

Iñupiaq Knowledge of Polar Bears (*Ursus maritimus*) in the Southern Beaufort Sea, Alaska

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ABSTRACT. Successful wildlife management depends upon coordination and consultation with local communities. However, much of the research used to inform management is often derived solely from data collected directly from wildlife. Indigenous people living in the Arctic have a close connection to their environment, which provides unique opportunities to observe their environment and the ecology of Arctic species. Further, most northern Arctic communities occur within the range of polar bears (*nanuq*, *Ursus maritimus*) and have experienced significant climatic changes. Here, we used semi-structured interviews from 2017 to 2019 to document Iñupiaq knowledge of polar bears observed over four decades in four Alaskan communities in the range of the Southern Beaufort Sea polar bear subpopulation: Wainwright, Utqiagvik, Nuiqsut, and Kaktovik. All but one of 47 participants described directional and notable changes in sea ice, including earlier ice breakup, later ice return, thinner ice, and less multiyear pack ice. These changes corresponded with observations of bears spending more time on land during the late summer and early fall in recent decades—observations consistent with scientific and Indigenous knowledge studies in Alaska, Canada, and Greenland. Participants noted that polar bear and seal body condition and local abundance either varied geographically or exhibited no patterns. However, participants described a recent phenomenon of bears being exhausted and lethargic when arriving on shore in the summer and fall after extensive swims from the pack ice. Further, several participants suggested that maternal denning is occurring more often on land than sea ice. Participants indicated that village and regional governments are increasingly challenged to obtain resources needed to keep their communities safe as polar bears spend more time on land, an issue that is likely to be exacerbated both in this region and elsewhere as sea ice loss continues.

Key words: Alaska; Indigenous knowledge; Iñupiaq; *nanuq*; polar bears; *Ursus maritimus*

RÉSUMÉ. La gestion réussie de la faune dépend des efforts de coordination et de consultation avec les collectivités locales. Toutefois, il arrive souvent qu'une grande partie de la recherche utilisée pour éclairer la gestion dérive uniquement des données recueillies directement de la faune. Les peuples autochtones qui vivent dans l'Arctique entretiennent des liens étroits avec leur environnement, ce qui crée des occasions uniques d'observer l'environnement et l'écologie des espèces de l'Arctique. Il y a également lieu de remarquer que la plupart des collectivités du nord de l'Arctique se trouvent dans l'aire de répartition des ours polaires (*nanuq*, *Ursus*) et connaissent d'importants changements climatiques. Dans le cadre de cette étude, nous nous sommes appuyés sur des entrevues semi-structurées réalisées entre 2017 et 2019 pour documenter les connaissances des Iñupiaq au sujet des ours polaires découlant d'observations échelonnées sur quatre décennies dans quatre collectivités de l'Alaska situées dans l'aire de répartition de la sous-population d'ours polaires du sud de la mer de Beaufort : Wainwright, Utqiagvik, Nuiqsut et Kaktovik. Les 47 participants, sauf un, ont décrit des changements directionnels et remarquables en ce qui a trait à la glace de mer, dont des débâcles plus hâtives, le retour plus tardif de la glace, de la glace plus mince et moins de banquises pluriannuelles. Ces changements correspondent aux observations d'ours qui passent plus de temps sur la terre ferme en fin d'été et en début d'automne au cours des dernières décennies. Ces observations coïncident avec les études sur les connaissances scientifiques et autochtones réalisées en Alaska, au Canada et au Groenland. Les participants ont fait remarquer que la condition corporelle des ours polaires et des phoques ainsi que leur abondance à l'échelle locale variaient d'une région à l'autre ou n'affichaient aucune tendance. Cependant, les participants ont décrit un phénomène récent selon lequel les ours sont épuisés et léthargiques lorsqu'ils arrivent sur la rive à l'été et à l'automne, après avoir parcouru de longues distances à la nage depuis les banquises. Aussi, plusieurs participants ont laissé entendre que les aires de mise bas se retrouvent plus souvent sur la terre ferme que sur la glace de mer. Les participants ont indiqué que le gouvernement des villages et les gouvernements régionaux ont de plus en plus de difficulté à obtenir les ressources nécessaires pour assurer la sécurité de leurs collectivités, car les ours polaires passent plus de temps sur la terre ferme, un enjeu qui risque de s'aggraver, tant dans cette région qu'ailleurs, à mesure que la glace de mer continuera de perdre de l'ampleur.

Mots clés : Alaska; connaissances autochtones; Iñupiaq; *nanuq*; ours polaires; *Ursus maritimus*

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INTRODUCTION

Environmental scientists, policy makers, and managers have increasingly recognized the opportunity to learn from the knowledge and observations of Indigenous people, especially regarding local transformations resulting from global environmental change (e.g., Orlove et al., 2010; Alexander et al., 2011; Mistry and Berardi, 2016; Makondo and Thomas, 2018). Simultaneously, there has been an increased effort to incorporate Indigenous knowledge (IK) in management and policy decisions, particularly when those decisions directly impact Indigenous people (e.g., Kotierk, 2010a, b; Cuerrier et al., 2015; Shea and Thornton, 2019).

The Arctic is warming more than twice as fast as the global average (Serreze et al., 2009; Johannessen et al., 2016). Increasing temperatures have been associated with widespread environmental change, including permafrost melt (Biskaborn et al., 2019), reduction and thinning of sea ice (Stroeve et al., 2012, 2014; Kwok, 2018), and changing distribution and abundance of wildlife (Thomas et al., 2006; Brommer et al., 2012; Macias-Fauria and Post, 2018). Indigenous people living in the Arctic observe and are most impacted by the direct and indirect effects of global warming because of their close connection to their environment (Krupnik and Ray, 2007; Green and Raygorodetsky, 2010; Ford, 2012). Thus, they can provide a unique breadth of knowledge about the occurring changes that are important to informing management and policy. Numerous studies have documented the value of this knowledge (Laidler, 2006; Alexander et al., 2011; Born et al., 2011; Laforest et al., 2018; Laidre et al., 2018a), particularly in developing strategies to manage the effects of climate change (Riedlinger and Berkes, 2001; Vinyeta and Lynn, 2013).

Throughout much of the Arctic, Indigenous people in coastal environments coexist within the range of polar bears (*Ursus maritimus*). Polar bears or *nannut* in the Iñupiaq language (singular *nanuq*, dual *nannuk*, and plural *nannut*; MacLean, 2014) feature in subsistence-hunting practices, oral history, and Indigenous spiritual traditions. Polar bears have long been recognized by many Indigenous people as sharing a common niche with humans in the Arctic as top hunters of marine mammals, with their survival depending on patience, resourcefulness, and skill (D'Anglure, 1990; Voorhees, 2014). Both polar bears and northern Indigenous people are living in an environment of rapidly changing and unpredictable sea ice, wind, and weather (Krupnik et al., 2010; Huntington et al., 2017, 2020; Wang et al., 2018; Screen and Deser, 2019). These changes have affected distribution patterns and behavior of polar bears (Stirling et al., 1999; Schliebe et al., 2008; Rode et al., 2015; Atwood et al., 2016) in ways that are likely to affect both subsistence activities and the safety of the communities within their range (Wilder et al., 2017).

The Southern Beaufort Sea (SB) polar bear subpopulation ranges across the North Slope of Alaska

and Canada (Fig. 1) and has experienced some of the most significant declines in summer sea ice of any subpopulation in the circumpolar Arctic (Stroeve et al., 2014; Stern and Laidre, 2016; Onarheim et al., 2018). Recent studies of the SB subpopulation have documented declines in body condition, cub and adult survival, and abundance associated with sea ice loss (Regehr et al., 2010; Rode et al., 2010; Bromaghin et al., 2015). Decadal changes in sea ice also have the potential to increase the frequency of interactions between polar bears and humans. In both the Alaska Beaufort and Chukchi Seas, sea ice retreats from coastal areas starting in early summer, retreats northward until mid-September, and then returns to coastal areas during autumn freeze-up. Polar bears respond to summer sea ice melt by either coming on shore or remaining with the sea ice as it retreats northward (Atwood et al., 2016). In a study of radio-tagged SB polar bears, the percentage of bears using land increased from ~6% before 2000 to 37% afterwards, and the amount of time spent on land increased by ~3 weeks (Atwood et al., 2016). Most polar bears that come to land in the SB congregate at the remains of bowhead whales (*Balaena mysticetus*) from subsistence harvests (Schliebe et al., 2008; Miller et al., 2015; Wilson et al., 2017), which puts them in close proximity to communities. Further, these increasing congregations of polar bears have resulted in tourism growth in some Arctic coastal communities (Rode et al., 2018).

Communities within the range of polar bears have a strong tradition of subsistence use of Arctic coastal resources, and people from these communities spend considerable time on the land, sea ice, and coastal waters in polar bear habitat. As a result, systematic documentation of IK has provided insights on polar bear habitat use and ecology in the context of sea ice loss in Canada (Dowsley, 2007; Kotierk, 2010a, b; Laforest et al., 2018), Russia (Kochnev, 2018), Alaska (Voorhees et al., 2014), and Greenland (Born et al., 2011; Laidre et al., 2018a). However, prior to the present study, IK has not been documented for the SB subpopulation since the 1990s (Kalxdorff, 1997). Gaps in documentation prevent IK from entering fully into the scientific conversations shaping management policies (Reyes-Garcia and Benyei, 2019), and both Alaska Indigenous representatives and wildlife managers have called for greater attention to IK as a component of polar bear science (e.g., Brower et al., 2002; Vongraven et al., 2012; U.S. Fish and Wildlife Service, 2015). This study, which summarizes interviews conducted with Iñupiaq residents and hunters from 2017 to 2019, seeks to provide an updated account of IK about polar bears in and around four Alaska communities within the SB polar bear range. Interviews focused on recording observations of sea ice; the abundance, condition, and health of seals; bear-human interactions; and the local abundance, body condition, health, and feeding behavior of polar bears.

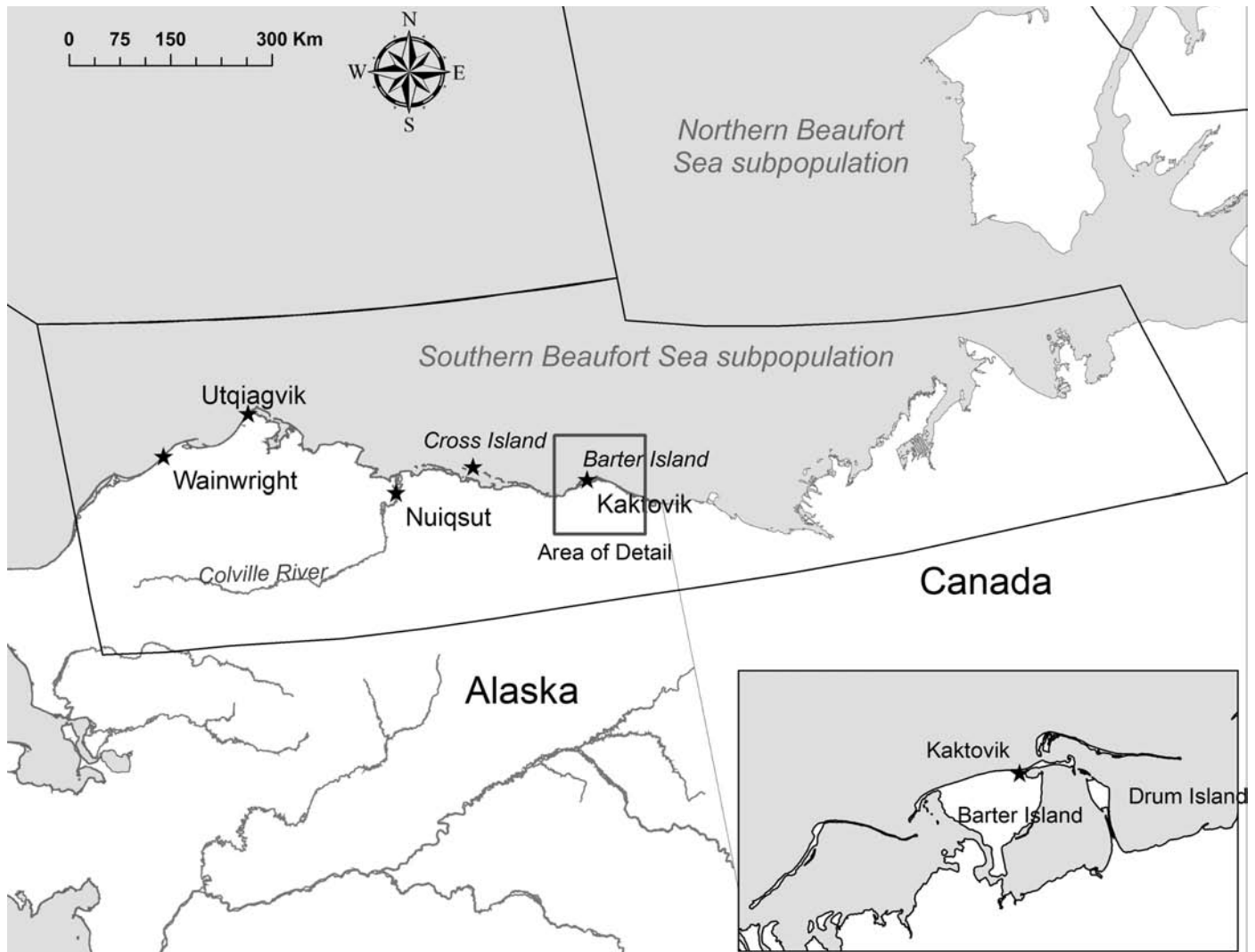


FIG. 1. Location of the four Alaska communities (Wainwright, Utqiagvik, Nuiqsut, and Kaktovik) within the boundaries of the Southern Beaufort Sea polar bear subpopulation. Iñupiaq knowledge of polar bears was documented via 47 semi-structured interviews with participants from the four communities. Participants from Nuiqsut, a village inland along the Colville River, encounter polar bears primarily during fall whaling on Cross Island. The community of Kaktovik occurs on Barter Island (see map inset). The boundaries of the Southern Beaufort Sea polar bear subpopulation are shown as defined by the Polar Bear Specialist Group of the International Union for the Conservation for Nature as of 2019 (PBSG, 2019).

METHODS

Communities

We conducted interviews with residents and hunters from the four communities that occur within the boundaries of the SB polar bear subpopulation in northern Alaska: Wainwright, Utqiagvik, Nuiqsut, and Kaktovik (Fig. 1). All four of these communities are part of the North Slope Borough of Alaska (<https://www.north-slope.org/>). The population size of each community in 2010 was 4212 residents in Utqiagvik, 556 in Wainwright, 402 in Nuiqsut, and 239 in Kaktovik (www.censusviewer.com). Tribal councils of these villages are represented by the Alaska Nannut Co-Management Council, which co-manages SB polar bears and polar bears in the neighboring Chukchi Sea subpopulation with the U.S. Fish and Wildlife Service. Because these communities fall within the boundaries of

the SB polar bear subpopulation, they are included in the Iñupiaq-Inuvialuit Southern Beaufort Sea Agreement, established in 1988 and renewed in 2011 (Brower et al., 2002; Kanayurak, 2016). The Iñupiaq-Inuvialuit Agreement includes neighboring communities in Canada and in doing so facilitates international Indigenous-to-Indigenous polar bear management.

Utqiagvik, Wainwright, Nuiqsut, and Kaktovik are predominantly Iñupiaq and rely heavily on subsistence hunting and fishing for traditional foods, with a particular focus on harvesting bowhead whale (Koski et al., 2005; Bacon et al., 2009; Suydam and George, 2018). Utqiagvik and Wainwright hunters harvest whales during the spring and fall whereas Nuiqsut and Kaktovik hunters harvest whales in fall only. Wainwright, Utqiagvik, and Kaktovik are coastal villages with Wainwright situated on the Chukchi Sea coast 115 km southwest of Utqiagvik, which is located near Pt. Barrow between the Chukchi Sea and

Beaufort Sea. Kaktovik is located on Barter Island on the Beaufort Sea coast adjacent to the Arctic National Wildlife Refuge (Fig. 1). Unlike the other three coastal villages, Nuiqsut is located 56 km inland, along the Nigliq Channel of the Colville River. The Nuiqsut area has a long history of traditional use but was only formally settled as a year-round village by families from Utqiagvik in 1973 (NSB Department of Planning & Community Services, 2016). Residents of Nuiqsut primarily encounter polar bears at their whaling camp on Cross Island, 120 km to the northeast of the village (Fig. 1). Polar bear hunting is more common in Wainwright and Utqiagvik than in Nuiqsut and Kaktovik. For example, between 2007 and 2016, 108 and 53 polar bears were harvested by residents in Utqiagvik and Wainwright, respectively, whereas less than 20 bears per village were harvested by residents in Nuiqsut and Kaktovik (Wilder et al., 2018).

Research Approach

We developed our study objectives and approach in collaboration with Indigenous representatives from the four participating communities, representatives of the North Slope Borough Department of Wildlife Management, polar bear biologists with the U.S. Geological Survey and the U.S. Fish and Wildlife Service, and the Inuvialuit Game Council. At a joint meeting of these parties we identified the following themes to be addressed in interviews with participants from the four communities: sea ice change, local abundance and condition of polar bears, changes in feeding behavior, human-polar bear interactions, and ice-seal condition and abundance.

Interviews

IK of polar bears was documented through semi-structured interviews and participatory mapping in 2017 and 2018, followed by verification of results with participants in 2019 (Voorhees et al., 2014; Huntington et al., 2017; Laforest et al., 2018; Kaltenborn et al., 2019). While standardized surveys are useful for documenting certain kinds of information, semi-structured interviews that respond to individuals and their life histories and experience are better suited to capturing emergent, unexpected themes and observations (Huntington, 1998; Huntington et al., 2017) and allowed participants to express their perspectives and personal observations (Ferguson and Messier, 1997; Laforest et al., 2018). Further, semi-structured interviews were preferred by our Indigenous advisors.

Some studies that document IK of polar bears (e.g., Born et al., 2011; Laidre et al., 2018a) included only polar bear hunters. Our sample design departed from this model because we included the villages of Kaktovik and Nuiqsut, which primarily identify as whaling communities and where active polar bear hunting is not a common tradition. Residents of all communities in the study have

opportunities to observe polar bears in the course of other subsistence activities, including spring and fall whaling. Purposive sampling was conducted by requesting a list of potential participants from each village tribal council; that is, tribal councils identified members of their community most knowledgeable about polar bears based on factors such as having inherited strong oral traditions from respected Elders or extensive experience hunting or observing polar bears. Subsequent purposive “snowball” sampling was also pursued, as participants recommended other knowledgeable individuals; names repeated by multiple other participants were prioritized for inclusion.

Prior to each interview, the interviewer shared the project’s background, funding sources, and goals, and emphasized the voluntary nature of participation. The age of each participant was recorded along with the number of years he or she had spent living in the community. During research design, the investigator and Indigenous advisors agreed that interviews would be documented through detailed live note taking rather than audio recording. Each interview was conducted in English, as all participants were fluent and comfortable in that language. Interviews lasted 30–60 min. Participants provided both direct observations and secondhand information relevant to the topics discussed. Participants were given an honorarium for their time. We inquired about trends over the past 15 years, but participants either described changes observed over specifically defined time periods, generally as a “recent” trend, or along a continuum based on the time frame of their knowledge which varied depending on their age. We further discuss below our attempts to consider the range of time frames addressed.

Based on conversations with participants, seasonal boundaries were set as fall from September to November, winter from December to February, spring from March to May, and summer from June to August. Maps served a central role in the interviews, acting as points of reference for generating discussion, as well as a context for documenting data (Dowsley, 2009). Participants were assigned unique identifiers in connection to their textual and map-based interview records in order to facilitate analysis and maintain anonymity.

Mapping techniques were modeled on those used by Kalxdorff (1997) and consistent with methods used in previous Bering and Chukchi Sea polar bear IK research (Voorhees et al., 2014). For each village-based region in the study, the interviewer (H. Voorhees) used up to three laminated 1:250 000 scale USGS topographic maps (depending on how many maps were required to cover local hunting territory). Each participant was given his or her own mylar overlay sheet(s) marked with their unique, confidential ID number as well as geographic reference points for subsequent compilation with geographic data from other interviewees in the village. Place-based information was drawn onto mylar sheets overlaid on maps as points, lines, and polygons. The approximate year and season of each observation were recorded. Maps were

transferred from mylar sheet drawings into GIS datasets by digitizing. Initial compiled maps were reviewed and edited by participants.

Notes from interviews were coded by community, identifying both anticipated topics elicited by targeted questions (e.g., local ice-seal abundance) and emergent and unanticipated themes brought up by participants (e.g., more “tired” behavior observed in bears). A draft report summarizing results was shared with each original participant via mail; they were also invited to meet with the researcher during a second in-person visit in 2019. This review process provided an iterative opportunity for participants to comment on the results synthesized for their community as a whole. Those who met with the investigator during the verification were given a second honorarium. A final report was also provided to all participants as well as to Indigenous community leaders.

Interviews were conducted with a single participant except in three interviews where additional family members were present. Since these individuals only added information occasionally, we considered each interview as a single sample that recorded primarily the observations and knowledge of the single focal participant. Thus, we summarized data across participants where each interview was equated to a single participant. In almost all cases, only a proportion of participants provided observations or knowledge of a topic, which we report as the sample size for each topic. Participants sometimes provided observations that matched more than one category of description (e.g., there is less multiyear ice and earlier ice breakup). In all cases we report the number of participants that report similar observations or knowledge relative to the total number of participants commenting on that topic. We provide the percentage of participants reporting an observation when the number of total participants providing observations on the topic was 10 or more, since percentages at lower sample sizes are not likely to be adequately representative when applied to a larger sample. However, it is important to recognize the limitations of quantifying IK from semi-structured interviews.

IK is the product of careful observation and confirmation over a lifetime combined with information learned from previous generations. In our study, we coordinated with local communities and Indigenous leaders to identify participants with the knowledge and experience best suited to address the objectives of the study. In some cases participants responded about their personal experiences (e.g., “I’ve never seen a polar bear den”), but in many cases they shared generalized knowledge of their community (e.g., “We don’t see polar bears dens” or “Polar bears don’t den around here”). We have attempted to differentiate these responses in the results. We report information about time frames as they were received, including specific years and time periods when identified or specific terms used when years were not identified (e.g., “compared to the past,” “in recent years”). We report the average age of participants and used a one-way ANOVA with a Bonferroni post-hoc test to compare

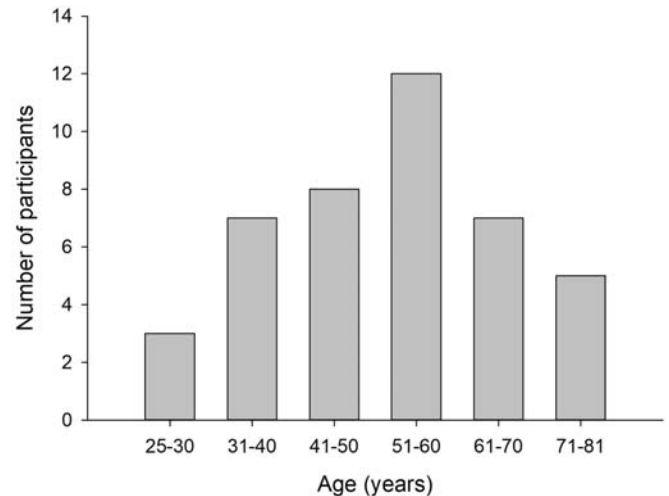


FIG. 2. Histogram of the age of 42 of 47 Iñupiaq residents and hunters interviewed about polar bear knowledge and observations from 2017 to 2019 from four Alaska communities within the range of the Southern Beaufort Sea polar bear subpopulation. Not all participants provided their age.

the age of participants among the four communities, since participant age reflects the time frame of trends reported.

In many cases, individuals elaborated with specific details on a topic. In that case, we have noted the number of individuals reporting similar details, but not the proportions. Because the individuals in this study were selected by community members and leaders based on their knowledge, their statements may reflect more general patterns than might be perceived by considering those statements as a sample size of 1. To capture the depth of information provided we have included statements made by participants and recorded in the notes of the interviewers (since communities requested that interviews not be recorded) as examples of some of the results (Kaltenborn et al., 2019). Finally, the four communities in this study occur in areas that have substantial variation in environmental conditions and in the breadth and focus of subsistence activities (Bacon et al., 2009; Wilder et al., 2018). As a result, we identify community differences and similarities to account for the potential effect of this variation while simultaneously determining where commonalities may occur.

RESULTS

We recorded observations and knowledge of Iñupiaq residents and hunters during 47 interviews, including 10 from Wainwright, 13 from Utqiaġvik, 12 from Nuiqsut, and 12 from Kaktovik. This sample size was a result of the number of participants recommended by the communities combined with the snowball sampling described in the methods. All but one of the participants were male, averaging 53 ± 15 years of age (range: 27–81 years; Fig. 2). The age of participants was similar across most communities with the exception that participants from Utqiaġvik were younger (45 ± 9 years) than participants

TABLE 1. Examples of statements made about subsistence use of polar bears by Iñupiaq hunters and residents from four communities in the Alaskan southern Beaufort Sea during 47 semi-structured interviews. Each observation was provided by a different participant.

Statement	Community
Polar bear hunting is very important. It's one of our nourishments, that makes us Iñupiaqs. When we're eating Western foods, we stay hungry; when we eat Eskimo foods, we stay full.	Wainwright
The polar bear hunting tradition is important; it nourishes everyone. When a bear is caught, they [the hunters] share with the community, everyone who wants to get a taste. They'll share their catch with everyone, it gets in their immune system of liking the bear meat. When hunters always share their catch with the community, it's part of our tradition. It's part of who we are; we are interconnected with our sea mammals and land mammals. It's just normal everyday living, harvesting, and stuff. They're good for handicrafts. Some that are gifted in doing handicrafts.	Wainwright
We are a whaling community, but there is a spiritual mystique of the polar bear because it is a strong, smart, vicious animal that survives on the ice. To be a hunter of that, there had to be something about that that was a rite of passage.	Utqiagvik
I have taught many family members, such as my grandnephews, how to polar bear hunt. It seems like they will get one or two, then it's hard for them to go out because they have work. It's hard to go out when it's time to go out.	Utqiagvik
We just chase them away, we don't [try to] kill bears; we aren't bear hunters. Our people just don't butcher bears, you leave them alone, they'll leave us alone.	Nuiqsut
We're mainly in the middle of [the land, away from the sea]. Nobody goes out polar hunting looking for bears.	Nuiqsut
I don't consider myself a polar bear hunter; it's a safety issue and also a mercy kill. I eat them, I help others that catch them, but I don't look to catch them myself. I grew up eating polar bears.	Kaktovik

from Wainwright (63 ± 16 years; Bonferroni post-hoc test $p = 0.03$). The mean ages of participants from Kaktovik and Nuiqsut were 57 ± 9 and 52 ± 18 years, respectively. Participants also reported the number of years they were active users of the local area around the community (i.e., based on the age at which they became active or if they had not lived in the area their entire life). Kaktovik (38 ± 22 years active), Utqiagvik (41 ± 12 years), and Nuiqsut (39 ± 8 year) participants reported spending approximately 40 years active around their community whereas Wainwright participants on average, had spent 53 ± 20 years active in the region, although these differences were not significant ($F_{3,36} = 1.5, p = 0.23$).

Polar Bear Hunting

Interest and participation in subsistence hunting of polar bears varied across communities. Participants in Wainwright continue to have a strong interest in subsistence hunting of polar bears (7 of 10; 70%), although bears are typically harvested opportunistically during other subsistence activities (Table 1). Two participants indicated that they had not hunted polar bears in their lifetime and another suggested that polar bear hunters are largely gone. Although polar bear hunting is often opportunistic (i.e., dependent on encountering a polar bear during other activities rather than targeted hunting), participants emphasized the importance of polar bear harvests to the community. In Utqiagvik, 10 of 13 (77%) participants had harvested a polar bear; three indicated that harvest is opportunistic. Two participants indicated that fewer Utqiagvik residents hunt polar bears than in the past, and one indicated that it is a specialized subsistence practice of a small group of individuals.

All Nuiqsut ($n = 8$) and Kaktovik ($n = 6$) participants who discussed polar bear hunting indicated that they had not harvested a polar bear and, more broadly, that members of their community are not active polar bear hunters, as they have more interest and invest more effort in whaling and hunting caribou and other animals. However, one participant in Nuiqsut identified polar bear hunting as an important tradition and noted that Elders in particular enjoy eating polar bear meat. Kaktovik participants indicated that most bears that are shot in their community are taken in defense of the community. Participants in all four communities indicated that the meat of harvested bears is shared among the community and that hides, teeth, and claws are made into clothing, boots, fishhooks, rugs, and other handicrafts.

Nobody hardly wants to harvest a bear to eat; it's just for life and death matters that [they] need to get put down.
(Kaktovik)

There are hardly any hunters hunting for polar bears.
(Nuiqsut)

Sea Ice

Forty-four participants provided observations of sea ice conditions; 43 (98%) indicated changing sea ice conditions, including thinner ice, earlier retreat, later return, younger ice, slushier ice, weaker ice, lack of summer ice, less ice, and warmer ocean temperatures (Table 2). No participants noted thicker ice or more ice.

TABLE 2. The number of participants using various terms to describe changes in sea ice conditions during 47 semi-structured interviews with Iñupiaq residents and hunters from four Alaska communities. Participants were not asked whether these changes occurred or not. Rather, these are responses to the general inquiry of whether sea ice has changed and how. Some participants used more than one of the categories below to describe sea ice conditions.

	Wainwright	Utqiagvik	Nuiqsut	Kaktovik
Thinner ice	2	4	1	
Slushier ice	1		1	1
Younger ice	1		1	
Weaker ice			1	
Less ice	1	4	5	1
Earlier retreat		1		3
Later return	1	2		2
Lack of ice	5		1	2
Ice conditions have changed		3		1
No change in sea ice				1

Sea ice is taking off sooner and coming in later. Sea ice used to go out at the end of June and come back at the end of October. It's not like it used to be. Longer summers and shorter winters.

(Kaktovik)

In recent years, multiyear ice has been replaced by annual ice that is substantially thinner (Table 2). An Utqiagvik participant estimated that multiyear sea ice in past years was 8–10 feet (~2.5–3 m) thick, whereas the shorefast ice that has replaced it is only 2–4 feet (~0.6–1.2 m) thick. Similarly, reductions in sea ice thickness were reported by a participant in Kaktovik: “Here in the lagoon the ice is like 2 ½ feet thick; it used to be 4 feet.”

Weather

Of the 20 participants who described weather patterns, the most common observation was warmer weather with shorter winters (n = 11; 55%). Other observations included more rain (n = 1), less snow (n = 2), later snow (n = 1), and changing wind patterns (i.e., strength or direction; n = 2). Wind was described as affecting the distribution of ice both by breaking up thin ice and pushing ice away from the shore.

Local Polar Bear Abundance

Thirty-three of the 47 participants (70%) provided observations of trends in the abundance of polar bears in their local area (Table 3). A decline in annual polar bear abundance in Wainwright (Table 3) was identified to have started in the 1980s, but one participant indicated that there are more bears on land during the summer now compared to the past. Further, a participant indicated that during the 1980s, spring whaling used to be the time the greatest number of polar bears was observed, but in more recent years fewer bears are seen during whaling, and the number varies more from year to year. There was a lack of

TABLE 3. Observations of the local abundance of polar bears provided by 33 Iñupiaq hunters and residents from four communities in the Alaska southern Beaufort Sea residents during 47 semi-structured interviews. Nuiqsut observations were specific to the summer and fall while whaling on Cross Island, whereas observations by participants from the other three communities were generalized across seasons.

	Wainwright	Utqiagvik	Nuiqsut	Kaktovik
Same number of bears	1	3		1
More bears		3	10	
Fewer bears	4	2	1	5
Every year is different		1	1	
The only time we have more bears coming around is during the fall whaling				1

consensus on patterns of polar bear abundance in Utqiagvik (Table 3).

There are not enough polar bears this year. They are probably out somewhere where there's ice, like 150 miles out. There is no ice this year. There's no ice, so there are hardly any polar bears around. There are fewer bears because of climate change. Once in a while they walk from somewhere or swim across the ocean.

(Utqiagvik)

Another participant described patterns of abundance more generally:

From the '80s until now, there [are] more bears [now] than it seems like [there were] in the '80s. There [have] been more bears; a lot of Elders have told me the same thing, people that go out and see bears can recognize this over the years.

(Utqiagvik)

One Utqiagvik participant noted that fluctuations from year to year in local abundance were normal, and one said that although overall abundance has shown no trend over time, there is more variation than he remembered from earlier years of his life. Two Utqiagvik participants indicated that the number of polar bears during the summer has increased but did not clarify the time frame over which that change has occurred, whereas two others indicated it was the same as always.

Nuiqsut participants indicated that polar bears are encountered primarily during fall whaling at Cross Island, rather than in the area surrounding their village. Local abundance on Cross Island was reported to have increased over the past 20 to 30 years, and that this increase accelerated after 2014 (Table 3).

There are more bears on the island than ever before. Twenty years ago there was nothing at all. I first went whaling [at Cross Island] in 1993. [At that time] we were in a tent, we had no fear of polar bears. In 1998 they

TABLE 4. Examples of summer and fall polar bear observations relayed by Alaska Iñupiaq hunters and residents from four communities along the southern Beaufort Sea during 47 semi-structured interviews. Each observation was provided by a different participant.

Statement	Community
The bears come every year, never miss. In May, June, July, August, September.	Kaktovik
If you walk when everything thaws out early July, August, and midsummer, there are bears, you have to get out of there. That whole area used to be safe to be in.	Kaktovik
We used to have a lot of ice here during the summer months, now that's all gone. We don't have ice here anymore, and the polar bear population has declined; there are fewer than 15 years ago. I started to notice that decline around 2008. There was no summer ice around that time. [I] noticed ice retreating. Last year there were about 80 bears at the bone piles. [Bears] just like to eat and conserve energy.	Kaktovik
They need ice to survive for the seals...but during the summers we're ice-free. That's why the bears are coming from the barrier islands, from the west side and coming from east, coming to Kaktovik for two months.	Kaktovik
There have been changes in sea ice; there are no seals. It must be harder for the polar bears, especially for the ones that go to these barrier islands. That's where they are mostly staying in the summer months—on the barrier islands. They have no ice; they are stranded.	Nuiqsut
A long time ago there were no bears here in summer. Now they are here any time they want—in June, July, August, and September.	Utqiagvik
There are more bears in the summer now than there used to be, at the Point.	Utqiagvik
Some bears get stranded in summer and may come to town when they're hungry; that's happening the same as in the past. There is the same number of bears in the summer as always.	Utqiagvik
It wasn't until the late '80s...around '89 when bears started finally showing up on our beaches. There were more problems. The ice was starting to recede, and it was further and further away each summer. In 1993 we had the most bears ever seen at once—over 100 bears on shore, and 50 or 60 more in the ocean.	Utqiagvik
I had never seen bears in August or September on the land [before] but the ice must be so far out, I think they're spending more time on the land than on the ice	Wainwright
Fall is when they usually come into town, if there's no ice.	Wainwright
You always see bears down the coast through the fall time, and then during whaling.	Wainwright
We're starting to see a lot more bears along the coast in the fall and wintertime.	Wainwright

started coming to the barrier islands. Polar bears were all over the coastline the first time there was no ice. Some years if there's lots of ice then we don't see them.
(Nuiqsut)

Participants attributed increased summer abundance on Cross Island to decreased sea ice and the opportunity to feed on whale remains left from the harvest (Table 3). A participant from Nuiqsut noted: "As long as there's ice they'll hardly be on the island."

Like Nuiqsut, Kaktovik participants reported that residents observe more bears during fall whaling than during other times of the year. Three participants indicated that the number of bears during fall whaling ranges between 60 and 100, and bears frequently venture into town during the fall. Despite relatively high numbers of bears in Kaktovik in the fall, five of the seven participants who responded indicated that polar bears have declined in abundance during the past 10–15 years prior to 2019 (Table 3).

The bone pile has been there for about 30 years. The number of bears coming to the bone pile has declined over the years; [I've] definitely noticed fewer. When I first came around there would be 100 plus bears around.
(Kaktovik)

Polar Bear Seasonal Habitat Use

Maps of seasonal habitat use were generated via input from all participants (Figs. 3 and 4). Utqiagvik participants reported that bears have been observed on barrier islands in the late summer and later in fall to scavenge on fall-harvested bowhead whale remains (see example statements in Table 4). Nuiqsut participants indicated that polar bears are most commonly observed on Cross Island from August through December. Kaktovik participants reported that in their region female polar bears with cubs move from their dens on land out to the sea ice in spring. In fall, bears arrive in the vicinity of Kaktovik, and in the past few years have done so before the whaling season starts. Near Kaktovik, participants reported that polar bears return to the sea ice during freeze-up, which is occurring later in the past decade. In recent years, some bears have been seen in and around the community in winter, a time when they used to be absent.

Fifteen participants described the timing when bears are observed on land as concurrent with fall whaling ($n = 3$), in late summer/fall ($n = 9$), in November and December ($n = 1$), when there is no ice ($n = 1$), and prior to sea ice forming in the late fall ($n = 1$) (e.g., Table 4). Five indicated

TABLE 5. Observations of polar bear body condition and health provided by Iñupiaq hunters and residents from four communities along the Alaska southern Beaufort Sea during 47 semi-structured interviews. Statements are summarized separately for trends in body condition versus observed recent body condition.

	Wainwright	Utqiaġvik	Nuiqsut	Kaktovik
Trends in body condition:				
No change	5	11	1	
Condition of bears are variable				3
Bears are skinnier than in the past	3	1	4	2
Current body condition:				
Some skinny ones	2		3	2
Bears “are healthy” or most are healthy or in good condition	4		1	1
Bears are skinny when they arrive on shore			2	1
Bears are fat after feeding on whale				2
Bears on shore not skinny; those that stay with the ice are skinny			1	
Bears coming to town are skinny				2

that bears spend more time on land in the summer and fall (Nuiqsut: n = 2, Utqiaġvik: n = 2, Wainwright: n = 1) (Table 4).

Participants in Wainwright, Nuiqsut, and Utqiaġvik identified specific areas of inland sightings of polar bears up to approximately 30 km from the coast (Figs. 3 and 4) although there was variation among communities in the seasons and frequency of identified inland habitat use. For example, no areas of inland habitat use were identified around Kaktovik in spring/summer or fall/winter whereas Wainwright and Nuiqsut participants identified specific areas used inland in both seasons (Figs. 3 and 4). Seven participants in Wainwright reported seeing polar bears inland more than they had in the past, particularly in the 10–20 years prior to 2019. Some of the inland habitat use around Wainwright was attributed to denning, but three participants specifically indicated polar bears being observed inland more during the summer months and occurring more in prime grizzly bear habitat. Two Wainwright participants indicated that the bears are drawn inland to look for food when there are no marine mammal carcasses available along the coast. Five Utqiaġvik participants similarly described that bears are observed inland during the summer. One participant noted seeing polar bears as far inland as 90 miles (144.8 km) in the 1980s and indicated that these observations are unusual and that the frequency has not changed. Two Nuiqsut participants mentioned observing bears inland during the summer while two other participants observed inland habitat use attributed to denning. A Nuiqsut participant indicated that the frequency of non-denning bears being observed inland has not changed during the years of observations.

Polar Bear Body Condition

Eleven of 12 (92%) participants in Utqiaġvik and five of eight participants in Wainwright indicated that bears remain healthy and have not changed in body condition (Table 5). All three of the five Wainwright participants that indicated that bears had become skinnier (Table 5) were Elders. Kaktovik participants generally described more

variability in body condition (n = 3), but two participants indicated that bears are skinnier now than in the past. Four of the five participants in Nuiqsut who described patterns in body condition indicated that bears are skinnier now than they were in the past (Table 5).

Bears are in good condition. There were only two skinny older bears that I’ve seen. It’s possible they’ve gotten to be in better condition. Late in the summer into fall before the ice comes back is when they are not in peak condition, but even then I wouldn’t say they’re in bad condition.

(Utqiaġvik)

Two participants in Kaktovik indicated that bears are in the best condition in the fall post-whaling season. Skinny bears were identified as those most likely to come into Kaktovik and to be observed by locals (n = 2). One Kaktovik participant reported that bears that stay on the barrier islands over the summer tend to be in better shape than ones that “swim across the ice, trying to come back.”

Observations of bears that are “tired” or “exhausted” when they arrive on land or are “lethargic” and unresponsive when encountered on land during the summer when sea ice retreats were reported by three participants in Utqiaġvik, three participants in Nuiqsut, and five participants in Kaktovik (23% of all participants; Table 6).

Although we did not inquire about polar bear size, three participants from Utqiaġvik commented that bears are smaller than they were in the past, whereas one indicated that there has been no change in size. Nuiqsut and Utqiaġvik participants suggested that bears have become smaller in size, a point emphasized by Elders. The observations about size were distinct from discussion of condition or whether bears were fat or skinny. Across all communities, participants reported that sick polar bears have always been and continue to be rare. One participant from Utqiaġvik characterized the observation of a sick polar bear as a “once in ten years” event.

TABLE 6. Examples of observations of the behavior and condition of polar bears arriving on land or in open water during the late summer and fall described by Iñupiaq hunters and residents from three communities along the Alaskan southern Beaufort Sea during 47 semi-structured interviews. Each observation was provided by a different participant.

Statement	Community
One year [in the fall] we were out scouting for whales, and we were out by Narwhal Island, 20 miles northeast of Cross Island. There was no ice, and there was a polar bear that was very tired and trying to get in our boat. [Then it] turned its body straight towards Cross Island. We were way out, but he knew just where he was going.	Nuiqsut
When they get to the beach they are tired and dehydrated, [and] they will make a nest. [They sometimes] freeze to the beach, then can't get out. In the fall time. The first thing they always do is make a bed to rest. There have been quite a few dead on the beach.	Kaktovik
When bears are tired and come on beach, it doesn't matter what [people] do [because they are so tired]. Last year there was a skinny one [that came on the beach] and didn't respond. It was a big one.	Utqiagvik
When they come to the beach in September or October, they just sleep because they are so tired.	Utqiagvik
In summertime, bears come to the beach that are very exhausted. There was one that was so exhausted that it was just resting on the beach, like it had come from a really long distance. It was really skinny, although it was average size, about an 8 to 10-footer. There are a few more tired bears than we saw in the past.	Utqiagvik
I've noticed that they have to cover a long distance to come to the land; they come super exhausted and tired. I see more coming than when I was little. But I haven't seen any bears that died from doing that.	Utqiagvik
We see bears out there when we're whaling in the fall. Only in recent years have we seen them out in the open ocean. Last year in October we saw a sow and two cubs 28 or 30 miles out. They jumped in the water off a big piece of ice; that wasn't multiyear ice.	Utqiagvik
The ones that stay on the islands [in the summer] aren't that skinny; it's the ones that swim across from the ice, trying to come back; those are the ones that are skinny, the ones that stay on the island are fatter. The ones that swim are unpredictable and dangerous. I've seen them attack loader forks.	Nuiqsut
When bears arrive in fall they just drop; I think it's a comfort for them to stay close to the water. I have observed bears literally falling asleep, where the waves would wash up, in October the last several years.	Utqiagvik

Maternal Denning Habitat and Cub Production

Elders stated that extremely detailed knowledge of the land is required to be familiar with denning areas. Denning areas are sometimes identified by footprints left by cubs. Participants indicated that polar bears den in November or December and emerge between March and May. Nineteen participants among the four communities provided information on whether or not dens have been observed or occur in areas around their village. All of the Wainwright participants who commented on dens ($n = 7$) indicated that they were aware of dens from information provided by other residents or had observed them directly. In prior decades, dens were primarily in snowbanks below coastal bluffs. In the recent decade dens have been observed farther inland along rivers and creeks ($n = 2$; Fig. 3).

Until 20 years ago you only saw bears when they were denning. They are going farther and farther inland, which is prime grizzly [or brown bear, *Ursus arctos*] country. It's really new. I've never heard that there were so many bears there. In old reports there weren't that many. The only place they used to den was along the banks, along the shore, but nowadays you see dens all over, around the Utukok river [Fig. 4], and kind of far up there. Dens are on banks, wherever they could find a good bank along the river.

(Wainwright)

In Utqiagvik, two of six participants who discussed denning reported having seen a den, but one indicated that "dens are rare." An additional Utqiagvik participant indicated that "there are no dens around." There was no consensus as to whether dens had become more common or less common. However, participants suggested that denning on sea ice has been reduced due to the absence of multiyear floes.

The ice used to be like multiyear ice, the layers on top of layers, with fresh water on top, and we'd used to find ice like that out on the ocean. The ice was over 14 feet thick in the past. Polar bears would hang out around that multiyear ice, and their den would be near that kind of ice. They probably would feed on that thick ice too.

(Utqiagvik)

Participants in Nuiqsut primarily described the distribution of dens and habitats used for denning. Elders noted that more bears are denning on barrier islands ($n = 1$) and inland ($n = 1$) because of lack of sea ice and denning areas now overlap with areas of industry development. One indicated that there has been no change in the total number of dens observed. Maternal dens have been seen on Cross Island, but this is rare.

More bears are coming into den because of lack of snow on ice. They are denning in areas that overlap with industry. Polar bears come out in March. A lot of bears,

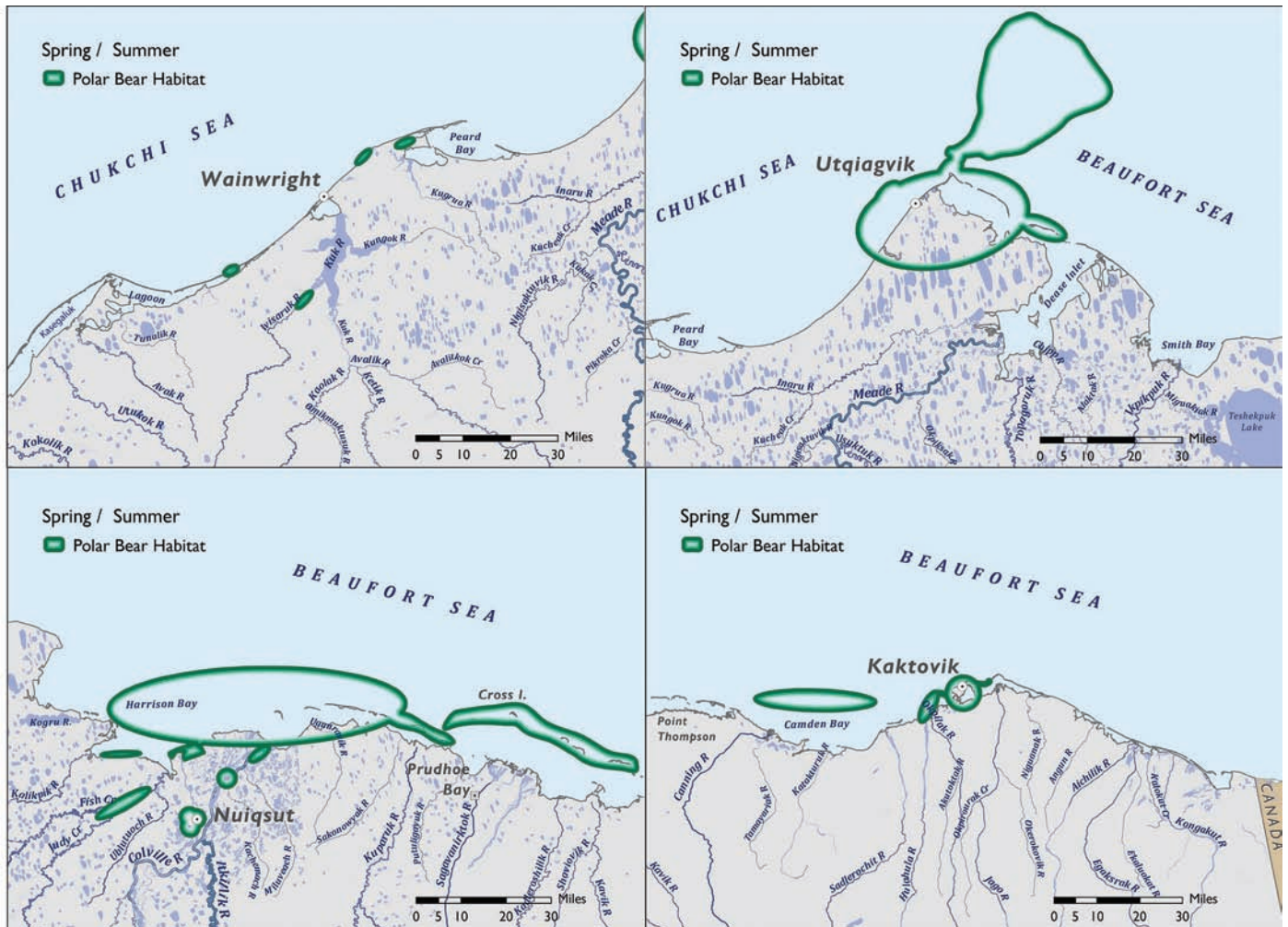


FIG. 3. Spring and summer habitat of polar bears identified by Iñupiaq participants from the communities of Wainwright, Utqiagvik, Kaktovik, and Nuiqsut in the Alaska southern Beaufort Sea during 47 semi-structured interviews.

they'll come out [in the direction of] town, [and] some come right through town. You see a lot. It's females with cubs most of the time.

(Nuiqsut)

Kaktovik participants indicated that bears den on the sides of mountains and riverbeds, wherever deep snowbanks accumulate in the late fall and early winter. However, these conditions do not occur in the Kaktovik area traversed by participants. Thus, the exact location or frequency of dens in the region was not known to most participants. One participant noted that dens used to occur on sea ice but now occur only on land. Another participant suggested that barrier island erosion may be reducing denning habitat. Finally, one participant stated that reduced snowfall has contributed to the reduction of denning habitat in recent years.

Participants indicated that it is most common to observe females with two cubs (19 out of 31 responding; 61%) and five specifically indicated that litters with three cubs are rare. A participant from Wainwright reported observing a female with four cubs. Only three participants reported trends in

litter size, indicating that the number of cubs in a family group has stayed about the same (one participant each from Nuiqsut, Kaktovik, and Utqiagvik). All of the participants who reported the condition and health of cubs indicated that they are either fat ($n = 2$) or in good health and condition, “not skinny” ($n = 4$; 1 in Kaktovik, 1 in Utqiagvik, and 2 in Wainwright). Cubs were not distinguished by age but were considered cubs if they were with their mother. Thus, litter sizes were based on observations of females with first-year cubs, yearlings, and two-year olds.

Trends in Seal Abundance, Body Condition, and Health

Twenty participants provided observations of seal abundance, condition, and health, sometimes specifying the species and other times generally referencing “ice seals.” Ice seals include primarily ringed (*Pusa hispida*) and bearded (*Erignathus barbatus*) seals, which are the most common species in the southern Beaufort Sea, but spotted seals (*Phoca largha*) also range in these areas. We report responses of participants about seals in Table 7 without specificity to species since species were identified

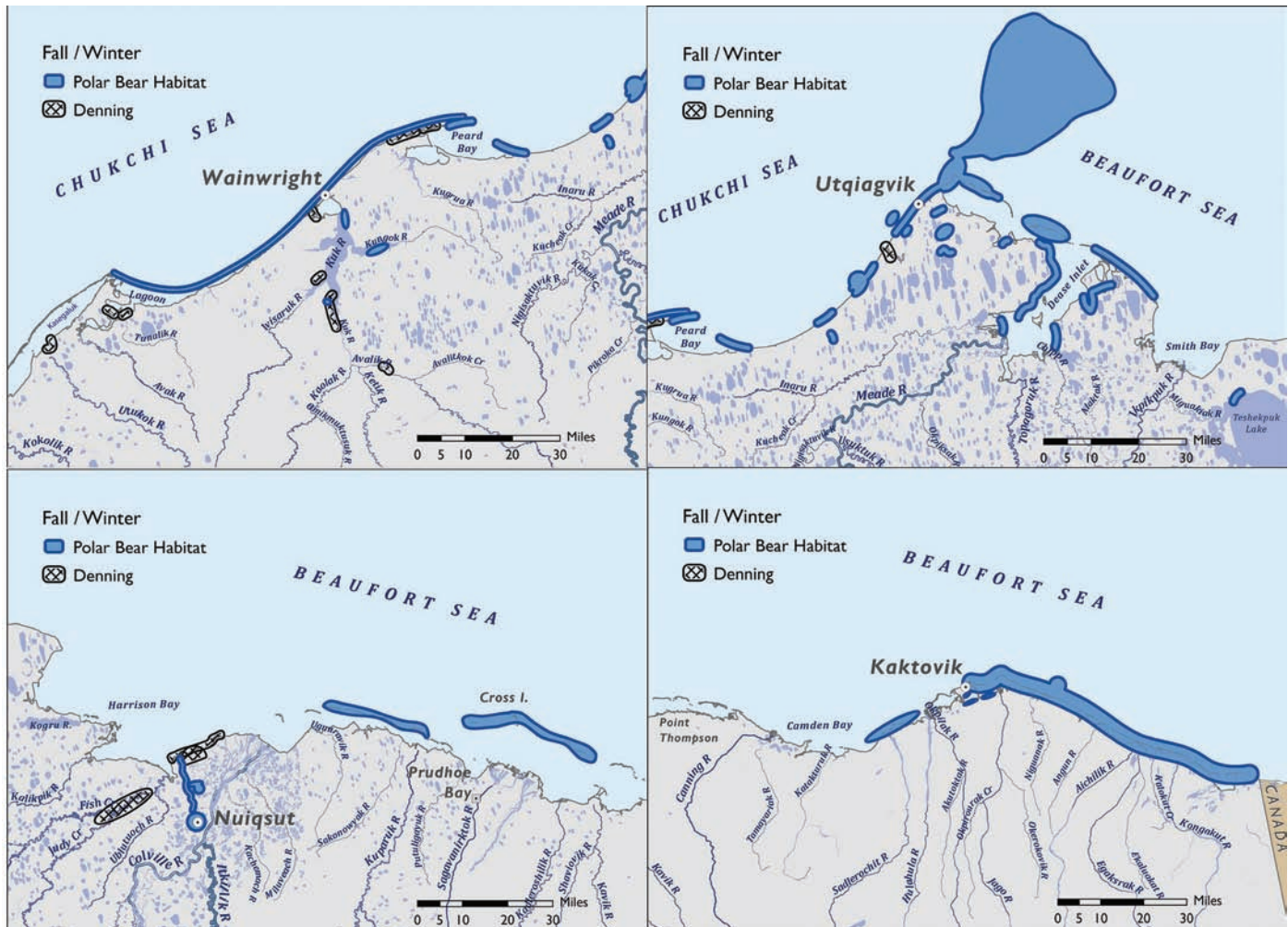


FIG. 4. Fall and winter habitat of polar bears as identified by Inupiaq participants from Wainwright, Utqiagvik, Kaktovik, and Nuiqsut in the Alaska southern Beaufort Sea during 47 semi-structured interviews.

in only some responses. Thirteen of the 20 participants who responded (65%) indicated there has been no change or there has been an increase in the abundance of seals on the sea ice while seven participants (35%) indicated decreased abundance (Table 7).

Three Kaktovik participants and a single participant in both Wainwright and Nuiqsut indicated that there are fewer bearded seals than there were in the past. In contrast, two Utqiagvik participants indicated that there has been no change in bearded seal abundance. Four Utqiagvik participants specified no change in the abundance of ringed seals, but participants in the other three communities did not comment specifically on trends in ringed seal abundance. Participants from all four communities reported observing spotted seals and one Utqiagvik participant indicated that spotted seals became more common about 10 years ago. A single participant in both Utqiagvik and Wainwright indicated that fur seals (*Callorhinus ursinus*) have been observed for the first time in their region in the past five years.

Observations of seal condition focused on their present condition compared to the past or simply observations of

current condition without a temporal comparison. Most participants (Wainwright: 4 of 5, Nuiqsut: 2 of 4, Kaktovik 1 of 1, and Utqiagvik: 4 of 6) who commented on the condition or health of seals indicated that they appear to be “healthy.” Observations of sick or “deformed” ringed seals or ringed seals with “patchy” fur were described by residents of Wainwright ($n = 1$), Utqiagvik ($n = 2$) and Nuiqsut ($n = 2$). Three participants indicated that observations of sick seals have occurred only within the last three to eight years prior to 2019.

Terrestrial Foods Consumed by Polar Bears

Participants primarily described foods that polar bears have been observed eating while on land. During discussions, participants acknowledged the reliance of polar bears on bearded and ringed seals often without explicitly stating that these species were their primary prey on the sea ice. One Utqiagvik participant and one Kaktovik participant indicated that polar bears prey on spotted seals, although another participant in Kaktovik suggested that they may be hard for polar bears to catch. Participants

TABLE 7. Observations of trends in seal abundance provided by Iñupiaq hunters and residents from four communities along the Alaska southern Beaufort Sea during 47 semi-structured interviews. In most cases participants did not specify the species of seal. Thus, these patterns potentially describe ringed seal, bearded seal, or spotted seal.

	Wainwright	Utqiaġvik	Nuiqsut	Kaktovik
More seals		1	1	
Same or more seals		2		
No change in seal abundance	3	5		1
Fewer seals	1		3	3

in Wainwright (n = 4) and Utqiaġvik (n = 4) indicated that polar bears primarily scavenge on Pacific walruses (*Odobenus rosmarus divergens*) found dead on land. One participant from Utqiaġvik and one from Wainwright indicated that polar bears will actively hunt small walruses or calves only. A Wainwright participant described observing a large male polar bear attack a female walrus on the sea ice near Hanna Shoal in July or August that was unsuccessful. Two participants from Utqiaġvik described observations of large polar bears successfully hunting beluga whales (*Delphinapterus leucas*) in narrow leads on the sea ice and two participants in Kaktovik indicated that beluga whale is a polar bear food item.

Participants in Utqiaġvik, Nuiqsut, and Kaktovik indicated that bears on land during summer scavenged on carcasses of beluga whales, bowhead whales, and walruses. In Utqiaġvik, participants observed that a greater number of marine mammal carcasses are available to polar bears in the summer. Nuiqsut participants suggested that polar bears are increasingly reliant on bowhead whale remains left by hunters. Polar bears have been observed eating the eggs of King Eiders (*Somateria spectabilis*) (Nuiqsut: n = 1), gulls (*Larus* spp.) (Nuiqsut: n = 1), and Snow Geese (*Anser caerulescens*) (Utqiaġvik: n = 1). Two participants indicated that polar bears eat fish, and one reported that bears on barrier islands will catch fish with their paws. A single participant from Nuiqsut suggested that bears do not actively catch fish. Kaktovik (n = 2) and Wainwright (n = 1) participants reported that polar bears on occasion take fish from nets. Three participants (two in Utqiaġvik and one in Kaktovik) had observed polar bears eating caribou (*Rangifer tarandus*) and participants in Wainwright (n = 2) and Nuiqsut (n = 1) described observing polar bears pursuing caribou or in areas where caribou occur. Although they did not observe a successful predation event or polar bears eating caribou, they stated that polar bears are known to eat caribou. None of the participants suggested that use of terrestrial food by polar bears has become more common in recent years.

Their hunting grounds are dwindling down; I think that's why they come to the land. I usually don't see them inland when I'm hunting caribou. [But one time in July a couple years ago] I was hunting caribou and

thought, what the heck is a [polar] bear doing there? That was different. I knew it was skinny, I should have gotten it because it started busting into peoples' camps. That was in the channel where it was shallow, before you got to the camps. It was waiting for caribou to cross the river.

(Wainwright)

Human-Bear Interactions

In Wainwright, three of the five participants indicated that human-bear interactions in and near the village have declined, while one indicated an increase and one indicated no change. Participants felt that human-bear interactions in and around the villages of Kaktovik and Utqiaġvik and during their whaling activities appear to be largely the same as they have been in the past. Six of eight Utqiaġvik participants thought that the number of bears coming into the village was the same as in the past, whereas the other two participants indicated that there were fewer. One Kaktovik participant suggested a decrease and another an increase whereas other participants made no comment regarding trends in human-bear interactions over time, but instead only commented on the nature of interactions and deterrence strategies. Nuiqsut participants identified that their interactions with polar bears occur primarily during whaling. One participant suggested that problems with polar bears while whaling are new. Another participant indicated that they have a long history of coexistence with bears, implying that they are used to managing interactions with bears.

The timing of interactions with bears outside of the whaling season varied. In Wainwright, bears are more likely to come into the village in winter; in Utqiaġvik, bears come into the village when the ice is forming in fall; and in Kaktovik, bears may be found at the bone pile left from the fall bowhead subsistence harvest throughout the year and not just during the whaling season.

All four communities have polar bear patrols to actively haze and deter polar bears or drive them out of the villages. Participants from all communities noted that patrols are often augmented by informal patrollers and hunters because it is not possible for one patroller to protect the entire village and finding people willing to serve as patrollers is difficult. During whaling, Wainwright and Utqiaġvik participants indicated that bears are so intent on scavenging the whale carcasses in the spring that they ignore normal deterrence methods and occasionally follow people hauling whale meat back to the community. A Wainwright participant indicated that when bears approach whaling camps, the captain may speak in Iñupiaq and tell the bear to go away, after which he may shoot firecracker shells as a deterrent. Participants from all communities described strategies to actively reduce attractants to bears. Utqiaġvik residents discard animal remains, including blubber, on the sea ice rather than in the village to deter bears. In Kaktovik, bear-proof meat lockers have been used to store meat from subsistence hunting, and bowhead whale bone piles are maintained

outside the village as diversionary feeding (i.e., providing food to distract bears from a butchering site or village). A Kaktovik participant indicated that ice cellars, which were once used to store meat, are used less frequently now than in the past. However, Kaktovik residents indicate that lockers are inconvenient to access and are not always used, especially if they drift over with snow. Nuiqsut whalers similarly maintain a bone pile away from the butchering site and camp, which appears to help but not completely resolve attracting bears away from people.

Participants from Wainwright, Utqiaġvik, and Nuiqsut identified the most aggressive bears as being bears that are either young (i.e., subadults) or old (i.e., not of prime, adult age), skinny, or perceived as being hungry. A Wainwright participant described that bears appear more willing to approach butchering sites in recent years because they are hungrier than they were in prior years.

Polar Bear–Brown Bear Interactions

Two Kaktovik participants reported that brown bear and polar bear distributions have increasingly overlapped in recent years. Brown bears typically occurred south of Barter Island but have extended their range northward in recent years and now interact with polar bears at the bowhead whale bone piles. Drum Island, approximately 2 km east of the village, is another location where polar bears and brown bears have been observed to interact. When the two species meet, brown bears dominate, and large numbers of polar bears will disperse with the appearance of even a single brown bear. Participants in the other three communities indicated no observations of interactions between polar bears and brown bears. However, a Wainwright participant once observed a brown bear stalking a seal (species unknown) on the sea ice, another indicated seeing more brown bears, and three participants indicated that polar bears were traveling farther inland where they overlap with grizzly bears more. Neither Nuiqsut or Utqiaġvik participants described changes in brown bear distributions or interactions with polar bears.

DISCUSSION

The 47 residents from the four Arctic Alaska coastal communities interviewed in this study demonstrated that their lives continue to be closely connected to interactions with polar bears through observation, managing safety in their communities and in bear habitats, and subsistence use. The mean age and years of local experience of participants resulted in the observations presented here generally representing changes that have been observed in the Alaskan Arctic landscape over the past 40–50 years. Our approach of seeking recommendations of knowledgeable and experienced hunters and residents from community leaders resulted in a sample of participants most familiar with the landscape in which polar bears live. Among these

four communities, Wainwright participants expressed the strongest interest in polar bear hunting, followed by Utqiaġvik, whereas Nuiqsut and Kaktovik participants identified themselves primarily as whalers who only occasionally take polar bears. In Utqiaġvik, polar bear hunting remains a specialized subsistence practice and a small group of young and middle-aged hunters is taking up the practice with interest, often learning from people outside their own family. Polar bears are primarily taken opportunistically during other subsistence activities or in response to a problem bear, although some targeted hunting does occur. Both bear meat and hides remain highly valued and culturally important resources. Further, handicrafts made from polar bear fur and other parts can be an important source of supplemental income. Participants from all four communities also indicated that residents regularly cope with managing interactions with bears.

Participants overwhelmingly reported directional changes in sea ice and weather over recent decades, including the disappearance of thicker, more stable multiyear ice, a greater tendency of shorefast ice to breakup or be blown offshore, later freeze up, shorter winters, and stronger and more persistent wind patterns. Similarly, two IK studies conducted on the Canadian side of the Beaufort Sea documented loss of shorefast ice beginning in the 1980s and altered wind patterns and warming resulting in unpredictable sea ice conditions (Joint Secretariat, 2015). Increased distances between summer multiyear sea ice and land, increased mobility of sea ice, and decreased ice thickness in the southern Beaufort Sea have also been documented via satellite data over the past three decades (Markus et al., 2009; Stroeve et al., 2012; Atwood et al., 2016; Petty et al., 2016). Participants in this study indicated that these changes in the sea ice have made conditions less safe for traveling and hunting. Similarly, effects of declines in sea ice availability and thickness and changing weather conditions on subsistence have been reported from IK studies in Northwest Greenland (Born et al., 2011), the Northwest Territories (Joint Secretariat, 2015), Quebec (Laforest et al., 2018), and East Greenland (Laidre et al., 2018a).

Changing weather and sea ice conditions were also identified by the participants of this study as impacting the spatial-temporal distribution of polar bears. Bears appear to be spending more time on shore and on barrier islands than they did within the prior lifetime observations of participants and can now be seen along the coast and in communities in the summer as well as during fall, winter, and spring. Similarly, Utqiaġvik and Nuiqsut participants associated a lack of sea ice with increased denning on land, a result similarly documented for radio-tagged female polar bears (Fischbach et al., 2007; Olson et al., 2017). The use of sea ice habitat has also changed as the sea ice season has become shorter, with bears that summer on land unable to move offshore as early in fall as they did previously (e.g., comparison with the IK findings of Kalxdorff, 1997). Hunters in East Greenland also report an increased

frequency of bears coming on shore and apparently looking for food (Laidre et al., 2018a). Increasing numbers of bears and length of time summering on shore has similarly been documented via aerial surveys and distributions of collared female polar bears in Alaska in association with a reduction in summer sea ice (Schliebe et al., 2008; Atwood et al., 2016; Wilson et al., 2017).

Participants in this study indicated that bears are observed primarily on barrier islands and immediately along the coastline except for denning. However, participants in Utqiagvik and Wainwright indicated that bears have increasingly been observed inland, not only associated with denning but also during the summer months. Alternatively, Nuiqsut residents rarely observe polar bears in or near their community, which is about 56 km from the coast. Rather, participants from both Nuiqsut and Kaktovik identified areas between the coast and inland as being primarily grizzly bear habitat while coastal areas and barrier islands have typically been polar bear habitat with little overlap in range between the two species. Participants in both Wainwright and Kaktovik indicated more overlap between these two species in recent years both as a result of brown bears occurring on Barter Island and the two species overlapping inland around Wainwright. However, the predominant use of coastal habitats and barrier islands by polar bears in the summer is consistent with aerial survey and radio-telemetry data on the Alaskan coast (Schliebe et al., 2008; Atwood et al., 2016; Wilson et al., 2017).

Participants in three communities reported a new phenomenon of exhausted bears on beaches in summer and fall, which they attributed to long-distance swims across the expanding gap between sea ice and land that has become typical of the contemporary period. Consistent with these observations, radio-telemetry data from female polar bears between 2004 and 2009 in the southern Beaufort Sea show increased frequency in long-distance swims (Pagano et al., 2012) and substantial energetic costs from these swims (e.g., loss of 22% of body mass; Durner et al., 2011; Griffen, 2018). Bears that summer on shore are often observed congregating at subsistence-harvested and naturally occurring whale carcasses. Participants in Wainwright and Utqiagvik observed that gray whale (*Eschrichtius robustus*) and bowhead whale carcasses have become increasingly available to bears, which was similarly suggested by Laidre et al. (2018b) in the neighboring Chukchi Sea.

Although changing weather and sea ice conditions were associated with changes in behavior and distribution, trends in body condition were less apparent. Seasonal variation and conditions in which bears are observed make generalization of polar bear body condition across years difficult. For example, some communities observe bears where they congregate to feed on subsistence-harvested whale carcasses, whereas other communities observe bears as they primarily rest and wait for the sea ice to return in the summer. A participant in Nuiqsut suggested that body condition also varies with a bear's survival strategy

such that bears that stay near the shore in summer are in better condition than those that stay with the sea ice. This observation is consistent with several studies that documented that polar bears remaining with the sea ice during the summer in the Beaufort Sea are primarily fasting, whereas bears that come to shore have access to the remains of subsistence-harvested bowhead whales (Rogers et al., 2015; Whiteman et al., 2017). The observation of little or no change in body condition is also consistent with findings from IK studies elsewhere. Hunters in Northwest Greenland noted that polar bear condition varies among individuals and seasons but noted no particular trend over time (Born et al., 2011). Similar to an observation noted by some participants in Nuiqsut and Utqiagvik in this study, hunters in the Northwest Territories reported seeing fewer exceptionally large and fat polar bears but otherwise have not observed a change in body condition (Joint Secretariat, 2015). In East Greenland, some hunters reported a decrease in body condition and that bears are eating more of the seals they prey on, including the bones, but most hunters noted no overall change (Laidre et al., 2018a). A study on Alaska's North Slope, which overlapped with this study in Wainwright and Utqiagvik, also found that despite great changes in sea ice, polar bear body condition remained largely unchanged (Braund et al., 2018). Participants in the present study agreed that sick bears continue to be rare.

Differences in responses about body condition and abundance of seals and polar bears are likely affected by the time perspective of participants and the season of observations. Elders have a longer period over which to compare condition and abundance from year to year whereas younger participants, with a shorter window, may have missed an earlier baseline condition with which to compare the present. Alternatively, it is possible that Elders, who are less active out on the landscape after they retire from hunting, observe more skinny bears because those are the ones that come into human settlements. Participants generally acknowledged that skinny bears are the ones most likely to come into town. The context in which participants from the different communities view bears likely has some effect on their observations and is important to consider when interpreting the observations reported here. Thus, the absence of clear distinctions reported by participants between season-specific and general patterns in polar bear and seal abundance, health, and condition may have limited our ability to identify long-term trends. Both seal and polar bear distribution and body condition are known to vary seasonally. Future IK studies building on this work could focus more specifically on distinguishing season-specific long-term trends, but such patterns in body condition and local abundance may also be difficult to detect with IK, particularly if trends are subtle rather than pronounced.

The participants from all communities interviewed in this study expressed challenges with protecting human safety via polar bear patrols due to limited staffing, financing, and other resources. Participants indicated that it is difficult to identify, hire, and train individuals to serve

on patrols, and that funding is inconsistent. The need to address polar bears near areas of human activity is likely to be a continuing issue (Wilder et al., 2017).

CONCLUSION

Projected continued loss of sea ice, including an estimated 60-day reduction in sea ice duration in the Beaufort Sea as early as 2030 (Wang et al., 2018), suggests that polar bears and the people who are dependent on the Arctic marine ecosystem will be increasingly impacted by a warming Arctic. Hence, the observations of the village residents that are presented in this report will help to set a baseline from which future observations may be assessed. The Indigenous residents of Wainwright, Utqiagvik, Nuiqsut, and Kaktovik are in a unique position to witness future changes in the Beaufort and Chukchi Seas and make observations that can serve as a barometer on the severity of change. Collectively, the knowledge contributions of Indigenous peoples and scientific findings may be used to inform decisions that benefit polar bears and the people who share the Arctic environment. Numerous studies have examined the effects of sea ice loss on polar bears, but IK provides insights into the interactive effect of sea ice loss on polar bears and people—information that is critical to effective management. In this study, the apparent increase in late summer and fall land use by polar bears is consistent with patterns identified in other parts of the Arctic and emphasizes the need for community-based monitoring of seasonal patterns of local polar bear abundance to detect trends in bear-human interactions and mitigate potentially negative consequences for bears and people. The observations reported here were consistent with those reported from recent scientific studies, including substantial changes in sea ice conditions, increased use of land by polar bears during the summer and for denning, decreases in bear body size, primarily nearshore use of coastal mainland habitats and barrier islands by bears when they are summering on shore, and increased frequencies of long-distance swims.

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