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# Inuit Methods of Identifying Polar Bear Characteristics: Potential for Inuit Inclusion in Polar Bear Surveys

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ABSTRACT. As a result of their close proximity to and frequent interactions with polar bears, Inuit hunters are aware of changes in polar bear population ecology and characteristics. This valuable information could contribute to any polar bear research or monitoring program. Understanding how Inuit gather ecological information on polar bears and how this knowledge is shaped by individual experiences can also overcome any barriers to Inuit inclusion in bear monitoring and management. On the basis of interviews in four Nunavut communities, we report Inuit hunting experiences and methods of identifying polar bear sex, age, body size, and health status. Across communities, Inuit share techniques in identifying and distinguishing bear characteristics that overlap with scientific methods, suggesting that Inuit could provide immediate and inexpensive information to polar bear research programs. Hunting preferences are shaped by individual experiences with polar bears (e.g., through hunting or bear encounters), as well as familiarity with polar bear research and management. Identifying and incorporating community perspectives in management will be necessary to sustain local support for programs that affect Inuit knowledge formation and persistence.

Key words: Inuit; polar bear; traditional knowledge; interviews; hunter; elder; Nunavut; research; management

RÉSUMÉ. En raison de leur grande proximité des ours polaires et de leurs interactions fréquentes avec ceux-ci, les chasseurs inuits prennent connaissance de changements qui s'opèrent sur le plan de l'écologie et des caractéristiques de la population d'ours polaires. Cette précieuse information pourrait jouer un rôle dans n'importe quel programme de recherche ou de surveillance d'ours polaires. Le fait de comprendre comment les Inuits recueillent des renseignements de nature écologique sur les ours polaires et comment ces connaissances sont moulées par les expériences de chacun pourrait permettre de surmonter les obstacles en matière d'inclusion des Inuits aux travaux de surveillance et de gestion des ours. À la lumière d'entretiens réalisés dans quatre collectivités du Nunavut, nous faisons état des expériences de chasse des Inuits ainsi que de leurs méthodes de détermination du sexe, de l'âge, de la taille et de l'état de santé des ours polaires. Dans les collectivités visées, les Inuits se servent de techniques communes pour déterminer et distinguer les caractéristiques des ours. Ces techniques recouvrent les méthodes scientifiques en partie, ce qui suggère que les Inuits pourraient fournir de l'information immédiate et à bon marché aux programmes de recherche sur les ours polaires. Les préférences de chasse sont façonnées par les expériences de chacun avec les ours polaires (par le biais de la chasse ou de rencontres) de même que par la familiarisation avec les travaux de recherche et de gestion des ours polaires. Il y aura lieu de déterminer les perspectives communautaires et de les intégrer aux travaux de gestion pour maintenir le soutien local envers les programmes qui ont des incidences sur la persistance et la formation des connaissances des Inuits.

Mots clés : Inuit; ours polaire; connaissances traditionnelles; entretien; chasseur; aîné; Nunavut; recherche; gestion

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## INTRODUCTION

Accurate estimates of population status and dynamics are critical for polar bear conservation and management, especially in the face of rapid Arctic climate change. The need for contemporary data on population trends parallels a growing need for management actions, which undoubtedly affect northern communities economically, socially, and ecologically. Polar bears are legally harvested by Inuit (INAC, 1993) for traditional and personal uses, which include meat for consumption; hides for clothing, bedding, or auctions; and bones for carving (Foote and Wenzel, 2009). Polar bears are also harvested by trophy hunters guided by Inuit. These hunts provide economic benefits to Inuit through employment, and wages for guides, assistants, outfitters, dog owners, and cooks are reinvested into a subsistence economy (Foote and Wenzel, 2009; Tyrrell, 2009; Wenzel, 2009). Because they consider

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polar bears important and interact frequently with them, Inuit continue, independently of scientific monitoring and management, to gather data on the ecological effects of habitat change (Dowsley, 2009a) and human activities (Keith, 2005) on polar bears, as well as noting the sex, age, and body size of bears encountered (Wong et al., 2011). Inuit can thus offer a nuanced historical and contemporary understanding of polar bear population activity to complement ongoing scientific surveys in conservation and management.

Inuit traditional ecological knowledge (TEK)—ecological observations that are acquired through experience and passed on from one generation to the next (Berkes et al., 2000)—is already considered in wildlife co-management and conservation decision making at territorial (INAC, 1993) and national levels (e.g., Government of Canada, 2002). In Canada, polar bears are managed as 13 subpopulations, using the best available local—in addition to scientific—knowledge (Peacock et al., 2011; Vongraven and Peacock, 2011). In Nunavut, territorial (Nunavut Wildlife Management Board) and regional wildlife boards and community hunters and trappers organizations (HTOs) establish harvest quotas (Tyrrell and Clark, 2014) for each subpopulation (Dowsley, 2009a; Peacock et al., 2011), as sanctioned by land-claim agreements (INAC, 1993). Male-biased quotas (to protect females and cubs) are allocated to HTOs harvesting the same subpopulation, who distribute tags, usually through a lottery, to individual hunters. HTOs also gather and represent local community interests to higher levels of government through community consultations and public meetings (Dowsley, 2009b, 2010).

At the local level, community members also participate in scientific monitoring programs and data collection that ultimately inform management decisions affecting them (e.g., allocation of harvest quotas). Inuit hunters are frequently employed as guides and research assistants in polar bear surveys (e.g., Wong et al., 2011; Van Coeverden de Groot et al., 2013), which allows them to apply and reinforce their experience and traditional skills in research contexts. Harvest monitoring programs, in which hunters actively collect biological samples and morphometric data from harvested bears, allow population data (e.g., minimum abundance, sex and age distribution, health correlates) to be collected in the years between population surveys as well. Independently of research participation, Inuit TEK and experience have the potential to reveal critical population trends (e.g., Dowsley, 2009a; Kotierk, 2010, 2012) before scientific surveys are conducted.

Unfortunately, uncertainty and the dearth of data on range-wide polar bear responses to climate change have contributed to political tension and conflict among stakeholders, decision makers, scientists, and northern communities (Derocher et al., 2004; Tyrrell, 2006; Clark et al., 2008; Tyrrell and Clark, 2014). Sustainable harvest rates are based largely on scientifically collected population data on sex, age, and, body condition (e.g., Bromaghin et al., 2015) associated with aerial mark-recapture methods (e.g., tattoos, radio-collars, and ear tags), which are not supported by all communities (Tyrrell, 2006). Though less invasive alternatives to gathering the same data have recently been developed (e.g., Van Coeverden de Groot et al., 2013; Stapleton et al., 2014), conducting scientific surveys is still expensive (Dowsley, 2009a), time-intensive, and often logistically challenging (Stapleton et al., 2014). Not surprisingly, scientific surveys are infrequent, and research intensity, time scales, and techniques vary for most populations (Vongraven and Peacock, 2011).

Beyond the lack of information on most polar bear populations (Peacock et al., 2011; Vongraven and Peacock, 2011), criticisms of both TEK and scientific types of information that inform decision making have also created challenges and barriers to co-management. Other nations have criticized Canada for considering TEK in decision making (Tyrrell and Clark, 2014), perhaps because TEK is context-specific in nature and actively shaped by the knowledge holder or gatherer (Houde, 2007) and differs from objective, conventional natural sciences. Northern communities also criticize decisions based on scientific practices (Tyrrell, 2009), perhaps because of their misconceptions about research and management practices in the past and their distrust of researchers and managers who failed to address northern interests (Moller et al., 2004; Clark et al., 2008). This atmosphere of criticism and distrust does not bode well for polar bear conservation.

At local scales, supporting the role played by Inuit in polar bear monitoring programs can increase understanding of TEK and scientific information by Inuit and scientific communities alike, as well as addressing gaps in population data. In these contexts, it is important to document both Inuit methods of identifying polar bear characteristics and their motivations for doing so in order to highlight Inuit methods of characterizing population information at a level finer than broad trends in abundance. Inuit TEK and practice influence decision making through co-management, yet through their impacts on harvesting opportunities, management decisions could also affect the persistence of Inuit TEK and practice. An understanding of how management regulations direct and influence the process of Inuit knowledge formation can provide insights into receptivity and levels of local support for those management decisions. For Inuit, documenting their methods can also safeguard TEK for future generations.

Building on our previous work with Gjoa Haven hunters (Wong et al., 2011), we report here on new interviews with hunters and elders in four Nunavut communities (Gjoa Haven, Arctic Bay, Arviat, and Kimmirut) about their participation in hunting, research, and management activities.

## METHODS

Interviews in this study built on previous assessments of consistency and accuracy in estimates of polar bear characteristics by Gjoa Haven hunters from in situ tracks, which

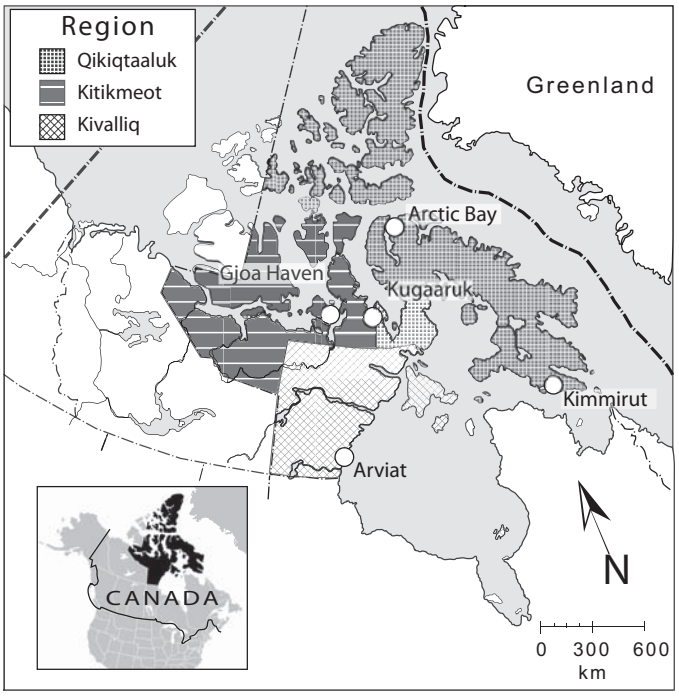


FIG. 1. Location of Gjoa Haven, Arctic Bay, Arviat, and Kimmirut communities involved in this study. One participant (KU1) was interviewed in Kugaaruk.

largely focused on inferences from tracks and provided little information on management perspectives and hunting preferences (Wong et al., 2011). We initiated interviews about methods of identifying polar bear characteristics with additional Gjoa Haven hunters and elders and a single Kugaaruk hunter. We then added interviews in Arctic Bay, Kimmirut, and Arviat, three communities that participate in ongoing harvest monitoring programs with the Government of Nunavut. These four communities span all three Nunavut regions (Kitikmeot, Qikiqtaaluk, and Kivalliq), covering a broad range of community perspectives, methods, and polar bear ecology (Fig. 1).

To discuss research objectives, recruitment, and wages, we met face to face with HTOs in all communities except Arviat, where these discussions took place by telephone. HTOs prescribed and led all recruitment procedures. We recruited interview participants through a combination of key informant and snowball sampling methods (Marshall, 1996). HTOs and appointed interpreters initially recommended interview participants and, unless they were absent from the community (e.g., out of town or out hunting on the land), all recommended participants participated in this work. Except in Kimmirut, we also announced interview locations and times (based on HTO recommendation) on the radio to give all community members a chance to participate if they wished to do so and thus cover a broad range of perspectives (Marshall, 1996). Initial interview participants recommended additional experienced community members until we had recruited a maximum of 20 participants from each community (based on budget constraints) or until data had become saturated (no new themes emerged).

Participants were identified as elders (60 years old or older and recognized by other community members for their experience on the land) or hunters (less than 60 years old and usually less experienced than elders) and classified according to hunting experience as active hunters, nonactive hunters (e.g., elders who had hunted but no longer do so), and less experienced hunters. To protect confidentiality and assist readers in linking themes and quotations to each community, we coded participant names according to their home community (GH for Gjoa Haven, AB for Arctic Bay, K for Kimmirut, and AR for Arviat) and the order of interviews. The one Kugaaruk hunter interviewed in Gjoa Haven was coded as KU.

One of us conducted all interviews to maintain consistency. Interviews were semi-structured, with open-ended questions following a guideline (Huntington, 2000; online Appendix 1: Table S1). Follow-up questions were intended to encourage participants to produce their own understanding and clarify our discussions (Huntington, 1998). Interviews began with direct icebreaker questions (e.g., name, age, birthplace) followed by discussion of methods for identifying polar bear sex, age, and body size. Additional discussions on identifying health of polar bears took place in Arctic Bay, Kimmirut, and Arviat. To determine the context and motivation for learning these methods, we documented participant interactions with polar bears (e.g., through hunting, guiding sport hunts, or bear encounters while hunting other animals) and preferences for particular bear characteristics when hunting.

Though we covered most anticipated topics by following the guideline, some participants raised additional relevant topics, such as how to identify aggressive or dangerous bears (usually reported by Arviat participants), personal encounters with polar bears, and discussions over hunting and identification techniques unique to some participants. We did not probe for these unique experiences when participants did not mention these topics themselves to ensure that participants led discussions according to their own knowledge. Thus, if a participant did not mention a particular observation, perspective, or theme, it did not necessarily mean that he or she had (or lacked) knowledge or experience on the subject unless that was explicitly indicated.

An audio recorder was used to allow for subsequent transcribing. The interviewer recorded in a journal all nonverbal cues, verbal styles, as well as any relevant information that was informally shared, along with personal reflections. Interviews were analyzed following conventional content analysis (Hsieh and Shannon, 2005). We summarized unique participant perspectives, original quotations, and information that best described common themes and categories that arose through discussions.

Communities vary in local harvest regulations, seasons, and constraints, as well as access to technology (Ford et al., 2006). Participant age, interpretations, recollections, and sensitivity to topics also influence individual knowledge and responses (Huntington, 2000; Gagnon and Berteaux, 2009). Together these contexts shape participant responses

and interpretations. Hence, data validation by revisiting, reporting back to, and engaging with HTOs constitutes a critical form of peer review (Huntington et al., 2004) to ensure participants are accurately represented. Follow-up meetings with HTOs were held to clarify our interpretations and discuss preliminary results, while allowing representative community members to incorporate additional information that they felt was important and relevant. Spending this additional time with community members revealed community-wide hunting perspectives and concerns.

## RESULTS

During five visits from May 2011 to April 2014 and a follow-up visit in February 2015, we interviewed 23 hunters and 33 elders individually (Table 1). Interviews lasted from 6 to 63 minutes and took place on the land (for GH hunters and KU) or at participant homes, hotels, and HTO offices. Interpreters translated 34 interviews. Participants ranged from 27 to 82 years old and comprised 32 active, 14 non-active, and 9 less-experienced hunters, including at least 21 participants who had previously guided sport hunts. Five participants from Gjoa Haven had previously participated in noninvasive polar bear surveys and sampling (Wong et al., 2011; Van Coeverden de Groot et al., 2013). Arctic Bay participants included an individual who was experienced in identifying bear characteristics through her experience in hide preparation and sales across Nunavut (AB14). One Arctic Bay participant was a previous wildlife officer who was experienced with polar bear surveys and sampling (AB15). Arviat participants included two local bear patrollers (AR1, who had also participated in polar bear surveys, and AR2), regional wildlife (AR3) and HTO (AR20) board members, and previous wildlife and assistant wildlife officers (AR15 and AR8). As a result of frequent daily encounters with bears in the fall, most Arviat residents were able to identify polar bear characteristics, or at least comment on how to identify them.

TABLE 1. Number of interview participants from Gjoa Haven, Arctic Bay, Kimmirut, and Arviat classified by participant type (elder or hunter), by hunting experience (active, non-active, or less experienced), and by mention during interviews of experience guiding sport hunts.

| Community | Gjoa Haven[1] | Arctic Bay | Kimmirut | Arviat |
|---|---|---|---|---|
| Participant type: | | | | |
| Hunters | 3 | 5 | 5 | 10 |
| Elders | 7 | 10 | 6 | 10 |
| Hunting experience: | | | | |
| Active | 5 | 9 | 8 | 10 |
| Non-active | 5 | 4 | 1 | 4 |
| Less-experienced | 0 | 2 | 2 | 5 |
| Previously guided sport hunts: | 5 | 5 | 3 | 8 |

[1] Includes a single participant from Kugaaruk.

### *Hunter Preference for Bear Characteristics*

Across all communities, active hunters and elders are more selective for bear characteristics than less experienced hunters. Whether a hunter is selective or not during a hunt depends partly on logistical constraints, such as the number of bears (or tracks) encountered during pursuit, the time available for harvest (48 hours in most communities), and the amount of fuel and supplies taken to the field.

> We go by machines now…if he has enough gas…he'll see a track. If it's small, he'll look for a bigger one… but if he doesn't have enough gas, thinking that he won't come back…he'll get the first tracks.
>
> (Interpreter translating for AB12)

> If I don't get my bear in 48 hours, and I lose my tag and—and I'm out of the hunt…the guy behind me will get a chance… sometimes you don't really concentrate, trying to see all the—whether it's a male, female, how old, and you [are] really concentrating on getting that bear and after you get your bear you finally see what kind of bear you shot and sometimes you can tell.
>
> (AR1)

When asked if they prefer to hunt males or females, participants indicated that their choice of sex (large males) is driven by management practices that protect females and cubs (online Appendix 1: Table S2). Many participants believe this practice sustains populations and encourages population growth.

> There's a by-law for hunters and trappers so they have to go for the males. But if there's like no male they go out for the female…they're [thinking] for the polar bears… they don't want the polar bears to [diminish].
>
> (Interpreter for GH5)

> We [would] prefer more males because…there's that law…you can't take females so much because they give birth and produce more polar bears…so that's how it is.
>
> (AB2)

Some participants preferred to hunt females and cubs before these practices were implemented, while others would hunt any type of bear that they encountered.

> Before there was a by-law they could catch females—even [if] they got cubs, and when after there was a by-law now they have to catch only males. The big ones.
>
> (Interpreter translating for GH3)

> When they see a bear they don't just shoot it…figuring that there'll be a bigger one coming up and there are other bears too that have cubs…They don't go for bears with cubs because it's the law…or the policies—guidelines that they have—have to follow. But back

> then when they were kids their parents used to go for any bear.
>
> (Interpreter translating for K1)

Hunting preference also depends on whether bears are hunted for food, clothing, or the sale of hides. Most participants today prefer large, old males with thick, white (clean) fur because of the high market value of their hides. Current 2:1 male-biased harvests (following Memoranda of Understanding; see Dowsley and Wenzel, 2008:179) also reinforce these preferences.

> When I used to go with my stepfather, he preferred the—for money-wise…the big male…but for meat, for meat consumption…more fat, and softer meat, female… for consumption, it's important…and for money, they used to sell [hides] to the Hudson Bay back then…the bigger the [male]…we used to get more money with the bigger hide… nowadays money is more important, … the meat is important too but we don't starve like when we used to. Long time ago.
>
> (GH8)

> If by chance, if he had a choice, he'd go for the bigger one, because they're more expensive…and also how clean they are. Like if [the] bum part is really dirty then it's harder to sell them because they—people want to buy clean, white [fur]…But there's also a [point] where if there's not many choices in the bear, if there's few bears…they wouldn't try to go for the skinniest one—the unhealthy one. And also his third option would be… if…they had to kill in defense. Then it wouldn't matter if it was female or not.
>
> (Interpreter translating for AR4)

In contrast, some participants still prefer small, young females for consumption.

> I prefer younger…they're a lot [more] tender…with female they tend to get tender very faster…because I'm always cooking…[old] males, they're a little harder because probably they're constantly walking and hunting…but females they're mostly feeding or just survive or something like that.
>
> (AB14)

Some participants prefer middle-sized bears.

> He would try and get one that's not too much of a cub… not too old—if he had a choice, he wouldn't go for the older bear because it's leading the other bears…he would try and get the one in the middle.
>
> (Interpreter translating for AR6)

Health is also important to participants who hunted polar bears for their hides or for consumption.

> If it's easy to clean that means it's a healthy animal… whereas unhealthy one it's hard to scrape off the fat as much.
>
> (Interpreter translating for AR6)

Hunters across the North prefer different characteristics of polar bears that they hunt, depending on their use. With the time available for hunting limited by tag requirements and small harvest quotas, Gjoa Haven, Arctic Bay, and Arviat participants are no longer selective for a broad range of bear characteristics. In contrast, Kimmirut participants are still selective when hunting, and some hunters are able to hunt more than one bear per season. Unlike those in most communities, Kimmirut hunters rarely pursue bears and usually hunt them when they are encountered while harvesting other animals. Tags are distributed after each hunt, and lottery distributions take place when only two or three tags are left to avoid overharvest.

*Methods of Identifying Polar Bear Characteristics*

Because of individual experience, preferences for bear characteristics, and harvest regulations, it is important for Inuit hunters to identify and distinguish polar bear characteristics when hunting. Participants identify bear sex, age, body size, and health status by observing the bear directly (e.g., body shape and size, fur, behaviour) or its tracks (in situ footprints). In Arviat, being able to identify polar bear characteristics is also important to avoid potentially aggressive (dangerous) bears. Bears often frequent the community in groups. Some community members compare individuals within groups to distinguish characteristics.

> [If] there were two bears, male and female, and you can tell the difference, like size at the same time and you can look at the neck…longer necks and shorter necks.
>
> (AR1)

*Distinguishing Males and Females*

Some participants indicated sex could be identified from tracks alone (online Appendix 1: Table S3). Larger tracks are usually associated with males. Most participants reported male footprints are generally angular and wide, whereas female footprints are round and narrow.

> The female footprints are mostly, almost round… females is shorter, male is longer …when they're males even they're older or younger they're long and big.
>
> (Interpreter translating for GH6)

> When you find the track, female…they're more round… male tracks look [almost] like triangle…more square, more triangle.
>
> (Interpreter translating for AB3)

Some participants use gait or footprint orientation to distinguish males from females. Males tend to walk with a longer stride, and their footprints turned inward. Some participants also observe patterns of long fur along tracks of males.

> If the snow is soft at the time the polar bear walked through there, [they] would have fur drag marks, a big male…because the big males seem to have longer fur, on the outside of the feet and the bottom of the feet… if there's any nails broken that's a big male broken in fight...Or in [making a seal hole].
>
> (GH8)

Some participants indicated female movements are more direct than those of males.

> When they see the prints, if they're kind of straight footprints…they know it's a female…male, when you're tracking their tracks, they don't go straight they kind of maneuver around.
>
> (Interpreter translating for K4)

Participants in other regions indicated the opposite.

> Where he was taught, the mother bear usually is being followed by the cubs…so it wanders back and forth, looking for seal…they know it's a female leading, because it's, you know, turning. Whereas a male bear would walk straight, going by the footprints. If the footprints are going straight…that means it's like a male bear, traveling by itself.
>
> (Interpreter translating for AR4)

Participants also mentioned sex is more difficult to determine in younger (smaller) bear tracks than in those of adults.

> The female bears' prints are shorter than the male bears'…he can tell that kind of difference but if it's a cub, not full-grown, he doesn't quite know if it's a male or female too.
>
> (Interpreter translating for K2)

> If it's a smaller bear I can't really tell [if] it's a female or male…if they're really big, I know that that's [a] footprint of a big male.
>
> (K9)

When observing bears directly, some participants indicated it is difficult to identify sex from a distance.

> From a distance sometimes it's hard when it's not in the right angle…if it's completely sideways and you [can't] see the neck.
>
> (AR1)

> In the far distance when you see bears traveling they all look the same, but as they get closer it's easier to determine whether it's female or not. By the fur, the back of the neck…and the long neck.
>
> (AR4)

Participants also mentioned it is difficult to identify sex in older (larger) bears.

> If it's a male…same size as a female, if it's fat you can't really tell if it's a male or a female…but if it's skinny, same size as female but you know it's a male.
>
> (AB12)

> If it's an older bear, he wouldn't know how to determine because the fur is yellowing as it's aging…so, the older the bear, then it would be more kind of hard to determine whether it's female or not.
>
> (Interpreter translating for AR4)

Participants across all communities associated larger body sizes with males. Participants also used head and body shape to determine sex. Females tend to be more round, with shorter "snouts" and smaller heads compared to males.

> [Females] looks like they're shorter and chubbier…and the males, they're a bit bigger and more slender kind of…the female, they might have what looks like two forehead on top…and shorter face…and the male, they have the longer face...can also observe the hind legs… [females] their tail looks like lower, and the males will have a higher—their position—tail a bit higher.
>
> (AR5)

Arctic Bay participants generally indicated longer or narrower necks in females versus males.

> With the female, they're more round…and they have a little longer neck…with the males they got [a] thicker neck and they're larger…they have a bigger head… [you can also tell] with the shape of their bum area.
>
> (AB14)

Arviat participants indicated the opposite.

> You can tell by lookin' at their ears…the distance. A female's is going to be more closer…and shorter necks. And the male bears, their ears are going to be more far apart. And they got longer neck…you can tell by their legs, where they got all that long hair.
>
> (AR1)

> Seems like [females] got more short neck…from head to the body, seems like they're shorter. But a male, it seems like [they] always have their neck stretched out.
>
> (Interpreter translating for AR14)

Participants described females as having whiter, "cleaner" fur, with dark coloration around the crotch area, compared to males.

> If it's going—running away from him, and the bum area, if it's not dirty, he knows it's a male…the female ones, when they're heading away from him, the crotch area is yellow.
>
> (Interpreter translating for K6)

> He can tell by the bum part whether it's a female because they're more—they tend to be more yellowish.
>
> (Interpreter translating for AR4)

Participants also use behaviour to determine sex.

> By the movement you could tell they're female… because they're like, cleaner. Very gentler…whereas the male is [a] very aggressive kind and kind of walks aggressively too.
>
> (AB15)

> And a male…they never around with another polar bear…they don't stick around with a polar bear, and they got their movement—it's more hyper…they always aggressive like anxious and look around, look all over, but the female ones, they're a lot easier to tell.
>
> (AR14)

*Identifying Age and Body Size*

Participants indicated that it was not important, historically, for Inuit to identify ages of bears. Instead, body sizes were and continue to be of interest.

> By Inuit knowledge they didn't care about the age… when renewable resources started asking for samples, then the government started finding out how old the bear is.
>
> (Interpreter translating for AB4)

> They know, yearly, like last year [cubling]…and estimating…what the height is…they guess how old the bear might be…they don't put actual age.
>
> (Interpreter translating for K2)

Participants from Gjoa Haven, Arctic Bay, and Kimmirut mentioned that inferences on body size can be made by placing their *kamiks* (traditional boots) together along tracks (online Appendix 1: Table S4).

> He wear caribou kamiks…just by the footprints, you put your feet near it…they're really fluffy, the kamiks…if it's smaller than that they're small.
>
> (Interpreter translating for AB1)

> By Inuit ways, they put their feet together to determine how big the bear might have been…to his knowledge as he [was] growing up that's the only way the hunters determined how big the bear might be…using their feet together.
>
> (Interpreter translating for K1)

While few participants use tracks alone to determine age, participants associate larger tracks with larger body sizes and older bears. Some participants mentioned that bears reach large body sizes quickly.

> They grow really fast…they age really fast…like dogs have 7 years, for us, a year.
>
> (Interpreter translating for AB4)

> The height, if it's last year's [cubling] it's that big … not many years, the bear cub tends to grow as big as the mother…so, looking at the cub and the mother, they estimate the age of the bear.
>
> (Interpreter translating for K2)

Most participants use age categories versus chronological age (in years) to distinguish bears.

> In Inuktitut there's—we have names for yearling… second year, third year, and those that are the same size as the mother…and then there's a next to adult male, young male, and big adult male…there's names on every stage.
>
> (AB15)

> The younger ones, you can['t] really say exactly how old…you can see a yearling…a cub that's like full grown…you can guess like there's like 2 or 3, 4 year old…a full year, like 2 years, 3 years, and when they reach their—where they stop growing. And so I think they go from 3 to 4 when they [finally] stop growing.
>
> (AR1)

Several participants mentioned large, old bears—*Tulajuittaq*—that stay in open water and never come inland.

> There's stories of polar bears that never go on land. There's a term in Inuktitut, they're called *tulajuittuq*, which means 'they never go on land'…they always stay in the moving ice...*tula* is to go, like a boat to go ashore…*juit* is never, and 'doing it'…so *tula*—on land—not—do…they're the biggest bear you'll ever see.
>
> (AB15)

> There's biggest and biggest bears and that doesn't come to the town or, it doesn't go inland…he said that there are only few, few, less and less humongous bears… [sport hunters] usually want to get the biggest bear that he was talking about these bears that usually [don't] hunt inland.
>
> (Interpreter translating for AR12)

Two participants indicated bears appear to be smaller, with less body fat, as they reach older ages.

> The big males…are older when they really can't run anymore…they're just walking, even if their fur is nice…when they're older, their feet…they're bad…and they're a little skinnier than the younger ones.
>
> (Interpreter translating for AB10)

> When they get too old, I guess they're not so good at hunting seals…so they get really skinny. And they appear smaller…they have a better time hunting and are successful hunting when they're younger. And stronger I guess.
>
> (K9)

Arctic Bay and Arviat participants also use fur colour to infer the age of bears; younger bears are associated with white (versus yellow) fur.

> He would use wolf, for example. He knows with the wolf that the fur starts to get more yellowish…so the same would probably go for bears, a healthy, younger bear would have more white…the hide, would be more whitish. Whereas an older bear…would start yellowing more.
>
> (Interpreter translating for AR4)

> There's an [Inuktitut word] meaning between a cub and a full-grown. There's a middle, category that we say… you can tell by the colour of the fur whether they're reaching full adult or whether they're still in their middle…stage. You can tell by the colour of the fur like how white it is…[and also by] the fiber [of] the fur itself.
>
> (Interpreter translating for AR6)

Participants in all communities also examine behaviour. Younger bears tend to run away faster when being pursued.

> The old one…they cannot run. They only walk…they're very easy to catch…they ['re] not going to run from you, they're just going to walk very slow.
>
> (AB6)

Participants also indicated younger bears are more active and aggressive toward humans.

> The big adult male, they're kind of—they got confidence, when they're walking…slowly. They know that then they kind of just…move around. Slowly. Young one—young ones are very curious. They move around and…they look around, they go into camps…they're the one[s] that follow the people more…because they're young, they don't know, they don't have experience. Whereas the big males, they know not to bother the camps, so they don't. They're kind of cool.
>
> (AB15)

> Old polar bears, they're not aggressive…because they understand…they know when we have weapon as they approach they can tell if we have a rifle or not…the younger ones, they don't seem, to have, knowledge if we have weapon or not…they just approach…so we feel more comfortable with the older ones.
>
> (AR16)

At least one participant from each of Arctic Bay, Kimmirut, and Arviat communities examined teeth from harvested bears to estimate age.

> He thought that's why the bear was old, some teeth were broken and chipped off.
>
> (Interpreter translating for K6)

*Identifying Health of Individual Bears*

When asked about health of individual bears, all participants mentioned body fat or size as a direct indicator of health.

> If it's skinny, it might not be getting enough to eat, or it—it might be sick…but I've never really seen a sick bear. Like I just seen a skinny bear or, who's had hard luck of like, catching prey…all I know is like, they appear very unhealthy when they're skinny…I guess when they're not eating then—when they're too hungry like they appear, unhealthy.
>
> (K9)

> When they're unhealthy they're skinny and tiny and when they're healthy they're big…they're chubby and big fat on their tummy…when they're getting old, and they're—when they're not eating enough…they start to [get] skinnier. Skinnier and skinnier.
>
> (Interpreter translating for AR13)

Three Arctic Bay participants infer body fat by observing footprint shape (online Appendix 1: Table S5).

> Polar bear[s], when they're fat…their tracks are round… but the skinny ones [have tracks] just like my foot.
>
> (AB6)

One participant observes gait from tracks.

> When they're skinny their tracks are closer to each other…and they tend to take longer steps, like further steps…the nice and healthy ones, their—their tracks are more apart…and their steps are closer.
>
> (Interpreter translating for K6)

Relevant to this, when observing bears directly, Arctic Bay, Kimmirut, and Arviat participants indicated unhealthy bears move more slowly or in a more staggered and unpredictable manner than healthy bears.

> One time he saw a polar bear that seems like [it] was drunk because it's so hungry…it was staggering…and he didn't want to catch that one.
>
> (Interpreter translating for K7)

> A healthy bear would walk in a more, straight fashion or orderly fashion than an unhealthy bear, kind of like a drunk person not walking straight, walking around.
>
> (AR8)

Some participants infer health from fur colour. White (versus yellow) fur is associated with healthier bears.

> You can tell by looking at it because with the healthy bear, the fur is shinier and more, you know, clean looking…whereas [an] unhealthy bear, it's dirty…the fur's not shiny as much...[like humans] before we reach the adult we have good skin…so we can tell by looking at our skin.
>
> (Interpreter translating for AR6)

Most participants indicated health is affected by hunting ability or ability to acquire food.

> They're like humans. Some humans tend to catch more animals and some hardly catch anything, and he believes bears are like that too. In order to be healthy some bears…catch regularly, but some bears may not be catching regularly like the healthy ones.
>
> (Interpreter translating for K2)

> I saw one, big male, and you could just tell the ribs… the head's even seems like it was a huge head…the body was like—like just really skinny and you can see the bones…I bet that bear didn't even make it through the early fall. Because it wasn't even scared…I think he was not a very lucky bear to get a free meal from another kill somewhere along the shore…sometime they're just going to starve and, and never regain their energy… they're going to miss, miss, miss, miss and—and they're going to be forced out [by] other bears and, so I think that's [when] they just start going downhill.
>
> (AR1)

Some participants indicated that polar bear health corresponds to changes in local prey populations.

> When he was a teenager there were a lot of seals around. Young seals, the ones that were born same year but they were together and there were lots of them...[then] the bears started…being more populated around—around Kimmirut…nowadays there's hardly any seals…when he was a teenager he—they were catching abundance of seal. So back then they were quite healthy. Seems like majority of the bears that he saw were fat, and healthy… but nowadays there's hardly any seals, he knows too that they don't only eat seals but like, vegetation around the land, they eat those, but nowadays, with hardly any seals, some tend to be—look unhealthy.
>
> (Interpreter translating for K2)

> It's hard for the bear to catch seals a lot, that's when it starts losing its weight…it helps them to get ready for the full winter…the seal meat helps them prepare, that they can help hibernate longer. So they try and eat as much seal…if there's hardly any seals around, like this [spring] time of the year, then the bear's going to be hungry for longer [because] they eat mainly off seal.
>
> (Interpreter translating for AR3)

Participants indicated that bears that are more aggressive toward humans are less successful in hunting and therefore less healthy.

> When you will see a healthy bear, and when you see a track when you're hunting them, they go…scared away…they kind of run, right away…but a sick bear doesn't care…you know, they lost that will…[to] get away…so they kind of just slowly, kind of walk away, but not—not in a hurry…as if they're trying to show us, "look I'm sick already…so don't bother me" ...kind of thing. But a healthy bear will go, scattering away…very fast. Their fur is white too. The sick bear [has] yellow fur.
>
> (AB15)

> The less they eat, they're going to be…skinnier and more desperate…and not afraid of humans when they're hungry.
>
> (AR5)

Participants also described male-to-male and intersexual combat affecting body condition.

> Not really sickness that affects the polar bear from being skinny, it's when they fight males, they break muscles… or bones. That really stops them from hunting because they're in pain…especially during mating season.
>
> (Interpreter translating for AB4)

> The female can fight the bigger ones…they're really strong…those females, they really love their cubs… and when that big male started to get close to the cub. Then that female start to—started to run after that big one, it's trying to fight it—maybe sometimes, they kill that female…I've seen that [a] couple of times...down at northern Manitoba.
>
> (AR11)

Indeed, participants provided insight into potential causes of recent changes and observations related to polar bear (population) health. Many of these observations were made through frequent opportunities to observe and

interact with polar bears; these immediate observations might not be made available through scientific methods alone.

## DISCUSSION

Participant methods and ability to discern polar bear characteristics continue to play an important role in hunting. Traditional skills in identifying characteristics associate with personal preferences and experiences, which vary among communities and community members. Hunters generally prefer larger males for trophy hunts and hides, and females and cubs for food. Identifying sex is also important because of differences in hunting challenges and hide preparation, as well as meat quality, between males and females. Although identifying age was not important to Inuit in the past, hunters today associate fur quality and body size with age classes. Discussions over health always involved implications for human use; many community members associate polar bear health with food consumption, ease of skinning and hide preparation, and coloration and quality of fur. Arviat participants, who experience frequent interactions with bears, always identify polar bear characteristics associated with aggression, which have direct implications for human safety. Personal experiences also shape the acquisition of hunting skills, as shown by frequent instances when participants discussed hunting methods in the context of their own concerns and priorities, for example, a preference for personal versus trophy hunting, or a tendency to pursue bears actively rather than avoiding them. Below we discuss the implications of including Inuit TEK and experience in polar bear monitoring and management.

### *The Role of Inuit Methods of Identifying Polar Bear Characteristics in Monitoring Programs*

Community-based monitoring programs are attractive because they can supplement scientific population data and allow Inuit, through participation, to inform management decisions that affect them. Inuit methods of distinguishing individual polar bears could be particularly applicable in surveys for population abundance, sex and age structure, and health condition, especially in years between comprehensive scientific surveys when these data are not available. These methods could also complement scientific surveys through Inuit participation, for example, in identifying individual bears to avoiding resampling the same individuals. Inuit could also provide rapid preliminary sex, age, and health information on individual bears without requiring physical capture, sampling, or untimely laboratory processing to collect these data. These data could be evaluated for consistency and inferences drawn on their accuracy (Wong et al., 2011) before they are included in quantitative surveys.

While there was general agreement among participants across communities on methods of identifying sex, there were some inconsistencies, namely, whether males or females were associated with longer necks or snouts, or rounder footprint shapes. These inconsistent reports were single observations only and were not discussed by all participants. Lack of agreement on these methods could be due to new observations that have not yet been validated by other community members through extensive practice (Alessa et al., 2016), or to inaccurate observations reported by inexperienced individuals. It is also possible that polar bear morphology and behaviour (e.g., footprint shape) differ in the various regions; however, this is more difficult to confirm empirically, requiring extensive scientific sampling and comparison of local reports of these unique observations in the various regions. Inconsistencies or lack of agreement among participant reports should be considered if these observations are incorporated into any monitoring program. Group discussions in which participants and elders from different communities are able to share their observations might overcome or clarify any discrepancies.

The limitations of participant hunting experience and methods of identifying characteristics cannot be discounted and should be considered and evaluated prior to Inuit inclusion in any polar bear monitoring program. Some participants reported difficulty in identifying sex from far distances and in some age classes of bears (old or young bears, depending on the hunter). Inuit diagnoses of age categories (as a recently acquired technique) and body size might be more reliable or consistent than estimates of chronological age in polar bear surveys, as participants indicated chronological age was not important to them historically. For Inuit, it may also be more meaningful to refer to categories of observations within their traditional contexts (e.g., desirability of hide or tenderness and tastiness of meat) rather than the sex and age categories that scientists and managers use. The few participant reports of examining teeth from harvested bears also suggest that community members may be learning from scientific methods (e.g., aging polar bears using teeth; Christensen-Dalsgaard et al., 2010); hence, scientific methods could also shape TEK. Inuit participation in research could provide unique opportunities for Inuit to become aware of—and perhaps build on—what TEK is relevant in scientific and decision-making contexts. Research participation could also allow both Inuit and scientists to see how observations that are important to Inuit correspond to categories relevant to science and management, and vice versa. Clearly defined terminology for categories according to the contexts of their application will be necessary.

### *Inuit versus Scientific Methods of Identifying Polar Bear Characteristics*

Identifying overlaps between TEK and science will not only facilitate dialogue between Inuit and scientific researchers but also support the role played by Inuit in scientific research and management. Though Inuit focus on identifying characteristics that are most relevant to them,

community members from different communities and regions share identification techniques that overlap with scientific methods. For example, participants distinguish males from females by identifying larger head and body sizes and the presence of foreleg guard hairs (Derocher et al., 2005). Hunters use age categories versus chronological age to age bears; age categories are also used in mark-recapture surveys and population viability analysis to estimate population structure (e.g., Taylor et al., 2006). Several participants indicated that younger males are more active and that activity is related to health condition. This connection is supported by the finding that prime-aged bears (5 to 20 years old) have better body condition because they can survive nutritional stresses by hunting and taking seals from subordinate bears (Regehr et al., 2007). Some participants reported higher growth rates in younger bears, and such growth rates have also been empirically reported (Derocher et al., 2005). Participants also indicated that, in their search for food, younger bears are more likely than older bears to enter communities; this finding corresponds with the larger proportion of young bears killed in defense of life and property across Nunavut (Dyck, 2006). Bears are also more likely to enter communities when food availability is low (Rogers, 2011), especially younger males that are naive or have not yet learned risk-averse behaviour. Participants also linked health to fat and body size; fatness is used as an indicator of body condition in monitoring programs (Stirling et al., 2008). Together these observations suggest that hunter knowledge could complement science in any polar bear monitoring or research program.

Spending time with Inuit in search of polar bears (Wong et al., 2011) allows for knowledge gathering and ground-truthing, as researchers cultivate a deeper understanding of Inuit interactions with polar bears and experience how TEK is applied. Unfortunately, most community members lack scientific capacity, and many do not trust science (Moller et al., 2004). Basic science is often viewed as being inseparable from management because science largely informs management decisions (Bocking, 2007). Timing, funding, and logistical constraints, as well as other academic priorities mean that most researchers cannot spend enough time in the North to interact as closely as surrounding communities with what is being researched (e.g., polar bears). This limitation might explain why local critics find that monitoring programs do not adequately capture local ecological phenomena (Moller et al., 2004). In areas where scientific survey data are outdated or simply lacking, there is also ongoing pressure for decision makers to adjust harvest quotas according to immediate (local) observations. Quotas based on inaccurate scientific data can potentially lead to overharvesting, which can result in detrimental and potentially irreversible population effects (e.g., Taylor et al., 2006). Instances in which quotas are too small after incorporating defense-kills may also lead to more frequent human-bear interactions (Stirling and Parkinson, 2006; Peacock et al., 2011; Vongraven and Peacock, 2011). Persistent long-term engagement of Inuit in scientific monitoring can facilitate a comprehensive understanding, at the community level, of how science and TEK can synergistically inform management decisions. This understanding might diminish local misconceptions about both research practices (Pearce et al., 2009) and TEK. Documenting TEK on population characteristics—beyond broad statements of "more" or "less" bears—not only allows for a better understanding of the formation of TEK and polar bear ecology, but also provides Inuit with a chance to share their own ecological methods and observations independently of science.

### *The Role and Persistence of Inuit Knowledge in Polar Bear Management*

Participant discussions made it evident that harvest regulations continue to affect motivations for gathering and transmitting TEK of polar bear characteristics. The ability to distinguish males from females is especially relevant to male-biased harvest regulations, while body size remains important for protecting younger bears. Economic incentives and demands for hides and sport hunts have also driven hunting preferences for large males; evidence for this pattern has also been reported in other communities (Dowsley, 2009b).

> When he was young, hunters were catching any bear they saw…back then when he was growing up…he noticed the hunters were hunting any bear, even the cub, or the mother…back then they used to not know… if it's a female or male…they caught it whether it was female or male back then, but nowadays they can tell the difference between the females and the males... nowadays they tend to try and get the bigger bears.
>
> (K4)

Canada is home to two-thirds of the world's bears (Peacock et al., 2011) and 70% of the world's legal harvest (Tyrrell and Clark, 2014). It is also the only country that allows international trade of polar bears through aboriginal subsistence hunting. One might expect the economic benefits of selling a tag to sport hunters to outweigh the benefits from personal hunting (Dowsley, 2009b, 2010). However, Arviat community members indicate there is little incentive for sport hunting after expensive supplies (e.g., oil and gas) and time-intensive labor (e.g., hide preparation and outfitting) are taken into account. Arctic Bay community members also report frequent disputes during public community meetings over the number of tags allocated to sport hunters. In Clyde River, Nunavut, no more than 20% of hunting tags are assigned to sport hunts (Dowsley, 2009b). These reports together suggest that a strong cultural value still persists in polar bear hunting for personal (traditional) purposes.

With smaller quotas and fewer hunting opportunities, younger hunters are less experienced and no longer able to distinguish polar bear characteristics at the same level of detail as elders and older hunters. Elders express concern that younger hunters lack in-depth knowledge of the

ecological and ethical relevance of their hunting practices. Elders and more experienced hunters frequently stress that TEK is experiential: knowledge is gathered through active participation and engagement on the land. Hunting opportunities have been lost in some areas, such as M'Clintock Channel, where communities' overharvesting led to a moratorium (Taylor et al., 2006) and only recently, reinstatement of a small quota. The moratorium led to abandonment of traditional practices, which could result in overreliance on technology over TEK, as well as poor hunting practices and ethics among young people (e.g., Gómez-Baggethun and Reyes-Garcia, 2013).

Contemporary changes in local wildlife authority and social structure of harvest management also affect the degree to which TEK is integrated into increasingly Westernized and modernized northern communities (Padilla and Kofinas, 2014). Historically, TEK was used as an educational tool to promote sustainable harvests, including ethics regarding relationships with animals and how people should behave in society and their environmental surroundings (Natcher et al., 2005; Houde, 2007; Berkes, 2012). This practice differed from following the prohibitive wildlife management regulations today (Moller et al., 2004); an example is harvesting only as much as you need versus harvesting according to a quota to avoid overharvest. Community-based population surveys and bear safety programs hold promise to provide unique and frequent opportunities for community members to interact with bears in non-harvest contexts. The inclusion of youth as observers or assistants in research also encourages inter-generational knowledge transfer, while supporting researchers in outreach activities. Because management decisions actively shape the formation of Inuit knowledge and its persistence, policy-relevant projects guided by community interests and concerns will enhance the preservation of knowledge.

### *Barriers to Inuit Inclusion in Polar Bear Research*

Community members use the same observations and cues (e.g., fur coloration, body shape, tracks) to make inferences on multiple characteristics of polar bears. It is challenging to integrate these data into a scientific framework in a systematic, objective manner. Notably, TEK and experience link intimately with the context through which they are formed and thus are subject to misinterpretation when isolated (Houde, 2007; Berkes 2012). As opposed to conventional scientific practices that treat phenomena as controlled, isolated subjects of study, Inuit view animals as constantly interacting with humans and their environmental surroundings and incorporate their observations as part of a holistic experience (Huntington et al., 2004; Berkes et al., 2007). This interaction is evident when participants describe polar bear characteristics through comparisons with human behaviour. Community members are also more likely to note unusual patterns in local animal distributions, behaviour, disease, or breeding failures (Moller et al., 2004) on the basis of their unique individual experiences (Huntington et al., 2004). Knowledge holders are also selective in the type of information they share and interpret; this selectivity is their own form of management (Parlee et al., 2014) according to their own political interests, cultural values, and status within their communities (Berkes et al., 2000; Padilla and Kofinas, 2014). When key knowledge holders or local decision makers (e.g., wildlife board representatives) do not view themselves as representing community voices, it is a challenge to establish representative community perspectives (Parlee et al., 2014). These complexities make it particularly difficult to devise locally endorsed, cohesive policies that take into account the broad range in community and participant views over large regions (Parlee et al., 2014).

As a first step, understanding how management goals affect Inuit and the animals that they interact with will allow conservation decision makers to consider the socio-ecological impacts and receptivity of management decisions before implementing them. For local communities, understanding common conservation goals that underlie scientific research and monitoring could perhaps reveal cultural incentives for hunters to apply existing traditional skills in a contemporary conservation context. Inuit inclusion is critical for conservation management across the North, as the fate of the polar bear will affect social, economic, and cultural aspects of Inuit communities.

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## APPENDIX 1

The following tables are available in a supplementary file to the online version of this article at:
http://arctic.journalhosting.ucalgary.ca/arctic/index.php/arctic/rt/suppFiles/4605/0
TABLE S1. Interview guideline.

TABLE S2. Number of participant responses indicating preferences for characteristics of hunted bears, by community.
TABLE S3. Number of participant responses corresponding to observations used to identify sex of polar bears, by community.
TABLE S4. Number of participant responses corresponding to observations used to identify age and body size of polar bears, by community.
TABLE S5. Number of participant responses corresponding to observations used to identify health in polar bears, by community.

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