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# Traditional Ecological Knowledge of Polar Bears in the Northern Eeyou Marine Region, Québec, Canada

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ABSTRACT. Polar bears are important socio-cultural symbols in the communities of the Eeyou Marine Region (EMR) in northwestern Québec, Canada. Members of the Cree communities in this region are generally not active polar bear hunters, but they encounter polar bears when fishing, trapping, or hunting during the ice-free season. A growing body of scientific evidence suggests that reduced annual sea ice cover in Hudson Bay has led to declines in body condition of polar bears in the local Southern Hudson Bay subpopulation and to a population decline in the neighboring Western Hudson Bay subpopulation. In June 2012, we conducted 15 semi-directed interviews on the subject of polar bear biology and climate change with local elders and hunters in three communities in the northern EMR: Wemindji, Chisasibi, and Whapmagoostui. The interviews held in Whapmagoostui included informants from Kuujjuarapik, the adjacent Inuit community. The interviews addressed knowledge gaps in the Recovery Strategy for Polar Bear in Ontario. Transcripts of the interviews were coded thematically and analyzed using both qualitative and quantitative methods. The interviews revealed important insights into polar bear distribution, terrestrial habitat use, denning, and foraging patterns. Participants were unanimous in their recognition of a warming climate and prolonged ice-free season in the area in recent years. However, communities differed in their observations on other issues, with latitudinal trends evident in observations of polar bear distribution, denning activity, and foraging habits. Communities also differed in their perception of the prevalence of problem polar bears and the conservation status of the species, with one-third of participants reporting that polar bears will be unaffected by, or even benefit from, longer ice-free periods. A majority of participants indicated that the local polar bear population was stable or increasing. Interviewees also identified future research priorities pertinent to the communities, and provided comments on the methods employed by polar bear biologists. Our results demonstrate that communities in the EMR have important knowledge about polar bear ecology and illustrate the unique opportunities and challenges of combining traditional ecological knowledge with wildlife science in the context of a rapidly changing subarctic environment.

Key words: polar bear; *Ursus maritimus*; traditional ecological knowledge; Cree knowledge; Eeyou Marine Region; James Bay; Hudson Bay; sea ice; climate change; subarctic wildlife

RÉSUMÉ. L'ours blanc revêt un caractère socioculturel important pour les communautés de la Région marine d'Eeyou (RME), située dans le nord-ouest de la province de Québec, au Canada. Bien que les Cris de ces communautés ne soient pas reconnus pour chasser particulièrement l'ours blanc, ils partagent le territoire avec l'ours blanc lors de leurs déplacements et activités de chasse, de pêche et de trappe. Un nombre croissant de preuves scientifiques suggère que la réduction annuelle de la couverture de glace dans la baie d'Hudson aurait causé une dégradation de la condition physique des ours blancs de la sous-population sud de la baie d'Hudson et un déclin de la sous-population voisine, dans l'ouest de la baie d'Hudson. En juin 2012, nous avons réalisé une série de 15 entrevues semi-dirigées concernant la biologie de l'ours blanc et les changements climatiques avec des aînés et des chasseurs de trois communautés de la portion nordique de la RME : Wemindji, Chisasibi et Whapmagoostui. Les entrevues tenues à Whapmagoostui ont inclus des répondants du village inuit adjacent, Kuujjuarapik. Les entrevues abordaient des lacunes au niveau des connaissances, telles que déterminées par le Programme de rétablissement de l'ours polaire en Ontario. Les entrevues ont été transcrites et codées par thèmes afin d'être analysées suivant des méthodes qualitatives et quantitatives. Les entrevues révèlent d'importantes informations relativement aux connaissances sur la distribution, l'utilisation des habitats terrestres, les aires de mise bas et les habitudes alimentaires des ours blancs. Les participants ont unanimement constaté le réchauffement du climat et la prolongation de la période libre de glace au cours des dernières années sur leur territoire d'activités. Cependant, les points de vue des participants diffèrent pour ce qui est de certains enjeux, selon un gradient latitudinal évident, concernant la distribution, les activités de mise bas et les habitudes alimentaires de l'espèce. Les perceptions des communautés diffèrent aussi relativement à la prévalence des ours blancs problématiques et en ce qui concerne le statut de conservation de l'espèce, avec le tiers des participants jugeant que les ours blancs ne seraient pas affectés,

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ou pourraient même bénéficier, d'une plus longue période libre de glace. Une majorité de participants indique que la population locale d'ours blancs est stable ou en augmentation. Enfin, les répondants ont indiqué les priorités de recherches pertinentes à leur communauté et partagé des commentaires sur les méthodes employées par les biologistes. Les résultats montrent que les communautés de la RME possèdent des connaissances importantes concernant l'écologie de l'ours blanc, illustrant ainsi les opportunités et les défis afin de combiner ces données à celles des sciences biologiques, ceci dans un contexte de changement rapide de l'environnement subarctique.

Mots clés : ours blanc; *Ursus maritimus*; connaissances écologiques traditionnelles; connaissances des Cris; Région marine d'Eeyou; baie James; baie d'Hudson; couverture de glace; changement climatique; faune subarctique

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## INTRODUCTION

Recognizing the knowledge of Northerners when conducting research in the Arctic is gaining momentum in Canada (Riedlinger and Berkes, 2001; Huntington, 2011; Canadian Polar Commission, 2014). Indeed, traditional ecological knowledge (TEK) has informed and complemented a variety of wildlife studies in the North (Gilchrist et al., 2005; Lewis et al., 2009; Huntington et al., 2011; Ferguson et al., 2012; Herrmann et al., 2012; Kendrick, 2013; Polfus et al., 2013; Royer et al., 2013; Voorhees et al., 2014; Joint Secretariat, 2015). The localized effects of a warming climate vary across regions and communities in the North: they are dependent on geography, as well as social, historical, and economic contexts (Duerden and Kuhn, 1998). TEK can serve to portray the effects of a warming climate on a human scale by situating the impact of broad-scale phenomena in local communities (Furgal et al., 2006; Pearce et al., 2009).

The Arctic is warming two to three times faster than the global average rate (IPCC, 2013), and the effects of this warming will profoundly influence northern traditional ways of life (i.e., hunting and traveling on the land) (Furgal and Seguin, 2006; Downing and Cuerrier, 2011; Laidler et al., 2011; Meier et al., 2014; Pearce et al., 2015). Rising atmospheric temperatures have led to increased water temperatures in the Arctic Ocean and decreased the extent and thickness of summer sea ice (Comiso, 2002; Gagnon and Gough, 2005; Comiso et al., 2008; Kwok and Rothrock, 2009). The greatest increase in sea surface temperature in the Canadian Arctic is predicted to occur in southeastern Hudson Bay and James Bay (Joly et al., 2011; Castro de la Guardia et al., 2013). Hudson Bay and Foxe Basin have experienced a loss of up to 1.5% per year in sea ice extent over the past 29 years (Sahanatien and Derocher, 2012), and models of future sea ice conditions in Hudson Bay suggest a continued disappearance of winter sea ice cover in the coming decades (Castro de la Guardia et al., 2013).

Polar bears (*Ursus maritimus*) rely on the sea ice as a platform for feeding, traveling, and mating (see Stirling and Derocher, 1993). A growing body of scientific evidence has demonstrated the reliance of polar bears on sea ice habitat, with projections and observations of reproductive and nutritional stress across the species' range as sea ice conditions decline (Laidre et al., 2008; Molnár et al., 2010, 2014; Rode et al., 2010; Bromaghin et al., 2015).

Polar bears in Hudson Bay and James Bay are forced to move on shore when the sea ice completely melts each summer (Obbard and Middel, 2012). Without access to the marine mammal prey species that comprise most of their diet, polar bears on shore must rely largely on stored fat for energy. Climate warming has increased the length of this seasonal fasting period by three to four weeks compared to 40 years ago (Gough et al., 2004; Gagnon and Gough, 2005; Hochheim and Barber, 2014; Obbard et al., 2016). Recent scientific studies have demonstrated that the Western Hudson Bay subpopulation of polar bears has experienced declines in body condition, reproduction, and survival, which have contributed to a population decline of more than 30% since 1987 (Regehr et al., 2007; Lunn et al., 2016). However, the Western Hudson Bay subpopulation has remained stable over the past decade because of the recent stability in sea ice conditions (Lunn et al., 2016). The neighboring Foxe Basin subpopulation to the north has also remained stable in size, despite deteriorating sea ice conditions in that region (Stapleton et al., 2016).

While on land, polar bears in Hudson Bay consume terrestrial vegetation (Derocher et al., 1993), but past stable isotope analyses have indicated that these foods do not contribute significantly to the energy budget of polar bears (Ramsay and Hobson, 1991; Hobson and Stirling, 1997; Hobson et al., 2009). Although recent modeling work has demonstrated that goose eggs may represent an increasingly important food source for polar bears in western Hudson Bay (Rockwell and Gormezano, 2009; Rockwell et al., 2011; Gormezano and Rockwell, 2013a, b), supporting empirical evidence is lacking (Rode et al., 2015a).

Polar bears of the Southern Hudson Bay subpopulation come ashore along the north coast of Ontario, the west coast of Québec, and the islands of James Bay, making this the most southerly subpopulation of polar bears in the world (Obbard and Middel, 2012). Recent scientific evidence suggests that the body condition of these bears has declined over time (Obbard et al., 2016), but no change in population size has been documented (Obbard et al., 2015).

Polar bears are important socio-cultural symbols in Cree and Inuit communities in the Eeyou Marine Region (EMR) of northwestern Québec (Fig. 1). The original

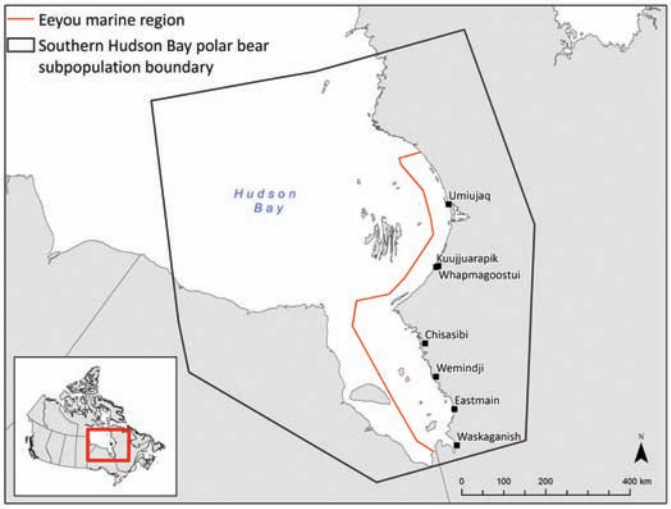


FIG. 1. Map showing the communities where the interviews took place (Wemindji, Chisasibi, and the adjacent communities of Whapmagoostui and Kuujjuarapik) and the boundaries of the Southern Hudson Bay polar bear subpopulation (Obbard et al., 2010).

people of the Hudson Bay lowlands have been interacting with polar bears for millennia (McDonald et al., 1997; Bird, 2005). Although the Cree of the Québec James Bay communities do not generally self-identify as polar bear hunters, they have knowledge of bear movements and behaviour based on incidental observations (rather than active pursuit) of polar bears and on interactions with neighboring Inuit communities. As a result, Cree elders, hunters, and fishers from these communities are well placed to provide observations of behaviour, distribution, and local abundance of polar bears in the ice-free season. The Inuit community of Kuujjuarapik is located adjacent to the Cree community of Whapmagoostui, within the boundaries of the EMR. Inuit community members encounter polar bears on land during the ice-free season, as well as on the sea ice in the winter months through either incidental encounters or direct observations during subsistence hunting (McDonald et al., 1997). Thus, Inuit inhabitants of this region are also well placed to contribute to the body of knowledge surrounding polar bears in the EMR.

Genetic analyses have indicated that the polar bears in James Bay are genetically differentiated from the other polar bears in Hudson Bay, which perhaps suggests the need for a separate James Bay management unit (Crompton et al., 2008, 2014; Peacock et al., 2015; Viengkone et al., 2016). The published literature lacks TEK perspectives on James Bay polar bears within the EMR. Residents of EMR communities are the only people who live within the summer range of these bears in Québec and thus are uniquely situated to contribute to our understanding of polar bear biology in the region. Here, we expand on previous studies of TEK in the EMR (see McDonald et al., 1997; Cuciurean et al., 2011), with a focus on polar bears in some of the most northern EMR communities. Our study focused on the behaviour and ecology of polar bears, changes observed in their habitat, and local perceptions of human-polar bear conflict and research methods.

## METHODS

We conducted interviews in the communities of Wemindji, Chisasibi, and Whapmagoostui/Kuujjuarapik, Québec, in June 2012 (Fig. 1). We identified these communities in collaboration with the Cree Nation Government (CNG) and the Cree Trappers' Association (CTA) to participate in a study on TEK of polar bears because of interest within the communities and because they have a higher encounter rate with polar bears during the ice-free season than the more southerly (Eastmain and Waskaganish) and northerly (Umiujaq) communities in the EMR. We employed a targeted sampling technique (Newing, 2011), whereby local CTA representatives in each community identified the individuals to take part in the interviews (including three Inuit participants) because of their knowledge of polar bears and the location of coastal family traplines.

We conducted semi-structured interviews with participants to document polar bear knowledge in the EMR. This interview method has proven appropriate in North American Arctic Indigenous groups (Ferguson and Messier, 1997; Huntington, 1998; Dowsley, 2007; Ferguson et al., 2012), as well as Cree communities in Ontario and Québec (Lemelin et al., 2010; Herrmann et al., 2012; Royer et al., 2013). The interview strategy is flexible and open-ended, and it allows for the expression of personal positions and beliefs. A set of 32 questions (online Appendix 1) was approved by the CNG and the CTA. Participants did not necessarily address every question, depending on earlier responses throughout the interviews.

Interviews were conducted by B.J. Laforest and J.S. Hébert in either an individual or a group setting of two to four people, depending on the preference of the participants. Although a social setting may have had some influence on interview responses, we ultimately deferred to participants to decide on the forum that made them the most comfortable. During the group interviews, the participants reached consensus in many (but not all) instances when answering questions, allowing for a more robust account of TEK through the contributions of multiple sources (Huntington, 1998). However, we told participants ahead of time that their responses would be individually recorded and prompted them to provide an individual response, which was recorded separately. If a participant did not provide a response in either an individual or a group setting, the response was recorded as "did not respond." Interviews were conducted in either English or Cree with the help of a local translator and lasted from 29 min to 2.5 h (n = 9, mean = 79 min). Participants relayed both direct observations and second-hand information they deemed to be valid. During the interviews, the interviewers and participants jointly

marked large maps of the area surrounding each community to facilitate the localization of specific sightings, historical events, and species ranges. Maps for each interview were then combined to create three community-scale maps and a regional map of information provided by all participants. Participants were given the choice of remaining anonymous or having their name acknowledged for their contributions. It was made clear to the participants that their names would not be associated with any of the information they provided. All of the participants in this study chose to be acknowledged. All research methods were reviewed and approved by the Human Participants Review Committee at York University.

The study was developed to address questions on local polar bear population abundance and trends, regional habitat use, terrestrial foraging, human-bear conflict rates, and community views on scientific research methods. The interviews also addressed the local abundance and distribution of ringed seals (*Pusa hispida*) and bearded seals (*Erignathus barbatus*). Interviewees described local changes in climate and sea ice and their implications for wildlife. Questions were geared towards filling knowledge gaps in Ontario's recovery strategy for polar bear (Tonge and Pulfer, 2011), but also allowed for personal input and additional knowledge sharing. There were no pre-formulated responses for any interview questions. Each interview concluded with a discussion on what community members would identify as the future research priorities of both scientific and TEK studies of polar bears and other wildlife in the EMR. Participants were asked to provide answers in the context of their community or region. However, where appropriate, responses were compared with other TEK and scientific knowledge from the broader Southern Hudson Bay subpopulation of polar bears, which is the management unit for polar bears in the EMR.

The resulting interview data were transcribed to allow qualitative and quantitative analysis. The responses from each interview file were broken down into smaller units and coded thematically by B.J. Laforest using the software NVivo® (QSR International, Burlington, Massachusetts, 2014) (Siccama and Penna, 2008; Hilal and Alabri, 2013). The patterns of responses were then summarized at one or more of the following levels depending on the variation of responses: within each community, between communities, and for the northern EMR as a whole. For the purposes of this analysis, the responses of participants from Whapmagoostui and Kuujjuarapik were pooled and treated as one community, as these communities are directly adjacent to each other and share municipal infrastructure. Logistical constraints precluded a return validation visit to give participants the chance to review transcripts of their interviews. However, the local Cree Trappers Association office in each community was given the chance to review and comment on the results and the draft manuscript. With the consent of the participants, each interview was recorded to facilitate analysis. Where appropriate, we categorized the responses of participants into nominal variables (e.g., presence or absence; increase, decrease, or stable). Given the small sample size in each community, we used the Fisher-Freeman-Halton exact test of independence to test for differences in observations among communities (Lydersen et al., 2007).

## RESULTS

We interviewed 15 individuals from three communities in the northern EMR: three from Wemindji, six from Chisasibi, and six from Whapmagoostui/Kuujjuarapik. Participants in the study were men ranging in age from late 20s to late 70s, with most over the age of 50. All participants indicated that they had extensive experience hunting and trapping in the EMR and had encountered polar bears in the past.

### *Local Observations of Climate Change*

Participants agreed unanimously that the climate in the area was changing. The key descriptors each participant chose to illustrate these changes varied significantly across communities (Fisher-Freeman-Halton exact test, $p = 0.042$), but similarities were present across the region as a whole (Table 1). The three most prominent changes noted by participants in all communities were that the winter season is shorter (n = 8), the winter is not as cold as it used to be (n = 8), and the summer season is longer (n = 7). Three participants specifically indicated that summer is now one-and-a-half to two months longer than it used to be. This shifting in the seasons was well articulated by a Cree participant in Whapmagoostui, who noted that the Cree language names for the months used to correspond to environmental characteristics of that month, but these names no longer apply.

> November is the month that you would be able to walk without having to worry about the condition of the ice. But that's not true anymore. February is the month when it's the coldest part of the year and January is the month when you're supposed to be able to travel safely out in the bay, but that's not the same.
>
> Participant from Whapmagoostui

Other indicators of climate change across the region that were noted to affect local wildlife and vegetation included faster melting of freshwater lakes (n = 3) and a stronger, hotter sun (n = 4). In Chisasibi, all of the six participants noted the shift in prevailing winds from north and northwest to south and southeast. One participant noted that the time frame in which these changes have occurred was very brief, and therefore the effects on wildlife, vegetation, and people are expected to be profound.

All participants also agreed that the duration of sea ice in James Bay and Hudson Bay has been declining (Table 2). The particular descriptors of these changes

TABLE 1. Summary of participants' responses on the observable effects of a warming climate in the Eeyou Marine Region, by community.

| | Wemindji | Chisasibi | Whapmagoostui/Kuujjuarapik | Total |
|---|---|---|---|---|
| Winter is not as cold | 2 | 4 | 2 | 8 |
| Winter is shorter | 1 | 2 | 5 | 8 |
| Summer is longer | 1 | 3 | 3 | 7 |
| Sea ice is not as thick | 1 | 4 | 1 | 6 |
| Spring is longer | 2 | 0 | 3 | 5 |
| Cold in the winter is more damp | 1 | 0 | 3 | 4 |
| Dominant winds have shifted | 0 | 4 | 0 | 4 |
| Stronger sun | 0 | 0 | 4 | 4 |
| Sea ice melt pattern changing | 2 | 0 | 1 | 3 |
| Skidoo safety issues | 0 | 1 | 2 | 3 |
| Not as much snow in the winter | 0 | 0 | 2 | 2 |
| Higher tides | 1 | 0 | 0 | 1 |
| Changes in the coastline | 1 | 0 | 0 | 1 |
| Water is warming year round | 1 | 0 | 0 | 1 |
| Harder to predict the weather | 0 | 0 | 1 | 1 |
| Freshwater lakes melting quicker | 0 | 0 | 1 | 1 |
| More powdery snow | 0 | 0 | 1 | 1 |

TABLE 2. Summary of participants' responses on the sea ice conditions in the Eeyou Marine Region, by community.

| | Wemindji | Chisasibi | Whapmagoostui/Kuujjuarapik | Total |
|---|---|---|---|---|
| Delayed freeze-up in the fall | 3 | 6 | 6 | 15 |
| Early melt in the spring | 1 | 6 | 6 | 13 |
| Traveling on the sea ice is difficult | 2 | 6 | 5 | 13 |
| Sea ice moves more than it used to | 0 | 0 | 4 | 4 |
| Sea ice is weaker/not as thick | 3 | 0 | 1 | 4 |
| Increased turbidity is grinding the sea ice | 1 | 2 | 0 | 3 |
| Sea ice melt pattern is different | 0 | 0 | 3 | 3 |
| More open water in the winter | 0 | 0 | 2 | 2 |
| Less sea ice | 1 | 0 | 0 | 1 |
| Sea ice is harder to predict | 0 | 0 | 1 | 1 |
| Warmer sea water in the summer | 1 | 0 | 0 | 1 |

expressed by participants did not vary across communities ($p = 0.072$). All participants noted that freeze-up in the fall is now delayed relative to 20 years ago, and 13 participants indicated that the spring melt of sea ice is occurring earlier now than 20 years ago (two participants did not comment on spring ice conditions). Thirteen participants from across all three communities noted that this lengthening of the ice-free season in both the spring and the fall has limited their ability to safely travel on the ice as they could in the same seasons 20 years ago.

> There has been traumatic change in the ice conditions. Today the breakup seems to happen earlier and the ice seems to be forming later and the thickness of the ice is very noticeable today and everything is changing including the ice. As soon as there's open warm season, the warm seems to open [the ice] up regularly.
>
> Participant from Whapmagoostui

One participant noted that the ice used to be frozen by October 31, but now remains very weak until the middle or end of November. Five participants from Whapmagoostui/Kuujjuarapik discussed how it used to be possible for residents of Sanikiluaq, Nunavut, to travel to Whapmagoostui/Kuujjuarapik at Christmas time, as well as in the months of April to June, but trips at those times of the year are no longer possible because of the weakening and unpredictable ice conditions. Participants from all communities (n = 8) noted that it used to be possible to travel on James Bay by snow machine at the end of May, but this is also no longer the case. One participant from Wemindji indicated that the weakening sea ice now prevented travel on the bay even as early as mid-April.

Other notable observations of the sea ice include that the ice is weaker or not as thick as it used to be (n = 6), the ice is moving more once it has frozen (n = 4), the spring melt pattern has changed and occurs much faster now (n = 4), and the increased turbidity of the water is grinding away at the underside of the ice (n = 3).

### *Environmental Changes and Polar Bears*

None of the participants from Wemindji commented on the effects of a changing sea ice platform on polar bears. In Chisasibi, four participants indicated that changes in the Arctic marine food web linked to sea ice and water turbidity may cause polar bears to come inland more often during the ice-free season in search of food. The other two participants from Chisasibi indicated that because polar bears are adept swimmers and capable of hunting seals in the open water,

they would not be affected by declines in the sea ice. Similar viewpoints were expressed by three participants from Whapmagoostui/Kuujjuarapik, who indicated that polar bears prefer longer summers and are capable of hunting seals when there is no ice. The other three participants from Whapmagoostui/Kuujjuarapik indicated there would be unspecified behavioural changes in polar bears in relation to the changing climate and sea ice.

*Population Numbers and Body Condition*

Individual views on the local population status of polar bears differed across the three communities ($p < 0.001$). Participants from Wemindji and Chisasibi either indicated that they were not able to comment on population size (n = 4), or that they thought the local polar bear population was stable (n = 5), whereas all participants interviewed in Whapmagoostui/Kuujjuarapik indicated that the polar bear population is increasing (n = 6).

> To my knowledge I don't think there has been that much abundance of polar bear along the coast but okay every once in a while do have a sighting of polar bear, but I don't recall that you know there was abundance of polar bear that year or you know a certain decade or years that you know there would be abundance, but it just varies for every once in a while there would be a sighting of polar bear.
>
> Participant from Chisasibi

> When I was starting to wake up and start listening it was just a story…. It was just a story, polar bear, we [had] never seen one… but today they are coming, coming – they are coming, populating in this territory.
>
> Participant from Kuujjuarapik

Most participants across all communities did not comment on changes in polar bear body condition (n = 11); participants cited interannual variation, seasonal variation, variation among individuals, and limited observations of polar bears each year as reasons they found it difficult to comment on changes in body condition. One participant noted that he would expect bears forced to travel longer distances to be skinnier, but also noted he had not seen this himself as it is difficult to observe trends in polar bear body condition. The three participants from Whapmagoostui/Kuujjuarapik who specifically answered this question all indicated that polar bear body condition is stable; they cited the fact that polar bears are capable of hunting seals in open water as a factor contributing to the stable body condition of the bears.

*Distribution during the Ice-Free Season*

Many of the responses from participants were supplemented by our joint marking of maps to place their observations on the landscape. The maps for each interview were aggregated to create physical representations of polar bear and other marine wildlife TEK specific to each community (Figs. 2–4) and for the northern Eeyou Marine Region overall (Fig. 5).

In Wemindji, all participants noted that polar bear tracks are very rarely seen near the community, but are more common on the small offshore islands. Most sightings of polar bears described by participants from Wemindji took place on the Twin Islands in James Bay (Fig. 2). Participants noted the presence of polar bears on Walter Island and the absence of polar bears on Weston Island.

In Chisasibi, all participants also indicated that polar bears are very seldom found around town, but noted that some bears do spend the ice-free period on the islands along the coast (Fig. 3). Participants from Chisasibi also cited an abundance of bears on the Twin Islands and noted that polar bear tracks are sometimes spotted along the coast north and south of town in the winter.

Participants from Whapmagoostui/Kuujjuarapik noted that bears are found in the vicinity of the community, along the coast, south of town, north of town, inland, and on many of the nearshore islands close to the community (Fig. 4). The three Inuit participants noted that there are very few bears on shore in the ice-free season close to Umiujaq, Québec, the Inuit community to the north. They also noted the presence of polar bear day beds on Long Island, and indicated that polar bears commonly spend the summer months on Long Island.

*Inland Habitat Use and Denning*

When we asked participants whether polar bears go inland during the ice-free season, their responses varied significantly by latitude across the participants' traditional hunting grounds ($p = 0.005$). Two of the three participants from Wemindji and the two participants from Chisasibi with traditional hunting lands south of Chisasibi noted that polar bears stay close to the coast and they have not heard of polar bears going inland. The other participant from Wemindji did not comment on this. All four participants from Chisasibi with traditional hunting grounds north of the town, and five of the six participants from Whapmagoostui/Kuujjuarapik noted that polar bears have been found very far inland. The remaining two participants were unsure. Accounts of polar bears observed far inland included distances of 15 km, 40 km, 60 km, 90 km (by Bull River), 120 km (by Clearwater Lake), and up to 300 km inland (by Hydro-Québec's LG4 complex). One participant noted that accounts of polar bears being far inland (more than 60 km) was something he had only heard of in his adult life, not as a child. However, it should be noted that all participants indicated that most polar bears are found near the coast or on coastal islands.

When we asked about the presence of winter maternity denning sites, we found the same relationship with latitude of traditional hunting ground ($p = 0.002$). Once again, two of the three participants from Wemindji and the

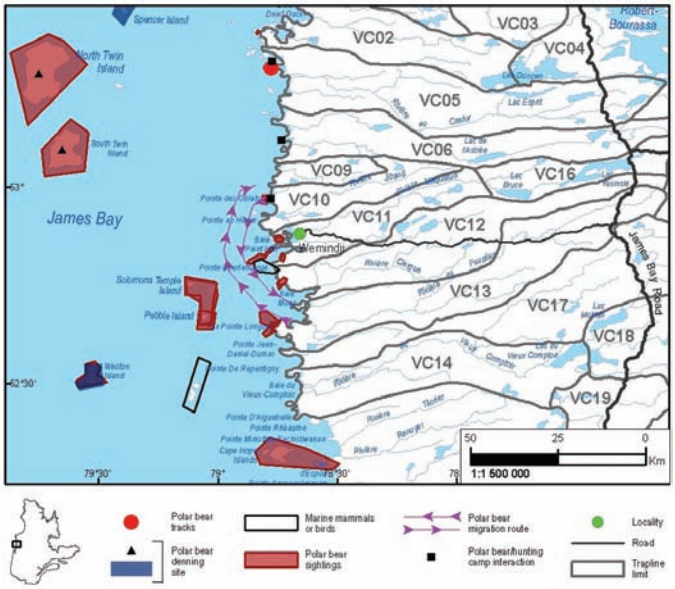


FIG. 2. Results of the joint exercises held in the community of Wemindji to map traditional ecological knowledge about polar bears and other subarctic wildlife. Letter-number combinations (e.g., VC17) denote traplines.

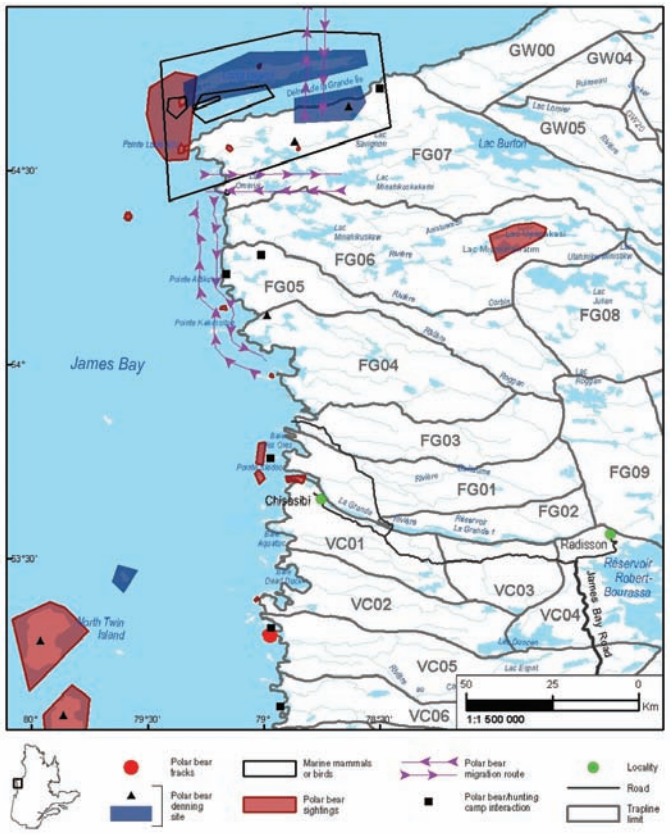


FIG. 3. Results of the joint exercises held in the community of Chisasibi to map traditional ecological knowledge about polar bears and other subarctic wildlife. Letter-number combinations (e.g., VC05) denote traplines.

two participants from Chisasibi with traditional hunting lands south of the town indicated they had not heard of polar bears denning in their area. One participant from north of Chisasibi recounted seeing tracks from a mother and two cubs headed from inland toward James Bay in March or April (which is interpreted as evidence of polar bear denning inland from the coast). Further, five of six participants from Whapmagoostui/Kuujjuarapik noted that polar bears den in the vicinity of town, with participants classifying den sites as being in areas of deep snow, far from human activity (e.g., snow machines), and close to the shore. One participant noted that it is relatively common knowledge that polar bears den inland near the community, identifying Burton Lake (10–15 km inland) as a particular denning site. The other five participants from across the three communities were either unsure or did not provide any information on denning. Two Wemindji participants also highlighted the importance of the Twin Islands as important denning sites in James Bay.

> He says that during the mid-winter, that's where he hears of dens… further away from the bay, but not too far inland. And because that's the period that she looks after her young cubs…the polar bear doesn't move too much away from the area where she would tend to her cubs. But as soon as the spring, the early spring, the days start to become longer, then she would start to travel towards the bay.
>
> Interpreter's report of response from a Whapmagoostui participant

When asked if the timing of seeing polar bears on land has changed or stayed the same in the past 20 years, three participants indicated that the timing is the same, and 12 participants either provided no information or indicated that they were not able to answer that question because of annual variation in timing of bears on land or not seeing polar bears consistently enough to tell.

*Terrestrial Feeding*

Participants identified a wide variety of terrestrial and freshwater (hereafter terrestrial) food sources used by polar bears, ordered here by frequency of identification: Black Guillemot (*Cepphus grylle*) juveniles (n = 6), vegetation/berries (n = 6), garbage (n = 5), Common Eider (*Somateria mollissima*) eggs (n = 4), inland fish [including northern pike (*Esox lucius*), brook trout (*Salvelinus fontinalis*), lake whitefish (*Coregonus clupeaformis*)] (n = 3), Arctic Tern (*Sterna paradisaea*) eggs (n = 3), Black Guillemot eggs (n = 3), freshwater harbour seals (*Phoca vitulina mellonae*) (n = 2), seagull (unidentified species) eggs (n = 1), Canada Goose (*Branta canadensis*) goslings (n = 1), moulting adult Canada Geese (n = 1), Canada Goose eggs (n = 1), and caribou (*Rangifer tarandus*) carcasses (n = 1) (Table 3). Reported instances of terrestrial feeding by prey type were not evenly distributed across the three communities ($p < 0.001$). For example, Black Guillemot juveniles were identified as a food source for polar bears only by participants in Chisasibi, whereas only participants

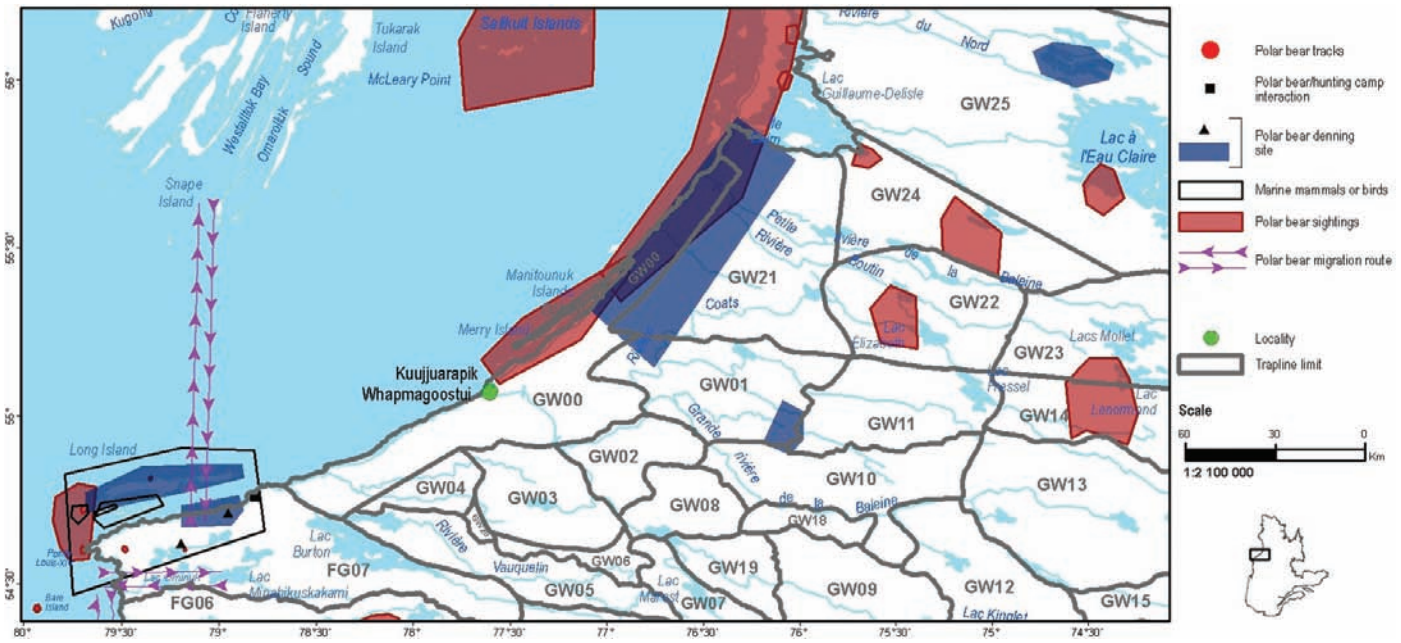


FIG. 4. Results of the joint exercises held in the communities of Whapmagoostui/Kuujjuarapik to map traditional ecological knowledge about polar bears and other subarctic wildlife. Letter-number combinations (e.g., GW13) denote traplines.

TABLE 3. Summary of participants' responses on the terrestrial and freshwater food items consumed by polar bears in the Eeyou Marine Region, by community.

| | Wemindji | Chisasibi | Whapmagoostui/Kuujjuarapik | Total |
|---|---|---|---|---|
| Black Guillemot juveniles | 0 | 6 | 0 | 6 |
| Garbage | 1 | 2 | 2 | 5 |
| Common Eider eggs | 0 | 1 | 3 | 4 |
| Vegetation and/or berries | 0 | 0 | 6 | 6 |
| Inland freshwater fish | 0 | 1 | 2 | 3 |
| Arctic Tern eggs | 0 | 0 | 3 | 3 |
| Black Guillemot eggs | 0 | 0 | 3 | 3 |
| Freshwater seals | 0 | 0 | 1 | 1 |
| Seagull (various species) eggs | 1 | 0 | 0 | 1 |
| Canada Goose goslings | 1 | 0 | 0 | 1 |
| Moulting adult Canada Geese | 1 | 0 | 0 | 1 |
| Canada Goose eggs | 0 | 0 | 1 | 1 |
| Caribou carcasses | 0 | 0 | 1 | 1 |

from Whapmagoostui/Kuujjuarapik identified vegetation/berries, Arctic Tern eggs, Black Guillemot eggs, and freshwater harbour seals as food sources.

> In August…when these guillemots are just in their prime, [polar bears] don't go after the eggs: they go after the guillemot because there is nothing but fat in them.
>
> Participant from Chisasibi

Only one participant noted that he had never heard of polar bears eating anything while on land. When asked if the rate at which polar bears are exploiting terrestrial food sources is decreasing, consistent, or increasing, three participants indicated that the rate was increasing, with one noting that polar bears are acting more and more like American black bears (*U. americanus*) these days by eating more on land. The other two participants who indicated an increase in polar bear terrestrial foraging cited changes in the marine ecosystem such as increased turbidity in the water causing the bears to go on land more often in search of food. Five participants indicated that the rate at which polar bears are exploiting terrestrial sources is consistent with past levels, and the other seven either did not comment or indicated they were unable to tell.

### *Human-Polar Bear Conflict*

There was a significant difference in the perception of human-polar bear conflict across the three communities ($p < 0.001$). None of the participants from Wemindji or Chisasibi noted that human-polar bear conflict was an issue in their respective communities.

> The town doesn't really have problems with polar bears. It's not a safety concern… I never came across any serious problem. But I guess the people probably should

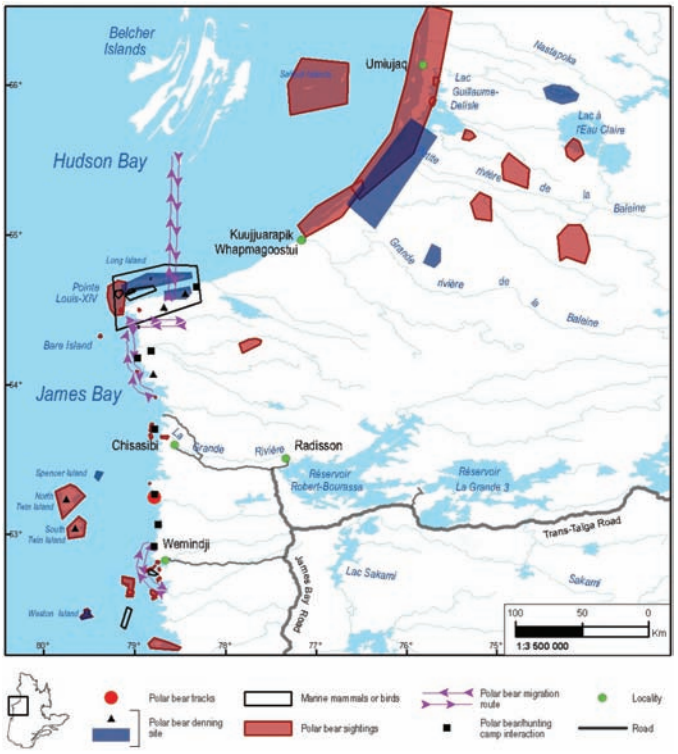


FIG. 5. Map of the Northern Eeyou Marine Region showing combined results from the communities shown in Figures 2 to 4.

> be alert when they're out there. I always try to keep it in mind.
>
> Participant from Wemindji

Conversely, all of the participants from Whapmagoostui/Kuujjuarapik indicated that human-polar bear conflict was a safety concern within the town, and that the rate of problem polar bear encounters in town was increasing. The participants from Whapmagoostui/Kuujjuarapik shared numerous accounts of damage caused by polar bears, as well as human-polar bear encounters in town.

> I have seen personally a polar bear too that came into our camp, just walked right into the area where we left the garbage… and then just walked up to the garbage and just went through that, went through the garbage looking for I guess something to eat, so I think it's very familiar, or something that they do more often now because there's more camps along the shore, and along the shore up there at Hudson Bay. I think that's where the tracks [are] because people leave garbage behind and sometimes they do leave some food behind, bones and stuff like that from the hunt, and I believe that's what they're going after.
>
> Participant from Whapmagoostui

A significant difference was noted between Wemindji and the other two communities in terms of problem polar bears and hunting cabins ($p$ = 0.002). Two of the participants in Wemindji noted that polar bears were not a problem at hunting cabins (one participant from Wemindji was unsure), whereas all 12 participants from Chisasibi and Whapmagoostui/Kuujjuarapik indicated that polar bears are both a safety concern and a cause of damage at hunting cabins. Five of the participants indicated that the occurrence of polar bears at cabins was a relatively new issue, whereas seven others indicated it has always been a concern or were unable to answer whether this was a new issue or not. None of the participants had ever observed or heard of polar bears disrupting trapping activities in this region.

Participants from Chisasibi and Whapmagoostui/Kuujjuarapik cited the scent of food and fire (n = 6), decreased fear of humans among polar bears (n = 3), increased population numbers (n = 3), and decreased food availability in James Bay (n = 1), as reasons to explain the presence of polar bears at hunting cabins and in town. Three of the participants from Whapmagoostui/Kuujjuarapik also noted that polar bears are found more often in groups now than they used to be, which the participants identified as a rising safety concern for community members.

There were no patterns identified concerning the description of problem polar bears, as most participants (n = 12) were unable to comment on trends in problem polar bears, or indicated that no such trend existed. However, two participants indicated that bigger bears were more likely to be problematic, and one participant indicated that younger bears were more destructive.

### *Other Marine Wildlife*

Participants across all three communities unanimously agreed that ringed seals are the most common type of seal in the EMR, with bearded seals also present throughout the region in lower abundance. However, there was disagreement on the status of ringed and bearded seal populations, with no trends across communities ($p$ = 0.368). Eight participants spread across all three communities indicated that the general seal population was decreasing; three participants (one from Whapmagoostui/Kuujjuarapik and two from Chisasibi) indicated that the seal population was increasing; and four participants across all communities indicated the population was stable. Individuals who thought the population was increasing cited the fact that seals are not harvested at the same levels as in the past as the main reason. Of those who held that the population was decreasing, five cited increased turbidity in the water as the reason and one cited a decreased sea ice platform.

### *Research Methods and Future Research Priorities*

There were no objections noted in any of the three communities to studying polar bears through aerial surveys. However, participants from all three communities stressed that it is important for aerial survey research work not to interfere with goose hunting activities. Two participants from Whapmagoostui/Kuujjuarapik stressed

the importance of being careful not to overheat polar bears by excessively chasing them with planes or helicopters during the ice-free season.

There was a significant difference in the views of participants in Wemindji and Chisasibi compared to those in Whapmagoostui/Kuujjuarapik on the subject of capture-based polar bear research ($p < 0.001$). All nine participants from Wemindji and Chisasibi said they were either not opposed to or had no opinion on chemical immobilization methods, but the importance of ensuring the bears' health and not angering the bears was stressed. In contrast, all six participants from Whapmagoostui/Kuujjuarapik indicated that they were opposed to the use of tranquilizing drugs to study polar bears, including the use of satellite radio collars. Some reasons for their opposition were that collaring animals can lead to animals starving (n = 4); the health of animals that have been tranquilized is compromised (n = 3); tranquilizing animals will lead to behavioural changes (n = 2); and tranquilizing can scare (n = 1) and anger (n = 1) polar bears.

> I wonder what [tranquilizing] does to the meat. Nevertheless when you have to do scientific test on them that's one of the ways to calm them down and I have no objection to that as long as it is proven that it is healthy.
>
> Participant from Chisasibi

> He understands why all these studies are necessary, but he just cautions of the methods. Because if there is any method that's used to frighten the species in any way, this is the natural instinct of anybody, any living creature to try and get away from that scary, scary place.
>
> Interpreter's report of response from a Whapmagoostui participant

Participants identified seven research priorities for the Southern Hudson Bay subpopulation of polar bears. Five participants prioritized movement analyses to determine the location of the bears on the sea ice and how close to town they are coming throughout the year; another five suggested studies of the effects of live-capture and collaring on the health of polar bears and quality of their meat. Two gave importance to research into the changing food web of the EMR as James Bay warms, and two to studies on the effects of hydroelectric development and explosions on polar bear health. Studies to determine the number of polar bears in the region, studies on whether a changing climate will lead to more dangerous polar bears, and research into developing less invasive methods to study polar bears were each cited by one participant.

## DISCUSSION

There is some limited information on polar bear TEK in the Southern Hudson Bay region based on a study conducted in the Ontario communities of Fort Severn and Peawanuck (Kakekaspan et al., 2010; Lemelin et al., 2010). However, little information has been compiled and published on the TEK of polar bear populations from the EMR communities in Québec (McDonald et al., 1997; Herrmann et al., 2012). Though most participants in this study were not active hunters of polar bears and their observations were largely limited to the ice-free season, the participants in this study possessed a wide breadth of knowledge on many aspects of polar bear biology. The participants were also well positioned to discuss aspects of climate change in the region and other environmental issues pertinent to the communities. A survey of marine ecosystem TEK of Hudson Bay and James Bay communities conducted in the mid-1990s collected some information on polar bears in James Bay, but was more focused on the Inuit communities of Hudson Bay (McDonald et al., 1997). A recent survey of TEK of eastern James Bay wildlife involving the southern Cree communities of the EMR produced limited information on polar bears, as polar bears were not the focus of the study (Herrmann et al., 2012).

### *Environmental Change, Sea Ice, and Polar Bears*

The participants unanimously indicated that the climate is warming in the EMR. The manifestations of these changes were best described by changes in the onset and duration of seasons, as well as by warming in the winter months. This coastal warming is consistent with reports that the greatest sea surface temperature increases in the Canadian Arctic will occur in and around the EMR (Joly et al., 2011; Castro de la Guardia et al., 2013). The lengthening of the ice-free season in Hudson Bay and James Bay described by the participants in our study is also consistent with scientific research (Gagnon and Gough, 2005; Obbard et al., 2016).

The finding that Cree and Inuit observations of climate are consistent with long-term meteorological monitoring has also been demonstrated in the more southern communities of the Eeyou Istchee region. TEK was found to be both in agreement and complementary to scientific meteorological data from the area (Royer et al., 2013). In addition to describing the physical effects of a changing climate, TEK is able to document the effects of climate change on people living in the region. This ability was demonstrated by the translation of deteriorating sea ice conditions into specific effects on lifestyle and community safety concerns of traveling on the sea ice in the spring and fall. It should be noted that in addition to noting the effects of warming climate, participants also attributed the declining sea ice in James Bay to an increase in freshwater input from hydroelectric projects.

None of the participants explicitly linked the effects of a warming climate to specific impacts on polar bears. Five participants indicated that polar bears are adept swimmers capable of hunting seals in open water. Residents of communities along Baffin Bay have also expressed this viewpoint (Dowsley and Wenzel, 2008), whereas Inuvialuit

of the Western Arctic had variable perceptions of the ability of bears to catch seals in open water (Joint Secretariat, 2015). The view of polar bears as effective open-water hunters is not consistent with the Western scientific understanding that bears rely on the sea ice platform for catching prey (Stirling and McEwan, 1975; Smith, 1980). The implications of this disagreement are paramount, given that scientists suggest that the greatest threat to polar bears associated with a decrease in sea ice is a significant decrease in access to marine mammal prey (Stirling and Derocher, 1993; Derocher et al., 2004).

*Population Numbers and Body Condition*

There were significantly different views among communities on the conservation status of polar bears in the northern EMR, with only participants from Whapmagoostui/Kuujjuarapik indicating that the population was increasing. The view that the Southern Hudson Bay polar bear subpopulation is increasing has similarly been expressed in coastal Ontario communities (Lemelin et al., 2010), communities in the southern EMR (Herrmann et al., 2012), and the Belcher Islands community of Sanikiluaq, Nunavut (McDonald et al., 1997), though the latter work refers to changes between the 1940s – 50s and the early 1990s. A recent aerial survey of the Southern Hudson Bay subpopulation concluded that the abundance of polar bears has remained steady since 1986 (943 bears; SE: 174) (Obbard et al., 2015). The survey included the entire coastal range and offshore island habitat of the Southern Hudson Bay subpopulation, except for the eastern James Bay coast. Taken together, the results of the aerial survey and the participant responses from Wemindji and Chisasibi indicate that the local population has remained stable. However, the unanimous responses from participants in Whapmagoostui/Kuujjuarapik suggest that there has been a localized increase in the number of bears near Whapmagoostui/Kuujjuarapik.

Scientists suggest that increased sightings of polar bears by community members can be tied to the deteriorating sea ice habitat that is forcing bears to spend more time on land (Stirling and Parkinson, 2006; Towns et al., 2009; Rode et al., 2015b). However, northern residents from across the Canadian Arctic have associated increased sightings with increased population size (Tyrrell, 2006; Dowsley, 2007; Dowsley and Wenzel, 2008; Kotierk, 2010a, b). One implication of this disagreement relates to the setting of sustainable harvest limits. Recent high-profile increases in the level of harvest of Southern Hudson Bay bears, combined with scientific evidence of decreasing body condition (Obbard et al., 2016), necessitate the continued monitoring of the conservation status of the subpopulation. Both scientific data and TEK could contribute to a comprehensive mixed-methods approach to population monitoring in southern Hudson Bay.

The inability of most participants to comment on the body condition of polar bears is consistent with pronounced seasonal and annual variation in body condition in both individual bears and the subpopulation (Atkinson and Ramsay, 1995; Atkinson et al., 1996). Although recent scientific evidence suggests the body condition of Southern Hudson Bay polar bears has declined in recent decades (Obbard et al., 2016), these observations are based on detailed morphometric measurements of more than 900 immobilized bears (Cattet et al., 2002; Cattet and Obbard, 2005; Obbard et al., 2016). The fact that interview participants did not observe trends in body condition is consistent with their smaller numbers of observations based on infrequent personal encounters with polar bears, in contrast to the tracking and hunting activities that may provide additional information to TEK holders in other regions (e.g., Joint Secretariat, 2015). The trends in body condition identified by scientific studies in southern Hudson Bay may not be visually recognizable to an observer and may require more frequent or closer encounters to be detected.

*Polar Bears on Land*

All participants from Whapmagoostui/Kuujjuarapik cited the presence of polar bears in the vicinity of their community during the ice-free season, yet a 2012 aerial survey of the population made no observations of polar bears along the Québec coast from Puvirnituq to Pointe Louis-XIV, where Hudson Bay meets James Bay (Obbard et al., 2015). This discrepancy, along with the observations of a localized increase in polar bear abundance in the vicinity of Whapmagoostui/Kuujjuarapik, suggests that further studies are required into the distribution and local population status of polar bears in the EMR.

The polar bears of James Bay appear to be genetically differentiated from other southern Hudson Bay polar bears (Crompton et al., 2008, 2014; Peacock et al., 2015; Viengkone et al., 2016), and documenting the distribution of James Bay polar bears has been identified as a research priority for the subpopulation (Obbard and Middel, 2012). Through mapping observations of polar bear sightings, harvest locations, and human-bear conflict sites, our study provides the basis for further research on the abundance and distribution of polar bears during the ice-free season along the Québec shores of James Bay. In particular, the mapped migration routes and denning sites (Figs. 2 – 5) provide important information for both survey design and management of the subpopulation.

The results of this study suggest a latitudinal gradient of inland habitat use by polar bears in the northern EMR. The range of distances inland (15 – 120 km) where polar bears were found is consistent with scientific observations of habitat distribution in the Hudson Bay lowlands. Solitary adult females and family groups have been observed to travel 24 – 84 km inland in Wapusk National Park in Manitoba (Derocher and Stirling, 1990; Clark and Stirling, 1998) and 29 – 118 km inland in Polar Bear Provincial Park in Ontario (Kolenosky and Prevett, 1983; Obbard and

Walton, 2004). The observation of an individual polar bear up to 300 km inland by the Hydro-Québec LG4 complex, as described by one participant in our study, would be an outlier compared to the rest of the population, but extensive inland migrations of polar bears are not unprecedented. A young male polar bear was shot more than 600 km from James Bay, near the mouth of the Peribonka River in the Lac St. Jean district of Québec, in October 1938 (Jackson, 1939). Another presumed subadult male polar bear was sighted in northeastern Saskatchewan, near the Manitoba border and 420 km from Hudson Bay, in September 1999 (Goodyear, 2003). In April 2008, a female polar bear and her two cubs were shot and killed by police in Deline, Northwest Terrritories, more than 400 km inland from the Beaufort Sea (CBC, 2008).

The northerly concentration of denning females in the EMR along the southeastern Hudson Bay shore documented in our study is analogous to observations of denning and family group distribution in Polar Bear Provincial Park, where many denning sites have been identified along the southwestern shore of Hudson Bay between the Winisk and Shagamu Rivers (Kolenosky and Prevett, 1983; Obbard and Walton, 2004). All of the bears denning in that portion of the park return to the sea ice on Hudson Bay after leaving the den, which would also be expected for polar bears denning in the vicinity of Whapmagoostui/Kuujjuarapik. Considering that young polar bears potentially learn of denning sites from their mothers (Derocher and Stirling, 1990; Scott and Stirling, 2002), even a small number of polar bears consistently denning along the Québec coast could contribute to the continued use of this habitat by polar bears.

*Terrestrial Feeding*

Six participants identified various vegetation and berries as terrestrial foods for polar bears, which is consistent with published accounts from Hudson Bay (Russell, 1975; Derocher et al., 1993; Gormezano and Rockwell, 2013a). Garbage was the only food item that was identified by at least one participant in all three communities, which is consistent with accounts of polar bears feeding at garbage dumps in other communities in the Canadian Arctic (Lunn and Stirling, 1985; Dyck, 2006; Gormezano and Rockwell, 2013a, b). The significant differences in food items reported across the communities could be due to local food availability, infrequent observations by the participants, observational bias of the participants based on land use, or the small sample size of our study. Regardless, it can be concluded that polar bears exploit a wide variety of terrestrial foods during the ice-free season.

The results of our study are consistent with an analysis of polar bear terrestrial feeding along the Ontario coast of James Bay and Hudson Bay and the Twin Islands in James Bay during summer and fall (Russell, 1975). More recently, Gormezano and Rockwell (2013b) found an increased amount of caribou, snow goose, and eggs in polar bear scats collected on the Cape Churchill Peninsula in Manitoba compared to the scats collected in the late 1960s in Ontario. In our interviews, 12 participants indicated either that use of terrestrial foods by polar bears was the same as 20 years ago, or that they were unable to tell, compared to only three participants who indicated that bears are consuming more terrestrial food than they did 20 years ago. The discrepancy between our interviews and the recent studies highlighting increased polar bear foraging on geese could be due to subpopulation differences or local variability in the availability of food items, or the participants in our study may be unaware of depredation on geese by polar bears in the coastal environment.

*Human-Polar Bear Conflict*

All of the participants from Whapmagoostui/Kuujjuarapik indicated that the rate of problem polar bear encounters in town is increasing, which is consistent with reports from several Canadian Arctic communities (McDonald et al., 1997; Tyrrell, 2006; Dowsley and Wenzel, 2008; Kotierk, 2010a, b). Scientists have correlated the number of problem bears in the town of Churchill, Manitoba, with the date of sea ice breakup, bolstering the hypothesis that nutritional stress contributes to human-polar bear conflict (Towns et al., 2009). Nevertheless, there has been little research into the characteristics of problem polar bears. An analysis in Churchill from 1970 to 2004 revealed that 62% of conflict bears were subadults (Towns et al., 2009), which may be less cautious behaviourally and have higher energetic demands than solitary adults (Lunn and Stirling, 1985). No trends in age, gender, or body condition of problem polar bears were identified in our study, but roughly half of the participants who identified polar bear presence at hunting cabins as an issue also characterized this behavior as relatively new. The results of our study suggest that systematic monitoring and analysis of the frequency and context (e.g., sea ice breakup date) of human-polar bear conflict around Whapmagoostui/Kuujjuarapik are warranted.

*Seals and the Coastal Marine Habitat*

The unanimous assertion from participants that ringed seals are more abundant than bearded seals in the EMR is consistent with past surveys in both southern Hudson Bay and James Bay (Smith, 1975) and in western Hudson Bay (Lunn et al., 1997). Most participants indicated that ringed seal populations are decreasing, which is consistent with studies on ringed seal recruitment in western Hudson Bay (Ferguson et al., 2005; Stirling, 2005; Young et al., 2015). Studies on bearded seal population status in Hudson Bay are currently lacking.

Scientists have linked decreased snow depth and warmer temperatures with decreases in ringed seal recruitment (Ferguson et al., 2005), whereas increased water turbidity was identified as the biggest contributor to seal population

declines by participants in our study. Elsner et al. (1989) demonstrated that vision is the primary sense used by ringed seals to navigate underwater, suggesting that increases in water turbidity could impair ringed seal navigation and hunting success. Although decreases in snow depth and sea ice persistence and a general warming trend may be the main drivers of ringed seal population dynamics in Hudson Bay, increased water turbidity may also be negatively contributing to ringed seal recruitment in the EMR. The results of our study, combined with the well-documented dependence of polar bears on ringed seal populations (Stirling and Øritsland, 1995; Stirling, 2002) and evidence of decreased ringed seal recruitment in Hudson Bay (Ferguson et al., 2005), demonstrate the importance of ringed seal monitoring programs to polar bear management efforts.

The participants in our study noted an increase in water turbidity in the EMR, which they linked to hydroelectric development in the region. Participants also linked increased turbidity to declining coastal eelgrass (*Zostera* sp.) abundance, which is a major concern for communities in the EMR region because waterfowl depend on eelgrass as a food source (Peloquin and Berkes, 2009). The decline in eelgrass is thought to be attributable to changes in water temperature, salinity, and turbidity (Short, 2008) and climatic variability (Lalumière et al., 1994), but conclusive evidence is lacking (Pachano et al., 2014). Future research programs, in partnership with local communities, should address the main contributing factors of eelgrass decline and the consequent reduction in waterfowl hunting success.

### *Research Methods and Future Research Priorities*

The potential for polar bear research activities to interfere with the fall goose hunt is important to consider given the reduced eelgrass and goose hunting success reported by members of EMR communities farther south (Herrmann et al., 2012). Coordination with community members can also provide insights into the most appropriate time to conduct aerial surveys in the vicinity of their communities to get reliable estimates of polar bear abundance, as was done for the 2012 aerial survey (Obbard et al., 2015).

The objections to chemical immobilization and collaring put forward by the participants from Whapmagoostui/Kuujjuarapik have been expressed in other communities across the Canadian Arctic (Beardy and Coutts, 1996; McDonald et al., 1997; Dowsley and Wenzel, 2008; Henri et al., 2010). Polar bear researchers should work in conjunction with northern residents to address concerns about methods used in capture-based research programs. Recent advances in our understanding of the effects of research methods on individual polar bear fitness are encouraging (see Amstrup and Durner, 1995; Cattet et al., 2008; Thiemann et al., 2013; Rode et al., 2014), but further studies could directly address additional concerns of northern communities (e.g., effects of capture on the quality of bear meat, efforts to reduce pursuit time) and be communicated to community members in a way that makes the information accessible and relevant to them. Peacock et al. (2011) note that simply calling for "increased communication" between local stakeholder groups and scientists is unlikely to yield results as there has been a long history of community contact in both research and management. Though communication may not need to be increased, a call for meaningful partnership with increased effort to better understand the perspective of the other may be valuable. Mixed-method initiatives from other fields of study can provide recommendations for successful integration of science and TEK (Gearheard et al., 2010, 2011).

## CONCLUSIONS

The participants in this study were generally more optimistic than scientific predictions about the future status of local polar bears of the Southern Hudson Bay subpopulation. The findings of our study indicate that one of the main contributors to this difference between scientists and many TEK holders in the EMR is a difference of understanding on some fundamental aspects of polar bear biology, such as feeding ecology and the dependence of polar bears on the sea ice for many facets of their life history.

The results of this study highlight future priorities for polar bear research in the region and the potential of TEK to contribute to our understanding of polar bear biology. Specifically, we suggest that TEK holders in the EMR are well placed to contribute to collaborative studies with scientists on local polar bear population status, distribution on land during the ice-free season, distribution in the vicinity of communities during the winter months, habitat use of polar bears inland, and foraging patterns during the ice-free season. Our results also highlight the potential for TEK holders to conduct their own research into human-polar bear conflict. Such efforts would be bolstered by a systematic approach to recording the date, location, and characteristics of each human-bear interaction to allow for analyses and predictions of future locations and rates of conflict.

We have also identified areas of polar bear research that TEK holders of the EMR had difficulty commenting on: identifying trends in polar bear body condition, tracking movement patterns and feeding ecology on the sea ice, and monitoring the timing of onshore migration as the sea ice retreats. These research questions may be better addressed by scientific methods such as morphometric measurements and telemetry studies. The rationale behind the methods employed by scientists should be clearly communicated and justified. The results of these studies should also be relayed to local communities to allow for their independent interpretation of the findings, and to foster a collaborative research partnership on other aspects of polar bear biology more pertinent to northern communities. Future studies should also focus on collecting TEK on the subject of polar

bears from the southern Cree communities in the EMR, as well as the more northern Inuit communities to increase the geographic range of published TEK information in Hudson Bay.

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## APPENDIX 1

The interview questionnaire is available as a supplementary file to the online version of this article at: http://arctic.journalhosting.ucalgary.ca/arctic/index.php/arctic/rt/suppFiles/4696/0

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