable. The weather is changing.

Today, a combination of “old” and “new” techniques may be used to forecast the weather, but the role of the weather in Inuvialuit life has not changed. The internet, television and CBC radio are used alongside the time-tested signs like the way the sled dogs howl in the early evening or the clouds that stretch themselves along the tops of the hills in long, thin, pale streaks that bring good weather. People know about the weather the same way they know about the land and the sea ice. It is a part of being Inuvialuit.

Chapter Three

Research Approach and Methods

Over and over again, villagers' statements reflect their view that how things are done in their area is as important as what is accomplished.

- Fienup-Riordan (1999), in "Yaqlget qaillun pilartat (what the birds do): Yup'ik Eskimo understanding of geese and those who study them". Arctic 52: 1-22

I think all projects should be considered this way, where you meet with the people and start from where the knowledge is – and work your way up from there.

- John Keogak, Hunter and Trappers Committee, Sachs Harbour, NWT. 1999.

3.0 Community-based traditional knowledge research: problems and prospects

The growing recognition of the value of traditional knowledge as a perspective different from scientific knowledge, coupled with the assertion of Aboriginal rights to manage and govern resources, has made traditional knowledge one of the leading issues in the north. The collection and analysis of traditional knowledge is a recurring theme in Arctic science and literature (e.g. Ferguson and Messier 1997; Huntington 1998; Fehr and Hurst 1996). Although the value of promoting collaboration between traditional knowledge and western science is recognized, questions of how to link or create a conversation between scientists and communities remain unresolved.

The push to use both traditional knowledge and western science in areas such as policy, protected areas, co-management and environmental assessment, has left researchers, practitioners, decision-makers, bureaucrats and communities alike scrambling to address how to find common ground. The last decade and a half has seen an explosion of conferences, workshops, working groups, information networks, and other organizations, as well as a substantial body of academic literature devoted to collecting, documenting and finding ways to “integrate” traditional knowledge and western science (Nadasdy 1999).

Linking western scientific approaches with traditional knowledge is complicated by issues of intellectual property, power relations, interpretation, cross-cultural communication, verification, logistics, and epistemology (Wenzel 1999; Nadasdy 1999; Nutall 1998; Morrow and Hensel 1992). Attempts to bridge the gap between traditional knowledge and science have invoked questions of the decontextualization and reification of local knowledge (Cruikshank 1998, Nadasdy 1999). There is no established methodology for traditional knowledge research; as a relatively recent field of academic interest and study, the question of appropriate methods and protocols is still being addressed. In addition, research projects that seek to include traditional knowledge often have both time and financial requirements that surpass what is available through project funding structures.

The methods used in this thesis are very much a reflection of current perspectives and debates concerning traditional knowledge research. They are also a reflection of the

significant changes northern science has undergone changes in the last decades. Northern research in previous decades often extracted knowledge from communities for exogenous purposes (Briziski 1993). Arctic physical and biological research, for the most part, relied exclusively on western science. Traditional knowledge was frequently dismissed as anecdotal, lacking rigor and verification. While northern research was providing the information necessary to improve services to communities and manage resources, there was little meaningful input from communities, or traditional knowledge. Most northern research of the past often served to marginalize, rather than assist, northern people.

More recently, Arctic science has taken on an interdisciplinary flavor, often crossing the boundaries between the social, physical and biological sciences. Increasingly, scientists and other researchers are engaging in traditional knowledge research and seeking out partnerships with communities (e.g. Huntington et al 1999). Traditional knowledge is seen as both a source of environmental expertise, and a means to ensure that research is socially relevant to communities. The success of recent community-based projects such as the Tuktu and Nogak Project (Thorpe 2000), and the Hudson Bay Bioregion Project (McDonald et al. 1997) illustrate the potential and promise of this kind of research.

There are inherent challenges and problems, as well as prospects and promises, associated with traditional knowledge research. Community-based traditional knowledge research requires creative methodologies outside the scope of standardized research techniques and tools. Such research, by its nature, demands that projects benefit communities as well as providing information for others. Thus, methodologies must be founded on principles of respect, reciprocity and partnerships. This kind of research is characterized as *enriching*, as opposed to extractive (Grenier 1998).

3.1 Research Approach

The research for this thesis comes from two sources: (a) my role as a member of the *Inuit Observations of Climate Change Project* (IOCC), and (b) further independent research and fieldwork in Sachs Harbour. On a broad scale, the intent of this thesis is to explore the relationship between Western science and traditional knowledge, and propose ways to bridge the gap between them. The *Inuit Observations of Climate Change* project was an ideal opportunity to do this kind of research. It provided a process, or framework, to explore issues such as collaboration between scientists and communities. My role in the IOCC project was as a member of the science team, and working with a team of scientists within the larger project gave me firsthand experience in the process I wanted to explore.

The approach used by the IOCC project was based on designing a collaborative project, recognizing that the meaningfulness and accuracy of any traditional knowledge project is based on ensuring the direct participation of the community (Johnson 1992). The intent was to pass ownership of the project to the community, with the project team providing support and facilitation. Community-based workshops and other participatory methodologies were used to create a *process* for collaboration and communication.

In addition to my participation in the IOCC project, I spent additional time in the community after each trip. The purpose of this additional research was to add depth to observations, follow up on key issues, experience community life and how changes affect the community, and to build a relationship with the community upon which to base what I was learning.

In my own research, I adopted a *relationship-based* approach. In other words, I worked towards creating a relationship with people in the community that was characterized by trust, respect and reciprocity. When I began this project, I was very conscious of going into a community that was not my own and *doing research*, as a southerner, as a non-Inuk. In my experience, good research relies on establishing a relationship with the people from whom you want to learn, a relationship based on learning and sharing. This makes the research an exercise in receiving shared information rather than taking information (Robinson et al. 1994), and in trying to experience

traditional knowledge as well as study it. Such participatory research works with community members as collaborators rather than “informants” (Deloria 1995).

Part of taking a relationship-based approach to research was to ground my methods in Aboriginal perspectives and principles, at least to the extent of my own knowledge and experience. As articulated in the original proposal for this research, why not use “traditional methods” to study traditional knowledge? While not disregarding the diversity of First Nations and Inuit culture and peoples, there may be certain principles or “methods” for learning that may be distinguished as uniquely “Aboriginal” (see also Colorado 1988, Simpson 1999, Dyck 1996, Tuhiwai Smith 1999). Thus, while I used established social science methods, they were guided by Aboriginal principles. To this end, I focused on working with elders, listening, learning by doing, storytelling and oral traditions, humour, and reciprocity.

This approach emphasized the social context that my research was occurring within, and paid attention to how knowledge was communicated in the community itself. The goal was to generate a meaningful *process*, through building *relationships* within which to collaborate with the community in documenting their observations and knowledge of climate change.

A summary of the methods used for the IOCC project and in my own research is provided in Table 2 at the end of this chapter.

3.2 Inuit Observations of Climate Change Project: Methods

The nature of the *Inuit Observations of Climate Change* project, with both a scientific and documentary video component, resulted in a diverse group of methods to document and explain changes the community was experiencing. Thus, the research for this thesis is a product of a much wider range of methods and techniques than would have been possible in an independent study. My thesis is enriched by the methodologies and the expertise found in the interdisciplinary nature of the project team. In this section, I describe the methods used by the IOCC project, with emphasis on the scientific

component of the project, and the methods the science team used to work with the community to explore the contribution of traditional knowledge to scientific research.

The IOCC project was designed around participatory methodologies that would ensure that results accurately reflected Inuvialuit viewpoints, observations and traditions. These methodologies contain elements from Participatory Action Research (Ryan and Robinson 1990) and Participatory Rural Appraisal (Chambers 1991), emphasizing the direct participation of the community, with community members playing an active role in setting priorities and determining research topics. They include community-based planning workshops, filming of a video, travelling with people out on the land, the creation of an advisory board, and semi-directed interviews. These kinds of approaches have been used successfully in other northern traditional knowledge research projects (Johnson 1992; Johnson and Ruttan 1993; McDonald et al. 1997; Huntington et al. 1999; Ferguson et al. 1998).

The project also used techniques developed by the project leader from his experience with the “ZOPP” (*Ziel Orientierte Projekt Planung*, or, “*Objectives Oriented Planning*”) approach used by GTZ, a German development agency (Ford 2000). These techniques are designed by community-based workshops, to allow community members to identify and analyze issues, problems and priorities as they see them. Tools such as “problem trees” focus on encouraging participation by everyone at the workshop, regardless of age or gender. These techniques, in conjunction with several PRA methods, formed the basis of the initial planning workshop in the community, described below.

3.2.1 Participatory community-based planning workshop

The first trip to Sachs Harbour was made in June 1999, to hold a planning workshop for the project. This initial two day workshop had three purposes: (i) to describe the project to the community; (ii) to allow the community to describe their livelihood system and discuss the changes they are experiencing; (iii) to work with the community to plan further trips to the community. Using the exercises and techniques developed from ZOPP and PRA, the project team worked with the community to design

how the project would proceed in terms of presenting Inuit observations and knowledge of climate change through film and scientific interviews.

The focus of the planning workshop was to have the community identify and analyze the changes they were experiencing and the impacts on community life. This was accomplished using *brainstorming* (issue identification), “*problem trees*” (cause-effect analysis), *timelines* (establishing community history), *ranking exercises* (highest priority research items) and *seasonal calendars* (harvest activity). A more detailed description of these methods is found in Appendix A.

This workshop set the groundwork for all further research in three ways. First, it created a collaborative process, whereby the community is an active partner in designing and implementing the project. Second, it identified a wide range of environmental changes being observed by the community, observations that provide the basis for further research. Finally, it identified the times of year that the next three trips should take place, and the phenomena that should be investigated.

In addition, the workshop set a precedent for the project. As one member of the Hunter and Trappers Committee commented, “I think all projects should be considered this way, where you meet with the people and start from where the knowledge is – and work your way up from there” (J. Keogak, Sachs Harbour).

3.2.2 Community Liaison

Rosemarie Kuptana, originally from Sachs Harbour and now living in Ottawa, was a community liaison for the project. The high attendance at the June workshop (31 adults), while indicative of the community’s commitment to the project, was also largely a result of Rosemarie’s work. Our first two days in the community were spent going to each household with her, introducing ourselves at each household, having tea with people, discussing the project, and inviting everyone to the workshop. A second community liaison, Donna Keogak, was chosen by the community during the planning workshop. This position was created in order to keep communication open between the IISD in Winnipeg and the community. This liaison worked with coordinators in Winnipeg to plan each trip, organize transportation and accommodation in the

community, plan activities and other arrangements. Near the end of the project, this position was assumed by the Hunter and Trappers Committee.

3.2.3 Repeat visits

Further trips were made to the community were in August 1999, February 2000 and May 2000. During the planning workshop it was clearly important to the community that the project provide a picture of change in all seasons, and within the context of specific seasonal activities such as the spring goose hunt. This would give the project team the opportunity to go out on the land and see firsthand how climate-related changes are impacting their way of life.

The project team was in Sachs Harbour for one week during each of the four trips. During this week the video team worked with the community to document changes and experiences for the video, and the science team conducted individual and group “expert on expert” semi-directed interviews.

3.2.4 Filming

The filming of a video documenting the community’s perceptions of climate change was one of central features of the IOCC project. While I was not involved directly with the filming of the video, it was valuable to experience and observe the potential of film or video in documenting or communicating traditional knowledge. The video was also key to community involvement; it was a tangible output, through a medium familiar and accessible to community members.

3.3 Working with a team of scientists

The second goal of the *Inuit Observations of Climate Change* project is to explore the contribution that traditional knowledge, local observations and adaptive strategies can make to scientific research on climate change in the Arctic. In keeping with this goal, a group of northern “guest scientist” researchers was invited to participate in the project as a science team. The goals of the science team were to: explore the extent of climate-related traditional knowledge and local observation in the community; determine the relevance of that knowledge to scientific research on climate change; and develop a process to facilitate collaboration and communication between scientists and communities in the North.

The scientific component of the project was designed to provide a framework to give individual scientists the opportunity to learn from the community and see how local observation and traditional knowledge could contribute to their research. Guest scientists were selected based on their research expertise and the phenomena that the community had identified as priority in the planning workshop. The team included Theresa Nichols (Oceans Policy, DFO), John Nagy (Renewable Resources, GNWT, Inuvik), Stephen Robinson (Geological Survey of Canada, Ottawa) as guest researchers for each individual trip, and the lead scientists Norm Snow (Joint Secretariat, Inuvik) and myself. My role was to work with the team to conduct interviews, transcribe interview tapes, and conduct follow up interviews after the team departed.

The idea of guest scientists ensured that there was enough expertise within the science team to capture the depth and richness of community-based assessments of change and traditional knowledge. For example, investigating the potential impacts of climate changes on wildlife such as *tuktu* (caribou) and *umingmak* (muskox) could only have been carried out to the extent it was by having two groups of experts, scientists who knew about caribou and muskox, and local experts who knew about caribou and muskox. Involving a group of specialists addresses one of the potential problems in traditional knowledge projects, particularly those focused on specific environmental or ecological information. Johannes and Lewis (1993) point out that often the lack of expertise in the area of study by the researcher makes such research difficult.

3.3.1 *Semi-directed interviews*

The primary method of the science team was the semi-directed interview. Open-ended, semi-directed interviews, where the researcher does not ask predetermined questions but allows for the flexibility of responses, are accepted as appropriate study methods for understanding the complex relationship between land and land users (Mailhot 1993, Huntington 1998). The method is described as an informal listening technique that uses some predetermined questions and topics, but allows for new topics to be pursued as the interview develops (Grenier 1998, Chambers 1991).

We used the technique to build on the observations and examples collected in the initial planning workshop, using topics pre-determined in the June workshop as a starting point for our questions. For example, an open-ended question would begin with statements such as “the last time we were here, people said there was less ice in the summer”, or “last time when we were here, people told us the land was going down in some places”. These questions, based on earlier comments and observations, allowed the person being interviewed to start from a familiar starting point. By using the results of the issue identification exercise in the planning workshop as a base from which to build upon, we found that subsequent interviews:

- added more detail
- gave context; placed the observations in time and space
- allowed for the separation of climate-related observations from non-climate related observations of change.
- allowed for the stratification of observations and the identification of which community members were observing which phenomena
- gave insight into indicators of change, as used by the Inuvialuit
- helped to secure unclear species identification (i.e. fish species) using both Inuvialuktun and common names.

Each trip interviewed many of the same community members, but involved a different guest scientist and looked at a different climate change phenomena. A summary

of topics covered during each trip is provided in Table 2. Interviews generally began by establishing when the person came to Banks Island and the extent of the person's knowledge of the area, including primary hunting, trapping areas, travelling and camps. For example, we would begin an interview with a discussion of where a former trapline was located.

Table 2. Summary of topics covered during each trip.

Trip 1 (June 1999)	Community workshop, introduction of all issues, brainstorming session, identification of priority concerns
Trip 2 (August 1999)	Sea ice related change; changes related to multiyear and pack ice conditions; changes in the distribution and extent of sea ice, sea mammals such as ringed and bearded seals, polar bears, ice thickness, ice safety, ice features such as pressure ridges, ice thickness, indicators of change, freeze up and break up, as well as changes relating to summer seasonal activities such as gill net fishing and seal hunting.
Trip 3 (February 2000)	Wildlife related change; caribou, muskox, wolf populations over time, the relationship between species, animal condition/health, severe weather events and the impacts on caribou and muskox, snow depth on winter ranges, occurrence of freezing rain, vegetation changes; changes related to insects and the impacts on animals, as well as the impacts of change experienced by the community during fall and winter harvesting and community activity.
Trip 4 (May 2000)	Potential impacts of climate change on permafrost; active layer processes, thaw slumps, inland lakes and erosion, coastal erosion, water levels and ice wedges, as well as the impact of permafrost melt on travel, accessibility, buildings and roads; changes experienced by the community during spring seasonal activities, such as ice fishing and goose hunting.

Most interviews were conducted in people's homes over tea, however, some interviews were conducted out on the land. This allowed the interviewees to take the science team out, following the interview, to show what they were talking about. For example, two men were interviewed at the spring goose hunting camp at Middle Lake. The discussion centered on permafrost and erosion. During the interview, the men made several references to pingos, thaw slumps and erosion in the area. When the interview concluding, they took the science team out to these areas to show them what they were describing.

All interviews were taped on 90-minute audiocassettes, and later transcribed. In most cases, detailed notes were taken as well. Translators were used when needed, however most of the interviews were conducted in English. I did much of the transcription while in the community, thus leaving room for verification or double-checking information. In some instances the Elder I lived with (Mrs. Sarah Kuptana) was present when I transcribed, and offered help with translations and clarifications, as well as adding in further stories and observations.

A total of 36 interviews were conducted in the community with 17 community members over the length of three trips. 30 of the 36 interviews were done by the science team during project trips; I conducted the other 6 interviews on behalf of the team. Five people were interviewed only once, seven were interviewed during all three trips, and five people were interviewed at two of the three trips. Interviewing people more than once helped to maintain consistency and continuity in our interviews.

These interviews were done with active harvesters and Elders, both male and female. Approximately half of the interviewees were Elders. We used a combination of individual and group interviews (i.e. individual, father/son, three women, two men, husband/wife). When the number of interviews is considered in the context of the community population and age structure, the interviews represent the full population (and not a sample) of Elders and those families who are active harvesters. Appendix B shows the gender and age stratification of the community of Sachs Harbour.

3.3.2 Mapping techniques

Mapping techniques have been used in northern research to learn about individual and community land use, wildlife habitat, distribution and movement, local place names and history, as well as a variety of other phenomena (e.g. Ferguson et al. 1998). Map biographies are used in land use and occupancy studies such as Freeman (1976), Riewe (1992) and Robinson et al. (1994). The use of mapping techniques has extended into community-based GIS projects, used to store and convey traditional knowledge (Harmsworth 1998; Tabor and Hutchinson 1994).

We used several types of mapping techniques in the community interviews. Photocopied representations of the entire Island and coastal ocean region were used in Trip one, to allow community members to draw the extent of pack ice in specific seasons, the location of near shore leads, or other sea ice related change. While this exercise had the potential to be very useful, it did not produce any results that could be compiled into a map of sea ice related change over time. Very few interviewees actually drew on the maps. We think this was due to the coarseness of the map scale we used; a finer scale showing rivers and lakes would have represented more of a realistic picture of the land and ice (T. Nichols, pers. comm.). However, I also tried to map other aspects of sea ice related change in subsequent trips and was not successful. I was told that “*it changes too much, you can't draw change with a line on a map*”. While we had assumed it would be relatively easy to illustrate where the permanent pack ice used to be, as opposed to where it is now, community members felt it was more appropriate to verbally describe these changes.

We also used topographic (1:250 000) maps, depicting the land area around the community, to use as references (for the science team) to locate places that people were talking about. For example, a group of lakes southeast of the community are often referred to in interviews, as they are primary fishing lakes. It was important to visualize and reference these and other locations, to place observations in context.

3.3.3 Pictures and photographs

When you are working with two kind of experts in one room, trying to establish and explain the kinds of changes that are occurring, there is a need for different kinds of methods to aid communication. Pictures and photographs were used during the interviews to help the science team and interviewees communicate phenomena that were difficult to convey verbally. The pictures ensured that we were all talking about the same thing. For example, the term *thaw slump* was not very helpful in our interviews, but a picture I had taken the previous trip of thaw slumping at a nearby lake communicated the concept ideally, and made a good starting point for further discussion.

The usefulness of this kind of tool is illustrated in the following excerpt from an interview with John Lucas Sr., in trip four, focusing on permafrost-related change. We were using a picture of Angus Lake, a lake that used to be a popular fishing spot, but now the banks are too steep to fish in the lake. We were discussing thaw slumps, and trying to get at how recent thaw slumps can be distinguished from natural, expected occurrences.

Q: We are trying to get some sort of idea as to how long those things would last....is it year after year after year that you would see mud in the water?

A: These ones here (refers to picture) when you see them.. it is just about all in same place all the time. When the ground get dry up here (top of ground in picture), this is always wet, it continues (bottom). Because there is permafrost under here, and it is melting all the time when the snow is gone. It is always dark... you can notice from a distance when you are travelling.

Pictures were also used in follow-up research to clarify species identification and Inuvialuktun terminology for several fish species. For example, in many interviews, people described recent increases in *herring*, or blue herring. The Inuvialuktun name was given as *qaaqtak*. In following up on the species, using pictures from Scott and Crossman (1973), I found that the fish called *herring* was a *Least Cisco*. Interestingly (and not unexpected!), when I approached one elder about how I had finally figured out that herring was a cisco, he told me “of course it is!”.

3.3.4 Feedback to the community

Feedback to the community was an important component of the IOCC project. After each trip, a trip report was prepared, summarizing the activities of both the science and video team, as well as including several pictures taken by the project team during the trip. It also included the production of a newsletter (Appendix C), as feedback for the community, describing conferences, papers and other activities relevant to the project. Finally, a rough-cut of the video (9 minutes) was shown to the community in February to get initial response to the direction the video was taking. In July, a second rough-cut was shown, allowing the community to make final changes before the video was completed and distributed. As well, several hours of reel to reel film canisters were loaned to the project team by several members of the community to use in the video. The coverage included shots of the schooner days, dog sleds, and early life in Sachs Harbour. In exchange for the use of the archival footage, the video team transferred the images onto videocassettes, a format more useable by the community.

3.4 Independent Research and Fieldwork

A good part of this thesis stems directly from my participation in the *Inuit Observations of Climate Change* project. Doing this kind of research as part of a larger project gave me the opportunity to work in a team setting with scientists, in an “expert talking to expert” framework, thus allowing more depth and accuracy in questions and answers than otherwise possible. It also allowed me the opportunity to experience firsthand the collaborative process that is at the heart of my research.

However, the research presented here is also a reflection of further independent research and fieldwork. This research focused on spending time in the community and learning from people outside of the organized framework of the project. It also included historical research. My independent research was designed to complement the process established by the project team.

3.4.1 Spending time in the community: Relationship-based research

An additional thirteen weeks were spent in Sachs Harbour over three trips. Rosemarie Kuptana, a member of the project team, arranged for me to live with her mother, Mrs. Sarah Kuptana. Mrs. Kuptana is the “eldest Elder” in Sachs Harbour, she turned 80 during my stay in the community.

Spending additional time in the community allowed me to follow up on the findings of the science team, adding depth to observations and explanations of change. I conducted additional semi-directed interviews for the purposes of the larger project, however much of my learning was informal, relying on direct observation and experience. This additional research reflects social science methodologies such as participant observation (Jorgenson 1989, Dene Cultural Institute 1994, Bernard 1994, Kirby and McKenna 1989). Participant observation is considered an appropriate methodology for community-based traditional knowledge research (DCI 1994), particularly when there are differences between the views of “outsiders” and “insiders” (Jorgenson 1989).

However, while I used established social science methodologies, they were guided by a broader approach to research. As described in the introduction to this chapter, my research was *relationship-based*. The way I did my research was as important to me as what I accomplished. Thus, the emphasis was on creating a research space and process, characterized by respect, sharing, reciprocity, humour and humility. These principles are based on Aboriginal knowledge, learning and codes of conduct. For me, coming from a First Nations community, using these guiding principles ensures *doing things the right way*. In my mind, how the community viewed me and my research was a measure of the quality, accuracy and promise of the research.

Staying in the community gave me the opportunity to place what I learned in a richer community context, to an extent not possible within the time and methods used by the project team. Participating in everyday activities lent to a fuller understanding of the changes the community is seeing, and how they perceived them in the context of the Inuvialuit way of life. Most of my learning came from conversations, observations and reflections while having tea with people, plucking geese, preparing food, working

outside, hanging around the co-op and generally participating in community activities. People knew why I was in the community and the nature of the research I was doing, and thus information was often volunteered and conversations initiated.

Sillitoe (1998: 229) describes indigenous knowledge as “passed on by informed experience and practical demonstration; more often shown than articulated, it is as much skill as concept”. It is this kind of learning that I feel most fortunate to have been given the opportunity to experience. Citing the Dene Tha, Goulet (1998:30) explains, direct experience is the essence of all true knowledge: “To know is to perceive directly with one’s senses or one’s mind. What one has not experienced or perceived directly, one does not know”. Such direct experience has provided a context and a starting point to begin discussing Inuit perspectives and knowledge of climate-related change. Learning *how* to study traditional knowledge occurred within the same process as its documentation. I had time to explore the dichotomy between western science and traditional knowledge, and gain a broader perspective of the challenges, methods and issues associated with this kind of research.

Respect and reciprocity were reflected in my fieldwork. There were so many times that I wanted to ask so many questions, figure everything out right away, but knew it was better to wait and learn, respecting the community’s need not to be ‘researched to death’. It is important to be humble, and recognize yourself as a guest, or as Simpson and Driben (2000) articulate, a *beginner*. It was important for me to give back to the community, and I was fortunate to be able to live and help a community elder. I also tried to give back to the community through taking books with me that had archival pictures of the community or stories from community elders. I took material on climate change, such as the special issue of Native Americas that was dedicated to aboriginal perspectives on climate change. I also acted as a liaison between the community; I helped the HTC set up an advisory council for the project. Finally, I made a lot of lemon pies. The lemon pie allowed me to go visiting, without going empty-handed. The pie dissipated my feelings of shyness and not wanting to be intrusive. I would bake a pie or a small mountain of tarts and head off to visit. Based on my own experience, in Sachs Harbour and in my own community, nothing finds the way to an Elder’s heart like a lemon pie!

3.4.2 Learning from Elders, listening to stories

Much of my research was shaped by living with Mrs. Kuptana, who became my *nanuk* (grandmother) and teacher. It was through her guidance and patience that I found my footing in the community.

I attribute much of the quality of my research to the opportunity I was given to live with an Elder. The arrangement created a space for a relationship of sharing and learning, as she needed someone to help her do many of the things she wanted to do, and I needed someone to help figure out how to do everything I wanted to do. My relationship to Mrs. Kuptana was a base from which to form other relationships. Her house was often busy with people dropping off a young seal, geese or caribou, or just stopping over for tea. People often told me how pleased they were to see me helping Elders out, and having so much fun doing it! It allowed me to somewhat transcend the status of “outside researcher” to “Sarah’s granddaughter”. Mrs. Kuptana quickly became my second “advisor”. She provided advice, support and encouragement (as all advisors do). She told me stories of long ago, of how things used to be and the ways that things have changed (as all advisors do).

Working with elders is central to discussions of working in Aboriginal communities and learning using Aboriginal methods. Simpson (2000) discusses apprenticeship with Elders in terms of the role of the Elder in communities, as teachers, historians, keepers of culture and tradition, philosophers, and providers of healing, inspiration, advice and counsel. Colorado (1988) also discusses the role of Elders, in terms of bridging western and native science.

The visit [apprenticeship with Elders] is an essential ingredient of Native scientific methodology. The visit includes introductions, establishing the relationship between the Elder and the younger person (Who is you clan? Who is your family? What is your Indian name?), socializing including humour and finally raising the purpose of the visit. Through visits a contract is established. Often the contracting process requires several visits, the apprentice will do chores around the Elder’s home, listening attentively and follow direction about mundane activities. Through this process, trust is established and a genuine interest in the welfare of the Elder is promoted. This is important – the Elder is about to share

knowledge that is powerful, sacral and often of a personal nature – the recipient must be prepared (1988: 57).

3.4.3 *Historical research*

Another aspect of my independent research was historical. I wanted to understand where people had traveled, what brought them to settle in Sachs Harbour, stories, management practices, adaptive strategies, etc. Such experiences and phenomena I learned from people in the community, from others who had worked in the community, and from doing library and archival research. Historical research looks at the political, social, economic and cultural background of the region and the community. This kind of background research, both in and out of the community, is an important methodological component of traditional knowledge research. Traditional knowledge is situated in time and place, and studying it requires understanding the historical context within which it occurs.

3.4.4 *Background Climate data analysis*

A final component of my independent research was the analysis of selected climate data for the Sachs Harbour weather station. The Sachs Harbour station was established as a surface and upper air records station in 1955 by the Meteorological Service of Canada. Weather data for this station is collected using an automatic weather station and airport reports. For this analysis, I looked at the annual record of monthly data (MLY) for selected temperature and precipitation elements from 1956 to 1999, using the long term mean and deviation from mean rather than absolute values.

The analysis of climate data can serve two purposes: first, to give the researcher some degree of *expertise* or background concerning the climate history of the area. Second, it allows specific community historical knowledge, observations and recollections to be placed in time if not explicitly identified in an interview or conversation. This kind of cross-referencing may give additional context to community observations, help place them in time and assist in organizing information. For example, I

could refer to temperature records for the mid 1960s to see the kinds of temperatures associated with conditions that allowed dog sled races on the sea ice, July 1, 1967. It is important to note that the use of historical climate data is to cross reference and compare, not to verify or legitimize, Inuit knowledge.

While cross-referencing Inuvialuit observations with another source of climate history can illustrate the benefit of using multiple sources of climate information, a detailed analysis and comparison is beyond the objectives of this thesis. Given the objectives of my research, it is more appropriate to limit my focus to Inuvialuit observations of change. Thus, while the data was useful as background material for the research, examples of cross-referencing do not appear in the thesis itself. However, as I propose in Chapter 6, this kind of cross-referencing is an opportunity for future work.

3.5 Summary

The key strength of this research, and the *Inuit Observations of Climate Change* project is that it was a *process*. It was a process of collaborating with the community of Sachs Harbour, of developing a way to work to document and explore Inuvialuit knowledge and observations of climate change. As a process, flexibility and adaptability were central features of our work; we adapted, modified and adjusted as we went, learning from mistakes, gaining ground on our successes.

Three main reasons lend to the success of the project: first, because it was a collaborative research effort; second, because the community fully supported the idea and nature of the project; and third, because the project occurred over the period of a year, with four return visits, in all seasons. Much of the success can be attributed to the time taken to organize and carry out the initial planning workshop in June 1999, setting the groundwork for the project as collaborative research. The commitment of Norm Snow and John Nagy was also central to establishing a collaborative space, as both men are well known in the community. As well, concern over recent changes mean that the community felt that the project could raise awareness about the impacts of climate change. Finally, the length of the project and that it occurred in all seasons was key to building a relationship with the community upon which to do this research.

Table 3. Summary of methods used in the IOCC project and independent research

METHOD	DESCRIPTION
Planning workshops (methods from PRA and ZOPP)	Used to collaboratively plan and design how the project would proceed. Identifies key issues, providing a guide for future work.
Filming	Situates discussions in the context of seasonal activity on the land. Allows the community to discuss and explain changes as they see them.
Repeat visits	Four trips to the community, each in a different season, built community partnership and trust, as well as allowing for follow-up and verification processes.
Community liaison	The community liaison worked to maintain communication between the community and IISD in Winnipeg.
Project feedback	Trip reports, newsletters and rough-cuts of the video were used to maintain communication with and feedback to the community.
Map biographies and other mapping techniques	Used to learn about individual and community land use, wildlife, local place names and history, as well as change over time.
Picture/photographs	Helps to clarify and communicate complex terminology.
Semi-directed interviews	Informal, flexible interview technique that has been used successfully in other traditional knowledge projects in the North.
Going out on the land	Going out to view phenomena that are changing and discussing change while out on the land.
Historical research	Understanding the historical, social, political, and economic context of the community and region.
Participant observation	Learning about the community from participating in daily life and activities. Based on direct observation and experience.
Learning by doing	Putting the focus on watching and doing, rather than asking.
Living with an elder	Living with an Elder enriched my experience by providing a caring, positive atmosphere for learning.
Relationship-based research (spending time in the community)	All research was conducted in the spirit of collaboration, partnership, respect for one another, humility and reciprocity.
Background climate data analysis	Provides additional context for the research. Used to cross-reference observations.

Chapter Four

Inuvialuit knowledge of climate change

I am not worried about it, but our dad when he was... before he died, he used to talk. He said that around here, our land, it is going to quit freezing later on... from long long time from now, he said. Our dad said. And it is going to be no more winter. Long ago he never talk about warm weather, but he used to talk about the North going to get warm and south going to get colder than the north. That is what our dad used to talk about.

– E. Haogak, Sachs Harbour, 2000

When I first came to Banksland the ice was always here. Weather changes so much now. Now it has really melted lots. 1967 in July 1st we had dog races in the Bay. In July 1955 to 1957 we were on the ice hunting seal. So hot up here now. I notice it – bugs here now. No mosquitoes when I first come here. Grass is taller now. Travel on the land and see landslides from melting.

– P. Esau, Sachs Harbour, 1999

4.0 Introduction

This chapter documents Inuvialuit observations and knowledge of climate change. The purpose of the chapter is to show, through selected examples, the richness of local knowledge related to climate change in this region. Largely descriptive, it presents the community's observations of the environmental changes that they are currently experiencing. Such observations are basis of the community's assessment of climate change.

In order to present the community's observations and knowledge as accurately as possible, much of the chapter makes use of examples from interviews and conversations that allow people to speak for themselves, as local experts. In addition, throughout the chapter there are additional italicized words or phrases. These are descriptive phrases for phenomena that are used fairly consistently by the community as a whole rather than individuals (i.e. *the land is going down in some places*).

The chapter starts with an overview of key points that reflect the extent and scope of Inuvialuit knowledge of climate change, and concludes with summary of the community's own assessment of climate change. The discussion sets the stage for the following chapter, in which a conceptual framework of the contributions of this knowledge to understandings of Arctic climate change is presented.

It is not possible, nor desirable, within this thesis to document the totality of what I learned from the community related to climate change and the environment. Instead, I focus the discussion on four groups of change - those related to sea ice, permafrost, weather and wildlife. These categories are reflective of those used by the community to organize their observations in the initial planning workshop for the IOCC project. They represent the phenomena that are most noticeable, and most concerning. Recorded here are the community's observations of change related to four broad areas:

- A. Changes related to the sea ice environment
- B. Changes related to permafrost and erosion
- C. Changes related to weather and the seasons
- D. Changes related to fish and wildlife

Table 4 provides a list of community members whose knowledge is the basis of this chapter. While the list identifies key collaborators, it is important to acknowledge that the community's assessment of climate change as presented in this chapter reflects what was learned from the entire community. Such an assessment is a product of interviews conducted with specific community members, but also of hours of informal conversation, observation and discussion with people who were not directly interviewed. The observations presented here belong to the community; however, I am solely responsible for any errors of fact, interpretation and understanding.

Table 4: Community members interviewed by the science team for the IOCC project. Decade of birth or actual year (where known) in the Age Group column.

Name	Approx. age group	Name	Approx. age group
1. Andy Carpenter	1932	11. Margaret Elanik	1930
2. Roger Kuptana	1950s	12. Edith Haogak	1932
3. Sarah Kuptana	1921	13. Shirley Esau	1936
4. Lena Wolki	1940s	14. Frank Kudlak	1920s
5. Geddes Wolki Sr.	1932	15. Martha Kudlak	1930s
6. Larry Carpenter	1950s	16. Joe Kudlak	1950s
7. Joe Apian	1920s	17. John Keogak	1950s
8. John Lucas Sr.	1940s		
9. Samantha Lucas	1950s		
10. Peter Esau Sr.	1934		

4.1 The extent and scope of Inuvialuit knowledge of climate change

There is abundant knowledge in the community relating to historical and current sea ice conditions, weather patterns, erosion / permafrost melt and wildlife populations, as well as the linkages and relationships between these phenomena. However, in the process of learning about climate change from the community of Sachs Harbour, it was clear that there are defining characteristics of community's knowledge of climate change. Working with the science team and conducting interviews in the community, several themes emerged that reflect the extent and scope of Inuvialuit knowledge of climate change. These themes provide valuable insight into the nature of this knowledge. They address questions such as: What is the scale of the observations? Who knows what about which phenomena? What are the influencing factors on the knowledge? How far back does knowledge go? Why do people know about climate change? How do people observe climate change phenomena? Examples of these themes are given here:

1. The extent and scope of Inuvialuit knowledge of climate change is closely connected to the history of land use and occupancy for the region. The experience and knowledge of past conditions may vary based on whether families were trappers from the mainland or Copper Inuit from Victoria Island. For example, trappers who waited each year for the spring break-up to return to the mainland will know more about past sea ice conditions on the Beaufort Sea than other families. Elders remember years such as 1933, when the ice never left the Bay. Other families have a longer history inland.
2. The extent and scope is closely connected to current land use and community activity. Observations and knowledge of climate change are closely tied to the extent and scope of community activity, including where people travel, when they travel, and what features are most noticeable within the scope of seasonal activity. For example, in some cases, permafrost depth is largely outside of the scope of what people know. They will know the relative depth for the decades when ice houses were in use, but more recently permafrost depth is noticed only if there is a reason to dig down into it.

3. Knowledge and observations are related through peoples' own life experience and histories. Time is often identified through past experiences. For example, an Elder will say it was like that *when I used to drive dogs*. A specific time of year is identified as *when we snap traps*. A past event is referenced in terms of when my eldest child was born, or when the oil companies started coming around.
4. In many cases, living memory is extended back through oral tradition. In many interviews, people spoke about what their parents or grandparents told them.
5. Men and women contribute to discussions of climate change in different ways. As Ingold and Kurtilla (2000) point out, because men and women engage in different activities, their perceptions of changes (i.e. what they notice, how they notice it) will differ. Women describe how it is more difficult to prepare gravesites. Women also tend to know more about conditions of animals in terms of fat content and hide condition.
6. Different age groups contribute to discussions of climate change in different ways. For example, Elders tend to describe broader seasonal change in a historical context, whereas younger people may describe more specific phenomena and in a shorter time frame.

4.2 Changes related to the sea ice environment

Changes related to the sea ice environment are clearly one of the most noticeable areas of change that the community has experienced in recent years. Such changes represent the largest group of observations and information, and were a recurring theme throughout all four trips to the community. The condition of the ice, distribution of ice floes, location of the floe edge, and the timing of freeze-up and breakup are monitored from both kitchen windows and the ice itself, since knowledge of the ice is critical to hunting success and safety. Knowledge of the sea ice includes a detailed understanding of interrelated factors such as temperature, salinity, wind direction and strength, currents, shoreline topography and previous ice conditions (see also Riewe 1991, Nelson 1969). The recent increase in variability associated with sea ice is seen as an indicator of larger scale environmental change.

Observed change is most commonly compared to sea ice conditions in the 1950s and 1960s. However some Elders describe recent changes in a broader context dating back to the first half of the 20th century when the Island was seasonally occupied by both mainland trappers and Inuit from Victoria Island. As with other changes, sea ice related change is most noticeable in the 1990s, however one Elder described ice conditions as becoming more variable in the last thirty years.

This section looks at changes related to sea ice within five subsections: i) seasonal extent, distribution and movement of ice; ii) timing of freeze-up and break-up; iii) ice thickness; iv) surface topography; and v) distribution, availability and health of sea mammals.

4.2.1 Changes to the seasonal extent, distribution and movement of sea ice

In general, the community of Sachs Harbour is observing less sea ice, both annual and multiyear. Less ice, as discussed by community members, often refers to the absence of ice floes (often termed *icebergs* during interviews) in the summer, but also includes more specific discussions of less landfast ice, more open water in the winter and spring,

and the retreat of the multiyear or permanent polar pack. The decrease in sea ice extent has significant impacts on hunting and travelling and is considered a primary indicator of climate change. While the community has experienced fluctuation and variability in the seasonal extent and distribution of ice before, recent changes are believed to be beyond the range of expected variability. For example, a “string” of ice-free summers, as opposed to isolated events, leads people to believe that this may become the normal rather than the anomaly.

Long ago there was always ice all summer. You would see icebergs all summer... ice moving back and forth this time of year. Now no ice. Should be icebergs. You used to be able to see that old ice from the west side to Sachs. No more. Now between Victoria Island and Banks Island there is open water. Shouldn't be that way. – F. Kudlak

It finishes right away, just like that those icebergs around here. I thought it would stay, but it melts right away. – E. Haogak

Used to be ice close by most of the summer. Now you see ice in June, sometimes part of July. After that no ice. A few miles out from Sachs we used to hit ice in our boats. In June, twenty miles out hunting seals in open leads we used to go. Now it is easier, the planes tell us where the ice is. – A. Carpenter.

The last couple of years we didn't see any ice [pack ice] at all. July and August. It is uncommon not to see any ice in the summer . – J. Keogak

Now there is not too much ice. When it goes it goes. You might get a few pieces back, but not like quite a while back we used to get ice from the west all the time, or the east. It was good hunting in them days. Everyone was after seal because the seal prices were good. But now when the ice goes it stays out just about the whole summer. – J. Lucas Sr.

We are not getting multiyear ice like we used to. It is all freshly frozen ice that we are hunting on now. – J. Lucas Sr.

Most community members who described changes in ice distribution related it to differences observed in wind direction, strength and frequency. The lack of ice, both floes and the retreat of the pack ice, is attributed to more frequent, stronger east winds that push the ice away. These winds are described as occurring for longer periods of time, and at different times of the month than normal.

There is less ice because of the weather, lots of east wind. Ice goes out. – P. Esau

Years before we used to have ice off and on when we get different kinds of wind from the west...and from the east they come from that... all the ice come this way through that straight...and from the west you get a lot of the older ice, and myself I never see that much anymore because there is too much wind. – J. Lucas Sr.

The changes in ice abundance and distribution are impacting the way Inuvialuit use the sea ice environment. The water is rougher now (more waves), because of the lack of summer ice floes that keep the water calm. Rougher conditions make boat travel more difficult; “it used to be calmer out when the ice was around more; now we stay closer to shore when we go out” (L. Carpenter). It also contributes to increased coastal erosion. As one Elder commented, “now there is big swells where the ice is gone, erodes banks. No ice” (A. Carpenter).

When there is lots of ice, you don't worry too much about storms. You get out there and travel in between the ice. But last few years there has been no ice, so if it storms you can't get out. People used to go to Cape Kellet to hunt seals. Last few years they haven't been able to. Early July they go out there for a while, but after it [the ice] is gone, end of July there is no more travelling out on the ocean. – A. Carpenter

Long ago we used to have ice floe all the time out there...we used to go hunting...you know its rough on the water when there is no ice. Boy it used to be nice. We could go out anytime. –L. Wolki

Changes related to the permanent ice pack, to the northwest of the community, were also discussed. This multiyear ice that moves as one unit and does not melt in the summer, is normally visible to the community throughout the year. Hunters would make trips to the pack ice to hunt for marine mammals. Now people in the community describe not seeing the ice pack anymore, “the ice that is just like land it is so big” (G. Wolki Sr.), and that it stays far away, even when you can see it. Changes in the pack ice are observed in terms of its proximity to the community, as well as size and thickness. Several men observed that the pack ice was melting – that it was smaller in size now – and that it was not as thick anymore. As with other observations of ice-related change, the changes noticed with the pack ice appear most evident in the 1990s.

This multi-year ice never melts, just moves around. Four years ago we saw multi-year ice on the west side. Ever since that time not as much. This year when we travel ice is very thin. When I first came to Banksland it was always here. Weather changes so much now. Now it has really melted lots. – P. Esau

You used to be able to see that old ice coming from the west side to Sachs. No more. Now between Victoria Island and Banks Island there is open water. Shouldn't be that way. – F. Kudlak

That pack ice used to be about 60-70 miles away. I think now it is more like 80 or 90 miles... maybe more – J. Lucas Sr.

That old ice must be farther away, because it hardly come around here anymore. Sometimes you see icebergs that side alright... but they never reach here anymore. Just like land, so big that ice. –G. Wolki Sr.

4.2.2 Timing of freeze-up and break-up of sea ice

Changes in the timing and rate of freeze-up and break-up, or ice consolidation and ablation events are seen by the Inuvialuit as indicators of changes in the overall weather of the region, or climate. Everyone who commented on ice spoke about earlier break-up, later freeze-up and a subsequent longer ice-free season, as well as increased variability associated with these events. Earlier break-ups are more noticeable than later freeze-ups, but both events are considered to have changed. One man described it as “a little bit on both sides.... It freezes up a little later and thaws out a lot quicker” (J. Lucas Sr.).

Now it is breaking up earlier and earlier. When we first came here [community of Sachs Harbour] in 1955 all the people used to wait for the ice to go so they could go across [to the mainland]. In July we already came from DeSalis Bay, walking over by the land. Fred Carpenter was still waiting for the ice to leave. Finally the ice took off. We were walking from that way and Fred Carpenter was on top of the hill looking that way for open water with binoculars. We met him on top of the hill when we were coming in. – L. Wolki.

Years ago it never open up in the springtime the way it does now. In the springtime ducks used to be in the cracks, small cracks, and they would starve. Long ago just a little crack. Never happens anymore. Water always there now. Ducks have no problem. –J. Apian

While the timing of the spring break-up has changed, what is more noticeable is the *rate* of this event. Break-up is occurring earlier, and *faster*. Once the ice starts breaking up, it *goes out right away*. Now when spring comes the *leads open up faster because of the weather*, and *boat travel is possible by early July*.

Freeze-up should occur in the end of September in the Bay, starting with the Sachs River and freezing outward, but in recent years it has been several weeks late. An Elder whose father was one of the first trappers on Banks Island described how in the 1950s by the end of September it used to be frozen all the way in the Bay, and he used *to break through the ice with his boat, running his dogs alongside* (A. Carpenter). In 1998 people in Sachs Harbour were using their boats in November. According to one hunter, the earliest he had ever seen that before was early October. The lack of ice floes in the summer, warmer water and higher temperatures are attributed to ice forming later in the fall.

Lot of it depends on the wind in the falltime. You get wind, when it starts to build up ice in here and you get a wind and it pushes it out. In the falltime we used to always have ice come in just before freeze-up, and we are not seeing that in the last few years. That could be the reason [for later freeze-ups]. It is all being blown out. Not enough ice out there. – L. Carpenter

Freeze-up is way later; less icebergs. Doesn't make water cold. Notice this the last 3 or 4 years. Ice melts so fast nowadays. – F. Kudlak

There is a lot of difference if there is not ice out here in the falltime. It doesn't freeze-up for a long time because you always have wind smashing up the ice and taking it out. When there used to be ice quite a few years back it used to freeze-up right away. But now there is no ice out there, nothing to hold when the ice is formed. It just keeps breaking with the wind. – J. Lucas Sr.

4.2.3 Sea ice thickness

People in Sachs Harbour have noticed that the sea ice is not as thick as it used to be. Most observations focus on landfast ice and the annual ice that extends between Banks Island and the mainland, but several hunters who spend significant amounts of

time on the sea ice also reported changes to the multiyear pack ice as well. Thinner ice is a concern for the community as it creates safety concerns. Many community members described an increased difficulty with travelling on the ice; that in the past they rarely had to worry about thin ice like they do now. Few people quantified the changes in ice thickness. However, one man described the landfast ice as “about a foot thinner” (R. Kuptana). Another man described the change as:

The ice used to be 8 feet thick. This year the ice is not as thick. Before that I remember really good 8 feet. I travel all over the ice. Even up north I never see any really thick ice now. When I first come here 8 feet of ice.- J. Apian

One aspect of Inuvialuit understanding of ice thickness and thus ‘safe’ vs. ‘unsafe’ ice relies on knowledge of ice texture and color. Unsafe young ice is very dark, almost black; new ice is saturated with water and thus translucent enough to reveal the dark color of the sea below. Thicker ice becomes grayer and is then safe enough for travel. When describing changes in ice thickness, some Sachs Harbour hunters qualified their observations with statements about ice colour. “Lots of thin spots where you can see ice is broken up.. the ice is fairly thin...and you can tell by the color” (P. Esau).

The ice is not as thick as it used to be. I remember going out hunting. We never had to worry about ice. It is not as safe. Moves around a lot. Not as many pressure ridges – J. Keogak.

You really have to watch when you travel on the ice now. You have to have experience to travel on the ice. You have to know the condition of the ice – L. Wolki

Ice thickness is interrelated with other ice phenomena such as ice movement and the formulation and distribution of leads (*uiniq*), cracks (*aayuraq*, *siiqtiniq*) and pressure ridges (*quglungniq*). Thinner ice is weaker and more liable to crack or buckle. Such ice conditions lend to smaller and fewer local pressure ridges and increased ice movement.

4.2.4 Surface topography: Pressure ridges (*quglungniq*), leads *uiniq* and cracks (*aayuraq*, *siiqtiniq*)

As described above, the formation and distribution of pressure ridges, leads and cracks on the sea ice are interrelated with other changes to the sea ice environment. They are also linked to wind and currents. In the community of Sachs Harbour, it is clear that less ice and more open water in general has produced changes to ice-related phenomena such as pressure ridges, piled ice, rough ice, cracks and leads.

Quglungniq [pressure ridge] depends on moving ice, depends where you have moving water – like where it opens up and closes up that’s where you get those quglungniq and aayuraq [crack in the ice that doesn’t close in the winter], that sort of thing. The ones that keep opening and closing – you see some of those but not as frequent. A lot of times when they close up they really don’t freeze like before. Before if it was cold it would have froze and made another opening and different pressure ridges here and there. But now when we go out we hardly see any because the open water is so close. Lot closer to land – some places you can’t even go around bluffs where the open water is. Because the open water is so close to the land. – J. Lucas

Several people in the community described seeing less local pressure ridges now because of thinner ice and more ice movement; one man commented that they cannot really be called pressure ridges anymore, “just piled up ice” (J. Keogak). One woman described how the pressure ridges now are smaller, likely in the same sense.

I never see quglungniq anymore. Long ago when I was a kid, people used to make iglus on the quglungniq, they were so high those quglungniq, lots of snow around it – so we used to make iglus around them and hunt seals through the ice. Set hooks and all that stuff. I never see those quglungniq anymore . L. Wolki

Changes observed with these aspects of ice topography indicate a change in the overall nature of the ice, and thus the way people use the ice. Differences observed in the occurrence and stability of near shore leads have forced hunters to go farther out on the ice as the close leads close over with increased wind and ice movement. As one woman whose husband hunts on the sea ice recalled:

In the 1970s you could go out 30 or 40 miles in winter hunting polar bear, then only 20 miles, then 10. Last year only 6 miles out and you reach ice you have to worry about. – J. Kuptana.

4.2.5 Distribution, availability and health of marine mammals

Distribution and abundance of marine mammal populations such as seal and polar bear are closely related to sea ice conditions, and therefore the effect of climate change on the sea ice will have direct impacts on the health and abundance of these marine mammals. Seal distribution relies on the occurrence of stable landfast ice; *natchiq* (ringed seal) pups are born on the ice in April, *ugyuk* (bearded seal) pups as late as the first week of May (SHCCP 1992). Polar bears rely on ringed seals for food, and ice for hunting and travelling.

Many of the observations of marine mammal related change centered the effects of poor ice years on seal health, distribution and abundance. As one couple described, “*last year [1998] even ugyuk going on the land because there was no ice*” (F. and M. Kudlak). Warmer temperatures and less ice can result in increasing numbers of skinny seals, particularly skinny young seals. This is most noticeable in the last few years when early breakup results in the abandonment of seal pups on the ice. Seals have their pups on the ice in April, and if the ice breaks up before the pups are mature enough to leave, they are abandoned as the mothers are carried away by the ice. It may also impact seal health. A healthy seal should have 3 inches of fat on it; in poor ice years such as those recently experienced by Bankslanders, “ringed seals have only ¼ inch of fat on them in June” (R. Kuptana).

Several hunters addressed the difficulty of assessing the effects of climate-related change on seal populations, since they are known to fluctuate quite a bit. However, it is clear that changes in the seasonal extent and distribution of sea ice have a noticeable effect on seal distribution and abundance in terms of availability, and thus on harvesting. “There is less seals now because not enough ice” (L. Wolki).

When there is no old ice, there is not very much seal too. They travel on the bit old ice. Long ago when the old ice used to come in, we head for the big ice out there. Just stop and seals start coming. Nowadays it is not like that anymore. Those small ice, hardly any seals on them. They are too small. Its warmer

summers – I think those thin ice melt right down. That is why there is hardly anymore ice. Used to be old ice coming from the North all the time. And when it freeze-up with old ice, seems to be more bears all the time. When it has leads, around March, boy lots of bears when you go out. I used to feel safe when I would camp on the old ice. Just like islands, that old ice. Good for tea! That old ice always open up too, all kinds of seals. Because that old ice is smooth, good for seal holes. –G. Wolki

The following excerpt from an interview with J. Lucas Sr. illustrates the relationship between polar bears, changing ice conditions and the impacts on the community.

A: Well now, when you are sport hunting you can really notice it now. All the bears are further out, they are not closer. I don't know if it could be from too much traffic close by the beach or that sort of thing, but from what I have seen – all the ice that is out there has frozen this year – and you could only go so far. You can't pass a certain point because other side of that there is some more open water... that is where all the bears are. Alot of them they don't get polar bears because the bears are out here where the hunters can't reach them.

So it is kind of changing it a bit.. you know, where there is no old ice, that sort of thing. Long ago when we used to travel with dogs, we never even hunt the polar bear, and people used to get a whole bunch. Now you take a sport hunter out, sometimes you are lucky to get a bear – sometimes you don't see anything because the open water out here. Like, if there was old ice you could travel places, because it is more solid than the way it is now.

Q: so you have to be more careful?

A: yes...

Q: So what if it keeps getting thinner?

A: I think eventually the bears are going to get further. Even the polar bears they hunt where there is really thin ice, where there is a lot of seals. They wouldn't hunt like up here where there.. the seals are going to be where there – where they feed. I kind of find a difference...you know.. .within the 10 years I was.. within the 30 odd years I been doing this. Polar bears are getting further out. We are left up here hunting and they are out there.

Q: And you can't get there.

A: yes... because there is open water out there... there is a crack up here that you can't pass really because it is too thick.

4.3 Changes related to permafrost and erosion

On Banks Island, periglacial features and processes such as thermokarst topography, tundra polygons, striping, ground ice, frost boils, hummocking, mass wasting and slumping characterize the landscape. While these physical processes and characteristics are expected in a region dominated by permafrost, there is indication that the rate and spatial extent of these features may be changing. The active layer, or top layer of permafrost that melts each year, is observed to be thawing earlier, faster and deeper. Thaw slumping on hillsides and lakes edges is seen as more extensive now; *staying wet all summer*. The rate of erosion from one summer to the next is described as noticeable faster in recent years.

Descriptions of permafrost and erosion related changes are most commonly prefaced with *“there is more now than before”*, *“yes I have seen that before, but there is more now”*, *“it is all over now, not just some places”*, *“it used to get warm, but only for a day or two”*, and *“it melts so much faster now”*. For example, coastal and inland erosion are expected occurrences in this type of landscape; a product of wind, rain, sun and waves. However, as a father and son described, *“the slides are all over now, not just certain areas”*. People are familiar with such occurrences, *“but there is more now. Before it was once in a while, mostly coastline. Now, more inland. Even a lake that dried up because an outflow developed”* (A. and L. Carpenter). Such changes are attributed to warmer temperatures, an increased rate of melt in the spring, longer periods of hot days in the summer and increased precipitation in the form of rain.

Permafrost and erosion related changes are significant concerns for the community. Such changes affect the community in terms of ability and ease of travel on the land, and also in terms of building stability and construction, road damage, gravesite preparation and general community maintenance.

There is a lot of softer soil, such as mud; I notice that there is a lot more erosion in many lakes, towards Massik Pass. Especially this kind of feature [picture of erosion at Angus Lake]. It starts melting at the end of fox trapping season, which is really early, in April, and it never used to be like that long ago. And the Massik River and Massik Pass in general seem to be melting a lot sooner than it did, several months earlier than my recollections as a young man. – J. Apian

The last few years the permafrost is melting deeper. It is wet. It makes slides on the hills. Always around the coast there are slides from waves and sun. The last few years have been really hot and when you dig down it isn't solid anymore. It is just like pebbles . It is thawing a lot more down, and thawing earlier. – A. Carpenter

I think it may be a lot warmer than before because the permafrost is a lot deeper. The frozen ground is a lot further from the surface now. Long ago you used to have to dig a foot and half, two feet...then you used to reach permafrost. When we used to make ice houses long ago the permafrost used to be about 2 feet, but now you dig and dig – 3 and a half to 4 feet now. – J. Lucas Sr.

You notice the permafrost showing on the hills. It melts and the top layer of the ground falls off – slips and slides. Along the coast pretty obvious the last 4-5 years. On the land, last year was really bad after all the rain, then hot summer, then fall and more rain. It made the ground move. – J. Keogak

And our house is crooked too. Our door barely close. You can see cracks between here and the school. Never used to be like that, that permafrost melt and the ground in some places goes down. – L. Wolki

I notice too with the gravesites. The graveyard is way up high on the hill. The last time they had a funeral here they had to put plywoods so that the mud wouldn't slide. Even at the top of the hill we notice that... it is such a big difference. They put plywood so everything didn't slide down. – S. Lucas

That ground in the gravesite had water in it too instead of ice. You did 5 or 6 feet down it should be frozen solid. But lots of time you get water that deep. – J. Lucas Sr.

Last year it melt so much...close to the warehouse over there water kept coming out from the ground. And then when it started to freeze more water come up and then it freeze. It was solid ice over there for a while. –G. Wolki

Most people in the community describe permafrost-related change in the context of the *land going down in some places*. In scientific terms, this may suggest increases in thermokarst processes – the process of ground ice melt accompanied by local collapse or subsidence of the ground surface. People say the land is *shifting* or *hollowing in*, and there are more *v-shaped creeks* on the land with *water going way down*. Permafrost thaw is related to the land becoming *rougher*, with *water coming up as the land goes down*, more mud and wet ground, *holes in the ground*, exposed ground ice on hillsides and lake edges, and increased coastal and inland erosion and slumping. In some places the whole side of a hill has *slid down* on southfacing slopes (the active layer is thickest on

southwest facing slopes due to influence of southwest winds). Pingos are decreasing in size, and people do not see as many “knolls”, on the land anymore (these are small mounds that consist of “pushed up” ground ice covered by sand; they are used by trappers to place traps).

Land goes down now and the water come up. The land gets rough. Melted too much. The trail at the top of the hill is like that. Melted too much under the ground. It used to be smooth three summers ago. Never used to be like that. – F. and M. Kudlak

The ground is eroding. We used to have a lot more beach than that. I can remember in the early 1970s, there was a lot more beach. And now the ground is eroding along the coast. I guess the water is getting higher too. – J. Keogak.

I see changes in puddles... little lakes in the flats when I am out hunting. I notice melting. Where I used to trap, there are big deep cracks where it has melted. I have to go around them now. Too deep. The ice in the ground is melting. Makes creeks deep and full. Summertime melts so much every year. Now we see big holes [makes V shape]. It is really melting down. You see it at the airport so much. June is the time when it really melts fast. – P. Esau.

I think the hills below, all the way to Fish Lakes, you can really notice how dark they are now compared to a few years back. Almost like caves in some of them now. When you travel by the coast, by the ice. You can see the big holes in some of them. – L. Carpenter

You can notice the ground is starting to, kind of shift. Like a lot of places, where you used to drive..it is kind of hollowing in. Some places when you travel, and you run into a little crick, and the water is going down... and it is way down. It is melting that permafrost. Big hole under there, and you know the ground from the top is going down. –J. Lucas Sr.

A thermokarst thaw lake (created by ground ice thaw) known as Angus Lake, just west of the community, was a key reference for discussions of erosion on the land. The lake, as well as a second lake that dried up because an outflow developed are held up by the community as evidence that warmer temperatures are increasing permafrost thaw. The effects of increased melting, ground ice slumping and erosion are especially evident in these two cases. While ground ice slumping and erosion are natural periglacial processes for the area (see French 1996), permafrost thaw at Angus Lake has had a very marked effect in a relatively short time span. The lake edge has retreated significantly in the last two years, representing what the community sees as a marked increase in the rate

of erosion. A well-traveled trail exists along the lake edge; one that was a safe distance from the lake edge not long ago, but now is precariously close, forcing a new trail to be made farther back.

Permafrost related changes have not impacted seasonal harvesting activity to the extent that other changes have. However, there is concern for the future with continued thawing and erosion on the landscape. In addition, many people feel that such occurrences make the land and the town look ugly.

The permafrost is melting but right now it doesn't really have a huge impact on the hunting and trapping. But I predict that what will happen is that there is going to be a lot more erosion. It also makes the town look ugly. – J. Apian

It just looks bad, and in some areas you have to try to get around it. Main thing is how it will... I don't know how it will effect us later, but right now when you see it doesn't look nice, and you have to avoid places. You get stuck in the mud.
– L. Carpenter

4.4 Changes related to weather and the seasons

Inuvialuit observations of weather and seasonal changes include changes in temperature, precipitation (snow, freezing rain, rain), storms, and wind. As with changes on the land and the sea ice, those related to the weather are described in terms of increased variability. Such changes are most noticeable during the fall and spring months when the seasons are changing. People have noticed changes in the frequency, timing, amounts and severity of weather events. There are more sudden, intense weather events. The weather is increasingly variable and there are more extremes. Elders in Sachs Harbour say that it is more difficult to predict the weather these days.

The weather never change that much years ago. It is always cold. Not like today. You can't even tell when the weather is going to change. Mild weather, it is going to be a storm coming... we get ready for it even. But today it changes so much, boy, we expecting a big storm.... Next day, clear as can be. I can't predict the weather anymore like we used to years ago. I used to predict weather when I could see it...its coming. All these old trappers, when they used to go trapline

they camp early, build their snowhouse because there is going to be a big storm, they even know that. Never happen that much anymore. – P. Esau

Elders often discuss change in the context of seasons rather than specific weather patterns and events. They describe longer summers, shorter winters and a *faster* melting season. For many older community members, things are happening at the *wrong time now*; the years and the seasons were *getting crazy*. Many people also describe weather-related changes as an increase in *bad weather*, including more overcast days, whiteouts, wind, rain, and storms.

It used to be really nice weather long ago when I am a kid. Bad weather now. So much mosquitoes. Sometimes hot, sometimes cold. Not like now. Wrong time now. Way different now. August cool off time, now it is hot. Really short in winter now. – E. Haogak

I think people have a lot of different opinions about how things are now. Myself... I see that weather is changing – a lot different than before. – J. Lucas Sr.

Sila changed alright. Really late falltime, really fast and early springtime. Long ago summer short, not anymore. –S. Kuptana

Lots of bad weather in the summer now, but in the winter we have good weather. In the fall too, we have lots of winds now, never used to. Lots of snowstorms. – L. Wolki

4.4.1 Changes related to temperature

People in Sachs Harbour are consistent in reporting warmer temperatures, with the most pronounced warming occurring in the last decade. Winters are considered shorter and less severe in the past 15 years, with temperatures not reaching the lows they did in the past. *You do not hear the lake ice crack in the winter as often anymore*. Such temperatures make winter travelling easier; and are considered to easier on wildlife. Hot days in the summer come in strings of days now, rather than one or two days. Warmer springs are attributed to the increased rate of spring melt. In the fall, higher temperatures

keep the land from freezing longer. Elders say that August used to be the *cooling off month*; now it stays warm.

While people in Sachs Harbour are clear that in general the weather is warmer now; they stress that it is not changes in mean temperature that they are noticing. What is noticeable is the increase in variability and unpredictability associated with temperatures. As well, changes in the weather are more sudden. It gets cold *all at once now*, making it *more difficult to travel* in the fall. The same phenomena occurs in the spring; it gets warm all at once making the snow melt too fast and spring travel more difficult as well. People are used to long spring and fall seasons. These are times when the community spends long periods of time on the land.

In the 1990s the community experienced very warm springs that left people travelling to goose hunt camps by four wheeler instead of snowmobiles because the snow melted away so quickly. However, in the spring of 2000 there was more snow than the community had seen at that time of year since the 1960s, and it was very cold. There was no open water and the geese came three weeks late. As several people explained, the problem is not only warmer temperatures, but not knowing what kind of spring it is going to be anymore as well.

Long ago used to be a long spring, used to just stay out there for months. In the springtime, you know we do fishing first. After that we hunt geese and then go fishing again after that. Now we don't even go fishing after the geese hunting because it melt too fast. – G. Wolki Sr.

I notice temperature the most... it is getting warmer. And sometimes the years get crazy. It is always changing. One time ducks in May; eiders. They were flying on the land – supposed to be in the open water. –F. and M. Kudlak.

Back in the early 60s we got temperatures a lot different than today. The weather was also colder, that sort of thing, 45-50 below. We don't get that anymore around here, it seldom reaches 40. For me...the climate has warmed up a lot more than what it was when we used to trap. – J. Lucas Sr.

It takes longer to melt in the springtime long ago. Nowadays it melts faster... warmer now. Within a few days hardly any snow. Long ago it takes a long time to melt. I think it is getting warmer every year just about. We have longer summers now. You know, June 6th one time it was so cold it hardly melt. – G. Wolki Sr.

Long time ago spring was really late...more snow on the ground. Long time ago winter really really cold. Really changed now. Not even 60 below now. Not like long ago. –S. Kuptana.

4.4.2 Changes related to precipitation

The Banks Island environment is characteristically cold and dry. However, Inuvialuit observations suggest that the precipitation regime for the region is changing. Overall, most changes associated with precipitation can be categorized in terms of more rain, increased variability associated with precipitation, less snow in spring due to an increased rate of melt, less snow inland and different kinds of snow.

Used to get almost no rain on the Island. Used to be snow in the fall. Now rain. This place used to be a dry place. Hardly any rain. –Andy Carpenter

Increased rainfall is most noticeable in the late summer and fall. The actual amount of rain has increased, rain falls more often and for longer periods of time. Much of autumn precipitation would normally be snow; but warmer temperatures lend to rain instead. Community members attribute increased rainfall to compounding the permafrost thaw and erosion, particularly in the summer.

This summer we had rain. But long ago you would go all summer no rain. Just day. Last five years more rain. Used to get rain and it would be half an hour or so. Now all day. – J. Keogak.

Used to rain long ago, but last summer rain for how many months? That is when the permafrost really melt, really lots of mudslides, lots of rain. Last summer. This summer is good, not really rain. – S. Kuptana

With more of the actual falltime precipitation occurring as rain instead of snow, the potential for freezing rain is a concern. Rain in the late fall may create a layer of ice on the bare or snow-covered ground. This ice layer coats vegetation making it difficult for wildlife to forage. Elders in the community cited several individual years in the past 40 years that severe icing events have occurred. Many discussions of freezing rain

centered on the response of caribou to these events. Inuvialuit hypotheses maintain that when there is freezing rain, bulls and calves are more affected than cows; and that caribou may move away from the Island out onto the ice when these events occur.

Just in the fall sometimes. Not every fall, just once in a while. Sometimes when there is snow on the ground first, and it rains and there is ice on the ground. That is why lots of caribou really travelling. Even go to open water, try to go someplaces. Must be hungry, starving I guess. – F. Kudlak

Only in the falltime, not in the springtime. I only see it a couple of times in the (1960s, 1970s). And I see a lot of dead animals when there is freezing rain. Only calves and bulls die off though, the rest survive. Always the cows and young bulls ok. They get skinny but they always survive. – P. Esau.

You know in the falltime, really icing up that ground. Too warm that weather. The days are too warm weather, nighttime frozen. And everything is wet; and frozen. It is no good for animals. Ice. – E. Haogak

Precipitation related change also include changes to snow and snow cover. Such observations describe change to the rate of melt in spring and different kinds of snow more than actual changes to the quantity of snow. However, it does seem that over the last decade there is less snow on the land than there used to be. This is most noticeable inland and in the springtime. Changes to snow cover are attributed to factors such as more rain (that should be snow), less snow in general, and more wind that blows the snow away). However, they are not easily explained.

It is strange, you would think that there would be more snow because we've had more water up here, but its not that way. Maybe we are getting the snow, and it is just blowing off... we get so much winds maybe that is why, and it is blowing off. Because if you go on ice right now there is quite a bit of snow on it... lots of drifts and that. Quite a bit of snow on it. – L. Carpenter

There are different kinds of snow as well. People are seeing more loose snow, soft snow and blowing snow, rather than the hard packed, *good for travelling* snow. The snow is *not as reliable anymore*. As with other climate-related phenomena, observations of precipitation related change such as snow cover are often described in the context of cumulative observations from seasonal hunting or fishing trips, and are associated with disruptions in modes of travel or ease of travel on the land.

There is less snow inland. We used to hunt caribou by the end of September long ago by dogsled. There is less snow now...we notice because we travel to our cabin in October. – F. and M. Kudlak

When I travel to the end of the island sometimes there is no snow. Only time you find snow is in the valleys. You can't do anything when there is no snow on top of the hills when you are hunting. Around here, there is always lots of snow...but when you go to the other end [of the island] some places no snow. Nothing but sand. –J. Lucas Sr.

In the 80s there were a lot of drifts. 1970s, 80s, not like now. Now they are smooth. Long ago they used to be just... rough. – L. Carpenter

During the first three trips to the community, in June and August of 1999 and then February of 2000, people in Sachs Harbour spoke of warm springs, less snow and how fast the snow and ice melted in recent years. However, the spring of 2000, as described earlier was unusually late. Thus, as with other changes, it is increases in variability and unpredictability that are most noticeable.

Well this weather here, we are all saying...you know... how it is warming up and everything. And then you see this kind of weather at this time of year! What the hell is the weather going to do [next]? - A. Carpenter

4.4.3 Changes related to storms

A significant feature of climate-related change observed by Inuvialuit is that storm events have become more frequent, sudden, intense and less predictable. This includes windstorms, snowstorms and rainstorms with thunder and lightning. These events are most noticeable in the fall.

Many Sachs Harbour community members have seen thunder (*kallut*) and lightning (*enikoyak*) for the first time in their lives only recently, within the last 3 to 5 years. Some older community members and Elders recall seeing these storms only once before in their lifetime. One Elder described how long ago this had happened as well, but that no one would know or remember anymore. "Long time ago really big *kallut*, long ago before me. The *kallut* noise makes ice fall. Right now that doesn't happen, right now

people don't know." (S. Kuptana). Another Elder described how when she was really young she had experienced thunder. "Sometimes I notice really loud thunder. Water is really pouring. When I was five years [circa 1930] old first time I saw that. Just like it was finishing." (E. Haogak).

First saw thunder and lightning three years ago on Banks Island. Water going way up down by the boats. Big storm. Just loud. – F. and M. Kudlak

We had that thunder and lightning 3-4 years ago... this old man who passed away, he said that hasn't happened for 30 years. We had a thunder storm that summer. It is really unusual for us up here. – S. Lucas

Only one time just before falltime a thunder and lightning storm. Really loud. Hear it from the end of town to here. First time I seen it that way. – M. Elanik

First really bad thunder and lightning storm about five years ago. Scary for people who don't see that. – J. Keogak

Severe wind storms in the fall months have damaged buildings in the community. One falltime storm 2 to 3 years earlier (1996 or 1997) with strong northeast winds had blown 45 gallon drums around, knocked over small buildings and almost blew several boats away. These kinds of storms are more intense and more difficult to predict than they have been in the past.

You can't tell is its going to be a really big storm. Years ago, when I first come here, when there is going to be a big storm there is a sign...we prepare for it. Now I can't predict the weather. Used to be "it is really warm, lets get our stuff ready..." That is how it used to be. Now I can't tell. – P. Esau

4.4.4 Changes related to wind

Wind patterns experienced in the Banks Island region are a result of prevailing wind conditions combined with topographical location, as well as the presence of storm tracks and other weather conditions. Observations of wind related changes by the community center on changes to wind direction, velocity, duration and intensity. When

people in Sachs Harbour talk about wind, they most often talk about more and stronger winds, longer lasting winds, winds at the *wrong time*, and the influence of changing wind patterns on the sea ice.

We have been getting a lot of wind the past few years, mostly from the east. We don't usually get that a while back. That kind of wind; the one that lasts 2 or 3 weeks. – J. Lucas Sr.

Not too much wind long ago. More warmer wind now. Windy more often, but not as strong [cold]. – F. Kudlak

Wind always comes in the last whiles. This winter always storming. Sometimes the ground no more snow from the wind. – E. Haogak

The distribution and movement of sea ice is influenced by wind direction and intensity, particularly during break-up and freeze-up events. In Sachs Harbour residents, stronger, more frequent east winds in the spring are encouraging an earlier breakup, as well as increasing the *rate* of breakup. These winds bring warmer temperatures from the Prince of Wales Strait and push the ice away. "There is less ice because of the weather – lots of east wind now. Ice goes out." (P. Esau). During August and most of September 1999, as with the summer of 1998, there were no ice floes in the harbour or pack ice visible on the horizon. Easterly winds kept the ice away. When the winds push the ice away, there is no old ice around which the new ice can form, and people are forced to travel on first year ice in the winter.

On a regular basis I guess you expect wind from all directions. But me I notice more east wind then what we used to get. The past few years sport hunting [March and April] we had a lot more open water on the west side, due to the fact of more wind. – J. Lucas Sr.

Now we are starting to get (past couple of years) more wind from the east. Last year we had wind for a good three weeks. A couple of years ago when I was out sport hunting, east wind started and it never stopped. That is why nobody got bears that time. Too much open water. – J. Lucas Sr.

Years ago we used to have ice off and on...when we get different kinds of wind from the west, and from the east because the ones from the east they come from that...all the ice comes this way through the strait, and from the west you get a lot of the older ice, and myself I never see that much anymore because there is too much wind. – J. Lucas Sr.

There is more wind now, the winds are stronger, and they last for a longer period of time. Strong fall winds are manifesting as storms. Expected wind conditions and seasonal patterns are changing, making it harder to predict for example, when a storm is coming. One man described strong east winds that occurred in August and into July. He described how “this was a little bit early for a big storm from the east. Whitecaps in the Bay. This should be happening in late August” (P. Esau). While most people contended that changes in duration and velocity of wind events were more noticeable than changes in direction (wind has remained mostly from the east and north), an Elder noted that there were two things he had noticed, “that the east wind and south wind have gotten noticeably stronger” (J. Apian). Such observations closely parallel those made by scientists studying the region. A recent paper on sea ice changes in the Beaufort Sea region attributes the reduction of sea ice to increases in easterly and southerly winds in the Western Arctic (Agnew 1998).

4.5 Changes related to fish and wildlife

One of the major impacts of climate change in terms of subsistence economies will be the impact on fish and wildlife. The indirect effects of climate change will have the most impact on wildlife, impacts such as changes to food and water availability, timing and abundance of forage availability and parasite infestations (Mathison and Christopherson 1994). New species may arrive, indigenous species may move from the region, and species distribution and movement in the region may change, as well as the health of the animal. The impacts of climate change on wildlife availability and health may have consequences in terms of community dietary health. Country foods make up a substantial part of household food intake, and they are a key factor in maintaining physical and cultural health.

This section looks at observations in Sachs Harbour of recent changes related to fish and wildlife species, including birds. The discussion will not include marine mammals, as this topic was addressed in the section on sea ice related change.

4.5.1 Changes related to fish

Changes associated with fish species were related to species abundance, size and distribution (For a description of common fish species to the region see table 5). Many community members described the char as getting bigger; one hunter suggested they were perhaps feeding on something different now (J. Keogak). A couple described how in the early 1950s they used 2" fish nets for char, and now they use 3.5" nets (F. and M. Kudlak). However, an Elder also described that "you never really see those really big fish in the rivers like long ago" (J. Apian). He attributes this to less water in the rivers compared to long ago. Several people commented that people in Holman, a community on Victoria Island southwest of Sachs Harbour, were finding that the eggs were earlier in char. When asked about the health of fish caught around Banks Island, community members were clear that the fish are healthy – "good condition... you can tell by the liver" (J. Keogak), and "getting *qaaktaq* now – and just fat" (F. and M. Kudlak).

Table 5 Common Fish Species Harvested on Banks Island, NWT.

Common Name	Inuvialuktun term	Scientific term	Habitat
Arctic char	iqalukpik /char*	<i>Salvelinus alpinus</i>	anadromous
Lake trout	singayuriaq	<i>Salvelinus namaycush</i>	freshwater
Arctic cod	rock cod uugavik	<i>Boreogadus saida</i>	ocean
Least Cisco	herring, blue herring, qaaktaq	<i>Coregonus sardinella</i>	coastal waters

*Char is also known as *iqaluk*, which is a fish of salmonid family such as trout or char; it can just mean fish.

Note: Arctic char and lake trout are the most common catches, and are the only fish reported to the Harvest Study (see Table 1)

Several people commented that cod were becoming more noticeable again. Cod are not considered something new to the area. One hunter explained that there used to be lots of cod, but that they were almost fished out in the 1970s. He said that while they are getting more noticeable in the area, they are not as big. Older people spoke of numerous cod long ago, when they used to hook and jig for them through natural holes on the sea ice.

One of the most significant changes related to fish occurred in 1993, when several of the hunters caught two different species of Pacific salmon in their nets, far from their geographic range. These were identified by the Department of Fisheries and Oceans as Sockeye and Pink salmon (*Oncorhynchus nerka* and *O. gorbuscha*) (also see Babaluk *et al.* 2000). For the families that caught these fish, what was most unusual was that when they took the fish out of their nets, "the eggs were just pouring out" (A. Carpenter). For many of the hunters and elders in the community, the 1993 salmon are representative of the larger changes occurring in the area.

Never saw salmon here before. People here been setting nets for quite a while. First time I ever see that. Even herring for that matter. It is kind of changing around here for us. I really find a difference with the fish that they are catching. Chars are getting bigger than they used to catch. – J. Lucas Sr.

Frank didn't get one when those other guys did in 1993, but he got one last year. Must be getting warmer! Maybe beluga will come soon too. And really strange – getting qaaktaq now – and just fat. And the char are getting bigger from when we first came. We used to only use 2" fishnets, now we use 3.5. –M and F. Kudlak.

My boys used to get that salmon...you know the big ones with red meat. My boy Charlie got them down there, across the ice house. First time I see that kind. – E. Haogak.

Other changes include an increase in Least Cisco or *qaaktaq* (often called herring or blue herring in the community). Almost everyone in the community addressed the increase in *qaaktaq* in their nets. These fish are not common to Banks Island; they are from the ocean and are caught in nets along the Bay in the mouth of the Sachs River in July and August. As well, several community members described *minnows* appearing in the Bay; *seen in great numbers in the water*, most noticeable when the water is calm. One hunter described how they were all around the boat, the water was full of them.

The blue herring I haven't seen much. Probably 5 – never really caught them out here before. Long ago they get caught every so often. They go in the direction towards the lakes along the river. – R. Kuptana.

This year again, they seen herring right out front in the ocean. You don't see that often. Guys getting herring. – P. Esau.

We never used to get qaaktaq around here. Now you see qaaktaq in people's dry fish. We never used to get it – that herring. Just start coming. – L. Wolki

No qaaktaq on Banks Island long ago. – S. Kuptana

A lot of those little ones, I don't know what they are called. Something I have noticed before. And seagulls out there...they are diving in the water. First time I ever see that kind of diving. Last time Wayne was in the river he couldn't see the bottom. – J. Keogak.

4.5.2 Changes related to birds

Banks Island supports a large number of migratory birds that arrive on the Island in the spring to lay their eggs. The Banks Island Migratory Bird Sanctuary (Canadian Wildlife Service) covers a large portion of the southwestern part of the Island. This area supports the largest breeding colony of lesser snow goose in the Western Arctic, as well as thousands of nesting Pacific Brant, King Eider and Old Squaw ducks. It is also the primary harvesting area for these species in the spring, particularly around Egg River. The timing of the migration of birds such as geese and waterfowl is closely associated with the availability of open water in the spring and freeze-up in the fall. As one man described, "the weather has to be right... then they come" (P. Esau).

Bird-related changes that may be associated with climate, or weather, included different kinds of birds, changes in abundance of certain species and behavioral changes, perhaps related to habitat changes. Other changes, such the dramatic rise in snow goose population, are linked instead to government quotas, changes in hunting, and natural population cycles.

Most noticeable is *more different kinds of birds*. These changes are considered fairly recent, in the last five years. Robins and swallows were seen on the Island in recent years. Most noticeable is the appearance of small, unidentified birds (“dicky birds”). Most people in the community point to the presence of these “mainland” species as evidence of warmer temperatures. Pintail ducks, considered mainland ducks, are increasingly common, and mallard ducks have been spotted as well. Several hunters commented that they have observed increases in Canada geese, yellow legs, swans and guillemots, birds that are not historically abundant on Banks Island.

If it gets warmer all kinds of different birds will come around here...Canada geese and things like that. –Geddes Wolki

Seabirds, ducks...years ago it never open up in the springtime the way it does now. In the springtime ducks used to be in the cracks – small cracks- they would starve. Long ago just a little crack. Never happens anymore, water always there now, ducks have now problem. –Joe Apian.

4.5.3 Changes related to land animals

Observations associated with weather-related change and land animals focus predominately on caribou and muskox populations on Banks Island. The Island supports the largest herd of muskox (*umingmak*) in the world, comprising 1/3 of the world’s population by 1990 (Gunn et al. 1991). In 1998, there was an estimated 45 833 non-calf muskox on the Island (Nagy et al. 1999). Caribou (*tuktu*) on Banks Island are Peary Caribou (*Rangifer tarandus pearyi*), and were estimated at just under 500 animals as of 1998. Historically and currently, caribou are the preferred food source (Gunn et al. 1991, S. Kuptana, pers. comm. 1999). There is currently a quota of 36 male caribou or one caribou per family in Sachs Harbour (Nagy, pers.comm.).

Some aspects of Inuvialuit knowledge of caribou and muskox ecology, such as competition between the species, have differed from those held by many government wildlife biologists, and have been a source of conflict between local users and government biologists (Norm Snow, pers. comm.). Many Inuvialuit feel that the exponential growth of the muskox population (from a very low population in the 1970s to

65 000 by the mid 1990s) in the last two decades have resulted in the decline of the caribou. They believe that the rapid increase in muskox will result in disease and eventual overpopulation problems.

My mother said we were going to have lots of muskox – we are going to have no more caribou. She was right. Government said no, can't be allowed to kill them. My mother kept saying kill them off or we are going to have no more caribou. And she is right. Now hardly any caribou. –L. Wolki (*Mrs. Wolki's mother was Susie Titalek, well known by everyone in the community as someone who knew about caribou and muskox*)

There used to be no muskox, but lots of caribou. When I was a girl [circa 1930s] no caribou just muskox and geese. Wished for caribou. Get tired of muskox. Then no more muskox and lots of caribou. Lots of muskox now...no more caribou. –E. Haogak.

Determining the potential impacts of climate change on caribou and muskox on Banks Island is complicated by the conflict and uncertainty associated with natural population cycles, inter and intra species interaction, wildlife management practices, movement patterns of some species (inter-Island), harvesting patterns, quotas and predation issues. For example, most of the wolves on Banks Island were killed during a government sponsored poisoning program in the late 1950s; people believe that the natural balance among many species was disrupted as a result. The difficulty associated with assessing the impacts is illustrated in the following excerpt from an interview with A. Carpenter:

Q: Do you think that those changes you are talking about – more rain and longer summers – do you think that has an impact on caribou and muskox?

A: It is hard to see that – because when changes start occurring here, well... the caribou population is down, and so how can you really tell?

When asked specifically about climate change and caribou and muskox, people in the community most commonly responded with information relating to the relationship between weather and wildlife, the impacts of freezing rain on wildlife, recent changes to vegetation, and finally, general descriptions of animal health and abundance. These

interviews and discussions produced a series of observations related to wildlife ecology and climate change. Some of these observations can be articulated as hypotheses relating to phenomena such as caribou movement and forage resources, as well as explanations and predictions for how wildlife respond to climate-related change such as severe weather events. Examples of such observations are given below:

How do animals respond to bad weather or severe weather events such as freezing rain?

1. Severe weather events such as freezing rain and hard winters will impact caribou more than muskox.
2. Severe weather events such as freezing rain will impact caribou and muskox most noticeably when they are carrying calves (spring). Most freezing rain occurs in the fall.
3. When there are severe weather events such as freezing rain, caribou calves and bulls die off first. Cows and young bulls will not be impacted to the same extent; “they get skinny but always survive”.
4. When freezing rain occurs in the fall, caribou will remain in the south of the Island longer before migrating north.
5. When there are severe weather events such as freezing rain, caribou will travel away from the Island. They will move out on the sea ice and may even go to the open water. In 1952, severe icing conditions caused large numbers of caribou to migrate off the Island.

How will other climate-related changes impact caribou and muskox?

1. Caribou are migrating north in the spring little bit later; they are staying around the Fish Lakes a little longer. They are also coming back south a little earlier in the falltime.
2. Vegetation has increased on the Island as a result of warmer temperatures and increased rain. This is evidenced by the fact that muskox are staying in one place longer. This increase in vegetation is most noticeable in the flats and along the rivers. There is more moss around. This will be good for the caribou. Vegetation is increasing despite the high muskox numbers.
3. Warmer, milder winters will be better for caribou and muskox.

4. More wind is making it easier for the caribou to cope with mosquitoes in the summer.

Why have caribou numbers declined?

1. The caribou numbers are not low because of bad weather (high snowfall and freezing rain). Changes in the amount of snow cover do not really effect caribou, because the tops of hills are always bare from the wind. This is why you see caribou on top of the hills in the spring. Caribou stay on top of the hills in the springtime and they wait for the ground to dry.
2. Increasing wolf populations impacts caribou. This is partly a factor of the low population size of caribou. When herds are healthy, wolves have little impact.
3. Wolves currently kill more muskox than caribou, because caribou numbers are low and are widely distributed.
4. Caribou travel between Victoria Island and Banks Island. When the caribou numbers started going down on Banks Island, their numbers started to increase on Holman Island.
5. When there were lots of caribou (1960s) they ate everything, and it takes a while for the vegetation to recover.
6. Part of the reason that caribou have declined is that people were killing too many cows in the 70s and 80s.
7. The low caribou population is partly due to the natural population cycles.
8. Caribou and muskox eat the same thing. This is part of the reason why the caribou have declined.
9. Even if caribou and muskox don't eat the same thing, the muskox trample the areas where the caribou feed and make it hard on the caribou.
10. Caribou don't like the smell of muskox; they stink in the summertime.

Community members reported that the health of *tuktu* and *umingmak* had not noticeably declined; animals were still in good condition, "muskox especially" (J. Keogak). Edith Haogak described muskox as "all the time fat, even in the wintertime, all fat". However, some changes have been observed with caribou, notable the size of the

racks or antlers on the bulls. Smaller racks are attributed to the lack of big, old bulls in the herds. In addition to these comments, some hunters describes changes to fat content.

One thing you notice now, a lot of caribou now, we get them and the fat on them is anywhere from... in the hindquarters about, when you get them in the fall now is half an inch to an inch, but you used to get caribou with two inches easy. You really notice. – L. Carpenter

People in Sachs Harbour described how changes in the weather can impact wildlife, but they also described how conditions such as freezing rain have not been prevalent and then stressed that these conditions have not been prevalent there is significant difficulty associated with assessing the impacts of weather on wildlife when populations are at such extremes.

As late as the seventies, caribou with big racks, now caribou decline. Does this have anything to do with the weather? My own way of thinking this is natural. Back in the 50s we had the same thing, other way around. –R. Kuptana.

If you are going to have a die off of caribou then you are going to have to have a really hard winter, and we haven't had that...you know where it gets really cold. A lot of people say it is because there are too many muskox. Me I don't agree. I think it is just the downcline of the caribou. When I travel the muskox and caribou are grazing side by side. I think they will come back. –J. Lucas Sr.

You know that old Titalek, that old one that used to be around. She said it was a cycle, after so many years they will come back. – S. Lucas.

There is an abundance of knowledge in the community relating to historical and present populations, behavior and health, and of the relationship between weather and wildlife. This knowledge is the basis for Inuvialuit hypotheses relating to how species will respond to changes.

4.6 Conclusions: An assessment of climate change based on Inuvialuit knowledge, Sachs Harbour

Documenting what the community of Sachs Harbour knows about climate change provides an example of a community-based assessment of climate change, as expressed through traditional knowledge and local expertise. The final section of the chapter summarizes this assessment, drawing the common themes from the preceding sections together to articulate an overall community assessment of change for this region.

1. While people describe general “trends” (i.e. earlier break-up, warmer temperatures), what is most noticeable is increased *variability*. Observed environmental change is measured against a “window” of expected or “normal” fluctuation and variability. People are clear that change and variability are natural aspects of the Arctic; that conditions are not the same every year. However, they consider many of the current changes as without precedent and beyond natural variability.
2. Changes in mean temperatures are not as noticeable as changes in variability associated with the weather. Changes in the weather are often more sudden, more frequent and more intense. For example, when it warms up in the spring, it warms up all at once.
3. Increased variability and change in the weather are most noticeable in the spring and fall months.
4. In some cases, people believe that phenomena that were once considered isolated events or anomalies are becoming more frequent. For example, an ice-free summer was once considered an anomaly; however, this phenomena is more frequent now. “Hot” spells that extend over a week or more have replaced isolated incidents of hot days.

5. A key aspect of climate change is the occurrence of more *extremes*. For example, there are more extreme hot days in the summer now, as well as more hot days in a row.
6. There is increased *unpredictability* now associated with the weather and seasons, as well as phenomena such as ice conditions.
7. The changes the community is experiencing are not seen as “gradual”. Rather they are seen as *fast* change.
8. People consistently reported that the rate of change appears to be accelerating.
9. A good assessment of change remains difficult to achieve, because the changes are relatively recent. Community’s own assessments of change are evolving, as are science-based assessments.

Chapter Five

Contributions of Traditional knowledge to Understanding Climate Change in the Canadian Arctic

This chapter will be published in the journal Polar Record in October 2001, as a paper co-authored by Dr. F. Berkes, titled "Contributions of traditional knowledge to understanding climate change in the Canadian Arctic". Some changes have been made to the original manuscript to provide a link to the rest of the thesis.

5.0 Introduction

Documenting Inuvialuit knowledge can illustrate the richness of the community's knowledge of climate change, and the potential of this expertise in understanding Arctic climate change. However, documentation is only the first step; recognizing and including this expertise requires building relationships between scientists and communities. This process is, as in the past, hindered by questions of how to integrate or bridge the gap between western science and this knowledge. These questions are addressed here. In this chapter, I apply my experience of documenting and learning about climate change to developing a framework for linking Western science with Inuvialuit knowledge.

The chapter will focus on five areas of convergence that may facilitate the use of traditional knowledge and Western science as distinctive, yet complementary, sources of knowledge in the North. The ability of Inuit knowledge to address the complexities of the Arctic environment at spatial and temporal scales currently underrepresented in climate change research will also be examined. The five areas of convergence are the use of traditional knowledge (i) as local scale expertise; (ii) as a source of climate history and baseline data; (iii) in formulating research questions and hypotheses; (iv) for insight into impacts and adaptation in Arctic communities; and (v) in long-term, community-based monitoring.

5.1 Traditional knowledge in climate change research

One of the earliest examples of traditional knowledge in climate research is Spink's (1969) work showing the value of Inuit oral history in corroborating evidence for isostatic rebound and sea-level change. Cruikshank's (1984) research in the Yukon identified oral history as providing insights on past climate. The benefits of considering traditional knowledge to understand climate change has been suggested by several authors (Kassi 1993; Fast and Berkes 1998; Bielawski 1995, 1997; Chiotti 1998; Cohen 1997; Ferguson 1997; Ingold and Kurttila 2000; Maxwell 1997). But there are relatively few studies specifically on Inuit knowledge of climate change. Fox's (1998, 2000)

research in the Eastern Arctic demonstrated that Inuit possessed an understanding of climate change, but concluded that further research was needed before this knowledge could be integrated into climate change assessments. The Tuktu and Nogak project in Nunavut has documented some Inuit ecological knowledge of climate-related change in relation to caribou and calving grounds (Thorpe 2000).

Some of the first attempts to understand environmental change through traditional knowledge come from the Hudson Bay Bioregion project (McDonald et al. 1997) and the Northern River Basins Study (Bill et al. 1996). These community-based projects documented environmental change due to large-scale developments and incidentally addressed climate-related change. They demonstrated that Aboriginal elders were able to distinguish subtle patterns, cycles and changes in ecosystem structure (Bill et al. 1996), and that accumulated knowledge of the land and environmental indicators gave Inuit the ability to interpret and understand seasonal change processes (McDonald et al. 1997). The Mackenzie Basin Impact Study was only able to skim the surface of traditional knowledge, but noted the value of such knowledge in climate change research (Cohen 1997).

Thus, there is evidence that traditional knowledge can enhance the understanding of climate change in the Arctic. However, there are no conceptual frameworks on how to bridge the gap between Inuit knowledge and Western science. Looking to Inuit perspectives on climate change requires clear identification of specific research areas that can facilitate the use of both traditional knowledge and scientific approaches. To expand the scope of conventional climate change research to include traditional knowledge, this thesis explores five areas of potential convergence to link traditional knowledge with Western science (Table 6).

Table 6. Five convergence areas that may facilitate the use of traditional knowledge and Western science, in the context of Arctic climate change research.

Local scale expertise	The importance of local-scale expertise has been emphasized in discussions of traditional knowledge in the North. Climate change will be first noticeable through biophysical changes in sea ice, wildlife, permafrost and weather. These changes will not go unnoticed at the local scale in Inuit communities.
Climate history	Traditional knowledge can provide insight into past climate variability, providing an essential baseline against which to compare change. Climate history is embedded in Inuit history of wildlife populations, travels, extreme events, and harvesting records.
Research hypotheses	Traditional knowledge can contribute to the process of formulating scientific hypotheses as another way of knowing and understanding the environment. Collaboration at the initial stage of research expands the scope of inquiry and establishes a role for communities in research planning.
Community Adaptation	Traditional knowledge lends insight into adaptations to changes, explaining them in the context of livelihoods and community life. How are communities responding to change? What are the social, economic and cultural limits to adaptation in northern communities?
Community-based Monitoring	Traditional knowledge reflects a cumulative system of environmental monitoring and observation. Monitoring projects have the potential to bridge the gap between science and traditional knowledge by providing a collaborative process.

5.2 Five areas of convergence

5.2.1 Local-scale expertise

Combining the knowledge and skills of Western science with local Inuit expertise can translate global processes such as climate change into local scale understandings of potential impacts. Forecasts generated by climate and other models, while key to predicting change, typically simulate phenomena at coarse spatial and temporal scales, and thus are limited in their capacity to explain change at local or regional scales. Concepts such as climate change and global warming are nebulous until they are considered at scales at which the impacts are most likely felt (Jacobs and Bell 1998). In fact, predictions will be of most value to decision-makers on a regional basis (Watson et. al., 1998).

As Usher (2000:187) points out, traditional knowledge can contribute to a fuller understanding of local environmental processes “at a finer and more detailed geographical scale than conventional scientific knowledge can offer... because it deals with outcomes and prediction: what people think will happen and why”. Traditional knowledge is what Harvey (1984) calls ‘applied peoples’ geography’: local geographical knowledge describing the world and providing a basis for appropriate decision-making. “Knowledge of the land constitutes intense, highly functional local geographies” (Duerden and Kuhn 1998: 34).

The ecological and environmental expertise found in Inuit communities can highlight parameters rarely measured by scientists and help make sense of scientific findings by placing them in a local context. Such expertise can also “groundtruth” scientific predictions and provide supporting evidence for coarse-scaled models. Traditional knowledge and local observation can elucidate complex feedback linkages between climate and the biophysical environment that are variable in time and space, and thus are difficult to quantify. Given the expected increases in regional variability associated with climate change, local observation and expertise are important components of understanding change.

One example of this local expertise is evidenced in the description of sea ice changes by community members in Sachs Harbour, a coastal community on the Beaufort Sea. Changes related to sea ice are the most noticeable changes that the community has witnessed in recent years. Community members describe changes through a complex of interacting variables, including water temperature, currents, ice thickness, ice colour, ice phenology, pressure ridge and lead distribution, hunting and travelling safety, polar bear and seal distributions, animal health, and wind patterns – in comparison to the past and present. These descriptions capture aspects of localized change such as the increased timing and *rate* of break-up in the spring, or the intensified east winds in the fall that push ice floes away from the community and result in no multiyear ice around which new ice can form. This in turn forces hunters to travel on new or first year ice. Whereas weather stations and satellites provide data on wind velocity, temperature, precipitation and ice cover data, scientists are still unable to predict ice distribution and condition at a given location, such as Sachs Harbour, in early summer. This is because, as community members point out, ice distribution depends on the *relationship* between wind direction, velocity, currents, temperature, and other environmental variables.

Changes in climate are recorded; but changes in the weather are experienced by local people (Ingold and Kurttila 2000). Whereas climate is an abstract scientific concept, weather is time and place-specific, a phenomenon experienced firsthand. For example, the Inuvialuktun term (Western Canadian Arctic dialect) used in Sachs Harbour, *sila*, means “weather”, and there is no term to distinguish between weather and climate (For a more detailed meaning of *sila*, see Appendix C). Table 2 summarizes several examples of locally experienced changes, as described by the community of Sachs Harbour.

Time and place-specific empirical observations, such as those in Table 7, can help explain larger scale phenomena. For example, the scientific evidence regarding the freshening of the Arctic Ocean (a thicker low-salinity layer in the surface waters) is inconclusive (e.g. Dickson 1999). However, some Sachs Harbour hunters have noticed that seals are sinking to a deeper water level at the floe edge, a phenomenon attributed to a lowered fat content and/or the greater freshening of the ocean water from melting sea

Table 7: Examples of recent local environmental change related to climate as described by Inuvialuit in Sachs Harbour, Western Arctic.

Phenomena	Observed change
Sea Ice	<p>Less/no multiyear ice in July and August; more open water (and "rougher" water)</p> <p>More ice movement than before</p> <p>Not able to see the permanent pack ice to the west</p> <p>Ice breaks up earlier and freezes up later</p> <p>Rate of ice break-up has increased</p> <p>Annual ice in harbour is weaker, thinner (not safe)</p> <p>Less and thinner landfast ice (shore ice)</p> <p>Changes in distribution and extent of local pressure ridges</p> <p>Leads (openings in ice) farther away from shore</p> <p>Ice pans do not push up on shore anymore</p> <p>Open water in winter is closer than before</p> <p>Changes in ice colour and texture</p>
Permafrost	<p>Land subsiding in some places</p> <p>Increasing slumping and landslides, both inland and along the coast</p> <p>Exposed ground ice (ice lenses) on hillsides</p> <p>Increased depth of active layer in spring</p> <p>Increased rate of melt in spring</p> <p>Water and "ice pebbles" in the ground rather than ice in some places</p> <p>Increased puddles, ponds, water in pools on the flat land</p> <p>Pingos decreasing in size</p> <p>More mud on the land</p>
Changing seasons	<p>Longer, warmer summers</p> <p>More rain and wind in the summer</p> <p>Melts faster in the spring than it used to</p> <p>Spring comes earlier now than it used to</p> <p>Shorter, warmer winters</p> <p>August is warm month now; used to be "cooling off month"</p> <p>Falltime comes later now than before</p> <p>Seasonal change is more unpredictable now</p>
Fish and Wildlife	<p>Two species of Pacific salmon caught near the community</p> <p>Increased numbers of <i>Coregonus sardinella</i> (least Cisco)</p> <p>Less polar bears in area because of less ice</p> <p>Increasing occurrence of "skinny" seal pups at spring break-up</p> <p>Observations of robins; previously unknown small birds</p>
Weather	<p>More rain in the fall; rain that should have been snow</p> <p>Different kind of snow, less rough drifts</p> <p>Longer duration of "hot" days, now a whole week rather than 1-2 days</p> <p>Thunder and lightning – none seen before</p> <p>Weather more unpredictable</p> <p>Changes in wind velocity and direction; more intense wind storms</p> <p>Winters are shorter and not as cold</p> <p>Spring is shorter now (snow and ice melt faster)</p>

ice. In late winter, seals tend to be relatively low in fat and the spring melt results in low density surface waters, hence seals are less buoyant and tend to sink deeper (possibly to the depth of the halocline, where the salinity changes sharply). The fact that seals in recent years are sinking deeper may be local evidence that the low salinity surface layer has become thicker.

5.2.2 Climate history and baseline data

A second convergence area for the use of traditional knowledge and scientific approaches together, concerns change over historic time. Climate history of the Arctic is central to understanding future (or present) climate change. History of Arctic peoples and their activities is partly a product of past climatic change. The arrival of the Thule, ancestors of present day Inuit, in the Canadian Arctic 1000 years ago, is believed to have been related to the expansion of the environmental zone to which the culture's maritime hunting technology was adapted (McGhee 1970).

Establishing a historical record of change utilizes a variety of scientific and non-scientific sources of information, including instrumental (e.g. meteorological), documentary (e.g. Hudson Bay records, expeditions), and proxy data (e.g. ice core samples). As information sources they can be applied with varying success to both the physical and human context of climate change research. However, the chronological scope of data for establishing a climate record in the Canadian Arctic is limited. The systematic collection of meteorological data for the Canadian Arctic Islands did not begin until 1947 (Maxwell 1980); the Sachs Harbour weather station was not established until 1956. Prior to 1947, isolated climatic studies for the Arctic were based on historical documents and fragmentary short-term records (Maxwell 1980). Proxy sources such as ice cores and lake sediment records can be used to reconstruct past climate events (Overpeck et al. 1997), but the coarse spatial resolution makes it best suited to time scales greater than the past 100 years. McGhee (1981) used archaeological evidence to construct a picture of Arctic climate change, correlated with human occupation for the past 5000

years. Is traditional knowledge another source of climate history, providing important baseline data against which to compare change?

Traditional knowledge, through cumulative experience and oral history, provides insights into past climate variability and fluctuation; such knowledge is embedded in Inuit history of wildlife populations, travels, unusual events, harvesting records, and migrations. For example, many elders in Sachs Harbour describe extreme ice years in their stories of travelling from the Island to the mainland when they were trappers. Years such as 1933 are described as cold years when the ice never left and they could not travel by schooner. This kind of knowledge can complement data gathered from instrumental, documentary and proxy sources used to piece together climate history, and provide a more comprehensive baseline against which change can be established.

Traditional knowledge and oral tradition are validated by Inuit historical and current occupancy of the north (Freeman 1976; Weinstein 1996). In Sachs Harbour, living memory extends back to the 1920s. However, interviews conducted in the community consistently include oral history, elements of knowledge and stories passed on by parents and grandparents. The history and land use of Banks Island extends beyond the mid 1950s, when the permanent settlement was established. Inuit from Victoria Island area historically traveled back and forth to Ikahuuk – the crossing place (S. Kuptana, Sachs Harbour, NWT). Inuvialuit from the mainland began coming to the island in the 1920s to trap white fox, spending fall and winter on the Island and returning to the mainland after breakup. This history provides a context for change, as depicted in the following descriptions of the “long ago” offered by elders.

In the early days, we used to have a schooner and we used to go back and forth every summer. We would spend the winter here and go back every summer. But we always can't get out of here until around August. We tried to get out of here in July and one time we had to go by Holman Island just to get to mainland. Now in July it is clear across. (A. Carpenter, Sachs Harbour, NWT)

My mom said long long time ago before I was born, it always used to be so good weather on Banks Island – when they used to live on Victoria Island. And those angatkuq (shaman) they used to go get good weather from Banks Island to Victoria Island. Long long time ago before I was born my mom used to tell me. Now we blame the angatkuq take our good weather away! That's how my mom used to talk and its true. Banks Island used to be really good weather long ago (L. Wolki, Sachs Harbour, NWT).

When there is no old ice, there is not very much seals too. They travel on the big old ice. Long ago when the old ice used to come in, we head for the big ice out there. Just stop and seals start coming. Nowadays it is not like that anymore. Those small ice – hardly any seals on them. They are too small. Its warmer summers - I think those thin ice melt right down. That is why there is hardly anymore ice. Used to be old ice coming from the north all the time. And when it freeze-up with old ice, seems to be more bears all the time. When it has leads, around March, boy lots of bears when you go out. I used to feel safe when I would camp on the old ice. Just like islands, that old ice. Good for tea! The old ice, it always open up too, all kinds of seals. Because that old ice is smooth, good for seal holes (G. Wolki, Sachs Harbour, NWT).

As Usher (2000) describes, the time depth of Inuit knowledge provides a diachronic perspective, creating a baseline for expected deviations from “normal” conditions. This baseline is fluid and evolving, rather than static. Elders in Sachs Harbour say that “long ago the weather was not the same as it is now”. They describe it in terms of seasons; that “the seasons are getting crazy now”. There has always been change -- the timing of seasons, freeze-up, break-up, and wildlife migrations has always fluctuated. The difference in recent years, however, is that changes are beyond the range of expected variability and fluctuation. Many people say, “things are happening at the wrong time now”. As one elder described, “there used to be hardly any summer [here], and in the winter you needed two parkas; two caribou skins back to back (S. Kuptana, Sachs Harbour, NWT).

Researchers have shown the accuracy, consistency and precision of Inuit historical recall with respect to studies of Arctic caribou populations (Ferguson and Messier 1997; Ferguson et al. 1998), and land use and occupancy (Arima 1976). Inuit knowledge is a valuable source of climate history for many parts of the Canadian Arctic, providing a record for the North that in some cases may exceed that of other sources, particularly during the last century.

5.2.3 Formulating research questions and hypotheses

A third convergence area is the contribution of traditional knowledge to the process of formulating research questions and hypotheses. The method of empirical science is hypothetico-deductive; constructing hypotheses and testing them by observation and experience (Popper 1959; Peters 1991). Even if we did know how to measure climate change in the Arctic, first we would need to know what to measure. Traditional knowledge may expand the range of concepts and possibilities upon which to base research questions and formulate hypotheses.

Knowledge systems, or ways of knowing the world, provide the boundaries that either constrain or enhance the process of asking questions, observing, testing and understanding. Formulating hypotheses is considered the most important part of the research process in determining the research that follows. It can also be the most subjective step in the research process. Researchers formulate hypotheses based on the range of questions of which they are aware (Keddy 1989). The kinds of questions asked are a function of the concepts available; they originate within a culturally specific picture of the world. The Western scientific tradition holds a particular concept of the world, which is usually considered “the correct” picture of the world (Feyerabend 1987).

However, limiting research to one “correct” view of the world may constrain the understanding of complex environmental phenomena such as global change. Both Inuit and scientists choose what to observe over time, whether based on the need to travel safely and hunt successfully, or the need to study those phenomena deemed relevant for specific research goals. Inuit knowledge can contribute to the process of formulating scientific hypotheses as an alternative way of understanding the environment. Time-tested observations can expand the scope of inquiry through insight into ecological relationships and provide a starting point for research (Thorpe 2000, Berkes and Folke 1998).

A good example of how Inuit observations can lead to scientific questions comes from the Hudson Bay Bioregion project, in which Sanikiluaq hunters reported major changes in currents and regional sea ice conditions (McDonald et al. 1997). They related these changes to increases in winterkill of common eiders (*Somateria mollissima*). The

hunters' observations were later corroborated in scientific studies (Robertson and Gilchrist 1998). A second example is Ferguson's (1997) research on caribou migrations and severe weather events. Ferguson found that in many cases, Inuit knowledge of caribou ecology and subsequent hypotheses relating to caribou density, movement, and forage resources provided a better fit than did conventional science in both explaining and predicting caribou behavior related to adverse weather conditions.

The contribution of traditional knowledge to hypothesis development is important to bridge the gap between community concerns and research efforts. Communities that are directly experiencing change can better identify research priorities. The Sachs Harbour Community Conservation Plan (1992) identifies two species, *ugyuk* (*Erignathus barbatus*, bearded seal) and *natchiq* (*Phoca hispida*, ringed seal), as requiring research into the occurrence of "skinny" animals on spring sea ice. The community observed the increased occurrence of abandoned seal pups related to early break-up and general lack of sea ice. These kinds of observations provide community-based directions to formulate research questions. Table 8 provides additional hypotheses from Sachs Harbour. Such hypotheses articulate a community-based assessment of climate change.

Increasingly, Inuit communities are questioning conventional research processes and demanding more involvement at the design stage and the implementation of research that affects their communities and livelihoods. Arctic communities, as the 'canaries' of global climate change, are already seeing the effects of such change. Collaboration between communities and scientists at the initial stage of research expands the scope of inquiry and also ensures meaningful involvement of communities in research planning.

Table 8: Hypotheses generated from interviews with community members in Sachs Harbour.

Hypothesis	Explanation
1. Observed changes are beyond the natural range of variation.	People describe trends, such as earlier ice break-up and warmer temperatures, but emphasize the importance of “variability”. They observe change as measured consider recently observed changes as without precedent and beyond natural variability.
2. Observed changes result in increased unpredictability in environmental phenomena.	Related to increased variability, Inuvialuit notice that it has become more difficult to predict or anticipate weather, seasons, ice conditions, game availability and timing animal migrations.
3. Increased variability and unpredictability are most noticeable in the spring and fall months.	Changes are observed in winter and summer, but the most noticeable changes occur in the transition months.
4. Rare and extreme weather phenomena are becoming more frequent.	What used to be considered rare and isolated events such as ice-free summers in ocean waters near Sachs Harbour, extended hot spells in summer and thunder storms, people note, may no longer be anomalies.

5.2.4 Impacts and Adaptations: How Inuit see change

Human dimensions of change, including planning for and understanding human adaptation, is an important aspect of climate change research but poorly understood (IPCC 1995; Maxwell 1997; Smithers and Smit 1997). Including traditional knowledge in adaptation research can establish the changes that the communities see, how they perceive them, and how they explain these changes in the context of livelihoods.

How does a 1 to 3.5 Celsius degree temperature increase over the next 100 years (IPCC 1997) translate at the community level in the Western Arctic? The geographical

location and resource dependency of Arctic communities means that small increases in global temperatures will be more noticeable than in other regions. Humans and the environment are closely linked in the Arctic (Roots 1994), and societies dependent on Arctic resources are more sensitive to environmental change (Krupnik 1993). Northern livelihoods are resource based, and hunting and fishing remain important aspects of social and economic life (e.g. IHS 1996; SHCCP 1992).

The relationship between Inuit and the Arctic environment is closely tied to cycles of seasonal activity and resource use. Environmental change is an expected part of the daily life and a capacity to adapt to change is a part of livelihood systems. However, unexpected or extreme events and unusual fluctuations create hardships because they interfere with the ability of people to access the various resources on the land, and make resource availability itself less predictable (Fast and Berkes 1998). In some cases, early freeze-up of the sea ice has shortened the walrus hunting season in some communities, causing meat supplies to run low (Fox 1998). Increased coastal erosion in places such as Tuktoyaktuk in the Western Canadian Arctic risk making parts of the community uninhabitable (Shaw et al. 1998).

Climate change at rates outside of the historical experience may also make some aspects of traditional knowledge unreliable (Fast and Berkes 1998). For example, Inuvialuit elders in Sachs Harbour say, "long ago when it was going to be a big storm, there was a sign, and then the hunters would prepare for the storm. Now it is increasingly difficult to predict the weather" (P. Esau, Sachs Harbour, NWT). Such signs usually include physical changes, such as the appearance of clouds or the horizon, and subtle changes in the temperature or wind. Fox (1998) commented on the role of "reading" the sun and moon in predicting weather among eastern Arctic Inuit. Such environmental cues become difficult to interpret under conditions of climate change.

At the 1998 Circle of Wisdom Native Peoples/Native Homelands climate change workshop, a Siberian Yup'ik elder described the change as "The earth is so fast now; we can't predict the weather anymore" (Gonzales and Rodriguez 1999). How much change can be accommodated by the current system of traditional knowledge and practice? The amount of perturbation a system can absorb and adapt to is a measure of the resilience (or flexibility) of that system (Berkes and Folke 1998). The question of resilience is

important because little is known about the cultural, social and economic limits to adaptability.

Changes observed in Sachs Harbour are not beyond the range of the community's ability to respond and cope with them, predominately through adjusting subsistence activity to accommodate seasonal fluctuation and change. However, these changes are relatively recent events, and how Inuvialuit are coping and responding up to now, may not be a reliable indication of the community's ability to adapt in the future.

The key to understanding the impacts of climate change on northern communities is through the perspective of northern people. Gaining insight into the adaptability and resilience of northern economies to future change, can be achieved through working with communities to understand how they perceive the change. Awareness of climate change in the Arctic, as described and explained by Arctic communities, may provide the necessary impetus to policy makers and governments to plan more effectively in addressing climate change impacts.

5.2.5 Community-based environmental monitoring

A primary difference between Western science and traditional knowledge is that traditional knowledge holders are the resources users themselves, and their knowledge is grounded in the observation of environment and resources over an extended period of time (Berkes 1999). Environmental monitoring occurs in the context of seasonal rounds of resource harvesting activities; it is closely tied to travel routes, and the times and places of harvesting. This kind of community-based monitoring ensures that ecological relationships are noted, as in the case of possible competition between caribou and muskox for forage. Such monitoring recognizes and uses environmental indicators, as in the case of Sachs Harbour residents noting "signs" of an impending storm (see previous section).

In the community of Sachs Harbour, many families maintain camps at inland lakes that they travel to regularly, often at the same time every year. These trips provide a time series of observations which can be recalled years later, on such things as inland

snow conditions, sea ice, and the appearance of migratory animals such as the lesser snow goose. Such observations provide an in-depth, cumulative, relational, diachronic set of information for a given area. By contrast, scientific monitoring techniques often focus on individual environmental phenomena in isolation from other factors, and are best suited for synchronic (simultaneously observed) data collection.

Climate-related environmental change monitoring can use the capacity of local people to add site-specific information, bring attention to signs or indicators, and highlight relational information. It can also capture anomalous observations, such as the two species of Pacific salmon (*Oncorhynchus nerka* and *O. gorbuscha*) caught in Sachs Harbour in 1993. The occurrence of these species represent significant extensions of known, normal distributions (Babaluk et al. 2000).

Monitoring can be collaborative, bridging the gap between scientists and communities by combining synchronic and diachronic information. Such projects enable local input into the environmental variables to be monitored. Community-based projects can provide cost-effective means of establishing baseline data and monitoring change. Within regional scale monitoring projects, traditional knowledge can also help to distinguish natural variability from 'non-natural', or unexpected changes. For example, Sachs Harbour community members describe land and coastal erosion as a result of the thawing of permafrost. This is a natural process that can be seen all around Banks Island. But in recent years, the rate and extent of permafrost thaw have increased, resulting in unnaturally high amounts of erosion. Community members describe soil erosion, slumping and mudslides as being "all over now, not just in certain areas. People have seen them before, but there is more now. Before it was once in a while, mostly coastline. Now, more inland." (A. Carpenter and L. Carpenter, Sachs Harbour, NT).

Thus, community-based monitoring projects can help link traditional knowledge and scientific approaches. However, attempts to combine traditional knowledge and science often raise the question of the decontextualization of local knowledge, to fit it into an established scientific framework (see Nadasdy 1999). Collaborative community-based monitoring projects have good potential to retain traditional knowledge in its cultural context, rather than reifying it as an information source separate from its local applicability. The Arctic Borderlands Ecological Knowledge Co-op (2000) is one project

example of an attempt to link communities and scientists to monitor northern resources such as caribou, in this instance the Porcupine Caribou herd.

5.3 Discussion: Scale, Context and Arctic climate change research

Inuit knowledge can be an accurate and sophisticated source for understanding climate change and variability in the Canadian Arctic. The five convergence areas presented here as a conceptual framework for facilitating the linkage of traditional knowledge with Western science illustrate the potential for collaborative climate change research. Even though the five areas were presented as separate items, they contain a common theme: that traditional knowledge can complement Western scientific approaches to climate change research through understanding change in contexts and at scales currently underrepresented in climate change research. In this section, we expand on the discussion of scale, context and Arctic climate change research.

Climate change research relies on comparing what is happening at present to what has happened in the past. To this end, Western science has employed several approaches, from paleoclimatic investigation to modeling temperature records. Each approach is best suited to certain spatial and temporal scales, as well as contexts (Ingram et al. 1981). As put forth in this paper, traditional knowledge represents another approach to investigating climate change. Figure 2 summarizes the spatial and temporal extent of these various approaches to investigating climate change in the Arctic.

As Figure 2 illustrates, weather station data provides relatively short historical record, and consists of measurements made at one point in space. Thus, even though temporal resolution is high (i.e. hourly records), the length of record is relatively short (last 50 years) and the data provide a limited spatial scale, some 1m to 10^3 m. A second information source, satellite imagery, is capable of providing land and ice surface data over large and small scales, but its use is relatively recent. Third, archival sources such as expedition records, whaling logs or Hudson Bay Company annals may provide more historical depth than other sources, but are often isolated records (i.e. spatially limited).

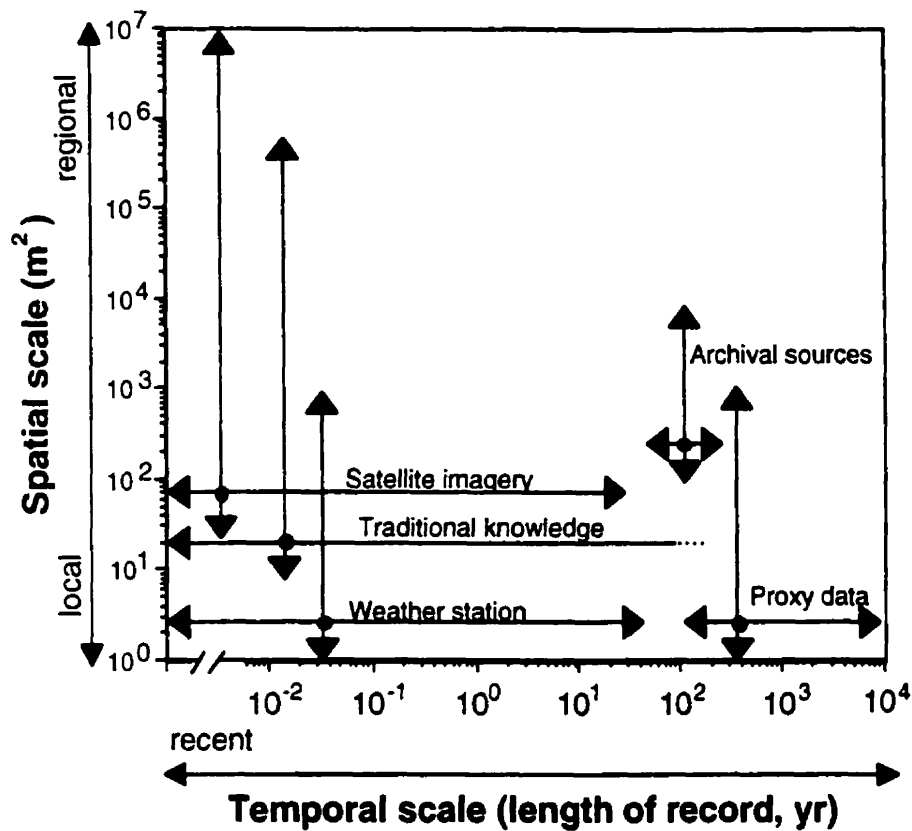


Figure 2: Spatial (resolution) and temporal (length of record) scales of various approaches to investigating climate change in the Canadian Arctic. The spatial scale of a given approach indicates the extent to which it is suited to providing local or regional information. The temporal scale of a given approach illustrates the temporal depth of information coverage, from recent to historical.

Fourth, proxy data such as ice cores and lake sediment cores provide a climate history for one locality; they are most useful for recognizing historical patterns, i.e., have a temporal scale that spans some 10² years to 10⁴ years. Fifth and last, traditional knowledge can be applied to a range of spatial scales (local to regional) for the region of occupancy. In terms of temporal scale, it spans from the present and living memory to the past through historical recall and oral tradition. For the purpose of Figure 2, it is difficult to assign a temporal scale to traditional knowledge, given that it is representative of a knowledge system as a whole, and not a specific technique, as with the other approaches.

The temporal depth attributed to traditional knowledge is variable, as it is dependent on the community itself, and on what kind of knowledge/history is being shared.

Figure 2 and the discussion of scale demonstrates how Inuit knowledge can complement other approaches. For example, the availability of three sources of climate knowledge (traditional knowledge, weather data, and satellite imagery) have overlapping time and spatial scales, suggesting the potential for using multiple approaches, cross-verification and groundtruthing.

An examination of the spatial and temporal extent of various approaches to understanding climate change is useful in conveying the complementary nature of traditional and scientific knowledge. However, the discussion would be incomplete without a detailed examination of the attributes, or context, of each approach. For example, on the basis of the spatial scale alone, satellite imagery appears to be the most extensive. But its use is limited to spectral signatures of land and ice surface cover. The specific attributes of each approach can be expressed using general criteria such as available record, type of information, consistency, reliability, ease of information transfer, and accessibility, as well as the kinds of questions that can be answered using the approach.

Table 9 provides a evaluation of the attributes of selected approaches to climate change research. **Available record – temporal scale** refers to how long data have been available from each information source. **Available record – spatial resolution** refers to the extent to which the given source provides local and regional coverage. **Available record – temporal resolution** describes the “fineness” of temporal coverage, or how often the information is measured. **Type of information** identifies whether the data are quantitative; qualitative or both. **Consistency** is a measure of the evenness of information and whether the data are continuous or interrupted. **Reliability** refers to the objectivity/subjectivity of data; whether it can be independently verified. **Ease of information transfer** addresses the facility by which one source can be combined with another, and **accessibility** is meant to measure the amount of money, time or labour required to extract and use the information. Finally, **kinds of questions that can be answered** clarifies the type of information that a source most suitably provides.

As with Figure 2, this assessment highlights how traditional knowledge compares with other approaches. While these comparisons are not intended to be comprehensive, Figure 2 and Table 9 together demonstrate that the best approach to understanding climate change and the potential impacts on northern ecosystems and communities is through a combination of approaches. The five areas of convergence discussed in the previous section provide a conceptual framework within which to address temporal and spatial scale issues, from both Inuit and scientific perspectives.

5.4 Summary

This chapter concentrates on areas of convergence and complementarity between western science and traditional knowledge. The five convergence areas provide a starting point for building relationships between communities and scientists. However, it is important to recognize that traditional knowledge does not necessarily “fit” with scientific models or research frameworks in all cases. As a number of authors have pointed out, there are cases in which scientific models do not adequately account for local observations (Nadasdy 1999). Part of the reason for this divergence is that the two kinds of knowledge are based on different worldviews (Cruikshank 1998; Berkes 1999). For example, Fienup-Riordan (1999:1) found that scientific understandings and Yu’pik understandings of changes in brant goose behaviour generally agree on what is occurring, but “they do not always agree on why these changes are taking place”. There may be other areas outside of a conventional climate research framework in which traditional knowledge can inform science. Riffenburgh (pers.comm.) commented that “conceivably local models may actually suggest reframing some of the larger questions about how humans are to come to terms with climate change – a phenomena that science may monitor very effectively but certainly not fix”.

Western science represents only one set of approaches to knowledge and inquiry. An exclusive focus science may restrict our understandings of climate change, and the impacts of change on northern ecosystems and the communities that depend on them. For understanding a phenomenon as unpredictable and far-reaching as climate change, the

Table 9: Evaluating the attributes of various approaches to investigating Arctic climate change. This discussion is not intended to be a comprehensive summary, but rather an indication of the general characteristics of various approaches.

Source	Instrumental data from weather stations	Satellite Imagery	Archival (documentary sources)	Proxy data (i.e. ice cores)	Traditional Knowledge
Available Record -- temporal scale (length of record)	1947 in most of the Arctic	Some types of imagery starting in early 1970s, others more recently	150 years in many parts of the arctic	Hundreds of years to many thousands of years	Living memory; extended through oral history; monthly, seasonally changes represented well. Dependent on individual communities
Available Record -- Spatial resolution	Local: measures variables at one point in space and time; Regional: data from several stations, but may not give regional picture if regional variability is high	Local: variable resolution from approx. 10 m (RADARSAT) to 30 m (SPOT). Regional: approx. 25m pixels from some sensors; image mosaics can provide extensive coverage	Local: can cover individual expedition routes; Regional: region a HBC post/store was located	Local: measures one or a few points in space; Regional: aggregating several independent measures	Diachronic information of a locale or region over time
Available Record -- Temporal resolution	Fine resolution -- hourly, daily, monthly summaries	Constant record, with constraints (i.e. cloud cover for optical and thermal wavelengths)	Fine resolution -- daily, weekly logs	Coarse resolution	Best suited to relatively coarse measures such as monthly and seasonal change
Type of information/ observation	Quantitative; measures temperature, precipitation, wind, etc.	Quantitative; Land and ice surface cover only; restricted to signatures of spectral reflectance	Mostly qualitative (records, journals); some quantitative (date of ice break up, temp); observations of land use, wildlife, weather events	Quantitative paleorecords of climate or atmospheric composition.	Mainly qualitative but can be quantitative. Knowledge of weather, land, sea ice, animals, etc. based on resource use

Consistency	Data can be fragmented; missing variables; isolated network of stations not all collecting same variables; changes in technology over time	Can be consistent, but often interrupted because of cloud cover. Consistency will vary dependent on data set. Limited in temporal depth	Fragmented record in time and space	Relatively few sites used to generalize from	Cumulative observations over time; Consistency can be evaluated through cross-referencing within and between communities
Reliability	Objective; but unknown how reliably isolated stations represent surrounding area	Objective; but limited in what can be monitored; problems with data archiving and retrieval. Subjective; relies on user expertise	Subjective; often of unknown context; difficult to verify	Objective; relatively high reliability; depends on analytical techniques used	Subjective; validated through land use, history and occupancy; by triangulation and by local expert verification
Ease of information transfer	Relatively easy; can be used to calibrate models	Compatible with other sources	Difficult to use with other sources; isolated records	Relatively easy to use with other sources	May be difficult to incorporate into scientific approaches, requires working with communities
Accessibility	Relatively inexpensive in money, time and labour; easily obtained	Easily obtained, but relatively expensive for imagery. Some data sets better than others	Relatively inexpensive in money, but expensive in time and labour	Relatively expensive logistics	Time and labour intensive; requires community participation and partnership
Kinds of questions that can be answered	Amounts, highs and lows, means, difference from normal, extremes, trends in regional climate and weather	Concentration (extent) of sea ice and snow cover over time, vegetation and productivity change over time, seasonal patterns, landforms	Extremes, past weather events, impacts of severe weather on human or wildlife populations, weather patterns in the context of a particular place	Past, historical climate information; distinguishing long-term trends from cycles	Indicators; rates of change; impact on wildlife, natural variability compared to unexpected change; extremes; human adaptation to change

wise approach is one that takes a pluralistic view. As articulated by a past Inuit Circumpolar Conference president at a United Nations convention on climate change, “Your science can not tell you how fast climate change will happen and your science can not tell you what and when the surprises will be – just that they will happen” (Kuptana 1996).

Arctic science is becoming more pluralistic and participatory, evidenced by areas such as wildlife co-management, coastal zone management and environmental assessment (Berkes et al. *in press*). Traditional knowledge is identified as one of the mechanisms by which participatory approaches can be developed. Research partnerships between scientists and communities are not uncommon in the North. For many scientists, their knowledge already incorporates what has been learned from Inuit communities. However, at the same time, communities still express frustration over the lack of useful feedback from scientists or input into research and decision-making. There is room for more progress in accepting traditional knowledge as a source of knowledge and understanding, not in the abstract, but in practice.

The evolution of an Arctic science that looks to both traditional and scientific knowledge will be achieved by determining how to include traditional knowledge in a research paradigm that, in the Arctic, is largely influenced and constrained by external budgets, logistics, methods and values. This chapter addresses the “how” question, not as a methodological discussion, but by suggesting a framework for the contributions of traditional knowledge to climate change research. The “how” question is also addressed by demonstrating, through the Sachs Harbour example, how different ways of perceiving the physical and biological environment can complement each other. In the framework proposed, the five clusters of potential complementary relationships may help make Arctic research more participatory and pluralistic.

Chapter Six:
Synthesis and Opportunities for further research

6.0 Synthesis: Bridging the gap between scientists and communities

The Arctic has emerged as a focal point for climate science in recent years (Fox 2000). Accumulating observational evidence from the scientific community and from northern communities suggest that the impacts of climate change are already noticeable in high latitude regions. Western science based research is providing an extensive body of literature on climate change trends and impacts (see Serreze et al. 2000). However, as described in this thesis, climate change as observed, experienced and explained through Inuvialuit or Inuit knowledge has received less attention.

Inuvialuit possess a substantial body of knowledge about climate and climate change. This knowledge is a product of cumulative observations and time-tested experience, a rich understanding of the weather, and the ability to recognize and distinguish subtle changes on the landscape. It is closely connected to land use and occupancy, both past and present, and is generally communicated through individual life experience, often extended through oral tradition. Local observations and traditional knowledge are the basis of community assessments of climate change.

Inuvialuit knowledge can make valuable contributions to understanding Arctic climate change. As local land-based expertise, this knowledge can capture the regional variation associated with predictions of climate change; variation that may be missed in coarse-scaled assessments produced by modeling. It can translate global-scale processes such as climate change into local-scale understandings of impacts, vulnerability and sensitivity of natural and social systems.

Bridging the gap between Western science and Inuit knowledge is an emerging theme in Arctic climate change studies. The benefits of considering traditional and local knowledge to understand climate change have been suggested by many researchers (e.g. Cohen 1997). The importance of northern involvement at the community level has also been asserted (Kassi 1993, Kuptana 1996). However, very few studies have addressed the contributions of Inuit knowledge to understanding climate change.

The thesis is a response to the need to look in new directions to understand Arctic climate change. It recognizes that bridging the gap between Western science and traditional knowledge is about Inuit becoming involved in the process (Arctic science as

including Arctic peoples and traditional knowledge), *and* about identifying the contributions of Inuit knowledge to that process. Importantly, this research complements two other projects that are currently exploring similar topics (see Thorpe 2000, Fox 2000).

In this thesis, I propose that using traditional knowledge and Western science together as complementary sources of information is best addressed through identifying common ground – research areas or topics that facilitate contributions from both scientists and local experts. In the context of climate change research, I have identified common ground in five such “convergence areas”: (i) local scale understandings of change; (ii) climate history and baseline data; (iii) formulating research hypotheses; (iv) impacts and adaptation in Arctic communities; and (v) community-based monitoring. These areas of convergence highlight the strength of traditional knowledge as local, time-tested expertise, and demonstrate how such expertise is suited to investigating climate change at scales and in contexts that are currently underrepresented in climate change research.

6.1 Opportunities for future research

My research provides insight into Inuvialuit knowledge of climate change and the relationship between traditional knowledge and western science in the context of understanding Arctic climate change; it also identifies clear directions for future initiatives. Overall, there is a need for more research such as been described here. Community-based projects that are working to create partnerships between researchers and communities for investigating climate change should be encouraged and supported. Each new project will take this kind of research a step further, finding new ways to bridge the gap between communities and science.

However, there are several specific directions for further research that stand out from my experience learning about Inuvialuit knowledge of climate change. These include i) developing methods for documenting climate-related traditional knowledge, ii)

cross-referencing community observations with other sources of information, and iii) assessing human adaptation, and are outlined below.

6.1.1 Developing methods for documenting climate-related traditional knowledge

Appropriate methods for collecting, documenting, and learning about traditional knowledge remain a prominent theme in traditional knowledge research. As discussed in Chapter three, there is no established methodology for community-based traditional knowledge research, although methods such as the semi-directed interview have gained popularity in recent years.

As with other traditional knowledge research, documenting local knowledge of climate change requires creative, interdisciplinary methodologies that may be beyond the scope of conventional techniques. In my own experience, learning about climate change as expressed through traditional knowledge can be hindered by the lack of appropriate methods for collecting information. This can lead to communication difficulties and risk misunderstanding and misinterpretation. Other researchers that have explored Inuit knowledge of climate change have echoed this difficulty (Hart, pers.com.).

Working with local experts on climate change requires finding ways to communicate place or culturally specific terms, expressions and concepts. Methods for documenting Inuit knowledge of climate change should create processes that captures the subtlety, richness and detail of the changes people are describing and their explanations for them. The interview process that evolved from the work of the science team in the IOCC project explored several methods that were useful for documenting climate change. Such methods included the use of pictures to ensure both parties are talking about the same thing (i.e. thaw slumps), and maps to locate specific places (where erosion is occurring and the landscape in which it occurs in). Documenting climate change information may also require learning local terms and expressions for phenomena (i.e. pressure ridge, piled up ice, rough ice), or spending time out on the land. Some researchers have suggested conferences, bioregion meetings, or “on the land summits” as

appropriate tools for bringing together scientists and local experts to discuss climate change (Fox, pers.comm., Thorpe, pers.comm.).

Linking traditional knowledge and western science requires both new conceptual and methodological frameworks. Here, I focused on the *how to* question conceptually. *How to* methodologically is an opportunity for further study.

6.1.2 Cross-referencing and using multiple sources of information

One of the methods I used for this research project was the analysis of climate data for the Sachs Harbour weather station. The purpose of this analysis was two-fold: to provide background climate information for the region, and to cross-reference community observations. As my research progressed I realized that including this information was largely outside the scope of this thesis. I chose instead to focus exclusively on Inuvialuit knowledge of climate change, without explicit comparisons to other sources of information. However, cross-referencing community observations with weather records (or other sources of climate history) is clearly an opportunity for future study. Working with weather data and cross-referencing it to community observations was useful for highlighting parallels between the two, but also, in some cases, the inability of weather records to capture local change.

For example, many people in Sachs Harbour described warmer spring temperatures (May), with increasingly variable snow conditions. Such observations are paralleled by temperature and precipitation records for the Sachs Harbour station. Figure 3 illustrates temperature differences from mean for the month of May. Figure 4 shows deviation from mean for snowfall for the month of May. The figures clearly support observations of higher spring temperatures, as well as increased variability (though not as clearly). However, changes in the *kind* and *distribution* (related to wind) of snow, also observed by the community, cannot be identified by temperature or precipitation records. Thus, these secondary observations can provide a more comprehensive picture of local changes in spring snow and temperature conditions.

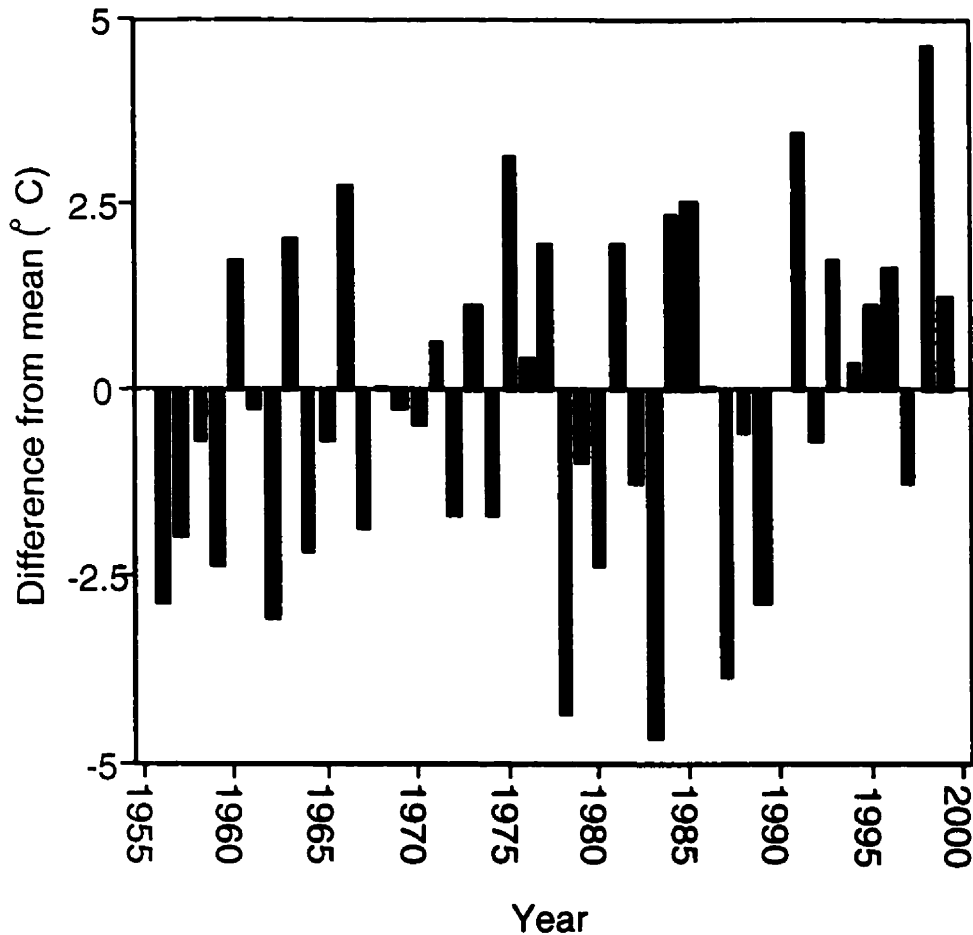


Figure 3: May temperature (differences from mean), Sach's Harbour, 1956-1998.

While some community observations of change clearly correlate with weather records, connections with others were more difficult to establish. For example, people in Sach's Harbour observed more snow in the spring of 2000 than they had seen since the early 1960s. However, as Figure 4 and 5 illustrate, weather records show predominately below normal snowfall in the early 1960s; except for one year that is clearly above normal. Even though this one-year is above normal, there are several other years between 1970 and 1990 that reflect more significant differences from normal. Is the difference possibly due to differences in snowfall, as opposed to *snow depth*? Does the difference

reflect the Inuvialuit conceptualization of snow phenomena as being a function of kind of snow, time of year, and snow depth? Exploring how and why these differences might occur reminded me of an Elder at a recent conference, who said that the real difficulty in trying to link science and traditional knowledge arises when the two do not agree.

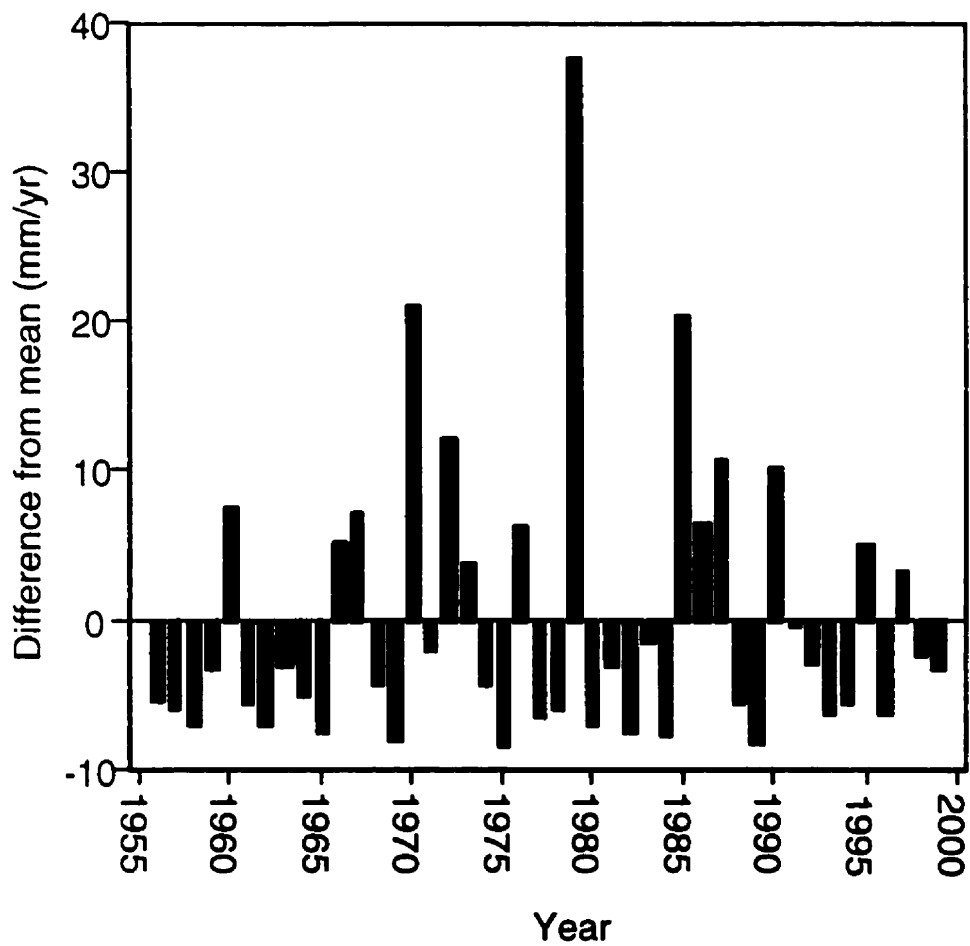


Figure 4: Snowfall in May (difference from mean), Sachs Harbour, 1956-1998.

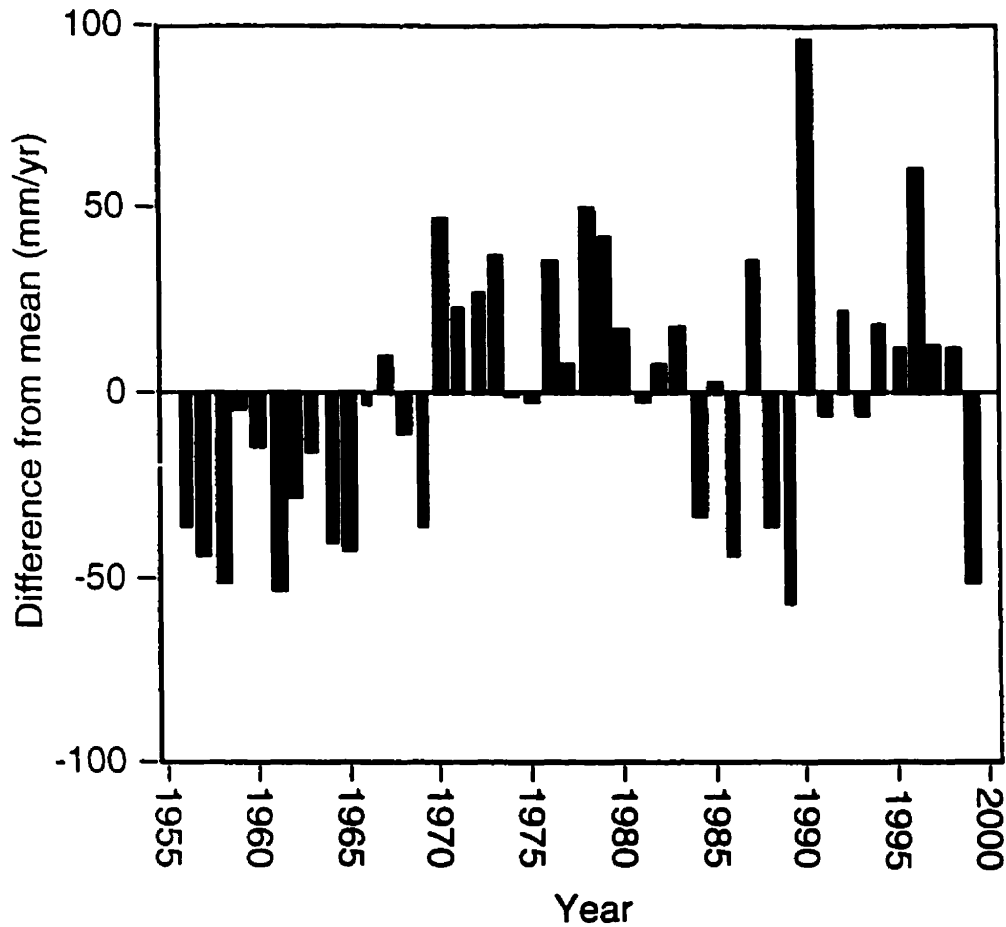


Figure 5: Annual snowfall (difference from mean) Sachs Harbour, 1956-1998

In addition to weather records, other sources of information could be utilized for cross-referencing purposes. Several researchers have constructed past climate records using Hudson Bay records and other archival material. Such studies have established a historical record of break-up and freeze-up events (Moodie and Catchpole 1975), and storm events over time (Solomon and Hart 1998). The use of historical and archival records to cross-reference information compiled in interviews was also used by Ferguson and Messier (1997), in a study that compared Inuit observations of caribou ecology with

written reports. Their research concluded that in many cases Inuit knowledge was more complete than written sources at the local scale, and that it complements scientific information at larger scales, as argued in Chapter 5. One very productive and promising approach is to cross-referencing local and traditional knowledge across different regions and different communities. An example is the comparison of Inuit and Inuvialuit knowledge from Kivalliq, Kitikmeot and Banks Island (Riedlinger, Fox and Thorpe, *in prep.*).

6.1.3 Assessing adaptation and coping with climate change

There has been substantial emphasis on predicting the biophysical impacts of climate change on polar regions. However, the potential social and cultural impacts of climate change on northern communities remain largely unaddressed. How are Arctic communities coping with climate change now, and how will they adapt in the future? The question of adaptation is a lens through which to further investigate Inuit understandings of climate change.

The impacts of recent environmental changes are most noticeable in terms of impacts on subsistence livelihoods and seasonal activities. Kinds of impacts can be grouped in four areas: access (ability to travel), safety, predictability, and species availability and health (Table 10). Changes in the physical environment, both on land and the sea ice, will result in significant impacts on Arctic fish and wildlife populations, and thus on community health and well being. Climate change poses a threat to local food sources and the ability of Inuit to hunt and fish, thus contributing to dietary problems and medical costs that are associated with increased consumption of non-country foods (Fast and Berkes 1998).

The community of Sachs Harbour is successfully coping with the recent climate-related changes they are experiencing (Riedlinger 2000). The flexibility found in the system of resource use has allowed the community to, for the most part, absorb these changes through modifications of seasonal harvesting activities. People have coped by

changing the timing, location, or method of harvest activity, changing the species harvested and minimizing risk and uncertainty. However, climate changes are relatively recent; the community is concerned about the future. The rate of change appears to be accelerating; how the community has responded to changes up to now may not be an accurate indicator of future responses.

Further research is needed on past strategies used by Inuit to cope with environmental changes. Human history in the Arctic is described by some scholars in terms of a *series of adaptations*, or a process of sequentially accumulating cultural and social mechanisms (Krupnik 1993). These mechanisms, or *adaptive strategies*, are ways that Inuit have responded to resource fluctuations or other environmental changes in the past. Such strategies include mobility, population growth, and flexibility in seasonal harvest cycles (Krupnik 1993), as well as risk minimization based on social networks (Sabo 1991). Oral tradition and group memory of past situations is another strategy that Inuit have used to address fluctuations in the physical environment (Minc 1985). As long term adaptations, they are different from coping responses, or short term adjustments.

Are the strategies that Inuit used in the past still applicable today? What are the social and cultural limits to adaptability? These questions will become increasingly important if current environmental changes continue or accelerate, and can no longer be addressed within existing community and resource use frameworks.

Table 10: Examples of local environmental changes and impacts on subsistence activity

Impacts as described by the community of Sachs Harbour	
Access	<p>Old ice doesn't come in close to the settlement in summer anymore, harder to hunt seals and get drinking water</p> <p>Less ice in summer means that the water is rougher</p> <p>Open water is closer now in winter, cannot go out as far when hunting</p> <p>More rain in summer and fall, makes it hard to travel</p> <p>Permafrost is not solid; difficult to dig gravesites</p> <p>A lot of water and puddles on the ground that don't dry up in summer</p> <p>Not seeing little "knolls" on the land anymore, the ones we set traps on</p> <p>Rough on the land to travel now; have to make new trails</p> <p>Snow is not hard packed like before; more loose, soft snow, harder to travel</p> <p>Harder to hunt geese in the spring because it melts so fast</p>
Safety	<p>Too much broken ice in winter makes travel dangerous</p> <p>Unpredictable ice conditions make travel dangerous</p> <p>Less multiyear ice in fall at freeze up means we have to travel on first year ice all winter, less safe</p> <p>Less ice means you have to worry about storms now</p>
Predictability	<p>Cannot tell when the rivers will break in the spring</p> <p>Cannot tell when there is going to be a storm</p> <p>Spring seasons have become very unpredictable, from year to year the arrival of spring is different</p> <p>It is easier to travel in winter now that it is not so cold</p> <p>Wrong winds sometimes now, stronger</p> <p>More bad weather with blowing snow and whiteouts; hard to travel</p> <p>More overcast days, strange weather</p> <p>Rivers are flowing earlier and dry up quicker, unpredictable</p>
Species Availability And Health	<p>More rain in the fall increases chances of freezing rain, which can lead to caribou starving</p> <p>Warmer summers and more rain mean more vegetation; good for animals</p> <p>Less fat on the seals</p> <p>Seeing different species of fish and birds</p> <p>Less summer ice means less seals around to hunt</p> <p>Seeing less polar bears in the falltime because of lack of ice</p> <p>One fishing lake drained away into the ocean from erosion</p> <p>More Least Cisco getting caught now</p> <p>More wind means caribou do not have to travel as far to escape bugs</p>

6.3 Community defined research needs

The three sections above identify opportunities for additional research relating to northern communities and climate change. These are opportunities that I see for future study – contributing to further discussions (both academic and non-academic) of Inuit and Inuvialuit knowledge of climate change. In addition to these areas, however, are research needs as defined by northern communities such as Sachs Harbour themselves.

The community of Sachs Harbour was and is very committed to the *Inuit Observations of Climate Change* project. The project is seen as a way to raise awareness of the changes the community is experiencing. It is also seen as a *starting point* from which to continue addressing the issue of climate change in Arctic communities. The desire for continued involvement in this project and in follow-up activities was clearly expressed in the project's evaluation. For example, the need to monitor the impacts of climate change was specifically identified as a priority for the community, and for other Western Arctic communities as well. Other community-defined research needs will be the focus of a proposed workshop in Sachs Harbour in January of 2001.

6.4 Concluding comments

In this thesis, I explored one community's assessment of climate change. Inuvialuit knowledge of change was documented in four broad areas: sea ice, weather patterns, permafrost and wildlife. This knowledge was shared by the community during a series of interviews that were geared towards giving scientists an opportunity to collaborate with local experts, and in the additional time I spent in the community doing follow up. Based on my experience as part of this process, I addressed the question of *how* to bridge the gap between western science and traditional knowledge.

This thesis started with two objectives: one, to explore the extent and scope of Inuvialuit knowledge of climate change; and two, to provide a conceptual framework to facilitate using traditional knowledge and western science together for understanding Arctic climate change. The first objective is addressed in detail in Chapter 4. The

community's observations of climate change have been documented in other places as well, as part of the larger Inuit Observations of Climate Change project (Ford 2000, Riedlinger 1999, Riedlinger 2001, Riedlinger and Berkes (2001), including the video "Sila Alangotok" (IISD and the community of Sachs Harbour 2000). The second objective is addressed in Chapter 5, which is based on repeat visits to the community over a 12 month cycle, and borrows heavily from the work of the IISD project team, without which this analysis would not have been complete.

It is clear that community-based knowledge and assessments of climate change can and *should* have a role in climate change research. However, as with other environmental, resource management, political and development issues in the North, there remain many challenges associated with trying to 'create a conversation between' western science and community-based knowledge. The research presented in this thesis is intended to contribute to ongoing theoretical and practical efforts in this broader direction. The approach and findings presented here are applicable to a range of resource and environment issues, which require cross-cultural approaches in seeking to broaden the range of inquiry. Climate change research provides a worthy context for this discussion, as the issue is clearly one of concern for both scientists and communities.

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Appendix A

Workshop results

Six primary activities took place during the planning workshop in Sachs Harbour, June 1999. (Adapted from Ford 2000, and Trip Report One, Inuit Observations of Climate Change project, IISD).

1. **Issue identification:** Community members wrote down examples of the environmental changes that they have been experiencing that may indicate that the arctic climate is changing. Each observation or example was written on a separate card. People wrote their own observations, or they were recorded by the project team or other community members.
2. **Cause-effect analysis:** Community members arranged the cards into “problem trees”, with the extent and scope of each phenomena forming the “roots” of the tree, and the effects of each phenomena forming the “branches” of the tree.
3. **Timeline:** Community members, particularly Elders, traced the changes they have experienced (environmental, wildlife-related, social, economic) back through time in living memory, providing a historical context for recent observations.
4. **Ranking:** A set of categories was developed by the participants to organize the observations collected in the issue identification exercise. Each participant was then given three colored dots to vote with, by placing a dot next to the category they considered most important.
5. **Annual calendar:** A circular chart of the seasons and seasonal harvest activity was developed by participants, along with the identification of key times of the year that changes were most noticeable.
6. **Trip planning:** Based on all of the exercises, the community then decided when the best times of year would be for the project team to return, and what phenomena would be best to focus on in both the video and interviews.

Appendix B
Population of Sachs Harbour, by age and gender

Sachs Harbour Population (by age and gender)

Male

Female

Number of persons		Age		Number of persons
		80+		1
		75-79		1
1		70-74		
4		65-69		2
		60-64		2
1		55-59		
4		50-54		2
4		45-49		3
4		40-44		1
4		35-39		8
3		30-34		3
5		25-29		3
8		20-24		5
3		15-19		3
5		10-14		6
5		5-9		6
6		0-4		12

Source: Sachs Harbour Nursing Station. Figures are for 1998-9.

Appendix C
The meaning of *sila*

The meaning of Sila in selected Inuit dialects, and associated words

cila	(spirit of) weather or outside world	silailunngituq	intelligent, wise, prudent (word used in stories)
sila	weather, world, outside, awareness	silallituq	to make the outside double stitch of waterproof boots
sil'a	weather, outside, atmosphere, air	silaluk	bad weather, rain
sila	weather, air, atmosphere, the world, intelligence	silalutsiuti	rain coat
silaqqi	be good weather	silalulitaq	shelter against rain
silaasiarivaa	he leaves it to tarnish in the air	cilali	become bleached by the sun; become weathered
siaarsiaq	what one makes darken or change in the air, outside	cilan	outside

Sources:
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