Chapter 12

Hunting, Herding, Fishing, and Gathering: Indigenous Peoples and Renewable Resource Use in the Arctic

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Summary

This chapter discusses the present economic, social, and cultural importance of harvesting renewable resources for indigenous peoples, provides an assessment of how climate change has affected, and is affecting, harvesting activities in the past and in the present, and considers what some of the future impacts may be. Key to this chapter are several detailed case studies based on extensive research with indigenous communities in a number of arctic settings. These case studies discuss past, present, and potential impacts of climate change on specific activities and livelihoods. It is not possible to provide circumpolar coverage of the situation for all indigenous peoples, as detailed descriptions are not available for all regions of the Arctic. The material presented in this chapter, however, does illustrate some of the common challenges faced by indigenous peoples in a changing Arctic.

One aim of this chapter is to assess the adaptive strategies that have enabled communities to respond to and cope with climate change in the past, and to assess to what extent these options, if any, remain open to them. While there are few data available on this topic, research shows that while indigenous peoples have generally adapted well to past climate change, the scale, nature, and extent of current and projected climate change brings a very different sense of uncertainty, presenting different kinds of risks and threats to their livelihoods and cultures. The chapter also points to pressing research needs. Compared to the extensive scientific literature on climate change considered in most other chapters in this assessment, data on the impacts of climate change on the livelihoods of the Arctic's indigenous peoples are limited, particularly in the case of the Russian North.

This chapter illustrates the complexity of problems faced by indigenous peoples today and underscores the reality that climate change is but one of several, often interrelating problems affecting their livelihoods and cultures. This chapter is, therefore, as much a scoping exercise, the beginning of a process, as it is an assessment of current knowledge. It emphasizes the urgency of extensive, regionally-focused research on the impacts of climate change on hunting, herding, fishing, and gathering activities, research that will contribute to a much greater understanding of climate change impacts, as well as to place these impacts within the much broader context of rapid social, economic, and environmental change.

12.1. Introduction

Indigenous peoples throughout the Arctic maintain a strong connection to the environment through hunting, herding, fishing, and gathering renewable resources. These practices provide the basis for food production and have endured over thousands of years, with cultural adaptations and the ability to utilize resources often associated with or affected by seasonal variation and changing ecological conditions.

Climatic variability and weather events often greatly affect the abundance and availability of animals and thus the abilities and opportunities to harvest and process animals for food, clothing, and other purposes. Many species are only available seasonally and in localized areas and indigenous cultures have developed the capacity and flexibility to harvest a diversity of animal and plant species. Indigenous cultures have, in many cases, also shown resilience in the face of severe social, cultural, and economic change, particularly in the last 100 years.

The longstanding dependence of present indigenous societies on hunting, herding, fishing, and gathering continues for several critically important reasons. One is the economic and dietary importance of being able to access customary, local foods. Many of these local foods – fish, and meat from marine mammals or caribou and birds, for instance, as well as berries and edible plants – are nutritionally superior to the foodstuffs which are presently imported (and which are often expensive to buy). Another reason is the cultural and social importance of hunting, herding, and gathering animals, fish, and plants, as well as processing, distributing, consuming, and celebrating them (Freeman, 2000).

These activities remain important for maintaining social relationships and cultural identity in indigenous societies. They define a sense of family and community and reinforce and celebrate the relationships between indigenous peoples and the animals and environment upon which they depend (Callaway, 1995; Nuttall, 1992). Hunting, herding, fishing, and gathering activities are based on continuing social relationships between people, animals, and the environment (Brody, 1983; Callaway, 1995; Freeman et al., 1998; Nuttall, 1992; Wenzel, 1991). As such, they link people inextricably to their histories, their present cultural settings, and provide a way forward for thinking about sustainable livelihoods in the future.

The significance of hunting, herding, fishing, and gathering has wide cultural ramifications. Seal hunting, for example, is not only an occupation and a way of life, but also a symbolic part of Inuit cultures (Nuttall, 1992; Wenzel, 1991). The cultural role of activities relating to the use of living marine and terrestrial resources is not only of concern to those who depend economically on these activities, but also to those who live in towns and are involved in occupations with no direct attachment to hunting, fishing, and herding (e.g., Caulfield, 1997). Yet whatever the importance for social identity and cultural life, the primary need for, and use of animals is based purely on a need for survival.

Arctic communities have experienced, and are experiencing, stress from a number of different forces that threaten to restrict harvesting activities and sever these relationships. The arctic regions are tightly tied politically, economically, and socially to the national mainstream and are inextricably linked to the global economy (Caulfield, 2000; Nuttall, 1998; Osherenko and Young, 1989; Young, 1992). Rapid social, economic,

and demographic change, resource development, trade barriers, and animal-rights campaigns have all had impacts on hunting, herding, fishing, and gathering activities. The material in this chapter on the Russian North, for example, illustrates how poaching, oil development, and clear-cutting of forests undermine the subsistence base for indigenous peoples. Hunting, herding, fishing, and gathering are also being challenged by environmental changes such as climate variability. Despite this, indigenous peoples have reasserted cultural rights and identities, have called for the recognition of self-determination, and are achieving significant levels of regional government (Nuttall, 1998).

For many arctic residents, consuming food from animals is fundamentally important for personal and cultural well-being. Indigenous peoples have reported a loss of vitality, a decline in health, and a decrease in personal well-being when they are unable to eat traditional/country foods (Wein and Freeman, 1992). These problems do not just emerge when climate change denies people access to traditional/country foods, but are very much linked to problems associated with the undermining of local modes of production. The erosion of a person's position as a provider of welfare to family and community also has serious ramifications. A recent study of the importance of whaling for Inuit societies illustrates the negative social, cultural, economic, and nutritional consequences of not being able to gain access to, and to eat, traditional/country foods (Freeman et al., 1998) and points to the kinds of problems that indigenous peoples may experience if climate change denies them access to wild food resources.

The conservation of arctic wildlife and ecosystems depends in part on maintaining the strength of the relationship between indigenous peoples, animals, and the environment, and in part on securing the rights of indigenous peoples to continue customary harvesting activities. As this assessment shows, these activities and relationships appear to be threatened by severe climate change. The potential impacts of climate change on harvesting wildlife resources are of fundamental concern for the social and economic well-being, the health, and the cultural survival of indigenous peoples throughout the Arctic, who live within institutional, legal, economic, and political situations that are often quite different from non-indigenous residents. Furthermore, indigenous peoples rely on different forms of social organization for their livelihoods and well-being (Freeman, 2000).

Many of the concerns about climate change arise from what indigenous peoples are already experiencing in some areas, where climate change is an immediate and pressing problem, rather than something that may happen, or may or may not have an impact in the future. For example, Furgal et al. (2002) discussed local anxieties over environmental changes experienced by communities in northern Quebec and Labrador, and argued that the impacts on human health and the availability of important traditional/country foods from plants and animals can already be observed. Indigenous accounts of current environmental change say that such changes in climate and local ecosystems are not just evident in animals such as caribou shifting their migration routes and altering their behavior, but in the very *taste* of animals.

As the various chapters of this assessment show, scientific projections and scenarios suggest that there will be significant changes in the climate of the Arctic, in the character of the environment, and in its resources. For example, latitudinal shifts in the location of the taiga–tundra ecotone will have significant effects on ecosystem function and biodiversity at the regional scale. One dramatic anticipated change, taking place over several decades to hundreds of years, is the gradual forestation of tundra patches in the present forest–tundra mosaic and a northward shift of the treeline by hundreds of kilometers. These changes will affect vegetation structure and the composition of the flora and fauna and will have implications for indigenous livelihoods, particularly reindeer herding and hunting and gathering (see Chapter 7).

The aims of this chapter are:

- to discuss the present economic, social, and cultural importance of harvesting renewable resources for indigenous peoples;
- to provide an assessment of how climate change has affected, and is affecting, harvesting activities in the past and in the present; and
- through a selection of detailed case studies based on extensive research with indigenous communities in several arctic settings, to discuss some of the past, present, and potential impacts of climate change on specific activities and livelihoods.

The case studies were selected to provide a sense of the impacts that climate change is having in the present, or could have in the near future, on the livelihoods of indigenous peoples. It is not possible to provide circumpolar coverage of the situation for all indigenous peoples. Apart from space constraints, detailed descriptions are not available for all regions of the Arctic. The material presented in this chapter, especially through the case studies, illustrates the common challenges faced by indigenous peoples in a changing Arctic.

Another purpose of this chapter is to assess the adaptive strategies that have enabled communities to respond to and cope with climate change in the past and to establish the extent to which these options remain open to them. There are few data published on this topic, but based on those that are available the chapter shows that while indigenous peoples have often adapted well to past climate change, the scale and nature of current and projected climate change brings a very different sense of uncertainty for indigenous peoples, presenting different kinds of risks and threats to their livelihoods.

It should be noted that, compared to the scientific chapters in this assessment, data on the impacts of climate

change on the livelihoods of indigenous peoples are limited, particularly in the case of the indigenous peoples of Russian North. The case studies in this chapter illustrate the complexity of problems faced by indigenous peoples today and underscore the reality that climate change is but one of several, often interrelating problems affecting their livelihoods.

This chapter is, therefore, as much a scoping exercise as it is an assessment of current knowledge. It emphasizes the urgency for extensive, regionally-focused research on the impacts of climate change on hunting, herding, fishing, and gathering activities, research that will not just contribute to a greater understanding of climate impacts, but will place these impacts within the broader context of rapid social, economic, and environmental change.

12.2. Present uses of living marine and terrestrial resources

12.2.1. Indigenous peoples, animals, and climate

12.2.1.1. Animals, food, and survival

The indigenous peoples of the Arctic include the Iñupiat, Yup'ik, Alutiiq, Aleuts, and Athapaskans of Alaska; the Inuit, Inuvialuit, Dene, and Athapaskans of northern Canada; the Kalaallit and Inughuit of Greenland; the Saami of Fennoscandia and Russia's Kola Peninsula; and the Chukchi, Even, Evenk, Nenets, and Yukaghir of the Russian Far North and Siberia (see Chapters 1 and 3 for an extended discussion). These peoples have subsisted for thousands of years on the resources of land and sea, as hunters, gatherers, fishers, and reindeer herders. Today, many indigenous communities across the Arctic continue to depend on the harvesting and use of living terrestrial, marine, and freshwater resources. In recent decades indigenous peoples have demanded the right to be involved in the policy-making processes that affect their lives, lands, and communities. Responding to rapid social change and threats to the arctic environment, demands for land claims and self-government have been based on historical and cultural rights to lands and resources.

The species most commonly harvested by the indigenous peoples of the Arctic are marine mammals such as seals; walrus (*Odobenus rosmarus*); narwhal (*Monodon monoceros*); beluga (*Delphinapterus leucas*), fin (*Balaenoptera physalus*), and minke (*Balaenoptera acutorostrata*) whales; polar bear (*Ursus maritimus*) and land mammals such as caribou (*Rangifer tarandus*), reindeer (*Rangifer tarandus*)[4], and muskox (*Ovibos moschatus*); and fish such as salmon (*Oncorhynchus* spp.), Arctic char (*Salvelinus alpinus*), northern pike (*Esox lucius*), and other species, such as whitefishes (*Coregonus* spp.). Many of these species are used as food, and for clothing and other products, as well as figuring prominently in the cash economy of local households and communities (Caulfield, 2000; Dahl, 2000; Huntington, 1992; Nuttall, 1992).

Ringed seals (*Phoca hispida*), bearded seals (*Erignathus barbatus*), and hooded seals (*Cystophora cristata*) are widely hunted in Greenland and Canada. Harp seals (*Phoca groenlandica*) and harbour seals (*Phoca vitulina*) are also used locally. Smaller toothed whales like the beluga and the narwhal are hunted in many areas of Canada and Greenland and are prized for their *mattak* (skin) and meat. Baleen whales like bowhead (*Balaena mysticetus*), minke, fin, grey (*Eschrichtius robustus*), pilot (*Globicephala melaena*), and other larger whales are also a valued source of food. Walrus are also commonly taken in Inuit areas, especially in the Bering Strait region and in the Canadian Arctic (Caulfield, 2000).

Fish species used by arctic communities include those that move seasonally from marine to freshwater environments, such as salmon and Arctic char, which are particularly important for indigenous peoples of Alaska (including Inuit communities around Kotzebue Sound, Norton Sound, and the Yukon and Kuskokwim Deltas). The five species of Pacific salmon are also an important food source and a major source of cash income for many households (Caulfield, 2000). Other arctic species used locally include Atlantic salmon (*Salmo salar*), lake trout (*Salvelinus namaycush*), several species of whitefish, pike, and grayling (*Thymallus arcticus*).

Marine fish are an important source of food and a cornerstone of economic life in the Arctic. Arctic cod (*Boreogadus saida*) is used for domestic consumption but also has a long history of use for commercial purposes, especially in Greenland. While its numbers today are reduced, it remains an important part of northern economies in Canada, Greenland, Iceland, and Norway. Greenlandic-owned (and largely Greenlandic-crewed) fishing vessels also fish in waters beyond Greenland, such as in the Barents Sea. In the Bering Sea, the large fishery for pollock (*Theragra chalcogramma*) is undertaken mainly by vessels coming from outside the Arctic, but indigenous peoples are increasingly participating in this and other Bering Sea fisheries. Several flatfish, including halibut (*Hippoglossus hippoglossus*), Greenland halibut (*Reinhardtius hippoglossoides*), and flounder (*Pleuronectes ferrugineus*) are important locally for food and for cash. In Greenland, deep-water shrimp (*Pandalus borealis*) is the major source of export income; indeed, Greenland is the world's largest exporter of shrimp, while the economies of small communities along the west coast are increasingly based on fishing for local stocks of Greenland halibut and cod. Capelin (*Mallotus villosus*), which spawns in large numbers on rocky beaches, is a particularly important coastal fish used locally in Canada and Greenland for human and sled dog food.

Several terrestrial species – especially caribou, reindeer, muskox, and moose (*Alces alces*) – are extremely impor-

[4]Caribou are wild animals in North America. Reindeer are domesticated animals in or originally from Eurasia. There are also "wild reindeer", meaning the wild relatives of the animals that were domesticated in Eurasia.

tant in local economies. Caribou, in particular, are hunted widely in Alaska and Canada and in some parts of Greenland, and are used both for food and for other products. Caribou populations are known to vary dramatically over time, and hunters are attuned to the near predictability of their seasonal abundance and migratory routes. Reindeer underpin the culture and economy of herding societies in Fennoscandia and Siberia. Moose are common in the subarctic boreal forest, but their range is expanding into more northerly environments. Other terrestrial species of economic importance to arctic residents include muskox, grizzly bear (*Ursus arctos*), wolf (*Canis lupus*), arctic fox (*Alopex lagopus*), muskrat (*Ondatra zibethicus*), and ground squirrel (*Spermophilus parryii*).

Indigenous peoples have also collected eggs and hunted birds among coastal colonies of auks and other seabirds. For example, Greenlanders hunt, among others, Brünnich's guillemot (*Uria lomvia*), common eider (*Somateria mollissima*), king eider (*Somateria spectabilis*), and kittiwakes (*Rissa* spp.), and take the eggs of all these species. They also collect the eggs of birds not hunted for food, such as the Arctic tern (*Sterna paradisaea*).

Literally hundreds of harvest studies have been carried out in the Arctic and subarctic, particularly in Alaska and Canada. The wide range and diversity of plant and animal species used for food by indigenous peoples is illustrated by data from recent studies and surveys from the Canadian Arctic summarized in reports by the Arctic Monitoring and Assessment Programme (e.g., AMAP, 1998). Figure 12.1 shows harvest levels in the different Inuit regions and in the Yukon.

In 1989, the total harvest in the Northwest Territories was estimated to be about 5000 tonnes, or 232 kilograms per person per year, excluding commercial fish catches. There is very little information about the harvesting activities of most Dene and Métis communities, except for fur-bearing species and commercially significant fish. Employment figures indicate that subsistence activities are important, as almost 40% of the indigenous population in Dene communities were not part of the labor force according to a survey in 1991 (AMAP, 1998). Almost 38% of people over 15 years old said that they used non-cash activities to provide for their families. A slightly larger percentage said that they had lived on the land in the previous twelve months. An estimate of the per-capita harvest suggests that the communities are self-sufficient in their protein requirements. Yukon First Nations also rely heavily on subsistence activities. About one third of the people in the 1991 Aboriginal People's Survey said that they had lived on the land in the previous year and 30% supported their families with activities that were not part of the cash economy (AMAP, 1998).

The AMAP assessment shows that studies support the picture of a high reliance on subsistence production throughout northern Canada (AMAP, 1998). Even if

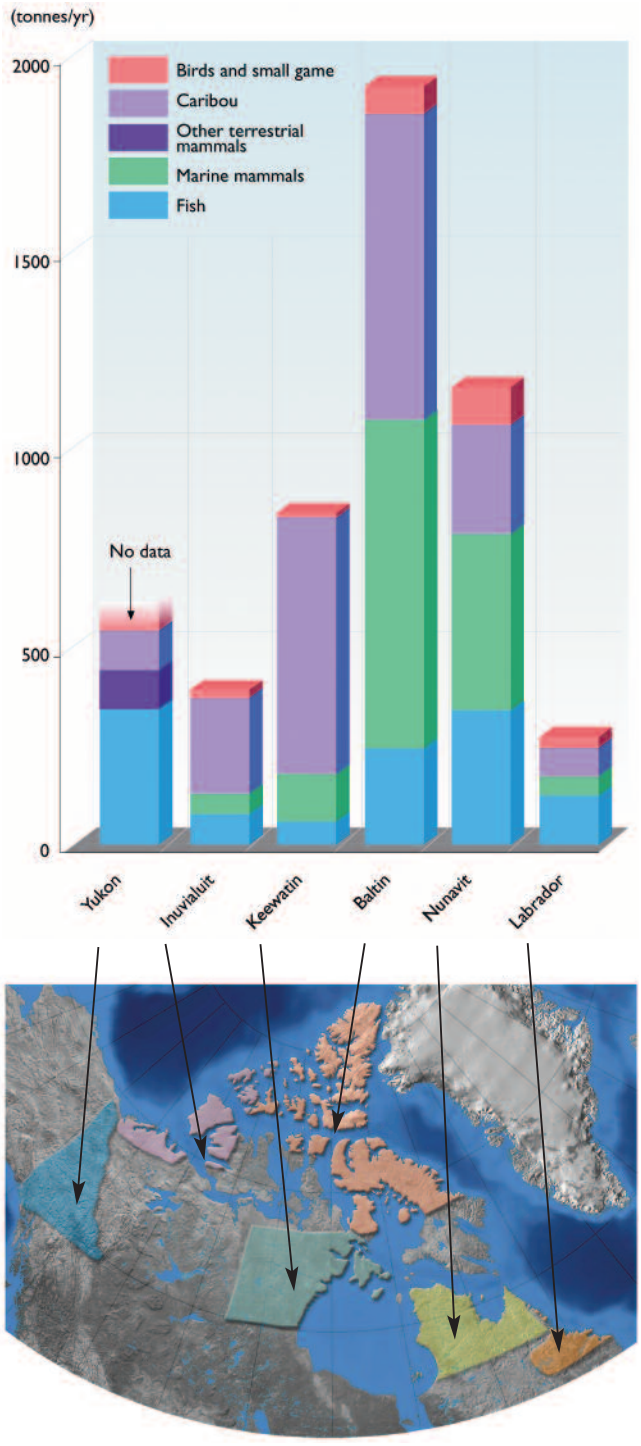

Fig. 12.1. Average annual indigenous subsistence production in arctic Canada (based on AMAP, 1998).

store-bought foods are also common, traditional/country foods contribute a significant proportion of the daily nutritional intake.

The traditional diets of indigenous peoples in northern Canada are more balanced than a diet of foods imported from southern Canada, which have higher levels of sugar and more saturated fats. Using traditional/country foods is regarded by indigenous peoples as more economical than purchasing food in the store. This becomes especially important in communities where many people are not employed or where many have incomes below the

poverty line. Traditional/country foods are also important for reinforcing the social relationships that are central to the culture and subsistence economy.

Diets and food preferences vary between communities and between families, but detailed studies provide some examples of what people eat. In Aklavik, Northwest Territories, more than half the Inuit households consume caribou, beluga, Arctic hare (*Lepus arcticus*), muskrat, whitefish, cisco (*Coregonus* spp.), burbot (*Lota lota*), inconnu (*Stenodus leucichthys*), Arctic char, ducks, geese, cloudberries (*Rubus* spp.), cranberries (*Oxycoccux* spp.), and blueberries (*Vaccinium* spp.), with caribou the most common food (Wein and Freeman, 1992).

The types of food eaten also depend on the time of year. In Aklavik, autumn is caribou and moose hunting season, as well as being the hunting season for Dall sheep (*Ovis canadensis dalli*), ducks, and geese. Winter activities are trapping small fur-bearing animals and fishing. When the ice breaks up in April, muskrat are harvested for their pelts and meat. The waterfowl return, and are used as food until they begin to nest. Fishing resumes after ice break-up. Spring is the time for gathering roots. Summer is whaling time, and people travel out to the Yukon coast to hunt beluga. Willow tops, bird eggs, and wild rhubarb supplement the diet. As autumn approaches again, it is time to dry fish and caribou meat and to pick berries. Among the Dene, a few dietary studies have been carried out specifically to estimate the amount of contaminants in traditional/country foods. These surveys show, for example, that moose are eaten in summer, barrenland caribou in winter, and ducks in spring. Other important foods are inconnu, whitefish, cisco, and blueberries. In the winter, moose, rabbit, whitefish, and loche are part of the diet, and in the spring woodland caribou (Wein and Freeman, 1992). The influence of the fear of contaminants on food harvesting is an important issue that needs development (Weinstein, 1990).

A survey of dietary preferences in the communities of Fort Smith, Northwest Territories, and Fort Chipewyan, Alberta, showed that people ate traditional/country foods six times per week and that animals from the land made up one-third of the diet. In a survey of Yukon First Nations (Haines Junction in the traditional territory of the Champagne–Aishihik First Nation, Old Crow, which is a remote community on the Porcupine River relying heavily on the Porcupine Caribou Herd that migrates through their land, Teslin at Teslin Lake, and Whitehorse, which is the territorial capital with a more diverse population), virtually all households used moose and salmon, as well as berries and other plant foods. Many also used caribou, hare, ground squirrel, beaver, ducks, grouse, chinook salmon (*Oncorhynchus tshawytscha*), sockeye salmon (*O. nerka*), coho salmon (*O. kisutch*), whitefish, lake trout, and Labrador tea (*Ledum* spp.). In total, mammals accounted for about half the traditional food, fish for a fifth, berries for a fifth, other plants for a tenth, and birds for a twentieth. People got most of their food from hunting and fishing (AMAP, 1998).

As the dietary surveys carried out in Yukon First Nation communities show, traditional/country food harvested from the local environment has a central role in the daily lives of individuals, families, households, and communities. Traditional/country foods improve the quality of the diet as shown by the lower fat and saturated fat content of the diet when traditional food is consumed. Traditional/country foods also represent important sources of dietary energy, protein, iron, and zinc. The increased physical activity associated with traditional food harvest, and the role of the traditional/country food system in cultural and social support systems is also likely to contribute to health (Receveur et al., 1998; Wein, 1994).

12.2.1.2. Animals and cultural identity

Successful harvesting of all the species used by indigenous peoples requires specialized knowledge of animal and fish behavior, sea ice and terrestrial conditions, and arctic weather. The detailed knowledge of the Arctic's indigenous peoples about these factors is widely recognized. Indigenous peoples have detailed and complex systems of classification and knowledge about the natural world which is developed and enhanced through long-term experience and generational transmission (Nuttall, 1998). This knowledge has enabled indigenous societies to exploit highly productive ecosystems effectively in the region for thousands of years (Caulfield, 2000) and provides a foundation for economic, cultural, spiritual, and ethical concerns that guide the use and management of natural resources (Nuttall, 1998).

The living resources of the Arctic do not just sustain indigenous peoples in an economic and nutritional sense, but provide a fundamental basis for social identity, cultural survival, and spiritual life. As such they are as much important cultural resources as they are economic ones. This dependence on animals for food and social, cultural, and economic well-being is reflected in rules for community hunting, in herding traditions, and in patterns of sharing and gift-giving based on kinship ties and other forms of close social relatedness. Participation in family and community hunting, herding, and fishing activities contributes to defining and establishing a sense of social relatedness and is important for community and cultural identity, as well as for providing a moral framework for relationships between people and between people and animals.

Across the Arctic, the sharing and distribution of meat and fish is central to daily social life and expresses and sustains social relationships, and the case study from Nunavut (section 12.3.2) illustrates vividly the sharing practices and networks in one particular region. Harvesting and its associated processing and sharing activities reaffirm fundamental values and attitudes towards animals and the environment and provide a moral foundation for continuity between generations (Callaway et al., 1999; Nuttall, 1992; Wenzel, 1991).

In seal hunting households in Greenland and Canada, for example, the meat, fat, and skin of the seal is utilized. There is rarely much wasted. Complex and precise local rules determine the sharing and distribution of the catch, and seal meat is commonly shared out to people beyond the household, whether those people are related to the hunter or not (Petersen, 2003). For arctic hunting peoples, sharing can only be understood with reference to the sense of social relatedness that people feel they have with each other and with animals and the environment. This has been well documented by recent research on the consumption of traditional/country foods in Greenland (Caulfield, 1997; Nuttall, 1992; Pars et al., 2001).

The cultural expression of the relationships between humans and animals is evident in first-catch celebrations. At an early age, boys are taken on hunting trips with their fathers, who begin to teach them the skills and impart the knowledge necessary to be a successful hunter. In small Greenlandic hunting villages, for example, when a boy catches his first seal, he will give gifts of meat to every household in his community and people are invited to his parents' home for coffee or tea and cake. A first catch celebration is not only a recognition by the community of the boy's development as a hunter, but is a statement of the vitality and cultural importance of the hunting way of life (Nuttall, 1992). For arctic hunting peoples such as the Inuit, sharing the products of the hunt is a social event that demonstrates relatedness, affection, and concern. Obligations to share underlie customary ideologies of subsistence and contribute to the reproduction of kinship ties and other close social relationships (Nuttall, 1992; Wenzel, 1991). Climate change not only disrupts hunting activities, it has an impact on such social relationships, as the case study from Nunavut (section 12.3.2) shows.

Rich mythologies, vivid oral histories, festivals, and animal ceremonialism also illustrate the social, economic, and spiritual relationships that indigenous peoples have with the arctic environment. Animals have a spiritual essence as well as a cultural and economic value, and land and water are not just seen as commodities. For indigenous peoples, many features in the landscape are sacred places, especially along migration routes, where animals reveal themselves to hunters in dreams, or where people encounter animal spirits while traveling (Brody, 1983).

In Alaska and Canada, Athapaskan oral histories describe how features of the landscape, or the elements, such as the moon, sun, wind, stars, and so on, were originally human beings and whose spirits are now embodied in aspects of the natural world. In Greenland, Canada, and Alaska, Inuit stories about the origin of the elements, the sun and the moon, and other celestial bodies, are often related to myths about the balance between daylight and darkness, time and space, and between the human and natural worlds. In Siberia and Sapmi, one can find reindeer antlers that have been placed at sacred sites and adorned with gifts, and sacred stones placed on the tops of mountains and near lakes and rivers.

12.2.1.3. Place, environment, and climate

Although the Arctic is often labeled one of the last remaining wilderness areas on earth, this ignores the fact that the Arctic is a homeland for indigenous peoples. The indigenous names for features of the landscape – for streams, lakes, mountains, valleys, plains, and tundra meadows – as well as the icescape and features of the sea are not merely geographically descriptive. The names that indigenous peoples have given to the arctic landscape are multidimensional, in that they contain information about physical features, the availability and movement of animals, community history, and historical and mythological events (Nuttall, 1992, 2001). This differs sharply from the practice of naming places by explorers, colonialists, and settlers in order to control, own, and dominate the landscape.

Often, place names provide information about climate change and significant weather-related events. For indigenous peoples, stories and discussions about the weather and climate are interwoven with stories and experiences of particular tasks, like hunting, herding, fishing, berry-picking, or traveling (see Chapter 3). Much of this is bound up with memories of past events, of local family histories, and of a strong sense of attachment to place and locality (Nuttall, 2001). The weather connects people to the environment and to animals.

One example of this is the understanding of *sila* in Greenland. In Kalaallisut (Greenlandic) the word for weather and climate is *sila*. *Sila* is also used to mean "the elements" or "the air". But *sila* is also the word for "intelligence/consciousness", or "mind," and is understood to be the fundamental principle underlying the natural world. *Sila* is manifest in each and every person. It is an all-pervading, life-giving force – the natural order, a universal consciousness, and a breath soul (Nuttall, 1992). *Sila* connects a person with the rhythms of the universe, integrating the self with the natural world. As *sila* links the individual and the environment, a person who lacks *sila* is said to be separated from an essential relationship with the environment that is necessary for human well-being. When people in Greenland experience a change in the weather, this change is experienced in a deeply personal way. And when they talk about their concerns about climate change, they articulate this not only in terms of how their own sense of self, personhood, and well-being is changing in relation to external climatic fluctuations, but in their concerns for their own sense of self and well-being in terms of climate change (Nuttall, in press).

Memories and knowledge of how the weather and climate has changed are also found in oral histories as well as in contemporary observations. For Athapaskan people of Canada's Yukon Territory and southeast Alaska, memories of the Little Ice Age play a significant role in indigenous oral traditions. Cruikshank (2001) shows how these stories are "sedimented" on land just like geological processes. Athapaskan clan histories document travel

across glaciers from several directions. Eyak, Athapaskan, and Tlingit place names encapsulate information and local ecology and climate now rendered invisible by English names. Cruikshank (2001) shows that surging glaciers present navigational, spiritual, and intellectual challenges of a sentient "land that listens". Stories about changes in the weather, to the landscape, and to glaciers persist with a richness, range, and variety because of ongoing risks they posed to everyday life well into the 20th century.

Today, as Athapaskan people demonstrate concern with climate change, there is a contemporary validity to these stories. They not only record the consequences of climate change, and enrich scientific understandings of past climatic conditions, but also provide information on the responses that helped indigenous communities cope with and adapt to climate change. Observations and understandings of change are invaluable to scientists working on the impacts of climate change and increased levels of ultraviolet-B radiation by providing long-term records of observed changes with which to compare and contrast their results (De Fabo and Bjorn, 2000).

12.2.2. Mixed economies

In indigenous communities in the Arctic today, households are economic units within villages, settlements, and small towns characterized by a blend of formal economies (e.g., commercial harvesting of fish and other animals, oil and mineral extraction, forestry, and tourism) and informal economies (e.g., harvesting renewable resources from land and sea). The ability to carry out harvesting activities is not just dependent on the availability of animals, but on the availability of cash, as the technologies of modern harvesting activities are extremely expensive in remote and distant arctic communities. Throughout the Arctic, many indigenous communities (whether they are predominantly seal hunting communities in northern Greenland or Canada, fishing communities in Norway, or reindeer herding societies in Siberia) are increasingly characterized by pluri-activity in that cash is generated through full-time or part-time paid work, seasonal labor, craft-making, commercial fishing, or other pursuits such as involvement in tourism that support and supplement renewable resource harvesting activities.

In mixed economies, half or more of household incomes may come from wage employment, simple commodity production, or from government transfer payments (Caulfield, 2000; Langdon, 1986; Weinstein, 1996). Increasing reliance on other economic activities does not mean that production of food for the household has declined in importance. Hunting, herding, gathering, and fishing activities are mainly aimed at satisfying the important social, cultural, and nutritional needs, as well as the economic needs, of families, households, and communities (see Bodenhorn (2000) for northern Alaska, Hovelsrud-Broda (2000) for East Greenland, and Wenzel (2000) for eastern Baffin Island).

Research points to the continued importance of harvesting activities despite a growing proportion of the population of indigenous communities not being directly involved in harvesting (e.g., Usher, 2002). Purchased foodstuffs supplement diets composed mainly of wildlife resources (Callaway, 1995; Nuttall, 1992) and individuals and households that do not have the means or ability to hunt often have regular access to country foods through local distribution channels and networks of sharing (see the case study of Inuit sharing patterns in Nunavut in section 12.3.2).

Nor has money diminished subsistence-oriented production as a central feature of life in the Arctic – indeed cash has made the continuation of hunting, herding, and gathering possible in some cases, rather than contributing to its decline (Kruse, 1991; Nuttall, 1992; Wenzel, 1991; Wolfe and Walker, 1987). In parts of the Arctic commercial and subsistence uses of country foods are intrinsically linked. In Alaskan villages fish for the household are often taken during commercial fishing trips, the profits from which are often invested in new equipment for subsistence pursuits (Callaway et al., 1999).

Cash is often used to buy equipment for procuring food from harvesting activities (e.g., boats, rifles, snowmachines). Cash also meets demands for a rising standard of living: to purchase oil to heat homes, to buy consumer goods, or to travel beyond the community. While food procured from renewable resource harvesting continues to provide arctic peoples with important nutritional, socio-economic, and cultural benefits, finding ways to earn money is a major concern in many arctic communities (Caulfield, 2000). The interdependence between formal and informal economic sectors, as well as the seasonal and irregular nature of wage generating activities (such as tourism) means that families and households are often faced with a major problem in ensuring a regular cash flow. For example, Callaway et al. (1999) demonstrated that the ability to carry out harvesting activities in Alaska – and thus the quality of life in rural communities – is linked to the state's economic and political environments.

The impacts of climate change on formal economic activities will also have implications for renewable resource harvesting activities. In Alaska, recent climate change has increased the cost and risk of subsistence pursuits. On the coast of northern Alaska, where the ice pack has retreated a significantly greater distance from land, North Slope hunters have to cross a greater expanse of open water to reach hunting grounds. The increased time and distance added to a hunting trip adds to the cost and risk of accessing marine mammal resources. Fuel and maintenance costs are greater because of the longer distance to travel, which also decreases the use and expectancy of the technology used (boats, engines, rifles). For safety reasons, boats with larger engines are required, adding strain to limited budgets (Callaway et al., 1999).

The economic value of traditional/country food is emphasized by the level of food insecurity common among indigenous peoples. In a major dietary survey in Yukon First Nation communities, 39% of respondents reported having insufficient resources to purchase all the food they would need from the store if traditional food was not available; the average weekly "northern food basket" was priced at Can$ 164 in communities, compared to Can$ 128 in Whitehorse (Receveur et al., 1998). The Nunavut case study (section 12.3.2) illustrates the problems hunters face in gaining access to money. While hunting produces large amounts of high quality food – the Government of Nunavut estimates that it would cost approximately Can$ 35 000 000 to replace this harvest production – as the case study illustrates, virtually none of this traditional wealth can be converted into the money needed to purchase, operate, and maintain the equipment hunters use. Abandoning hunting for imported food would be less healthy and immensely costly.

12.2.3. Renewable resource use, resource development, and global processes

Despite variations in economic and cultural practices, many indigenous communities throughout the Arctic share one important characteristic – their economies are vulnerable to changes caused by the global processes affecting markets, technologies, and public policies in addition to the environmental impacts of climate change. Residents of arctic communities are increasingly tied to world markets and the growth of the mixed economies of arctic communities points to widening interaction of arctic societies with the global economy (Caulfield, 1997; Nuttall, 1998). Greenland's largest single source of export income, for example, is deep-water shrimp, marketed in Europe, North America, and Japan. Oil from Alaska's North Slope meets 25% of total US demand, and provides healthy tax revenues for the North Slope Borough's Iñupiat residents. Development of hydropower has sparked major conflict between Saami in northern Norway and industry and governments to the south (Caulfield, 2000).

> *Renewable resources are a part of this global dynamic: salmon from Alaska's Bering Sea is found in fashionable restaurants of Boston and Los Angeles within hours of being caught; Japanese technicians advise Greenlanders about how to produce specialized shrimp products ["fantails"] for Tokyo markets; wealthy European and North American hunters pursue polar bear in northern Canada for trophies; wilderness enthusiasts in places like Alaska's Denali National Park seek wildlife experiences where subsistence hunting by indigenous peoples is banned; and animal rights activists lobby to keep Inuit hunters from selling seal skins on the European market, no matter how justifiable the practice on biological grounds.*
> Caulfield, 2000

Arctic fisheries are a good example of how the effects and influences of global processes are increasingly felt in all aspects of social, economic, and cultural life in the Arctic today. Many problems experienced by North Atlantic coastal communities in the Arctic, for instance, can be attributed in part to the global restructuring of fisheries, the balance of competition between different species and different fishing areas, the globalization of the sourcing of supplies for processing plants and retail markets, and the redistribution of wealth from traditional actors, such as local fishers and local processors, to powerful global players in the form of transnational corporations. Fisheries are being transformed from industries or ways of life subject to the control and regulation of local, regional, and national authorities to a global enterprise dominated by a handful of transnational corporations (Nuttall, 2000).

Industrial development, deforestation, and pollution are also significant. In northern Russia, domesticated reindeer populations are decreasing due to the degradation of winter reindeer pastures by deforestation, industrial pollution, and overgrazing. Fewer winter pastures are available for reindeer as large territories are being occupied by the mining, oil, and gas industries, leading to greater pressure from grazing on increasingly fragile tundra and lesotundra ecosystems (Callaghan et al., 2002; Vlassova, 2002). Several ecosystems in northern Russia are already overgrazed by reindeer. The reindeer population of the Yamal Peninsula, for example, exceeds the carrying capacity of pastures by 1.5 times, with 70% of pasture registered as low quality (Vlassova, 2002).

In Yukon Territory, concern over contaminants and dietary risks include: (1) the risks associated with increased market food consumption (for example, fewer of the protective factors associated with traditional food use, lower nutritional intake, and higher saturated fat intake), and (2) risks associated with exposure to chemical contaminants from the consumption of traditional food. Concentrations of organochlorine compounds and heavy metals are known to be very low in most market food, but are of potential concern in traditional food. Standard government analyses assume therefore that market food does not contain chemical contaminants, and that risk from contaminant intake via traditional food will be related to the level of exposure; the higher the level of exposure, the higher the supposed risk (Receveur et al., 1998).

Thus, for some indigenous communities climate change may not be the most immediate issue of local concern. Yet the interrelations between industrial development, pollution and contaminants, international trade, sustainable development, and climate change (and their cumulative impacts) are poorly understood and further research is needed. With an increased focus on sustainable development of both renewable and non-renewable resources in the Arctic, future research on how local, regional, and national economies throughout the circumpolar North are being affected by climate change will need to contextualize arctic case studies with reference to the internationalization of production and exchange,

the globalization of economic and industrial activity, and the activities and influences of transnational corporations and transnational practices.

There is scientific difficulty in stating how far climate change alone has affected arctic marine ecosystems in the past fifty years, for instance, as the impacts of overfishing and over-hunting may be far greater (Sakshaug and Walsh, 2000). However, Finney et al. (2002) presented results that support a strong role for climate forcing in regulating abundance of northeastern Pacific fisheries over the last two millennia. Sockeye salmon return to spawn and die in the lakes in which they were born, releasing nutrients into the lake which accumulate in the sediments. By analyzing sediment cores from nursery lakes in Alaska, their research revealed the existence of multi-century regimes in salmon abundance. The two noticeable multi-century shifts in salmon abundance at ~100 BC (the beginning of a sustained period of low abundance) and ~AD 800–1200 (the beginning of a sustained period of high abundance) correspond to periods of major change in ocean–atmosphere circulation in the northeastern Pacific. Historical catch records, being of short duration, provide only a limited understanding of fish population dynamics and their response to climate change. This 2200-year record demonstrates that very low productivity regimes, lasting for centuries, can occur even without the influence of commercial fisheries, in response to climate changes and associated oceanic changes (Finney et al., 2002).

Nor is climate change the only cause of changes to the treeline and tundra. The overgrazing of reindeer pastures in northern Russia leads to the overgrazing of lesotundra, damaging shrubs, and has an impact on the treeline, pushing it further south in some areas (Vlassova, 2002). In Fennoscandia the development of reindeer husbandry over the last 100 years has also increased the risk of overgrazing. The shift from intensive to extensive reindeer husbandry probably reduced pressure on vegetation in some places; however it also meant that larger numbers of reindeer could be kept. In Finland, for example, the number of reindeer rose dramatically in the 1950s, with herds growing rapidly throughout Fennoscandia during the 1970s. The result was increasing grazing pressure over very wide areas (Bernes, 1996).

In Norway, the growing numbers of reindeer and herds, together with the reduction of available pasture, have strongly reduced the most important asset of Saami pastoralists, namely flexibility. As a result, it is increasingly difficult for Saami herders to cope with variations in climate and pasture conditions (Bjørklund, 2004). Herders have strategies for dealing with climatic variability or changes in pasture which are becoming harder to utilize for a number of reasons. For example, if pasture becomes too scarce in summer owing to growing herd sizes, or if conditions become difficult because of climatic fluctuations one year, herders might leave the area early and keep their reindeer longer on autumn and winter pastures, or move their herds to temporarily vacant neighboring pasture. This flexibility is becoming increasingly problematic as fences, pasture regulations, a growing number of herds, and changing management systems combine to reduce the possibility of using such strategies (Bjørklund, 2004).

Human activities, industrial development, resource use regulations, and global economic processes have far-reaching consequences for the environment and so magnify the likely impacts on indigenous livelihoods of variations in weather and climate. Indigenous economies are not self-reliant closed systems and although their involvement in global networks of production and consumption may provide means of strengthening and extending possibilities for arctic communities, they also introduce greater elements of risk and could make people and their livelihoods less resilient to coping with and adapting to climate impacts.

12.2.4. Renewable resource use and climate change

12.2.4.1. Climate change impacts: some key facts

Renewable resources will continue to be central to the sustainable development strategies of numerous arctic communities. However, renewable resources and the harvesting of renewable resources by indigenous peoples in the Arctic could be affected by global climate change and increased levels of ultraviolet radiation caused by ozone depletion. Climate change scenarios suggest that climate change will have impacts on marine and terrestrial animal populations, affecting population size and structure, reproduction rates, and migration routes (IPCC, 2001). Arctic residents, particularly indigenous peoples who depend on renewable resources for their livelihoods and cultural survival, will feel these climate change impacts first and most intensely.

However, because of the interdependence between arctic economies and global markets, indigenous peoples are multiply exposed – to climate change, to changes caused by the global processes affecting markets, technologies, and public policies, and to local and regional political and economic situations. It is important to contextualize climate change impacts with reference to other changes experienced by arctic residents. Being able to access traditional food resources and ensuring food security will be a major challenge in an Arctic affected increasingly by climate change and global processes.

This assessment shows that the results of scientific research and evidence from indigenous peoples (see Chapter 3) have increasingly documented climatic changes that are more pronounced in the Arctic than in any other region of the world. Yet although this indicates that the physical environment, as well as the flora and fauna, has been undergoing noticeable change, the impacts felt throughout the Arctic will be unique and will vary from region to region. Different climatic trends have been observed in different parts of the Arctic – while

average temperatures in the North American western Arctic and Siberia have been increasing over the last 30 years (e.g., annual temperatures in the Canadian western Arctic have climbed by 1.5 ºC and those over the central Arctic have warmed by 0.5 ºC), temperatures in Canada's Hudson Bay and in Greenland, particularly in the Davis Strait area, have decreased (Chapman and Walsh, 1993), suggesting that climate change involves regional cooling as well as global warming.

If the scientific projections and scenarios are realized, climate change could have potentially devastating impacts on the Arctic and on the peoples who live there, particularly those indigenous peoples whose livelihoods and cultures are inextricably linked to the arctic environment and its wildlife. Some scenarios suggest that the most direct changes will be noticeable in a reduction in the extent of sea ice and permafrost, less ice in lakes and rivers, pronounced reductions in seasonal snow, and the disappearance of the existing glacier mass, leading to a corresponding shift in landscape processes (Lange, 2000; Siegert and Dowdeswell, 2000; Weller, 2000).

Scientific research shows that over the last 100 years there has already been a significant reduction in the extent and thickness of arctic sea ice. Since 1979 alone, the extent of sea ice throughout the Arctic has decreased by 0.35%, and record reductions were observed in the Beaufort and Chukchi Seas in 1998 (Johannessen et al., 1999; Maslanik et al., 1999). Sea ice is highly dependent on the temperature gradient between ocean and atmosphere and on near-surface oceanic heat flow and will react swiftly to changes in atmospheric conditions (Lange, 2000). Atmosphere–ocean climate models project a reduction in sea ice of around 60% in the next 50 to 100 years under a scenario in which atmospheric CO_2 concentrations double. Models also project that permafrost will thaw more quickly in spring, but take longer to refreeze in autumn, and that the active layer boundaries will gradually move poleward, with most of the ice-rich discontinuous permafrost disappearing by the end of the 21st century.

Climate variability appears to have caused relatively rapid shifts in the organization of arctic marine ecosystems. In the Bering Sea ecosystem and the Barents Sea ecosystem climate-driven variability is significant (Sakshaug and Slagstad, 1992). There are difficulties, however, in establishing which of these changes result from natural environmental fluctuations and which result from human activities. In the eastern Bering Sea upper trophic levels have undergone significant changes in the past 100 to 150 years, largely due to commercial exploitation of mammals, fish, and invertebrates. Climatic changes may have contributed in part to the changes in animal populations. Higher ocean temperatures and lower salinities, changes in seasonal sea-ice extent, rising sea levels, and many other (as yet undefined) effects are certain to have significant impacts on marine species, with implications for arctic coastal communities dependent on hunting and fishing (Weller and Lange, 1999).

Most arctic species of marine mammal and fish depend on the presence of sea ice and many indigenous coastal communities depend on the harvesting of these species. The ice edge is unique among the world's ecosystems in that it moves thousands of kilometers each year, north in spring and south in autumn. Walrus, numerous species of seal, and cetaceans such as beluga and narwhal all follow the ice edge as it moves, taking advantage of the ready access to food and (for walrus and seals) the availability of ice to haul out on for sunning, mating, and raising pups in late winter and spring (an important time for Inuit hunting communities).

The almost complete elimination of multi-year ice projected for the Arctic Ocean is likely to be immensely disruptive to ice-dependent microorganisms, which will lack a permanent habitat. Preliminary results from research in the Beaufort Sea suggest that ice algae and other microorganisms may have already been profoundly affected by warming over the last 20 years. Research indicates that most of the larger marine algae have died out, and been replaced by a much less productive community of microorganisms more usually associated with freshwater ecosystems (see Chapters 8 and 9).

Walrus, seals, and whales are likely to undergo shifts in range and abundance in response to the projected changes in multi-year sea ice, while the migration routes of caribou will alter. These changes could impact upon the hunting, trapping, and fishing economies of many small, remote arctic settlements. Although warming may increase biological production in some wildlife species, the distribution of many species crucial to the livelihoods and well-being of indigenous peoples could change. Important wetlands may disappear, or drainage patterns and tundra landscapes will be altered significantly, which could affect ducks and other waterfowl. Changes in terrestrial vegetation will have consequences for reindeer herding, subsistence lifestyles, and agriculture (see Chapters 7, 11 and 14).

Terrestrial animals such as caribou and reindeer are important for indigenous communities throughout the Arctic and would be affected by climate change directly through changes in thermal stress in animals, and indirectly by difficulties gaining access to food and water. Arctic communities located on coastlines may be affected by rising sea levels, increased coastal erosion, and severe storms. The fortunes of subsistence fisheries will depend on marine fish stocks and their climate-related variations (Lange, 2000). As the amount of sea ice decreases, seals, walrus, polar bears, and other ice-dependent species will suffer drastically.

Recent observations have demonstrated that there has been a distinct warming trend in lowland permafrost of 2 to 4 ºC over the last 100 years (Fitzharris et al., 1996; Lange, 2000), leading to disturbances of animal and human activities due to thawing, thermokarst formation, and severe erosion. Further warming is likely to continue this trend and increase the likelihood of

natural hazards for people (particularly affecting hunting and herding), buildings, communication links, and pipelines. The documentation of widespread thawing of discontinuous permafrost in Alaska illustrates some of these hazards and the implications for habitat change and the physical infrastructure of communities. In western Alaska several communities in low-lying areas, including Shishmaref, Kivalina, and Little Diomede, are affected by recent climate changes and face severe problems as a result of erosion and thawing of the discontinuous permafrost (Callaway et al., 1999).

Unstable sea ice could make ice-edge hunting more difficult and dangerous. Temperature and precipitation changes could affect migration patterns of terrestrial mammals like caribou and alter breeding and molting areas for birds. Salmon, herring, walrus, seals, whales, caribou, moose, and various species of waterfowl are expected to undergo shifts in range and abundance (IPCC, 2001). Changes in snow cover could affect the growth and distribution of plants essential for survival of caribou and reindeer. Changes in snow cover could also make accessing hunting, fishing, and herding areas more difficult by dogsled, snowmachine, or other vehicles, making local adjustments in hunting practices and harvesting strategies necessary.

12.2.4.2. Indigenous observations of climate change

In many parts of the Arctic, indigenous peoples are reporting that they are already experiencing the effects of climate change. In Canada's Nunavut Territory, Inuit hunters have noticed the thinning of sea ice and the appearance of birds not usually found in their region; Iñupiat hunters in Alaska report that ice cellars are too warm to keep food frozen; Inuvialuit in the western Canadian Arctic report thunderstorms and lightning (a rare occurrence in the region); Gwich'in Athapaskan people in Alaska have witnessed dramatic changes in weather, vegetation, and animal distribution patterns over the last 50 years or so; Saami reindeer herders in Norway have observed that prevailing winds relied on for navigation have shifted and that snow cannot be relied on for traveling over on trails that people have always used and considered safe (see Chapter 3).

Indigenous peoples in Alaska, for example, have already reported that there has been little snow in autumn and early winter, but substantial snowfall in late winter and early spring (Chapter 3). According to local hunters, the lack of snow makes it difficult for polar bears and ringed seals to make dens for giving birth or, in the case of male polar bears, to seek protection from the weather. The lack of ringed seal dens may affect the numbers and condition of polar bears, which prey on ringed seals and often seek out the dens. People in northern coastal Alaska are concerned that hungry polar bears may be more likely to approach villages and encounter people.

Inuit observations of climate change have been recently documented for the Kitikmeot region of Nunavut (Thorpe et al., 2002). People have spoken of a changed climate in the 1990s compared with previous decades: increasing temperatures with earlier spring melts and later freeze-ups in autumn have meant periods of longer summer-like conditions, while weather has become variable and unpredictable. This change and variability has had many impacts on caribou. Migration routes and the location of calving grounds have shifted and food sources have sometimes become inaccessible. Inuit have recently noticed more frequent short-term changes in temperature, especially in freeze–thaw cycles, which, because these cycles help form an icy layer on the top of snow or tundra, prevent caribou accessing vegetation (Thorpe et al., 2002).

12.2.4.3. Consequences of climate change for the livelihoods of indigenous peoples: caribou hunting and reindeer herding

The case studies in section 12.3 provide detailed analyses of the current and potential consequences of climate change for the livelihoods of indigenous peoples. The case study on caribou hunting in Arctic North America (section 12.3.5), for example, shows how the location of modern-day human settlements relative to caribou migration routes has consequences for the success of community caribou hunting. Communities like Old Crow in Yukon Territory, located in the center of the range of large migratory herds, have opportunities to intercept caribou during autumn and spring migrations, whereas communities situated on the margin of a herd's range may have access to animals only during winter or briefly during the summer calving and post-calving periods. The range of a large herd can contract at low population levels and expand at high population levels, and the implications for local communities situated at a distance from a herd's range can mean a decline in successful hunting and even the abandonment of caribou hunting for several decades. Shifting migration routes because of climate change will have consequences for hunting success.

All caribou and reindeer herds depend on the availability of abundant tundra vegetation such as lichen for forage, especially during the calving season. Climate-induced changes to arctic tundra may cause major vegetation zones to shift significantly northward, as well as having an effect on freeze–thaw cycles. The timing and occurrence of ice crusts due to refreezing of molten snow layers, which might be affected by changes in climate, will be a major factor for the sustenance of caribou and reindeer herds (Lange, 2000). This will have significant implications for reindeer populations in relation to their ability to find food and raise calves. Future variations in weather and climate could mean a potential decline in caribou and reindeer populations and have an adverse effect on hunting and herding practices. This could threaten human nutrition for indigenous households and threaten a whole way of life for arctic communities.

Russian historical records from the 1800s and early 1900s provide startling documented evidence of devastating losses of reindeer stocks of Siberian indigenous herders due to occasional and dramatic weather events and environmental changes (Krupnik, 2000). Such changes also had severe social impacts, pushing wealthy pastoralists below the poverty line. Declines and increases in caribou and reindeer populations are cyclical. Reindeer populations display consistent instability, indicating that herds and grazing systems are strongly influenced by climatic variation (Chapter 17). Severe weather conditions in spring, or a late snow melt, can have significant effects on reindeer populations, resulting in the death of young or weak animals during winter periods of starvation (Lee et al., 2000). Research suggests that climate change may already be contributing to the decline of caribou and reindeer herds. For example, the caribou disappeared from northern East Greenland in 1900 through migration to West Greenland in search of an adequate food supply as a result of climatic changes; this, in turn, caused the arctic wolf to disappear by 1934 owing to the loss of its main source of food (WCMC, 1990).

The disappearance of some caribou on Canada's Banks Island may be linked to climate change according to recent research (see Riedlinger and Berkes, 2001; and the case study in section 12.3.1) and also the observations of Inuvialuit, as discussed by Nagy M. (2004):

> *In the '70s I guess, that's when they really started noticing it, muskox taking over. But [regarding] caribou, sometimes […] in the fall, we get freeze-up on the whole island. Then, before the snow is really deep, we get our mild weather and rain. Then it's cold enough for the rain to freeze on top the snow and that's when the caribou try to leave the island, even go out into the ocean. 'Cause they were eating mostly ice.*
>
> *We were still here when one year it happened. When dogs started seeing the caribou, they'd be running. Nothing wrong with them but they just stop and start kicking. They have too much water in their stomach, their heads are spinning. So a lot of big bulls died off by spring […]. There was even one year, that worst year that time, the cows didn't have any calves, they didn't. That hit them just before the rutting season.*
>
> *I don't think [the muskox] really pushed the caribou away. Like right now the caribou are just dying, now. […] in the fall time, […] when the weather is not good, the ones that are born, they just freeze when the weather is not good.*

Using the results of Wilkinson et al. (1976), Gunn et al. (1991) dismissed forage competition between muskox and caribou and linked the disappearance of caribou on Banks Island to changing climate conditions associated with earlier spring snow disappearance, warmer winters that are snowier (hence more difficult for accessing forage), and with higher incidence of freezing rain. Although annual die-offs of 60 to 300 caribou occurred during the winters of 1987–1988, 1988–1989, and 1990–1991 when freezing rains occurred (Nagy J. et al., 1996), Larter and Nagy (2000, 2001) concluded that the drop in number of Banks Island caribou in 1994 and in 1998 happened despite high calf production, high overwinter survival rates of calves, and less severe winter snow conditions. Thus, severe winter weather might not be the major cause of caribou decline. According to Nagy M. (2004), some Inuvialuit think that caribou do not like the strong smell of muskox and prefer to be away from them. Accordingly, some Inuvialuit say that caribou have moved out of the island to avoid muskox. Lent (1999) noted that reindeer herders in Alaska believed that "caribou and reindeer will avoid muskox, moving away when muskox enter their vicinity" but added "there is no quantitative evidence to support this contention, nor has a controlled study been undertaken". Hence expressing some of the distrust wildlife scientists might have towards local knowledge.

As Chapter 17 discusses in more detail, recent modeling studies indicate that the mean annual temperature over northern Fennoscandia is likely to increase by 0.3 to 0.5 °C per decade during the next 20 to 30 years, with the annual amount of precipitation increasing by 1 to 4% per decade. Such changes are likely to affect snow conditions and foraging conditions for reindeer. In Finland there is increasing concern about the effect of a changing climate on the winter snowpack and on the distribution of lichens, the main winter food for reindeer. Climate change is expected to mean that fast-growing vascular plants may out-compete slower growing lichens, which will affect the eating habits of reindeer. In Finland, Saami reindeer herders are aware of when reindeer numbers fall due to adverse weather and attempt to preserve their herds by adjusting the number of animals they slaughter (Lee et al., 2000).

12.2.4.4. Concerns over irreversible impacts

Indigenous peoples live with fluctuations in weather and climatic conditions. Experiencing year-to-year changes in weather, ice and snow patterns, animal behavior and movement, and in hunting conditions is part of life in the Arctic. Yet the trends currently being observed give concern over major, irreversible impacts on indigenous communities and livelihoods. For example, since the late 1970s Alaska Natives in communities along the coast of the northern Bering and Chukchi Seas have noticed substantial changes in the ocean and the animals that live there, particularly in the patterns of wind, temperature, ice, and currents (see also Chapter 3).

A significant collection of indigenous environmental observations was recorded during a study of environmental changes in Canada's Hudson Bay region. The results are published in *Voices from the Bay* by the Canadian Arctic Resources Committee and the Municipality of Sanikiluaq, a small Inuit community on the Belcher Islands in the midst of Hudson Bay. Completed

in 1996 and published in 1997, the study brought together 78 Inuit and Cree hunters and elders from 28 communities on the shores of Hudson and James Bays in a series of workshops held over three years to describe, record, and verify ecological changes in the region, including but not limited to climate change (McDonald et al., 1997). Observations include wholesale changes in location, number, and duration of polynyas – open water areas in winter – in eastern Hudson Bay, and changing routes of Canada geese (*Branta canadensis*) and snow geese (*Anser caerulescens*), but the study indicates that alterations in weather and climate are by no means uniform within the region. *Voices from the Bay* and other observations by indigenous peoples (see Chapter 3) illustrate an important and inescapable fact: that much of the impact of climate change on northern indigenous peoples will be channeled through ecological changes to which they will have to respond, cope, and adapt.

As indigenous peoples perceive and experience it, the Arctic is becoming an environment at risk (Nuttall, 1998) in the sense that sea ice is now unstable where hunters previously knew it to be safe, more dramatic weather-related events such as floods are occurring, vegetation cover is changing, and particular animals are no longer found in traditional hunting areas during specific seasons. The weather is becoming increasingly unpredictable and local landscapes, seascapes, and icescapes are becoming unfamiliar.

Hunters and herders in some places are already altering their hunting patterns to accommodate changes to ice, tundra vegetation, and the distribution of marine and terrestrial harvested species (Callaway et al., 1999). As the case study from Sachs Harbour shows (see section 12.3.1), physical environmental change is immediately observable in terms of reduced sea-ice cover and lack of old (or multi-year) ice around the community in summer, and the thawing of permafrost. These changes challenge Inuvialuit knowledge and understanding of the environment, and make prediction, travel safety, and resource access more difficult. The Inuvialuit, like most indigenous groups who live off the land, rely on their ability to predict environmental phenomena such as snow and ice conditions, the weather, and the timing of wildlife migrations. For the Inuvialuit, as is increasingly reported throughout the Arctic by many other peoples, seasons have become less consistent, and weather events have become less predictable in the last few years (Krupnik and Jolly, 2002).

12.2.5. Responding to climate change

12.2.5.1. Flexibility and adaptation

The Arctic has experienced significant climate change in the past, just as the global climate has changed historically in response to natural variations. What may seem to be relatively minor variations in temperature have produced large positive feedbacks in the environment that have often had dramatic impacts on physical and biological systems (e.g., Vibe, 1967). The successful long-term occupation of the Arctic by indigenous peoples has been possible, in part, owing to their adaptive capacity (in social, economic, and cultural practices) to adjust to climate variation and change. Hundreds and even thousands of years ago, arctic populations adapted to gradual or even rapid environmental change by settling amid favorable climate conditions and along the paths of animal migration routes.

The study of the origins, migration patterns, and socioeconomic development of arctic cultures is significant to any assessment of climate change in that it offers insight into long-term environmental adaptations, the impact of environmental change on humans, and in turn how humans have utilized resources and impacted upon the environment (e.g., Sabo, 1991). Historical, archaeological, and anthropological evidence suggests that indigenous peoples had elaborate ecological knowledge that was crucial to their successful adaptation to changing environmental conditions, as well as to seizing the opportunities presented by climate change. The archaeological and ethno-historical record reveals that, in dealing with climate change, resource availability, social and economic change, and the introduction of new technology, indigenous populations have developed significant flexibility in resource procurement techniques and in social structure.

Climate change or the overexploitation of animal and fish populations meant that arctic hunting bands would have been forced to move to other areas in search of game, or to have adapted and diversified their range of subsistence techniques. Odner (1992), for example, has argued that Saami populations in northern Norway coped with the periodic scarcity of wild reindeer in the middle ages by diversifying their subsistence activities, intensifying the exploitation of other species, moving on to other hunting grounds, developing techniques of animal husbandry, or by storing meat.

In the Canadian Arctic, Sabo (1991) showed how Inuit in the eastern Canadian Arctic coped with the effects of climatic change on the population dynamics, distribution, and availability of terrestrial and marine resources by rescheduling their hunting activities and adapting their hunting techniques, and by maintaining flexibility in settlement patterns and social organization. Developing an ecosystem model and reviewing evidence for climate change over a 1000-year period for southern Baffin Island, Sabo (1991) demonstrated that the rescheduling of resource procurement systems and the continuation of a flexible arrangement in Inuit settlement patterns and demographic organization ensured both the availability and production of food and acted as regulatory social mechanisms which were able to respond to environmental change. Sabo (1991) argued that, while there is paleoenvironmental evidence to suggest climate change did affect Inuit subsistence activities on Baffin Island during this period, climate change is only one of several factors contributing to adaptive responses. Rather than resulting

in environmental determinism, the ecology and climate of southern Baffin Island enabled successive human populations to develop long-term strategies of environmental diversification. By using a variety of resources and habitats the prehistoric population and historic Inuit retained a resilient human/ecosystem relationship during a long period of continuity and change.

The expansion of the Thule tradition across the North American Arctic, from western Alaska eastward to the central Canadian Arctic and beyond to Hudson Bay, Labrador, and Greenland offers another example of how indigenous peoples have adapted and migrated as the climate has changed. During the Neo-Atlantic Optimum (ca. AD 1000), the Canadian Arctic passed through a period of 400 to 500 years (the Scandic Period) during which mean summer temperatures were 1 to 2 °C below the current average to a warmer period with summer temperatures around 2 °C higher than at present. This warming period resulted in the Canadian eastern Arctic experiencing less summer sea ice, longer periods of open water, and ice-free summers. For Inuit groups, access was opened up to maritime habitats with a variety of marine mammals, mainly narwhal, beluga, harp seal and, significantly, the bowhead whale (Wenzel, 1995a). While this climatic shift changed the ecology of the Canadian eastern Arctic, the cultural effects of the Neo-Atlantic Optimum on coastal Inuit groups were also far-reaching. The major shift was perhaps the replacement of the paleo-eskimo Dorset culture by Thule migrants from the Beaufort/Chukchi Seas region, whose subsistence culture was underpinned by their dependence on the bowhead whale (Wenzel, 1995a). The eastward movement of these migrants was facilitated by the changing ecological conditions and the movement of the bowhead whale into previously ice-closed areas of the eastern Arctic (Wenzel, 1995a).

The Thule tradition bore the hallmark of what is the essence of successful indigenous resource use systems throughout the Arctic – flexibility in technology and social organization and an ability to cope with climate change, responding both to its associated risks and seizing its opportunities. The archaeological record, ethnohistorical accounts, and the memories of elders provide detailed accounts of how human life in the Arctic has always been dominated and influenced by periodic, irregular, and often dramatic ecosystem changes, triggered by periods of warming and cooling, extreme weather events, and fluctuations in animal populations (Krupnik, 2000).

12.2.5.2. Barriers to adaptation

Change is a fact of life for arctic peoples, and they have a rich heritage of cultural adaptations to deal with it. Many of the short-term (or coping) responses appear to be based on this tradition of flexibility and innovation. The transition from sedentary to nomadic subsistence livelihoods and vice versa was the key to the survival and sustainability of arctic indigenous cultures. Cultural and ecological diversity required flexibility and resilient coping strategies during periods of extreme change and subsistence diversity was the outcome of a successful cultural and social response to climate variation and the resource instability of the Arctic (Krupnik, 1993).

Yet, a word of caution must be added: while there are success stories in terms of adaptation to climate change, it would be wrong to assume that adaptation is simple and not fraught with difficulties. There are losers as well as winners when climate change challenges indigenous peoples to respond in ways that can mitigate the negative impacts. In the Canadian eastern Arctic, the Dorset people lost out while the Thule migration was facilitated by climatic change, and as research on the social consequences of climate change in Greenland shows, people living in towns with similar social and economic settings and political and institutional structures showed a marked difference in their abilities and readiness to adapt to changing conditions (see Rasmussen and Hamilton, 2001).

Environmental changes, particularly in climate and ocean currents, that have affected fisheries in West Greenland are well documented, as are the associated social and economic changes, especially at the beginning of the 20th century (Hamilton et al., 2000). As the waters of southern and west Greenland warmed, seals moved further north, making seal hunting harder for the Inuit population. Cod and other fish (halibut and shrimp) moved into the now warmer waters and made the development of a cod fishery possible. The development of fishing in West Greenland shows how climate change can provide opportunities for some people, some local communities, and some local regions. As Thuesen (1999) argued, the political and economic changes taking place in West Greenland at the beginning of the 20th century meant that Greenlanders were now involved in and participating in the new political structures of local municipal councils and two provincial councils established in 1908. In 1910, experimental fisheries were taking place in West Greenland and Greenlandic fishers were learning new skills in fisheries training programs. The west coast town of Sisimiut was able to take advantage of these new developments, advantageously situated as it is at the northernmost limit of the ice-free waters on the west coast.

For those Greenlanders who embraced change and the opportunities now arising, some were able to benefit more than others because they played crucial roles as local entrepreneurs and took advantage of the opportunities to diversify local economies. Thuesen (1999) argued that the development of Sisimiut as an important fishing centre was due in part to a strong sense of local identity and strong dynamism in the community – in short, people had a willingness to embrace change, to diversify the economic base, and to work to develop new industries. This stands in contrast to the development of the southwest Greenlandic town of Paamiut around the same time. Paamiut's development was based

largely on plentiful resources of cod. With few other resources available in commercially viable quantities, there was little incentive to diversify the local economy (Rasmussen and Hamilton, 2001). The concentration on a single resource demonstrated the vulnerability of Paamiut in the face of environmental change. The cod population began to fall, due to a combination of climatic change and overfishing, and the economy and population of Paamiut declined as a result (Rasmussen and Hamilton, 2001). This highlights the importance of recognizing that, in any adaptive strategy, local conditions and social differences are considerable factors in the success of a region affected by change, be it from climate, social, economic, or political factors. The development of cod fishing in Greenland also shows, however, how climate change and social change go hand in hand. Cod fishing developed at a time when climate change was having an adverse effect on seal hunting, yet the population of Greenland was also growing, making it necessary to find alternative ways for the majority of the population to make a living.

Arctic hunters and herders have always lived with and adapted to shifts and changes in the size, distribution, range, and availability of animal populations. They have dealt with flux and change by developing significant flexibility in resource procurement techniques and in social organization. Yet the ecological and social relations between indigenous peoples and animal species are not just affected by climate-induced disruption, changing habitats and migration routes, or new technology. The livelihoods of the indigenous peoples of the Arctic are subject both to the influences of the market economy and to the implementation of government policy that either contributes to a redefinition of hunting, herding, and fishing, or threatens to subvert subsistence lifestyles and indigenous ideologies of human–animal relationships.

Today, arctic peoples cannot adapt, relocate, or change resource use activities as easily as they may have been able to do in the past, because most now live in permanent communities and have to negotiate greatly circumscribed social and economic situations. The majority of indigenous peoples live in planned settlements with elaborate infrastructures, and their hunting and herding activities are determined to a large extent by resource management regimes, by land use and land ownership regulations, and by local and global markets. As the case study on Inuit in Nunavut shows (section 12.3.2), the mobility that Inuit once possessed to move in response to shifts in the pattern and state of their resource base is no longer possible. Inuit in Nunavut now live in communities that are a direct result of Canadian government policy and which represent hundreds of millions of dollars of infrastructure and other investment. Clyde River, for instance, which is home to about 800 people and more or less representative of the kind of infrastructure and services found across Nunavut, is the result of some Can$ 50 million of government investment. In today's social, political, and economic climate, migration to remain in contact with animals and, more broadly, to maintain traditional Inuit hunting livelihoods would seem to be virtually impossible.

Changes to settlement patterns and to the ecological relations between humans and animals often arise from government attempts to introduce new economic activities or to "sedentarize" indigenous peoples. In northern Russia and Siberia, for example, the Soviet authorities "industrialized" reindeer herding as a way of facilitating the development of the Soviet North. The new settlements and industries in Siberia came to depend on reindeer herders to supply them with meat. Today, in post-Soviet Russia, privatization and the transition to a market economy bring new challenges to reindeer herding peoples in Siberia and the Russian Far East, highlighting the dependence of arctic reindeer systems on the complex interlinkages between local, regional, and global economies.

In a similar vein, caribou management on the Canadian Barrens became an integral part of a broad program of social engineering – federal, provincial, and territorial authorities imposed management strategies based on their own (rather than Inuit and Dene) ideas about conservation and hunting (Usher, 2004). There are similar stories from other parts of the Arctic. For example, the introduction of reindeer to the Seward Peninsula in western Alaska during 1892 to 1902 was done to provide meat for Iñupiat communities, yet was also intended as a way of transforming Iñupiat from being subsistence marine mammal hunters to reindeer herders and thus to play an active role in the wider cash economy of the United States (Anderson and Nuttall, 2004).

Strict regulatory regimes and management practices imposed by states and federal and provincial agencies increasingly affect hunting and herding (Anderson and Nuttall, 2004). Some, while aiming, in principle, to protect and conserve wildlife also restrict access to resources. In Alaska, for example, state and federal policies make subsistence issues extremely complex. State and federal law define subsistence as the customary and traditional non-commercial use of wild resources and regulations limit the prospects of finding markets for caribou meat. Earning money through more commercial channels is not an option for Alaskan subsistence hunters. In northern Fennoscandia, Saami reindeer herders have traditionally ranged far and wide, crossing national borders as they follow their reindeer herds between winter and summer pastures. In modern times, political developments have restricted migration routes over the last 100 years or so. Economic development in the 19th and 20th centuries, such as mining, forestry, railways, roads, hydro-electric power, and tourism have all had an impact on traditional Saami livelihoods.

In Greenland, threats to the cultural and economic viability of hunting livelihoods in small communities come from transformations in resource management regimes and Home Rule government regulations, which conflict

with local customary practices and knowledge systems (Dahl, 2000; Nuttall, 2001). Caribou, whales, seals, and fish, which have traditionally been subject to common use rights vested in members of a local community, are becoming national and privately-owned divisible commodities subject to rational management regimes defined by the state and the interest groups of hunters and fishers, rather than to locally understood and worked out rights, obligations, and practices. As is still evident in some parts of Greenland today, it has traditionally been the case that no-one owns animals – everyone has the right to hunt and fish as a member of a local community. A caribou, fish, or marine mammal does not become a commodity until it has been caught and transformed into private property. Even then, complex local rules, beliefs, and cultural practices counter the exclusive sense of individual ownership (Nuttall, 2001). However, trends in caribou hunting since the 1980s are illustrative of general wildlife management policies in Greenland, where membership of a territorial, or place-based, community no longer gives hunters exclusive rights to harvest caribou. In West Greenland, caribou hunting was largely a family event until the 1970s. Kinship, locality, and territory were the mechanisms for regulating harvesting activities. Today, hunting rights are vested in people as members of social and economic associations irrespective of a local focus. Discussing the situation in central West Greenland, Dahl (2000) showed how the traditional hunting territories of various communities are not the same as the administrative boundaries that surround villages, towns, districts, and municipalities. The relevant territorial unit for hunting caribou (and other animals such as beluga and narwhal) is Greenland, rather than a place-based community.

Hunters and herders are thus constrained by institutional frameworks and management structures, as well as by the legal recognition to resource use rights. They are commonly experiencing a transition from herding and hunting, from what may be called a "way of life", to an occupation and industry. The similarities with commercial fisheries management in the circumpolar North are notable, especially the effects of the implementation of individual transferable quotas (ITQs). The ITQ system is a management response to overfishing and to declining catches of major fish species, particularly demersal species. Although designed to ensure the viability of fish stocks, sustainable catch levels, and economic efficiency, ITQ management results in the transformation of traditional common use rights in fish stocks into privately owned, divisible commodities. As Helgason and Palsson (1997) argued, ITQs represent the idea that both the human and natural worlds can be organized, controlled, and managed in a rational way. Nature is not only "presented as an inherently technical and logical domain, the project of the resource economist and manager is sometimes likened to that of the engineer or the technician". Helgason and Palsson (1997) described the public discontent in Iceland with the commoditization of fishing rights as a consequence of the ITQ system and which has resulted in fishing rights being concentrated in the hands of a few large operators – a discontent articulated in feudal metaphors such as "tenancy" and "lordships of the sea". The ITQ system, although ostensibly seen by economists and resource managers as a way of achieving the sustainable use of fish stocks, has in reality a social impact in terms of changing power relations within local communities and regional fisheries, by contributing to the concentration of wealth into the hands of a few large fishing vessel owners. The ITQ system has effectively meant the enclosure of the commons and the privatization of resources, which allows parallels to be drawn between fisheries and rural land use debates throughout the Arctic.

12.2.5.3. Opportunities for adaptation and response

Commercial, political, economic, legal, and conservation interests have reduced the ability of indigenous peoples to adapt and be flexible in coping with climatic variability. The contemporary reality for many hunters and herders is that they are placed in very inflexible situations. Faced with climate change they are not necessarily in a position to respond appropriately. However, indigenous peoples have demonstrated resilience and adaptability in the face of change. In the climate-changed Arctic that this assessment considers, how indigenous peoples can take advantage of the opportunities that may arise, as well as how they can modify or change their mode of production in response to climatic variability, for example by switching hunting and fishing activities, is a critical research need.

For some arctic peoples, the political and management systems are already in place that could assess the impacts of climate change, allow local and regional governments to act on policy recommendations to deal with the consequences, and improve the chances for indigenous peoples to deal successfully with climate change. Although complex, solutions to environmental problems are potentially realistic.

Significant political changes since the 1970s have included land claims in Alaska and Canada and the formation of regional governments in Greenland and Nunavut. Settlements include the Alaska Native Claims Settlement Act (1971), Greenland Home Rule (1979), the James Bay and Northern Quebec Agreement (1975–1977), the Inuvialuit Final Agreement (1984), and the Nunavut Agreement of 1992 (the Territory of Nunavut was inaugurated in 1999). These political changes often include changes in the ways that living and non-living resources are managed. A greater degree of local involvement in resource use management decisions has been introduced, including in some cases the actual transfer of decision-making authority to the local or regional level (CAFF, 2001).

In addition, significant steps have been taken with innovative co-management regimes that allow for the

sharing of responsibility for resource management between indigenous and other uses and the state (Huntington, 1992; Osherenko, 1988; Roberts, 1996). Examples include the Alaska Eskimo Whaling Commission, the Kola Saami Reindeer Breeding Project, the Inuvialuit Game Council, and the North Atlantic Marine Mammal Commission. Self-government is about being able to practice autonomy. The devolution of authority and the introduction of co-management allow indigenous peoples opportunities to improve the degree to which management and the regulation of resource use considers and incorporates indigenous views and traditional resource use systems (Huntington, 1992).

Co-management projects involve greater recognition of indigenous rights to resource use and emphasize the importance of decentralized, non-hierarchical institutions, and consensus decision-making. This presents tremendous opportunities for collaboration between indigenous peoples, scientists, and policy-makers concerned with the sustainable use of living resources (Caulfield, 2000). And it is within this new political and scientific environment of power sharing and dialogue that indigenous communities, scientists, and policy-makers can work together to find solutions (such as building flexibility into otherwise constraining wildlife management regimes) to the pressing problems climate change may bring to the Arctic. Although knowledge integration in co-management systems remains fraught with technical, methodological, and political difficulties (Nadasdy, 2003), some of the case studies presented in this chapter show how evolving forms of co-management institutions create opportunities to increase local resilience and the ability to cope with, respond to, and deal with change. For example, new governance mechanisms through the Inuvialuit Final Agreement of 1984 are helping Inuvialuit to negotiate and manage the impacts of change. For instance, the five co-management bodies established by the Agreement provide an effective means for Inuvialuit communities to communicate with regional, territorial, and federal governments and, indeed, to the Arctic Council.

The detailed case studies that follow show how climate change is having an impact on hunting, herding, gathering, and fishing activities. However, they also show that some of the impacts have been absorbed through the flexibility of the seasonal cycle and local ways of life. For the Inuvialuit of Sachs Harbour, for example, coping strategies relate to adjusting subsistence activity patterns: modifying timing of harvest activity; modifying location of harvest activity; modifying method of harvest activity; adjusting the species harvested; and minimizing risk and uncertainty. Yet, for indigenous peoples, dependence on animals and involvement in complex global processes, combined with the natural vulnerability of the Arctic and the concern with the accelerated nature of climate change, magnify the potential effects of global climate change on their cultures and livelihoods.

12.3. Understanding climate change impacts through case studies

12.3.1. Canadian Western Arctic: the Inuvialuit of Sachs Harbour

Sachs Harbour has been studied and reported on intensively through the Inuit Observations of Climate Change project, undertaken jointly by the Community of Sachs Harbour and the International Institute for Sustainable Development. The Inuvialuit (the Inuit of the Canadian western Arctic) themselves initiated the study because they wanted the documentation of the severe and disturbing environmental changes that they were witnessing. The project was undertaken with several objectives (Ford, 1999; IISD, 2000; Riedlinger and Berkes, 2001):

- to produce a video on how climate change is affecting the people;
- to disseminate Inuit observations to the world;
- to document local knowledge of climate change; and
- to explore the potential contributions of traditional knowledge to climate change research.

The project was planned and carried out using participatory research methods. Results are based on a 12-month study of Sachs Harbour covering all four seasons in 1999/2000, with follow-up visits for verification and project evaluation (Jolly et al., 2002). Inuvialuit perceptions shaped the study from the very beginning; the project started with a planning workshop which asked the people of Sachs Harbour *their* objectives and what *they* considered important for the project to focus on. Video documentation plans, research questions, and the overall process were all defined jointly by the study team and the community (Berkes and Jolly, 2001; Jolly et al., 2002).

The community of Sachs Harbour is located on Banks Island in the Canadian western Arctic. It is a tiny community of some 30 households, and the smallest of the six Inuvialuit communities in the region covered by the comprehensive native land claims agreement; the Inuvialuit Final Agreement of 1984 (Fast and Mathias, 2000). Sachs Harbour, a permanent settlement only since 1956, is an outgrowth of the white fox trade beginning in the 1920s (Usher, 1970). Many of the current residents have relations in the Mackenzie Delta area. Some are descendants of the Copper Eskimo of Victoria Island to the east; many are related to the Iñupiat (Alaska Inuit) who had earlier moved to the Delta.

There are no previous studies about how climate change may have affected resource use in the past on Banks Island. Major changes in resource use concern the development of the white fox trade and its subsequent collapse with the disappearance of the European fur market in the 1980s, and the dramatic changes in muskox and caribou numbers on the island. Muskox were present in extremely low numbers in the early 1900s, but populations increased in the latter half of the 20th century, giving Banks Island the largest muskox population in the

world. In the meantime, however, caribou numbers have declined. There is no consensus on the question of whether the caribou decline is related to muskox increase. Nor is there agreement regarding the impact of climate change on these two species, but a number of potential negative impacts are possible, including those related to extreme weather events (Gunn, 1995).

Although Sachs Harbour, as the permanent village, only dates from the 1950s, local observations, as captured by the Inuit Observations of Climate Change project, go back to the 1930s (Jolly et al., 2002). Perceptions of Sachs Harbour hunters and fishers are consistent in indicating that changes observed in the 1990s are without precedent and outside the range of variation that the Inuvialuit consider normal. Before addressing the observations of change and how the people have coped with them, it is necessary to review patterns of subsistence.

12.3.1.1. Patterns of subsistence and the impact of climate change

Some 20 species of terrestrial and marine mammals, fish, and birds were taken in 1999/2000 at Sachs Harbour. During the winter, people hunted muskox and, to a lesser extent, caribou, Arctic fox, wolf, polar bear, and ringed seals. Small game included ptarmigan (*Lagopus* spp.) and Arctic hare. As the weather began to warm in March and April, people headed out to numerous inland lakes to ice-fish for lake trout and Arctic char.

In May, fishing slowed down as the snow goose season approached. Banks Island supports a large breeding colony of snow geese. Goose hunting and egg-collecting were important community activities. Family groups camped at rivers and inland lakes, and the entire community harvested and processed geese, some of it for inter-community trade. The goose hunt was over by mid-June, as people returned to lakes to fish where there still was ice. They also fished for Arctic cod on sea ice and went sealing. With ice break-up in June and July, people hunted mainly for ringed seals, and some bearded seals, off the ice floes and from boats in open water. July through early September, people set gillnets for char, Arctic cod, and least cisco (*Coregonus sardinella*), and some did rod-and-reel fishing in lakes. In September, people turned to muskox and caribou.

In some years, including 1999/2000, the muskox hunt is a commercial harvest that employs almost the entire community throughout November. Guiding and outfitting for sport hunting for polar bears and muskox also provide employment and cash income. These commercial activities complement the subsistence harvest, and are a major source of cash income for the community.

The cycle of hunting and fishing varies from year to year, but the usual pattern has been affected by environmental changes being observed by the people of Sachs Harbour. These changes, as documented by IISD (2000), Riedlinger and Berkes (2001), and Jolly et al. (2002), may be summarized under five headings: physical environmental change; predictability of the environment; travel safety on land and ice; access to resources; and changes in animal distributions and condition (see Table 12.1).

Physical environmental change is most readily observable in terms of reduced sea-ice cover and lack of old (or multi-year) sea ice around the community in summer, and the thawing of permafrost. These changes challenge Inuvialuit knowledge and understanding of the environment, and make prediction, travel safety, and resource access more difficult. The Inuvialuit, like most indigenous groups who live off the land, rely on their

Table 12.1. Examples of environmental changes impacting upon subsistence activities (adapted from Riedlinger and Berkes, 2001; Jolly et al., 2002).

Physical environmental change
• Multi-year sea ice no longer comes close to Sachs Harbour in summer
• Less sea ice in summer means that water is rougher
• Open water is now closer to land in winter
• More rain in summer and autumn makes travel difficult
• Permafrost is no longer solid in places
• Lakes draining into the sea from ground thawing and slumping
• Loose, soft snow (as opposed to hard-packed snow) makes it harder to travel
Predictability of the environment
• It has become difficult to tell when ice is going to break-up on rivers
• Arrival of spring has become unpredictable
• Difficult to predict weather and storms
• There are "wrong" winds sometimes
• More snow, blowing snow, and whiteouts
Travel safety on the land and ice
• Too much broken ice in winter makes travel dangerous
• Unpredictable sea-ice conditions make travel dangerous
• Less multi-year ice means traveling on first-year ice all winter, which is less safe
• Less sea-ice cover in summer means rougher, more dangerous storms at sea
Access to resources
• It is more difficult to hunt seals because of a lack of mult-year sea ice
• In winter, cannot go out as far when hunting because of a lack of firm sea-ice cover
• Harder to hunt geese because the spring melt occurs so fast
• Warmer summers and more rain mean more vegetation and food for animals
Changes in animal distributions and condition
• Less fat on seals
• Observe fish and bird species never before seen
• Increase in biting flies; never had mosquitoes before
• Seeing fewer polar bears in the autumn because of a lack of sea ice
• More least cisco caught now

ability to predict environmental phenomena such as snow and ice conditions, the weather, and the timing of wildlife migrations. Seasons have become less consistent, and weather events have now become less predictable.

Travel safety is closely related to physical environmental change and loss of ability to predict the environment. For example, sea ice near the community is used for travel, ice-fishing, and seal and polar bear hunting. Sound knowledge of the sea ice and the ability to monitor and predict changes are critical to hunting success and safety. In the 1990s, people in Sachs Harbour observed increased ice movement in winter and spring, changes in the distribution of leads, cracks, and pressure ridges, as well as overall thinning of the ice. People say that in the past they rarely had to worry about the ice the way they do now; one has to be more cautious than ever before when traveling on ice.

Access to resources is often related to travel access and safety. For example, changes in the rate of spring melt and increased variability associated with spring weather conditions have affected access to hunting and fishing camps. When families go out to camps at lakes for ice fishing and goose hunting in May, they travel by snowmobile, pulling a *qamutik* (sled), staying on snow-covered areas or using coastal sea ice and frozen rivers. However, warmer springs have resulted in earlier, faster snow melt and river break-up, making access difficult. The availability of some species has changed due to the inability of people to hunt them under changing environmental conditions. For example, less summer ice means that ringed seals are harder to spot and hunt.

However, not all changes in species availability are related to access. Changes in animal distributions have also occurred, with respect to birds (many new mainland species never before seen on Banks Island), fish (two species of Pacific salmon), and insects. Some of the changes may operate through ecological mechanisms. Sachs Harbour hunters discuss and speculate on the impacts of environmental change on species distributions and availability. For example, warmer temperatures and higher rainfall may have increased summer forage for caribou and muskox. But these changes may also increase the risk of extreme weather events such as freezing rain in autumn that may cover the ground with a layer of ice, making forage unavailable.

12.3.1.2. Short-term and long-term responses to change

The Inuvialuit of Sachs Harbour draw on accumulated knowledge and experience in dealing with change. They recognize that they have always adapted to change – social, political, and economic change, as well as environmental change. When asked about the impact of environmental change on subsistence activities, most people are quick to point out that they always find some way to deal with changes. Change is a fact of life for indigenous peoples, and they have a rich heritage of cultural adaptations to deal with change. Many of the short-term (or coping) responses appear to be based on this tradition of flexibility and innovation.

Environmental changes observed in Sachs Harbour are not trivial, and these are having an impact on subsistence activities. However, many of the impacts have been absorbed through the flexibility of the seasonal cycle and the Inuvialuit way of life. Inuvialuit coping strategies mostly relate to adjusting subsistence activity patterns: modifying timing of harvest activity; modifying location of harvest activity; modifying method of harvest activity; adjusting the mix of species harvested; and minimizing risk and uncertainty. Table 12.2 provides examples of each.

Modifying the timing of harvest activity is often related to increased seasonal variability. Hunters adjust their seasonal calendars to deal with change. Since change is unpredictable, hunters also use waiting as a coping strategy; people wait for the geese to arrive, for the weather to improve, and so on. Modifying the location of harvest activity is often necessitated by physical changes. Changes related to sea ice require hunters to stay close to the community because of safety concerns. The thawing of permafrost in many areas has left travelers to make new trails to avoid slumps and mudslides. Also, hunters have had to use different modes of transport to adjust how they harvest animals.

Table 12.2. Short-term or coping responses to environmental change in Sachs Harbour: changing when, where, or how hunting and fishing takes place (adapted from Berkes and Jolly, 2001).

Modifying the timing of harvest activity
• Warmer temperatures and unpredictable sea-ice conditions mean hunters go out earlier for polar bear • Shorter springs and an increased rate of snow melt have reduced the time spent on the land; people return to the community after the goose hunt, instead of proceeding to lakes for ice fishing
Modifying the location of harvest activity
• Erosion and slumping at one fishing lake near the community has necessitated fishing at other lakes instead • More bare ground and unreliable snow conditions mean families travel over coastal sea ice rather than along inland routes
Adjusting how harvesting is done
• Use of all terrain vehicles instead of snowmobiles to travel to spring camps when there is not enough snow • Hunters take seals from boats in open water, necessitated by the lack of summer sea ice on which seals normally haul out
Adjusting the mix of species harvested
• More *qaaqtaq* (least cisco) caught in nets at the mouth of the Sachs River • Hunters are taking different kinds of mainland ducks previously rare in the area
Minimizing risk and uncertainty
• River- and sea-ice conditions monitored more closely • Only the more experienced hunters travel on certain types of sea ice

A major coping strategy is switching species. Reduced fishing opportunity in one area (e.g., spring ice-fishing in lakes) may be compensated for by an increase in another (least cisco). Climate change has brought new potential resources through range extensions. Pintail (*Anas acuta*) and mallard ducks (*A. platyrhynchos*), both mainland species, and white-fronted goose or "yellow legs" (*Anser albifrons*) and tundra swans (*Cygnus columbianus*), both historically rare on Banks Island, have been observed in increasingly larger numbers.

Hunters have adopted a number of strategies to minimize risk and uncertainty. In response to increased variability and unpredictability associated with the weather and other environmental phenomena, they monitor ice conditions more closely and take fewer chances. Hunters say that "you really need to have experience to travel on the sea ice now", and describe being more careful when they travel.

The short-term coping strategies summarized in Table 12.2 are ultimately based on cultural adaptations. Berkes and Jolly (2001) compiled from various sources a list of cultural practices which are considered to be adaptive responses to arctic ecosystems: (1) mobility and group size flexibility; (2) flexibility of seasonal cycles of harvest; (3) detailed local environmental knowledge; (4) sharing mechanisms and social networks; and (5) inter-community trade.

Table 12.3 provides a summary of these adaptive mechanisms and evidence from Sachs Harbour as to whether they are still viable. The first of these adaptive mechanisms is no longer operative owing to settlement of people into permanent villages, but the other four seem viable.

The flexibility of seasonal cycles and the creativity with which hunters take advantage of harvesting potentials are backed up by oral traditions and by Inuvialuit cultural values that emphasize the appropriateness of harvesting what is available and acting opportunistically.

Regarding local environmental knowledge (traditional or indigenous knowledge) and related skill sets, some have obviously been lost, and some are being transmitted incompletely. Certain kinds of skills that were once universal in Inuvialuit society have become restricted to relatively few families who are active on the land. For example, almost all teenage boys in Sachs Harbour can use guns, but not many can build snow houses. The nature of people's practical engagement with the environment has changed; skill sets and land-based knowledge have also changed. For example, hunters use GPS units for navigation and safety, a very recent skill. The use of snowmobiles since the 1970s, also a new skill, has necessitated a greater knowledge of ice conditions because sled dogs can sense dangerous ice while snowmobiles cannot.

Sharing mechanisms for food and social networks for mutual support are still very much in evidence in Sachs Harbour, especially within extended family units and in providing for elders. A relatively small number of hunters account for most of the harvest; thus, relatively few people are providing for the families of occasional hunters and non-hunters. The imbalance is addressed by new forms of reciprocity whereby food-rich members of extended families share with cash-rich members, thus bringing wage income into the realm of sharing relationships. Inter-community trade is extensive. Sharing between communities does not seem to have declined but rather increased in importance. Sachs Harbour has an abundance of snow geese and muskox, and these are exported to other communities, in return for caribou and beluga whale products. These exchanges use the norms of generosity (giving without asking), sharing and generalized reciprocity, and not the Western rules of economic exchange involving cash exchange.

In sum, the Inuvialuit of Sachs Harbour have coped with the effects of recent climatic changes by modifying when, where, and how hunting and fishing are carried out. These coping strategies borrow from traditions of

Table 12.3. Cultural practices which may be considered adaptive responses to changes in the arctic environment, and evidence of their viability in Sachs Harbour (adapted from Berkes and Jolly, 2001).

Cultural practice	Viability–evidence from Sachs Harbour
Mobility of hunting groups; seasonal settlements; group size flexibility with grouping and regrouping of self-supporting economic units	No longer operative owing to permanent settlements; compensated for by the use of mechanized transport to increase mobility of family groups and all-male hunting groups
Flexibility of seasonal cycles of harvest and resource use, backed up by oral traditions to provide group memory	Source of major short-term coping strategies, aided by rapid transport and communication technology to monitor animal population movements
Detailed local environmental knowledge (traditional knowledge) and related skill sets for harvesting, navigating, and food processing	Underpins ability to change when, where, or how subsistence harvesting occurs; loss of universality of some skills; loss of some knowledge and skills compensated for by new knowledge and skills
Sharing mechanisms and social networks for mutual support and risk minimization; high social value attached to sharing and generosity	Sharing of food and associated social values still important, especially within extended family units; special considerations for elders; new forms of reciprocity involving cash
Inter-community trade along networks and trading partnerships, to deal with regional differences in resource availability	Active inter-community networks, especially within Inuvialuit region; more extensive than practiced by previous generations; norms of generosity and generalized reciprocity still alive

flexible resource use, and dynamic traditional environmental knowledge and skills. Also important among adaptive strategies is food sharing through intra-community social networks and inter-community trade. All these cultural practices are still largely intact in Sachs Harbour and the Canadian western Arctic in general. All these strategies provide considerable buffering capacity to deal with climate change, or with any other kind of social or environmental perturbation.

12.3.1.3. Climate change and social and ecological relations

There is no evidence that climate change, as observed in the 1990s, has altered the ecological relations between the people of Sachs Harbour and their resources, or altered social relations within the community. It has not resulted in increased or decreased pressures on any of the major resources. However, it has had some consequences for the local perceptions of the environment and local cultural understandings of resources. For example, the Inuvialuit of Sachs Harbour are concerned about the impact of the lack of sea ice in the summer on ringed seal pups. Some of them are also concerned about the risk of extreme events to animal populations, such as the potential impact of freezing rain on caribou forage.

One major impact of climate on the local perception of the environment concerns the issue of loss of predictability. Land-based livelihoods in the Arctic depend on the peoples' ability to predict the weather (is the storm breaking so I can get out?), read the ice (should I cross the river?), judge the snow conditions (could I get back to the community before nightfall?), and predict animal movements and distributions. A hunter who cannot predict the weather or read the ice would be limited in mobility; one who cannot decide what to hunt and where cannot bring back much food.

Climate change has the potential to impact on indigenous environmental knowledge and predictive ability, thus damaging the self-confidence of local populations in making a living from their resources. Such changes may ultimately leave them as strangers on their own land. Arctic peoples are experts at adapting to conditions that outsiders consider difficult. However, climate change impacts raise the issues of speed and magnitude of change, as compared to how fast people can learn and adapt. The evidence from Sachs Harbour hunters indicates that current environmental change is beginning to stress their ability to adapt. Rapid change requires rapid learning, and unpredictability superimposed on change interferes with the ability to learn. Predictability is affected by extreme weather events and higher variability, and appears to be an area of climate change research that deserves consideration in its own right.

Even though this case study focuses on impacts and adaptations associated with harvests and subsistence, climate change also has other economic and cultural consequences. For example, in addition to harvesting implications the lack of sea ice also makes some people "lonely for the ice", as the ice is a central feature of Inuvialuit life (Riedlinger and Berkes, 2001). Other environmental changes that are permafrost-related (e.g., thaw slumps, soil erosion) may not be a major threat to subsistence, but may have direct impacts on other aspects of community life, such as the maintenance of buildings and roads.

12.3.1.4. Climate change impacts in context

Inuvialuit society in Sachs Harbour has been affected by many social and environmental changes over recent decades. Major changes in subsistence and other resource use patterns have been caused by changes in global fur markets (white fox), commercialization of muskox (early 1900s depletions), and their subsequent protection followed by population recovery. These changes, plus government policies, have resulted in major social and economic transformations in Inuvialuit society, turning these migratory hunting peoples into village-dwellers who use mechanized transport to go out on the land. Further changes in recent years have seen the introduction of commercial muskox hunts, and sport hunting based on muskox and polar bears.

Compared to these major changes, the impact of climate change is relatively minor, at least so far, and it is not beyond the ability of the community to adapt. However, climate change is a relatively recent event, and the ability of Sachs Harbour Inuvialuit to respond to and cope with it, mainly by adjusting subsistence activities, may not be a reliable indication of the community's ability to adapt in the future. How much change can be accommodated by the Inuvialuit and their resource use systems? Elsewhere, recent publications have focused on the *resilience*, or the amount of perturbation that the Sachs Harbour hunting system can absorb and adapt to by learning and self-organization (e.g., Berkes and Jolly, 2001). The question of resilience is important because little is known about building adaptive capacity in the face of climate change.

Evolving co-management institutions in the area create additional opportunities to increase resilience and the ability to deal with change. New governance mechanisms through the Inuvialuit Final Agreement of 1984 seem to be helping the people of Sachs Harbour to negotiate and manage the impacts of change. There are five co-management bodies established through the Agreement that make it possible for the Inuvialuit communities in the area to communicate with the regional, territorial, and federal governments, and eventually with the Arctic Council.

Co-management has created linkages that were not possible only a few years ago. For example, indigenous hunters have been interacting with scientists in meetings such as the Beaufort Sea 2000 Conference, organized by one of the co-management agencies, the Fisheries Joint Management Committee (FJMC, 2000). Co-management bodies, connecting local-level institutions with govern-

ment agencies, provide vertical linkages across levels of organization and horizontal linkages across geographic areas. Berkes and Jolly (2001) hypothesized that such governance mechanisms have the potential to contribute to learning and to self-organization, and hence to build adaptive capacity to deal with change.

12.3.2. Canadian Inuit in Nunavut

The impact of climate on Inuit has been a dominant, if not the predominant, theme in Eskimo anthropology since Franz Boas (Boas, 1888) undertook research on Baffin Island. At a time when the study of hunter-gatherers has become a virtual sub-discipline within anthropology, the "attribute" that still sets Inuit apart from the Kalahari San and other hunting peoples is the same one that European visitors to Nunavut, from Martin Frobisher (an early explorer) to today's tourist, remark upon. That is, how can any people adapt to the arctic environment, and to most people the arctic environment is epitomized by climate, especially the cold and the long, dark winters.

This case study focuses on the adaptability (or adaptiveness) of the traditional Inuit economy in Nunavut in a (presumed) time of climate-induced ecological instability. The relationship between Inuit ecology and Inuit economy is almost too obvious. Inuit are hunters and the most referenced passage in Boas's seminal *The Central Eskimo* (Boas, 1888) is about the relationship between sea ice, ringed seal distribution, and Inuit hunting and settlement. So a part of this case study is necessarily about Inuit hunting and wildlife harvesting. In other words, it will speak to the production component of the traditional economy, particularly Inuit hunting and the production of *niqituinnaq* (real food) including what at Clyde River (the community from which much of the material in this case study is derived) is called *ningiqtuq* – the sharing or, put formally, the Inuit system of resource allocation and redistribution.

Gaining an understanding of how environmental change due to a warming (or cooling) climate may affect the material aspects of Inuit resource production (i.e., the economics) is important. And so are the possible effects of climate-induced ecological instability on the traditional economy because it is the socio-cultural rules that order who gets what when that make the economy Inuit.

With regard to generating hypotheses, or at least envisioning scenarios, modern workers have the benefit of the archaeology and paleoclimatology undertaken over the past 40 years in the North American Arctic. Much of this was to answer questions about how climate has influenced the economics of Inuit life. There is less information about the Inuit economy as it is impossible to know exactly how a seal or caribou was shared within communities, let alone who received what piece, 500 or 1000 years ago. However, as Inuit economics and economy are linked, there is at least the possibility, using data about past changes and about how the system currently functions, to model the socio-economic impact among Nunavummiut (the Inuit of Nunavut) because of a large-scale change in climate.

12.3.2.1. Inuit subsistence and climate: the long-term record

The relations between climate and Inuit material subsistence and cultural adaptation can be examined through what is known from climatology, physical oceanography, and biology about two long-term climate trends. These are the Little Climatic Optimum–Medieval Warm Epoch (also known as the Neo-Atlantic Period, ca. AD 1000–1250), and the Second Climatic Optimum/Neo-Boreal Period/Little Ice Age, which lasted from ca. AD 1550 to 1900 (Andrews and Andrews, 1979; Grove, 1988; Lamb, 1982; Vasari et al., 1972).

Data from northern Europe, Iceland, and the eastern Arctic indicate that during the Neo-Atlantic Period temperatures across the high latitudes of the North Atlantic region were as much as 2 to 2.5 ºC above the annual average that prevailed in the eastern Arctic through most of the 20th century. Conversely, the Little Ice Age involved a significant cooling of this region, with the most pronounced thermal effect in summer. Data from northwestern and mid-Europe suggest that summers

Box 12.1. Inuktitut terms

Akpallugitt	form of sharing between individuals ("inviting in")
Ilagiit	extended family
Isumataq	head of an *ilaqiit* (lit. "one who thinks")
Katujiyuk	apportioning of meat within a cooperating task group
Minaqtuq	commensal sharing/distribution of stored food
Nalaqtuk	behavioral terms meaning respect or obedience
Ningiq	a share of a hunted animal
Ningiqtuq	to share a portion of a hunted animal
Niqiliriiq	those who share; "neighbors"
Niqisutaiyuq	a form of commensal sharing
Niqitatianaq	transfers of food between two unrelated hunters
Niqituinnaq	meat from a hunted animal ("real food")
Nirriyaktuqtuq	commensal meal
Nunavummiut	people of Nunavut
Paiyuktuq	a gift of food (related forms: *quaktuaktuq*, *niqisutaiyuq*)
Quaktuaktuq	a form of commensal sharing; food gifts to close affines
Sila	weather, climate; also: mind, consciousness
Tigutuinnaq	transfers (usually food) from an *isumataq* to a subordinate
Tugagauyuk	transfers (usually food) from a subordinate hunter to superior kin
Uummajusiutiit	unrelated cooperating hunters
Ungayuk	behavioral term meaning affection or solidarity
Umiaqa	traditional woman's boat
Qayaq	kayak

averaged 0.5 to 0.8 °C less then those in the preceding moderating Pacific Period. Further north, in Scandinavia, the first half of the 17th century saw 13 summers at least 1 °C colder then the estimated average for the 16th century (Briffa et al., 1990; Pfister, 1988).

These episodes also produced large-scale positive feedback in the North American arctic ecosystem. The impact of each episode on northern physical and biological systems in turn correlates with climate-related adaptive adjustments by Inuit (see Barry et al., 1977; Dekin, 1969; Maxwell, 1985).

The most discussed episode is the Second Climatic Optimum, which warmed the North American polar stage from the Chukchi Sea to West Greenland. This warming, beginning around AD 1000, saw the central and eastern Canadian Arctic experience a spatial and temporal reduction in the amount of seasonal sea ice present.

This change in the physical environment created extensive new range for bowhead whales and for longer periods. And the expansion of bowhead whales from north Alaskan waters eastward (while North Atlantic bowhead whales were able to penetrate farther west) enabled Thule Culture people, the direct ancestors of modern Inuit, with their whale hunting experience, to follow. With a technology adapted to exploit a resource that the indigenous population of this part of the Arctic could not, the migrants rapidly displaced the late Paleo-Eskimo population that had developed *in situ* over the previous two millennia from the whole of Nunavut, Ungava–Labrador, and Greenland. Thus, while Thule Culture lasted only the few centuries that this extreme warm period allowed large whales passage into most of the Canadian Arctic, many of the technologies that the *Qallunaat* (non-Inuit) world associates with Inuit – dog traction, the *umiaq* and *qayaq*, and large marine mammal hunting – are Thule legacies.

The Little Ice Age, the deep cold that set in following a transitional cooling from the Medieval Warm Epoch, is the reason why the Inuit culture that Europeans met as they quested for a northern route to Cathay looked as it did (and still looked until about 1970). The long summers with almost ice-free open water were gone and, except on the western and easternmost fringes of the Inuit area, so were bowhead whales. The whole tenor of Inuit life had changed.

The winter security that came with the harvesting of a 20- or 30-tonne whale was gone and so was the large supply of fuel and building material that came with capturing a bowhead whale. Instead, Inuit developed what McGhee (1972) somewhat over-generally called a "*Netsilik* adaptation" based on the exploitation of a variety of seasonally available smaller prey species, chiefly caribou in summer, ringed seals through the winter, and anadromous Arctic char during their passage to and from the ocean.

In addition, the Inuit pattern of winter settlement across much of Nunavut changed from the land to the sea ice and the Thule Culture Classic Stage semi-subterranean whalebone and boulder house was abandoned in many areas for the snow *igliuk* or iglu. Overall, Inuit became less sedentary because large supplies of food could no longer be rapidly developed and the new primary resource suite comprised species that were highly mobile and/or elusive.

12.3.2.2. *Ningiqtuq*: the traditional/contemporary economy

An economy is the orderly movement of goods and services from producers to consumers (Langdon, 1986).

> *…a subsistence economy is a highly specialized mode of production and distribution of not only goods and services, but of social forms…* Lonner, 1980

An extensive discussion on the economy of Nunavut is beyond the scope of this case study. However, other than in the territorial capital and main regional government centers, the term "subsistence", as it is used by Lonner (1980), describes the situation for the rest of Nunavut.

Table 12.4. Clyde Inuit *ningiqtuq* interaction sets. *Ningiqtuq* is generally seen as a multi-layered strategy by which participants achieve the widest possible intra-community distribution of resources. However, while Damas used *ningiq* to refer only to the social movement of *niqituinnaq*, *ningiqtuq* is conceptualized here as a set of socio-economic operations that also encompass labor and non-traditional resources.

Interaction set	Flow direction	Reference
Traditional	1a. *isumataq* << *ilagiit* subordinates	*Tugagaujuq*[a]
	1b. *isumataq* >> *ilagiit* subordinates	*Tigutuinnaq*[a]
	2. father-in-law << son-in-law	*tugagaujuq* (?)
	3. *isumataq* >> community	*Nirriyaktuqtuq/minatuq* (?)
Modern	4. between unrelated hunters	*Uummajusiutiit*
	5. *angijukak* << unrelated hunters	*Taliqtuq*
	6. *angijukak* >> community	*Nirriyaktuqtuq* (?)
Other	7. between unrelated young and elders	*nalaktuq* related
	8. between same generation non-kin; generally among the elderly	inviting in and "gifting"

[a]*Tugagaujuq* and *tigutuinnaq* are complementary and participants are generally seen as being *niqiliriiq* (sharers of food).

Put another way, it is a mixed economy (sometimes described wrongly as a dual economy) in which traditional and non-traditional resources – represented by wild foods and money, respectively – interact, although "optimal economy" is probably a more accurate description. The reality for most Nunavummiut is that the best return for one dollar comes from hunting, but without a dollar hunting is not possible. What is optimal (i.e., how much of each resource type is best) differs from household to household, but few households can manage reasonably without some mix of country and imported food. As Fienup-Riordan (1986) observed, "…[monetary income] is perceived as the means to accomplish and facilitate the harvest, and not an end in itself".

With respect to the traditional economy, this case study concentrates on the social form(s) that organize the material flow of food once it has been captured. To some extent, these rules also apply when money is "captured" (Wenzel and White, 2001). However, this is more uneven owing to the scarcity of money and the costs that are almost always associated with its acquisition.

12.3.2.3. The system in outline

Ningiqtuq is not a single defined process by which seal meat or *maktaaq* are distributed. It is generally translated as meaning "to share", but it is in fact a web of social mechanisms for distributing and redistributing food and other resources. How allocation is accomplished differs across Nunavut (see Collings et al., 1998; Damas, 1972), but the term is used in almost all regions of the territory to describe the overall process of transferring food between individuals, households, and across entire communities. Table 12.4 outlines the array of distributional mechanisms in Clyde River. Not all the processes included in the table are "traditional", there are several that the older generation of Clyde River people consider the result of modern village circumstances. However, each form shown was referenced by at least three informants to a traditional type or behavioral precept (see Table 12.5).

As Table 12.5 shows, food sharing at Clyde River is a multi-level system that encompasses social relations ranging from the action that occurs between paired isolates (as in *akpallugiit*) to means that span the entire community (*minaqtuq*). And while *ningiqtuq*, as practiced today by Clyde River Inuit, includes aspects related to the changed pattern of settlement that came about through Canadian government centralization policies in the 1950s and 1960s, organization of the system based on traditional principles of, foremost, kinship and, second, intra-generational solidarity, remains.

In functional terms, almost every form of sharing encompassed by the concept of *ningiqtuq* has as its basis a social, rather than an economic, referent. The greatest sharing activity in terms of social focus occurs within the context of the restricted extended family. Within the *ilagiit* essentially all members are in a *niqiliriiq* (literally, "those who share food") relationship. And it is within the *ilagiit* that the *nalaqtuk* (Damas' (1963) respect–obedience dyad, but which may be conceptualized as responsibility–obligation (Wenzel, 1981)) directive that structures intergenerational/interpersonal behavior is most apparent.

Whereas *tugagaujuk–tigutuinnaq* activities function almost wholly within the social context of the extended family, as Tables 12.4 and 12.5 indicate, mechanisms for the more generalized distribution of food resources are also present. The main one being *nirriyaktuqtuq*, or communal meal. Such commensalism may be restricted to the *ilagiit*, particularly when resources are scarce, or may include a large segment of the community. In either circumstance, communal meals are always held in, or immediately adjacent to, the dwelling of the hosting extended family head.

12.3.2.4. Generalized reciprocity

A major reason for presenting an exhaustive review of the Inuit economy in Nunavut is to dispel the commonly held view that the Inuit traditional economy can be summed up by the term generalized reciprocity. It cannot, and this is as inappropriate as saying that catching a seal sums up the traditional economy (Collings et al., 1998; Damas, 1972; Wenzel, 1981, 1989, 1995b, 2000).

Table 12.5. Aspects of Clyde Inuit *ningiqtuq*.

Social context	Behavioral directive	Form	Description
1a. Individual	*Ungayuk* (solidarity–affection)	*akþallugiit*	inviting in guests (typically same generation non-kin)
1b.	*Ungayuk*	*quaktuaktuq/niqisutaiyuq/ þaiyuktuq*	food gifts to close affines and non-kin (generally restricted to elders)
1c.	*Ungayuk*	*niqitatianaq*	*Uummajusiutiit* ("partnered" hunters)
2a. Intra-*llagiit*	*Nalaqtuk* (respect–obedience)	*niqiliriiq*	*tugagauyuk-tigutuinnaq* complementary
2b.	*Nalaqtuk*	*nirriyaktuqtuq*	restricted commensalism
3a. Inter-*llagiit*/community	*Ungayuk*	*nirriyaktuqtuq*	open commensalism
3b.	*Ungayuk*	*minaqtuq*	distribution of stored food
3c.	*Nalaqtuk*	*Katujiyuk*	within task group

The *ningiqtuq* economy is socially complex. Although some of its forms are general in scope – commensalism being an example – most of its operations are founded in balanced reciprocal relations, with reciprocity enforced by social precepts that provide for inclusion as well as sanction.

12.3.2.5. Climate change and the economy

Warming versus cooling

Based on what is known of the impacts of the two most recent major climatic events to have affected the Inuit (section 12.3.2.1), warming would appear to be a good thing for the Inuit economy; the Second Climatic Optimum spurred an amazing cultural expansion, with Inuit traveling nearly 8000 km in barely 200 years, in the process displacing a cultural tradition nearly 2000 years old.

However, the *Netsilik* hunting adaptation (section 12.3.2.1) was a response to a cold environment and the *ningiqtuq* economy differs markedly from the economy practiced around bowhead whaling in North Alaska since at least the 19th century (Burch, 1985; Spencer, 1959). (This is not to say that a *ningiqtuq*-type of sharing is absent among Iñupiat (Bodenhorn, 2000), but rather that it is overlain by a more corporately-oriented mechanism.) This suggests that the present warming, should it continue to increase, may not be good for either the traditional economy or the subsistence economy.

The best evidence for testing this theory comes from the West Greenland work of Vibe (1967) on the effect of climate change on northern biota and Inuit resource use. Using a 150-year database (1800–1950) drawn from Danish colonial meteorological, ice, and trading records, Vibe (1967) correlated the episodes of warming and cooling over this period with the rise and fall in the capture of ringed seals and polar bears. By comparing the official trading records with sea-ice conditions during this period it was apparent that when the local climate ameliorated, which reduced the duration of the seasonal sea ice, the capture of both species declined. Vibe (1967) also pointed out that ringed seals are the main prey item for polar bears and that a stable sea-ice environment is critical to ringed seal ecology, especially for successful spring pupping.

Vibe's study, which drew on the rich scientific and commercial records available from Greenland, is unique in those terms. However, the conclusion that ringed seal pup production suffers when increased temperatures seasonally destabilize the sea ice and that this affects the polar bear harvest supports statements by Inuit based on their long empirical experience with both species.

Ringed seals

Ringed seals and polar bears are as important now as at any time in the past to the economic well-being of small Nunavut communities. The ringed seal, or *natsiq*, is one of the principal items in the traditional Inuit diet. Besides being the most abundant marine mammal in circumpolar waters, ringed seals are present throughout the year along the entire Nunavut coastline. Their presence through winter offsets the absence of most other important food species at this time. Finally, *natsiq* provide high quality nutrition when few alternatives, except for the most costly imported foods, are available.

To Inuit, *natsiq* are an all-season, all-year food. At Clyde River, where it is one of eighteen species of mammal, fish, and bird that are regularly harvested, ringed seals comprised 54% of the edible biomass captured by Clyde hunters between 1979 and 1983 (Wenzel, 1991). In 1979, of the 169 tonnes of country food that came into the community, 109 tonnes (64.9%) were ringed seal (Wenzel, 1991). Thus, a substantial reduction in the seal harvest would have profound implications for the ecological economics of Inuit life. This is even more apparent in terms of the seasonal dietary contribution of ringed seal. Ringed seals represent 58% of the winter food supply, but 66, 81, and 64% in spring, summer, and autumn, respectively (Wenzel, 1991). Caribou, the next most important food species by edible weight, comprises 39% of the winter food capture, and 30, 13, and 18.5% for the other seasons, respectively.

A substantial reduction in ringed seals would also affect the overall economy of Inuit subsistence. This is mainly because there is no other species on the land or in the waters of Nunavut that is as abundant or as available as *natsiq*. In simple terms, no other species could sustain the subsistence requirements of Inuit. But, more importantly, the cultural meaning of *ningiqtuq* would suffer. This is because *niqituinnaq* (real food) is quite literally the stuff of sharing. To hunt, catch, and share this kind of food is to an Inuk the essence of living *Inuktitut* (Wenzel et al., 2000). Ringed seal is as much a cultural commodity in Inuit subsistence culture as it is an item of diet.

Polar bears

Polar bears also play an important role in the contemporary subsistence system. Like ringed seals, they are also *niqituinnaq*. And, if climate change affects the ecology and distribution of ringed seals, it will thus affect polar bears. However, in food terms, polar bears, especially when compared to ringed seals, are of minor importance. Nevertheless, they represent one of the few sources of money that Inuit can access through traditional activities. While polar bear hides have long had a market outside the traditional uses to which Inuit put them, a polar bear hunt sold today to an American, Swiss, Mexican, or Japanese sport hunter may bring as much as US$15 000 per bear to a community. Rifles, snowmobiles, and gasoline are now as effective a part of Inuit subsistence as dog teams, seal oil lamps, and fishing leisters were sixty years ago. (Why this is requires looking at Canadian internal colonial policy from 1945 to 1985.)

The quandary that confronts every Inuk hunter is how to gain access to money at a minimum cost in time. While hunting produces large amounts of high quality food – the Government of Nunavut estimates that it would cost approximately Can$ 35 000 000 to replace this harvest production – virtually none of this traditional wealth can be converted into the money needed to purchase, operate, and maintain the equipment hunters use. Yet abandoning hunting for imported food would not only be less healthy but would also be immensely costly. But this is not in fact a viable alternative as approximately 30 to 35% of adult Nunavummiut are unemployed and another 15 to 20% are underemployed or only able to work seasonally.

Polar bear sport hunting helps meet the cash resource needs of many hunters while imposing a minimal cost in time. In 2001, ten sport polar bear hunts at Clyde River brought approximately Can$ 212 000 into the community, with half going directly to the Inuit – more income than entered Clyde River from four years of hiking, kayaking, and other forms of ecotourism. And these hunt revenues directly capitalized the purchase of five snowmobiles, a 7 m inboard-engine equipped boat, a large outboard engine, and two all-terrain 4-wheel drive vehicles (some Can$ 75 000–90 000 of equipment) by sport hunt workers for use in sealing and other subsistence activities. (Note: hunt workers purchased one all-terrain vehicle and one snowmobile for relatives not involved in sport hunting; money does enter the *ningiqtuq* sharing system.)

Projected climate change

If the projected climate change scenarios are correct (see Chapter 4), some Nunavut communities, possibly even Clyde River, may find that the traditional and contemporary aspects of their subsistence systems are affected as described by Vibe (1967). In which case, if access to ringed seals and polar bears decreased, could Clyde River hunters shift to other subsistence sources, like narwhal, caribou, and harp seal that are at present of only minor importance?

The answer is probably yes, but not easily for a variety of reasons. Firstly, because it is highly likely that at least some potential "fallback" species will also be affected by a continued warming. For instance caribou, now the principal terrestrial resource for Inuit, are highly sensitive to the kinds of wet/cool conditions that may occur in autumn when rain, rather than snow, may lead to the icing over of vegetation and so limit their ability to obtain winter food. This occurred in autumn 1972 (see Kemp et al., 1978) on several islands in the Canadian High Arctic with the result that caribou disappeared for nearly six years from Bathurst and Cornwallis Islands.

The present reduced state of the Peary Caribou Herd, sufficiently serious for a number of central arctic communities to limit and even ban their subsistence harvests of this species, may have been triggered by autumn rains that iced the winter food supply and crusted the snow cover. In most areas, muskox, which are better adapted to these conditions, have replaced the caribou, but are themselves vulnerable to exploitation.

Narwhal and harp seal may provide some replacement for any reduction in ringed seals. Neither is an arctic winter species, but if summers come earlier and stay ice-free for longer, the harvest of both may be increased significantly. Narwhal, because its *maktaaq* (skin) is a favored food and the ivory tusk of males has commercial value, would draw increased subsistence attention. And the northwest Atlantic harp seal herd, which summers between Baffin Island and West Greenland, has grown geometrically since southern Canadian commercial exploitation was limited in the mid-1980s.

However, there are serious issues concerning both species. Narwhal probably do not possess the population size to sustain any significant increase in their harvest. Moreover, there are serious Canadian and international regulatory issues that would need to be addressed even if an expanded harvest were solely for food. Similarly, any increase in the use of harp seals, which at present draw minor attention from Nunavummiut, would re-ignite the political activity that caused the collapse of markets for seal products (Wenzel, 1991).

One thing is certain. The mobility that Inuit once possessed to move in response to shifts in the pattern and state of their resource base is no longer possible. Inuit in Nunavut now live in communities that are a direct result of Canadian government policy and which represent hundreds of millions of dollars of infrastructure and other investment. Clyde River, for instance, which is home to about 800 people and more or less representative of the kind of infrastructure and services found across Nunavut, is the result of some $50 million of government investment. In today's political-economic climate, migration to remain in contact with *natsiq*, polar bear, or more broadly, to maintain traditional Inuit subsistence culture is virtually impossible.

12.3.2.6. Conclusions

Inuit, whether Nunavummiut, Alaskan, or Kalaallit, have shown adaptiveness in the face of the incredibly rapid change in their cultural environment as they have passed through successive stages of colonization in just six or seven decades. Having been able to adapt to that kind of environmental change, global warming will be far less formidable.

12.3.3. The Yamal Nenets of northwest Siberia

Given the lack of data on historic and prehistoric patterns of indigenous wildlife harvests and subsistence hunting in relation to climate or "weather" change, this case study focuses on the potential interactions between climate, land use, and reindeer management in the Yamal Nenets Autonomous Okrug of northwest Siberia. This is a region of ice-rich permafrost that has been

subject to large-scale petroleum development over the past few decades, while at the same time giving indications of its sensitivity to decadal and even interannual variations in climate.

For at least a millennium (Fedorova, 1998), this region has also served as the homeland of the Yamal Nenets, nomads who have either hunted or herded reindeer as their main livelihood, supplemented by fishing, hunting, and gathering. Nenets have recently expressed great concern in a number of fora regarding their future in reindeer husbandry because of forces largely beyond their control (Forbes and Kofinas, 2000; Jernsletten and Klokov, 2002; Khorolya, 2002). These concerns are discussed here within the context of climate change.

Arctic peoples are experts in adapting to changing conditions (environmental, social, and economic) and recognize their abilities in this regard. Nonetheless, Yamal Nenets are currently showing signs of stress adapting to the recent barrage of simultaneous changes in their homeland – from health and demography (Pika and Bogoyavlensky, 1995) to questions of land tenure (Golovnev and Osherenko, 1999) and increasingly severe "overgrazing", predation, and poaching on reindeer pastures (Jernsletten and Klokov, 2002). There is a risk that a rapidly changing climate may accelerate ecosystem degradation in ways that Nenets are unable to cope with, given the constellation of other factors impinging upon their ability to maintain herding as a viable livelihood.

Krupnik (1993) argued that indigenous reindeer pastoralism expanded rapidly throughout the Russian Arctic during the 18th century as a result of two interwoven factors – socio-economic transformation and environmental change, in particular climate change resulting in "ecologically favorable conditions". The biological factors Krupnik (1993) cited which positively affected semi-domestic herd development were improvements in summer pastures and a concomitant increase in reproductive rates, coupled with a drop in summer and winter mortality. Proxy climate data for the past millennium for Yamal are summarized by Shiyatov and Mazepa (1995) and indicate a summer warming trend throughout the 1700s, as described by Krupnik (1993) for Eurasia in general.

Shiyatov and Mazepa (1995) also reported late 19th and 20th century climate trends for Yamal and these indicate a warming trend during the early and mid-summer periods between about 1940 and 1960. The total reindeer population began a period of rapid growth around 1950, following the near decimation of the herds during the Second World War, and this continued through the 1990s (Golovnev and Osherenko, 1999). At present there are around 180 000 animals on the Yamal Peninsula and more than 600 000 animals in the okrug managed by 2618 mostly family-based units with a nomadic lifestyle (WRH, 1999).

Since the collapse of the Soviet Union, various collaborative teams of scientists have made available a great deal of data on the relationship between climate and permafrost across the Russian Arctic. The Circumpolar Active Layer Monitoring (CALM) program is paramount among these efforts to observe changes in the seasonally thawed active layer and near-surface permafrost, including thermokarst erosion. Although the annual depth of substrate thaw (the "active layer") poorly reflects contemporary climatic warming on Yamal (Pavlov, 1998), inter-seasonal variability is strongly correlated with summer thawing degree-days. At the same time, the frozen ground beneath Yamal is characterized as "warm" permafrost with its temperature amplitude not far below 0 °C and these substrates have been warming in recent years (Pavlov, 1994).

With regard to air temperature, combined regional data from the mid-1970s onward show relatively small magnitude, positive trends in thawing degree-day totals, and a rise in mean annual air temperature. There is evidence that this is not the case in other parts of the Russian Arctic, such as neighboring Taymir and Chukotka in the Russian Far East (Kozhevnikov, 2000). Some recent modeling efforts project the onset of a climatic regime that is not conducive to the maintenance of permafrost over extensive areas of northwestern Siberia, with warmer spring and summer temperatures and additional precipitation. The authors concluded that such a development would have serious ramifications for engineered works in the region, owing to the extensive area underlain by massive ground ice (Anisimov and Nelson, 1997).

In general, the ecological impact of large-scale climate variability and recent climate change on northern ungulates is well documented. Variations in growth, body size, survival, fecundity, and rates of population increase have all been correlated with major atmospheric phenomena including the North Atlantic and Arctic Oscillations (Griffith et al., 2002). There is evidence from northern Fennoscandia, for example, that both extremely high and low oscillation indices have adverse effects on reindeer (Helle and Timonen, 2001). The mechanisms underlying these correlations derive from direct and indirect impacts on grazing conditions for the animals, such as the phenological development and nutritional quality of forage plant species, late-lying snow cover in spring and early winter icing events, and the animals' immediate thermal environment (Mysterud et al., 2001; Post and Stenseth, 1999).

Regardless of these historical trends in climate impacts and future scenarios emphasizing risk, the overriding concerns for contemporary Nenets herders of Yamal revolve around what is collectively referred to as "the pasture problem" (Jernsletten and Klokov, 2002; see also Podkoritov, 1995) and related issues pertaining to land tenure (Osherenko, 2001). Nenets have constantly adapted to change prior to, during, and since the development of intensive reindeer management that became the dominant management regime in the early 1900s. They have survived first Tsarist and later Soviet dreams of establishing state and religious authority over even the

most remote human populations. Yet nothing has challenged them like the ongoing search for petroleum beneath their ancestral lands.

Oil and gas development began in the 1960s and intensified steadily through the 1970s and 1980s, quickly followed by the collapse of the Soviet Union and, almost simultaneously, the overnight disappearance of the largely artificial market for reindeer meat, and the replacement of barter with a cash economy. In the confusion of sorting out ownership of animals and title to land in a newly capitalist society, herd sizes continued to increase to historic highs as land withdrawals for industry pushed the animals onto progressively smaller parcels of land and restrictive migration routes, resulting in extensive pasture degradation (Forbes, 1999; Golovnev and Osherenko, 1999).

The so-called pasture problem is multifaceted and has developed over a long period of time. The collectivization of the herds, which took place under Stalin, is partly to blame, as it instituted the restrictive "brigade" system of management and sought to maximize meat production for the Soviet "market". This took away Nenets' ability to adjust to changing environmental conditions resulting from changes in weather, climate, social relations, and forage conditions, including grazing/trampling impacts. At present there are no fallow or "reserve" pastures on Yamal, as there previously were under traditional Nenets management. However, there were already reports of heavy grazing in some areas even before the onslaught of Soviet-style management (Golovnev and Osherenko, 1999; WRH, 1999).

The continued presence of the Nenets after the fall of communism, with their culture, livelihood, and ecosystems more or less intact, shows how successfully they had adapted to the period of collectivization. However, petroleum exploration developed rapidly and relatively unchecked, with a virtual lack of meaningful protocols and lax enforcement of the few new rules (Forbes, 1999). The problem now, from the herders' perspective, principally concerns land withdrawals for petroleum exploration, infrastructure development, and related degradation processes such as quarrying for sand and gravel, blowing sand and dust, and off-road vehicle traffic in summer (Forbes, 1995; Jernsletten and Klokov, 2002; Khorolya, 2002; WRH, 1999).

Alongside herding, Nenets have always supplemented their diet, clothing, and other needs by fishing and hunting. Nenets observe that the massive influx of industrial workers to Yamal and the concomitant increase in hunting and fishing pressure has meant the decimation of many freshwater ecosystems and some preferred game species (e.g., polar fox) in areas around the main gas fields and transport corridors (Okotetto and Forbes, 1999).

In attempting to adapt to the heavy grazing pressure on the pastures the herders now see themselves as "racing" along their migration routes (Golovnev and Osherenko, 1999). During field research in late summer 1991, the same week as the coup in Moscow took place, Bruce Forbes, one of the authors of this case study, met with herders near the main gas field of Bovanenkovo on north-central Yamal. The number of fully loaded sledges scattered around the camp surpassed the number of empty sledges. The head of the brigade explained that the reason was that they were breaking camp every 24 to 48 hours. He explained that as the herds have become larger they must now have the animals on the move almost constantly. One reason is to avoid rupturing the vegetation mat and exposing the fine-grained sand and loess beneath, which are prone to aeolian erosion, another is reduced forage quality.

Assessing the consequences of climate change and petroleum development, either individually or in combination, is particularly difficult for *Rangifer* spp. compared to other ungulates due to the complexity of their ecological relations (Gunn and Skogland, 1997; Klein, 1991). These involve traditional patterns of migratory movements, resulting in transitory dependence on different ecosystems and special physiological and morphological adaptations that enable them to use a unique food resource. Also, their complex social structure varies seasonally (Klein, 1991).

In the west, reindeer herders and caribou hunters display an acute awareness of the need for coupling indigenous knowledge about wildlife and environment with scientists' efforts to understand climate change and have clearly expressed their concerns as they pertain to traditional livelihoods (Krupnik and Jolly, 2002; Turi, 2000). Among reindeer herders in northern Russia, impacts other than those arising from changes in climate appear to be of more immediate concern and the overall situation has been described as a crisis (Krupnik, 2000). This has led to what has been described as passive rather than active adaptation (Klokov, 2000) to the many and drastic changes.

Dmitri Khorolya is himself Nenets and is both president of the Reindeer Herders' Union of Russia and director of Yarsalinski sovkhoz, the largest collective management unit on Yamal. In his address to the Second World Reindeer Herders' Congress in June 2001 he observed that:

> *the vulnerable ethnic-economical systems of [Russian] reindeer peoples are frequently exposed to hard market conditions, particularly where oil and gas mining has become the principal factor in the development of arctic areas. Industrial activity in the [Russian] north has resulted in the destruction of many thousands of hectares of reindeer pasture. The process is continuing. In some regions pasture degradation threatens preservation of reindeer husbandry and the anxiety of reindeer herders for their future should be heard by the world community.*

Although permafrost-related changes may not be a major threat to subsistence in Inuvialuit (see section

12.3.1), the situation in Yamal has the potential to be different owing to the long, restricted migrations involved, and the loss of the Nenets' traditional capacity for flexibility. As studies have shown, permafrost in the form of massive ground ice is common and the landscapes range from moderately to highly unstable even in the absence of industrial development or intensive reindeer management (Nelson and Anisimov, 1993). For Yamal, "what if" scenarios pertaining to climate change must include:

- the prospect of early melting/late freezing sea ice in the Ob River delta, as this would remove access between winter and summer pastures for the main herds (e.g., Yarsalinski sovkhoz); and
- increased traffic from the Northern Sea Route, perhaps inevitable but certainly benefiting from early melting/late freezing sea ice in the Kara Sea. This could accelerate the pace of regional development.

Either scenario risks additional stress on the adaptive abilities of the Yamal Nenets. Yet even in the absence of climate change, within the next two to three decades there are critical and immediate threats from questions of title to land and accelerating changes in land use. The latter includes local and widespread damage from industry, and the ecosystem-level effects of reindeer grazing and trampling, as well as poaching. Throughout this period the various parties must strive to minimize conflict (Klein, 2000). In the longer term, if the current climate warming continues, extensive changes to existing tundra communities can be expected as permafrost begins to thaw and large areas are either denuded by landslide events (Leibman and Egorov, 1996) or subject to paludification by thawing ground ice via thermokarst. Adaptation to such changes will require: (1) greater efforts on the part of industry to prevent or mitigate additional disturbance; (2) a flexible system of land use, emphasizing property rights, that is acceptable to both the Nenets and the State; and (3) additional practitioners' and scientific knowledge on the composition and potential forage utility of emergent plant communities which will necessarily be exploited by the reindeer.

12.3.4. Indigenous peoples of the Russian North

This case study is based on the ongoing work of the Russian Association of Indigenous Peoples of the North (RAIPON), together with the NorthSet project of the Institute of Geography at the Russian Academy of Sciences. This work concerns the assessment of climate change impacts on the indigenous peoples of the Russian North within the context of broader social, economic, and political changes. This case study is based on the preliminary results of initial research, but is included here because it illustrates the tremendous challenges faced by indigenous peoples throughout the Russian North.

The indigenous peoples of the Russian North have depended on traditional hunting, fishing, and gathering for thousands of years and, for several hundred years, many groups have practiced nomadic reindeer breeding. Human impacts and environmental transformation in the Russian Arctic have intensified over the last few decades. Significant climate change is also becoming evident, as is the destructive impact of industry. The biggest sources of pollution are the oil and gas industries, as well as mineral extraction and processing, aggravated by poor purification facilities. The main negative impacts of industrial development threatening the livelihoods of indigenous peoples include:

- the destruction of reindeer pastures and widespread degradation of ecosystems, especially due to the construction of industrial infrastructures and industrial pollution;
- massive toxic pollution of marine and freshwater environments, affecting the habitats and spawning grounds of fish and causing the destruction of fisheries;
- deforestation due to the timber industry using concentrated methods of clear-cutting, leading to the destruction of the non-timber forest resources of high cultural and economic importance;
- large-scale landscape and soil destruction, erosion (especially thermokarst erosion), and the degradation of tundra and taiga vegetation as a result of air pollution from industrial emissions (especially emissions from the non-ferrous metal industry);
- flooding of valuable subsistence areas due to the construction of hydroelectric power dams; and
- forest fires, partly associated with poaching and partly with increased recreational pressure around the regions of industrial development.

These impacts have added to the tremendous problems faced by Russia's northern indigenous peoples, which can only be understood by reference to Soviet and post-Soviet transformations. During Soviet times, public policies resulted in the resettlement of the inhabitants of small settlements into large villages. This coercive resettlement of indigenous peoples signaled the beginning of the destruction of the social and ecological relationships that characterized their subsistence lifestyles. Resettlement, the separation of children from their parents in favor of education at boarding schools, preservation orders on vital grasslands and reindeer pastures, and the reduced possibilities for engaging in traditional activities, together with many other changes, led to a spiritual and social crisis among the indigenous peoples (Vlassova, 2002). Since the 1970s, unemployment and alcoholism have become widespread, family structures are breaking down, and traditional culture is being destroyed.

In recent years, the destruction of traditional subsistence activities, especially reindeer herding – the most important activity for many indigenous groups – has continued apace. The difficult period of transition to a market economy in post-Soviet Russia has brought sharp changes to the economic and social conditions of the indigenous peoples of the Russian North, to which they have had to adapt quickly in order to survive. In the

1990s, when the formation of the market economy and democratization of society in the Russian Federation began, the situation in reindeer husbandry changed dramatically. This period of transition has seen a rapid decay of collective reindeer husbandry and a partial return to the private ownership of reindeer herds. This has occurred without the introduction of sufficient legal reforms, particularly affecting agricultural and traditional lands. One major trend has been a significant reduction in the population of domesticated reindeer. Combined with a lack of approaches for the development of an alternative program for sustainable development, and faced with increasing climate variability and change, the situation for the indigenous peoples of the Russian North is increasingly bleak.

The indigenous peoples of the Russian North comprise a mere 2% of the entire northern Russian population and number approximately 200 000 individuals belonging to forty different peoples (Haruchi, 2001). The most numerous are the Nenets, who comprise around 35 000 persons; the least numerous are the Enets with about 209 and the Orok with 109. The subsistence area of the indigenous peoples is roughly 60% of the overall territory of the Russian Federation and their traditional subsistence activities include reindeer herding, hunting (including marine mammals), fishing, gathering wild plants and, to a certain degree, craft-making and traditional art. The specific activities of the different peoples vary significantly from region to region.

The indigenous communities of Russia are the most endangered social group in the current period of transition to a market economy. Between 1990 and 2000, the number of indigenous people employed on northern livestock farms, as well as in hunting and fishing, fell by 37%. In these years of market reforms, the actual rate of unemployment in the indigenous settlements of the Russian North is, on average, not less than 40 to 50% of the economically active population. The situation is worse for young people in remote areas. Some small villages of autonomous okrugs (e.g., in the Koryak Autonomous Okrug) face an unemployment rate of 75 to 80%; in some districts of Habarov Kray the unemployment rate among the indigenous peoples increased six-fold during the 1990s.

Social ills associated with unemployment – poverty, disease, family breakdown, crime, suicide, and alcoholism – are increasing in indigenous settlements. Mortality among indigenous peoples increased by 35.5% in the 1990s (Abdulatipov, 1999). The nature of mortality has changed over the last few decades: the main risk group is no longer children, but young adults, and the main cause of death is no longer sickness, but death as a result of injuries, accidents, and suicide. The main cause of this situation is the destruction of traditional lifestyles (Vlassova, 2002). For Saami living in Lovozero on the Kola Peninsula, whose health and livelihoods have been affected by pollution and ecological degradation, environmental improvement is an even greater priority than the improvement of housing conditions, which are extremely poor (Afanasieva, 2002). According to the Saami, the climate is becoming less comfortable, and they articulate this in terms of their livelihoods and health. The environment is one in which they dwell and comfortable housing will not improve their health if the climate is changing. During a workshop organized by RAIPON in April 2003 many Saami participants expressed concerns about a link between rapid and frequent climate/weather changes and the increase in cases of high blood pressure. As they spoke, they connected health and illness directly to climate variability and change.

Significant shifts have occurred in unemployment structure. The indigenous share in municipal positions, and in the service, educational, and cultural sectors has increased considerably while the participation of indigenous peoples in the traditional economy has decreased sharply. The highest levels of unemployment are observed in the areas where indigenous peoples retain traditional livelihoods. In larger settlements with a developed service sector, employment within the indigenous population is slightly higher. Yet, an increasing reliance on service sector activities does not always mean that harvesting renewable resources and production of traditional food for the household has declined in importance. As in other arctic states, hunting, herding, gathering, and fishing still satisfy important cultural, social, and nutritional needs, as well as the economic needs of families, households, and communities.

In this changing social and economic climate, indigenous systems of traditional resource use are under threat. Traditional land use areas are mainly located within zones of political and economic interest, particularly those concerning oil, mineral, and timber production, and military complexes with nuclear test sites. From the initial results of the research being conducted by RAIPON, a majority of indigenous people consider poaching, forest fires caused by humans, industrial logging, and clearing of forests for firewood to be some of the most significant issues that affect the physical environments and well-being of their communities.

- Decreasing populations of animal and plant species are a serious concern and it may be that this is not due to climate and ecological changes alone, but is aggravated by poaching, which is a serious problem in several regions.
- Fires, the frequency and scale of which have recently increased, are either natural or man-made. In the Tyumen region alone, which is now being intensively explored for natural resources, over 1.5 million hectares of reindeer pasture have been destroyed by fire. One of the causes of escalation of fires in the tundra, the taiga–tundra zone, and the taiga might also be climate warming, especially summer droughts.
- In recent decades, commercial logging operations have advanced closer to the taiga–tundra zone across much of the boreal forest region. The transforma-

tion of the northern parts of the taiga zone into a taiga–tundra, or even tundra, as a result of human activity is occurring in Russia (Vlassova, 2002).
- The fuel deficit in remote communities is one reason for illegal logging. Serious ecological problems arise with cutting of forests for fuel in Kovran, Loveozero, and Kuumba.

One of the causes of the decrease in reindeer numbers is the degradation of the treeline (taiga–tundra) winter reindeer pastures caused by industrial forestry, clearing of forests for firewood, and industrial pollution. The traditional ways of life of indigenous peoples are characterized by high adaptability to seasonal as well as to spatial differences in the physical environment. Climate changes may interfere with the human–nature cycle of reindeer herding, where herders follow the paths of reindeer between summer grazing lands in the tundra and mountains and winter grazing lands in the treeline. Winter pastures are of great importance for reindeer herding. During the long arctic winter, reindeer depend upon access to pasture rich in ground lichens, which are their basic food. In the autumn, reindeer start to move to forested areas that provide layers of soft snow that they can dig through to find the ground lichens. Epiphytic lichens on old trees are important reserve fodder when the ground lichens can not be reached due to ice layers on or within the snow. The lichens almost exclusively provide these animals with the carbohydrates required to maintain their body temperature in winter (Vlassova and Volkov, 2001).

Another cause of the decrease in reindeer numbers is the overgrazing of tundra and taiga–tundra pastures. Increasingly fewer winter pastures are available for reindeer herding as large territories are being occupied by mining and petroleum industries. This increases the pressure by domesticated reindeer on the tundra and taiga–tundra ecosystems, and thus leads to further degradation. Ecosystems are completely overgrazed by reindeer in many areas. The overgrazing of reindeer pastures leads to deforestation of the taiga–tundra winter pastures, especially owing to the damage to trees and shrubs. This has the effect of pushing the treeline southward in many areas (Vlassova and Volkov, 2001).

Fires are contributing to the degradation of reindeer pastures and to the decline in reindeer herding. Although their frequency and scale have increased, the interaction of fires with pastures and forest is complicated. For example, fires may play an important role in forest regeneration as they provide important minerals and free soils from leaf litter and ground vegetation cover, which under some conditions inhibit forest growth. Such interactions should be included in ecosystem management schemes. A decline in reindeer herding could also have a negative impact on reforestation as reindeer promote the removal of leaf litter and thereby the ability of new trees to become established.

It is within this extremely complex socio-economic and changing ecological situation that indigenous peoples in the Russian North must deal with climate change issues. RAIPON's initial work on climate change impacts suggests an important way forward: indigenous observations of climate change must be examined together with greater emphasis given to the concerns of indigenous peoples in terms of environmental degradation and habitat loss due to other factors. A broader understanding of change and discussions on how to deal with this must be included in environmental impact assessments, in environmental policy, and in the elaboration of local programs for sustainable development.

12.3.5. Indigenous caribou systems of North America

Subsistence caribou hunting in North America is practiced by Dogrib, Koyukon, Gwich'in, Dene, Cree, Chipewyan, Innu, Naskapi, Yupiit, Iñupiat, Inuvialuit, Inuit, and other indigenous peoples from the Ungava Peninsula of Labrador (Canada) to the western Arctic of Alaska (Fig. 12.2). While the cultural role of caribou differs among these groups, caribou is arguably the most important terrestrial subsistence resource for indigenous hunters in arctic North America (Hudson et al., 1989; Klein, 1989; Kofinas et al., 2000). The total annual harvest by North American hunters is estimated to be more than 160 000 animals, with its replacement value as store-bought meat roughly equivalent to US$30 000 000.

While this monetary value illustrates the enormous contribution caribou make to the northern economy, it does not capture the social, psychological, and spiritual value of caribou to its users. For many indigenous culture groups who identify themselves as "caribou people", like the Gwich'in, Naskapi, and Nunamiut, caribou–human relations represent a bond that blurs the distinction between people, land, and resources, and links First Peoples of the North with their history. This intimate relationship between people and caribou suggests that negative impacts from climate change on caribou and caribou hunting would have significant implications for the well-being of many indigenous communities, their sense of security and tradition, and their ability to meet their basic nutritional needs.

The caribou production system of the Vuntut Gwitchin, people whose traditional territories and settlement are centered on Old Crow, Yukon, may be used to illustrate variables that must be considered in climate change assessments of northern caribou user communities.

12.3.5.1. The enduring relationship of people and caribou

Caribou have been of critical importance to northern peoples of North America for millennia (Burch, 1972; Lynch, 1997; Hall, 1989). Archaeological evidence suggests that during the Wisconsin Glaciation, the distribution of *Rangifer* extended across much of the western hemisphere (Banfield, 1961, 1974; Kelsall, 1968; Spiess, 1979), from as far south as New Jersey to New Mexico

Fig. 12.2. North American distribution of *Rangifer* subspecies and selected indigenous peoples of North America (Kofinas and Russell, 2004).

and Nevada (Jackson and Thacker, 1997; Lynch, 1997). Caribou were available to paleo-indigenous hunters seasonally, with variation in availability related to a herd's ecological rhythms, human territoriality and mobility, and access to other living resources. Shifts in climate regimes that precipitated glacial epochs had dramatic consequences for caribou and the peoples that depended upon them. Recent evidence from the southern Yukon shows how shifts in climate have resulted in dramatic changes in the distribution of caribou, while remaining a part of the oral traditions and identity of indigenous peoples well after the disappearance of large herds (Farnell et al., 2004; Hare et al., in press).

The traditional caribou hunting grounds of the Vuntut Gwitchin are located within the caribou range of the Porcupine Caribou Herd, a region referred to as the Yukon–Alaska Refugium (see Chapter 11), and considered to have been unglaciated throughout the four glacial epochs. Paleontological evidence suggests that caribou have continually inhabited the Alaska–Yukon Refugium for over 400 000 years, through the Wisconsin Glaciation. Archaeological evidence of human habitation in this region is among the oldest excavated in North America. While questionable artifacts have been used to suggest the presence of humans in the area 25 000 to 29 000 years ago, confirmed findings at the Bluefish Caves, located on the Bluefish River southeast of Old Crow, Yukon have been dated 17 000 to 12 000 years old, including the bones of caribou.

Archaeological research linking proto Gwich'in to the present-day hunters identifies a complex of sites on the Porcupine and Crow Rivers, and indicates continual human inhabitation of the region and use of Porcupine Caribou for around 2000 years. Many of the sites are situated at present-day caribou river crossings, with material culture and subsistence patterns closely related to the caribou resource. Other noteworthy sites include more than 40 caribou fences, strategically located across the southern range of the Porcupine Caribou Herd, and used by the Gwich'in families until the beginning of the 19th century (Greer and Le Blanc, 1992; McFee, no date given; Warbelow et al., 1975).

Social organization of caribou production traditionally reflects the seasonal cycle of caribou movements, overall changes in herd population, and access to other important subsistence resources. In winter, when caribou herds are mostly sedentary, traditional hunting involved small-group hunts and stalking; autumn migration brought large numbers of caribou and was undertaken by larger parties and family groups, intercepting caribou at traditional river crossings and/or directing movements of wild caribou into corrals. High demand for caribou meat in preparation for winter required large-scale harvests involving considerable effort by family groups. Limited summer hunts of young caribou provided lighter hides that were important for clothing. While traditional caribou hunting is often described as cooperative in behavior and egalitarian in social structure, recognition of exceptional hunting abilities was critical to survival. Caribou fences of the Vuntut Gwitchin are reported to have been "owned" by skilled hunting leaders, with a fence complex capable of harvesting as many as 150 animals in a single round-up, and managed by as many as 12 families. Cooperation among groups situated at different fences was necessary for managing the annual variability in migration patterns and uneven hunting success of family groups.

Ethnological studies of Porcupine Caribou users document the central role of caribou in community life (Balicki, 1963; Slobodin, 1962, 1981). Oral histories are replete with accounts of human migration, exceptional hardship, and starvation, due to the unavailability of caribou. While some have argued that over-hunting has been a key factor driving the declines observed in many

northern wildlife populations (Martin, 1978), there is little evidence that over-hunting of caribou by indigenous peoples was the sole cause of population decline in large herds. Given the population estimates of indigenous hunters in the pre-contact period, it is more likely that changes in caribou populations of large herds and shifts in their distributions were driven primarily by climate (Peterson and Johnson, 1995), with hunting contributing to these changes at low population levels.

12.3.5.2. Modern-day subsistence systems

Caribou is still a vibrant component of many caribou user communities' dual cash–subsistence economies. For example, harvest data for the community of Old Crow (population ~275) show that the annual per capita caribou harvest has been as high as five animals (Kofinas, 1998). Modern-day harvesting in the community of Old Crow generally occurs during autumn, winter, and spring, with the autumn harvest the most important. In autumn, bull caribou are in prime condition (i.e., fat) and the cooler temperatures allow open-air production of drying meat, with use of boats to hunt at crossings. Winter harvesting does occur, but is generally limited because the herd's winter distribution is too far from the community to allow affordable access. The spring hunt by the Vuntut Gwitchin provides a supply of fresh meat after the long winter, but is limited by the warmer temperatures which constrain caribou production and storage of meat in caches. Governing the activities of harvesters is a strong local ethic against waste.

The location of modern-day settlements has consequences for the success of community caribou hunting. Communities, like Old Crow, sited at the center of the range of large migratory herds are able to intercept caribou during autumn and spring migrations, whereas communities sited on the margin of a herd's range may have access to animals only during winter or briefly during the summer calving and post-calving periods. History shows that the range of a large herd can contract at low population levels and expand at high levels. The consequence for local communities situated away from the heart of a herd's range can be a decline in hunting success and in some cases abandonment of caribou hunting for several decades until the herd returns to a higher population level.

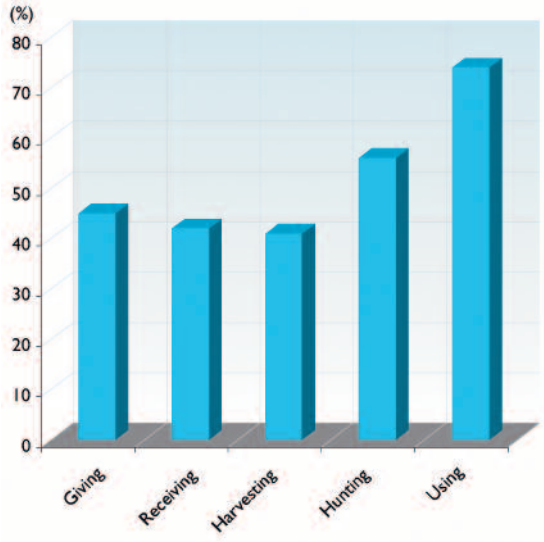

Fig. 12.3. Subsistence systems of reciprocity (data source: Alaska Department of Fish and Game/Division of Subsistence Community Profiles).

An important mechanism for adaptation and survival of traditional indigenous subsistence economies is a system of reciprocity through the sharing of harvested animals. Data from the Alaska Department of Fish and Game show the extent to which household sharing occurs in fifteen Western Arctic Herd user communities (Fig. 12.3). Networks of exchange are internal to communities and usually kinship-based. These networks also extend to residents of neighboring communities and regional centers (Magdanz et al., 2002). Central to this exchange process and in hunting success for many traditional hunters is the concept of luck. Like many hunting peoples, luck in hunting is regarded by many Vuntut Gwitchin not just as a matter of hit-or-miss probability, but also as the consequence of human deference and respect for animals, and generosity in sharing harvests with fellow community members (Feit, 1986).

Caribou subsistence hunting in indigenous communities of the north is today practiced as part of a dual cash–subsistence economy (Langdon, 1986). Cash inputs (e.g., jobs, transfer payments, investments by Native Corporations) supply essential resources for the acquisition of modern-day hunting tools. The transition to improved hunting technologies (e.g., bigger and faster snowmobiles and boats, outboard motors with greater horsepower, high-powered rifles, and access to caribou radio-collar distribution and movement data via the internet), allows greater access to caribou than in previous years, and a more consistent availability of fresh meat, which thus changes the level and type of uncertainty that has traditionally been associated with indigenous caribou hunting.

Government policies and agreements dictate if and how caribou harvesting enters into the realm of monetary exchange. For example, the State of Alaska and the U.S.-Canada International Agreement for the Conservation of the Porcupine Caribou Herd (1987) prohibits the commercial harvest and sale of caribou, whereas commercial tags for caribou of other herds are permitted for herds of the Northwest Territories, Nunavut, and Quebec, where several for-profit native and non-native corporations participate. Outfitter caribou hunting is also practiced as a component of local mixed economies in some regions. In some indigenous communities, there is a resistance to engage in guided caribou hunting, a policy that is defended as a need to retain traditional values and avoid commercialization of a sacred resource.

Many have speculated that engagement of subsistence hunters with the cash economy and the effects of modernization would ultimately lead to a decease in participation in the subsistence way of life (Murphy, 1986).

Yet, evidence demonstrates that under some conditions subsistence hunting can thrive in a modern context (Kruse, 1992; Langdon, 1986, 1991). The changes have, however, affected the allocation of time resources, including the time community members spend on the land pursuing a subsistence way of life (Kruse, 1991). Whereas before 1960 there was great flexibility in the allocation of time for subsistence harvesting and trapping, today's pursuit of employment and educational opportunities and its attendant shift to "clock time" is noted by many people at the local level as constraining opportunities for harvesting and affecting the transmission of cultural hunting traditions to younger generations. Relevant in the discussion about climate change and subsistence caribou hunting is the process by which financial resources compensate for the more constrained schedules of today's hunters, by improving technologies for time-efficient travel to hunting grounds (Berman and Kofinas, 2004). The shift to improved harvesting technologies also suggests that climate change impacts on community caribou hunting be considered within the context of a cultural system that is highly dynamic and with some (but not infinite) capacity for adaptation.

Critically relevant to a community's adaptive capacity is its collective knowledge of caribou and caribou hunting (Berkes, 1999), which includes an understanding of the distribution and movement of animals in response to different weather conditions (Kofinas et al., 2002). Community ecological knowledge of caribou is local in scale, and provides an important basis for hunters' decisions about the allocation of hunting resources (time, gas, and wear and tear on snow machines and boats) and the quantity of caribou to be harvested. This knowledge is sustained through the practice of caribou hunting traditions (i.e., time spent hunting and being on the land), and the transmission of knowledge and its cultural traditions to younger generations.

12.3.5.3. Conditions affecting caribou availability

Maintaining conditions for successful caribou hunting is not just a question of sustaining caribou herds at healthy population levels, but includes consideration of a complex and interacting set of social, cultural, political, and ecological factors. While environmental conditions (e.g., autumn storms, snow depth, rate of spring snow melt) may affect the Porcupine Caribou Herd's seasonal and annual distribution and movements (Eastland, 1991; Fancy et al., 1986; Russell et al., 1992, 1993), associated factors (e.g., timing of freeze-up and break-up, shallow snow cover, and the presence of "candle ice" on lakes) may affect hunters' access to hunting grounds. Individual and community economic conditions affecting hunters' access to equipment and free time for hunting are also key elements. Consequently, assessing caribou availability in conditions of climate change requires an approach that is more multifaceted than standard subsistence use documentation or "traditional ecological

Table 12.6. Key variables and their implications for assessments of climate change effects on caribou availability (based on Berman and Kofinas, 2004; Kruse et al., 2004).

Caribou population level	A decrease in total stock of animals has implications for the total range occupied by the herd; the likelihood hunters will see caribou while hunting, and management policy affecting the allocation and possible restrictions of harvests.
Distribution and movement of herd	Climate conditions are critical in the caribous' selection of autumn and spring migratory patterns and winter grounds. Calving locations affect community hunters' proximity to caribou.
Time for hunting; time on the land	Time for hunting emerges as an important variable as more community members engage in full-time participation in the wage economy. It is also important functionally in the maintenance and transmission of knowledge of caribou hunting.
Community demographics	Community demographics determine present and future demand for caribou. Out migration of people to distant cities may also affect the knowledge base if residence outside the community is for an extended period.
Household structure	Household structure affects resources (people and gear) that can be pooled for hunting. For example, households comprising adult bachelors often serve as important providers for households with non-hunters (e.g., elders, women, full-time working members who have limited time or no skill).
Cash income	Cash income provides for acquisition of gear needed in harvesting and compensation when time restrictions limit hunting opportunities. Where barter and trade allow for monetary exchange, it permits direct acquisition of meat.
Technology for harvesting caribou	Faster boats and snow machines, improved GPS systems, and lighter outdoor gear can bring hunting areas previously inaccessible due to high travel costs, within reach. Increased use of high technology gear can increase the demand for cash to support subsistence harvesting.
Cultural value	Cultural value affects interest in caribou hunting rates of consumption, and ethics of hunting practice.
Sharing	Inter- and intra-community sharing buffers against household caribou shortfall. Some indigenous belief that sharing also ensures future hunting success.
Social organization of the hunt	Hunting as individuals or in "community hunts" are both successful strategies.
Formal state institutions for management of caribou	Formally recognized institutions, such as a rural or native hunting priority, may prove critical when a herd is determined by management boards to be at low levels (see Chapter 11 for more details).

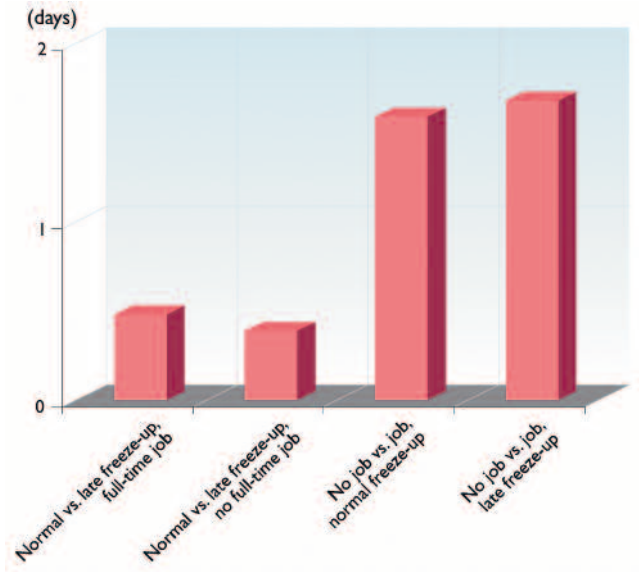

Fig. 12.4. Change in compensating variation from caribou hunting (Berman and Kofinas, 2004).

knowledge" documentation. Table 12.6 lists some of the key variables important in climate change assessments for caribou subsistence systems.

A simulation model based on Old Crow caribou hunting and the cash economy was constructed based on local knowledge and quantitative socio-economic data (Berman and Kofinas, 2004). The model drew on local knowledge and science-based research to assess the implications of a climate change scenario that assumed later break-up of ice on the Porcupine River, an important watercourse for intercepting caribou during the autumn migration. The model results revealed variation in compensatory levels for households with different types of employment. Figure 12.4 shows the estimated compensating variation for the possible changes in work and climate patterns based on 1993 hunting conditions for a household with three adults, two children, and no autumn harvest. The model suggests that late freeze-up costs the example household the equivalent of about half a day in lost leisure or family time. The loss for this scenario is modest because caribou were present near the community during early winter in 1993, which meant that the access restriction still left hunters with some harvest opportunities even though these were not plentiful for the season for which data were available, and relatively few households would have hunted even under normal climate conditions. The loss in leisure or family time is slightly less if no-one in the household has full-time work. The compensating variation for having a job is negative, and about three times as large as the cost of the late freeze-up. This suggests that having a full-time job under these conditions reduces the household's welfare because it leaves insufficient time to hunt. If the data were for a year with more plentiful caribou, the cost would have been greater. The model does not include the increased risk of exposure for hunters attempting to intercept caribou during late freeze-up conditions, which typically include traveling up river by boat through moving ice (Berman and Kofinas, 2004).

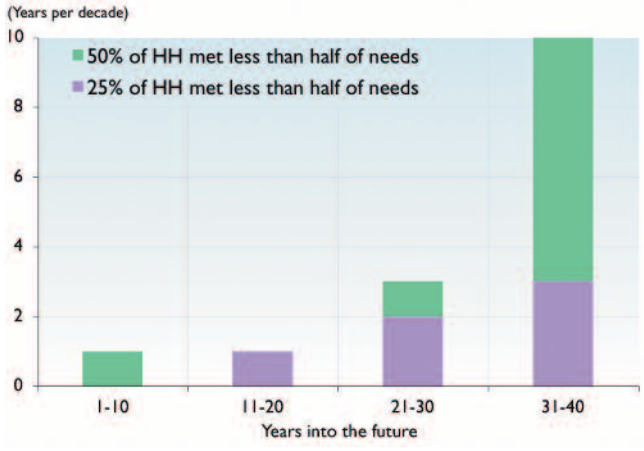

Fig. 12.5. Projected number of years in each decade that households (HH) have caribou harvest shortfalls (Kruse et al., 2004).

The Sustainability of Arctic Communities Synthesis Model (Kruse et al., 2004), based on the integrated assessment of 22 scientists and four indigenous Porcupine Caribou user communities, projected the effects of a 40-year climate change scenario. Scenario assumptions included warmer and longer summers and greater variability in snow conditions, including deeper snow in winter, shallower snow in winter, and fewer "average" snow years. The results show that the combined effects of these conditions result in a significant decrease in the herd's population (see Chapter 11 for details of the impacts on caribou populations). The model assumes that no harvest restriction is implemented, and that intra-community sharing of caribou and community hunts are organized in years when most of the community households do not meet their target needs. In this climate change scenario, the model projects that within seven years of the final decade, less than half the households will meet half their caribou needs (Fig. 12.5).

12.3.5.4. Keeping climate assessment models in perspective

Community involvement in the Sustainability of Arctic Communities Synthesis Model project and documentation of local knowledge on climate change through the Arctic Borderlands Ecological Knowledge Cooperative (Kofinas, 2002) provide insights into the challenges associated with trying to assess the impacts of climate change on subsistence caribou hunting. Despite the effort of researchers to capture the key drivers and stochastic characteristics of the systems, a local review of the model pointed to problems because of the complexity of the system. For example, the Sustainability of Arctic Communities Synthesis Model assumes that warmer summer temperatures under climate change will result in an increase in insect harassment for caribou and an associated cost to the caribou energy budget. Caribou hunters of Aklavik, Northwest Territories, who have observed a recent increase in summer temperature, have also observed an increase in summer winds, and thus an

overall *decrease* in insect harassment to caribou. Community members from Old Crow questioned the use of a climate change scenario that assumes a regional increase in snow depth, since the model does not include the mosaic of landscape variation in their region. While these interactions illustrate some of the limitations of models in the assessment of climate change effects on local community use of subsistence resources, they do highlight that the involvement of communities as full partners in an integrated assessment can be of value in identifying data gaps, directing the work of future research, and portraying assessment results in ways that reflect the uncertainty and complexity of changes in the relationships between people and their environment.

12.3.5.5. Conclusions

Local community hunters of Old Crow and many others across North America have noted an overall increase in the variability of weather conditions (Jolly et al., 2002; Kofinas, 2002; Thorpe et al., 2002). These observations are coupled with an awareness of social and cultural changes in communities. While it will be difficult to make predictions about the trajectories of future climate conditions and their anticipated impacts on caribou and caribou subsistence systems, it is clear that the associated variability and overall uncertainty pose special problems for caribou people like the Vuntut Gwitchin of Old Crow. Indeed, local observations of later autumn freeze-up of rivers, drying of lakes and lowering of water levels in rivers, an increase in willow and birch in some areas, shifts in migrations and distribution patterns, and restrictions on access suggest that the problems of climate change are already being experienced. While the challenges of climate change and climate change assessments for local hunters and researchers are considerable, there are clear opportunities for collaboration between groups to ensure the sustainability of the subsistence way of life.

12.4. Summary and further research needs

This chapter has considered existing research on climate change impacts and has illustrated, through detailed case studies for several arctic settings, some of the most pressing issues currently faced by indigenous peoples. Although the material is diverse and extensive, some common themes emerge.

- Indigenous peoples around the Arctic maintain a strong and vibrant connection to the environment through hunting, herding, fishing, and gathering renewable resources.
- Hunting, herding, fishing, and gathering activities provide the primary means for obtaining and producing food in indigenous communities. These practices have endured over thousands of years, with cultural adaptations and the ability to utilize resources often associated with or affected by seasonal variation and changing ecological conditions.
- Hunting, herding, fishing, and gathering remain important for maintaining social relationships and cultural identity in indigenous societies. Hunting, herding, fishing, and gathering activities link people inextricably to their histories, their contemporary cultural settings, and provide a way forward for thinking about sustainable livelihoods in the future.
- As the climate changes, the indigenous peoples of the Arctic are facing special challenges and their abilities to harvest wildlife and food resources are already being tested. Although this chapter shows that climatic variability and weather events often greatly affect the abundance and availability of animals and thus the abilities and opportunities to harvest and process animals for food, the rate and extent of current and projected change give cause for alarm.
- Adaptation refers to the potential to react in a way that mitigates the impacts of negative change. Becoming resilient to climate change, and preparing to respond, cope with, adapt to, and negotiate climate change and its impacts, risks, and opportunities will require urgent and special attention.
- Climate change cannot be understood in isolation from other environmental changes, rapid social and cultural change, and globalization. Arctic communities have experienced, and are experiencing, stress from a number of different forces that threaten to restrict harvesting activities and sever these relationships.
- Rapid social and economic change, resource development, trade barriers, and animal-rights campaigns have all impacted upon hunting, herding, fishing, and gathering activities. Section 12.3.4 on the Russian North, for example, illustrates how poaching, oil development, and clear-cutting of forests undermine the subsistence base for indigenous peoples.
- Arctic peoples cannot adapt, relocate, or change resource use activities as easily as in the past, because most now live in permanent communities and must negotiate greatly circumscribed social and economic situations.
- Hunting, herding, and fishing activities are determined to a large extent by resource management regimes, land use and land ownership regulations, and local and global markets. The mobility and flexibility that indigenous peoples once possessed to move in response to shifts in the pattern and state of their resource base is no longer possible.
- Commercial, political, economic, legal, and conservation interests have reduced the abilities of indigenous peoples to adapt and be flexible in coping with climatic variability. However, for some peoples of the Arctic, the political and management systems are already in place that could assess the impacts of climate change, allow local and regional governments to act on policy recommendations to deal with the consequences, and improve the chances for indigenous peoples to deal successfully with climate change. Although complex, solutions to environmental problems are potentially realistic.

This chapter demonstrates an urgent need for a greater understanding of the scope of these environmental, social, political, and economic issues and challenges in a rapidly changing milieu. The chapter is intended as a scoping exercise as much as it is an assessment of current knowledge. The case studies are based on extensive work in partnership with indigenous communities, and the chapter as a whole has developed with significant advice, guidance, and input from the Permanent Participants to the Arctic Council.

Communities across the Arctic are culturally and economically diverse and are affected by environmental change in different ways. Such diversity also means that local experiences of climate impacts and responses to climate variability and change may not be universal. How do communities, therefore, differ in how they utilize strategies for mitigating negative change and in the effectiveness of their adaptive capacity? Given this question, the case studies illustrate the importance of research on the localized, regional, and circumpolar studies of socio-economic impacts of recent climate change.

The emphasis of scientific research on climate change is to assess the impacts on the environment, ecosystem processes, and wildlife. One gap in knowledge is how climate change affects social relations in indigenous communities. This chapter highlights this as a critical aspect of climate change research, arguing that a change in the ability of indigenous peoples to access traditional/country food resources can have a corresponding impact on the social fabric of their communities. In a very real sense, therefore, the discussion of climate impacts on hunting, herding, fishing, and gathering by indigenous peoples is about sustaining human/food resource relationships and activities in indigenous societies, as well as being aware that climate change impacts pose a threat of severe and irreversible social changes. The case studies illustrate the complexity of problems faced by indigenous peoples today and underscore the reality that climate change is but one of several problems affecting their livelihoods. Clearly, research should place emphasis on understanding climate change impacts within the broader context of rapid social and economic change and seek to determine ways of distinguishing between changes that occur as a result of societal, cultural, and economic events, and changes that result from physical processes.

Future research on climate change should result in a deeper understanding of what exactly forms the basis for the social, cultural, political, and economic viability of arctic communities, and attempt to explore the research priorities highlighted by communities themselves. Significant and promising new research initiatives are currently underway that promise to break new ground in contributing the knowledge needed to formulate climate change impact assessments, national policies, and adaptation strategies, including the major U.S. interagency-led Study of Environmental Arctic Change (SEARCH, 2001) and the Canadian ArcticNet (http://www.arcticnet.ulaval.ca/index_en.asp) programs.

The case studies in section 12.3 were selected to provide a sense of climate change impacts on indigenous communities and their livelihoods. It was not possible to provide circumpolar coverage of the situation for all indigenous peoples. Nor was it possible to include detailed information on plant resources and freshwater fish. Indeed, there is a lack of good material on this, especially for the Russian Arctic, where industrialization and non-renewable resource development is happening much faster, and with a greater discernible impact than climate change, even though this is a region of recent and substantial warming. There are many kinds of side effects from industrialization in the Russian North, especially from accelerated road and railway building, such as the destruction of huge areas of pasture for gravel and sand mining, and the rapid increase in poaching, which give cause for immediate concern. The situation in the Russian North clearly demonstrates the importance of assessing and understanding the impacts of climate change within the broader context of other rapid changes.

One of the aims of this chapter was to assess the adaptations that have enabled communities to succeed in the past and to establish the extent to which these options remain open to them. There are few published data on this topic, but based on what is available this chapter shows that while indigenous peoples have often adapted well to past climate change, the scale and nature of current and projected climate change brings a very different sense of uncertainty and presents different kinds of risks and threats to the livelihoods of indigenous peoples.

Is an ability to respond and cope with climate change, mainly by adjusting subsistence activities, a reliable indication of an ability to adapt in the future? Research is needed on understanding how much change can be accommodated by the existing ways of life of indigenous peoples. Case studies in this chapter have pointed to the *resilience*, or the amount of perturbation that the resource use systems of indigenous peoples can absorb, and how they can adapt by learning and self-organization. How are indigenous communities adapting to and coping with change? How will reindeer, marine mammals, and fish themselves adapt to the changes in their habitats? Can the return of subsidies for meat distribution and marketing help in making coping and adaptation responses possible? These are questions of pressing concern for hunters, fishers, and herders active across the entire Arctic. The question of resilience and limits to adaptability is important and further research is needed since little is known about building adaptive capacity in the face of climate change. Above all, there is need to match or coordinate physical climate data on extreme weather events and the impact of these events on actual hunting, fishing, and herding practices.

Further research is also needed on co-management and governance institutions and whether they can create additional opportunities to increase resilience, flexibility, and the ability to deal with change. How can, for example, new governance mechanisms help indigenous peo-

ples to negotiate and manage the impacts of climate change? With a capacity-building strategy now being a key objective for the Arctic Council, tremendous opportunities exist for cooperation and constructive dialogue on dealing with climate change between communities, organizations, institutions, and governments at circumpolar and wider international levels.

Acknowledgements

Mark Nuttall wishes to thank the Polar Regions Section of the UK Foreign and Commonwealth Office for providing generous support to cover his participation in this assessment. The case studies are based on extensive work in partnership with indigenous communities, and the contributing authors express their thanks to all those involved. The chapter as a whole has developed with significant advice, guidance, and input from the Permanent Participants to the Arctic Council, and special thanks also goes to the large number of international reviewers who provided detailed, thoughtful and constructive comments and criticism.

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