Chapter 3

The Changing Arctic: Indigenous Perspectives

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> *We cannot change nature, our past, and other people for that matter, but we can control our own thoughts and actions and participate in global efforts to cope with these global climate changes. That I think is the most empowering thing we can do as individuals.* George Noongwook, St. Lawrence Island Yupik, Savoonga, Alaska, as quoted in Noongwook, 2000

Summary

Indigenous peoples in the Arctic have for millennia depended on and adapted to their environment. Their knowledge of their surroundings is a vital resource for their well-being. Their knowledge is also a rich source of information for others wishing to understand the arctic system. Many of the aspects of climate change and its impacts considered in this chapter are also considered in other chapters. To avoid excessive disruption to the flow of the text, cross-references are included only where other chapters contain extended discussion or additional material. Within the context of climate change, indigenous observations and perspectives offer great insights not only in terms of the nature and extent of environmental change, but also in terms of the significance of such change for those peoples whose cultures are built on an intimate connection with the arctic landscape.

This chapter reviews the concept of indigenous knowledge, summarizes those indigenous observations of environmental and climatic change that have been documented to date, and presents a series of case studies, largely from hunting and herding societies, examining the perspectives of specific communities or peoples. Although idiosyncratic, the case studies each attempt to convey the sense of how climate change is seen, not in the form of aggregate statistics or general trends, but in specific terms for particular individuals and communities. The case studies provide the basis for a discussion of resilience, or protecting options to increase the capacity of arctic societies to deal with future change, and a review of further research needs.

The observations and case studies contain some common themes. One such observation is that the weather has become more variable and thus less predictable by traditional means. Social changes, such as less time spent on the land, may influence this observation, but there are climatological implications that merit further study. In terms of perceptions of the significance of climate change, there are few, if any, areas where climate change is regarded as the most pressing problem being faced. Nonetheless, most arctic residents are aware of climate change, have experience of the types of changes being seen and anticipated, and are concerned about the implications for themselves, their communities, and the future.

Several of the general conclusions drawn in this chapter are likely to be applicable to all communities affected by climate change, whether the impacts are on balance beneficial or harmful. Climate change is not an isolated phenomenon, but one that is connected to the web of activities and life surrounding indigenous peoples. Thus, it must be understood and assessed in terms of its interactions with other phenomena and with current and future societal and environmental changes. Responses to climate change will not be effective unless they reflect the particular circumstances of each place. Increasing resilience is a useful way to consider the merits of various response options, which are best developed and evaluated iteratively to promote adjustment and improvement as experience and knowledge increase. Indigenous perspectives on climate change offer an important starting point for collaborative development of effective responses.

3.1. Introduction

The indigenous peoples of the Arctic have adapted to great environmental variability, cold, extended winter darkness, and fluctuations in animal populations, among many other challenges posed by geography and climate. Although the arctic climate has always undergone change, current and projected changes make it timely and important to reflect on the ways that such changes affect arctic residents, particularly the indigenous residents whose way of life is so closely linked to their surroundings. It is also important to consider how these indigenous residents observe and feel about the changes that are occurring. Together, such perspectives can help the global community understand what is at stake in a changing Arctic.

Much of the Arctic has been inhabited since at least the end of the last ice age, and some areas for far longer (Pitulko et al., 2004). During this time, human groups have come and gone, and evolved and adapted, their patterns of settlement changing, often abruptly, in response not only to climate but also to regional patterns such as resource availability, relations with neighbors, landscape change, hunting and fishing technology, and the rise of reindeer husbandry (Krupnik, 1993). In recent centuries and in particular the twentieth century, forces from outside the region have shaped human patterns in the Arctic, as the modern world has extended its reach and influence. Today, the Arctic is home to a large number of indigenous peoples with distinct cultures, languages, traditions, and ways of interacting with their environment (Freeman, 2000; Nuttall, 1998). They have in common a close connection to their surroundings, an intimate understanding of their environment (e.g., Fienup-Riordan et al., 2000), complex relationships with national and sub-national governments and non-indigenous migrants to the Arctic (Minority Rights Group, 1994; Nuttall, 1992; Pika, 1999), a way of life that mixes modern and traditional activities, and a major stake in the future of the region (CAFF, 2001; Huntington et al., 1998; Nuttall and Callaghan 2000; Slezkine, 1994). An overview of humans in the Arctic is given in Chapter 1.

This chapter attempts to show some of the observations of change that indigenous inhabitants of the Arctic consider to be related to climate change. In doing so, the comments and perspective also show what climate

change means to them and their communities within the context of the other forces affecting their lives and cultures. Although little material is available concerning indigenous perspectives on ultraviolet (UV) radiation and ozone depletion, the chapter includes a short summary of some related observations (Box 3.1). Other chapters describe impacts on specific components of the environment and areas of human activity and so draw extensively on indigenous knowledge and perspectives, a level of inclusion that is unprecedented in an assessment of this type and scope.

This chapter addresses the impacts of climate change and variability on those affected most directly: the people whose ways of life are based on their use of the land and waters of the Arctic. This has been achieved using a series of case studies drawn from existing research projects that have been selected to give, through specific examples rather than general summaries, a sense of the variety of indigenous perspectives on climate change in the Arctic. The case studies are idiosyncratic, reflecting differences in the communities they describe as well as differences in the aims and methods of the studies from which they derive. Because they are examples, the case studies cannot reflect all the views held within arctic communities. Some communities, such as those in Greenland that fish for cod, may see benefits from climate change if fish stocks increase, a perspective that may be missing from case studies focusing more on the negative impacts of climate change. Nonetheless, the case studies are intended to give a human face to some of the impacts of weather and climate change observed by arctic residents.

Although people plan around expectations that reflect the climate of their area, their daily activities are affected more by the day's weather. Many of the statements and perspectives contained in this chapter reflect perceptions of weather and changes in weather patterns and variability, which are also of interest to climatologists examining the ways that climate change is manifested in the Arctic (Overland et al., 2002; J. Walsh, International Arctic Research Center, University of Alaska, Fairbanks, pers. comm., 2003). The distinction between weather change and climate change is not simple, and observations about weather may indicate something significant about the arctic climate. It is also likely that the publicity surrounding climate change has led many people in the Arctic as elsewhere to interpret observations in the light of climate, whether or not this is appropriate. This chapter presents the connections indigenous peoples draw between their own observations and the general phenomenon of climate change.

Box 3.1. Indigenous observations concerning the sun and ultraviolet radiation

Many people in the Arctic have observed changes in the characteristics of the sun and its effects since the early 1990s (Fox, 1998; McDonald et al., 1997). While not discussed in terms of UV radiation, many indigenous observations do include the same concerns as UV scientists (see Chapters 5 and 15). Most commonly expressed is the perception that the sun is stronger or more "stinging" and "sharp" feeling (e.g., Fox, 1998). The sun's heat seems to have become more intense and northern residents report unusual sunburns, eye irritations, and skin rashes (Kassi, 1993; Fox, 1998).

> *The direct heat from the sun is warmer, it is not the same anymore and you can't help but notice that. It is probably not warmer overall, but the heat of the sun is stronger.* G. Kappianaq, Igloolik, 1997 as quoted in Fox, 1998

> *The reason why I mention the fact that the sun seems warmer is because another [piece of] evidence to that is that we get some skin diseases or some skin problems. Because I think in the past when Peter [a Clyde River elder] was a young boy they never seemed to have these skin problems and I see them more and more these days.* J. Qillaq, Clyde River, 2001 as quoted in Fox, 2004

Humans are not the only ones affected by a more intense sun. Inuit in Nunavut link other environmental changes to the sun. In some areas, for example, although the overall temperature may not be warmer, elders claim that the heat of the sun is causing small ponds to be warmer than usual or to dry up altogether. In some places, meat hung out to dry seems to get burned by the sun, and caribou skins seem to rip more easily around the neck area, a new condition elders link to skins possibly being burnt or becoming too hot from the sun (Fox, 2004).

Archaeological sites in the Arctic have contained sun goggles, indicating that indigenous peoples have, for a long time, made an effort to shield their eyes from the blinding light of sunshine on snow. These days, indigenous peoples are doing more to protect themselves from sun damage. High quality sunglasses and goggles are popular and many people who spend time on the land are now using sun lotion and lip balm. In Igloolik, Nunavut, for example, the nursing station has had more requests for sun lotion in recent years, but it is unclear whether this is due to more sunburn, or a greater awareness of the damage caused by sun exposure (Fox, 1998). Still, elders and older hunters who have grown up on the land and spent decades on the sea ice and snow say they are only now beginning to experience sunburn. While rates of skin cancer remain low in the Arctic (see section 15.3.3.2), community members note it will be important to monitor how serious the new sun-related skin ailments become. Residents also want to monitor how a more intense sun may affect arctic animals and plants over time.

In describing the significance of climate change for indigenous peoples, it is important to remember that there are many forms of environmental change in the Arctic, as well as extensive social changes related to modernization and globalization (e.g., AMAP, 1998, 2002; CAFF, 2001; Freeman, 2000; Gaski, 1997; Nuttall, 2000). The challenges these pose often require great attention and effort by indigenous peoples and organizations. From negotiating the creation of Nunavut in Canada to responding to threats from oil and gas development in northern Russia, arctic indigenous peoples have had to organize themselves to articulate and fight for their values and ways of life. In some cases, they have been successful in promoting global action. The Stockholm Convention on Persistent Organic Pollutants was adopted in 2001, in no small part resulting from concerns about contaminants in the Arctic and their impacts on indigenous peoples and cultures (Downie and Fenge, 2003). More recently, Inuit leaders have framed climate change as a human rights issue (Sheila Watt-Cloutier as quoted in Brown P., 2003). Climate change is a topic about which indigenous peoples have a great deal to share with the world.

3.2. Indigenous knowledge

Indigenous peoples have long depended on their knowledge and skills for survival, including their ability to function in small, independent groups by dividing labor and maintaining strong social support and mutual ties both within and between their immediate communities (e.g., Burch, 1998; Krupnik, 1993; Freeman, 2000; Usher et al., 2003). Knowledge about the environment is equally important. Understanding the patterns of animal behavior and aggregation is necessary for acquiring food. Successful traveling and living in a cold-dominated landscape requires the ability to read subtle signs in the ice, snow, and weather. Gradual shifts in social patterns and environmental conditions make this a continuous process of learning and adapting. In the past, sudden shifts in physical conditions, such as abrupt warming or cooling, led to radical changes including the abandonment of large areas for extended periods that is apparent from the archeological record (Fitzhugh, 1984; McGhee, 1996). Knowing one's surroundings was an often-tested requirement, one that remains true today for those who travel on and live off the land and sea (Berkes, 1999; Berkes et al., 2000; Fox, 1998; Huntington et al., 1999; Inglis, 1993; Krupnik and Jolly, 2002).

3.2.1. Academic engagement with indigenous knowledge

Those outside indigenous communities have not always recognized or respected the value of this knowledge. Occasionally used and less frequently credited prior to and during most of the twentieth century, indigenous knowledge from the Arctic has received increasing attention over the past couple of decades (e.g., Freeman, 1976; Inglis, 1993; Nadasdy, 1999; Stevenson, 1996). This interest, arising from research in the ethnosciences, has taken the form of studies to document indigenous knowledge about various aspects of the environment (Ferguson and Messier, 1997; Fox, 2002; Huntington et al., 1999; Kilabuck, 1998; McDonald et al., 1997; Mymrin, et al., 1999; Riedlinger and Berkes, 2001), the increasing use of cooperative approaches to wildlife and environmental management (Berkes, 1998, 1999; Freeman and Carbyn, 1988; Huntington 1992a,b; Pinkerton, 1989; Usher, 2000), and a greater emphasis on collaborative research between scientists and indigenous people (Huntington, 2000a; Krupnik and Jolly, 2002). This section describes some of the characteristics of indigenous knowledge and its relevance for studies of climate change and its implications.

The topic of indigenous knowledge is not without disputes and controversy. In fact, agreement has not even been found on the appropriate term – "traditional knowledge", "traditional ecological knowledge", "traditional knowledge and wisdom", "local and traditional knowledge", "indigenous knowledge", and various combinations of these words and their acronyms are among those that have been used (e.g., Huntington, 1998; Kawagley, 1995; Turner et al., 2000). Terms specific to particular peoples are also common, such as "Saami knowledge" or "Inuit Qaujimajatuqangit". Although their definitions largely overlap, each raises difficulties. The term "indigenous" in this context excludes long-term arctic residents not of indigenous descent, implies that all indigenous persons hold this knowledge, and emphasizes ancestry over experience. "Traditional" has a connotation of being static and from past times, whereas this knowledge is current and dynamic. "Local" fails to capture the sense of continuity and the practice of building on what was learned by previous generations. "Knowledge" by itself omits the insights learned from experience and application, which are better captured by "wisdom". All of these terms neglect the spiritual dimensions of knowledge and connection with the environment that are often of greatest importance to those who hold this knowledge. Some groups, such as the World Intellectual Property Organization, identify "indigenous knowledge" as a subset of "traditional knowledge", with the latter incorporating folklore (WIPO, 2001). The issue of terminology will not be resolved here, but the term "indigenous knowledge" is used in a broad sense, encompassing the various systems of knowledge, practice, and belief gained through experience and culturally transmitted among members and generations of a community (Berkes, 1999; Huntington, 1998).

By any term, indigenous knowledge plays a vital role in arctic communities, and its perpetuation is important to the future of such communities. It has also become a popular research topic. Scholars within and outside the indigenous community discuss its nature, the appropriate ways in which it should be studied and used, how it can be understood, and how it relates to other ways of knowing such as the scientific. Many agree that indigenous knowledge offers great insight from people who live close to and depend greatly on the local environ-

ment and its ecology (Berkes, 1998, 1999; Freeman and Carbyn, 1988; Huntington, 2000a; Inglis, 1993; Mailhot, 1993). Most of these scholars also recognize, however, that gaining access to and using this knowledge must be done with respect for community rights and interests, and with awareness of the cultural contexts within which the knowledge is gathered, held, and communicated (e.g., Krupnik and Jolly, 2002; Wenzel, 1999). Successful efforts are typically built on trust and mutual understanding. It takes time for knowledge holders to feel comfortable sharing what they know, for researchers to be able to understand and interpret what they see and hear, and for both groups to understand how indigenous knowledge is represented and for what purpose.

The legal and political contexts of indigenous knowledge must also be taken into account. The intellectual property aspects of indigenous knowledge are being explored (WIPO, 2001). Some jurisdictions in the Arctic require that it be considered in processes such as resource management and environmental impact assessment (e.g., Smith D., 2001). Throughout the Arctic, there is increasing political pressure to use indigenous knowledge, but often without clear guidance on exactly how this should be achieved. Most existing ethical guidelines or checklists for community involvement in research identify the areas to be addressed in research agreements, but do not resolve how the controversial questions are best answered (e.g., Grenier, 1998; IARPC, 1992). Such uncertainty may lead to reluctance on the part of some researchers to engage in studies of indigenous knowledge, but at present there are many good examples of collaborative projects that have benefited both the communities involved and those conducting the research (e.g., Huntington et al., 1999, 2002; Kilabuck 1998; McDonald et al., 1997).

3.2.2. The development and nature of indigenous knowledge

Careful observation of the world combined with interpretation in various forms is the foundation for indigenous knowledge (Cruikshank, 2001; Huntington, 2000a; Johnson, 1992; Kilabuck, 1998; Krupnik and Jolly, 2002). The ability to thrive in the Arctic depends in large part on the ability to anticipate and respond to dangers, risks, opportunities, and change. Knowing where caribou are likely to be is as important as knowing how to stalk them. Sensing when sea ice is safe enough for travel is an essential part of bringing home a seal. The accuracy and reliability of this knowledge has been repeatedly subjected to the harshest test as people's lives have depended on decisions made on the basis of their understanding of the environment. Mistakes can lead to death, even for those with great experience. Thus, information of particular relevance to survival has been valued and refined through countless generations, as individuals combine the lessons of their elders with personal experience (e.g., Ingold and Kurtilla, 2000).

Indigenous knowledge is far more than a collection of facts. It is an understanding of the world and of the human place in the world (Agrawal, 1995; Berkes, 1999; Berkes et al., 2000; Fehr and Hurst, 1996; Kawagley, 1995). From observations, people everywhere find patterns and similarities and associations, from which they develop a view of how the world works, a view that explains the mysteries surrounding them, that gives them a sense of place (Berkes, 1999; Brody, 2000; Nelson, 1983). In the Arctic, parallels may be drawn, for example, in the migrations of caribou, cranes, and whales (Huntington et al., 1999). Systems of resource use are developed to make efficient use of available resources (Berkes, 1998, 1999; Berkes et al., 2000). Hunters develop rituals and practices that reflect their view of the world (Cruikshank, 1998; Fienup-Riordan, 1994). Stories, dances, songs, and artwork express this worldview (Cruikshank, 1998). In turn, culture shapes perception, and the world is interpreted according to the way it is understood. When personal memories and stories are retold to family members, relatives, neighbors, and others, as is common practice across the Arctic, an extensive local record is built. Non-verbal transmission of knowledge and skills, for example through observation and imitation, is also common. It often extends over several generations and represents the accumulated knowledge of many highly experienced and respected persons. Learning the knowledge of one's people involves absorbing the stories and lessons, then watching closely to figure out exactly what is meant and how to use it, and adapting it to one's own needs and experiences. In these ways, indigenous knowledge is continually evolving (Ingold and Kurtilla, 2000).

3.2.3. The use and application of indigenous knowledge

Studies of indigenous knowledge often make comparisons with scientific knowledge in an effort to determine the "accuracy" of indigenous knowledge as measured on a scale that is intended to be objective. Other studies use indigenous knowledge in the generation of new hypotheses or for the identification of geographic locations for research (Albert, 1988; Huntington, 2000a; Johannes, 1993; Nadasdy, 1999; Riedlinger and Berkes, 2001). While this can be worthwhile, the value of indigenous knowledge lies primarily within the group and culture in which it developed. Holders of this knowledge use it when making decisions or in setting priorities, and an understanding of the nature of this knowledge can help explain the rationale behind these processes (Cruikshank, 1981, 1998; Feldman and Norton, 1995; Kublu et al., 1999). "Accuracy" in this context depends on the uses to which the knowledge is put, not on an external evaluation.

The emphasis on the cultural aspects of indigenous knowledge in this assessment is not intended to detract from the great utility it has in ecological and environmental research and management (Berkes, 1998, 1999; Fox, 2004; Freeman and Carbyn, 1988; Krupnik and Jolly, 2002; Riedlinger and Berkes, 2001). In this setting, accuracy as evaluated externally may be a key concern

Box 3.2. Place names as indicators of environmental change

Indigenous peoples use a variety of cultural mechanisms to pass on climatic and environmental knowledge and its "attendant adaptive behavior" from one generation to the next (Gunn, 1994; Henshaw, 2003). These mechanisms include place names, which reflect perceptions of the environment and can serve as a repository for accumulated knowledge. When conditions change, place names can serve as indicators of environmental change. Place names show how perceptions of physical geography, ecology, and climate transform observations and experiences to memory shared among members of a particular group (Cruikshank, 1990; Müller-Wille, 1983, 1985; Peplinski, 2000; Rankama, 1993).

As environmental conditions change, place names (or toponyms) may change or persist, providing insight into the nature of those changes and the adaptations that accompany them. For example, near Iqaluit, Nunavut, there is a site called Pissiulaaqsit, which translates as "a place where there is an absence of guillemots" (Peplinski, 2000). Local residents explain that the name is significant because guillemots nested there in the past. In the Sikusilarmiut land-use area, covering most of the Foxe Peninsula in Nunavut, Henshaw (2003) has documented more than 300 toponyms around the community of Kinngait (Cape Dorset). The extensive naming of places, often using descriptive terms, creates an important frame of reference for navigation, with crucial implications for safety, travel, and hunting. Many of the place names refer to features or phenomena that may be highly sensitive to environmental change.

For example, Ullivinirkallak is a place that used to be used for storing walrus (*Odobenus rosmarus*) meat. That it is no longer used for that purpose may indicate change to permafrost. Qimirjuaq is a large plateau with ice and snow even in summer. The area watered by melting snow produces abundant berries, and so the size and condition of the snowfield is monitored closely. The berry pickers quickly note changes in the persistence and characteristics of the snowfield. Seasonal features such as polynyas or migratory routes are also named, as are patterns of currents and sea-ice movements. Documenting these names and the conditions that occur at these locations can provide a means of monitoring and identifying future environmental change.

because the information is being applied for a purpose that may be very different from that for which it was originally generated. There are many instances where indigenous knowledge of the habits of an animal such as the bowhead whale (*Balaena mysticetus*) (Albert, 1988) or the interactions within an ecosystem such as sea-ice phenomena (Norton, 2002) were – and are – far in advance of scientific understanding, and in fact were used by scientists to make significant progress in ecology and biology (Freeman, 1992; Krupnik and Jolly, 2002). This is especially true in the Arctic, where scientific inquiry is a relatively recent phenomenon, and where researchers often depend on the knowledge and skills of their indigenous guides.

To apply indigenous knowledge to environmental research and management, consideration must be given to the ways in which it is acquired, held, and communicated. Indigenous knowledge is the synthesis of innumerable observations made over time (Agrawal, 1995; Huntington, 1998). Added weight is often given to anomalous occurrences, in order to be better prepared for surprises and extremes. It is typically qualitative; when quantities are noted, they are more often relative than absolute. Indigenous knowledge evolves with changing social, technological, and environmental conditions (Krupnik and Vakhtin, 1997), and thus observations of change over time can be influenced by these as well as by the vagaries of memory. Indeed, one of the main challenges in evaluating observations of environmental change is that of addressing the many factors that influence the ways in which people remember and describe events. In addition, some communities today are experiencing erosion of indigenous knowledge and the esteem in which it is held, which has emotional and practical impacts on individuals and communities (Fox, 2002).

Indigenous knowledge has been documented on various topics in various places in the Arctic, largely in North America. These efforts have rarely focused on climate change or even included climate change as an explicit topic of discussion. Nonetheless, substantial information is available, including evidence from place names (Box 3.2) and the archaeological record (Box 3.3). Further documentation is highly desirable, both for increasing the understanding of climate dynamics and as a means of engaging arctic residents in the search for appropriate responses to the impacts of climate change.

3.3. Indigenous observations of climate change

Indigenous peoples have only recently been engaged in climate change research and only through a relatively small number of projects. However, these projects have amassed a large collection of indigenous knowledge and observations about climate and environmental change, reflecting the depth of knowledge held by these peoples. Figures 3.1 and 3.2 present examples of observations documented in these projects, and highlight five major topic areas: changes in weather, seasons, wind, and sea ice (Fig. 3.1), and changes in animals and insects

(Fig. 3.2). This information is organized by community and region across the Arctic, but is derived from projects conducted in different ways, with different objectives, and at different times. This compilation provides a useful introduction to changes experienced by indigenous peoples, but should not be used for detailed comparisons across regions without referring to the original reports. Also, some of the changes were not necessarily considered by the observers to be climate-driven, and this is particularly true for information in Fig. 3.2, while some do have connections to climate. The original reports should be used for clarification.

Many of the topics addressed by indigenous observations in Figs. 3.1 and 3.2 are discussed in other chapters of this assessment. There are many links between indigenous and scientific observations of arctic climate and environmental change and many opportunities for complementary perspectives on the nature of various phenomena and their impacts. For example, Chapter 7 reports that biologists connect a changing climate to changing animal migration patterns, such as caribou (see section 7.3.5). Indigenous knowledge is cited as helping to explain how caribou migrations may be triggered by seasonal cues such as day length, air temperature, or ice thickness (Thorpe et al., 2001). Also, scientific descriptions of changes in the arctic climate (such as those reported in Chapter 2) are often consistent with indigenous observations. For example, observational data from the scientific record indicate that the Arctic is warming in western Canada, Alaska, and across Eurasia, but experiencing no change or cooling in eastern Canada, Greenland, and the northwestern Atlantic (see section 2.6.2.1). This is supported by indigenous observations by comparing those from communities in Alaska with those from Igloolik and Iqaluit in Nunavut, Canada.

Indigenous and scientific observations do not always agree, however. For example, in the Kitikmeot region of Nunavut, Inuit have observed more abundant and new types of shrubs and lichens (Thorpe et al., 2001). While the increased abundance of shrubs corresponds with aerial photography of vegetation change, experimental evidence suggests that lichens should decrease under the changing environmental conditions seen in the Kitikmeot (see section 7.3.3.1). There are probably

Box 3.3. Archaeology and past changes in the arctic climate

The documentation of indigenous observations of climate change has focused primarily on recent decades. But the arctic environment has long been recognized for its extreme variability and rapid fluctuations. Several past examples of both extreme warming and cooling events are documented in Chapter 2. In addition to the work by climatologists and physical scientists, social scientists, archaeologists, and ethnohistorians have accumulated a large body of evidence concerning past changes in the environment. They often use proxy data, such as rapid shifts in human subsistence practice, change in settlement areas, substantial population moves, or certain migration patterns, as indicators of rapid transitions in arctic ecosystems.

Since the 1970s, archaeologists have developed detailed scenarios of how past climate changes have affected human life, local economies, and population distribution within the Arctic. One of the clearest examples of such links was the expansion of indigenous bowhead whaling and the rapid spread of the whaling-based coastal Eskimo cultures from northern Alaska across the central Canadian Arctic to Labrador, Baffin Island, and eventually to Greenland around 1000 years ago. Based upon recent radiocarbon dating and paleoenvironmental data, this enormous shift in population and economy took place within less than 200 years, caused at least in part by the rapidly changing sea-ice and weather conditions in the western and central Arctic (Bockstoce, 1976; Maxwell, 1985; McCartney and Savelle, 1985; McGhee, 1969/70, 1984; Stoker and Krupnik, 1993; Whitbridge, 1999). When around 300 to 400 years later the arctic climate shifted to the next cooling phase, Inuit were forced to abandon whaling over most of the central Canadian Arctic. This extreme cooling trend around 400 to 500 years ago left many Inuit communities isolated and under heavy environmental stresses that triggered population declines and loss of certain subsistence skills and related knowledge.

One well-known example of these impacts illustrates that not all responses are effective, and that people may not be able to adapt to all types of change. The Polar Eskimo (Inughuit) of northwest Greenland lost the use of their skin hunting boats (kayaks), bows and arrows, and fish spears when they became isolated from other communities by expanded glaciers and heavier sea ice during the Little Ice Age. In consequence, open water hunting for seals and walruses declined, and hunting for caribou and ptarmigan (*Lagopus* spp.) was completely abandoned, to the extent that their meat was considered unfit for human consumption (Gilberg 1974-75, 1984; Mary-Rousselière, 1991). As game animals were labeled "unclean" or "unreachable", the whole body of related expertise about animal habits, observation practices, the pursuit and capture of animals, and the butchering and storing of meat was reduced dramatically or completely lost. Some shifts of this kind, as well as stories about hardship caused by environmental change, have been preserved in indigenous oral traditions, folklore, and myths (Cruikshank, 2001; Gubser, 1965; Krupnik, 1993; Minc, 1986). However, few systematic attempts have been made so far to use indigenous knowledge to track historical or pre-historical cases of arctic climate change.

Elim, Alaska, USA
Weather: Heavy storms washing up timber onto shorelines; not seen before. More warm days, sometimes several in a row (Charles Saccheus as quoted in Krupnik, 2000).
Sea Ice: Ice no longer stable in spring. Fast ice melting faster (Charles Saccheus as quoted in Krupnik, 2000).

Yukon Territory, Canada
Weather: Year of "no real summer" sometime in the middle of the 19th century recorded in oral tradition (Cruikshank, 1981). Summers getting hotter, winters getting warmer (Kassi, 1993).

Barrow, Alaska, USA
Sea Ice: Differences in quality of sea ice; less salty, easier to chop, breaks up sooner. Fast ice retreats early; breaks up and retreats 20 to 30 miles and does not come back. No longer ice coming in during autumn, now water freezes in place and ice floes no longer seen drifting to shore. Multi-year ice does not arrive until later (Charles Brower as quoted in Krupnik, 2000).

Arviat, Nunavut, Canada
Weather: Winters warmer; in 1940s and 1950s frostbite only took seconds; it is not that cold anymore (GN, 2001).
Sea Ice: Sea ice forms later and overall thickness is reduced. People are less confident in winter ice travel and sea ice breaks up earlier and more quickly, for example, in June the last few years (GN, 2001).

Northwestern Hudson Bay, Canada
Weather: Weather highly variably since the 1940s; by 1990s weather changes are quick, unexpected, and difficult to predict. Used to be more clear calm days, winters were colder, and low temperatures persisted longer. Cooler summers in the early 1990s (McDonald et al., 1997).

Western Hudson Bay, Canada
Weather: Longer winters and colder springs (McDonald et al., 1997).

Western James Bay, Canada
Weather: Winters shorter and warmer (McDonald et al., 1997).
Wind: Winds shift several times per day (McDonald et al., 1997).

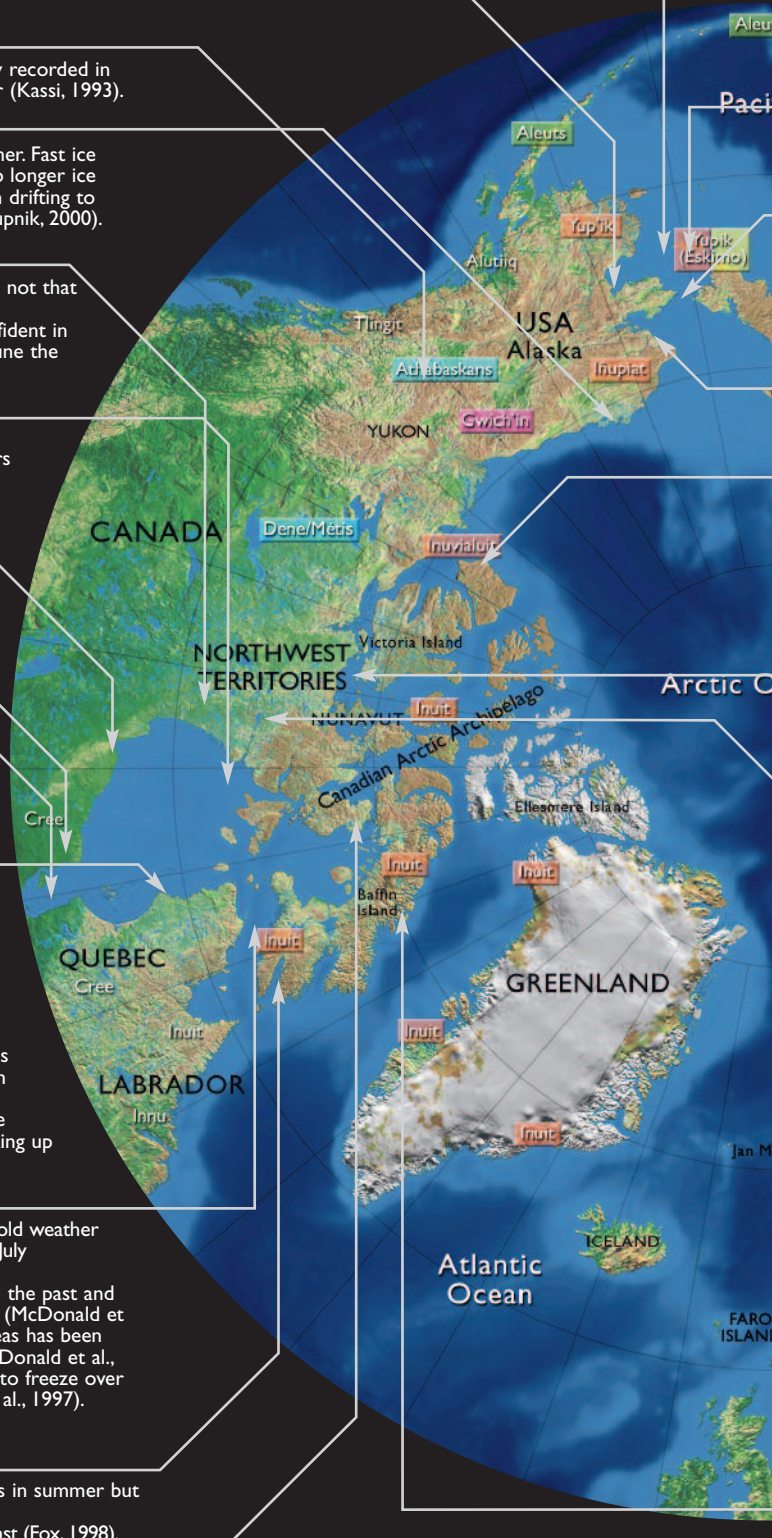
Eastern James Bay, Canada
Weather: In early 1990s autumn weather changed quickly. Cold weather arrives earlier but lakes freeze later (McDonald et al., 1997). Shorter spring and autumn seasons and colder winters in reservoir areas (McDonald et al., 1997).
Sea Ice: Salinity changing along the northeast coast with more freshwater ice forming in the bay. Ice less solid in La Grande River area. Sea ice freezes later and breaks up earlier (McDonald et al., 1997).

Eastern Hudson Bay, Canada
Weather: Persistence of cold weather into spring with spring and summer cooling trend (McDonald et al., 1997).
Wind: Since 1984, April and May winds in the Belcher Islands have blown mostly from the north, reducing the size of Canada geese flocks, slowing the spring melts, and contributing to the spring and summer cooling trend in eastern Hudson Bay (McDonald et al., 1997).
Sea Ice: Between the 1920s and 1970s the "ice bridge" between the Belcher Islands and eastern Hudson Bay mainland occasionally froze by late February or March. In the 1970s it began to freeze earlier and by late 1980s started freezing as soon as the early freezing season began. During the 1950s, 35 polynyas were open all winter in the Belcher Islands archipelago; in the 1960s to 1970s, 13, and in the early 1990s, only three (McDonald et al., 1997). Sea ice freezes faster and solid ice cover is larger and thicker with fewer polynyas. The flow edge melts before breaking up (McDonald et al., 1997).

Hudson Strait, Canada
Weather: Cooling trend observed – spring and early summer used to be warm, cold weather now returns following a March or April warm spell and persists into May, June, and July (McDonald et al., 1997).
Sea Ice: Timing of autumn freeze-up unchanged but sea ice freezes faster than in the past and quality deteriorated in some areas since more slush ice develops in early freezing (McDonald et al., 1997). Since the late 1980s, fast ice in the Lake Harbour, Ivujivik, and Salluit areas has been extending farther into Hudson Strait. In early 1990s, it froze over completely (McDonald et al., 1997). Large recurring polynya used by Ivujivik and Salluit sea ice hunters started to freeze over in the 1980s and no longer opened during early 1990s spring tides (McDonald et al., 1997). Floe edge melts before breaking (McDonald et al., 1997).

Iqaluit, Nunavut, Canada
Weather: Weather more unpredictable since the 1990s. More unusually hot days in summer but temperatures cooler overall (Fox, 1998).
Wind: Winds change suddenly, weather and wind changes were more subtle in the past (Fox, 1998).
Sea Ice: Ice conditions becoming more unpredictable through the 1990s with several accidents occurring in late 1990s. In mid/late 1990s, sea ice breaks up more quickly near Iqaluit and earlier than usual. Less sea ice near shorelines (Fox, 1998).

Igloolik, Nunavut, Canada
Weather: Weather increasingly unpredictable in recent years. Fewer periods of extended clear weather and more sudden storms (Fox, 1998).
Wind: Winds are stronger and occur more often. The winds are now responsible for ice break-up, as opposed to the ice thinning first. Recent changes in the winds have had an impact on sea-ice formation and decay processes (Fox, 1998).



- Saami Council
- Russian Association of Indigenous Peoples of the North
- Aleut International Association
- Inuit Circumpolar Conference
- Gwich'in Council International
- Arctic Athabaskan Council

St. Lawrence Island, Alaska, USA
Weather: More extreme weather conditions in the last 10 to 20 years (e.g., winds and storms that cause dangerous ice conditions that impede hunting). More warm weather (Noongwook, 2000).
Wind: More intense storms which last longer than in the past. Winds constantly change from one direction to another and with more intensity (Noongwook, 2000).
Sea Ice: Delays in ice packing and freeze-up due to changing winds (Noongwook, 2000). Increased frequency of windy and warm conditions creating dangerous ice conditions such as thin ice, snow-covered small open leads, and very rough ice (Noongwook, 2000).

Gambell, Alaska, USA
Wind: More westerly winds (Conrad Oozeva as quoted in Krupnik, 2000).
Sea Ice: Unusual sea ice conditions in winter 1999/2000; no icebergs that autumn (Edmond Apassingok as quoted in Krupnik, 2000).

Bering Strait, USA
Weather: Fewer calm days (Pungowiyi, 2000).
Wind: Winds stronger. Winds may shift direction but stay strong for long periods in spring. Wind changes distribution of sea ice. Mid-July to September more wind from the south makes for a wetter season, also more erosion due to wave action (Pungowiyi, 2000).
Sea Ice: Formation of sea ice is later in the autumn. Ice thinner than usual due to warmer winters and winds. Different formation processes and earlier break-up (Pungowiyi, 2000).

Kotzebue, Alaska, USA
Weather: Weather patterns change too fast to predict (Caleb Pungowiyi as quoted in Krupnik, 2000).

Sachs Harbour, Nunavut, Canada
Weather: Increased weather variability; more sudden and intense changes in weather; changes most noticeable in transition months; more extreme weather; weather more unpredictable. Longer, warmer summers. Spring melt is faster and spring comes earlier. Shorter, warmer winters. August is a warm month now, used to be the "cooling off month". Autumn comes later. Longer duration of "hot" days, now a whole week rather than one to two days (Jolly et al., 2002). More "bad" weather with blowing snow and whiteouts (Berkes and Jolly, 2001).
Wind: Changes in velocity and direction with more intense wind storms and more wind in summer (Jolly et al., 2002).
Sea Ice: Less/no multi-year ice in July and August; more open water and rougher water; more ice movement than before; not able to see the permanent ice pack to the west; ice breaks up earlier and freezes later; rate of ice break-up has increased; seasonal ice in harbor is thinner (not safe); less and thinner fast ice; changes in distribution and extent of local pressure ridges; leads farther away from shore; ice pans do not push up on shore anymore; open water in winter is closer than before; changes in ice color and texture (Jolly et al., 2002).

Kitikmeot Region, Canada
Weather: Warmer temperatures; unpredictable weather; late autumn; early spring; more extreme hot days; sporadic extreme heat days; spring melt came earlier than in the past in the 1990s; earlier snow melt (Thorpe, 2000).
Sea Ice: Unusually high number of cracks in sea ice in early spring around Hope Bay (Thorpe, 2000).

Baker Lake, Nunavut, Canada
Weather: Winters were colder and longer in the past, one used to get frostbite more quickly in the 1940s. Early and quick spring melt periods in recent years with warmer springs (e.g., snow "gets shiny" (i.e., a melt layer) earlier (March instead of April) and does not refreeze at night which is what is expected) (Fox, 2004). Summers are longer, caching meat has to be put off until later in the year to wait for lower temperatures (Fox, 2004). Increased weather variability; experienced hunters and elders no longer able to predict weather; sudden storms; more cloudy periods; and less long stretches of clear weather (Fox, 2002). Unstable weather recognized in temperature fluctuations, shifting winds, wind intensity, and storm behavior (GN, 2001). Summers warmer and winters less severe in the last 10 to 15 years (GN, 2001). More extreme hot days in summer (GN, 2001).
Wind: Winds blow stronger resulting in the snow being packed unusually hard. Igloos are difficult if not impossible to build because of this. The direction of the dominant wind has changed affecting hunters' ability to navigate using wind-formed ridges in the snow (Fox, 2002, 2004).

Northern Finland
Weather: Autumn and early winter are warmer. In recent years, the ground has not frozen properly in autumn and there has been little rain in September. Winters no longer have long cold periods as in the 1960s and even 1980s. Sudden shifts in weather in recent years and the weather is becoming more difficult to predict (Helander, 2004).
Wind: No longer any strong winds. Direction of the wind can shift fast, blowing from different directions on the same day (Helander, 2004).

Clyde River, Nunavut, Canada
Weather: Weather highly variable and more difficult to predict in recent years. Warmer springs with quicker spring melt (Fox, 2002, 2004).
Wind: Winds have changed in direction, frequency, and intensity. Winds also change suddenly (Fox, 2002, 2004).
Sea Ice: Usual leads have not formed in last few years and new ones have opened in unusual and unexpected areas. Ice is thinner and dangerous for travel in some areas, especially in spring (e.g., near Home Bay) and some residents have observed a trend in recent years of more icebergs (Fox, 2002). The texture of sea ice is different in some areas. For example, it can be mushy or too soft. Sea ice and icebergs are expected to chip off in a certain way when struck with an object. The ice is not chipping off as expected in some areas (Fox, 2004).

Fig. 3.1. Indigenous observations of changes in weather, seasons, wind, and sea ice.

Arviat, Nunavut, Canada
Caribou: Antlers not as thick (GN, 2001).
Bears: Polar bears and grizzly bears common in areas and during times not normal compared to the past, e.g., polar bears still around in July and August, and in December (GN, 2001).
Birds: Harder snow too difficult for ptarmigan, they are seeking out new habitat in willows where there is softer snow and better access to food. Sandhill cranes have changed with many observed eating carrion (GN, 2001).

Western Hudson Bay, Canada
Whales: Fewer whales now visit mouths of Nelson and Churchill rivers. Large numbers reported near Severn and Winisk rivers where abundant whitefish (McDonald et al., 1997).
Walrus: Decline in walrus populations in James Bay and southwestern Hudson Bay associated with changing shorelines and habitat alteration (overgrown with willow). Walrus also used to inhabit an island in the Winisk area until it began merging with the coastal shoreline in the early 1980s. Now walrus only return to visit in groups of two or three (McDonald et al., 1997). Large numbers reported near Severn and Winisk rivers where abundant whitefish (McDonald et al., 1997).
Moose: Change in taste of meat. Greater number drowning. No moose at Marsh Point (McDonald et al., 1997).
Caribou: Increase in numbers. Pin Island herd is mixing with Woodland herd (McDonald et al., 1997).
Bears: Thin-looking bears in York Factory area. Drink motor oil. Change in behavior (McDonald et al., 1997).
Birds: More snow geese migrating to and from the west. Habitat changes at March Point staging area. Earlier and shorter autumn migration.
Fish: Mercury contamination. Loss of habitat including spawning grounds. Change in taste of fish, some are inedible (McDonald et al., 1997).

Western James Bay, Canada
Walrus: Decrease in numbers in Attawapiskat area (McDonald et al., 1997).
Bears: Recent increase in reproduction rates. Fearless of humans (McDonald et al., 1997).
Birds: Habitat changes in Moose Factory area. More snow geese flying in from the west. Canada geese arrive from the north first part of June. Change in autumn migration pattern (McDonald et al., 1997).
Fish: Morphological changes in sturgeon. Dried river channels (McDonald et al., 1997).

Eastern James Bay, Canada
Whales: Decrease in beluga numbers (McDonald et al., 1997).
Walrus: No longer present in Wemindji area (McDonald et al., 1997).
Moose: Loss of habitat. Decrease in numbers. Change in body condition. Change in taste of meat (McDonald et al., 1997).
Caribou: Change in body condition and behavior. Increase in number of diseased livers and intestines. Change in diet. Change in taste of meat. More caribou along coast (McDonald et al., 1997).
Birds: Coastal and inland habitat changes for snow geese and Canada geese. Coastal flyways shifted eastward. Fewer geese being harvested in spring and autumn. Large flocks of non-nesting/molting geese along coastal flyway (McDonald et al., 1997).
Fish: Mercury contamination. Loss of adequate habitat for several species, e.g. white-fish, sturgeon, and pike. Morphological changes in sturgeon (McDonald et al., 1997).

Eastern Hudson Bay, Canada
Whales: Fewer beluga seen along eastern coast of Hudson Bay and James Bay; more offshore of east coast Hudson Bay (McDonald et al., 1997).
Walrus: Shift away from Belcher Islands (McDonald et al., 1997).
Moose: In-migration from southeastern James Bay (McDonald et al., 1997).
Caribou: Caribou from different areas mingle together. Very large herds. Traveling closer to coast. Change in diet. Change in taste of the meat (McDonald et al., 1997).
Bears: Polar bear numbers increased since the 1930s, and more rapidly since 1960s. Inuit think they are relocating to eastern Hudson Bay in response to effects of an abundance of ringed seals, the extended floe edge, and hunting quotas in effect since the 1970s (McDonald et al., 1997).
Birds: Canada and snow goose migrations have shifted east, from the Quebec coast towards the mountains of mid-northern Quebec. Along the Manitoba and northwestern Ontario coasts, more geese are entering and leaving Hudson Bay from the west and fewer taking north-south coastal route. Cree attribute this to combination of factors in last 20 years; weather system changes, coastal and land habitat changes, disturbance from inexperienced hunters, and wildlife management practices, e.g., aircraft and banding (McDonald et al., 1997). Smaller flocks of Canada geese arrive in Belcher Islands since 1984. Increase in non-nesting/molting geese in Belcher and Long islands (McDonald et al., 1997).
Fish: Fish habitat reduced due to lowering water levels. Decrease in Arctic char and Arctic cod in Inukjuak area (McDonald et al., 1997).

Hudson Strait, Canada
Whales: Decrease in beluga numbers in Salluit area (McDonald et al., 1997).
Walrus: Increase in numbers around Nottingham Island (McDonald et al., 1997).
Caribou: Increase in numbers and shifts in distribution, perhaps as part of long-term cycles (Ferguson et al., 1998). Increase in abnormal livers (e.g., spots and lumps). Change in diet (McDonald et al., 1997).
Bears: Decrease in numbers in Ivujivik area (McDonald et al., 1997).
Birds: New snow goose migration routes. Increase in number of molting snow geese. Canada geese no longer nest in Soper River area (McDonald et al., 1997).

Iqaluit, Nunavut, Canada
Birds: Robins sighted in Iqaluit and Kangirsuk (Northern Quebec) in 1999 (George, 1999).

Clyde River, Nunavut, Canada
Seals: Seals not as healthy in last few years; missing patches of fur, molting at unusual times of the season, suffering from skin rashes, white pustules on the meat (Fox, 2004).
Bears: Increased numbers of polar bears in the area and polar bears arrive at unexpected times of the season (Fox, 2004).

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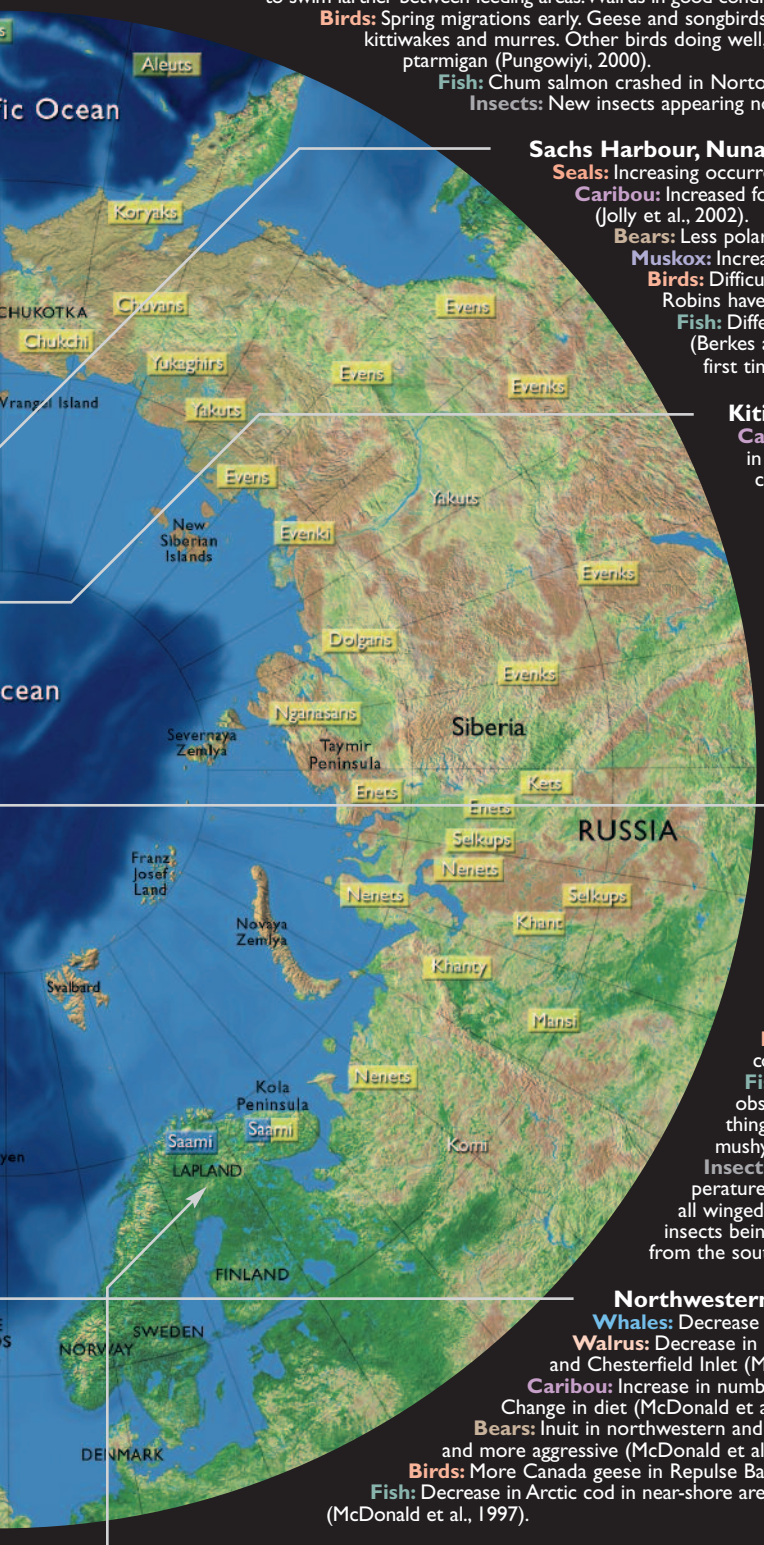

Bering Strait, USA

Seals: Spotted seals declined from late 1960s/early 1970s to present. 1996 and 1997 spring break-up came early resulting in more strandings of baby ringed seals on the beach. Fewer seals in Nome area these days, perhaps as result of less ice for ringed seal dens (Pungowiyi, 2000).
Walrus: Physical condition of walrus generally poor 1996-1998 – animals skinny and productivity low. One cause was reduced sea ice, which forces walrus to swim farther between feeding areas. Walrus in good condition in spring 1999 after cold winter and good ice in Bering Sea (Pungowiyi, 2000).
Birds: Spring migrations early. Geese and songbirds arrive in late April, earlier than in past. August 1996 and 1997 large die-offs of kittiwakes and murres. Other birds doing well, little snow (and lower hare population, food competitor) has been good for ptarmigan (Pungowiyi, 2000).
Fish: Chum salmon crashed in Norton Sound in early 1990s and have been down since (Pungowiyi, 2000).
Insects: New insects appearing not seen before. Mosquitoes still the same (Pungowiyi, 2000).

Sachs Harbour, Nunavut, Canada

Seals: Increasing occurrence of skinny seal pups at spring break-up (Jolly et al., 2002).
Caribou: Increased forage availability for caribou. Changes in the timing of intra-island caribou migration (Jolly et al., 2002).
Bears: Less polar bears seen in autumn due to lack of ice (Berkes and Jolly, 2001).
Muskox: Increased forage availability for muskox (Jolly et al., 2002).
Birds: Difficult to hunt geese in spring because of quick melt (Berkes and Jolly, 2001). Robins have been observed; previously unknown small birds (Jolly et al., 2002).
Fish: Different species observed. More least cisco (locally called "herring") caught now (Berkes and Jolly, 2001). Two species of Pacific salmon caught near the community for the first time (Jolly et al., 2002).

Kitikmeot Region, Canada

Caribou: Caribou changing migration routes due to early cracks in sea ice. Changes in vegetation types and abundance affecting caribou foraging strategies. Massive caribou drownings increasing due to thinner ice, e.g., massive drowning observed in 1996. Lower water levels may mean caribou can save energy by not having to swim as far, however, changing shorelines due to dropping water levels are affecting caribou forage (though unclear how). Caribou deaths due to exhaustion from extreme heat and attempts to escape more mosquitoes (Thorpe, 2000).
Seals: Seals come up through the unusually high number of cracks in sea ice in early spring around Hope Bay, which attracts polar bears (Thorpe, 2000).
Bears: Grizzly bears seen for the first time crossing from the mainland northward to Victoria Island in 1999. Spring 2000, unusually high numbers of grizzly bears and grizzly tracks (Thorpe, 2000).
Birds: New birds seen for the first time such as the robin and unidentified yellow songbird (Thorpe, 2000).
Insects: Number of mosquitoes increasing with temperature, but this occurs only to a threshold then the mosquitoes cannot survive (Thorpe, 2000).

Baker Lake, Nunavut, Canada

Caribou: Caribou not as healthy in recent years. Meat is tough and skin around the neck area tears too easily. More liquid in joints and more white pustules on meat (Fox, 2004). Caribou less fat and undernourished due to heat and dryness in summer. Caribou skins are weak and tear easily during field dressing. More diseased caribou, e.g., sores in mouth and on tongue (GN, 2001). Links between changing caribou condition and climate not always clear (GN, 2001; Fox, 2004).
Bears: More grizzly bear sightings and encounters around Baker Lake area (GN, 2001; Fox, 2004).
Muskox: More muskox sightings around Baker Lake area (Fox, 2004).
Birds: Birds seem smaller and not as happy. Redpolls and white-throated sparrows more common, lapland longspurs hardly seen any more (Fox, 2002). More ravens (GN, 2001).
Fish: Changes in fish (mainly char and trout); trout darker in color, little fat observed between meat layers when boiled, less fish in usual fishing spots, fish eating things they are not supposed to eat, fish too skinny, smell different – "like earth", mushy meat (Fox, 2004).
Insects: Mosquitoes decreasing in numbers in some areas with increasing summer temperatures since there is less standing water. At least ten new kinds of insects in the area, all winged insects, some recognized from treeline area (Fox, 2004). Strange kinds of flying insects being observed. Warmer temperatures may be responsible for arrival of flying insects from the south and for insects being active longer in the year (GN, 2001).

Northwestern Hudson Bay, Canada

Whales: Decrease in numbers in Arviat and Repulse Bay area (McDonald et al., 1997).
Walrus: Decrease in numbers near Arviat and Whale Cove. Increase in numbers near Coral Harbour and Chesterfield Inlet (McDonald et al., 1997).
Caribou: Increase in numbers. Not intimidated by exploration activity. Feed close to exploration camps. Change in diet (McDonald et al., 1997).
Bears: Inuit in northwestern and eastern Hudson Bay report increasing numbers of polar bears. Appear leaner and more aggressive (McDonald et al., 1997).
Birds: More Canada geese in Repulse Bay area during summers of 1992 and 1993 (McDonald et al., 1997).
Fish: Decrease in Arctic cod in near-shore areas. Arctic cod no longer found in near-shore areas off Cape Smith and Repulse Bay (McDonald et al., 1997).

Northern Finland

Birds: Many types of bird have declined in numbers including crows, buzzards, and some falcons. Arctic terns, long-tailed duck, and osprey have disappeared in some areas (Helander, 2004).
Fish: Fish populations have gone into decline in many lakes, partly to due overharvesting, but also due to factors unknown to local people. For example, in Rievssatjavri, in the reindeer village of Kaldoaivi, perch have disappeared but pike survive (Helander, 2004).
Insects: The number of insects has decreased, mosquito populations among others (Helander, 2004).

Fig. 3.2. Indigenous observations of changes in animals and insects.

other disagreements between indigenous and scientific knowledge. Examining the reasons for these differences, however, may drive interesting questions for further research on environmental change. Trying to link different perspectives may result in meaningful insights into the nature and impacts of arctic environmental change (Huntington et al., 2004).

The spatial scale of the observations in Figs. 3.1 and 3.2 is significant. Models of arctic climate provide information on regional scales. Indigenous observations, by contrast, are more localized. A major challenge is to refine model outputs to finer scales, which requires the connection of large- and small-scale processes and information. A corresponding challenge is to combine indigenous observations from various areas to create a regional picture of environmental change. Using these different sources of information across different scales may help to identify the local components of regional processes as well as the regional processes that account for locally observed change.

The information in Figs. 3.1 and 3.2 provides a starting point for studies of the link between indigenous knowledge and other research, for example by cross-referencing different perspectives on climate and environmental change. In this context, several important points about the figures should be noted. First, the information is not comprehensive. The projects cited and even the observations taken from particular projects are only examples. There is not the space to record all documented observations here. Second, each observation is from a particular person, from a particular place, and with a particular history and point of view. Such details are lost when the information is reduced to fit this type of format, and so the information presented here is out of context. The condensed format is valuable for certain purposes, such as a broad comparison across regions or with scientific findings, but the original sources should always be consulted when using the information presented here.

3.4. Case studies

Indigenous perspectives on the changing Arctic vary widely over time and space, as may be expected given the differences between the histories, cultures, ways of life, social and economic situations, geographical locations, and other characteristics of the many peoples of the region. These perspectives cannot be illustrated by generalizations nor, in the space allotted and with the materials currently available, comprehensively for the entire Arctic. The case studies used in this section were chosen as illustrations of indigenous perspectives on climate change, and were drawn from the limited number of studies that have been done on this and related topics. Such a sample of opportunity inevitably results in omissions, such as the lack of indigenous fishers' voices and the absence of case studies across most of the Russian Arctic. It is also important to note that climate change cannot be neatly separated from the many factors that affect the relationship of people with their environment. Many of the observations and interpretations given in the case studies reflect an interaction between climate change and other factors, rather than being the result of climate change in isolation.

Each of the case studies comes from an existing project, whose researchers were willing to contribute material to this chapter. The formats for the case studies vary greatly and were chosen by the authors to reflect the type of

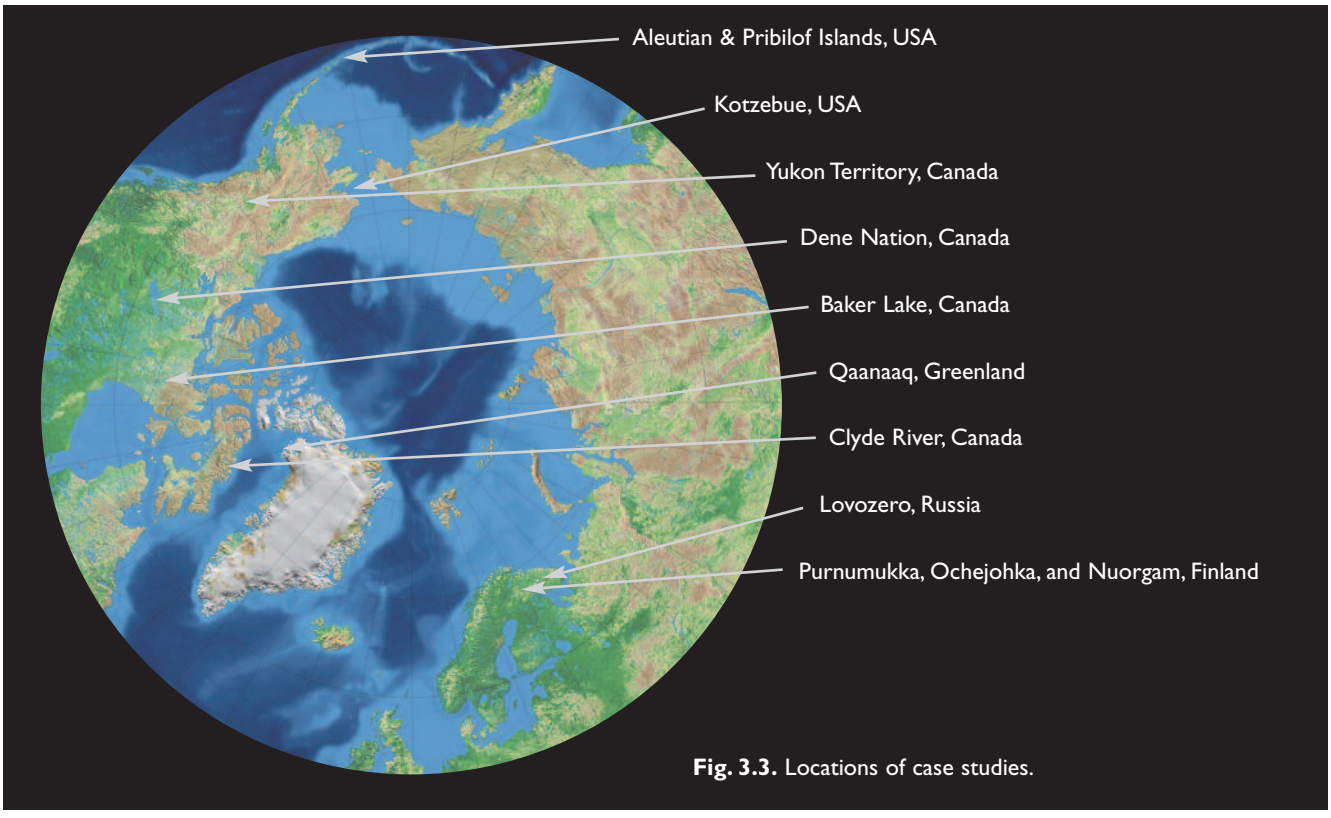

Fig. 3.3. Locations of case studies.

material they gathered and the way in which the study was conducted. It was felt that the resulting inconsistencies in style were preferable to imposing a uniform approach to very different materials generated in very different ways. Of course, each study is selective in that it cannot cover all that a given people or community has to say about climate change. The case studies describe those aspects of climate change and related topics that the authors and the communities represented find most significant. Figure 3.3 shows the locations of the case studies discussed in this chapter.

The projects from which the case studies are drawn have, in most cases, produced a separate report or reports elsewhere, which contain more thorough discussions of methods, approaches, and results. They also acknowledge the support that was required from funding agencies, collaborators, and, most importantly, indigenous communities and people in conducting and reporting each study.

In addition to the longer case studies presented, three short case studies are included to give perspectives from other parts of the Arctic or to emphasize a particular point of view. The Greenland case study (section 3.4.6) and the second case study from Finland (3.4.8) are drawn from interviews with individuals. The Aleut case study (section 3.4.2) describes the background and plans for a project to be carried out in the village of Nelson Lagoon, Alaska, with additional observations from other communities in the region. As is the case for the longer case studies, the three short case studies are illustrative rather than representative, and are given as examples.

3.4.1. Northwest Alaska: the Qikiktagrugmiut

The Native Village of Kotzebue, the tribal government of the community, conducted a study to document traditional knowledge of environmental change in their region from the 1950s to the present. The study was conceived, developed, and carried out by members and employees of the tribe. Interviewers used a semi-directive interview to engage elders in conversations about environmental change. The results were compiled in a report (Whiting, 2002), which included a discussion of the implications of the various observations recorded. The documentation of this knowledge will be valuable to future tribal members for historic preservation purposes and comparative analysis. The case study reported here draws largely on the discussion contained in the project's final report.

Kotzebue, a community of 3000 inhabitants, the majority of whom are Iñupiaq, is located on the Baldwin Peninsula 30 miles above the Arctic Circle in northwest Alaska. Its Iñupiaq name is *Qikiktagruk*, which means "almost an island". The people indigenous to this locality are the *Qikiktagrugmiut*, "people of Qikiktagruk", and the tribal government representing them is the Native Village of Kotzebue. This case study documents the perspectives of the Qikiktagrugmiut, who have lived in the area as a distinct group for centuries (Burch, 1998).

The subject of climate change, and environmental change in general, is of personal interest to a people that continue to interact directly with the natural world for their spiritual, cultural, and nutritional sustenance. The Qikiktagrugmiut, while giving some thought to the broader definition and future implications of environmental change mostly focus on present and near-future effects. They are specifically concerned with change as it relates to climate and day-to-day weather and how these compare to what is considered "normal" based on personal experiences over the last half of the twentieth century. Some significant changes in weather types and patterns have occurred in recent decades, in some cases creating conditions that have not been observed previously by the current generations of Qikiktagrugmiut. The implications of these changes are hard to predict.

Local hunter discussion focuses on the elements of the climate and "country" (the environment outside the settlements) on a daily basis. Their interest is not primarily comfort, although that is usually referred to in conversation, but on whether conditions are conducive to travel and how they will affect the movement of animals. Hunter mobility is critical to the ability to access a migratory and widespread animal resource. During summer, high winds and fog, along with the break-up of the ice at the end of May and beginning of June, heavily influence the ability to travel. In winter, high winds are more an inconvenience than an impediment to travel, unless the winds are associated with blizzards and whiteout conditions. While these will stop travel at times, it is still possible to travel under the most adverse winter conditions, unlike in summer. More commonly, extremely low temperatures restrict winter travel. In recent years, however, the period of time temperatures stay extremely low has been shortening. The timing of freeze-up, the thickness of the newly forming ice, and the timing and amount of snow are also key factors affecting travel. In other words, the weather is immediately important for daily activity.

There is little doubt that the weather and the entire environment that Qikiktagrugmiut depend on to support their way of life are changing. Environmental change is not necessarily bad. For instance, at the beginning of the twentieth century, caribou (*Rangifer tarandus*) were rare in the locality of Kotzebue. If not for the region's reindeer (*Rangifer tarandus*) herds imported at this time from the Chukotsk Peninsula, Russia, many people would have had a hard time finding enough meat and skins for clothing to survive the winter. Now the Western Arctic Caribou Herd that travels through the area numbers about half a million (attributed to natural variability in caribou/lichen cycles and a decrease in reindeer competition due to a loss of interest in herding and from caribou herds absorbing many reindeer and even reindeer herds), and local reindeer herds are absent. In addition, moose (*Alces alces*) also began to appear in the region from around the 1950s onward, again attributed to natural variability. These types of change contribute to the quality of life of the region's residents.

Weather has also changed over the last half century. Seasons are now less consistent. For example, higher temperatures have become more common during autumn and winter, sometimes creating mid-winter fog, a new phenomenon. At the same time, lower temperatures in the summer have also become more common. Daily changes are now more extreme. It is relatively common for the temperature to change from -35 ºC one day to 0 ºC the next or vice versa. Unusual swings in weather occur not just during winter. An exceptional example is the snowstorm during July 2000, which left snow covering the tundra for a day and reduced the berry crop dramatically that year. Another example includes having the least amount of precipitation recorded for the month of November during 1999 and again in 2001, 0.25 mm, or 100 times less than the average amount of precipitation recorded for that month over the last fifty years. According to Qikiktagrugmiut, the increased variability and unpredictability in weather appears to have started during the 1970s and has continued through the 1980s and 1990s and into the new century.

The relationship between weather and the Qikiktagrugmiut is more intimate than for most people in the United States. Their daily traditional activities are almost entirely dictated by the weather and other environmental conditions, such as snow depth and animal distribution. For most urban communities the concern with weather has more to do with comfort level and recreation. For the Qikiktagrugmiut, the weather determines if daily activities can be carried out safely and productively (for instance water and ice travel and being able to dry meat and fish successfully). The weather is also tied to the ability of the land to produce natural crops of fur, meat, and berries.

This disparity in how weather is perceived by the rural Alaskan communities versus the urban mainstream is apparent from watching weather forecasters across the country, including urban centers in Alaska, such as Anchorage. The premise of these forecasters is based on the urban view that "good" weather should be sunny and warm. For the Qikiktagrugmiut, however, weather is "good" if it is favorable to the country's productivity and the ability of people to access the land's resources. Thus, "good" weather may include rain in July to produce a bountiful berry crop and extremely low temperatures during early autumn so that Kotzebue Sound and the surrounding rivers and lakes freeze quickly and reliably for safe travel. These two conditions, rain and extreme low temperatures, are almost universally portrayed as "bad" weather in urban settings. In addition, the Qikiktagrugmiut's ability to cope with extreme weather events differs from that of most urban communities across the nation. Blizzards that would shut down entire cities and be portrayed as mini-disasters by the urban media are looked upon favorably by rural Alaskan communities as a means by which travel is improved (through additional snow filling in willow stands, tundra tussocks, creeks/gullies, and compacting snow cover by the associated winds), allowing greater access to the country for travel and harvesting animals. Even in the town of Kotzebue, extreme weather events have relatively little direct impact. Schools and businesses, for example, are rarely closed due to weather.

These characteristics of the people appear to show an ability to successfully adapt and live in an inherently variable local environment. The real challenge with assessing the impacts of climate change, however, is in trying to understand the interconnectedness and the wide-ranging impacts that collectively work to change the shape of the web of activities and life in this part of the world.

Some Qikiktagrugmiut live out in the country outside the communities. Their ability to travel and obtain the necessary requirements of life is dependent on the length and quality of the freeze-up and the length of the break-up, which are determined by the weather conditions during autumn and spring. In addition, many people who are at the fringes of production, the young and the elderly, depend on favorable weather to be able to participate in the limited harvesting activities available to them. Ice fishing in front of Kotzebue, for instance, supplies people with traditional autumn food (saffron cod (*Eleginus gracilis*) and smelt (*Osmerus mordax*)), and is an important social activity that binds the community and gives the elderly and young people one of their few chances during the year to harvest traditional foods. During autumns with a late freeze-up, ice fishing is limited or less productive. Thus, a single climate variable in one season disproportionately affects this segment of the population by substantially reducing their annual harvesting opportunity.

3.4.1.1. The impacts of late freeze-up

A closer look at the Qikiktagrugmiut understanding of one event and its impacts, such as late freeze-up, can show how they see consequences that are widespread and varied yet still intertwined, so that it is impossible to look at any one thing in isolation. Late freeze-up is one likely consequence of regional climate warming, and hence a relevant example for considering the impacts of climate change. To illustrate the complexity of determining whether overall changes are positive or negative and how this depends on context and perception, this section uses the example of late freeze-up and its impacts on people, spotted seals (*Phoca largha*), caribou, and red foxes (*Vulpes vulpes*). The impacts are those that the Qikiktagrugmiut would immediately associate with late freeze-up, showing both the scope of their environmental knowledge and the patterns of interconnection that they see in their surroundings. This exercise shows how the timing, quality of ice, speed of complete freezing, associated weather, and ecological effects all combine to produce the many and varied impacts of a late freeze-up.

Impacts on humans and their way of life

The impacts of late freeze-up on humans vary widely and include better whitefish (*Coregonus* spp.) harvests, better clamming (*Macoma* spp.), better spotted seal hunting,

better access to caribou, better arctic fox (*Alopex lagopus*) harvests, better access to driftwood, a shorter ice-fishing season, poor access to Kotzebue for people living out in the country, rough ice conditions, more danger from thin ice, and more erosion and flood problems.

- People living outside Kotzebue at remote campsites have an extended period for whitefish harvesting. Late season storm surges can reach the beach, piling porous sand across the mouth of a major harvesting river, trapping the fish behind the sand dam from where they are easily caught.
- Late season storm surges wash clams onto the beach at Sisaulik (a peninsula across the sound from Kotzebue where some of the Qikiktagrugmiut live during the summer and autumn), which can then be collected and stored in cool saltwater for many days of clambakes.
- Hunters have a longer period for using boats to hunt spotted seals, which are present in prolific numbers feeding on large schools of fish. Also, a long period of thin ice enables the seals to feed far into the sound. When the ice thickens overnight, many may try to return to open water by crawling on top of the ice, where they are easily reached by hunters now able to travel on the ice.
- Caribou hunters have a longer period in which to use boats to reach caribou (conversely snowmachine access will be delayed to later in the winter). There is, however, an increased risk during extended freeze-ups that boats will get caught in young ice and have to be abandoned for the winter. This happened during the late freeze-up of 2000.
- Arctic foxes are concentrated along the coast during the long season of open water, unable to get out onto the sea ice.
- More logs are washed up on the mud flats by late-season high water, for use by people living out in the country for their early autumn fuel supply.
- Ice for autumn fishing is missing, so the ice-fishing season is shorter in front of Kotzebue. In many cases, the ice fishers will then miss the largest runs of smelt and saffron cod, which tend to come past Kotzebue in large concentrations earlier, rather than later, in the autumn.
- People living out in the country must wait for a longer period before they can reach Kotzebue for expendable supplies such as gas, propane, medical needs and other necessities or must risk traveling under very dangerous conditions, which has caused the loss of life in some cases.
- Repeated incomplete freezing and thawing of the northern sound means that the ice that does appear can be piled up by the wind, creating very rough conditions and many obstacles to travel by snowmachine and dogs which begin once the ice freezes permanently.
- Snow can pile up on thin ice which makes such areas less likely to freeze completely and thus more dangerous once travel begins. There is often much snow on the ground during autumns with late freeze-ups because the low pressure conditions that contribute to slow ice growth are also associated with snow and storm fronts.
- Late season storm surges, unimpeded by ice, can create erosion and flood problems along the beach and road in front of Kotzebue.

Impacts on spotted seal

The impacts of late freeze-up on spotted seals include better access to inshore waters and the fishes that congregate there, better haul outs for resting, and greater risk of being trapped.

- Owing to the absence or patchiness of ice, spotted seals have increased access to the extreme inshore waters where smelt and saffron cod, and other food fishes, congregate in large numbers in early autumn. The seals force the fish into concentrated groups next to shore during the open water period, which is probably the most efficient way for them to catch the fish easily and in large numbers. Also, late freeze-up would allow seals increased access to the Noatak River, which holds large char (*Salvelinus malma*) and chum salmon (*Oncorhynchus keta*) at this time.
- Thin or patchy ice is better for hauling out on, allowing the seals to rest close to their major food source at this time of year, thus increasing the net amount of energy gained from this seasonal activity.
- Because the seals are able to haul out and breathe through the thin ice, they have a greater risk of becoming trapped too far from open water when the ice begins to thicken. Once temperatures drop well below freezing and stay there, which can happen rapidly at this time of year, the ice can become too solid and extensive for the seals to reach open water, which will force them to travel out over the ice (and in some cases over land) in order to reach the open water of the Chukchi Sea, leaving them vulnerable to starvation and predation.

Impacts on caribou

One of the impacts of late freeze-up on caribou is slower movements.

- The warm weather associated with late freeze-up makes caribou less likely to travel long distances thus slowing the autumn migration. In addition to being slowed by the warm weather and their own lack of initiative to move, extended thin ice conditions hamper movement, because the ice does not support the animals when they try to cross water bodies in their path. Although the consequences of this are unclear, they are probably many and varied, such as being forced to stay for extended periods of time on less productive ranges and increased vulnerability to predators such as wolves (*Canis lupus*) that are lighter and able to take advantage of the thin ice that is an obstacle for the caribou.

Impacts on red foxes

The impacts of late freeze-up on red foxes include better feeding and increased competition with Arctic foxes.

- A longer period of late season open water allows more storm surges to reach the shore, closing off coastal rivers with porous sand that allows large amounts of whitefish to become trapped and frozen into the ice at coastal river outlets. These provide a substantial food resource for many of the foxes along the coast. In addition, late season storms result in more sources of fox food in the form of enormous schools of baitfish and marine mammal carcasses that are deposited on the beach by the waves. Also, a longer hunting season for spotted seals and caribou by boat hunters means that more caribou gut piles and lost seals become available prior to the long period of beach foraging. Almost all foxes within the vicinity of the coast rely heavily on beach scavenging during the time around freeze-up, which also coincides with low human traffic along the coast. A particularly good year for late season beach foraging allows the foxes to accumulate critical amounts of fat to survive the long winter months ahead.
- An extended period of open water along the coast can impede the movement of arctic foxes onto the pack ice, which results in increased competition with the red foxes that rely on coastal food sources. If this occurs during a high in the four-year arctic fox population cycle, the effect is multiplied by the large numbers of arctic foxes migrating south and being stopped by the open water along the coast.

While this list of impacts arising from late freeze-up is not exhaustive, the examples indicate the interconnectedness that complicates an effort to understand the changes that occur from year to year as well as the long- and short-term effects of changes to the various combinations of environmental elements.

The challenge posed by climate change to indigenous peoples is their ability to respond and adapt to changes in the local environment, while continuing to prosper. Since the history of indigenous peoples is replete with change, it is important to ask whether they and their cultures are threatened by continued change, or whether change is just a threat to current understanding of the environment, which in any case is continually changing, slowly and on a daily basis. For example, seal hunting in leads during winter has decreased in importance and participation each year, due in part to the cultural economy's changing dependency on the seal for food and domestic utilitarian purposes, and in part to the unpredictable, and thus more dangerous, ice conditions of late. It is an activity that relies on the most extreme form of specialized knowledge of the environment that needs to be taught and learned over many years. More rapid environmental change is generally harder to adapt to. Recently, two experienced seal hunters were lost on the ice while hunting. Local interpretation of the event concluded that climate change has resulted in unusual and unpredictable ice conditions and that this must have been the cause of the tragedy, as the two men would not have had trouble traveling over ice under normal circumstances.

Even if processes are in motion that will change the entire ecosystem, whether this will result in circumstances that are not conducive to human existence, or in a new ecosystem with resources available for human consumption following some degree of adaptation, is unknown. Archaeologists have found this to have occurred in the past, with arctic societies having changed from terrestrial-based cultures to marine-based cultures and back again. The best that can be done at this point is to continue to observe, document, and discuss the changing environment and to hope that indigenous peoples will be able to adapt to whatever future environments may evolve in their traditional homelands.

3.4.2. The Aleutian and Pribilof Islands region, Alaska

The Aleut International Association (AIA) and the Aleutian and Pribilof Islands Association (APIA) prepared this summary of current observations, concerns, and plans related to climate change in their region. Michael Zacharof is President of AIA and lives on St. Paul Island in the Bering Sea. Greg McGlashan is the Tribal Environmental Programs Director on St. George Island. Michael Brubaker is the Community Services Director for APIA. Victoria Gofman is Executive Director of AIA.

There are several examples of how climate change is affecting people and communities in the Aleutian and Pribilof Islands region. The Nelson Lagoon Tribal Council has for several years been concerned about the effect of changing weather patterns on the narrow spit of sand they occupy between Nelson Lagoon (a prime nesting habitat for Steller's eider (*Polysticta stelleri*)) and the Bering Sea. The changing climate is having dramatic effects on the security of the village and the local infrastructure.

Like many Alaskan coastal communities, Nelson Lagoon has been battling the effects of winter storms for years, most notably by building increasingly strong breakwalls along the shore. The increasing violence of the storms and changing winter sea-ice patterns have exacerbated the problem, reducing sections of a structure they hoped would provide decades of protection to kindling within just a few seasons. This is because their breakwall was designed to brace the shore ice, which would in turn provide the real buffer from winter storm wave action. As the winters have been warmer over the past six years, the buffer provided by the shore ice has been lost, allowing the full force of the waves to surge against the wall and the village.

In addition to the breakwall, other vital infrastructure has been disrupted by the changing weather patterns. In 2000, the pipeline that provides the village's drinking water was threatened when storm waves eroded cover soil and caused a breach in the line. US Public Health Service engineers made an emergency trip to Nelson Lagoon to help repair the damage.

Based on these events, the Nelson Lagoon Tribal Council applied for funding from the US Environmental Protection Agency to establish a tribal environmental program with a focus on community planning and increasing understanding about the long-term impacts of climate change. This program is currently under development.

Other climate-related observations from the Aleutian Islands include the presence of non-indigenous warm-water fish species. One example is salmon sharks (*Lamna ditropis*), which have been observed as far north as False Pass, an important migratory passage for whales, salmon, and other marine life between the North Pacific and Bering Sea. It is likely that salmon sharks will soon be seen in the Bering Sea, competing for resources with marine mammals such as the Steller sea lion (*Eumetopias jubatus*).

On the Pribilof Islands in the Bering Sea, many changes have been seen. On St. George Island, the gravel of Staraya Artil Beach is being washed away, leading to shoreline erosion. As the gravel recedes and sea level rises, various artifacts and animal bones are appearing. No one on the island has seen anything like this before. On neighboring St. Paul Island, the 2002/2003 winter was warm with little snow. As a result, there were few eiders, which reduced subsistence hunting opportunities. On the other hand, northern fur seals (*Callorhinus ursinus*) and Steller sea lions remained on the island throughout the winter.

For such reasons, the Aleut are very interested in finding better ways to monitor and study climate-related changes in the region, as well as to affect global policies. The Aleut International Association recognizes the need for comprehensive monitoring of the Bering Sea region from the Alaska Peninsula in the east to the Commander Islands in Russia in the west. Climate change should be an integral part of such monitoring. Although climate change observations in the region are numerous, almost no systematic records have been analyzed to document climate change, either in Alaska or Russia.

The Aleut, who live in the region all year round, have intimate knowledge of the land, sea, and climate. They are an invaluable resource and important partners in research. Currently, Aleut tribes in Alaska are developing their marine research capacity, which includes working with villages all along the Aleutian chain and engaging the region's small-boat fishing fleet. This is a large untapped resource, which could provide an effective link between traditional and western knowledge, involve the region's people in efforts to understand scientific research, and empower those most affected by climate change and its impacts. The current tribal structure and environmental program capacity provide excellent opportunities for research focused on climate change and other emerging issues. The Aleut International Association enables international research and monitoring in the Bering Sea by connecting peoples and governments on both sides of the Bering Sea and by helping the Aleut people address the most vital problems that they face today, one of which is climate change.

3.4.3. Arctic Athabaskan Council: Yukon First Nations

The Council of Yukon First Nations held a series of workshops in February 2003 to address climate change. On February 12 and 13, twenty elders representing the Elders Council of the Council of Yukon First Nations took part in the Elders Climate Change Workshop. This workshop happened as a result of suggestions given by community elders. They said that the changing northern climate was an important issue because it had implications for human health and cultural survival. Following a round-table discussion, the elders divided themselves into three groups – representing the north, central, and south Yukon regions. Each elder shared his or her knowledge and concerns about changes in weather and how these changes have affected the way of life in their nation's traditional territory. A second Yukon First Nations Climate Change Forum was held February 26 and 27. Elders, community representatives, scientists, and government representatives participated in the forum. Elders listened to explanations of government programs and research and provided suggestions as to how federal and territorial governments and researchers could work in partnership with Yukon First Nations communities to develop a long-term strategy for climate change.

Yukon First Nations elders share a growing concern about the changes that are taking place on their lands and in their way of life. Climate change is responsible for some but not all of these changes. Contaminants from local sources and long-range transport have been a source of worry for cultural activities such as trapping, hunting, and eating traditional foods, resulting in changes to community social life. As the environment has changed, people have had to learn to cope with the change. Understanding why things have changed and why this is happening helps people to adjust. Yukon elders want to share what they know, and to learn as much as they can from others about climate change and its impacts. Only through knowledge and the ability to take action for themselves will Yukon First Nations be able to respond effectively to climate change.

At the Elders Climate Change Workshop and the Yukon First Nations Climate Change Forum, elders and community representatives described the changes that they have seen. In the northern Yukon, freezing rains in November have meant that animals cannot eat. Birds that usually migrate south in August and September are now

being seen in October and November. In some areas, thawing permafrost has caused the ground to drop and in some cases has made the area smell foul. In more southerly communities, rings around the moon are no longer seen, although they are still visible in the northernmost community. There are increased sightings of new types of insect and an increase in cougar (*Puma concolor*) and mule deer (*Odocoileus hemionus*). People used to be able to predict when it would get colder by looking at tree leaves. It is difficult to do that now. Lakes and streams are drying up, or are becoming choked with weeds, making the water undrinkable. Many animals are changing their distribution and behavior. Bears used to go into their dens in October and November, but are now out until December. One bear was spotted in winter sleeping under a tree but above ground, rather than in a den, which was regarded as an exceptional and unprecedented sighting.

Many of these changes have been observed since the 1940s, although some began earlier. These changes have produced much concern and anxiety. People are concerned about the future. Habits have changed, so that people now depend more and more on market foods and eat fewer traditional foods. In the face of such changes, people often mobilize to take action. One result in the Yukon is that elders are willing to assist in developing a strategy and are prepared to find ways to cope with the changes, as difficult as that may be. In many statements, the elders expressed their fears about these changes. One said that he had never expected to see the day when people would worry about water, but now he hears about that all the time. Another remembered, "We were able to read the weather, what it was going to be like".

At the workshops, Yukon First Nations elders made it clear that partnerships must be developed between the federal government, the territorial government, and Yukon First Nations, as well as with scientists and non-governmental organizations. Each community must have the ability to prepare for change and to be a part of designing the strategies that are being developed in relation to climate change. At the international level, Yukon First Nations elders have shared their traditional knowledge and cultural values to help shape policies through the Arctic Athabaskan Council. The elders and community representatives concluded that their workshops were just a start. More is needed. To that end, an elders panel of five members has been created. This is to be consulted and to have a representative who will work with the Council of Yukon First Nations and the Arctic Athabaskan Council.

3.4.4. Denendeh: the Dene Nation's Denendeh Environmental Working Group

This case study is the first official publication of Dene observations and knowledge on climate change. There have been documents by newcomers, missionaries, fur traders, and others, in which it was observed and noted that the Dene knew much about their relationship with the land. There have been articles and books written on the problems of relying on these observations (Brown J. and Vibert, 1996; Krech, 1999). The Dene are continuing to write their histories and curriculum for their schools, teaching us about their world, but these are beyond this discussion (Erasmus et al., 2003; Watkins 1977).

> *Raven is known as a trickster. He said let's see who can kill a moose. So everyone ran into the bush. The Raven said he killed a moose. The people asked what are we going to do with the intestines? They said to string it along the creek. They were melting the grease into the intestine. (This was the first pipeline). They were wondering why this grease was never filling up. So a couple of kids followed him. They found the Raven at the end drinking the grease. So they threw a bone in the grease. The Raven swallowed the bone. That's why the Raven today says, KAA!* Bella T'selie, Liidlii Kue, Denendeh, March 12, 2003

> *My mother used to get the best water and spruce bough for the floor. It was natural. Even if we spilt something it would seep through the spruce bough. So when we lived in a house we didn't know how to make the transition. People got sick. There's not many people who can live in both worlds. We have sacred lands that we don't go into. We knew of this one area to be a bad place (Deline). After development, we found out how bad it really was. Scientists like to talk about things apart. We think in holistic terms and cannot think about things separately. Dene spirituality is in traditional knowledge. Dene ways are very formal. We cannot separate spirituality in Dene, but scientists think this is ridiculous.* Bella T'selie, Liidlii Kue, Denendeh, March 12, 2003

> *We survive by caribou. When you hunt caribou it can take up to three weeks for the trip. That's why we need to protect our caribou. That's why I brought some caribou for you to taste.* Eddie Camille, Liidlii Kue, Denendeh, March 11, 2003

Like all environmental issues, climate change is understood and talked about by the Dene (Chief Roy Fabian in Dene Nation, 2002, Chief Sam Gargan in Dene Nation, 2003) as it relates to the people and the land (Dene Nation, 1984). Denendeh will face significant change based on current climate change scenarios and models. The issues of changing climate are different for Dene than they are for other indigenous peoples and each has much to contribute to this discussion. Dene knowledge speaks to the past, and explains the now, as well as what may occur in the future. This knowledge is different from what scientists know about climate change (see for example the discussion on climate and the high Arctic in Dick, 2001). Each form of knowledge can be gathered together, not necessarily to create a single synthesis, but to allow each to appreciate and increase what is known about climate change from both perspectives. The Denendeh Environmental Working Group workshops are a first step in a larger

effort to bring Dene views and voices into climate change discussions in the north, in Canada, and into international discussions such as the SnowChange Conference (see section 3.4.7) and this assessment.

3.4.4.1. Dene Nation

Dene Nation is a non-profit Aboriginal governmental organization mandated to retain sovereignty by strengthening Dene spiritual beliefs and cultural values in Denendeh, which encompasses five culturally and geographically distinct areas, six language groups, and is home to over 25 000 Dene in twenty-nine communities. The settlement of communities has varied as has the population and composition of each community. As indigenous peoples their cultures, languages, and title come from time immemorial. In the international arena the Dene use the Arctic Athabaskan Council, a Permanent Participant to the Arctic Council, and the Assembly of First Nations. These links enable the Dene to tackle difficult science and policy issues of climate change by maintaining activities at the local to international level.

3.4.4.2. Climate change policies and programs in Denendeh

The Dene have always observed the climate and have stories that speak about the way things were before time and as they are meant to be in the future. Climate change, as discussed here, is concerned with the phenomenon that has been speeding up following industrialization. Since the 1970s, a great deal of what has entered into Dene thinking has come from international discussions of greenhouse gas emissions and global warming (e.g., Brown et al., 2000). Changing climate is indeed being experienced as local changes on the land; however, policies and programs dealing with these changes often have little to do with the needs of the people on the land.

In order to discuss Dene knowledge, impacts, and adaptations of changes in climate, it is first important to place into context the reason why Dene observations and knowledge are being documented. The development of national government policy and programs has had a significant influence on Dene understanding of climate change and a brief summary of government policy and programs provides the context from which to understand the development of the Denendeh Environmental Working Group.

The Canadian government's initiatives fund a variety of activities. The general direction for the bulk of these programs, toward national objectives, means that there is a limited engagement for Dene in these activities. Work at the local level must serve some national priority or it is not funded. For example, taken to its full extent the development of the Hub Pilot Advisory Team and the Public Education Outreach gives the appearance of democratic and public institutions responding to national information needs surrounding climate change. Likewise, the Canadian Climate Impacts and Adaptation Research Network facilitates a transparent network of researchers and government scientists working collectively on climate change. These and other activities appear to be developing a critical mass of information, but are not focused on the specific or local realities of climate change in any single location; how it is being experienced. The Joint Ministers of Energy and Environment are not concerned specifically with the fact that indigenous peoples across the north are experiencing climate change differently. In order to counter the homogenizing influence of federal programs, limited attempts, in particular the Northern Ecosystem Initiative under Environment Canada, have evolved, responding to particular realities of northern Canada and the indigenous peoples living there.

Northern indigenous peoples' organizations in Canada have approached climate change independently and the result has been a piece-meal approach to bringing forward indigenous views and knowledge. Hearing from the people themselves is important (Dene Nation, 2002, 2003; Nunavut Tunngavik Inc. et al., 2001). Equally important is finding ways to interpret what is being said by these people to those who lack the historical and anthropological knowledge necessary to understand fully what is being said (Krupnik and Jolly, 2002). This is particularly pronounced in climate change research because of its heavy reliance on physical scientists who may wrongly conclude that indigenous knowledge is anecdotal and therefore without scientific value (Dene Nation, 1999). Dene Nation decided that the most efficient way of contributing to discussions on climate change was by sharing some of what was gathered during workshops where Dene knowledge could be shared and documented.

3.4.4.3. Denendeh Environmental Working Group

The Denendeh Environmental Working Group (DEWG) developed out of two complementary forces. First, a number of climate change issues were of interest to the Dene and had broad policy/program implications for Denendeh. Second, the Environment and Lands division of Dene Nation had previous experience with a Denendeh environment committee. Dene Nation's objective in forming the DEWG was to work on specific areas of collective interest, to educate about the issues and best apply the policies and programs that exist, and to lobby in all arenas regarding Dene sovereignty, spiritual beliefs, and cultural values.

The DEWG is a non-political forum where Dene and invited guests from government, academia, and non-governmental organizations can gather to share climate change knowledge and observations. The first workshop on climate change was held in Thebachaghe (Fort Smith) in 2002. The second, held in Liidlii Kue (Fort Simpson) in 2003, examined climate change and forests. Themes of future workshops include water and fish.

The DEWG membership changes with each meeting, but includes one technical staff member working on environment and lands issues from each region and a regional elder. There are a number of concerns about changes in climate that are specific and unique, as well as others that are common to each Dene community and region. These differences and commonalities are recognized and the issues and knowledge brought forward during each meeting are documented. The mixture of tradition and modernity find common hearing and attempts are made to improve what is known from both traditional knowledge and practices and science and government policy and programs. In the future, transcripts and tapes could serve a number of educational and other research purposes. The work of documenting Dene concerns and responses to climate change is still in its infancy. Conclusions should not be drawn on impacts and adaptations until a critical mass of information is gathered, the definition of which was an important consideration during the DEWG meetings during 2003 and 2004.

The DEWG facilitates more than the documentation of Dene views and knowledge on climate change issues. A significant goal is to facilitate the sharing among regions of climate change knowledge in a systematic way. The workshops are proving to be an opportunity for people from each region to hear from one another about changes they have observed.

The broad nature of climate change research and programs is being complemented and improved by focusing at the regional and local levels. The DEWG is important for education and outreach. In particular, each meeting challenges the participants to find ways to communicate the sometimes-complex science of climate change in a way that is accessible and free from technical jargon. It challenges elders and technical staff to speak with scientists and build, when necessary, research alliances and networks of researchers.

The DEWG has been shaped by four basic discussion questions:

1. Is there a difference today in Denendeh and is climate change having a role in these changes, what else may be causing it?
2. What climate change programs are there and how can our communities be more involved in research and communication about these changes?
3. If it is important to document Dene climate change views/knowledge, how should we communicate this knowledge with each other and to policymakers, governments, and others outside the north?
4. Is the DEWG a good mechanism to discuss climate change, what should we be talking about, and what else do we need to do?

Answers to these questions continue to evolve. Elders, in particular, find that there is a difference in how the climate is changing in Denendeh, and that many changes on the land are attributed to climate change, or that climate change is at least having a role in the land and animals being different. The behavior of Dene themselves, including increased use of transportation like vehicles and skidoos, is blamed in part for increased changes in the climate and overall health of Denendeh.

Change is manifest in how animals behave, such as wolves acting unpredictably. Invasive species, such as moose moving further north and buffalo (*Bison bison*) moving into Monfwi region, are being observed. Birds never before seen and increasing variations in insects are also being noted. A problem identified for trees was increased pine and spruce parasites and diseases.

The overall health of trees and their ability to fight disease and withstand the increased frequency of insect infestations is of concern for forests in Denendeh. For the past five to six years, trees have been dying in greater numbers. Elders noted that trees were soggy and not frozen through so that in cases of emergency one could not easily save oneself by making a fire. This was serious as ice was unpredictable in places and there were increased instances of people falling through.

In the Mackenzie Delta, many channels had changed with some widening, making winter land travel impossible. Groundwater is down in some areas because of increased levels of vegetation, especially willows. Changes in vegetation were not the cause but rather the effect of climate change. Changes in water also lead to increased disease in wildlife. Elders are observing how many freshwater fish populations and runs are less healthy, there is increased occurrence of "unhealthy fish".

Interconnectedness among all parts of the environment is a feature repeated by elders during the workshops. The links between activities on the land, development impacts, lack of capacity to deal with change, and the overall adaptive ability of Dene cultures are important considerations. For the Dene, it is wrong to separate climate change from human and governance issues. Dene talk about climate change in part as "how things grow" (Dene Nation, 2003).

Climate change is affecting how traditions are maintained. It is difficult to demonstrate to non-Dene the impacts of climate change on traditions and to identify those impacts that have other sources, for example television. The changes and associated impacts are known by elders and others who continue Dene traditions, and stem from the overall unpredictability of climate and increased warming which alters the availability of species and so on. An indication of the erosion of traditions is that, "in the old days, everything was dried; meat and fish". Less food is dried now. For example, the organizers of the DEWG workshops could not secure an adequate supply of dry fish and dry meat for participants, even though these foods were once abundant in Dene communities. There are very good lunches but typically few traditional foods are served. In the future the supply

of food and food preparation methods will be questioned in more detail. In this point lies the strength of having a series of workshops by and for the Dene on climate change and associated issues; to continue to learn and to share/protect Dene observations and knowledge.

Traditional knowledge teaches Dene about relationships, to know how things are related to each other. So for example, when asking how trees are affected by changes in climate, it may be appropriate to consider what is happening with drinking water. The relationship may be that there are different trees now, the willows having replaced spruce and other trees dying off, while the water tastes bad because of warming. Seen in this way, the entire world relates to all other parts, including the Dene.

Dene explain both the causes of climate change and the future in terms of their daily lives and cultural understandings. The physical connections Dene have with the land have been much discussed; always with an underlying concern about more than just the physical and immediate concerns of everyday life. What a person does affects everyone else, whether it is throwing garbage into the river and affecting those downstream, or the way that cities create huge ecological footprints from car exhaust, factories, and industries. Also, what was done in the past affects now and into the future.

The integrity of culture and land is essential to Dene. They have made many observations and see climate change as more than the weather becoming warmer. Some discussion was placed on the weather and how it was becoming unpredictable. In the past, Dene elders could predict the weather, but this is no longer the case. Warmer temperatures and changing precipitation patterns, although seasonal and spatially variable, cause concern for animal migrations, in particular the lack of snow causing caribou to wander all over the place whereas in the past they would break trail for each other and stay together. There is a Dene legend about people in the past who were able to control the weather. These people would predict the weather. They could tell what was going to come before it happened by watching the color of the sky and connecting this to cloud patterns. Not many people can predict weather anymore.

Holism of ecosystems means all Dene, elders and youth, working together equally. When Dene talk about trees, they talk as well about porcupine (*Erethizon dorsatum*) and fish. It is important to understand Dene concern for the overall health and faith all Dene have for the land. They are not as confident today with the natural environment. It is being changed by anthropogenic development far removed from Denendeh. Adapting to these impacts will depend, in part, on strengthening Dene teachings and traditional knowledge in order to provide a solid cultural foundation for actions that are taken. In this way, adaptations and other responses can be developed that are consistent with Dene cultural values but that may draw upon other resources such as outside technology.

Proceedings of the workshops have been produced which summarize the discussions and outcomes of the meetings. To protect the interests of the Dene, the detailed content of these reports is protected and cannot be reviewed or used without the full, involved, and meaningful consent of the Dene. In addition, Dene Nation has developed a web page summarizing the key findings of the DEWG (www.denenation.com). Digital photos and audio recordings, in each of the languages spoken during the meeting, were also collected and are housed in the resource center/archives of Dene Nation. The Dene want both to share and protect their knowledge. At the first workshop the working group asked that a book be written. Each region and each person is writing a chapter in this book on Dene observations and knowledge of climate change. Each meeting brings out something different from what is going on and what collectively is the traditional knowledge and practical projects the Dene are engaged in. Much is being learned from Dene elders, but it is often not written, as this is not how it has traditionally been conveyed, learned, and taught. An important issue raised was how intellectual property rights work and that knowledge holders had rights that had to be respected. Guests and observers to the workshops were asked not to present information verbatim, as expert testimony, and for profit. The ownership of traditional knowledge and stories, the benefits accrued by appropriating the voices or representations made without permission is a serious consideration. Once written, the form of knowledge that is conveyed is the lowest (crudest) level of understanding. Dene oral tradition and practice is the authority and so even what is written here is only one telling of the climate change story.

Regional technical staff spoke about changes in climate, and causes and responses to these changes, including traditional knowledge and stories passed down from their relatives. Dene have always been able to adapt to change. For example, Gwich'in learned to cope with and understand change. In the Sahtú, the people lived off the land for generations, and many recalled parents and grandparents teaching how the climate was changing and that the sun had changed the most. The strength of the moon was observed to be "not as bright" as it was in the past.

Dene demonstrate extensive knowledge about climate change in their daily lives and during the workshop a small amount was documented. This was done to share Dene views and observations among regions and at the international level. Dene knowledge is shared to educate non-Dene. There is significant concern that traditional knowledge, observations, and activities on the land be made apparent to Canadians and to the international community so that what is known can be improved, so that better decisions can be made.

> *All the problems are man-made. We have to make a lot of noise to be heard. There's some places down south you can't even go fishing but we can still go fishing up here. All the stuff going into the water from down south is coming up here. We need to put the fire out at the source.*

We can't forget our traditional knowledge and to use our Elders. I want our children a hundred years from now to say "My god, they did a good job!" Leo Norwegian, Liidlii Kue, Denendeh, March 13, 2003

3.4.5. Nunavut

In 1995, Shari Fox began a research project with the communities of Iqaluit and Igloolik to help document and communicate Inuit observations and perspectives of climate and environmental change. In 2000, the communities of Qamani'tuaq (Baker Lake) and Kangiqtugaapik (Clyde River) joined the project. A long-term, multiphase approach has driven the research and the integration of multiple techniques such as interviews, focus groups, videography, and mapping were used to collect, analyze, and communicate information (Fox, 2002). Close collaboration with individuals and communities has been central to the project. The case study presented here draws on two examples from the project to show how Inuit in Nunavut are observing and experiencing climate and environmental changes and their associated impacts and hazards. Comprehensive findings and discussion are presented by Fox (2004).

Inuit have a traditional juggling game. The weather is sort of like that now. The weather is being juggled; it is changing so quickly and drastically. N. Attungala, Baker Lake, 2001

The people of Nunavut have reported many observations of environmental change (e.g., Fox, 2002; Thorpe et al., 2002). Two examples that appear to be related to climate change are increased weather variability across the region and changing water levels in the Baker Lake area.

3.4.5.1. Increased weather variability

Participants in all four communities in this project have noted an increase in weather variability and unpredictability since the early 1990s, an observation shared by many other communities in several parts of the Arctic (Riedlinger et al., 2001; Whiting, 2002; sections 3.4.1 and 3.4.8). The weather has become unpredictable, with more extremes, and elders can no longer predict it using their traditional skills.

The weather has changed. For instance, elders will predict that it might be windy, but then it doesn't become windy. And then it often seems like its going to be very calm and then it suddenly becomes windy. So their predictions are never correct anymore, the predictions according to what they see haven't been true. P. Kunuliusie, Clyde River, 2000

The weather when I was young and vulnerable to the weather, according to my parents, was more predictable, in that we were able to tell where the wind was going to be that day by looking at the cloud formations… Now, in the 1990s and prior to that, the weather patterns seem to have changed a great deal. Contrary to our beliefs and ability to predict [by] looking at the sky, especially the cloud formations, looking at the stars, everything seems to be contrary to our training from the hunting days with our fathers. The winds could pick up pretty fast now. Very unpredictable. [The winds] could change directions, from south [to] southeast in no time. Whereas before, before 1960s when I was growing up to be a hunter, we were able to predict. L. Nutaraluk, Iqaluit, 2000

Right now the weather is unpredictable. In the older days, the elders used to predict the weather and they were always right, but right now, when they try to predict the weather, it's always something different. Z. Aqqiaruq, Igloolik, 2000

When I lived out on the land I would always know when the weather would be bad from the clouds but nowadays when you look at the clouds and they say there is going to be bad weather that evening it doesn't always happen. You could wake up and it would be nice and through the whole evening it would still be nice. The indicators that we would use before don't always happen. J. Nukik, Baker Lake, 2001

Sudden storms and unpredictable winds make for hazardous travel conditions. No longer confident in their weather predictions, experienced hunters in Clyde River pack for several extra days when heading out on the land, expecting to be caught in unpredictable weather. In Baker Lake, erratic weather has proved especially dangerous in winter. According to residents, changing wind patterns have changed the snow structure around Baker Lake and, in combination with unpredictable weather, dangerous situations have occurred in recent years. For example, changing wind patterns in the area have packed the snow extremely hard. As a result, hunters and travel parties are unable to build igloos, still commonly relied upon as temporary and emergency shelters. A number of accidents and deaths on the land in the last few years have been blamed on sudden storms and those involved not being able to find good snow with which to build shelters (N. Attungala, Baker Lake, 2001).

There used to be different layers of snow back then. The wind would not blow as hard, not make the snow as hard as it is now…But nowadays, the snow gets really hard and it's really hard to tell [the layers] and it's really hard to make shelters with that kind of snow because it's usually way too hard right to the ground. T. Qaqimat, Baker Lake, 2001

For many elders, increased weather variability and unpredictability also have an emotional and personal impact. For much of their lives they have been able to advise the people around them confidently about when and where to travel, providing weather predictions. As their skills no longer work, some elders are now less confident and feel sadness that their advisory roles have changed.

Some of the ways people are coping with more variable weather have already been mentioned – for example,

packing extra supplies on trips. Longer-term strategies are more difficult to design. Inuit are careful to note that the weather is always changing, it has always changed – the weather is always different. However, according to many people, the recent climate and environmental changes are outside the expected variability. In turn, while there have always been accidents on the land, some people are concerned that recent environmental changes are to blame for recent accidents and this requires further investigation so that precautions can be taken.

3.4.5.2. Changing water levels in Baker Lake

Baker Lake is the only inland Inuit community in Nunavut. Many of the groups that settled here brought a heritage closely tied to survival from lakes and rivers (Webster, 1999). For example, Harvaqtuurmiut depended on caribou and specialized in hunting at autumn river-crossings. Ukkuhiksalingmiut, from the Back River area, relied mainly on fish. Groups such as the Qairngnirmiut have always hunted and fished in the Baker Lake region. After settling in the community in the 1950s, these groups and others often returned to their traditional hunting and fishing grounds, but also used their skills in local waters.

Hunters explain that in the 1940s and 1950s they traveled without difficulty by boat and outboard motor through the lakes and rivers around Baker Lake. In the 1960s, residents began to observe that water levels were gradually dropping. Since the 1990s, water levels have dropped dramatically, with extremely low levels observed since 1998. Between 1998 and 2002, travel routes on rivers were blocked by shallow water and hunters were unable to get to the caribou hunting grounds and their usual camping areas. Large amounts of equipment made portaging difficult or impossible through these newly shallow areas and many hunting parties had to turn back. Accessible only by boat, these summer caribou hunting grounds can no longer be reached.

The shallow water has also affected fish. There are fewer fish in areas where they are traditionally expected, and when present are often small or skinny. Lake trout (*Salvelinus namaycush*) are darker than usual. Fish also smell different, "like earth", and no longer have white fat layers between the meat. While Inuit note that there are other possibilities for changes in fish (e.g., pollution), there are connections between the observed changes and recent water levels.

> *There is a lot less water, around all these islands [in Baker Lake]. The shore is getting closer to Sadluq Island, they are almost joined together. There used to be a lot of water. We could go through with our outboard motors and boats, but now there is getting to be less and less water all over... At the mouth of Prince River there used to be a lot of fish and you used to be able to get char [*Salvelinus alpinus*]. There's been a lot less fish because there's not as much water anymore. And we used to be able to get a lot of fish all the time at Qikiqtaujaq and all the other places where you can get fish. The fish were more plentiful and they used to be bigger. Now you hardly get char anymore at Prince River or any of these fishing places because the water level has gone down.* L. Arngna'naaq, Baker Lake, 2001

> *The lakes and the rivers are getting less water and a lot of them are getting more shallow and some places don't have any water left. They're not as healthy anymore. Things are not as healthy because there is not as much water and there were a lot places that probably in the '50s there was a lot of good water around [and] you could travel all over the place. [There used to be] a lot of water in the lakes and rivers and anything that had water was a lot cleaner, but now some of the waters have things that cause illnesses and that has really affected the food in the water and also things that eat things that are in the water. That is quite dangerous, the level of the water going down, because of the effect on the things in the water and the things that use them. Like we eat fish or anything that gets things out of the water because the water is not as healthy as it used to be and there is less water.* N. Attungala, Baker Lake, 2001

In the community, these observations are shared between hunting parties, families, and at meetings of hunters and trappers. Different individuals and groups make assessments about lake and river conditions based on their own knowledge and the knowledge and information shared by others. People understand lake and river changes by linking experiences on the water to observations of other factors such as precipitation, temperature, history of the water body, condition of animals and fish populations, and vegetation. In the case of recent low water levels around Baker Lake, residents identify the situation as unprecedented, both in terms of water levels and the condition of the fish populations. While unsure as to the cause, residents suspect lower water levels are related to changes in the climate over the last decade, particularly warmer, drier summers that last longer than normal. Others explain that the land is "growing", which may be another way of looking at permafrost thaw. Scientists have studied how thawing permafrost can cause water levels to drop since the soil is able to hold more water (Rouse et al., 1997).

Like many of the environmental changes being experienced in the Arctic, low water levels and subsequent impacts are a relatively recent phenomenon (or have not been experienced in a long time). Coping strategies are focused primarily on the day-to-day. Hunters adjust their travel routes and hunting grounds, looking for caribou in other areas. Residents change fishing areas looking for more abundant and healthier fish populations. While these strategies allow residents to continue day-to-day life, it is unclear what will happen if the water condition persists or worsens. In the community, long-term plans are yet to be developed, but are of interest.

3.4.5.3. Discussion

Unpredictable weather and lower water levels are two examples from a number of environmental changes observed by Inuit in Nunavut in recent years. In some cases, these changes are clearly linked to climate and in others they are not. Sometimes the observations with the least obvious linkages are the ones that spark the most interest for scientists and offer the most opportunity for advancing knowledge of climate change. For example, although unpredictable weather could be a matter of knowledge erosion (i.e., elders no longer live on the land and thus have lost prediction skills), something recognized by Inuit themselves, the fact that indigenous observers seem to consistently cite recent variable weather patterns across Nunavut and other parts of the Arctic has raised some scientific eyebrows that the phenomenon could be linked in some way to climate change (Fox et al., in prep). However, it is probably neither knowledge erosion nor climate change exclusively. As with many environmental changes in Nunavut, multiple factors including climate and cultural factors, interact to create the impacts felt by Inuit. For Nunavut, these factors and their interactions are just beginning to be uncovered. Also, many of the climate and environmental changes observed by Inuit refer to the last decade and so ties to long-term climate change are still to be made – although many useful indicators have been identified. What is clear is that Inuit will play a future role in such investigations and that their observations will help guide, inform, and challenge scientific efforts to understand arctic climate and environmental change.

3.4.6. Qaanaaq, Greenland

Uusaqqak Qujaukitsoq is a hunter from Qaanaaq, North Greenland. He has served in the Greenland Parliament and on the Executive Committee of the Inuit Circumpolar Conference. Uusaqqak has been involved in many natural resource use and conservation issues, including the Greenland Home Rule Government's seal skin campaign. His comments were made in response to an invitation to describe climate changes that have occurred in his region.

Change has been so dramatic that during the coldest month of the year, the month of December 2001, torrential rains have fallen in the Thule region so much that there appeared a thick layer of solid ice on top of the sea ice and the surface of the land. The impact on the sea ice can be described in this manner: the snow that normally covers the sea ice became *nilak* (freshwater ice), and the lower layer became *pukak* (crystallized ice), which was very bad for the paws of our sled dogs.

In January 2002, our outermost hunting grounds were not covered by sea ice because of shifting wind conditions and sea currents. We used to go hunting to these areas in October only four or five years ago. It is hard to tell what impact such conditions will have to the land animals. Since I haven't been out to see the feeding grounds of the arctic hares (*Lepus arcticus*), musk ox (*Ovibos moschatus*), and reindeer this year, I can't tell how it is, but I can guess that it will be difficult for the animals to find anything to feed on because of the layer of ice that covers everything. It is hard to say what can be done about these conditions.

Sea-ice conditions have changed over the last five to six years. The ice is generally thinner and is slower to form off the smaller forelands. The appearance of *aakkarneq* (ice thinned by sea currents) happens earlier in the year than normal. Also, sea ice, which previously broke up gradually from the floe-edge towards land, now breaks off all at once. Glaciers are very notably receding and the place names are no longer consistent with the appearance of the land. For example, *Sermiarsussuaq* ("the smaller large glacier"), which previously stretched out to the sea, no longer exists.

3.4.7. Sapmi: the communities of Purnumukka, Ochejohka, and Nuorgam

This case study comes from a project carried out as part of the SnowChange program organized by the Environmental Engineering Department at Tampere Polytechnic in Finland (Mustonen and Helander, 2004). SnowChange sponsored conferences in 2002 and 2003 at which arctic indigenous peoples, interested researchers, and other parties discussed their observations and concerns regarding their cultures and the effects of climate change and other aspects of the modern world. In addition, SnowChange researchers and students have conducted several projects around the Arctic, documenting indigenous observations and perspectives. The study took place in two locations: the small reindeer herding community of Purnumukka, in central Lapland, and the Saami communities of Nuorgam and Ochejohka (Utsjoki) in the northeast corner of Finland, the only part of the country where Saami represent the majority of the population. In Purnumukka, initial community contacts, networking, and interviews took place in September 2001. In March and April 2002, Mika Nieminen spent a month in the region, living and practicing reindeer herding with Pentti Nikodemus and Riitta Lehvonen and interviewing active herders, hunters, elders, and fishermen. SnowChange researchers have been in active communication with Purnumukka residents on a monthly basis since then. In Nuorgam and Ochejohka, SnowChange researchers spoke with elders, reindeer herders, fishermen, and cultural activists about the changes taking place in the local area and communities. The interviews were conducted in March 2002 in the Skallovaara reindeer corral area, in Ochejohka village, in Nuorgam, in the remote area of Lake Pulmanki, and in the village of Sirma, which is on the Norwegian side of the Deatnu (Teno or Tana) River.

Sapmi is the Saami homeland that extends across northern Norway, Sweden, Finland, and Russia. Residents of the Finnish part of Sapmi have many concerns about changes that are taking place in their region. Not all

changes are due to climate. The biggest environmental impacts in the region to date result from the construction for hydropower purposes of the Lokka reservoir in 1967 and the Porttipahta reservoir in 1970, and the massive clear cuts preceding the construction of the reservoirs. The best lichen areas were flooded and the herders had to move 5000 reindeer from the grazing grounds because of the construction. These particular grazing grounds were excellent autumn grazing areas. Many people continue to refer to the creation of the reservoirs as a marker of great change, including changes in weather patterns, snowfall, and ice formation.

This case study presents comments by elders, as they carry the most extensive knowledge, with additions from the younger generation of Saami living in the region. Many more people were interviewed than are quoted here. The quotes used are considered to best illustrate the themes and ideas that typify what was learned from the Saami interviewed and provides insight into what the changes mean for people in the area. The interviews covered more material than is presented in this brief case study. Some of the additional material was reported in section 3.3.

The following people are quoted in this case study.

- Veikko Magga – a reindeer herder for over 50 years and a member of the reindeer herders association of Lapin Paliskunta
- Niila Nikodemus – an 86-year-old elder and the oldest reindeer herder in Purnumukka
- Heikki Hirvasvuopio – 65 years old and still active in reindeer herding
- Aslak Antti Länsman – 55 years old and a local reindeer herder belonging to the Polmak Lake Siida
- Niillas Vuolab – an elder and the oldest reindeer herder in Ochejohka. Niillas Vuolab was born in the Saami Community of Angel in 1916 and came to Ochejohka in the autumn of 1916
- Ilmari Vuolab – the son of Niillas Vuolab. Ilmari Vuolab was a 51-year-old reindeer herder from the reindeer herding area of Kaldoaivi. He passed away in April 2003
- Taisto Länsman – a reindeer herder from Lake Pulmanki with extensive written records of the ice break-ups in the lake

3.4.7.1. Weather, rain, and extreme events

Heikki Hirvasvuopio reflected on the seasonal changes and the autumn weather.

> *Temperatures used to be well below freezing in autumn and winter came when it was supposed to. It was not mild autumn like now. It used to be longer, snow would fall. Now sleet and rain will fall. Summers used to be to the "standard form", this means that fair weather would stay longer. We would have the reindeers in the big fell areas because especially the beginning of the summer would be very hot. Insects would be there as well with the reindeers. Now this has changed. The summers are very unstable. Reindeer are staying in the forests now; they do not go up to the fells any more.*

Veikko Magga reported that the amount and consistency of snowfall has fluctuated in Purnumukka and the Vuotso region.

> *It is springtime nowadays when the snow actually comes. Some comes in the autumn, but there is no proper freezing, only so that the lowermost snow freezes. The lichen freezes solid into this layer and the reindeer cannot get proper food because of this. For a couple of years in a row there has been less snow in the autumn than previously but I think sometimes it falls earlier, sometimes later. It has always been this way.*

Niila Nikodemus discussed snow and ice cover based on his extensive experience and a lifetime of observations.

> *There is normal fluctuation in the amounts of snow. However, snow falls later. In the 1950s and 1960s, there used to be a permanent snow cover always in October. Starting in the 1970s, it can be November, middle of November. Ice has thinned, especially in the small rivers and ditches here. I wonder if the reservoirs affected this? It used to be that we could just drive away on the ice. There used to be a proper ice cover on the small rivers.*

Heikki Hirvasvuopio outlined the impacts of climate change on the reindeer herding.

> *During autumn times, the weather fluctuates so much, there is rain and mild weather. This ruins the lichen access for the reindeer. In some years this has caused massive loss of reindeers. It is very simple – when the bottom layer freezes, reindeer cannot access the lichen. This is extremely different from the previous years. This is one of the reasons why there is less lichen. The reindeer has to claw to force the lichen out and the whole plant comes complete with roots. It takes, as you know, extremely long for a lichen to regenerate when you remove the roots of the lichen. This current debate of loss of grazing grounds is not therefore connected with a larger number of reindeers, this is not the case. In previous years, the numbers of the herds were much bigger. The main reason for the loss of grazing lichen areas is the bad weather conditions that contribute to the bigger impact on the area. I do not think many people have observed this reason in their thinking.*

Aslak Antti Länsman said that for the past ten years the autumns have been mild with sleet, which has frozen the surface of the ground.

> *This has affected the reindeer economy for sure. As the ice cover was there this had a negative impact on the reindeer herding. It is a big question mark why these changes are taking place. Is it so called greenhouse effect, or air pollution? Or is it connected with the same events that melted the last ice age? Who knows?*

Ilmari Vuolab stated:

> *Yes, the weather conditions have changed overall so it is not possible to be certain that this amount of snow will be at this time. This is a problem.*

3.4.7.2. Birds

Heikki Hirvasvuopio talked about the disappearance of birds in Kakslauttanen.

> *… especially with ground birds, we could be talking about a near extermination when compared to the previous amounts. I used to hunt them quite a lot while reindeer herding, so I have a good idea of the stocks. We cannot even talk now about the same amounts during the same day. This affects especially ptarmigans, capercaillie, and ground birds. With small singing birds, the same trend is visible. Nowadays it is silent in the forest – they do not sing in the same way anymore. It used to be that your ears would get blocked as the singing was so powerful before. They have disappeared completely as well.*

Taisto Länsman was concerned that there were far fewer small birds compared to his childhood. Niillas Vuolab shared the concern and stated that:

> *Nature has grown much poorer. For example during summers migratory birds are fewer today. We see the usual species, but the numbers are down. Especially marine birds, such as long-tailed ducks [*Clangula hyemalis*], white-winged scoters [*Melanitta fusca*], black scoters [*Melanitta nigra*]; we do not see these anymore. After the war and even later great big flocks would come here. I feel ptarmigans have diminished as well.*

3.4.7.3. Insects

Heikki Hirvasvuopio said:

> *Both mosquitoes and gadflies have disappeared. Especially we can see gadflies disappearing. And the reason is that in the olden times reindeers had to move up to the big fells as the vermin were plentiful then.*

Niila Nikodemus pointed out that:

> *The [number of insects] really depends on the particular summer. If it is a rainy springtime they will be plenty, but if it will be a dry spring, hardly any will appear.*

3.4.7.4. Traditional calendar and knowledge

Veikko Magga stated:

> *Traditional knowledge has changed like reindeer herding in a negative direction. We have to feed the reindeers with hay and fodder quite much now. But I would not advocate that the traditional Saami calendar is mixed up yet. But traditional weather reading skills cannot be trusted anymore. In the olden times one could see beforehand what kind of weather it will be. These signs and skills holds true no more. Old markers do not hold true, the world has changed too much now. We can say nature is mixed up now. An additional factor is that reindeer herding is being pressured from different political, social, and economic fronts at all times now. Difficulties are real. A way of living that used to support everything is now changing and people do not find employment enough.*

Heikki Hirvasvuopio discussed traditional forecasts.

> *The periods of weather are no longer the norm. We had certain stable decisive periods of the year that formed the traditional norms. These are no longer at their places. Certain calendar days, like Kustaa Vilkuna [a Finnish folk historian of weather and culture from the mid-twentieth century] wrote, held really true. But these are no longer so. Today we can have almost 30 degrees of variation in temperature in a very small time period. In the olden days the Saami would have considered this almost like an apocalypse if similar drastic changes had taken place so rapidly. Before I spent all of my winters in the forest and was at home for one week at the most. Nowadays the traditional weather forecasting cannot be done anymore as I could before. Too many significant and big changes have taken place. Certainly some predictions can be read from the way a reindeer behaves and this is still a way to look ahead, weather-wise. But for the markers in the sky we look now in vain. Long term predictions cannot be done anymore.*

Ilmari Vuolab stated that:

> *The traditional markers of the nature do not hold true anymore. Ecosystem seems to have changed. It is a very good question, as what has contributed to the change. It cannot be all because of cyclic weather patterns of different years. I believe the changes we have seen are a long-term phenomenon. The wise people say that changes will be for the next 100 years even if we act now to reduce emissions. It is obvious that the reindeer herding is the basis of the Saami culture here and other subsistence activities that are related to the nature, such as picking cloudberries or ptarmigan hunting. I feel the Saami have been always quite adaptive people and we adapt to the changes as well. After all, climate changes in small steps, not in one year.*

3.4.8. Climate change and the Saami

Elina Helander is a researcher at the Arctic Centre of the University of Lapland as well as a Saami from Ochejohka. She took part in the preparation and community activities for the documentation work that produced the Sapmi case study in section 3.4.7.

The Saami have an ecological knowledge of their own, rooted in the traditional way of life. They have their own knowledge derived from experience, long-term observation, and the utilization of natural resources. This knowledge is best expressed and transmitted

through the Saami language. Saami ecological knowledge goes beyond observation and documentation because it is a precondition for their survival. Particularly interesting is the fact that indigenous people like the Saami have long-term experience in adaptation. People in the villages are worried as they face global changes. The Saami are used to combining different economic activities, such as berry picking, reindeer herding, fishing, hunting, trapping, and handicraft. If the changes are sudden, accumulate rapidly, and have impacts on all or most of local resources, and if the resource base is scarce, then the problems start to show themselves immediately. Many claim that the weather has become warmer, and especially the fall and early winter are warm. During the recent years, the ground has not frozen properly in the fall, and there has been little rain in September. There are many salmon rivers and lakes in the Utsjoki area where I come from. When the ground does not freeze in the fall, and there is little snow during the winter, there is very little water in late May and early summer in the rivers and lakes. Then, of course, with little rain during June, the rivers are almost dry and the fish cannot go upriver. But during the recent years, it has happened that in July there are heavy rains. Consequently, the amount of water increases enormously and it becomes impossible to fish in small salmon (*Salmo salar*) rivers. Many herders and subsistence hunters claim that there are no winds anymore. Wind has some positive effects. For instance, wind gathers the snow to certain spots. In other spots there is little snow and it is then easy for the reindeer to dig through where the amount of snow is small. The wind can also make the snow soft, but on the other hand, the extremely strong wind, *guoldu* in Saami, makes the snow hard. During the recent years, the weather has started to change rapidly, so that sudden shifts take place. There are no longer stable periods of a cold weather type. It has also become more difficult to predict the coming weather. People are more careful when moving across lakes and rivers. In our area the moose migrate in early November from north to south, but they can be hindered from doing this if there is no ice in the rivers and lakes. There must come about a radical change regarding the ecological awareness in humanity if we want to do something positive regarding the changes that occur and are predicted to come. When talking about the snow change, we should not only monitor and accept the changes. We have to resist the global changes when resistance is imperative, i.e., when the changes made by man cause serious damage to nature, societies, and people.

3.4.9. Kola: the Saami community of Lovozero

This case study is also drawn from research carried out as part of the SnowChange initiative. SnowChange cooperates fully with the Russian Association of Indigenous Peoples of the North, the national indigenous organization that is also a Permanent Participant of the Arctic Council. For this case study, researchers spoke with elders, reindeer herders, cultural activists, and other local people. Researchers selected from the material gathered in interviews the comments most relevant to the changes local people see in the local ecological and climatic situation. The interviews were recorded and edited by Jyrki Terva, Tero Mustonen, Sergey Zavalko, and several indigenous and non-indigenous students of ecology at the Murmansk Humanities Institute, Murmansk State Technical University, and Tampere Polytechnic. The community visits functioned as story-telling and ecological teaching experiences, especially for the indigenous students who participated.

> *The tundra is like my dear mother to me! We herded reindeer with the whole family. How else should we do it? We took care of the shelter. We knitted, we washed, we smoothed down clothes. What did we do? We baked bread. When it is warm, it is warm. When it is not warm, it is cold. I spent my whole life on the tundra. Even after I retired, I spent a year in the tundra. Life was easy; the only thing we missed was the television. Before that all we did was to stay in the earth hut. Summer or winter, always living in the shelter in the tundra.* Maria Zakharova, Lovozero Elder

The Murmansk Oblast (province) is located in northwestern Russia on the Kola Peninsula. It borders the Republic of Karelia (Russia) in the south and Lapland (Finland) and Finnmark (Norway) in the west. The oblast covers 144 900 square kilometers and has a population of around 900 000. The capital is the city of Murmansk, the largest city north of the Arctic Circle, with a population of around 350 000. The town of Lovozero (in Saami, *Luujavre*) is the main Saami community on the Kola Peninsula, with approximately 800 Saami among its 3000 inhabitants.

Climate change research among indigenous peoples is only just beginning in Russia. Russia's indigenous communities, as well as mainstream society, have many other, often more urgent, social, economic, and political issues to deal with. However, the massive differences in ecosystems and regions across the vast expanse of northern Russia make local assessments of climate change imperative in order to understand their real and specific impacts. Documenting change in the Russian indigenous communities is a vital and much-needed process. Even as the reclaiming of economic, ecological, social, and cultural rights continues, local voices in the remote regions of northern Russia are often not heard. The people consulted during this case study delivered a clear and coherent message – local people should be heard.

3.4.9.1. Observations of change in Lovozero

Documentation of change cannot be separated from broader questions of the development of Russian territories and their indigenous peoples. The people interviewed stated that there are many other concerns in addition to climate change, such as the state of Russian

society, economic hardship, and lack of resources. But climate change has had a definite impact on the traditional lifestyle. Larisa Avdeyeva, director of the Saami Culture Center in Lovozero, stated that:

> *Reindeer herders especially have observed change. They talk about the changes in the behavior of reindeer. People have to travel with the reindeer and navigate differently. Bogs and marshes do not freeze immediately, rhythms change, and we have to change our routes of movement and this means the whole system of living is under change. Everything has become more difficult. I have conversed with reindeer herders and they have told me of these kinds of observations. They have seen as well that in areas where it was possible to collect a lot of cloudberries [*Rubus chamaemorus*] before, now the berries are not ripe because of climatic warming and melting of glaciers. Changes are very visible.*

Climate change, particularly changes in local weather, has become an increasingly important issue for the reindeer herders and others in Lovozero. Avdeyeva continued,

> *Nowadays snows melt earlier in the spring time. Lakes, rivers, and bogs freeze much later in the autumn. Reindeer herding becomes more difficult as the ice is weak and may give away. The rhythm of the yearly cycle of herding and slaughtering of reindeer is disrupted and the migration patterns of the reindeer change as well.*

Broader social and environmental awareness penetrated into Russian society from the mid-1980s onward. Olga Anofrieva discussed how this has been seen in terms of local industrial pollution.

> *The biggest benefit of Perestroika was that the industries no longer polluted as much as before. Here, locally, nature rested. Now the arms race is being taken down, as are the amounts of military ships and military personnel. One could say that we have now a positive era, quite difficult, but nevertheless so. We find ourselves now in a situation where soon decisive moves have to be made. We must develop ourselves differently. I think changes in the weather are more to do with God's influences.*

3.4.9.2. Weather, rain, and extreme events

Avdeyeva reported that climate variation had been witnessed locally and had caused alarm.

> *I would say the climate is warming globally, we have already observed this here. For example the reindeer herders coming out off the tundra have said that last year the bogs and rivers stayed open for a long time and it was hard to gather the reindeer. If this event was previously due in November, now we have it in December or January. Bogs stay unfrozen for a long time and it is very difficult to try to catch reindeer in such conditions. The herders say the climate has warmed and everything is a result of that.*

Avdeyeva pointed out that change is more than general warming.

> *Extreme events have been seen mostly in the spring time. This year we had thunder in May, and usually this occurs in July. Monthly mean temperatures have increased and spring has warmed up. During the winter of 2001to 2002, there was little snow and that is why there was little water in rivers and lakes. The low water levels have affected negatively boating. Of course we understand all of these events are related. There is way too little rain and storms. There is certainly thunder though. Lighting was rare here before the 1990s, as well as heavy rains. Now there are more of those.*

Arkady Khodzinsky, a reindeer herder from Lovozero, provided more details.

> *The weather has changed to worse and to us it is a bad thing. It affects mobility at work. In the olden days [the 1960s and 1970s], the permanent ice cover came in October and even people as old as myself remember how on 7 of November we would go home to celebrate the anniversary of the Great Socialist Revolution. These days you can venture to the ice only beginning in December. This is how things have changed. This year the ice came and froze a little early but for sure the weather has changed very much. All began about six years ago. Everything went haywire. Yes, six years ago! Now it can rain in January. Once three years ago I came back from the tundra, there was a full winter there. I was here in the community for some time, resting and lo and behold! On the tundra spring had arrived because it had rained!*

Vladimir Lifov, another reindeer herder in Lovozero, concurred.

> *Oh, it is warmer. Before when going to the tundra we had to take a lot of warm clothes, otherwise we would freeze. But nowadays you can sleep with just one* malitsa *[reindeer-skin coat] on during the whole night. It is all right with that one* malitsa. *Previously we were using as well boots made out of reindeer skin. You never froze your feet in those. But now you do not need them any more.*

Lifov described recent winters.

> *Yes, it is very interesting. First it snows, then it melts, like it would be summertime. And this all over again. First there is a big snowfall, then it warms up, and then it freezes. During winter now it can rain, as happened last New Year. Before it never rained during wintertime. Rain in the middle of winter? To the extent that snow disappears? Yes, it is true. Rain, and the snow melts!*

3.4.9.3. Rivers, lakes, and ice

The herders traditionally use waterways, such as many rivers and lakes of the Kola Peninsula, in their transportation routes. Recent changes have caused uncertain-

ty and the fear that the routes cannot be traveled on safely. Arkady Khodzinsky described the situation.

> *Rivers do not freeze at all; they are only covered in snow. Ice arrives, but the surface of the water drops so that ice is like on top of empty space and then it is covered with snow. Of course the stream flows like it should. But the changes have taken place in the last six to seven years. Before we saw none of that. Well, for the past few years the weather has been different. No decent ice comes anymore. When the freeze-up occurs, the ice sometimes melts right away.*

Vasily Lukov, a reindeer breeder from Lovozero, saw both impacts and a possible explanation.

> *The River Virma grows shallower every year. Now there is hardly any water left and it can freeze all the way to the bottom. There used to be a lot of fish, but now they are almost all gone. I think it is due to the drying of the bogs and marshes, improvements of the ground. Now the melt is slow. First the water gets on top of the ice and the river melts first from the middle. Steep riverbanks are still frozen but gradually they melt as well. Nowadays there is no actual ice melting event like before.*

3.4.9.4. Plants, birds, and insects

In September 2001, Larisa Avdeyeva spoke about the changes in plant life.

> *New species of plants have arrived. We never saw them before. This is what we have observed. New plants have arrived here and on tundra. Even there are arrival species in the river, previously known in middle parts of Russia. This past summer and the previous were very hot here. Rivers and lakes are filled with small-flowered a kind of duckweed [Lemnaceae] and the lake started to bloom. Life for the fish is more difficult and likewise people's fishing opportunities as lakes are closed up by the new plants. We have observed that the trees in our village grow much faster. New unknown plant species have arrived here in great numbers. New bird species have arrived here. As well, the birds stay in our village longer than before. Some new beautiful never-before-seen birds have arrived.*

Reindeer herders have witnessed the changes as well, as Arkady Khodzinsky reported.

> *The birds are about the same as they have always been but their numbers are decreasing all the time. Yes, there are very few birds nowadays. It used to be that there were ptarmigan on top of every bush. Nowadays it is not like that anymore and it feels bad. To give you an example, in earlier times I was sitting and watching the herd. I tapped my foot to the ground and a ptarmigan would fly to me. When I would say "Kop, kop" to it, it would come so close I could even hold it. Then I said again "Kop, kop" and it took off. Now there are very few goose. It used to be that they were all over. Before, when we were at the camp and we would see geese, we would know the spring is coming. All people enjoy the arrival of spring. Nowadays we see no geese. Occasionally one or two flocks fly over, but this is a rare event. There are no birds of prey any more. Very small numbers of those remain. Every one has disappeared somewhere. We used to see northern goshawks, they would fly high and scream. It was nice to follow them in the sky. All of them have disappeared and I do not know where.*

Khodzinsky described how the presence of insects had also changed dramatically.

> *I cannot comprehend that there are no mosquitoes. I think for two years now there have been no mosquitoes. In recent times they have not troubled us at all. Here in Lovozero it will be soon like down south. Before there were insects and they would sting you, but we no longer need mosquito hats even. The biting midges come in August usually. This year there have not been biting midges or mosquitoes at all. Of course this is bad. I think they have disappeared from the northland altogether.*

3.4.9.5. Traditional calendar and knowledge

The legends, stories, and traditional knowledge of living off the land have taught the Saami to notice changes and to adapt locally. At the core of their knowledge is the Saami calendar, a system of local traditional knowledge of marker days, seasons, and certain activities tied to seasonal cycles. Now there is concern. Avdeyeva noted that the calendar is off balance, adding to the burdens of observed changes.

> *When we ask the elders and reindeer herders for example what kind of summer it will be, how many berries to expect, or what kind of fish and how much to expect, they answer us that they cannot predict anything because our Saami calendar of the yearly cycle has collapsed completely with the changes that have taken place in nature. They cannot foresee accurately and with precision. Before we would ask the reindeer herders and the answers would be right to the mark, but now the predicted times keep on moving and changing. Two days ago I had a conversation with my cousin who is a reindeer herder and had just returned from the tundra. I told him: "Look how nice the sky is, see those clouds, what a nice weather!" He would tell me: "Well you say the weather is good now when you are here in the village, but out on the tundra they do not know what is to come. You should not say this sort of thing". He told me a Saami saying: "Do not predict today something that an old lady can tell for sure tomorrow". The Saami weather calendar is not accurate with the changes that we are witnessing. Yes, the reindeer herders see it and keep on discussing this at all times. We talk and discuss the changes. It is difficult to make use of the elders' knowledge because the climate has changed. People have it hard. Yes, it is so.*

3.4.9.6. Reindeer

The most vocal and urgent messages of change relate to the reindeer, which remains a key species for the community in cultural, social, economic, and ecological terms. There is concern. Reindeer are acting differently, and herders spend less time with the herds on the tundra. Mixing herds with the wild or feral reindeer is another concern. People such as Maria Zakharova have spoken at length about the often-emotional relationships and concerns regarding the reindeer.

> *On the tundra the reindeers used to run towards people, but now they run away. The reindeers are our children. In the olden times when we used to have just the reindeers the air was clean. How should I explain? Now they drive around in skidoos and you can smell the gasoline, yuck! What did they herd with? The reindeer! Now they have started to herd with skidoos. Why on earth? They should rather train the reindeers like our fathers and forefathers did. Now everything is in ruins. There used to be many young reindeers. Yes, at the time the herds were bigger as well.*

As Vladimir Lifov put it:

> *Our income diminishes because of climate change, of course, and in a very drastic way. Even my wife has said that it would be time to forget the reindeer. But I tell her always: "Tamara, we depend on these reindeer. If there are no reindeer, we have nothing to do here either".*

3.4.9.7. Overall concerns

Larisa Avdeyeva stressed the main points felt by many.

> *The cycle of the yearly calendar has been disturbed greatly and this affects the reindeer herding negatively for sure. We should start working differently in a new way. We still have not thought this and we still have not pondered this – we try to start from the needs of the people and be flexible. We Saami have an anecdote, rather it is a legend, which has the law of the Saami life in it. People tell this onwards always. The Saami say: "We are not reapers, we are not field-plowers, we are reindeer herders. The reindeer are our bread. Everybody should cherish the land. The green land with its flowers and lichens was given to us so that we should pass it on to our children". We try to follow this Saami law because there are laws that the Saami follow. And the Saami guide other people to follow those laws in our land. It is true. This is the truth.*

In 2002 as the documentation teams returned to the community, she continued:

> *We feel some unexpected changes are taking place in the tundra. But in the recent years it has been wonderful to follow what our youth have been doing. They have understood that they are needed here. We need well-trained and strong-spirited youth here. Nowadays the young people are very different from 20 to 30 years ago. They are more self-confident, stronger in character and very proud of their nation. When I was 18, we could not even imagine that.*

She looks to the future with a positive sense. She concluded the interview session in June by saying that "Yes, respect is coming back. And the consideration for reindeer herding is increasing as well".

3.5. Indigenous perspectives and resilience

The Arctic is by nature highly variable. The availability of many resources is cyclical or unpredictable. For example, there are always uncertainties in caribou migrations. The lesser snow geese may arrive early or late; the nesting success varies considerably from year to year. Weather is changeable and inconsistent. There are large natural variations in the extent of sea-ice cover from year to year, and in freeze-up and break-up dates. Erosion, uplift, thermokarst, and plant succession change landscapes and coastlines. The peoples of the Arctic are familiar with these characteristics of their homeland, and recognize that surprises are inherent in their ecosystems and ways of life. That is why indigenous peoples tend to be flexible in their ways and to have cultural adaptations, such as mobile hunting groups and strong sharing ethics, that help deal with environmental variability and uncertainty (e.g., Berkes and Jolly, 2001; Krupnik, 1993; Smith E., 1991). Many of the points raised in this section are discussed further in Chapter 17.

Against this backdrop, especially in a time of rapid social change, climate change may be regarded as simply another aspect of the variable and challenging Arctic (see Box 3.4). Just as easily, it can be dismissed from further thought as a vast, slow, and unstoppable force to be accommodated over time, in contrast to rapid, worrisome, and potentially tractable political, economic, and social problems. Some of these larger socio-economic changes have had significant impacts on lifestyles and culture, including the erosion of indigenous knowledge and the social standing of its holders (e.g., Dorais, 1997). While some observers hold that impacts of climate change will be devastating for indigenous peoples over the course of the next several decades, others argue that climate change in the shorter term will be less important than existing and ongoing economic, cultural, and social changes. It is important, however, to be cautious in making comparisons between impacts from the very different phenomena of climate change and social change.

The case studies in this chapter show that while both views have some legitimacy, by themselves they are simplistic and inaccurate portrayals of how climate change is perceived by arctic residents. The chapter title itself is plural, reflecting the diversity of ways in which climate change and the arctic environment are seen by indigenous peoples of the Arctic. Even within one group, there is a range of views, and differences in the perceived

Box 3.4. Political relations, self-determination, and adaptability

Social pathologies resulting from social change clearly weigh more heavily on the minds of northerners now than the effects of climate change. It is important, however, to be careful when comparing social change apples with climate change oranges. The ACIA climate change scenarios point to very significant environmental changes across most of the Arctic within a couple of generations. Notwithstanding high levels of suicide and other social pathologies in many northern communities, many indigenous peoples in the Arctic are interacting with, and adapting to, changing economic and social circumstances and the adoption of new technologies, in short, to "globalization". In the midst of globalization, arctic indigenous peoples still identify themselves as arctic indigenous peoples. But the sheer magnitude of projected impacts resulting from climate change raises questions of whether many of the links between arctic indigenous peoples and the land and all it provides will be eroded or even severed.

Certainly arctic indigenous peoples are highly skilled in and accustomed to adapting, as the archaeological and historical records and current practices illustrate. Adapting to climate change in the modern age, however, may be a very different prospect than adaptations in the past. It is clear that support from regional and national governments will be important for the effectiveness of the adaptations required. Herein lies a crucial point: the policies and programs of regional and national governments can encourage, enable, and equip northerners to adapt to climate change, although it is important to note that the projected magnitude of change in the Arctic may, eventually, overwhelm adaptive capacity no matter what policies and programs are in place. On the other hand, policies and programs of national governments could, conceivably, make adaptation more strained and difficult by imposing further constraints at levels from the individual to the regional.

Empowering northern residents, particularly indigenous peoples, through self-government and self-determination arrangements, including ownership and management of land and natural resources, is a key ingredient that would enable them to adapt to climate change. Indigenous peoples want to see policies that will help them protect their self-reliance, rather than become ever more dependent on the state. There are compelling reasons for the national governments of the arctic states to provide northerners, specifically indigenous peoples, with the powers, resources, information, and responsibilities that they need to adapt to climate change, and to do so on their own terms.

Berkes and Jolly (2001) provide a practical and positive example of what needs to be done. The ability of Inuvialuit of the Canadian Beaufort Sea region to adapt to climate change is grounded in the Inuvialuit Final Agreement, which recognizes rights of land ownership, co-operative management, protected areas, cash, and economic development opportunities. For indigenous peoples themselves, their own institutions and representative organizations must learn quickly from the well-documented adaptive efforts of hunters as well as from positive examples such as the Inuvialuit Final Agreement. National governments, often slow moving and ill equipped to think and act in the long term, must also understand the connections between empowerment and adaptability in the north if their policies and programs are to succeed in helping people respond to the long-term challenge posed by climate change.

importance of various threats, of which climate change is only one (Fox, 2002). A comprehensive survey of the many and varied perspectives of all arctic residents has not been possible, and it is not clear in any case how valuable such a survey would be. The case studies herein illustrate that while generalizations are possible, the particular circumstances, location, economic base, and culture of a particular group, as well as each individual's personal history and experiences, are crucial factors in determining how and what people think about climate change, how climate change may or may not affect them, and what can or cannot be done in response.

The archeological record reveals that, with or without modern anthropogenic influences, the arctic climate has experienced sudden shifts that have had severe consequences for the people who live there (McGhee, 1996). In some cases, people have simply died as resources dwindled or became inaccessible. In other cases, communities moved location, or shifted their hunting and gathering patterns to adapt to environmental change. Indigenous peoples today have more options than in the past, but not all of these allow for the retention of all aspects of their cultures or for maintaining their ways of life. For example, many of these options have become available at the cost of dependency on the outside world. A wider range of foods is available, but communities are less self-sufficient than before. Settled village life provides educational opportunities, but indigenous knowledge is eroded because its transmission requires living on the land (Ohmagari and Berkes, 1997). Considerable infrastructure has been built over the past century, bringing improvements in the material standard of living in the Arctic. At the same time, the settled way of life has reduced both the flexibility of indigenous peoples to move with the seasons to obtain their livelihoods and the extent of their day-to-day contact with their environment, and thus the depth of their knowledge of precise environmental conditions. Instead, they have become dependent on mechanized transportation and fossil fuels to carry out their seasonal rounds while based in one central location. Together, these dependencies have increased the vulnerability of arctic communities to the impacts of climate change.

Resilience is the counterpart to vulnerability. It is a systems property; in this case, a property of the linked system of humans and nature, or socio-ecological systems, in the Arctic. Resilience is related to the magnitude of shock that a system can absorb, its self-organization capability, and its capacity for learning and adaptation (Folke et al., 2002; Resilience Alliance, 2003). Resilience is especially important to assess in cases of uncertainty, such as anticipating the impacts of climate change. Managing for resilience enhances the likelihood of sustaining linked systems of humans and nature in a changing environment in which the future is unpredictable. More resilient socio-ecological systems are able to absorb larger shocks without collapse. Building resilience means nurturing options and diversity, and increasing the capability of the system to cope with uncertainty and surprise (Berkes et al., 2003; Folke et al., 2002). Examining climate change and indigenous peoples in this way can illuminate some of the reasons that indigenous perspectives are a critical element in responding to climate change.

Life in the Arctic requires great flexibility and resilience in this technical sense. Many of the well known cultural adaptations in the Arctic, such as small group and individual flexibility and the accumulation of specialist and generalist knowledge for hunting and fishing, may be interpreted as mechanisms providing resilience (Berkes and Jolly, 2001; Fox, 2002). Such adaptations enhance options and were (and still are) important for survival. If the caribou or snow geese do not show up at a particular time and place, the hunter has back-up options and knows where to go for fish or ringed seals instead. However, cultural change and loss of some knowledge and sensitivity to environmental cues, and developments such as fixed village locations with elaborate infrastructure that restrict options, may reduce the adaptive capacity of indigenous peoples.

One approach to improve the situation is to develop policy measures that can help build resilience and add options. For example, Folke et al. (2002) have suggested that one such policy direction may be the creation of flexible multi-level governance systems that can learn from experience and generate knowledge to cope with change. In this context, the significance of indigenous observations includes their relevance for understanding the processes by which people and communities adapt to climate change.

While the scale of the impacts of climate change over the long-term is projected to be very significant, it is not yet clear how quickly these changes will take place or their spatial variation within the circumpolar Arctic. Be that as it may, human societies will attempt to adapt, constrained by the cultural, geographic, climatic, ecological, economic, political, social, national, regional, and local circumstances that shape them. As with all adaptations, those that are developed in the Arctic in response to climate change will protect some aspects of society at the expense of others. The overall success of the adaptations, however, will be determined by arctic residents, probably based in large part on the degree to which they are conceived, designed, developed, and carried out by those who are doing the adapting.

Nevertheless, support from regional and national governments may be important for the effectiveness of the adaptations required. For example, Berkes and Jolly (2001) have argued that co-management institutions in the Canadian Western Arctic under the Inuvialuit Final Agreement have been instrumental in relaying local concerns across multiple levels of political organization. They have also been important in speeding up two-way information exchange between indigenous knowledge holders and scientists, thus enhancing local adaptation capabilities by tightening the feedback loop between change and response (e.g., Smith D., 2001).

In this regard, response by the community itself, through its own institutions, is crucial to effective adaptation. Directives from administrative centers or solutions devised by outsiders are unlikely to lead to the specific adaptations necessary for each community. Indigenous perspectives are needed to provide the details that arctic-wide models cannot provide. Indigenous knowledge perspectives can help identify local needs, concerns, and actions. This is an iterative rather than a one-step solution because there is much uncertainty about what is to come. Thus, policies and actions must be based on incomplete information, to be modified iteratively as the understanding of climate change and its impacts evolve.

Indigenous perspectives are also important in that indigenous peoples are experts in learning-by-doing. Science can learn from arctic indigenous knowledge in dealing with climate change impacts, and build on the adaptive management approach – which, after all, is a scientific version of learning-by-doing (Berkes et al., 2003). Multi-scale learning is key – learning at the level of community institutions such as hunter-trapper committees, regional organizations, national organizations, and international organizations such as the Arctic Council. The use of adaptive management is a shift from the conventional scientific approach, and the creation of multi-level governance, or co-management systems, is a shift from the usual top-down approach to management.

One significant aspect of the indigenous perspectives introduced in this chapter is that they help illustrate that the vulnerability and resilience of each group or community differ greatly from place to place and from time to time. In considering the impacts of climate change in the Arctic and the options for responding to those changes, it is essential to understand the nature of the question. It is also essential to consider what is at stake. The indigenous peoples of the Arctic are struggling to maintain their identity and distinctive cultures in the face of national assimilation and homogenization, as well as globalization (Freeman, 2000; Nuttall, 1998). The response to climate change can exacerbate or mitigate

the impacts of that climate change itself. For policy-makers, taking the nature and diversity of indigenous perspectives into account is essential in the effort to help those groups adapt to a changing climate.

For indigenous peoples themselves, an understanding of the ways in which they are resilient and the ways in which they are vulnerable is an essential starting point in determining how they will respond to the challenges posed by climate change. As noted, physical, ecological, and social forces interact to shape these characteristics for each group of people. In times of rapid change, the dynamics of this interplay are particularly difficult for a society to track. An assessment of individual and collective perspectives of arctic indigenous peoples on the challenges ahead can help determine strengths, weaknesses, and priorities. This chapter is a first step in the direction of such an assessment, and shows the need for further work to enable indigenous communities in the Arctic to reflect on the implications of climate change for themselves and for their future.

3.6. Further research needs

This chapter reviews observations of the environmental changes occurring in the Arctic as well as the ways in which people view those changes. In both cases, there is a growing but still insufficient body of research to draw on. For some areas, such as the central and eastern Russian Arctic, few or no current records of indigenous observations are available. To detect and interpret climate change, and to determine appropriate response strategies, more research is clearly needed.

In terms of indigenous observations, documentation of existing knowledge about changes that have occurred and prospective monitoring for future change are both important (Riedlinger and Berkes, 2001; Huntington, 2000b). More research on knowledge documentation has taken place in Canada, particularly among Inuit, regarding indigenous knowledge of climate change than elsewhere (Fox, 1998, 2002, 2004; Furgal et al., 2002; Jolly et al., 2002, 2003; Nickels et al., 2002; Thorpe et al., 2001, 2002), but even there a great deal more can be done. In Eurasia and Greenland, little systematic work of this kind has been done, and research in these regions is clearly needed (Mustonen, 2002). Indigenous observation networks have been set up in Chukotka, Russia (N. Mymrin, Eskimo Society of Chukotka, Provideniya, Russia, pers. comm., 2002), and some projects have taken place in Alaska (Huntington et al., 1999, Krupnik, 2002; Whiting, 2002), but again, little systematic work has been done to set up, maintain, and make use of the results from such efforts.

In terms of indigenous perspectives and interpretations of climate change, most research has taken place in Canada (e.g., Krupnik and Jolly, 2002; McDonald et al., 1997), building largely on the documentation of observations noted above. To date, however, little has been done to connect these perspectives to potential response strategies (see Table 3.1). Some research on responses

Table 3.1. Indigenous responses to climate change in the Inuvialuit Settlement Region of Canada's Northwest Territories (adapted from Nickels et al., 2002).

Observation	Effect	Response/adaptation
Erosion of the shoreline	Relocation of homes and possibly community considered	Stone breakwalls and gravel have been placed on the shoreline to alleviate erosion from wave action
Warmer temperatures in summer	Not able to store country food properly and thus not able to store it for use in winter	Community members travel back to communities more often in summer to store country food. This is expensive as it requires more fuel and time
Warmer temperatures in summer	Can no longer prepare dried/smoked fish in the same way, it gets cooked in the heat	People are building thicker roofs on the smoke houses to keep some heat out, tarpaulins and other materials are used to shelter country foods from heat
Lower water levels and some brooks drying up	Not as many good natural sources of drinking water available	Bottled water now taken on trips
Changing water levels and the formation of shifting sand bars	More difficult to plan travel in certain areas	Community members are finding new (usually longer and therefore more costly) routes to their usual camps and hunting grounds or are flying, incurring still greater expense
Warmer weather in winter	Animal fur is shorter and not as thick, changing the quality of the fur/skin used in making clothing, decreasing the money received when sold	Some people do not bother to hunt/trap, while others buy skins from the store that are not locally trapped, are usually not as good quality, and are expensive
Water warmer at surface	Kills fish in nets	Nets are checked and emptied more frequently so that fish caught in nets do not perish in the warm surface water and spoil
More mosquitoes and other biting insects	Getting bitten more	Use insect repellent lotion or spray as well as netting and screens for windows and entrances to houses
Changing animal travel/migration routes	Makes hunting more expensive, requires more fuel, gear, and time – high costs mean some residents (particularly elders) cannot afford to go hunting	Initiation of a community program for elders, through which younger hunters can provide meat to elders who are unable to travel or hunt for themselves

has been undertaken recently or is underway in Alaska (e.g., Brunner et al., 2004; George et al., 2004), but more is needed to determine the needs of those designing response strategies, the ways in which information is used in the process of designing them, and the ways in which researchers and indigenous peoples can contribute. An essential component of this line of research is to understand how various actors see the issue of climate change, why they see it the way they do, and what can be done to arrive at a common understanding of the threat posed by climate change, the need for responses, and the needs and capabilities of local residents. Consideration of regional similarities and differences across the Arctic may help communities to learn from each other's experiences, too, as well as to incorporate greater understanding of the cumulative impacts of various factors influencing communities (see Chapter 17).

In working toward this goal, an often neglected topic is the linking of indigenous and scientific observations of climate change and the interpretation of these observations. Proponents of the documentation and use of indigenous knowledge often stress both similarities and differences with scientific knowledge (e.g., Stevenson, 1996), but little is done to bridge the gap (e.g., Agrawal, 1995). While the two approaches differ in substantive ways, there are examples of how interactions between them can benefit both and produce a better overall understanding of a given topic (e.g., Albert, 1988; Fox, 2004; Huntington, 2000a; Norton, 2002). Part of the problem is in determining how indigenous knowledge can best be incorporated into scientific systems of knowledge acquisition and interpretation. Part of the problem is in finding ways to involve indigenous communities in scientific research as well as in communicating scientific findings to indigenous communities. And a large part of the problem is in establishing the trust necessary to find appropriate solutions to both goals. Collaborative research is the most promising model for addressing these challenges, as demonstrated by the projects through which the case studies in this chapter were produced, as well as by the results reported from other projects associated with the ACIA, particularly the vulnerability approach described in Chapter 17. Further development of the collaborative model, from small projects to large research programs and extending from identifying research needs to designing response strategies, is an urgent need.

3.7. Conclusions

The case studies and the summary of indigenous observations presented in this chapter were drawn from a variety of studies, conducted in many arctic communities and cultures, and translated from a number of languages. From this diversity of sources, some common themes emerge. While the specifics of these themes and how they are dealt with will depend on circumstances particular to each community, indigenous peoples around the Arctic nonetheless have some shared experiences with climate change.

One topic that stands out across all regions is increased weather variability and unpredictability. Experienced hunters and elders from around the Arctic express concern that they cannot predict the weather like they used to: the weather changes more quickly and in unexpected ways. Arctic residents recognize that the climate is inherently variable. However, many indigenous observers identify the unpredictable and unseasonable weather of the last decade or so as unprecedented. It is true that many factors, such as less frequent time on the land and a tendency to remember the past in rosier terms than are justified, could contribute to changing perceptions of weather predictability even in the absence of actual changes in weather patterns. Nonetheless, similar observations have been made independently by many people in all areas around the Arctic. Such widespread observations of and concern over increased weather variability point, at a minimum, to an important and interesting area for further research, particularly in collaboration with meteorologists and climatologists. Fox et al. (in prep) have done the initial work to link indigenous and scientific observations of weather variability for one community on Baffin Island. Further investigation covering a larger region would be useful and desirable.

While increased weather variability clearly stands out as the most common observation of change across arctic communities, changes in wind and changes in sea ice are also important and widespread. The details of both, however, depend on the location of the observation. In some communities, residents are concerned about changes in wind direction, in others wind strength and the frequency of high winds have changed, and in some places both trends have been seen. Changes in sea ice are similarly variable in time and space. Sea ice may be of the usual thickness but lesser extent in one area in a given year, and the usual extent but reduced thickness in a different area or in another year. The common theme is the prevalence of unusual characteristics and patterns in winds and sea ice. This leads to another insight from analyzing indigenous observations, which is the stress on interconnections between impacts from climate and environmental changes.

Many of the examples of indigenous perspectives of climate change presented here illustrate how the impacts of climate change are connected, interacting to produce further changes. For example, the Nunavut case study (section 3.4.5) shows how wind changes in the Baker Lake area have packed the snow unusually hard, making igloo building difficult or impossible. When these wind-driven snow changes interact with the recent unpredictable weather conditions, dangerous situations arise as travelers are unable to build emergency snow shelters. The Kotzebue case study (section 3.4.1) offers several examples of the different and interacting consequences of change in a single variable in that region.

The climate and environmental changes observed by arctic indigenous peoples produce impacts through their

interactions with one another, and through the ways in which they play out in social, political, and cultural contexts. Indigenous perceptions of climate change do not arise in isolation, but are shaped by these contexts as well as the context of the overall climate change debate. This is best demonstrated in the case study from the Kola Peninsula (section 3.4.9). While the Saami of that region have observed the impacts of climate change and are concerned about the long-term implications, they are far more concerned about their immediate economic and political circumstances. When people are concerned about making a living and providing food for their families, it is not surprising that less immediate concerns do not rate as highly. In Nunavut, the situation is not as dire, but people are nonetheless very concerned about issues such as poverty, housing, and cultural preservation. Here, too, climate change may not be regarded as a top priority issue.

The contexts within which indigenous peoples observe, assess, interact, and respond to the impacts of climate change are extremely important, especially as individuals and communities begin to develop ways to adapt to these changes. Political or economic situations will play a role in constraining or enabling people to adapt. For example, Chapter 17 discusses how reindeer herders in Finnmark are hindered in their ability to deal with icy grazing areas in the autumn. In the past, herders could move the reindeer to other pastures that had not iced over. Owing to changes in land use and new boundaries, however, herders are now prevented from moving their herds and are thus vulnerable to localized freezing events.

Two areas in particular need further development to enhance the abilities of indigenous peoples to cope with the impacts of climate change. First, increasing flexibility and the response options available will allow a broader array of potential responses. This entails devolving authority and capacity to more local levels so that people and communities can choose for themselves the responses that make the most sense in their particular situation, given the costs and benefits of those responses. Such responses range from changing regulations concerning resource use to moving settlements to more favorable locations. Second, more information about the potential types of changes that may be seen will help identify particular areas of vulnerability. The common themes and concerns in this chapter – increased variability in weather, changes in wind patterns, changes in sea ice and snow, more freeze-thaw cycles, more and stronger storms – are topics that are not well addressed in typical climate models (see Chapter 4). Greater attention to the climate parameters that affect local people and ecosystems directly will help to identify critical areas for local and regional action.

These steps can and should flow from the documentation and presentation of indigenous perspectives on climate change. Indigenous knowledge and perspectives are a foundation upon which individuals, communities, and regions can design responses and take action. Other information and expertise are also essential to this process, and collaborative approaches are thus the most likely to be effective in identifying and addressing the challenges and opportunities posed by climate change. Randall Tetlichi, a Vuntut Gwitchin leader from Old Crow, Yukon Territory, referred to the need to draw on scientific and traditional knowledge as the need to "double understand" (quoted in Kofinas et al., 2002). For the peoples of the Arctic, whose future is at stake, having the ability to make choices and changes is a matter of survival, to which all available resources must be applied.

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