Chapter 7 – Analysis
Inter-community comparison of sea ice processes, use, and change

7.1 Importance of sea ice

As evidenced in Chapters 4 – 6, sea ice is very important to each of the communities involved in this project. It is a key means of traveling to access wildlife, engaging in subsistence or commercial hunting/harvesting, and enjoying leisure time. With Cape Dorset and Igloolik being on islands, sea ice is one of the most important means of getting out of the community. For Pangnirtung, sea ice is of equal importance for getting out of the community, as it is located in a fiord surrounded by mountainous terrain. Once the sea ice forms solidly there is little distinction between land and ocean. Then people are free to travel wherever they wish, as long as they are aware of the dangerous areas and local ice dynamics. Therefore, sea ice enables community members to access: i) neighbouring islands from all three communities; ii) Baffin Island from Cape Dorset and Igloolik; iii) the mainland (Melville Peninsula) from Igloolik; and, iv) the shorelines of Cumberland Sound from Pangnirtung. For all three communities, sea ice also allows people to reach inland fishing lakes or cabins, and neighbouring communities. Therefore, sea ice provides a smooth "highway" upon which people can travel more directly and quickly than inland routes. However, due to the relatively flat terrain on Melville Peninsula and other islands around Igloolik, there are more over-land travel alternatives than around Cape Dorset or Pangnirtung. In all three communities, people consider themselves stranded in town during transitional stages of freeze-up and break-up, where the ice is too thick to boat and not thick enough to travel on.

Sea ice also provides important habitat for marine wildlife, notably ringed seals, polar bears, and walrus, that have always been staples of northern life. Previously, marine mammals were a means of survival (i.e. clothing, fat/oil for light and heat, food for people and dogs, and equipment). Presently, they provide an important food source and/or income (from skins or

related clothing/craft products). So sea ice travel is rarely undertaken for the sake of traveling, it is usually associated with hunting or harvesting in some manner. In general, sea ice is used to access:

1) landfast ice (*tuvaq*), where ringed seals are hunted on the ice or through breathing holes;
2) the floe edge (*sinaaq*), where ringed seals, bearded seals, polar bears, beluga whales, narwhals, walrus, and marine birds may be found;
3) moving ice (*aulajuq*), where walrus and polar bears may be found, and where beluga whales and narwhals may travel;
4) polynyas (*saqvait/aukkarniit*), where ringed seals, marine birds, and less commonly polar bears and bearded seals, may be found; and,
5) tidal cracks (*naggutiit*), where ringed seal breathing holes are found in the winter and where ringed or bearded seals may be found in the open leads (*aajurait*) in the spring.

Much of this hunting is conducted to acquire food, although some profits can be made by selling the skins, furs, ivory, or meat of the animals. Sea ice is also essential to support the commercial turbot fishery operating out of Pangnirtung.

While there are many similarities between the importance of sea ice in each community, there are also localized differences in ice conditions and processes (Section 7.2), sea ice uses (Section 7.3), and observed sea ice changes (Section 7.4) that are valuable to explore.

7.2 Sea ice processes

In each community there are several commonalities between the descriptions of freezing and melting progressions of the sea ice. Many of the terms used to describe prominent ice conditions or features are shared between the communities, despite some local dialect differences. It is acknowledged that the focus on Inuktitut terminology of sea ice alone does not adequately characterize the complexity and interactions of sea ice conditions in each community. However, it became increasingly clear throughout the research process that to better understand Inuit expertise on sea ice, Inuktitut terminology is an essential starting point. Results from each community (Chapters 4 – 6) have highlighted the manner in which sea ice freezing and melting processes are explained by local experts. This section discusses the

similar, and unique, accounts between communities to determine where: i) unique ice conditions may occur due to local/regional geographic or oceanographic influences; ii) where similar conditions are referred to using different terminology; iii) the sequence of freezing or melting may differ; and, iv) there is overlap between processes/terminology in each community. In order to follow this analysis it would be helpful to refer to Figures 4-1, 5-1, and 6-1, along with the respective glossaries (Appendices 13 – 15), when necessary. Also, please note that the numerical summaries of terminology only provide an indication of relative similarities or differences. The terms identified in this thesis by no means cover all Inuktitut terminology for sea ice, and they reflect only the words that were specifically defined for me over the course of interviews. Therefore, they do not represent the entire scope of sea ice characteristics around each community. They do, however, provide the best basis for comparison at this point.

7.2.1 Freezing processes

7.1.1.1 Near shore freezing

Examining the terminology employed to describe the early stages of freezing along the shoreline, only one term is common to all three communities (Figure 7-1a, Table 7-1a). The process of the ocean freezing over is termed *sikuvaliajuq* (Figure 7-1a, Table 7-1d). However, it is used to describe the earliest freezing in Cape Dorset, early near-shore freezing in Pangnirtung, and sea ice thickening in Igloolik. This may reflect the greater emphasis that is placed on early freezing stages in Cape Dorset and Pangnirtung (Figure 7-1a, Table 7-1a), whereas in Igloolik it is the later stages of sea ice thickening that are described in more detail (Figure 7-1c, Table 7-1c). With Igloolik being further north, freeze-up would generally occur more rapidly, which may explain the lack of unique terms described in Igloolik for varying stages of along-shore freezing (Figure 7-1a). Furthermore, the tides are not as strong in Igloolik, so the common terms between Pangnirtung and Cape Dorset (Figure 7-1a) refer

a) near-shore freezing

1	CD	IG	PG
CD	4	0	2
IG		0	1
PG			2

b) open water freezing

1	CD	IG	PG
CD	3	0	0
IG		0	1
PG			1

c) sea ice thickening

7	CD	IG	PG
CD	6	1	1
IG		6	3
PG			9

Figure 7-1: Matrices of Inuktitut terminology showing the number of unique and overlapping sea ice terms for freezing processes, in each community.
Where: The number in the top left-hand box indicates the number of terms common to each community; shaded boxes indicate the number of terms unique to a particular community; un-shaded boxes indicate the number of terms that overlap between two communities only; and, the empty boxes would mirror the same numbers as the un-shaded boxes.
(CD = Cape Dorset, IG = Igloolik, PG = Pangnirtung)

mainly to tidal zone or shoreline formations (i.e. *ilaupalia*, *sijja*) (Table 7-1a). In Cape Dorset, the focus was on shoreline freezing progression as it varies according to sea ice stability at high or low tide (Table 7-1a). Unique to Pangnirtung was the description of *qillirusijuq*, the precursor to *qainngu* (Table 7-1a). In both Pangnirtung and Igloolik *qainngu* refers to a type of (relatively narrow) ice ledge that follows the contours of the shoreline. However, in Pangnirtung it functions as an important travel platform throughout the ice season, while in Igloolik it is distinguished as the main near-shore freezing condition (Table 7-1a, 7-1d). In Pangnirtung *sikutaq* (Table 7-1a) was specified due to its importance in traveling out of the community, but this general description of bays, inlets, and fiords freezing before larger water bodies was also discussed in the other two communities.

7.2.1.2 Open water freezing

The strength of currents around Cape Dorset, and the prominence of open water, is likely the main reason for a greater focus on open water freezing than in the other two communities (Figure 7-1b, Table 7-1b). Only the earliest formation of sea ice (i.e. *qinnu*) (Table 7-1b, 7-1d) was described similarly in all three communities (Figure 7-1b). Because it is an important indicator of the beginning of freeze-up, it is a commonly employed term across communities. There is minimal emphasis on early freezing stages in Igloolik (Figure 7-1b). However, the reference to *quvviquat* overlaps with Pangnirtung (Table 7-1b, 7-1d), albeit in a

Table 7-1: Comparison of Inuktitut terms related to sea ice freezing stages, in each community.

a) Near-shore freezing stages

Term (freezing)	CD	IG	PG
sikuvaliajuq	s	sp	s
ilaupalia	s		sp
ilu	x		
qillirusijuq			x
sikutaq			x
kuiviniq	x		
qaikut	x		
qaingu		s	sp
sikurtusijuq	x		
sijja	s		s

b) Open water freezing stages

Term (freezing)	CD	IG	PG
qinnu	s	sp	sp
qaikuin	x		
qalligirtuq^{c}	x		
quvviquat^{w}		s	d
sikualaajuq^{cw}			x
sikuliaq	x		

c) Sea ice thickening stages

Term (freezing)	CD	IG	PG
sikuaqtuq	s		s
sikuaq	s	s	s
millutsiniq	x		
qamittu	x		
nigajutaq^{cw}	s	s	s
nigajutaviniq		x	
sallivaliajuq	s	d	d
uqurusirtuqsimajuq	x		
sikuriaq		s	d
nutaaminiq			x
sikuqaq	s	s	
qanguti	s	s	sp
qangutaituq	x		
niuma		x	
niumakjuaq		x	
sikujuq	s	d	s
sikurinittuq^{w}			x
ittanilapaat			x
kiviniq			x
tuvaruajjuqtuq		s	d
kuvviliukajuq	x		
aggurtipaliajuq^{w}		x	
sikuvaalluuti			x
atuqsaruqtuq			x
nipittuq			x
siku	s	s	s
sikuvik		x	
tuvaq	s	s	s
apulliq		s	d
aputaittuq		x	
tuvallariuliqtuq			x
sikutiaqtuq			x
tuvatuqaq	x		

d) Similar freezing terminology

Cape Dorset	Igloolik	Pangnirtung
sikuvaliajuq	*sikuvalliajuq*	*sikuvaliajuq*
qinnu	*qinu*	*qinnuaq*
ilaupalia	n/a	*iluvaliajuq*
n/a	*qaingu*	*qainngu*
n/a	*quvviquat*	*quppirkuaq*
sallivaliajuq	*puimajuq*	*apputtattuq*
n/a	*sikuriaq*	*sikurataaq*
qanguti	*qanguti*	*qanngut*
sikujuq	*sikusaaq*	*sikujuq*
n/a	*tuvaruajjuqtuq*	*tuvaruqpalliajuq*
n/a	*apulliq*	*apputaniuliqtuq*

Where:
CD = Cape Dorset, **IG** = Igloolik, **PG** = Pangnirtung

s = same term, same meaning
sp = same term, same meaning, different spelling
sd = same term, different meaning
d = dialectical difference in terms, same meaning
x = unique term to that community
^{w} = associated with winds (Section 7.2.3.2)
^{c} = associated with currents (Section 7.2.3.4)

N.B. the different spellings or terms identified are shown in Table 7-1d.

different order in relation to *qinnu*. In Pangnirtung it is described as a precursor to *qinnu,* and in Igloolik it occurs afterwards. In Pangnirtung they also describe *sikuallaajuq* (Table 7-1b) forming in the open water, which is actually similar to *aqsajutak* in Igloolik (Section 7.2.3.4) and *qaikuin* (Table 7-1b) in Cape Dorset.

7.2.1.3 Sea ice thickening

In all communities, the early freezing processes converge with the formation of *sikuaq* (Figure 7-1c, Table 7-1c), the first continuous thin layer of sea ice. In addition, *sikuaqtuq* is commonly described in Pangnirtung and Cape Dorset (Table 7-1a). This process would also be understood in Igloolik (i.e. adding the "*tuq*" ending simply means the action of *sikuaq* forming), but it was not specified in the interviews. Interestingly, the most common, and the most unique, terms between all three communities are highlighted within the sea ice thickening stages (Figure 7-1c). The terms employed consistently in each community reflect prominent transitional stages during freeze-up (Table 7-1c, 7-1d). Therefore, they are commonly employed bench-marks in the progression of sea ice thickening. Within these transitions, the detailed focus in both Pangnirtung and Igloolik is placed on the different thicknesses (i.e. stability) of sea ice (Table 7-1c). While *atuqsaruqtuq* (Table 7-1c) is only mentioned in Pangnirtung during the freezing stages, it is referred to in all three communities regarding the dangers of sea ice travel. Therefore, this term is not actually unique to Pangnirtung. Unique to Cape Dorset are terms that focus more on the ice surface, and the potential deterioration of sea ice during the freeze-up process (Table 7-1c). Here, the sea ice may endure several cycles of freezing over and breaking up before becoming solid enough for travel. At that point the emphasis is on *tuvaq* becoming older (*tuvaqtuqaq*) (Table 7-1c). Between Pangnirtung and Cape Dorset, *nipittuq* and *kuvviliukajuq* (Table 7-1c) refer to similar phenomena of "becoming landfast ice", but they are subtly different in their descriptions. As the ice is "becoming *tuvaq*", *tuvaruajjuqtuq* (Table 7-1c, 7-1d) is referenced in both Pangnirtung and Igloolik. However, this

stage is placed between *siku* and *tuvaq* in Pangnirtung, while in Igloolik it is prior to becoming *siku*. This difference seems more perceptual than physical, it is a matter of when people consider the ice to be becoming stable, landfast ice. Finally, once the *tuvaq* is solid, snow accumulation on the ice (*apulliq*) is described in Pangnirtung and Igloolik (Table 7-1c, 7-1d). Snow also accumulates on sea ice around Cape Dorset, so this term would be understood although it was not specified in interviews. This phenomenon may not have been emphasized in Cape Dorset because: i) the lesser sea ice extent and thinner ice conditions do not allow as much snow accumulation; or, ii) snow accumulation is implied with reference to *tuvaq*.

7.2.1.4 Tidal cracks

Common to all three communities are the descriptions of two main types of tidal cracks (i.e. *nagguti*, *aajuraq*) (Figure 7-2, Table 7-2a, 7-2b). These relate to different diurnal, and monthly, tidal stages (Section 7.2.3.4), and serve as important features for hunting and safety assessment in each community. In Cape Dorset and Igloolik they also describe a tidal crack with a peaked formation (i.e. *qullupiarniq*) (Table 7-2a, 7-2b). Unique to Pangnirtung are descriptions of minor cracks, former cracks, and openings (Figure 7-2, Table 7-2a). Unique to Igloolik are descriptions of cracks that continue, stop, and then continue another place (i.e. *pilagiatinniq*), along with cracks that relate to the floe edge or moving ice (Figure 7-2, Table 7-2a). The additional cracks described in Cape Dorset relate to different widths of cracks (or leads) as they form in the spring (Figure 7-2, Table 7-2a). These differences between communities seem to relate to the emphasis on landfast and shoreline ice in Pangnirtung (as

2	CD	IG	PG
CD	3	1	0
IG		3	0
PG			4

Figure 7-2: Matrix of Inuktitut terminology showing the number of unique and overlapping sea ice terms for tidal cracks, in each community.

Where: The number in the top left-hand box indicates the number of terms common to each community; shaded boxes indicate the number of terms unique to a particular community; un-shaded boxes indicate the number of terms that overlap between two communities only; and, the empty boxes would mirror the same numbers as the un-shaded boxes.
(CD = Cape Dorset, IG = Igloolik, PG = Pangnirtung)

Table 7-2: Comparison of Inuktitut terms related to tidal cracks, in each community.

a) Tidal crack terminology

Term (tidal cracks)	CD	IG	PG
nagguti[c]	s	s	s
naggutiminiq			x
ajuraq[c]	s	sp	sp
qullupiarniq[c]	s	sp	
napakkuti[c]		x	
pilagiatinniq		x	
quppirniq		x	
nuttaq			x
aijuq			x
ikirniq			x
ikiqtusijuq	x		
nipittupaliajuq	x		
ikiqtuq	x		

b) Similar terminology for tidal cracks

Cape Dorset	Igloolik	Pangnirtung
ajuraq	*aajuraq*	*aajuraq*
qullupiarniq	*qugluknig*	n/a

Where:
CD = Cape Dorset, **IG** = Igloolik, **PG** = Pangnirtung
s = same term, same meaning
sp = same term, same meaning, different spelling
sd = same term, different meaning
d = dialectical difference in terms, same meaning
x = unique term to that community
[w] = associated with winds (Section 7.2.3.2)
[c] = associated with currents (Section 7.2.3.4)
N.B. the different spellings or terms identified are shown in Table 7-2b.

influenced by the ice pack in Cumberland Sound), the presence of nearby open water in Cape Dorset (especially a concern as cracks widen in the spring), and the importance of floe edge dynamics in Igloolik (for hunting and safety).

7.2.1.5 Floe edge

In all three communities, common terminology is employed for the floe edge, new ice forming at the floe edge, and ice breaking off from the floe edge (i.e. *sinaaq, uiguaq, uqaqtuq*) (Figure 7-3, Table 7-3a, 7-3b). Due to the prominent nature and importance of these features it is not surprising that they are referenced frequently, and similarly. In Pangnirtung and Igloolik, overlapping terminology relates to former/older *uiguaq* (Table 7-3a, 7-3b), whereas this likely does not have a chance to form in Cape Dorset. Between Igloolik and Cape Dorset, common terminology relates to sea ice that breaks off due to *uqaqtuq* (*uqakuti*) (Table 7-3a, 7-3b),

3	CD	IG	PG
CD	1	2	1
IG		11	1
PG			0

Figure 7-3: Matrix of Inuktitut terminology showing the number of unique and overlapping sea ice terms for floe edge, and related dynamics, in each community.

Where: The number in the top left-hand box indicates the number of terms common to each community; shaded boxes indicate the number of terms unique to a particular community; un-shaded boxes indicate the number of terms that overlap between two communities only; and, the empty boxes would mirror the same numbers as the un-shaded boxes.
(CD = Cape Dorset, IG = Igloolik, PG = Pangnirtung)

Table 7-3: Comparison of Inuktitut terms related to the floe edge, in each community.

a) Floe edge terminology

Term (floe edge)	CD	IG	PG
sinaaq	s	s	s
atirriaruti		x	
uiguaq	s	s	s
uiguaviniq		s	d
sinaaviniq		x	
uqaqtuq^{cw}	s	sp	sp
uqakuti	s	sp	
uukkaqtaqtuq^{cw}		x	
qanguti	s	s	
qangusirsimajuq		x	
niumakjuaq		x	
qullupiaqtuq	x		
qaangajuq^{w}		x	
qaatuq^{cw}		x	
sanimuangniq		x	
minuirniq^{cw}		x	
ukkuartinniq		x	
nipititaaq		x	
nunniq	sd		s

b) Similar floe edge terminology

Cape Dorset	Igloolik	Pangnirtung
n/a	*uiguaviniq*	*uiguatuqaq*
uqaqtuq	*uukkaqtuq*	*uukkaqtuq*
uqakuti	*uukkaruti*	n/a

Where:
CD = Cape Dorset, **IG** = Igloolik, **PG** = Pangnirtung
s = same term, same meaning
sp = same term, same meaning, different spelling
sd = same term, different meaning
d = dialectical difference in terms, same meaning
x = unique term to that community
^{w} = associated with winds (Section 7.2.3.2)
^{c} = associated with currents (Section 7.2.3.4)
N.B. the different spellings or terms identified are shown in Table 7-3b.

as well as *qanguti* (Table 7-3a) that forms along the *sinaaq.* This term is also used in Pangnirtung, but it was not specifically described in relation to the *sinaaq* during interviews. In Cape Dorset and Pangnirtung they both talk about *nunniq* (Table 7-3a), but it is used in a different context. In Pangnirtung this is a common reference to the freezing of Cumberland Sound, when the floe edge is far away. Whereas in Cape Dorset, it is used on the rare occasion that areas of Chorkbak Inlet freeze over. Prominent within floe edge descriptions in Igloolik is a unique emphasis on detailed accounts of floe edge dynamics (Figure 7-3, Table 7-3a). This is of most interest to Igloolik hunters since they are the only ones really using the moving ice to hunt walrus. Therefore, it is imperative that they are mindful of the different movements and conditions along the floe edge in order to safely cross onto, or back from, the moving ice.

7.2.1.6 Moving/multi-year ice

It was unexpected to have no common Inuktitut terminology for moving or multi-year ice (MYI) between the three communities (Figure 7-4). However, upon examining the

0	CD	IG	PG
CD	7	2	2
IG		2	2
PG			1

Figure 7-4: Matrix of Inuktitut terminology showing the number of unique and overlapping sea ice terms for moving or multi-year ice, around each community.

Where: The number in the top left-hand box indicates the number of terms common to each community; shaded boxes indicate the number of terms unique to a particular community; un-shaded boxes indicate the number of terms that overlap between two communities only; and, the empty boxes would mirror the same numbers as the un-shaded boxes.
(CD = Cape Dorset, IG = Igloolik, PG = Pangnirtung)

differences in moving/multi-year ice descriptions, results seem to reflect regional geography and ocean circulation patterns; both of which are highly influential on the types, and paths, of ice moving in open water. It was anticipated that Igloolik would have the most unique terminology for moving ice due to its implications for travel safety and walrus hunting. However, the most challenging and dynamic aspect of moving ice around Igloolik is at the interface between the floe edge and the moving ice (i.e. *aulaniq*) (Table 7-4a). Hence, the prominence of moving ice terminology around Igloolik has already been outlined in relation to the floe edge (Section 7.2.1.5). Free-moving ice in open water (i.e. *aulajuq*) (Table 7-4a) is further away, so these ice types are less frequently used or seen. Therefore, less terminology is

Table 7-4: Comparison of Inuktitut terms related to moving or multi-year ice, in each community.

a) Moving/multi-year ice terminology

Term (moving/ multi-year ice)	**CD**	**IG**	**PG**
puktaaq	sp	s	
aniqsai[c]	x		
asaluaan	x		
aulaniq	s	s	
aulajuq		s	s
tatijaujuq		x	
sikutuqaq		x	
piqalujaq		s	sp
marruluin	x		
qaikuin[c]	x		
qapvaq	s		sp
qunni	x		
savittuq	x		
sikurasaan	x		
killiminiq			x
tuvaminiq	sp		s

b) Similar moving/multi-year ice terminology

Cape Dorset	**Igloolik**	**Pangnirtung**
puktaan	*puktaaq*	n/a
qapvaq	n/a	*kavvaq*
n/a	*piqalujaq*	*piqalujat*
tuvaviniq	n/a	*tuvaminiq*

Where:
CD = Cape Dorset, **IG** = Igloolik, **PG** = Pangnirtung
s = same term, same meaning
sp = same term, same meaning, different spelling
sd = same term, different meaning
d = dialectical difference in terms, same meaning
x = unique term to that community
[w] = associated with winds (Section 7.2.3.2)
[c] = associated with currents (Section 7.2.3.4)
N.B. the different spellings or terms identified are shown in Table 7-4b.

associated with these conditions. The other communities share moving ice references with Igloolik that relate to their localized ice conditions (i.e. *aulaniq* in Cape Dorset because the interface between the moving ice and floe edge is close by, and *aulajuq* in Pangnirtung because the moving ice pack is far out in Cumberland Sound). In Cape Dorset, a number of unique terms are employed to describe how the ice is moving or the size of the moving ice (Table 7-4a). Terminology for simple floating pieces of ice (i.e. *puktaan*) is shared between Cape Dorset and Igloolik (Table 7-4a, 7-4b), while the MYI reference to *qapvaq* is shared between Cape Dorset and Pangnirtung (Table 7-4a, 7-4b). Unique to Igloolik are the descriptions of ice being dislodged by moving ice at the floe edge (i.e. *tatijaujuq*), along with old ice (i.e. *sikutuqaq*) (Table 7-4a). However, the reference to *sikutuqaq* (or *tuvatuqaq*) would be understood in any community, as the addition of "*tuqaq*" to the word ending simply refers to being "old". In addition, icebergs (i.e. *piqalujat*) (Table 7-4a, 7-4b) are mentioned in both Pangnirtung and Igloolik. There are many glaciers around Pangnirtung, and around Igloolik the currents sometimes bring glacier-calved ice into Fury and Hecla Strait from further north. Although this word would likely be understood in Cape Dorset, it may not be commonly employed because icebergs do not often circulate through Hudson Strait. In Pangnirtung, moving ice can refer to *tuvaq* that has become detached (i.e. *tuvaminiq*), while specific MYI formations in Cumberland Sound originate in the High Arctic (i.e. *killiminiq*) (Table 7-4a).

7.2.2 Melting processes

7.2.2.1 Snowmelt

In all three communities, elders and hunters mentioned that melt processes were hard to describe because they do not actually see the ice melting in the early stages. The sea ice begins to wear away from underneath, so the snow melting on top is the early indication of ice melt stages. A similar level of detail was described regarding the melt stages in each community. However, there were more locally distinct conceptions of ice melt than

overlapping ones (Figure 7-5a). The term used to describe areas that open up earlier than others (i.e. *aukaaniq*) (Table 7-5a, 7-5d) is common to all three communities. However, in Igloolik it refers to a polynya (i.e *saqvaq* in Pangnirtung and Cape Dorset), and not only to areas that open early in the spring due to the influence of currents (Table 7-5a). The term *manguqtuq* (Table 7-5a) is also used in all three communities, but the process itself is described somewhat differently in relation to spring snow conditions and timing of occurrence. In Cape Dorset it describes the snow softening and melting, while the ice is still solid underneath (i.e. comprising *aputlariq* and *qinningijuq*) (Table 7-5a). In Pangnirtung it is more of a diurnal cycle (i.e. comprising *manguqtaliqtuq* and *qiqsuqaqtuq*) that influences sea ice travel (Table 7-5a). In Igloolik *manguqtuq* is a distinct stage in the melt process, leading into *puimajuq* and *qiqsuqaqtuq* (Table 7-5a, 7-5d). General terminology for early melting (i.e. *aukajuq*) (Table 7-5a, 7-5d) is shared by Pangnirtung and Cape Dorset. Other than these overlaps, the specific conditions relating to snowmelt are unique to each community (Figure 7-5a, Table 7-5a). This is believed to be linked to the seasonal spring temperatures that vary geographically, thus influencing the speed with which melting occurs and the types of snow conditions produced.

7.2.2.2 Water accumulation and drainage

As the snow melts, water begins accumulating on the sea ice, creating melt puddles and melt holes. These are important transition indicators as melting progresses towards break-up, thus they are commonly employed in all three communities (Figure 7-5b, Table 7-5b, 7-5d).

a) snowmelt

2	CD	IG	PG
CD	4	0	1
IG		6	1
PG			5

b) water accumulation

3	CD	IG	PG
CD	1	0	1
IG		4	2
PG			3

c) break-up

1	CD	IG	PG
CD	7	0	2
IG		1	2
PG			2

Figure 7-5: Matrices of Inuktitut terminology showing the number of unique and overlapping sea ice terms for melting processes, in each community.
Where: The number in the top left-hand box indicates the number of terms common to each community; shaded boxes indicate the number of terms unique to a particular community; un-shaded boxes indicate the number of terms that overlap between two communities only; and, the empty boxes would mirror the same numbers as the un-shaded boxes.
(CD = Cape Dorset, IG = Igloolik, PG = Pangnirtung)

Table 7-5: Comparison of Inuktitut terms related to sea ice melting stages, in each community.

a) Snowmelt

Term (melting)	CD	IG	PG
aukajuq	s		d
auttuq			x
aukaaniq[c]	s	sd	sp
aputlariq	x		
uqurusirtuq	x		
apputailiqqaqtuq			x
qinallatut		x	
nanirlijuk		x	
nilaruqtuq		x	
ijaruvaujat		x	
manguqtuq	s	s	s
qinningijuq	x		
manguqtaliqtuq			x
qiqsuqaqtuq		d	s
puimajuq		x	
masaq			x
aktinniq		x	
sallivaliajuq	x		
aumasijuq			x

b) Water accumulation

Term (melting)	CD	IG	PG
immatuqtuq	s	sp	sp
ikiartirtuq			x
immatinniit	s	sp	s
quginiit	s		sp
qalluit	x		
puktailaq		x	
patikjiuqtuq		x	
tikpaqtuq		s	s
puttaijuq			x
maujaraq			x
saluraq		x	
itisiuraq		x	
immaktipaliajuk		s	sp
killait	s	sp	sp

c) Break-up

Term (melting)	CD	IG	PG
matsaaq	x		
qangitarniq	x		
pattituq	x		
sijjaviniq	s		sp
ajuqpaliajuq	x		
aukaaq	x		
tuvarliqtuq		s	sp
siggia[w]	s	d	d
qullupiaqtuq[cw]	x		
sikuviniq	x		
tuvaviniq	s		sp
tuvaijaqtuq		s	sp
tuvaijautiit		x	
sijjaijaliqtuq			x
qainnguijaliqtuq			x

d) Similar melting terminology

Cape Dorset	Igloolik	Pangnirtung
aukajuq	n/a	*aukkaavaliajut*
aukaaniq	*aukkarniq*	*aukkaturliit*
n/a	*qirsuqqaq*	*qiqsuqaqtuq*
immatuqtuq	*immaktittuq*	*immatittuq*
immatinniit	*immaktinniit*	*immatinniit*
quginiit	n/a	*kujjirtuq*
n/a	*immaktipaliajuk*	*immatillarittuq*
qillait	*killaq*	*killait*
siggia	*siruttiq*	*surattuq*
sijjaviniq	n/a	*sijjaminiq*
tuvaviniq	n/a	*tuvaminiq*
n/a	*tuvarliqtuq*	*tuvarluqtuq*
n/a	*tuvaijaqtuq*	*tuvaijaliqtuq*

Where:
CD = Cape Dorset, **IG** = Igloolik, **PG** = Pangnirtung
s = same term, same meaning
sp = same term, same meaning, different spelling
sd = same term, different meaning
d = dialectical difference in terms, same meaning
x = unique term to that community
[w] = associated with winds (Section 7.2.3.2)
[c] = associated with currents (Section 7.2.3.4)
N.B. the different spellings or terms identified are shown in Table 7-5d.

However, in Cape Dorset and Pangnirtung *killait* are described earlier in the melt process than in Igloolik, where it takes longer for the ice to wear right through. The presence of seaweed or other debris on the ice also contributes to melting, as described in Cape Dorset (*qalluit*) (Table

7-5b) and Igloolik. The reference to melt streams on the sea ice (i.e. *quginiit*) (Table 7-5ab, 7-5d) is common to Pangnirtung and Cape Dorset. This is likely due to more freshwater runoff influence than around Igloolik. Two stages of water accumulation and drainage are identified in Pangnirtung and Igloolik (i.e. one from snowmelt and another from the ice itself melting) (Table 7-5b, 7-5d). Ice thickness and snow accumulation around Cape Dorset likely does not accrue enough for this dual drainage to occur. Unique to Igloolik are terms describing various surface conditions that contribute to the gradual deterioration of the sea ice (Table 7-5b). The distinct terms used in Pangnirtung reflect different types of water accumulation on the sea ice, and localized shoreline ice break-up before the *tuvaq* actually begins breaking up (Table 7-5b).

7.2.2.3 Break-up

Perhaps due to its more southerly location and thus the faster progression of melt stages, elders and hunters in Cape Dorset do not describe as many melt stages as in Pangnirtung and Igloolik (Figure 7-5a, 7-5b). Cape Dorset descriptions focus more on the deterioration of shoreline ice, thus more terminology is incorporated during the final stages of break-up (i.e. *qangitarniq* and onwards) (Figure 7-5c, Table 7-5c). The only commonality between all three communities is a reference to the action of the ice breaking up (i.e. *siggia*) (Figure 7-5c, Table 7-5c, 7-5d). In Pangnirtung and Igloolik they describe the deterioration and break-up of the *tuvaq* (Table 7-5c, 7-5d) similarly. In Pangnirtung specifically, the *qainngu* breaking off (Table 7-5c) is very important because until this final stage occurs it is still possible to travel out of the fiord. Therefore, the focus on melting terminology seems to be mainly determined by the limitations for sea ice travel caused by each spring melt stage.

7.2.3 Wind and current influences on sea ice

7.2.3.1 Prevailing winds

Northwesterly winds are described as the prevailing winds in each community. These winds are most common in the fall and winter, and they tend to: i) bring in cold, clear weather;

ii) blow ice away from town; iii) contribute to smoother, faster freezing; and, iv) cause break-off events at the floe edge. For Pangnirtung these winds can also bring moving ice from Davis Strait into Cumberland Sound. The descriptions of winds, and influence of winds on sea ice, were most consistent between interviewees in Igloolik. In contrast, the descriptions of prevailing winds around Cape Dorset actually ranged from NE to NW (i.e. *tunuvia*) (Figure 7-6, Table 7-6a), and in Pangnirtung from NW to north. Nevertheless, the second-most predominant wind in each community was commonly described as being from the SE (although in Cape Dorset varying from SE to SW, and in Pangnirtung from SE to south). These winds are more common in the summer, but they are also an opposing force to NW winds in the fall and winter. SE winds are described as: i) being warmer; ii) causing the ice to break up; iii) preventing freezing because they push ice towards the floe edge or land; and iv) bringing multi-year or moving ice closer to town. In Pangnirtung and Igloolik they describe SE winds as creating rougher ice conditions when they blow in the fall. In Pangnirtung these winds also create more cracks in the *tuvaq* as the ice pack in Cumberland Sound is pushed into the floe edge. In Igloolik the importance of these winds is highlighted because they push moving ice towards land/the *sinaaq*, allowing it to stick temporarily. These conditions facilitate safer crossing from/onto moving ice. In Cape Dorset, when SE winds prevail they often push so much moving ice towards town that boat travel is impossible, and sea ice travel is more difficult and dangerous. In the spring time, these winds also speed up the break-up process in all three communities.

4	CD	IG	PG
CD	4	0	0
IG		6	3
PG			1

Figure 7-6: Matrix of Inuktitut terminology showing the number of unique and overlapping terms related to the influence of winds on sea ice, in each community.

Where: The number in the top left-hand box indicates the number of terms common to each community; shaded boxes indicate the number of terms unique to a particular community; un-shaded boxes indicate the number of terms that overlap between two communities only; and, the empty boxes would mirror the same numbers as the un-shaded boxes.
(CD = Cape Dorset, IG = Igloolik, PG = Pangnirtung)

Table 7-6: Comparison of Inuktitut terms related to the influences of winds on sea ice, in each community.

a) Terminology related the wind influences

Term (wind influences)	CD	IG	PG
tunuvia	x		
sikuqsasitarivuq	x		
aguttituq	s	sp	sp
aukaaq	x		
uqaqtuq	s	sp	sp
ivuniit	s	sp	s
ivujuq		s	s
sikuijaqtuq	x		
qimaruutisimajuq		x	
qaattuq		x	
qaangajuq		x	
sikutuqqijuq		x	
nipititaaq		x	
quvviquat		s	d
iilikulaak		x	
maniilaq[c]		s	s
qaliriiktinniit[c]	sp	s	sp
isirsangaq			x

b) Similar wind influence terminology

Cape Dorset	Igloolik	Pangnirtung
aguttituq	*aggurtipaliajuq*	*aggutittuq*
uqaqtuq	*uukkaqtuq*	*uukkaqtuq*
ivuniit	*ivuit*	*ivuniit*
n/a	*quvviquat*	*quppirkuaq*
n/a	*maniilaq*	n/a
qullupiaqtuq	*qaliriiktinniit*	*qalliriittipalliajuq*

Where:
CD = Cape Dorset, **IG** = Igloolik, **PG** = Pangnirtung
s = same term, same meaning
sp = same term, same meaning, different spelling
sd = same term, different meaning
d = dialectical difference in terms, same meaning
x = unique term to that community
[w] = associated with winds (Section 7.2.3.2)
[c] = associated with currents (Section 7.2.3.4)
N.B. the different spellings or terms identified are shown in Table 7-6b.

Unique to Pangnirtung is the influence of the fiords on wind direction and strength. Westerly winds (*isirsangaq*) (Figure 7-6, Table 7-6a) are prominent in Pangnirtung Fiord, and create a daily afternoon breeze in the spring and summer. These winds are considered unfavourable though, as they melt the ice/snow and blow ice into the fiord. Easterly winds are more prominent in Pangnirtung Fiord in the fall, and they can be very strong. This can cause new ice to break up and the floe edge to be closer to town.

7.2.3.2 Influences of winds on sea ice

While the main directional influences of winds on sea ice are similar in each community, the way they manifest is sometimes described differently. For example, the process of the ice freezing upwind (*aguttituq*) (Table 7-6a, 7-6b) is mentioned in each community (Figure 7-6), but in Pangnirtung it is more of a rough ice condition than in Igloolik and Cape Dorset (where it is associated with weak winds). In all three communities winds tend to be responsible for the occurrence of *uqaqtuq*, as well as the creation of *ivuniit* and *qaliriiktitinniit* (Figure 7-6, Table 7-6a, 7-6b). A generalized description of rough ice (i.e.

maniilaat) is shared between Pangnirtung and Igloolik, and would likely be understandable in Cape Dorset as well (Figure 7-6, Table 7-6a). Due to the emphasis on *aulaniq* in Igloolik, they have the most descriptive terms for rough ice along the floe edge (i.e. *nipitittaq* and *iilikulaak*) (Table 7-6a). Likely a result of the use of/proximity to the floe edge, Cape Dorset and Igloolik each have unique terms to describe the manner in which ice breaks off from the *sinaaq* (i.e. *aukaaq* and *qaatuq*, respectively) (Figure 7-6, Table 7-6a). In addition, weaker winds contribute to the formation of *quvviquat* (Table 7-6a, 7-6b), as described in both Igloolik and Pangnirtung. The greater number of wind influences on the sea ice identified in Igloolik relate to their implications for floe edge and moving ice dynamics (Figure 7-6, Table 7-6a). Unique to Cape Dorset are explanations of the manner in which winds influence sea ice formation or movement in open water (Figure 7-6, Table 7-6a).

7.2.3.3 Tidal cycles

Tidal cycles, and ocean circulation, around each community were not clearly described. I did not ask into these in depth, and where they were discussed conflicting descriptions of ocean circulation arose between interviewees. Therefore, this would require clarification to analyze further. Instead, emphasis is placed on understanding the influences of currents (i.e. strong or weak), or tidal cycles (i.e. high and low tide) on sea ice conditions. These are critical to consider when traveling on the sea ice, and thus were discussed in substantial detail.

7.2.3.4 Current and tidal influences on ice conditions or movement

In all three communities, the importance of understanding the diurnal tidal cycle, as well as the monthly lunar cycle was frequently emphasized. Each community experiences some tidal variations during the day, approximately every 6 hours, which influences local ice conditions. However, the tides are more pronounced, with greater variations, in Pangnirtung and Cape Dorset than in Igloolik (Section 2.2.2). The peak high and low tide each day exhibit the strongest currents in a diurnal cycle, but the monthly lunar cycle is of greater importance

for sea ice travel (Section 7.3.1.1). The full and new moons have a significant influence on tide height and current strength. These monthly increases in tidal variation can be most destructive on ice conditions, and can cause the greatest variation in polynya size or floe edge dynamics. In both Pangnirtung and Igloolik this "full moon effect" is referred to as *piturniq* (Figure 7-7, Table 7-7a). Although Cape Dorset elders and hunters did not specify this term in their interviews, I anticipate the same term would be employed to refer to the influence of moon phases. In Pangnirtung, different types of *piturniq* were also discussed in relation to the yearly cycle (Section 6.2.3.3).

In all three communities, areas with stronger currents are known to move ice around, creating dynamic ice conditions. Terms that are used commonly in each community generally describe the most evident, re-occurring sea ice features created/influenced by ocean currents (Figure 7-7, Table 7-7a, 7-7b). As explained in 7.2.2.1, it is essential to distinguish between the use of *aukkarniq* in Igloolik as compared to Pangnirtung and Cape Dorset. Polynyas (*saqvaq*) (Table 7-7a, 7-7b) are important areas, created and maintained by strong currents, and thus they are frequently discussed in each community. However, the dynamics associated with polynya formations are uniquely described in Igloolik and Pangnirtung (Figure 7-7, Table 7-7a). In Igloolik the focus is on the dynamics at the edge of an *aukkarniq*, whereas in Pangnirtung emphasis is placed on snow/water formations along the edge of a *saqvaq* that can become safe for travel. There is also a distinction in Pangnirtung which identifies a *saqvalariq*

7	CD	IG	PG
CD	3	1	2
IG		5	4
PG			3

Figure 7-7: Matrix of Inuktitut terminology showing the number of unique and overlapping terms related to the influence of currents and tides on sea ice, in each community.

Where: The number in the top left-hand box indicates the number of terms common to each community; shaded boxes indicate the number of terms unique to a particular community; un-shaded boxes indicate the number of terms that overlap between two communities only; and, the empty boxes would mirror the same numbers as the un-shaded boxes.
(CD = Cape Dorset, IG = Igloolik, PG = Pangnirtung)

Table 7-7: Comparison of Inuktitut terms related to the influences of currents on sea ice, in each community.

a) Terms related to current and tidal influence

Term (current influences)	CD	IG	PG
piturniq		s	s
aquanaq	x		
aukkaturliit	sp	sd	s
nigajutaq	s	s	s
saqvaq	s	d	s
saqvalariq			x
titirtuq			x
qattuattinniq			x
maniilaq^{w}		s	s
ivujuq^{w}		s	s
ivuniit	s	sp	
qalliriittipalliajuq^{w}	sp	sp	s
iilikulaak^{w}		x	
aksajutak^{w}		s	d
uukkaqtuq^{w}	sp	s	sp
ukpittuq		x	
iijaujuq		x	
kaniq		x	
nunguppaliajuq		x	
nagguti	s	s	s
ajuraq	s	sp	sp
qanguqtuq	s		s
nunniq	s		sd
qaarniku	x		
sikuliaqta	x		

b) Similar current influence terminology

Cape Dorset	Igloolik	Pangnirtung
aukaaniq	*aukkarniq*	*aukkaturliit*
saqvaq	*aukkarniq*	*saqvaq*
qullupiaqtuq	*qaliriiktinniit*	*qalliriittipalliajuq*
n/a	*aksajutak*	*sikualaajuq*
uqaqtuq	*uukkaqtuq*	*uukkaqtuq*
ivuniit	*ivuit*	n/a

Where:
CD = Cape Dorset, **IG** = Igloolik, **PG** = Pangnirtung
s = same term, same meaning
sp = same term, same meaning, different spelling
sd = same term, different meaning
d = dialectical difference in terms, same meaning
x = unique term to that community
^{w} = associated with winds (Section 7.2.3.2)
^{c} = associated with currents (Section 7.2.3.4)
N.B. the different spellings or terms identified are shown in Table 7-7b.

(Table 7-7a) as a polynya that will not freeze in the winter. Otherwise, the polynya references account for occasional freezing in the coldest months, or when the currents are weakest.

Strong currents can also be caused by shallow areas (*aquanaq* in Cape Dorset) (Table 7-7a), as discussed in all three communities. Where the ocean floor is close to the surface, the waters move faster, as well as in narrow areas where the water is funneled into closer confines. Unique to Igloolik are the localized influences of MYI that gets frozen into the newly formed ice. These tend to funnel the water from underneath, strengthening currents and wearing away the surrounding ice. In Pangnirtung, the effects of fiords are highlighted, where points of land and especially the mouths of fiords often have stronger currents than in larger areas of open water. In addition, whenever sea ice is moved around, it tends to create rough ice due to

ice pan collisions. Therefore, currents are linked to the creation of *iilikulaak* and *aksajutak* (Table 7-7a, 7-7b). In all three communities, areas with strong currents or the times of month when the currents are strongest, are frequently related to dangerous travel conditions (Section 7.3.1.1). The ice can be worn away from currents underneath (*nunguppaliajuq* in Igloolik), which is often imperceptible at the surface (Table 7-7a).

The seasonal influences of currents seem more prominent in Pangnirtung and Cape Dorset, likely due to the greater tidal variations creating more pressure on shoreline ice. The *piturniq* high tide in the mid-winter can cause *qanguqtuq* (Figure 7-7, Table 7-7a) in both communities. In Cape Dorset the ice may literally explode upwards due to tidal pressure (i.e. *qaarniku*) (Table 7-7a), while in Pangnirtung the *qainngu* may become detached during *piturniq*. In Igloolik, the influence of the mid-winter cold means that the sea ice is more brittle, so *piturniq* tides can more easily crack the ice or cause break-off events.

The above distinctions and similarities in sea ice conditions/processes are important to keep in mind when evaluating sea ice use around each community. Sea ice travel and hunting are intertwined with the ice types available, associated travel dangers, and wildlife habitat.

7.3 Sea ice use

Sea ice travel is predominantly undertaken for the purpose of hunting, or accessing inland fishing lakes, hunting grounds, or cabins. I have continued to discuss sea ice travel and hunting separately for ease of explanation, but the dangers of sea ice travel are directly related to sea ice hunting destinations and/or wildlife habitat. Therefore, several dangers of ice dangers are described first (Section 7.3.1.1) to help understand what is involved in evaluating ice safety (Section 7.3.1.2) and hunting on particular ice conditions (Section 7.3.1.3).

7.3.1 Sea ice travel

The dangers associated with sea ice travel are well understood in each community. Some of the most prominent dangers that hunters are exposed to around each community

include: i) varying tidal stages, whereby the strongest currents are associated with *piturniq*; ii) polynyas; iii) the floe edge; iv) snowfall or snow accumulation; and, v) the transition periods of freeze-up and break-up (Tables 4-2, 5-2, 6-2). In addition, the dangers associated with *aulaniq* and *aulajuq* – the moving ice – are very important in Igloolik. These are also mentioned to some extent in Cape Dorset but more in terms of how they affect boat travel or floe edge stability. While many of the risks associated with sea ice travel are shared between communities, the localized manifestations – and means of dealing with dangerous conditions – vary with geography, hunting techniques, and travel alternatives.

7.3.1.1 Dangers in sea ice travel

Inuit expertise on local and regional, land and sea ice, geographies is one of the most effective means of minimizing travel risks around all three communities. Knowing where the particularly strong currents are (e.g. narrow or shallow areas), the location of polynyas, areas that melt early in the spring, and the delineation of a stable floe edge, all contribute to safe navigation around danger zones. Sea ice travel routes are well established around Cape Dorset (Figures 4-16a, 4-16b) and Pangnirtung (Figure 6-14), and are used to reach particular destinations, or to avoid dangerous features. In Igloolik, with a greater ice extent, longer ice season, and flatter inland terrain, they have more travel options. While there are also many well-known local and regional travel routes, there are so many more alternatives around this community that interviewees were overwhelmed by the thought of delineating these on a map. Therefore, it would appear that Igloolik has more available choices for travel when attempting to avoid sea ice dangers. In Pangnirtung, routes must be well understood in order to navigate the dangerous fiords, polynyas, mountains, and cracks of the Cumberland Sound shorelines. Cape Dorset hunters are also somewhat constrained in their overland travel, but not nearly as much as around Pangnirtung. However, sea ice routes are fewer since they are forced to travel within the confines of a nearby floe edge. This renders travel around Cape Dorset potentially

more dangerous as alternative travel routes are not as available to avoid polynya, floe edge, or tidal dangers. Perhaps for this reason, hunters in Cape Dorset incorporate the use of boats more than in the other communities, to minimize sea ice risks.

Another important element of safe sea ice travel is the identification of the daily and monthly tidal stage. Avoiding the most dangerous times of the day or month is recommended in all three communities, or at least exercising additional caution and alertness when traveling at critical times. Along with high and low tide, the risks associated with *piturniq* were frequently mentioned. The focus of these descriptions related mostly to shoreline or polynya processes in Cape Dorset and Pangnirtung, while in Igloolik the emphasis was placed on polynyas and the floe edge. In Cape Dorset, flooded shorelines were cautioned as inappropriate for sea ice travel, and the dangers of ice wearing out from underneath (especially around polynyas) were highlighted. Because these areas are especially dynamic, elders and hunters warned that they should be avoided during windy conditions, and should never be traveled over (even if they are temporarily frozen). In Pangnirtung, the timing of travel is important for safely navigating shoreline ice (e.g. at low tide when the ice is close to the ground), due to the large tidal variations affecting the stability and roughness of the *sijja*. Furthermore, polynyas should be avoided when the tide is going in or out. But, these areas can be safer at low tide, or after high tide when the water has re-frozen along the edges. In Igloolik, the timing associated with tidal variations was mostly described in relation to floe edge dynamics and the possibility of safely crossing to or from the *aulaniq*. The combination of winds and currents has to be just right to access the *aulajuq*, and thus must be well understood to hunt and return safely. In terms of polynyas, the main risks described were *ugpittuq* and the *kaniq*. Perhaps due to the colder temperatures around Igloolik, polynyas are seen as more predictable and thus somewhat more stable for hunting and travel. Yet, as described in all

three communities, polynyas frequently change their size and extent and should generally be avoided (especially after fresh snowfall, during *piturniq*, or once spring melting has begun).

Understanding the expected seasonal stages and variations in freeze-up and break-up are also essential to minimize the risks of sea ice travel during transition periods. The ice can form in a non-uniform manner depending on fall wind and current conditions. Therefore, all three communities emphasize the importance of knowing where *nigajutait* form, and that the ice should be continually tested during the freezing stages. It is well understood that snowfall insulates the sea ice, creating especially dangerous circumstances on newly formed ice. Where the ice is thinner, snow allows the ice to melt or be worn away from currents underneath. Such conditions are cautioned to lead to dangerous travel on the sea ice, and that travel should be avoided after new snow has fallen. In addition, in Igloolik and Pangnirtung they add that travel after new snowfall should be avoided on the *uiguaq,* and at polynyas, because the snow hides dangerously thin ice conditions. These warnings also apply in Cape Dorset, but such travel would unlikely even be attempted at this stage, and thus were not discussed as frequently. Similarly, the process of melting and break-up also comprise ice conditions that deteriorate unevenly. In all three communities some areas were noted to open up earlier than others (i.e. around polynyas or areas of strong currents). Widening tidal cracks are also of concern as they create vulnerabilities where the ice is most likely to break off. In addition, freshwater runoff can speed up the melting process. This occurs most prominently in Pangnirtung, where meltwater running into the fiords contributes to rapid melting from the head of the fiord. Travel around the river mouths should be also avoided, and caution should be practiced once *immattinniit* have formed. Around Cape Dorset, once water begins accumulating on the ice people are more cautious, sometimes traveling closer to town to avoid being stranded by a sudden break-up of shoreline ice. The freshwater influence is also noted in

Gifford Fiord, north of Igloolik, but more often snow conditions were mentioned as concealing dangerous spring ice conditions (i.e. water may have drained through thin ice underneath).

Finally, the risks involved with travel or hunting on moving ice are uniquely described in Igloolik. Here, the moving ice is the platform upon which walrus are hunted (Section 7.3.1.3). There is always potential to become stranded on moving ice if the winds or currents shift unfavourably. Therefore, it is most important to understand the relationship between winds and currents with moving ice (i.e. know the best times to travel on/avoid moving ice). Dog teams are known to be more effective when crossing onto moving ice, as they can respond quicker than snowmobiles to the dynamic changes along the *aulaniq*. They can also help pull the *kamotik* out of water, or out of trouble, should someone have a close call. In Cape Dorset, there is some mention of moving ice conditions, but more as they pertain to the prevention of boat travel – in any season. In Pangnirtung, the dangers associated with moving ice are mentioned infrequently because the moving ice is typically far from town and not used for hunting. However, in all three communities, the importance of knowing where a person might land – should they be stranded on moving ice – is critical to arriving safely back on land/solid ice. It is essential to be able to assess wind and current directions, in order to: i) know which way to travel on moving ice to stay out of danger; and/or, ii) be in a position to cross to safety when the opportunity arises.

Overall, the sea ice travel risks described in Pangnirtung focus mainly on understanding the timing of tidal cycles, along with knowing the local geographies of polynyas, fiords, and floe edge variations. In Igloolik, the emphasis is more on the local geographies of dangerous areas, as well as the combined influence of winds and currents affecting the floe edge and moving ice. In Cape Dorset, hunters aim to manage the dynamic nature of local/regional sea ice conditions, mainly through an understanding of tidal variations. They are used to the open water close by, and thus will more often practice

avoidance of certain ice conditions or routes, depending on the season. Here, they have a lesser sea ice extent than the other two communities, so they do not have as many travel alternatives. Therefore, while the descriptions of several sea ice dangers overlap between the communities, they each emphasize the areas/conditions that are most important for local hunting or travel. Since many dangerous ice conditions are also important hunting destinations (i.e. polynyas, floe edge, moving ice, tidal cracks) (Section 7.3.1.3), they will never be completely avoided. The focus is then placed on effective evaluation of ice safety in order to travel or hunt to/in areas that are intrinsically more dangerous than common travel routes.

7.3.1.2 Evaluating ice safety

An essential element of sea ice safety evaluation is knowing what to look for, and where (Section 7.3.1.1). Many dangerous sea ice features, and indicators of danger, are shared among the three communities – to a degree. However, the local and regional sea ice extent/conditions factor greatly into hunters' choices for navigation or destination. Understanding local ice dynamics, along with a detailed and extensive network of Inuktitut placenames, helps to guide sea ice travel in a relatively consistent manner. Such placenames and a myriad of ice "highways" may be likened to the street signs guiding motorists in the south. A driver very familiar with one city cannot easily maneuver a new city street network without first knowing intricacies of that area (e.g. street names, grid orientation, one-way streets, dead ends, highway exits, etc.). Similarly, while indicators of ice stability or danger may be similar between communities, without knowing the local "street names" and "highways" it is more difficult for a hunter to transfer their knowledge to a different area. Like a motorist who is familiar with the general rules of the road, and how to interpret maps, a hunter is familiar with general sea ice travel/hunting techniques and prominent ice features. Therefore, the motorist can use that underlying knowledge to get to know a new city quicker, with the help of a map. Similarly, a hunter can use previous sea ice experiences to inform themselves of travel in a new area, but it

is faster – and safer – with the help of a hunter who knows the local geography. However, there are no formal maps available to help the hunter identify dangerous sea ice areas, and only recently have Inuktitut placename maps begun to be developed. While motorists can purchase a map to facilitate the learning curve, hunters need to accumulate substantial localized experience before confidently navigating new surroundings alone. This local geographic knowledge, along with an understanding of seasonal cycles, wind and current influences on sea ice, and extensive practical experience, is what renders some hunters and elders as experts on sea ice travel, hunting, and safe navigation.

No matter where sea ice travel takes place, the use of a harpoon to test ice thickness and stability was continually emphasized as the most definitive means of gauging ice safety. However, this tool must be well understood to use it effectively. When striking the ice with a harpoon, hunters take into account: i) the strength with which they are hitting the ice; ii) the weight of the harpoon; iii) their own weight; and, iv) their method of transportation (e.g. snowmobile and *kamotik*, dog team and *kamotik*, just snowmobile). All these factors influence the number of strikes it takes to be sure the ice is safe for travel (Sections 4.3.1.2, 5.3.1.2, 6.3.1.2). Therefore, while the harpoon is important to determine ice safety, it cannot be used in the exact same way by each person because: i) their purpose for testing may differ; ii) their own weight may differ; and, iii) the weight of their harpoon may differ.

A person's familiarity with sea ice travel, and the surrounding geographic area, relates to their degree of comfort traveling around their community. Those who use the ice the most, who are most experienced, and who know the area well, are more confident than those who are less experienced. However, no matter how experienced a person, accidents can happen. Hunters and elders in each community stressed the importance of being prepared if they become stranded on the ice, or if they must find alternative travel routes. Bringing along extra food, water, and shelter supplies is imperative if a trip lasts longer than anticipated, for

whatever reason. Also, knowing where to reach solid ice or land is critical to survival when stranded on moving ice. Traveling with other people is also a valuable safety precaution. This way, help is available when needed instead of having to wait for help, or a search and rescue party. Furthermore, continuous use of the sea ice was highlighted in all three communities as the main way to ensure that a hunter's knowledge of the ice is current and reliable. Each year ice conditions are different. So each year observations made from the earliest signs of freeze-up are useful for sea ice safety evaluations throughout sea ice thickening, winter travel, and melting. If there is a break in sea ice usage, it is almost as if the hunter has to re-learn the ice conditions before being able to use it freely and safely again as a travel and hunting platform.

7.3.1.3 Hunting in each community

In all three communities, sea ice is used as a hunting platform for marine mammals, as well as a travel platform to access inland hunting and fishing grounds. Sea ice is integral in efforts to hunt seals, walrus, and (to a lesser degree) beluga. The particular ice conditions and hunting techniques utilized vary in their importance depending on the community.

Seal hunting is important in all three communities, with ringed seal being the primary target. Bearded seals are less commonly hunted. However, due to their large size they will be hunted if the opportunity arises. Sea ice was frequently highlighted as essential habitat for ringed seals in order for them to mate, den, raise their young, and moult their fur. In each community, seals were described as using the ice more than any other animal, and that they tend to follow the sea ice through its cycles of formation and decay. They are always seeking areas of thin ice to make breathing holes, or areas of open water to access air. Despite the similarities in which seals use the sea ice, there are numerous ways that hunters go after seals, and they vary in importance between communities (Table 7-8). Breathing hole hunting through *tuvaq* is not as important in Cape Dorset since seals are more easily accessible when they are breathing in open water, or through *naggutiit* (Table 7-8). On the other hand, with

Table 7-8: Summary of ice conditions used for different types of marine mammal hunting, in each community.

Ice condition	Method	Community
Seal hunting		
sikuaq	Through breathing holes in the new ice	**Cape Dorset, Igloolik, Pangnirtung**
naggutiit	Seal net running under the ice	**Cape Dorset, Pangnirtung**
naggutiit	Through breathing holes	**Igloolik,** somewhat Cape Dorset and Pangnirtung
sinaaq	Retrieval from the ice edge, or by boat	**Cape Dorset**
uiguaq	Through breathing holes	**Igloolik**
saqvaq/aukkarniq	Retrieval from the ice edge, or by boat	**Cape Dorset**, somewhat Pangnirtung and Igloolik
tuvaq	Through breathing holes	**Igloolik**, somewhat Pangnirtung and Cape Dorset
tuvaq	Seals (often pups) basking on the ice in the spring	**Cape Dorset, Igloolik, Pangnirtung**
Walrus hunting		
aulajuq	Moving ice hunting	**Igloolik** (January – March)
open water	Hunting by boat	**Cape Dorset** (fall and summer), somewhat Pangnirtung (summer)
sinaaq	Hunting by boat	**Cape Dorset** (winter)
Beluga hunting		
sinaaq	Retrieval from the ice edge, or by boat	**Cape Dorset**, somewhat Pangnirtung and Igloolik

more extensive ice formations, and more solid floe edge positions, Igloolik hunters use the *uiguaq, nagutiit,* and *tuvaq* for breathing hole hunting whenever possible (Table 7-8). Pangnirtung seal hunting practices are quite similar to those described in Cape Dorset, although with a lesser emphasis on hunting at the *sinaaq* (Table 7-8). In all cases newer, thinner ice is preferred for breathing hole hunting because it is easier to locate the holes. In addition, spring seal hunting as the animals bask on the ice is one of the most popular forms of seal hunting in all three communities (Table 7-8).

Walrus are known to stay within moving ice pans in open water. They generally avoid solid ice formations, and are thus most often found beyond the floe edge, moving further as the ice extends further. Walrus hunting is highly emphasized in Igloolik and Cape Dorset, although it is conducted in very different ways (Table 7-8). These variations revolve around proximity to walrus, and localized ice conditions. The dynamic and dangerous *aulajuq*

environment is uniquely used by people from Igloolik (Table 7-8). This is the main reason why their terminology for moving ice (Sections 7.2.1.5, 7.2.1.6), and their consideration of many interrelated factors affecting moving ice travel safety (Section 7.3.1.1) are only described in Igloolik. The winter months, after the sun has risen again (i.e. after January), are the times to use moving ice for walrus hunting. However, in order to do so the moving ice has to have formed solidly enough for travel, combined with adequate wind and current conditions. In contrast, walrus hunting in Cape Dorset is done mainly by boat, and in a different season (mainly fall and summer, although open water hunting in the winter is occasionally conducted) (Table 7-8).

Beluga are also important marine mammals for community harvests. However, less detail was provided on these hunting methods (Table 7-8). Hunters did not associate beluga as much with the ice because these mammals do not 'travel' on the ice. Therefore, more specific beluga-related questions would be required to understand the dynamics of using sea ice to hunt beluga.

In Pangnirtung there was more frequent mention of polar bear hunting than the other communities. However, hunters have to travel quite far out Cumberland Sound to access either walrus or polar bear, so it is not commonly practiced. Furthermore, in Pangnirtung the sea ice supports the commercial turbot fishery. Fishermen depend on sea ice to access the best fishing spots and to support their long-line fishing method (i.e. from the ice platform through to the bottom). Although this is not hunting per say, this important economic venture is of great interest to the community. Therefore, ice conditions are of particular concern to fishermen when things are not forming properly (Section 7.4.2.7).

In looking at some of the means of using sea ice for hunting purposes, and the sea ice conditions in each community, there many similarities but also differences in technique and timing. In Cape Dorset, they have open water close by year-round so their use of the sea ice

focuses mainly on the floe edge (*sinaaq*) and polynyas (*saqvait*). The use of boats is possible throughout the winter due to the proximity to open water, and is also a safety precaution around dynamic polynyas and floe edge delineations. In Pangnirtung, they use the landfast ice and polynyas more often, although floe edge hunting is conducted when the floe edge is stable enough. Around Igloolik there is more extensive ice formation, so although landfast ice is abundant it is harder to hunt seals. Therefore, polynyas and the *aulaniq* (both floe edge and moving ice) are used most often. These variations in hunting practices between communities would suggest that similar changes in sea ice conditions may affect communities differently. Furthermore, they may experience different changes all together, due to their unique geographic locations and local variations of sea ice use.

7.4 Observations of change

Sea ice change is being observed and experienced in all three communities. The changes noted as unique, or unexpected conditions are mainly mentioned since 2000. In Cape Dorset and Igloolik these changes are compared to conditions in the 1960s or earlier, but the spring and fall of 2004 were highlighted as very unique in Igloolik. In Pangnirtung, changes are typically compared to the 1980s. In addition, spring and fall conditions of 2004 were also highlighted as unique. In all three communities, evaluations of change frequently centered around the position of the floe edge, weather predictability, ice thickness, freeze-up timing, and break-up timing (Figure 7-8). Other key indicators of change include wildlife and moving/multi-year ice.

7.4.1 Indicators of change

Change in the floe edge position is typically gauged by its proximity to the community. This is the most frequently referenced indicator of change in Cape Dorset and Pangnirtung (Figure 7-8). The alterations in floe edge delineation are most dramatic in Cumberland Sound, as they are forming considerably closer to the mouth of Pangnirtung Fiord (Figure 6-23). In

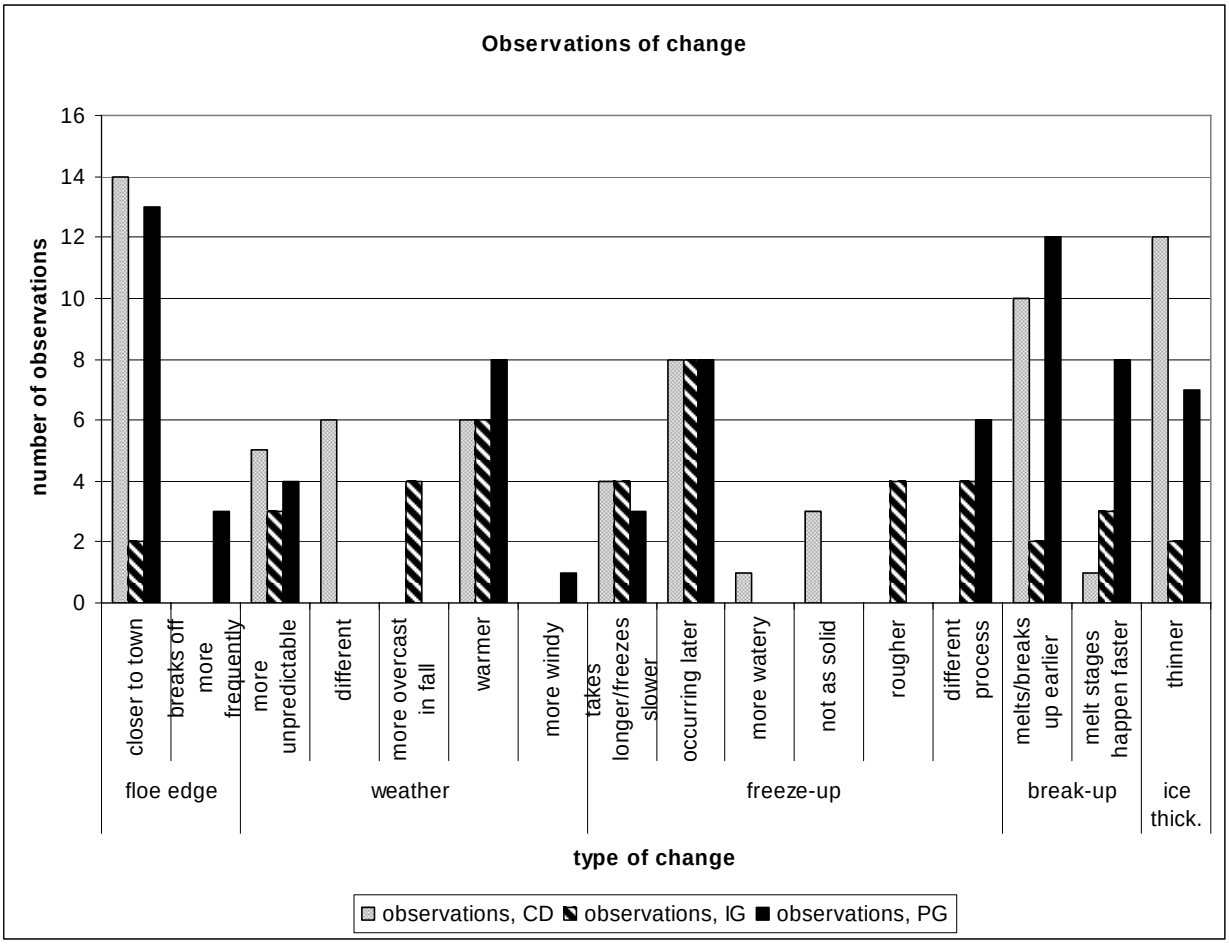


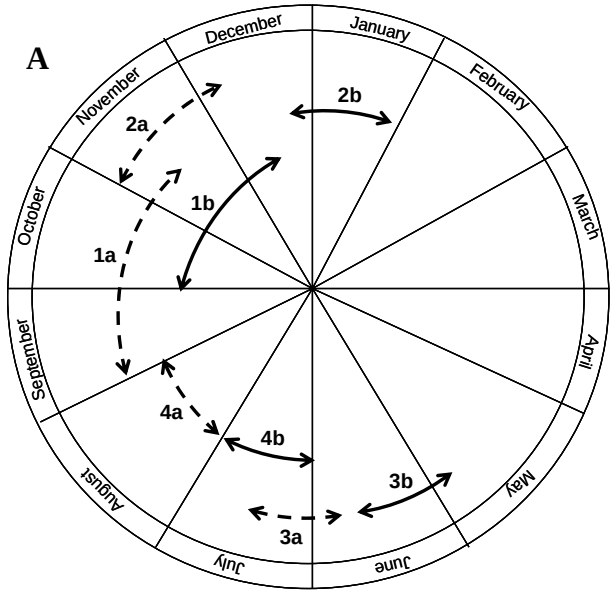
Figure 7-8: Summary of sea ice and related changes observed in each community.
Where: CD = Cape Dorset, IG = Igloolik, and PG = Pangnirtung. The number of observations refers to the number of interviewees that mentioned this change.

addition, more frequent occurrences of break-off events have been noted (Figure 7-8). In Cape Dorset a nearby floe edge is common due to the strong Hudson Strait currents, but recently the shifting floe edge position has been restricting travel access to some areas of the Baffin Island coastline (Figure 4-23). In Igloolik, the floe edge is described most often in the context of yearly variations, which are highly dependent on the piling of MYI on three nearby reefs.

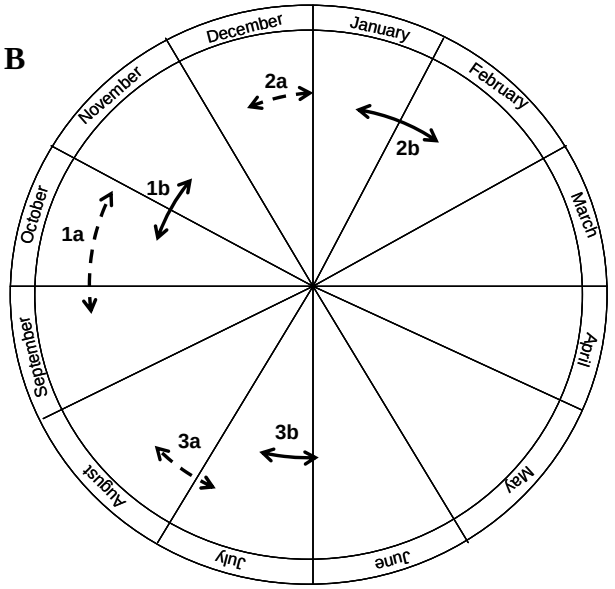
Between the three communities, the most common observation of weather change was a warming of temperatures (Figure 7-8). Another commonly shared observation was the increased unpredictability of weather, and shifts in the weather (Figure 7-8). This was also linked to changing prevailing winds in each community, whereby the NW winds were

commonly prevailing, but more SE winds have been experienced. Also, there have been more wind shifts noted, with no real prevailing direction. Unique to Cape Dorset was a general description of the weather being "different" than expected, while in Igloolik more overcast conditions have been noted in the fall. In Pangnirtung more windy conditions have been experienced in recent years. These shifting weather conditions were also linked to longer transitional periods in freeze-up and break-up, in each community, and are influential on the ice conditions year-round.

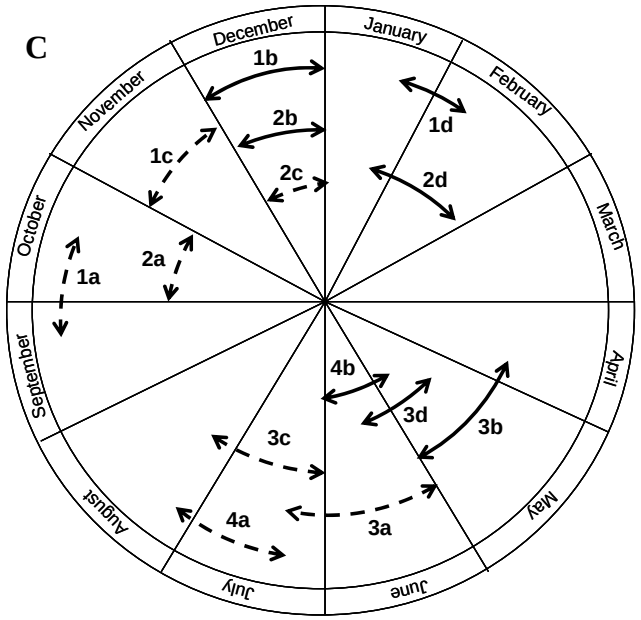
All three communities equally noted that freeze-up is occurring later each year, and to a slightly lesser degree that the freezing process is taking longer (Figure 7-8). Interestingly, the timing described for past, and more recent, freeze-up was not as different between communities as initially anticipated (Figure 7-9). However, it must be noted that not as many people in Igloolik specified the timing of freeze-up, in comparison to Cape Dorset and Pangnirtung. In all communities the freeze-up process was identified in two stages: the very early signs of freezing, and once the ice was travelable. The shifts identified in Cape Dorset (Figure 7-9a) and Igloolik (Figure 7-9b) were quite similar, although the travel references in Igloolik are referring to a much larger ice extent (i.e. to cross Fury and Hecla Strait vs. crossing Tellik Inlet to reach Baffin Island). In Pangnirtung, freezing was described distinctly for the timing within the fiord, and then within Cumberland Sound (Figure 7-9c). The most drastic shifts in freeze-up have been noted in this area, with almost a two-month shift in ice formation timing in both areas (Figure 7-9c). In addition to changes in timing, around Cape Dorset the ice has been more watery in the fall, and less solid as it is freezing (Figure 7-8). Around Igloolik the ice has been freezing more roughly than usual (Figure 7-8) (due to increased southeasterly winds in the fall). Furthermore, around Igloolik and Pangnirtung the ice was even noted to be freezing with a different consistency than previous years (Figure 7-8). All three communities have also noted a shift towards earlier spring ice break-up, and an increased



1a = Previous freeze-up
1b = Recent freeze-up
2a = Previous travelable
2b = Recent travelable
3a = Previous break-up
3b = Recent break-up
4a = Previous ice-free
4b = Recent ice-free



1a = Previous freeze-up
1b = Recent freeze-up
2a = Previous travelable
2b = Recent travelable
3a = Previous break-up
3b = Recent break-up



1a = Previous freeze-up (PG)
1b = Recent freeze-up (PG)
1c = Previous freeze-up (CS)
1d = Recent freeze-up (CS)
2a = Previous travelable (PG)
2b = Recent travelable (PG)
2c = Previous travelable (CS)
2d = Recent travelable (CS)
3a = Previous deterioration (CS)
3b = Recent deterioration (CS)
3c = Previous deterioration (PG)
3d = Recent deterioration (PG)
4a = Previous open water (CS)
4b = Recent open water (CS)

Figure 7-9: Summary of observed freeze-up and break-up timing changes, in each community.

Where: A) Cape Dorset;
B) Igloolik;
C) Pangnirtung (PG = Pangnirtung Fiord and CS = Cumberland Sound)
——— = recent timing
- - - - = previous timing

speed with which ice conditions deteriorate. However, these changes are most prominent in Cape Dorset and Pangnirtung for early break-up timing (Figure 7-8, 7-2a, 7-2c), and in Pangnirtung and Igloolik for faster melt stages (with some stages being skipped) (Figure 7-8).

Thinning ice conditions were most prominently noted in Cape Dorset, with Pangnirtung and Igloolik also mentioning this trend (Figure 7-8). It is challenging to evaluate the degree of change from interview descriptions, since changes in sea ice thickness vary according to a person's height and visual perception of depth, as well as the initial ice conditions to which they are comparing. For example, areas with strong currents would be thinner to begin with, but may be experiencing a greater amount of thickness change. Unfortunately, further clarification of specific areas used to evaluate change, complemented with sea ice thickness measurements, would be required to estimate the amount of thinning occurring around each community.

In addition to the physical indicators of sea ice change, some observed differences in wildlife presence or behaviour were also described as potentially related to changing ice conditions (Sections 4.4.6, 5.4.6, 6.4.6). First, in all three communities increased polar bear sightings were noted with concern, and were described as a combination of both sea ice and human-induced changes. Second, also in all three communities, the health and behaviour of ringed seals was described as changing along with ice conditions, as well as other environmental and human influences. However, the changes themselves were different in each community. In Cape Dorset seals have been popping up in polynyas more frequently, and have been basking on the ice in the winter (i.e. linked to warmer temperatures). In Igloolik, fewer seals were observed in *Ikiq*, along with a general decline in health (i.e. less fat). Also concerned with the health of seals, hunters in Pangnirtung noted the difference in fur conditions, and a lower survival rate for seal pups, due to earlier break-up (Figure 7-9c). Ringed seal numbers also seem to be decreasing in Cumberland Sound, but the number of harp

seals is said to be increasing rapidly. In both Cape Dorset and Pangnirtung, the number of bearded seals seems to be decreasing. Third, some notable differences in whale numbers were also mentioned. In Cape Dorset beluga whales were not sighted as often, but in Pangnirtung they seemed to be staying closer to the community year-round. In Igloolik, the number of killer whales seems to have increased, along with the number of bowhead whales sighted. Finally, unique to Igloolik were observations of changes in walrus congregation areas. They are no longer found in certain channels during freeze-up, and are taking different routes in their migration to the floe edge during freeze-up.

Moving and multi-year ice were also observed as different from the past, with a very different focus in each community. In Cape Dorset, less MYI has been noticed drifting by the community, and that the pieces seem smaller. In Igloolik, the two different types of MYI are concentrated in fewer areas, and are generally further from town. Also, the 'dirty' ice that normally comes up from the south has arrived later in the spring, while the 'clean' ice that normally comes from the north has been more common in recent years. In Pangnirtung, there have been fewer glacier-calved icebergs noted in the fiord. Furthermore, less MYI coming from the north has been collecting in Cumberland Sound, and it melts much faster than previously when it does enter the Sound.

7.4.2 Implications of change

After comparing the results between communities, the question remains: what do these changing ice conditions mean for each community in the context of their local ice processes and uses? Many of the changes described in Section 7.4.1 exacerbate the risks identified in Section 7.3.1.1, and make indicators of safety less reliable than they were in previous years. Therefore, the documentation of specific types of change, and their local implications, is an important first step towards a comprehensive assessment of community vulnerability to sea ice change. Based on the main indicators of change used in each community (i.e. floe edge, weather, freeze-up

and break-up timing, ice thickness, and moving/multi-year ice) the following sections present some of the implications of changing ice conditions for each community. These changes also have influence marine wildlife health and the success of subsistence and commercial harvests.

7.4.2.1 Floe edge

In all three communities, the increased proximity of the floe edge to the community leads to an increased potential of break-off events and people getting stranded on moving ice. Usually, smoother ice extending to the floe edge would indicate a higher likelihood of the ice breaking off. However, in all three communities the floe edge seems to break off more frequently, and more unpredictably, regardless of ice surface topography. Furthermore, key travel routes are being compromised, especially in Cape Dorset and Pangnirtung, where a floe edge that is too close forces people onto land. In Cape Dorset specifically, a closer floe edge means increased access to marine wildlife (associated with open water). However, this is also accompanied by enhanced danger of sea ice travel and reduced access to Baffin Island. In Igloolik the floe edge position is more variable, and is linked to other ice stability indicators (i.e. a closer floe edge would not be uncommon if ice was not piled on nearby reefs). Although there is less emphasis on change around Igloolik, when there is less MYI ice the floe edge is closer meaning increased access to the moving ice and wildlife. In addition, travel routes to the mainland or Baffin Island may have to be altered, depending on the extent of variation in the floe edge position. In Pangnirtung, the floe edge is now considerably closer to the mouth of Pangnirtung Fiord, meaning increased open water in Cumberland Sound. Sea ice travel is rendered more dangerous and travel routes must be altered. Moreover, commercial turbot fishing locations have limited access since the ice needs to extend a certain distance to reach the desirable, deep fishing areas. Indeed, the actual definition of *nunniq* has been altered. People now use this term when the northern end of Cumberland Sound freezes over, whereas it used to be used when the ice had formed solidly over more than half of the Sound. Therefore, even

sea ice references are being changed along with changing ice conditions. This is an important implication for language tied to environmental conditions, and it must be acknowledged in order to improve communications and minimize misinterpretations (Section 8.3.3).

7.4.2.2 Weather

Generally warmer winters are shortening the ice season, which means that hunters do not have as much time to use the ice. One benefit of this warming is that hunters do not have to wear the same heavy clothing during the winter, and tents suffice as shelter (i.e. building igloos is no longer a necessity). However, this concerns some people as they fear that the ice may no longer form at some point in the future. In contrast, others feel that the temperatures are not changing, which makes it even more difficult for community members to understand the cause of the altered ice conditions. Some postulations are that a warming water temperature is responsible, while others mention that increased windy/wavy conditions are preventing adequate ice formation. In all three communities, the increased unpredictability of weather shifts and traditional weather prediction techniques are rendering sea ice travel more dangerous. The diminished prevalence of NW winds have not only affected these shifting weather patterns, but also the ability to navigate accurately using snowdrifts. If snowdrifts form based on a shifted prevailing wind, then it is essential that hunters note the directional shift in order to continue using the drifts effectively. Moreover, increased prevalence of SE winds means more open water, or moving ice being blown towards the communities, making sea ice travel more difficult. It also makes wildlife more accessible where open water is maintained, but more frequent wind shifts increase the likelihood of ice breaking off from the floe edge. This (lack of) pattern has restricted walrus hunting opportunities in Igloolik, and influenced the amount of moving ice that concentrates around the community. In Pangnirtung, people have noticed more frequent windy conditions in the fiord as well as in the Sound, rendering ice conditions less stable and more prone to breaking up. These conditions

also speed up spring melt as the winds melt the snow on the ice surface faster than the sun alone. The changes in previously used indicators of weather and wind direction have meant that more people are: i) being stranded on the ice or land away from the community; ii) getting lost; and/or, iii) having more accidents. People are thus increasingly turning to weather forecasts, satellite imagery, and GPS technology to help evaluate ice conditions prior to travel, or to maneuver ice conditions in poor visibility (Section 8.2.3). Furthermore, since good weather systems are not remaining for as long as previously, hunters find that they have to be prepared for anything when they embark on longer sea ice trips.

7.4.2.3 Freeze-up timing

All three communities have noted later, slower freeze-up timing. In Cape Dorset and Igloolik sea ice travel has been delayed nearly a month, and in Pangnirtung nearly two months. This contributes to thinner and non-uniform ice conditions, which hamper ice travel and can lead to an early break-up. All three communities described a consistent freezing progression that occurred in previous years, whereas now it tends to form, break up/get blown out, then start forming again. This cycle goes on several times before the ice actually solidifies, which can lead to rougher ice conditions when it does form. This makes it more dangerous to begin traveling on the ice in the fall, and less predictable as changed weather conditions could drastically affect freeze-up progression. Shifting prevailing winds also lead to rougher ice conditions as the ocean freezes, making travel more difficult once the ice has solidified. In Cape Dorset, some freeze-up stages are being skipped completely, which makes it more difficult to evaluate the freezing conditions. This may also affect the usage of particular sea ice terminology (Section 8.3.3). In Igloolik, elders and hunters have noted that the ice is taking longer to form solidly. This is likely linked to more overcast conditions and higher amounts of snowfall in the fall months. These factors combine to delay freezing while contributing to thinner, more dangerous ice conditions. Furthermore, with the *qaingu* not forming along the

tidal zone earlier than when the ocean begins freezing, it can no longer be used for travel in the fall. Therefore, sea ice travel is less predictable and travel routes must be altered. In Pangnirtung, softer sea ice formations are also thinner, which creates new polynyas or other dangerous areas. Furthermore, the slower freeze-up progression has extended the boating season, while substantially delaying the start of the turbot fishing season. In all three communities, hunters and other community members are essentially stuck in town as they wait for ice to form solidly. People express their unhappiness and impatience with this delay, as they are eager to be on the ice hunting when it is newly formed. In addition, altered travel routes tend to be longer and rougher as zig zag trails follow thicker ice areas or shoreline contours. This not only affects sea ice hunting, but also inland hunting in areas that are only accessible by sea ice.

7.4.2.4 Break-up timing

All three communities have also noted a shift towards earlier spring ice break-up. Once water begins accumulating on the sea ice, deteriorating ice conditions become increasingly risky for travel. Specific areas open up two to three weeks earlier than others, so these non-uniform melt conditions translate into dangerous travel, and often altered routes. For people in Cape Dorset there is an increased potential to be stranded away from town if snow/ice melt is sudden. In addition, spring leads are opening up earlier than normal, forcing people to follow the shorelines for travel (which is longer and rougher than the regular routes). It also translates into a longer boating season, which increases access to soap stone mines, walrus hunting areas, and even other communities. In contrast, around Igloolik deeper water accumulation was noted in the spring of 2004 due to decreased numbers of tidal cracks. This meant that some areas were wearing out before the ice even started breaking up (due to inadequate meltwater drainage through the cracks). In Pangnirtung, the sea ice has been deteriorating more from underneath, which leads to faster more sudden melting and an

increased potential for break-off events. This augments travel danger and forces people to alter travel routes (e.g. traveling along the *qaingu* instead of the *tuvaq*, or having to travel inland due to open water areas). Earlier break-up has enabled earlier boat travel, but it has also markedly shortened the turbot fishing season (not to mention the ice season overall). Specific melt stages were noted as being skipped around Pangnirtung. Consequently, melt stages are occurring more rapidly as the ice begins breaking up after the snow meltwater has drained away – there is no second water accumulation stage from ice meltwater anymore. This has implications for travel danger, prediction of ice break-up, and use of sea ice terminology (Section 8.3.3). Moreover, with the mouth of Pangnirtung Fiord opening earlier in the year, access to Cumberland Sound is progressively restricted. In each community, longer transitional stages (both freeze-up and break-up) mean that people are 'stuck' in the community for longer periods of time.

7.4.2.5 Ice thickness

Observations of thinning ice were mentioned in all three communities. This greatly enhances the risks associated with sea ice travel. Thinner ice is less resistant to the influences of currents, lunar cycles, winds, and snowfall. In other words, thinner ice deteriorates more easily from currents underneath, or can be broken up more easily from waves or winds. Thinner ice can also initiate the occurrence of larger or new polynyas. Around Cape Dorset, thinner sea ice leads to less predictable ice safety along with enhanced danger associated with hunting around polynyas or at the floe edge. For example, one route that was used to access soap stone mines in the winter has not been used for 20 years due to increased amounts of open water – and thus dangers in that area. In Igloolik, thinning ice conditions were discussed mainly in the context of the unique fall of 2004, whereby more snowfall – and snow accumulation between MYI – caused the ice to melt from underneath. These conditions exacerbated the dangers associated with sea ice travel off the island of Igloolik, making it one

of the most dangerous years that some hunters had experienced. As for Pangnirtung, thinner sea ice makes it more difficult to access the southern coast of Cumberland Sound, which is a popular hunting and fishing destination. The ice has been wearing away from underneath even before all the snow has melted from the surface, rendering it deceptively solid when there little ice under the snow. If the ice is not solid enough at the mouth of the fiord, and along the northwestern shoreline of the Sound, then it is very dangerous to travel around the shores to reach the opposite part of the Sound. In all three communities, thinning sea ice was also linked to later freeze-up (i.e. not as much time for the ice to thicken), and earlier break-up (i.e. contributes to earlier break-up because the ice wears away faster).

7.4.2.6 Moving/multi-year ice

Less moving or multi-year ice around each community was linked to potentially warmer water or air temperatures, especially in the summer. This may, in turn, contribute to the delayed freezing of the sea ice in the fall and thinner ice conditions overall. Therefore, the presence or absence of MYI has implications for other ice conditions or indicators of change. In addition, more MYI frozen into the *tuvaq* around Igloolik contributed to enhanced travel danger as they strengthened currents under the ice. Snow then accumulated between the large protrusions above the ice, causing thinning to occur around these large ice formations due to the insulation from above and forces acting below the ice cover. In addition, moving ice hunting has been more dangerous around Igloolik because the ice itself has been smaller, had more cracks, and been less solid. It has also been further from town, and thus harder to access walrus. In both Igloolik and Pangnirtung, less MYI present in the summer renders boating conditions more difficult. Waves propagate higher and further when there are no large ice pans to shelter boats from the wind or to dampen the effects of waves. Also noted around Pangnirtung was that when *qapvaq* do enter Cumberland Sound, or are blown into Pangnirtung Fiord, they are melting much faster – they no longer last through the summer. This is another

potential indicator of warming water temperatures, as well as being a contributor to warmer water temperatures. Around Cape Dorset, less MYI was explained as potentially being part of an ice movement cycle. It was likened to the migration of animals, whereby the ice might congregate in an area one year, and another area another year, depending on wind and current circulation (e.g. accounts of MYI piling up recently around Coral Harbour and Nunavik).

7.4.2.7 Subsistence and commercial harvesting

All the implications for sea ice change affect sea ice travel, but they also influence subsistence and commercial harvesting success. Therefore, hunters are dealing with enhanced travel danger to access marine wildlife, reduced time within which to use the sea ice, as well as a changing habitat that may affect the health and well-being of the animals themselves.

Polar bear populations around each community have been observed to be increasing (to varying degrees). Some local postulations for this trend include: i) slower freeze-up meaning that bears may be staying on landfast ice longer (Igloolik, Pangnirtung); ii) sea ice conditions further south (i.e. Hudson Bay) are deteriorating and thus bears are moving northwards (Cape Dorset, Igloolik); iii) polar bears are not hunted as much these days due to the quota system, thus bear numbers are increasing (Cape Dorset, Igloolik, Pangnirtung); and, iv) bears are going after cached meat more frequently, thus they are seen more often (Igloolik). These noted changes in polar bear sighting or behaviour are a combination of both environmental and human-induced change, thus it is difficult to tease out which is more influential. Regardless of the cause (or combination of causes) polar bear populations seem to be increasing around each of the communities, which has several implications for community life. With their habitat diminishing, bears may become over-populated in more northern latitudes, which may in turn affect the number of ringed seals around the communities (the main prey for the polar bears). Furthermore, earlier break-up forces bears onto land earlier in the spring, not allowing them to catch their fill of baby seals during a critical time of the year (i.e. before summer 'walking

hibernation'). In addition, later freeze-up means the bears have to go longer without sea ice to hunt seals. Consequently, it has been noted around Igloolik that bears are becoming increasingly lean. They do not have the same amount of healthy fat that they need to survive the winter and to support their young. Furthermore, with shifting trends in timing, as well as thinning ice cover, it is believed that the polar bears may be less effective in their hunting. Therefore, some hunters expressed concern about the health of polar bears if the ice continues to retreat. There is also danger involved with increased numbers of bears, especially hungry bears. As more bears venture into communities seeking food, the number of defense kills have increased. The bears are raiding meat caches more often around Igloolik, and due to strict quotas people are not able to hunt those bears. It is believed that bears are becoming less afraid of humans, since they can raid caches and not be shot at (unless the person has a polar bear tag). For this reason, bears may become braver and venture into communities more often, creating enhanced risks of bear encounters or attacks. Setting quotas is thus becoming increasingly controversial. Community members believe that there are too many bears around, while conservation agencies and some scientists are concerned for the long-term vitality of the polar bear species and may seek more restrictions on polar bear hunting. Polar bear sport hunts are also an important source of income for some hunters, so there are economic implications of shifting polar bear populations and health beyond the environmental aspects.

Ringed seals were described as using the sea ice more than any other animals, thus they are likely the animal that would be most affected by sea ice change. All three communities noted a decreasing number of ringed seals around their towns. Hunters themselves may be influencing seal congregation areas since increased hunting and associated motor traffic around the communities tends to drive seals away. In Igloolik, increased numbers of killer whales in Fury and Hecla Strait were also mentioned as a potential reason for fewer seals in the area (nearly all marine mammals are scared of killer whales, and will flee the areas where they

are present). However, changing ice conditions are also influencing the health of seals. Thus, both the subsistence and commercial value of seal hunting may be affected. A healthy seal is a fat seal, and hunters in Igloolik have noted less fat on the seals they are catching in the fall. This has also been noted around Pangnirtung, where substantial changes in ice conditions are already translating into negative effects for the local seal population. One that has been mentioned previously is that with earlier break-up the seals do not get enough time to bask on the ice in the spring, meaning that they cannot moult adequately. For young seals this makes it more difficult for them to rid themselves of their white fur (to allow their dark, spotted fur to come in). Because this moulting cannot occur on land more brown seals are being caught in the spring. These are considered bad skins, meaning that hunters are affected economically because they cannot sell the furs. Even the practice of hunting seals as they bask on the ice is highly curtailed because of poor ice conditions. Furthermore, important denning areas are breaking up early. This forces the pups into the water when they are too young (i.e. they have not accumulated enough fat), meaning they die soon after being in the cold water. This may increase the mortality rate of young seals, in turn affecting both the seal population and hunting success. Increased snowfall on the sea ice would actually be a positive implication for seals, as they would be more effective in building and maintaining safe dens. However, a decrease in snowfall could be detrimental for seals as they would not be able to create adequate shelter for themselves or their pups in the winter months. Some hunters wonder where all the seals will go if the ice should cease to form, or become too thin for use.

Walrus around Igloolik are now much further from the community. This may be linked to the decreased prevalence of moving ice near the community, and/or to increased motor vehicle traffic on the sea ice or in the water. Eco-tourism and guided sport hunting were actually thought to be driving walrus away, since they track walrus and try to get as close as possible. In addition, sport hunters may approach walrus groups several different times sizing

up their choice animal, which means that walrus will continue traveling further from the disturbance. As a mainstay for the community, this makes it difficult for local hunters to continue practicing their moving ice hunting techniques to reach and catch walrus.

Perhaps most influential in an economic sense is the effect of shorter ice seasons, and thinner ice cover, on the commercial turbot fishery in Cumberland Sound. Several Pangnirtung fishermen make a living off seasonal long-line fishing, and solid ice cover is essential to reach the most desirable and productive fishing spots in the Sound (Figure 6-21). There is greater danger involved in this profession now, with increasingly unpredictable weather and ice conditions. In addition, the fishing season has been drastically shortened, and in the past few years it has barely occurred due to the frequency of storms and high winds. Fishermen are also more cautious now because of the enhanced likelihood of the ice breaking up, meaning they can lose all their equipment at once. This had happened to several people interviewed, and to several more that I met in Pangnirtung. Some people were able to claim this through worker's compensation, but in many cases the equipment is simply irretrievable and irreplaceable. This has caused many people to abandon fishing completely due to the financial burden of trying to start anew.

7.4.3 Considerations for assessments of change

An assessment of the influence of sea ice change on northern communities must consider the nature and degree of the environmental changes, and the implications for community members, simultaneously with social and lifestyles changes that northern communities are undergoing. Individuals may perceive, or react to, changes differently depending on their economic status, hunting methods, interest in new media, family history, to name a few. For example, increased open water could be considered a positive influence of sea ice change. It allows more access to air and food for marine wildlife and decreases travel time for hunters to reach marine wildlife. But, it also makes for potentially dangerous travel,

restricted hunting options, and less habitat for some key marine species (e.g. ringed seals and the polar bears who prey on them). Community members would also enjoy longer summer boating seasons. However, boat travel is more sensitive to wind, current, and weather conditions than sea ice travel due to the dangers of rough open seas or navigating through moving ice. In addition, the financial implications of boat ownership and maintenance are higher than for snowmobiles, so less people may be able to engage in boat hunting activities.

Additional considerations for the perception/influence of sea ice change relate to the degree to which community members participate in hunting or other traditional/cultural activities. Compared to the more traditional and mobile lifestyles prior to permanent community settlement, people are no longer traveling on the sea ice as much. Country foods are an important part of the local diet, but are no longer essential for survival. Furthermore, because dog teams are rarely used for travel the requirements for hunting have greatly diminished along with the necessity of feeding dog teams. Therefore, people are not hunting (or not hunting certain animals) as frequently as they would have in the past. Some people are too busy with employment to be able to use the ice on a regular basis, while others are aging and not as able to travel (and the younger generations in their family are not as interested). Therefore, ice conditions may seem different, or the weather may feel warmer, simply because community members are not spending as much time outside. Without using the ice regularly, some community members may be less aware of the environment, and less adept at sea ice travel. As such, accidents may happen more frequently not only because of sea ice change, but perhaps because: i) less people are checking the ice properly; ii) travel is faster by snowmobile and lacks the helpful canine instincts of dog teams; iii) people are not waiting long enough before traveling on the sea ice in the fall; and, iv) younger people are not as familiar with sea ice routes. Nevertheless, during the spring season sea ice travel remains popular. It is an

important time when extended families travel together to go hunting or fishing. In contrast, winter sea ice travel is mainly undertaken by hunters for subsistence or commercial harvesting.

A further consideration is that northern, and indeed global, news media are bombarding people with articles and reports of climate and environmental change of all sorts. This does not necessarily influence how community members report changes in their region, but in some cases it has rendered people more observant because of concerns for the local effects of climate change. It also meant that the issue of change was forefront on people's minds when discussing the topic of sea ice, although I never introduced change into interviews until after it was initiated by the participant. Community members are experiencing changes in sea ice, and they hear about it all the time, so it is not surprising that they want to talk about these issues. This is especially the case when they do not agree with scientific reports and findings. Their own observations and theories have not always been incorporated into studies of change or results analyses.

Interestingly, a few elders in each community explained that they were warned by their parents and grandparents that the weather and sea ice would be very different when they became adults and had their own grandchildren. In Pangnirtung, Anglican ministers were also said to have foretold that Cumberland Sound would not freeze over at some point in the future. Having now reached that age, the seemingly unbelievable predictions of warmer winters, thinner ice, and shorter ice seasons are actually coming true. Because they expected this type of change, some elders are not surprised or concerned. They were also told not to blame anyone for the changes because nothing can be done about it. There is no way to control the changes, so it was advised that whatever is destined to happen will happen. Moreover, some people feel that the current changes in ice conditions are part of a long-term (approximately 50-year) cycle, and that a cooler phase will return in the future. Therefore, long-term change has perhaps become a part of the ever-variable arctic sea ice system, whereby

the Inuit continue to adapt as best they can.

These are only a few of the potential influences of social or lifestyle changes on Inuit expertise, or local perception of change. These were not investigated in depth, but it would be important to attempt to tease out such effects when assessing change, and peoples' ability to adapt to changes. Ice conditions and processes are changing physically, but the degree to which they are noticed, and are affecting people, is also a function of: i) who is using the sea ice; ii) how the ice is being used; and, iii) what time of year the ice is being used. Many of the observations of change described in interviews depend on the initial sea ice conditions, and the areas used, around each community. This makes it challenging to compare the extent or implications of change for each community. For example, a similar reduction in floe edge extent could minimally influence sea ice travel around Igloolik, but could prevent community members in Cape Dorset from getting off the island. Another example would be that new polynyas around the shores of Cumberland Sound could prevent access to key hunting grounds outside Pangnirtung, while new polynyas near Cape Dorset could make it easier to access wildlife despite declining ice extents. Furthermore, changes occurring in areas that are not frequently used may be dramatic (i.e. some polynyas are too dangerous to venture near, so people are unable to monitor conditions), but these do not affect people as much as areas that are frequently used and are experiencing moderate change. Such considerations for the assessment of sea ice change, and related implications for northern community life, present an important argument for community-based studies that evaluate local implications. It should be clear by this point that it is essential to incorporate community knowledge and context in identifying indicators of change, assessing change, and evaluating the effects on community members. Otherwise, it is impossible to know how physical changes will affect community lifestyles and well-being. However, due to the relative nature of changes (as linked to local and regional geographies, local and regional sea ice use, and qualitative assessments of change), the

utility of some standardized measures to quantitatively assess physical change is also recognized. Therefore, linking local and scientific expertise on sea ice, while accounting for changing conditions and local uses, will lead to more comprehensive and representative assessments of community vulnerability to sea ice change. The next challenge is how to effectively link different conceptions of sea ice processes, and how to work collaboratively to adequately represent different perspectives and standards of knowledge valuation.