Climate, Society, and Natural Hazards: Changing Hazard Exposure in Two Nunavut Communities

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Abstract: This article analyzes changing exposure of Inuit to environmental hazards in two Nunavut communities. One hundred and twelve interviews were conducted in Arctic Bay and Igloolik to identify the environmental hazards to which people are susceptible, to provide insights into how hazard exposure has changed over time, and to identify those factors that influence exposure to environmental risks. Analysis of secondary sources was used to add historical depth. The research indicates a complex pattern of changing hazard exposure over the past fifty years. New hazards have emerged, old ones have disappeared, and there have been changes to the magnitude and frequency of hazards that have always affected Inuit. Long-term trends affecting hazard exposure in the two communities include changes in the timing, location, and equipment used in harvesting, which must be situated in the context of changing community socio-cultural dynamics in the second half of the twentieth century. Changing exposure in recent years reflects the interaction of climate change with social, economic, political, and technological changes that have affected Inuit environment interactions.

1. Introduction

In many Inuit communities in Canada hunting continues to be a valued activity with social, cultural, and economic significance (Furgal and Seguin, 2006). Risks associated with hunting are well-known and are an accepted part of Arctic life. As highlighted in table 1, frostbite, avalanches, blizzards, ice breakup, thin ice, and bad weather claim lives and extract significant financial cost in terms of lost equipment and search and rescue operations. According to the Nunavut Office of Chief Coroner, for example, and highlighted in table 2, from January 2000 to October 2006 there were forty

recorded deaths associated with hunting and/or travelling on the land in Nunavut.

It has been argued that climate change over the last decade has increased the risks of hunting and using the land (Gearhead et al., 2006; Huntington et al., 2005). Indeed, among Inuit in Nunavut, there is widespread feeling that the climate is changing and increasing the hazardousness of hunting (Ford, 2005, 2007; Ford et al., 2007; Krupnik and Jolly, 2002). The link between climate change and changing hazard exposure, however, is not straightforward. Exposure to environmental hazards is also dependent on the characteristics of the human system, which influence how people interact with the environment (McLeman and Smit, 2006; Smit and Wandel, 2006), which in turn is affected by social, economic, political, and technological conditions. Changing exposure to environmental hazards in recent years, therefore, needs to be understood within a context of interacting climatic and societal processes and changes.

Table 1. Hazards associated with harvesting activities in Nunavut

Hazardous condition	Date and location	Notes
Avalanche	January 2003 Pangnirtung	1 fatality, 3 injured rescued by helicopter after avalanche buried hunting camp
Ice floe breakup	July 2000 Arctic Bay	52 people rescued by helicopter from an ice floe that broke off the landfast ice
	January 2005 Iqaluit	3 rescued by helicopter from ice floe that broke free from landfast ice
Thin ice	October 2004 Kugluktuk	2 fatalities after snowmobile crashed through thin ice
	January 2005 Cape Dorset	Man rescued after snowmobile went through the ice
Ice cracks	December 2003 Igloolik	2 fatalities as skidoos plunged into open water on way to Hall Beach, 1 survivor
	May 2005 Cape Dorset	2 fatalities on ice when snowmobile plunged into open water after previous rescue
Storm	February 2004 Cambridge Bay	Stranded hunters rescued on two separate occasions

Table 2. Deaths related to hunting and use of the land between January 2000 and October 2006 (from Nunavut Office of the Chief Coroner)

Circumstance	Number of deaths	% of total
Boating accident while hunting	5	12
Through the ice while walking	2	5
Other boating accidents	5	12
Snowmobile breakdown / exposure	5	12
Snowmobile high speed / lack of control	9	21
Lost on the land / hypothermia death	2	5
Snowmobile and driver through ice	12	28

This article synthesizes previous climate change research by the author and integrates historic data on Inuit-environment relationships, to analyze how and why exposure to environmental hazards has changed in the communities of Arctic Bay and Igloolik, Nunavut. Two communities are selected to permit a comparative analysis of changing hazard exposure. The focus is on naturally occurring conditions or events with the potential to create harm to Inuit while they engage in harvesting activities. The article begins by discussing the concept of hazard exposure and identifies the conceptual basis of the research presented in this article.

2. Arctic Bay and Igloolik

Igloolik is a coastal Inuit community of approximately 1,500 people located on Igloolik Island in northern Foxe Basin, Nunavut, Canada (figure 1). Located off the east coast of Melville Peninsula, the island and the mainland are characterized by a relatively flat topography. Arctic Bay is also a coastal Inuit community, located on north Baffin Island, Nunavut (see figure 1). The region around Arctic Bay is mountainous, and steep hills surround the settlement on three sides with a nearly land-locked bay on the fourth side. The community itself sits on a low gravel beach near the water. The community has a population of around 700 people. Both settlements have expanded rapidly since the 1960s, and their economies have shifted from being based largely on subsistence activities to mixed economies where both the informal and formal economic sectors assume an important role (Damas, 2002).

Harvesting of renewable resources is a valued activity in both communities (DSD, 2002; NWMB, 2004; Rasing, 1999; Reeves, 1993). In Arctic Bay, narwhal (*Monodon monoceros*), ringed seals (*Phoca hispida*), arctic

char (*Salvelinus alpinus*), polar bear (*Ursus maritimus*), and caribou (*Rangifer tarandus*) are the mainstays of the wildlife harvest (NWMB, 2004) (table 3). Mainstays in Igloolik include walrus (*Odobenus rosmarus*), polar bear, ringed seal, caribou, char, and a variety of migratory birds during spring and summer (NWMB, 2004) (table 3). Except for the summer open water period, travel and harvesting in both communities are largely performed on sea ice. As highlighted in table 3, important differences in harvesting activities are also evident. Iglulingmiut (Inuit from Igloolik), for example, hunt walrus from the moving ice in winter, and offshore amongst the loose pack ice during summer, while there are few walrus in the Arctic Bay region.

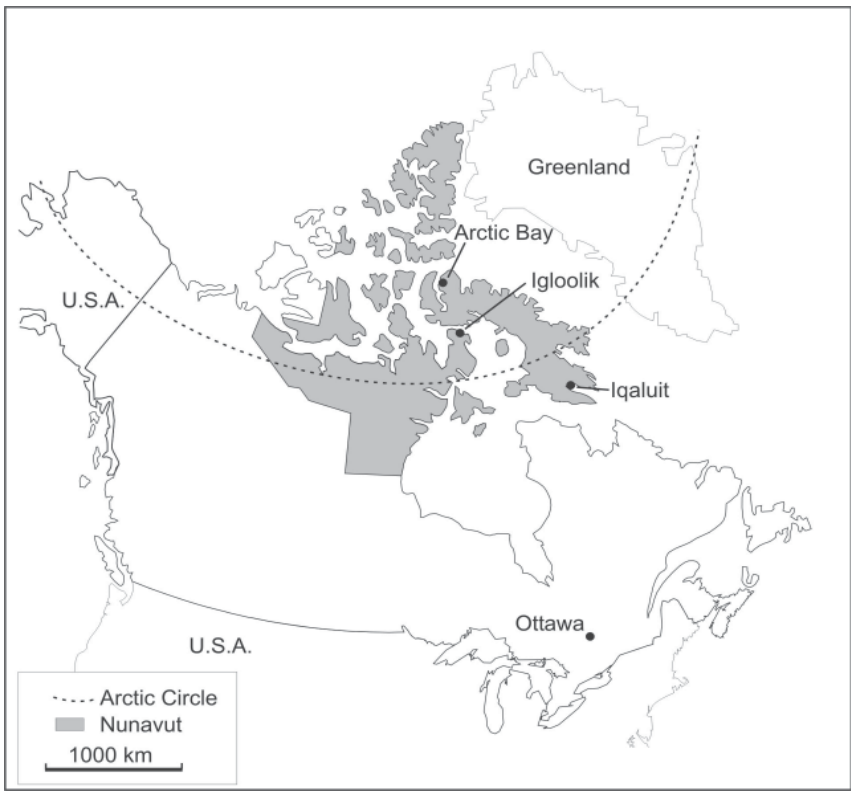

Figure 1. Location of Arctic Bay and Igloolik

Table 3. Mainstays of the community harvest in Arctic Bay (AB) and Igloolik (I) and mean annual harvest for the period 1996–2001 (modified from NWMB, 2004)

Species harvested	Harvest details	1996–2001 mean harvest
Arctic char	All year from rivers (AB), all year from mainland lakes (I)	10,237 (AB) 13,842 (I)
Caribou	All year (AB, I)	778 (AB), 1701 (I)
Narwhal	June–July from floe edge (AB), open water summer (I)	74 (AB), 2 (I)
Polar bear	October–March on sea ice (AB, I)	11 (AB), 10 (I)
Ringed seal	All year from sea ice and open water (AB, I)	1,450 (AB), 1,799 (I)
Walrus	Mainly winter on ice and summer on floating ice (I), opportunistic (AB)	3 (AB), 152 (I)

Both communities share similarities in the risks they face while hunting: white-out, blizzards, thin ice, ice instability, rain during winter, rough water in summer, and strong winds. There are also important differences. The mountainous nature of the Arctic Bay region creates risks such as rockfalls and landslides. In the Igloolik region, the lack of visual distinctiveness of the topography creates the potential for hunters to get lost without the navigational aids provided by mountainous terrain. The timing at which hunters interact with certain environmental risks also differs. In Arctic Bay, hunters face the possibility of getting stranded on drifting ice when it detaches from the landfast ice during the late spring floe edge narwhal hunt (Ford, 2006b; Ford et al., 2006b). In Igloolik, the harvest of walrus on the moving ice during winter exposes them to the risk of being stranded if the wind changes to the north/northeast, blowing the moving pack ice away from the landfast ice (Ford, 2006a).

3. Hazard Exposure

3.1. Conceptualization of Exposure

Much of the research on exposure to environmental hazards in the Arctic has focused on characterizing the nature of geophysical processes that pose risks, including the magnitude, frequency, spatial dispersion, duration, speed of onset, timing, and temporal spacing of physical conditions (Burgess

et al., 2000; Cohen, 1997; Nelson et al., 2002; Shaw et al., 1998). This work has significantly increased our understanding of the physical processes that influence hazard exposure.

Exposure, as conceptualized here, however, is not only the presence of some external stress, but is dependent on both the characteristics of the community and on the attributes of the environmental stimulus; it reflects the susceptibility of people and communities to environmental conditions (McLeman and Smit, 2005). The nature of the community concerns its location and structure relative to the environmental risks. Increasing exposure of Inuit communities to hazards since the 1950s, for example, reflects, in part, infrastructural development and urban expansion (Ford and Smit, 2004). The nature of the community also concerns how people behave with respect to environmental conditions. In Arctic communities, different species will be harvested in different locations at different times of the year on account of individuals' knowledge of the environment, past experience, differential time constraints, and access to technology (Ford et al., 2006b). Indeed, exposure is dynamic, changing as the community changes its characteristics relative to the environmental conditions, and changing as the stimuli themselves change. It also reflects human and biophysical conditions and processes operating at broader scales, which influence community social, economic, and political status (Ford et al., 2006b). Environmental change interacts to affect the characteristics of climate related conditions, changing the nature of the potential risks posed.

3.2. Community-Based Research Methods

To assess exposure and how it has changed over time, this article uses the approach of Ford and Smit (2004) and starts with the community itself. It incorporates the knowledge and observations of local residents to: 1) identify those environmental conditions that represent hazards, 2) provide insights into how they have changed over time, and 3) identify those factors that influence exposure to environmental risks. To this end, 112 semi-structured interviews were conducted with a cross-section of community members between 2004 and 2006. The data collection was undertaken with Inuit colleagues, with interviews conducted in Inuktitut and English. A second field session was undertaken in spring 2005 and fall 2006. The results and interpretation from the first field session were evaluated and reviewed with people interviewed during the first trip, and presented to both communities. Analysis of secondary sources was used to add historical context on how communities experience and manage environmental hazards and to document change over time.

4. Changing Exposure to Hazards

Over the past fifty years, exposure to hazards has altered significantly in Arctic Bay and Igloolik as a result of changes in how Inuit interact with the environment, and, more recently, changing climatic conditions. These trends have significantly affected exposure to environmental hazards.

4.1. Societal Change

As in other parts of the eastern Canadian Arctic, and Arctic Canada as a whole, there have been significant societal changes in Arctic Bay and Igloolik. With the exception of Christianity, introduced to the area in the 1920s, these changes have largely been experienced in the later half of the twentieth century (Ford et al., 2006a). These have included the introduction of legal and administrative government structures; the settlement of semi-nomadic groups in centralized permanent villages; the development of formal economic sector activities alongside the traditional; participation in, and dependence on, external markets; compulsory schooling for children; and population growth (Bisset, 1965; Brody, 1976a, b; Crowe, 1969; Mary-Rousselliere, 1984; Rasing, 1994, 1999). In Arctic Bay, the operation of a zinc mine at nearby Nanisivik from 1976 to 2002 provided employment and income to the community, acting as a catalyst in the social transformation of Inuit life in the region, including the creation of an uneven distribution of wealth in the community (DSD, 2002). In the Igloolik region, the building and operation of Distant Early Warning Sites (DEW), beginning in the 1950s, likewise played an important role in changing Inuit livelihoods (Crowe, 1969). These societal changes, as highlighted in this section, have impacted on harvesting behaviour, in turn, affecting hazard exposure.

4.1.1. Hunting technology. There has been significant change in technology used in hunting since the 1950s. Settlement of semi-nomadic hunting groups in fixed communities in the 1960s resulted in the increased use of, and dependence on, imported technology such as snowmobiles (beginning in the early 1960s) and motorized boats (beginning in the mid to late 1950s) to enable travel beyond the limited zone of exploitation imposed by fixed settlement (Condon et al., 1995; Crowe, 1969; Wenzel, 2004). Other technology adopted for harvesting includes Very High Frequency (VHF) radios and, more recently, Citizen's Band (CB) radios, Global Positioning Systems (GPS), personal location beacons—and hunters (particularly in Arctic Bay) now consult satellite images of the sea ice prior to travel. As Ford et al. (2006a, b) argue, the adoption of these modern technologies has

occurred in the context of decreasing time availability for hunting due to participation of hunters in the formal economic sector, the requirements of hunting with snowmobiles and motorized boats, the perceived safety that many of these devices provide, and a reduction in land based skills, especially among younger generations.

The adoption of new technology and equipment has had implications for harvesting. On the one hand, if used properly, as Ford et al. (2006a; 2006b) and Aporta and Higgs (2005) note, they confer improvements in safety and reduced susceptibility to environmental hazards. VHF radios allow the community to be contacted in case of an emergency, personal location beacons have saved lives by enabling rescue teams to locate lost or injured hunters, GPS makes navigation by boat easier, larger and faster boats offer more protection than kayaks when hunting in open water, snowmobiles allow land to be reached rapidly if the ice disintegrates, and satellite images allow hunters to identify dangerous areas to avoid prior to travel.

Technology, however, has created new hazard exposures and exacerbated old ones. The replacement of dog teams with snowmobiles, beginning in the 1960s, for instance, has increased the dangers of travelling on ice. Snowmobiles, unlike dogs, cannot sense dangerous ice and travel is particularly dangerous in fall when there is snow-covered thin ice.

> The dog teams know the thin ice and the thicker ice so [people] know that they [are] walk[ing] through thin ice. Snowmobile doesn't say, "Alert! This is thin ice." So it's more dangerous [by snowmobile] than by dog team. (Herve Paniaq, Igloolik, quoted in Ford et al. [2006a])

> [When travelling by snowmobile] I wouldn't be much aware of the environment. (Jobie Attitaq, Arctic Bay)

Since the introduction of snowmobiles, both communities have experienced fatal accidents where hunters have been unable to identify ice thickness and have gone through thin ice. In Arctic Bay in 1978, for instance, a young hunter was killed when his snowmobile plunged through the ice only a short distance from the community. His brother, who was riding with him, was lucky to survive. In many hunting accidents involving snowmobiles, speed often increases the risks; noticing thin ice or open water is difficult when travelling at 80 km/hr. This is reflected in reported deaths for Nunavut between January 2000 and October 2006: nine involved high speed and a loss of control.

Other mechanized equipment, including the use of larger, more powerful motorized boats, has also created new risks. The majority of modern boats are significantly heavier than the smaller, less powerful ones used previously; in early fall, when the ice is forming, it is almost impossible to haul these larger boats onto ice pans to avoid being crushed by moving ice. The more powerful boat engines also create risks associated with speed. In Igloolik in summer 1990, six hunters were killed when their boat hit submerged ice; it was determined that a combination of fog and incautious speed were principal factors in this accident (MacDonald, pers:comm.).

In Igloolik in particular, community members expressed concern regarding the widespread use of GPS and its implications for safety while hunting. GPS was first introduced in the 1990s, but had limited use until 2000 when the Hunters and Trappers Association made user-friendly devices available at subsidized cost. GPS is now in widespread use. Concern was expressed regarding the perception of safety among its users. GPS allows successful travel with limited knowledge about navigation and about the environment (Aporta and Higgs, 2005). Consequently, some young and inexperienced hunters now travel alone and to locations where they would not have previously gone.

> We go to areas where we wouldn't normally go because we are assured [by the GPS] we will know where we are. (Nick Arnatsiaq, Igloolik)

While inexperienced hunters often avoid travel at dangerous times (ice breakup and freeze-up) and to dangerous locations (the floe edge or moving ice), even travel along well used and perceived "safe routes" can be dangerous if the GPS fails and traditional navigation skills are not known.

> GPS enhances your navigation, but if it runs out of batteries it doesn't enhance navigation, it disables you. It can be your blessing and your downfall at the same time. (Theo Ikkumaq, Igloolik, quoted in Ford et al. [2006a])

This over-reliance on GPS is reinforced by a lack of knowledge of how to operate the GPS. Many GPS users tend to travel straight routes with few waypoints that follow the fastest course from A to B. These are rarely the safest routes and may cross through thin ice or areas of rough ice. This is particularly problematic for inexperienced hunters who are not as knowledgeable in the location of dangerous areas or skilled in determining how safe it is to travel over thin ice. Use in this way creates potential for accidents to occur. Arctic

Bay residents had fewer concerns over the use of GPS. The mountainous topography punctuated by deep fjords makes navigation easier than on the visually indistinctive landscape near Igloolik. Consequently, few Arctic Bay hunters use GPS on a regular basis, using it mainly to aid navigation in low visibility.

Additional risks are created by the costs of purchasing and operating mechanized equipment. Snowmobiles and boats represent a large capital investment, especially for those who have limited access to financial resources. In recent years, rising gas and commodity prices have stressed household finances in both communities to the extent that many hunters are struggling to afford equipment operating costs. In 2006, for example, interview participants noted taking as little gas as possible when making hunting or recreational trips and reducing the amount of spare gas taken due to cost. Consequently there have been instances in both communities where snowmobiles have run out of gas, particularly in Igloolik in fall 2006 when gas prices in November spiked and a late freeze-up, combined with the location of caribou at some distance from the community, forced hunters to travel further to hunt (figure 2). Running out of gas can be a serious incident if hunters do not have adequate clothing or survival skills: between January 2000 and October 2006 five deaths in Nunavut documented by the Nunavut Office of the Chief Coroner were related to snowmobile breakdown and death via exposure (table 2). In this manner, as depicted in figure 2, economic forces stemming from global trends have affected hazard exposure at the local level, and in the case of Igloolik in 2006 interacted with sea ice conditions and caribou location to exacerbate hazard exposure.

4.1.2. Risk-taking behaviour. Inuit risk assessment when making decisions regarding hunting has also changed in other ways with people now more likely to harvest in spite of poor weather or ice conditions. Ford et al. (2006a) argue that this is partly due to the reduced time available to harvest. Indeed, many hunters now balance full- or part-time jobs with hunting activities. Time off from work, which is used for hunting trips, has to be scheduled in advance (Ford et al., 2006b). Weather or safety concerns may, therefore, be superseded by consideration of time availability when harvesting decisions are made (Aporta, 2004).

> If the guy goes out hunting during holiday or weekend he has to rush [back to the community] whether [it is] bad weather or not. (David Kalluk, Arctic Bay)

More risk-taking behaviour is associated with technological developments. Interviews indicated that GPS, VHF radios, and the functioning of a community search and rescue group have resulted in less caution and overconfidence.

> [With these new technologies] we take more chances. (Nick Arnatsiaq, Igloolik)

Hunters are now travelling and hunting in conditions that would have traditionally been considered dangerous. In Igloolik, for instance, Beaubier et al.'s (1970) work on hunting behaviour in the late 1960s concluded that wind and visibility were major constraints to hunting. While true to a certain extent today, many community members now go out in conditions previously considered unsuitable. Indeed, during field work in November 2005, the author witnessed people departing to hunt during a near zero-visibility blizzard. In interviews the following week, elders described this rarely occurring in their youth despite their almost complete reliance on traditional foods. Today those who work during the week are more willing to harvest on the weekends, whatever the weather, if it is the only time they have available.

> I think some people will now go out when they wouldn't normally go out. (James Ungalak, Igloolik)

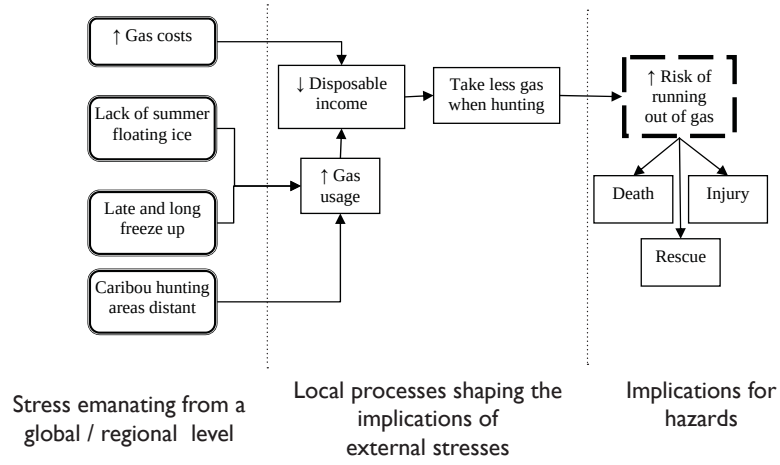

Figure 2. Hazard exacerbation in Igloolik as a consequence of gas price increase, sea ice conditions, and caribou location in 2006

Risk-taking behaviour is also linked to de-skilling and incomplete transmission of knowledge for safe hunting among younger generations. As Ford et al. (2006a, b) and Henshaw (2007) note, many younger generations do not have the knowledge to travel safely, including the ability to locate dangerous areas on the ice, identify precursors to hazardous conditions, or judge whether it is safe to go hunting.

> It is more dangerous for [the younger generation] because they don't know the conditions, what to avoid. (Kautaq Joseph, Arctic Bay)

> Nowadays [the younger people] just want to go out without realizing what the weather is going to be like. (Peter Awa, Igloolik)

This is reinforced by equipment such as snowmobiles and new technology, which enable young hunters to go hunting without the years of experience required to operate a dog team and navigate using traditional wayfaring methods (see MacDonald 1998, Aporta and Higgs 2005). A case in 2003, for instance, where two young Inuit from Igloolik drowned when their snowmobile went over a newly formed crack on the ice, has been linked to speed of travel, lack of experience, and risk-taking behaviour.

4.1.3. Timing of harvesting activities. Over the last fifty years there have been changes in the seasonal cycle of harvesting activities. In Arctic Bay, in particular, the result has been a significant increase in exposure to hazards associated with use of the sea ice.

During the 1950s, the majority of Inuit in the Igloolik and Arctic Bay area lived in semi-permanent camps characterized by seasonal dispersion according to the availability and location of animals. Commodities required from southern markets, including ammunition, rifles, tea, and whale boats, were obtained through the trading of skins and fur (Crowe, 1969; Damas, 2002; Freeman et al., 1998; Wilkinson, 1955). The "camp system" persisted until the late 1960s, by which time the majority of people had moved to the fixed settlements. With settlement in fixed communities came the need for mechanized equipment to access hunting locations. Initially, equipment was bought by trading skins and furs. Increased prices of equipment combined with declining markets in Europe for seal skins (Wenzel, 1991), however, resulted in the importance of securing an income from different sources to support harvesting. In Arctic Bay, this resulted in the commercial exploitation

of narwhal for its ivory tusk, beginning in the early 1970s (Ford, 2006b; Reeves, 1977). In response, Narwhal Protection Regulations were issued in 1976 by the Canadian government to limit the catch of this commercially important species (Kemper, 1980; Reeves, 1977; Roberge and Dunn, 1990). The regulations prohibited the killing of newborn calves or females accompanied by a calf, and introduced an annual quota (Reeves, 1977). As a result of these two trends, and facilitated by the availability of snowmobiles allowing rapid access, hunters attempt to maximize their chance of catching narwhal before the quota expires by hunting them as soon as they arrive in the region. This usually occurs during June and July from the edge of the ice that is anchored to the shore (known as the floe edge) when the ice is breaking up (Ford, 2006b; Ford et al., 2006b). Traditionally, hunters avoided this time, waiting for the narwhal to migrate closer to the community where they can be hunted close to the shore and safely (Wilkinson, 1955; Brody, 1976; Kemper, 1980; Freeman et al., 1998). The floe edge is a highly unstable environment and breakup is the most dangerous time to be on the ice (MSC, 2004).

> When I was growing up, the elders used to tell us not to do the narwhal hunting at the floe edge. (Kik Shappa, Arctic Bay)

The narwhal hunt is extremely popular, attracting the younger generations as well as the more experienced hunters. Hunting at the floe edge during breakup, however, has increased susceptibility of getting stranded on drifting ice when it detaches from the landfast ice (ice that is attached to the land). This happened numerous times in recent years, including in 2000 when fifty-two stranded hunters had to be rescued by helicopter, losing most of their equipment in the process (George, 2000). Climate change has increased the dangers of hunting at the floe edge by affecting the stability of the ice and wind predictability (see section 4.2).

In Igloolik, the location and timing of harvesting remains largely unchanged from the camp system. People avoid hunting or travelling on the ice during breakup, for instance, in line with traditional practices. This significantly reduces exposure compared to Arctic Bay. There are departures from the past in Igloolik, however. The most important concerns the location of the settlement with respect to hunting areas. During the camp system, the distribution of camps placed each settlement group in an area that offered a full range of animal species and a full cycle of seasonal activities (Crowe, 1969; Ross, 1960). By the late 1960s, however, the majority of Inuit in the region moved to the settlement at Igloolik. The location of the new settlement, however, as Anders (1965) notes, "is not one at which any large

number of self supporting Eskimo hunters would have chosen to live in order to exploit to their best the advantages of local resources." In the open-water season the bay at Igloolik is often covered with floating ice that gets trapped for prolonged periods when there is a southerly or easterly wind, making it difficult for hunters to get out in their boats; and the island is cut off from hunting areas on the mainland and Baffin Island during ice freeze-up and breakup when it is not possible to use snowmobiles or boats. With little hunting on Igloolik Island, hunters are stuck in the community during this period (Aporta, 2002). There have been cases in fall where hunters, eager to access hunting locations, have gone on the ice prematurely and have had accidents, or have been stuck on the mainland when the ice suddenly broke up.

> They try to go to the mainland even if there is thin ice, even if the ice is wavy. (Anonymous, Igloolik)

Changing climatic conditions are increasing the dangers of ice travel at this time of year (see section 4.2).

4.2. Changing Climatic Conditions

There is widespread feeling among Inuit in Igloolik and Arctic Bay that climatic conditions have been changing beyond expected natural fluctuations and variability since the 1990s (table 4) (Ford et al., 2006a; Ford et al., 2006b; Nickels et al., 2006). Community observations are supported by regional-scale instrumental records (Dumas et al., 2005; Moore, 2006; Noonan et al., 2005). These changes have exacerbated the risks associated with harvesting and have created new risks.

4.2.1. Climate change and increasing hazardousness. As Ford et al. (2006a, b) argue, climate change is challenging Inuit knowledge and understanding of the environment, specifically the ability to evaluate risks. With the visual clues of weather and wind becoming more difficult to read, identifying precursors of hazardous conditions is increasingly difficult. Prediction is essential as the ability to anticipate and respond to dangers, opportunities, and changes, is important for safe travel. Strong winds, for example, can be dangerous while boating on exposed water in the summer, can cause whiteout conditions in winter, and can cause the pack ice to suddenly detach from the landfast ice. According to community members, the weather was fairly predicable over the past several generations. In recent years, however, there have been

incidents in both communities where sudden and unexpected changes have stranded hunters on the land.

> Nowadays my traditional knowledge, I can't use [this] knowledge now. (Lisha Levi, Arctic Bay)

In Arctic Bay, the risks are particularly acute for those who hunt narwhal at the floe edge during breakup. In late spring 2000, for instance, as discussed in section 4.1.3, fifty-two hunters were caught by surprise when a strong wind from the south detached the ice they were on from the landfast ice and pushed them down Admiralty Inlet (Ford, 2005).

> A lot of people didn't realize that there's going to be a strong wind from the south. (Levi Barnabas, Arctic Bay)

In Igloolik, the changes have increased the risks for those who hunt walrus on the moving pack ice. Sudden changes in wind direction from the south/southwest to northwest have stranded hunters on drifting ice and have resulted in the loss of expensive hunting equipment (Ford et al., 2006a).

Unpredictable weather is also a problem for those who travel and hunt by boat during the summer open-water period. Hunters have been caught out in small boats by unexpected strong winds and have had to return quickly to shore. Others have been forced to spend extra, unplanned nights on the land waiting for conditions to improve to allow safe travel.

> The wind … when you [are] out hunting brings a lot of problems when you [are] not prepared for it. (Koonoo Muckpaloo, Arctic Bay)

Community members also indicated changes in the condition of the ice, including later and longer ice freeze-up, earlier breakup, thinner ice, more snow on the ice, and new areas of open water. Snow covered, thin ice presents a potential hazard, particularly in fall, and hunters have noticed more snow on the ice recently. There have been numerous cases in recent years where hunters have gone through unusually thin ice and lost their snowmobiles. Olayuk Kigutukarjuk of Arctic Bay and her husband, for instance, were lucky to survive when their snowmobile plunged through thin ice hidden by snow (Ford, 2005).

Table 4. Community-observed climatic changes in Igloolik (I) and Arctic Bay (A) (after Ford et al., 2006a, b)

Aspect of change	Reported change
Weather	• Increasing unpredictability—elders' predictions never correct anymore (I, A) • More extremes of temperature (I, A)
Wind	• Changes to the direction, strength, and frequency of the wind—especially in summer (I, A) • More unpredictable (I, A) • Stronger wind (I, A) • Change in the predominant wind direction is affecting the shape of snowdrifts (Uqalurait) (I)
Sea ice	• Later freeze-up, earlier breakup (I, A) • Less stable—breaks up suddenly (I, A) • Thinner in places (I, A) • Takes longer to form (I, A)
Snow	• Less snow on the land (A) • More snow on the ice in autumn (I) • More blizzards (I)
Rainfall	• More summer rainfall (A)

5. Discussion

Independent of each other, climatic and non-climatic changes have created new hazard exposures, exacerbated old exposures, and eliminated others. In many circumstances, however, changing exposure to hazards reflects the interaction of climate and other environmental conditions with social, economic, political, and technological conditions and changes, which affect how Inuit interact with the environment. The increasing dangers posed by unpredictable weather conditions and wind are occurring in the context of more risk-taking behaviour, alterations in hunting locations, de-skilling among younger generations, and rising gas prices. For example, throughout the 1970s and 1980s floe edge narwhal hunters in Arctic Bay managed the risks of narwhal hunting using their knowledge to identify precursors to hazardous conditions, avoiding travelling during or preceding a south wind. It is only with the increasing unpredictability of the wind in recent years that accurate recognition of precursors has become difficult and risks associated with floe edge hunting have emerged.

The dynamic nature of exposure, conditioned by the interaction of human and environmental conditions, is also reflected in differential exposure between the two communities despite the similarity in physical conditions and observed changes in climate. Differential exposure manifests itself through the nature of those conditions that pose a hazard. In Arctic Bay, many hunting accidents and search and rescue operations occur during the summer narwhal hunt. It is during this period that reported increased unpredictability of the weather and winds have been most problematic. In Igloolik, people do not go on the ice at this time. Hazards in Igloolik are largely encountered during ice freeze-up when hunters are eager to access hunting areas on the mainland or Baffin Island, and during winter on the moving ice where walrus are hunted. Additionally, in Igloolik, hazards associated with getting lost are more frequent due to the lack of visual distinctiveness of the topography in the Igloolik region.

Important differences also emerge with regard to those factors that have altered exposure to environmental risks. In Arctic Bay, new exposures appeared in the 1970s with the beginning of the late spring floe edge narwhal hunt, the development of which can be situated in the context of the increasing importance of money in the community, the imposition of quotas, and availability of snowmobiles. There have been limited changes in the timing and location of harvesting activities in Igloolik. Technology, however, especially since the 1990s, has had a major influence of exposure in Igloolik to the extent that it has not in Arctic Bay. In Igloolik, GPS, for instance, is used widely for navigational purposes creating potential for accidents involving improper use and over-reliance. The increasing use of technology has occurred in the context of decreasing time availability for hunting, a reduction in land based skills among younger generations, the requirements of hunting with snowmobiles and motorized boats, and the perceived safety that many of these devices provide.

A number of lessons from this study can be drawn for studies looking at the impacts of future climate change on hazard exposure in Nunavut and the North in general. Firstly, climate-related stresses rarely occur in isolation from other, non-climatic stresses. The next fifty years will likely see dramatic socio-economic changes in the North with continued globalization, industrialization, and political change. These changes will be as significant as climate change, if not more so, and will exacerbate or moderate the implications of changing physical conditions. A second lesson is that these larger scale socio-economic-political processes will play out differently at the level of communities depending on their physical location, infrastructure, social dynamics, and experience with past change. Communities may

therefore experience similar changes in physical conditions but the impact on hazard exposure may differ widely.

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References Cited

Anders, G. 1965. Northern Foxe Basin: An area economic survey. Industrial Division, Northern Affairs Administration Branch, Department of Northern Affairs & National Resources, Ottawa, 139.

Aporta, C. 2002. Life on the ice: Understanding the codes of a changing environment. *Polar Record* 38:341–354.

Aporta, C. 2004. Routes, trails and tracks: Trail breaking among the Inuit of Igloolik. *Inuit Studies* 28:9–38.

Aporta, C. and Higgs, E. 2005. Satellite culture: Global Positioning Systems, Inuit wayfinding, and the need for a new account of technology. *Current Anthropology* 46:729–753.

Beaubier, P. H., Bradely, J. M. and Vestey, J. G. 1970. *Human adaptability report (Igloolik, N.W.T.)*. International Biological Programme.

Bisset, D. 1965. Recent changes in the life of the Igloolik Eskimos. *The Albertan Geographer* 1:12–16.

Brody, H. 1976a. Inuit land use in northern Baffin Island and northern Foxe Basin. In Freeman, M. R. (ed.), *Inuit land use and occupancy project*, Thorn Press Limited Ottawa, 153–172.

Brody, H. 1976b. Inummariit: The real Eskimos. In Freeman, M. R. (ed.), *Inuit land use and occupancy project*, Thorn Press Limited, Ottawa, 223–226.

Burgess, M., Desrochers, D. T. and Taylor, A. E. 2000. Potential changes in thaw depth and settlement for three locations in the Mackenzie valley. In Dyke, L. D. and Brooks, G. R. (eds.), T*he physical environment of the Mackenzie Valley, Northwest Territories: A base line for the assessment of environmental change*, Geological Survey of Canada Bulletin 547:187–196.

Cohen, S. 1997. What if and so what in northwest Canada: Could climate change make a difference to the future of the Mackenzie Basin? *Arctic* 50:293–307.

Condon, R., Collings, P. and Wenzel, G. 1995. The best part of life: Subsistence hunting, ethnicity, and economic development among young adult Inuit males. *Arctic* 48: 31–46.

Crowe, K.J. 1969. *A cultural geography of Northern Foxe Basin, NWT*. Northern Science Group: Department of Indian and Northern Development, 130.

Damas, D. 2002. *Arctic migrants / Arctic villagers*. McGill-Queens University Press, 277.

DSD. 2002. *The Nanisivik legacy in Arctic Bay: A socio-economic impact study.* Prepared for Department of Sustainable Development Government of Nunavut by Brubacher Associates, Ottawa, 113.

Dumas, J., Flato, G. and Brown, R. D. 2006. Future projections of landfast ice thickness and duration in the Canadian Arctic. *Journal of Climate* 19(20): 5175–89.

Ford, J. 2005. Living with change in the Arctic. *World Watch* September / October: 18–21.

Ford, J. 2006a. Sensitivity of hunters to hazards associated with climate change: Iglulingmiut perspectives. In Oakes, J. and Riewe, R. (eds.), *Climate change: Linking traditional and scientific knowledge*, Aboriginal Issues Press, Winnipeg, Manitoba, 202–235.

Ford, J. 2006b. Vulnerability of Arctic Bay narwhal hunter to climate change. In Oakes, J. and Riewe, R. (eds.), *Climate change: Linking traditional and scientific knowledge*, Aboriginal Issues Press, Winnipeg, Manitoba, 236–254.

Ford, J. 2007. On the frontline of our changing climate: How Inuit in the Canadian Arctic are weathering the challenges of a warmer world. *Weatherwise* July / August: 1–6.

Ford, J., MacDonald, J., Smit, B. and Wandel, J. 2006a. Vulnerability to climate change in Igloolik, Nunavut: What we can learn from the past and present. *Polar Record* 42:1–12.

Ford, J., Pearce, T., Smit, B., Wandel, J., Allurut, M., Shappa, K., Ittusujurat, H. and Qrunnut, K. 2007. Reducing vulnerability to climate change in the Arctic: the case of Nunavut, Canada. *Arctic* 60:150–166.

Ford, J. and Smit, B. 2004. A framework for assessing the vulnerability of communities in the Canadian Arctic to risks associated with climate change. *Arctic* 57: 389–400.

Ford, J., Smit, B. and Wandel, J. 2006b. Vulnerability to climate change in the Arctic: A case study from Arctic Bay, Canada. *Global Environmental Change* 16:145–160.

Freeman, M. R., Bogoslovskaya, L., Caulfield, R., Egede, I., Krupnik, I. and Stevenson, M. G. 1998. *Inuit, whaling, and sustainability*. Altamira Press, Walnut Creek, CA, 208.

Furgal, C. and Seguin, J. 2006. Climate change, health, and vulnerability in Canadian northern Aboriginal communities. *Environmental Health Perspectives* 114, 1964–1970.

Gearhead, S., Matumeak, W., Angutikjuaq, I., Maslanik, J. A., Huntington, H., Leavitt, J., Kagak, D., Tigullaraq G., and Barry, R. G. 2006. "It's not that simple": A collaborative comparison of sea ice environments, their uses, observed changes, and adaptations in Barrow, Alaska, USA, and Clyde River, Nunavut, Canada. *Ambio* 35:203–211.

George, J. 2000. Helicopters rescue 52 Arctic Bay residents. *Nunatsiaq News*, Iqaluit.

Henshaw, A. 2007. Pausing along the journey: Learning landscapes, environmental change and place names amongst the Sikusilarmiut. *Arctic Anthropology* 43: 52–66.

Huntington, H., Fox, S., Berkes, F. and Krupnik, I. 2005. *The changing Arctic: Indigenous perspectives*. Arctic Climate Impact Assessment Scientific Report, Cambridge University Press, Cambridge, 61–98.

Kemper, J. B. 1980. *History of use of narwhal and beluga by Inuit in the Canadian eastern Arctic including changes in hunting methods and regulations*. Report of the International Whaling Commission 30, 481–492.

Krupnik, I. and Jolly, D. 2002. *The Earth is faster now: Indigenous observations of climate change*. Arctic Research Consortium of the United States, Fairbanks, Alaska, 384.

Mary-Rousselliere. 1984. Iglulik. In Damas, D. (ed.), *Handbook of North American Indians*, Smithsonian Institution, Washington, 431–446.

McLeman, R. and Smit, B. 2006. Vulnerability to climate change hazards and risks: Crop and flood insurance. *The Canadian Geographer* 50(2): 217-226.

Moore, G. K. W. 2006. Reduction in seasonal sea ice concentration surrounding southern Baffin. *Geophsical Research Letters* 33, L20501.

MSC. 2004. *Reducing the risk of hunting and fishing at the ice edge*. MSC Atmospheric and Climate Science: Research Making a Difference, Atmospheric and Climate Science Directorate, Meteorological Service of Canada, Downsveiw, Ontario, 33–34.

Nelson, F. E., Anisimov, O. A. and Shiklomanov, N. I. 2002. Climate change and hazard zonation in the circum-Arctic permafrost regions. *Natural Hazards* 26:203–225.

Nickels, S., Furgal, C., Buell, M. and Moquin, H. 2006. *Unikkaaqatigiit – Putting the human face on climate change: Perspectives from Inuit in Canada*. Ottawa: Joint publication of Inuit Tapiriit Kanatami, Nasivvik Centre for Inuit Health and Changing Environments at Université Laval and the Ajunnginiq Centre at the National Aboriginal Health Organization.

Noonan, G. J., Weatherrhead, E. C., Gearhead, S. and Barry, R. G. 2005. Arctic weather change: Linking Indigenous (Inuit) observations with the surface temperature record. Eos, Transactions, *American Geophysical Union* 86.

NWMB. 2004. *The Nunavut wildlife harvest study: Interim community report for Arctic Bay and Nanisivik*. Nunavut Wildlife Management Board, Iqaluit, 113.

Rasing, W. 1994. *Too many people: Order and nonconformity in Inglulingmiut social process*. Recht and Samenleving, Nijmegen, Netherlands.

Rasing, W. 1999. Hunting for identity. Thoughts on the practice of hunting and its significance for Iglulingmiut identity. In Oosten, J. and Remie, C. (eds.), *Arctic identities: Continuity and change in Inuit and Saami societies*, University of Leiden, Leiden, Netherlands, 79–108.

Reeves, R. 1977. Hunt for the narwhal. *Oceans* 10:50–57.

Reeves, R. 1993. The commerce of maktaq at Arctic Bay, Nunavut, Northern Baffin Island, NWT. *Arctic Anthropology* 30:79–83.

Roberge, M. M. and Dunn, J. B. 1990. *Assessment of the subsistence harvest and biology of narwhal (Monodon monoeros, L.) from Admiralty Inlet, Baffin Island, NWT., 1983 and 1986–89*. Canadian Technical Report of Fisheries and Aquatic Sciences no. 1747, Central and Arctic Region Department of Fisheries and Oceans, Winnipeg, Manitoba, 32.

Ross, W. G. 1960. The Igloolik Eskimos. *The Scottish Geographical Magazine* 76: 156–163.

Shaw, J., Taylor, R. B., Solomon, S., Christian, H. A. and Forbes, D. L. 1998. Potential impacts of sea level rise of Canadian coasts. *The Canadian Geographer* 42:365–379.

Smit, B. and Wandel, J. 2006. Adaptation, adaptive capacity, and vulnerability. *Global Environmental Change,* 16(3): 282-292.

Wenzel, G. 1991. *Animal rights, human rights*. University of Toronto Press, Toronto, 206.

Wenzel, G. 2004. *Polar bear as a resource: An overview*. Third Northern Research Forum Open Meeting Position Paper. www.nrf.is/open_meetings_files/Yellowknife_2004/Wenzel.pdf, accessed 25 May 2005.

Wilkinson, D. 1955. *Land of the long day*. Clarke, Irwin & Company Limited, Toronto, 261.