Earth's climate is changing, with the global temperature now rising at a rate unprecedented in the experience of modern human society. These climate changes, including increases in ultraviolet radiation, are being experienced particularly intensely in the Arctic. Because the Arctic plays a special role in global climate, these changes in the Arctic will also affect the rest of the world. It is thus essential that decision makers have the latest and best information available regarding ongoing changes in the Arctic and their global implications.

The Arctic Council called for this assessment and charged two of its working groups, the Arctic Monitoring and Assessment Programme (AMAP) and the Conservation of Arctic Flora and Fauna (CAFF), along with the International Arctic Science Committee (IASC), with its implementation. An Assessment Steering Committee was charged with the responsibility for scientific oversight and coordination of all work related to the preparation of the assessment reports.

This assessment was prepared over the past five years by an international team of over 300 scientists, other experts, and knowledgeable members of the indigenous communities. The report has been thoroughly researched, is fully referenced, and provides the first comprehensive evaluation of arctic climate change, changes in ultraviolet radiation, and their impacts for the region and for the world.

The scientific results reported herein provided the scientific foundation for the Arctic Climate Impact Assessment (ACIA) synthesis report, entitled "Impacts of a Warming Arctic", released in November 2004.

AMAP Arctic Monitoring and Assessment Programme

CAFF Conservation of Arctic Flora and Fauna

IASC

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ARCTIC CLIMATE IMPACT ASSESSMENT

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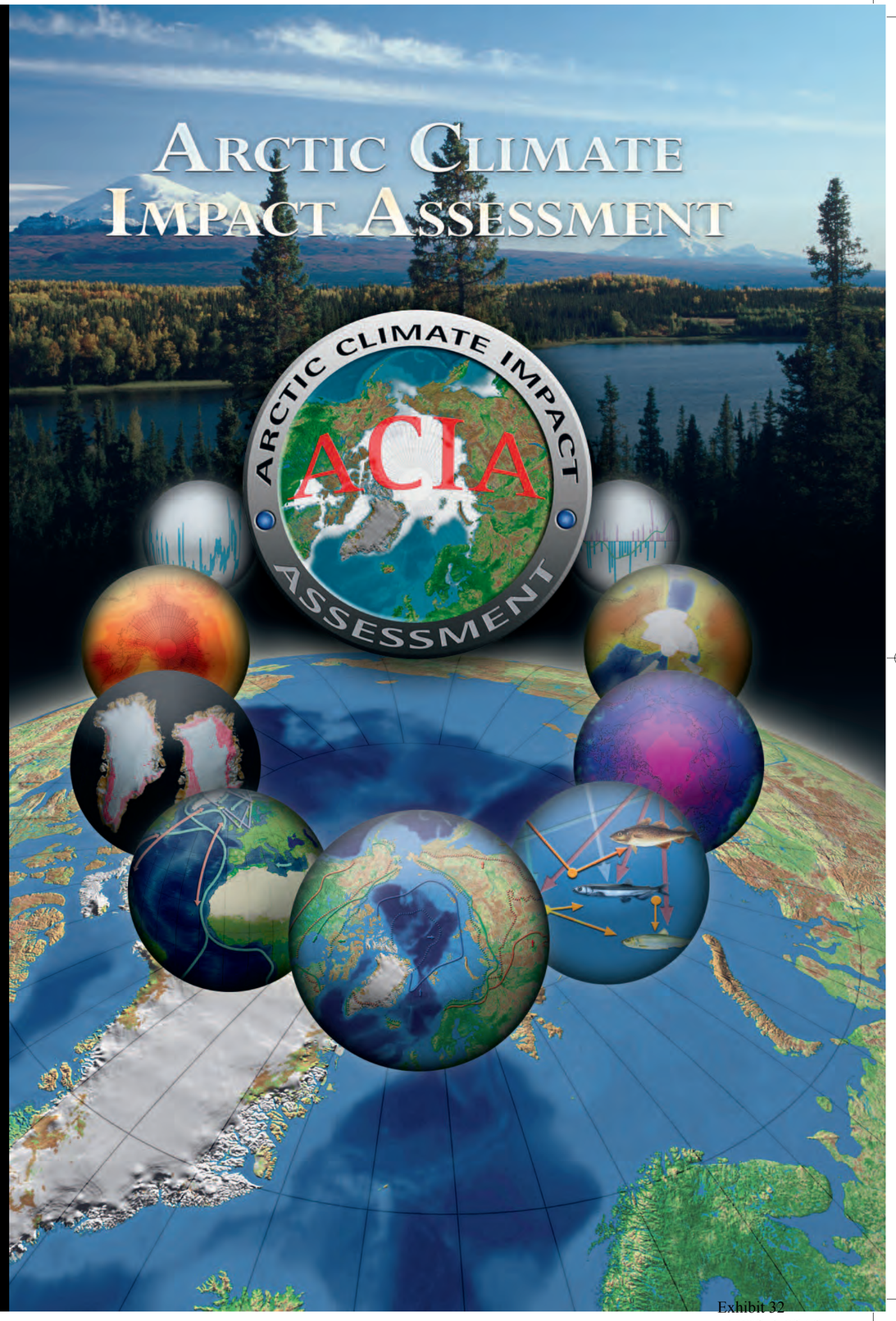

Weather has also changed over the last half century. Seasons are now less consistent. For example, higher temperatures have become more common during autumn and winter, sometimes creating mid-winter fog, a new phenomenon. At the same time, lower temperatures in the summer have also become more common.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

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

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

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

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

3.4.1.1. The impacts of late freeze-up

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

Impacts on humans and their way of life

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

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

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

Impacts on spotted seal

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

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

Impacts on caribou

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

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

Impacts on red foxes

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

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

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

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

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

3.4.2. The Aleutian and Pribilof Islands region, Alaska

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

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

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