

Traditional Knowledge about Polar Bears (*Ursus maritimus*) in Northwestern Alaska

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(Received 3 July 2013; accepted in revised form 4 April 2014)

ABSTRACT. Polar bears (*Ursus maritimus*) are an iconic Arctic species, but residents of Arctic coastal communities are among the few who have opportunities to observe their behavior for extended periods of time. Documenting traditional knowledge about polar bears is thus an important research approach, especially in light of recent rapid changes to summer sea ice extent. We interviewed polar bear hunters in seven Alaska Native communities along the coast of the northern Bering Sea and Chukchi Sea. Our study confirmed findings from similar research conducted in the mid-1990s and added information about the responses of polar bears to more recent environmental change. The distribution and local abundance of polar bears have changed over time, though different communities report different patterns. Polar bears arrive from the north later in fall than previously. Despite substantial changes in sea ice and other aspects of polar bear habitat, the animals generally appear to be in good body condition, and cubs continue to be observed regularly. While polar bears continue to feed primarily on seals, they have been observed eating a diverse range of foods, including eggs, greens, fish, berries, and other foods as available. Reduction in harvest levels due to environmental, economic, and social factors is the overriding trend; however, in years when bears are particularly abundant around villages, this pattern is temporarily reversed. Polar bears remain important spiritually and culturally for the indigenous communities of northern and western Alaska.

Key words: polar bears, *Ursus maritimus*, Alaska, sea ice, ice habitat, predation, traditional knowledge, Alaska Natives, Arctic warming, climate change, subsistence hunting

RÉSUMÉ. Les ours polaires (*Ursus maritimus*) constituent une espèce iconique de l'Arctique, mais les résidents des collectivités côtières de l'Arctique figurent parmi les quelques personnes qui ont l'occasion d'observer leur comportement pendant des périodes prolongées. C'est pourquoi la consignation des connaissances traditionnelles sur les ours polaires représente un aspect important de la recherche, surtout à la lumière des changements rapides caractérisant l'étendue de la glace de mer en été. Nous avons interviewé des chasseurs d'ours polaires de sept collectivités autochtones de l'Alaska situées le long de la côte nord de la mer de Béring et de la mer des Tchouktches. Notre étude a permis de confirmer les observations émanant de travaux de recherche similaires réalisés dans le milieu des années 1990 ainsi que d'enrichir l'information sur la réaction des ours polaires vis-à-vis des changements environnementaux plus récents. La répartition et l'abondance locale d'ours polaires ont changé au fil du temps, bien que les tendances diffèrent d'une collectivité à l'autre. À l'automne, les ours polaires arrivent du Nord plus tard qu'avant. Malgré les importants changements qui caractérisent les glaces de mer et d'autres aspects de l'habitat de l'ours polaire, les animaux semblent généralement en bon état corporel, et l'on continue d'observer des oursons régulièrement. Même si les ours polaires continuent de s'alimenter principalement de phoques, on les a vus en train de manger divers aliments, dont des œufs, des plantes vertes, du poisson, des petits fruits et d'autre nourriture, selon les disponibilités. Les taux de récolte à la baisse en raison de facteurs environnementaux, économiques et sociaux constituent la tendance prépondérante. Cependant, au cours des années pendant lesquelles les ours sont nombreux autour des villages, cette tendance est renversée temporairement. Par ailleurs, les ours polaires continuent de revêtir une importance spirituelle et culturelle pour les collectivités indigènes du nord et de l'ouest de l'Alaska.

Mots clés : ours polaires, *Ursus maritimus*, Alaska, glace de mer, habitat des glaces, prédation, connaissances traditionnelles, Autochtones de l'Alaska, réchauffement de l'Arctique, changement climatique, chasse de subsistance

Traduit pour la revue *Arctic* par Nicole Giguère.

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INTRODUCTION

Polar bears (*Ursus maritimus*) are an iconic Arctic species and of great cultural and material significance to circumpolar indigenous peoples, including Alaska Natives along the northern and western coast of the state. Alaska is home to two polar bear populations, the Southern Beaufort Sea stock and the Chukchi-Bering Sea stock. In 2008, polar bears were designated as a threatened species under the U.S. Endangered Species Act, in recognition of the threat posed by loss of Arctic sea ice due to climate change. It is vital to understand how ice loss may be affecting the condition, local abundance, and habitat use of polar bears to inform day-to-day management and ensure their long-term conservation.

Traditional knowledge (TK), the information and understanding acquired by experience and shared among members of a cultural group (e.g., Berkes, 2012), provides one means of documenting information about these topics (Ferguson and Messier, 2000; Huntington, 2000; Noongwook et al., 2007; Herrmann et al., 2012). This type of information is particularly important in the case of polar bears because they occupy remote sea ice habitats, where only the few nearby coastal communities have regular opportunities to observe their behavior. Furthermore, a recently issued circumpolar monitoring plan for polar bears highlights the need for TK in intensive and long-term monitoring of polar bears (Vongraven et al., 2012).

Previous TK studies of polar bears in Alaska and across the Arctic have had two main goals. The first has been to document current and historical relationships of Native communities with polar bears, including the symbolic and everyday significance of bears in indigenous Arctic cultures (D'Anglure, 1990; Russell, 2005; Kochneva, 2007; Zdor, 2007). It is important to document and illustrate subsistence use of polar bears in order to verify histories of subsistence use, ensure that community knowledge is preserved for future generations, and strengthen indigenous rights.

The second category of previous studies has worked to bring the knowledge that Native communities have developed through their relationship with polar bears into wildlife management. By connecting past and present knowledge, documentation of Inuit *qaujimajatuqangit* (IQ, a term for TK used in Nunavut) in Canada has sought to capture trends in polar bear denning (Van de Velde et al., 2003), local polar bear abundance, and distribution over time, and to discover how unfolding processes of climate change may be affecting these trends (Dowsley, 2005; Keith et al., 2005; Kotierk, 2010a, b). Studies in other parts of Canada, including northwestern Ontario (Kakekaspan et al., 2010; Lemelin et al., 2010) and the Inuvialuit Settlement Region (Slavik, 2010, 2013), have likewise built on TK and human–polar bear interactions to contextualize current indigenous observations about polar bears. In Greenland, Born et al. (2011) examined interrelated changes in ice conditions, polar bear abundance, growing polar bear catch, and shifting local hunting methods.

The Chukchi-Bering Sea (CS) polar bear population is shared by the United States and Russia. Beginning in the 1990s, studies on both sides of the Bering Strait translated hunters' experiences of living with bears into detailed maps that portrayed habitat use, effectively linking projects of wildlife conservation and indigenous practice (Kalxdorff, 1997; Kochnev et al., 2003). The present study builds on these two previous studies, and in particular, on Kalxdorff's (1997) documentation of hunters' TK about polar bear habitat use in northern and northwestern Alaska. Given that Kalxdorff's study preceded recent major declines in summer sea ice in the Arctic Ocean (e.g., NSIDC, 2012), it provides an invaluable baseline for comparison with our results. Updated documentation of TK offers a means of assessing, on the basis of continuous observation by hunters in villages from the northern Bering and Chukchi Seas, whether this physical change has affected the biology and ecology of polar bears.

Polar bears are a “cultural keystone species” for indigenous communities in this region, one that “informs [their] corpus of knowledge, orients symbolic practice, and provides material sustenance” (Sodikoff, 2012:7). Polar bears have historically been hunted for their meat, which is shared with the community and especially with Elders, as well as for their fur and claws, which are used in traditional clothing and handicrafts. Today, under the U.S. Marine Mammal Protection Act of 1972, Alaska Natives in coastal areas can legally hunt polar bears year-round for subsistence purposes. Polar bear subsistence hunting is likewise protected under the Endangered Species Act of 1973. Indeed, hunting for polar bears is one important context in which TK is acquired. Historically, there has not been an official limit on the number of polar bears that can be hunted for subsistence purposes, although such hunting must be done in a non-wasteful manner. Between 2003 and 2012, Chukchi Sea hunters reported to the U.S. Fish and Wildlife Service that they were harvesting approximately 33 bears per year (USFWS, unpubl. data).

Although there has been a moratorium on polar bear harvesting in Russia since 1956, unofficial reports from Chukotka indicate that illegal harvesting has reached high levels that may be unsustainable. The presumed high level of harvest based on these reports led to classification of the CS population as declining (Obbard et al., 2010). It is believed that from 1990 to 2005, the illegal harvest in Russia was 70 to 300 bears per year (US-Russia Scientific Working Group, 2010). More recent estimates suggest that illegal killing has steadily declined and may currently be at levels of 20–70 bears per year (A. Kochnev, pers. comm. 2014). In 2000, the U.S.-Russia Polar Bear Agreement was signed by federal and indigenous representatives from both countries. At the heart of the agreement was a joint decision by Alaska and Chukotka Natives to voluntarily adopt a shared hunting quota for the CS population.

Little is currently known about the CS polar bear population because it occurs at a relatively low density, is widely distributed, and moves between the United States



FIG. 1. Map of villages and other key locations in the study.

and Russia. Although the size of the population is currently unknown (Obbard et al., 2010), it has been estimated, from extrapolation of den surveys conducted in the early 1990s on Wrangel and Herald Islands (an area of high denning concentration) and expert opinion, as approximately 2000 (Aars et al., 2006). Durner et al. (2009) documented an 8% per decade decline in sea ice habitat used by polar bears in the CS between 1979 and 2006, and they project a continued 6% per decade decline through at least 2050.

TK is valuable in this region where polar bears may be experiencing a variety of population-level pressures and management occurs with relatively limited biological information. Ice habitats selected by polar bears occur in regions adjacent to the villages selected for this study (USFWS, unpubl. data; R.R. Wilson, pers. comm. 2014) and documented movement patterns support polar bear use of coastal areas near most of the participating villages (Garner et al., 1990). Thus local residents have an opportunity to observe bears in some of their preferred habitats. This study sought to identify where observations of hunters in local communities differed, suggesting local variation in polar bear biology, and where they were similar across communities, suggesting potential population-wide patterns.

METHODS

Study Area

Communities selected for the study were all those with a history of significant polar bear utilization within the region covered by the U.S.-Russia Polar Bear Agreement, which applies specifically to the CS polar bear population.

CS bears occur primarily on the sea ice ranging between the western Alaskan coast and northeastern Chukotkan coast, extended south past St. Lawrence Island and the Bering Strait and north beyond Wrangel and Herald Islands in Russia (Fig. 1; Garner et al., 1990; USFWS, unpubl. data). While all of the Alaska Native communities included in this study are located within the CS range as defined by the International Union for Conservation of Nature and Natural Resources/Species Survival Commission Polar Bear Specialist Group (IUCN/SSC PBSG), the range of CS polar bears overlaps with that of polar bears occupying the adjacent southern Beaufort Sea to the east (Amstrup et al., 2004). Bears in these areas are not genetically distinct, and therefore are technically “subpopulations” (Cronin et al., 2006). However, they are managed separately and typically referred to as “populations,” as we refer to them here.

The communities included in the study were Gambell, Savoonga, Wales, Shishmaref, the King Island Native Community (now located in Nome), Point Hope, and Point Lay (Fig. 1). Little Diomedes was also selected, but weather and logistics prevented us from visiting the island. Members of these communities primarily identify themselves as Iñupiaq, with the important exception of the Siberian or St. Lawrence Island Yupik communities of Gambell and Savoonga on St. Lawrence Island.

The experience of King Islanders regarding polar bears differs from that of other communities included in the study. Polar bears were historically encountered on King Island; however, residents relocated to Nome (nearly 135 km away) in 1959, shortly after the island’s school closed down. Because Nome is on the margins of polar bear seasonal migration, King Islanders have had fewer opportunities to observe polar bears since their relocation. However, hunting trips in Norton Sound and to Sledge Island provide a basis for some contemporary observations. Here, we include both historical observations from King Island, as well as more recent observations made in the vicinity of Nome.

Research Instrument Design

Key topics to be investigated through collection of TK about polar bears were identified jointly by the Alaska Nanuq Commission (ANC) and the USFWS. Selection was based on current management priorities and the desire to compare current observations with those recorded by Kalxdorff (1997). Because humans and polar bears are regarded as part of the same system in Alaska Native worldviews (Russell, 2005) and because interactions between humans and polar bears, including hunting, are an important aspect of polar bear management, trends in the cultural and subsistence roles of polar bears were included in the study scope. We used semi-structured interviews (Huntington, 1998) with a list of key topics to be covered, an approach consistent with recommendations in a recently published polar bear circumpolar monitoring plan (Vongraven et al., 2012). Our research instrument was designed to elicit

accounts of specific encounters with polar bears from hunting and other observations, as well as more general, shared knowledge about polar bear characteristics and trends. We refined our interview questions through consultation with a local subsistence hunter in Nome and continued to refine them during the project on the basis of experience with the actual interviews.

Permissions and Participants

Before we traveled to each village, the ANC contacted the tribal council to gain approval for our research proposal and request assistance in identifying potential participants, both active and retired. As leaders in their communities, tribal councils are well positioned to recommend the most knowledgeable members of the community. Further participants were recruited through chain referral or “snowball” sampling (Bernard, 2011). Because this study focused on polar bear hunters, and polar bear hunting is a traditionally male pursuit, almost all those interviewed were men, ranging from 21 to 86 years of age. However, we interviewed one woman from King Island who was recommended by hunters because she was from a successful polar bear hunting family and had often processed hides.

After receiving approval and contact information from village tribal councils, we contacted all potential participants by phone, briefly explained our project, and asked if they would be willing to be interviewed. Our initial research trips in 2011 were followed by visits in 2012 to verify our findings with the communities.

The Interviews

We conducted six to 10 interviews in each village. Despite the small sample sizes, saturation in the information collected (exhaustion of unique data; Corbin and Strauss, 2008) began to occur after only three or four interviews in all cases, reflecting the tightly knit nature of these communities and their knowledge-sharing practices.

The setting of our interviews was chosen for convenience to the participants. Participants were interviewed individually and in private, except in a few cases where participants chose to be interviewed together. We began an interview only after the participant had given his or her verbal consent. To maintain anonymity, we assigned a unique ID number to each participant. Interviews were conducted in English; an interpreter was used in only a few cases, when interviewing Elders. In these cases, the participants chose their own interpreter from the community, and the interviews were conducted in a mixture of English and Iñupiaq or Siberian Yupik.

Data Collection

Interviews were conducted by two ANC researchers, one keeping comprehensive written records of the interviews while the other recorded geographical information.

The length of interviews ranged from 40 to 90 minutes (on average, slightly less than one hour). To link the written and mapped data, we assigned consecutive map feature identification numbers, which were also noted in the narrative notes. In Gambell and the King Island Community of Nome, both researchers could not be present to conduct the interviews. A local research assistant was recruited and trained in our project goals and methods to work with the remaining researcher.

The methods developed by Kalxdorff (1997) formed the foundation for recording geographic data. For each interview, the locations of hunters’ observations were recorded on Mylar sheets placed over 1:250 000 scale U.S. Geological Survey maps, along with the year and month of the observation (to the best of the participant’s memory). Months were assigned to seasons corresponding to Kalxdorff’s (1997) definitions and color-coded accordingly on the Mylar maps that were later compiled by village. The full details of our mapping method are available in an original ANC report (Voorhees and Sparks, 2012).

Narrative Analysis

We analyzed the narrative portion of our data using ATLAS.ti 6.2 qualitative data analysis software (Friese, 2012). We uploaded interview notes into the program as individual primary documents, grouped by village. We used two parallel approaches for coding these documents or labeling them according to topic (Rubin and Rubin, 2005). First, the text was coded with reference to our original research instrument. For example, we coded descriptions of bears as “fat” or “thin” under our previously defined topic of “polar bear condition.”

Second, we used a grounded theory framework (Corbin and Strauss, 2008), an inductive method that builds on unanticipated themes in the data. For example, “king bears” (a special class of extremely large and powerful bears recognized by hunters) were not on our original list of topics. An open coding approach allowed for the inclusion of emergent information of this kind (Bernard, 2011). During open coding, we first defined new codes (e.g., “king bear”), and then used the newly defined codes to examine and label the rest of the documents.

Map Analysis

Seasonal data from each individual interview’s Mylar overlay were transferred to the new, village-specific maps, producing two comprehensive seasonal maps for each village. When combining data from interviews, we used the outer boundary of the areas indicated by all participants. The maps were digitized, and types of habitat use (such as feeding or denning) were key-coded for easy identification in the final report. These maps are available in Voorhees and Sparks (2012); their content is described in the text of this paper, and thus the maps have not been reproduced here.

Verification

We conducted follow-up group interviews with the original participants after initial analysis. Our group interview approach allowed us to determine basic consensus on our previous findings and led to iterative generation of further data as we discussed the drafts. Later we met individually with any interview participants who could not attend the group verification meeting. At that time, we also updated our dataset to include the interim period between our original and follow-up visits. We incorporated any information about the most recent polar bear season, including ice conditions, as long as this new information was supported by group consensus. The narrative and the maps were amended to reflect the outcome of the verification process.

RESULTS

Polar Bear Hunting

The timing of polar bear hunting varies by village and depends not only on the presence of bears, but also on the community's social calendar and the timing of other subsistence activities. The majority of bears are harvested between November and April; hunters prefer to catch bears in late fall and early winter because bears are in better condition at that time. Bears are hunted using snow machines, all-terrain vehicles, and boats and on foot, depending on the season and the condition of sea ice. On St. Lawrence Island, bears occasionally remain on the island over the summer, prolonging the period during which bears may be harvested, both for subsistence and in self-defense. In Wales and Shishmaref, polar bear hunting now begins several weeks later than in the recent past, largely because of the delayed fall arrival of bears in the area.

Occasionally hunters go looking specifically for polar bears, but more often polar bears are taken opportunistically, when they are encountered in the course of other outdoor activities, such as whaling, checking traps, and traveling between villages. Inupiaq and Siberian Yupik Alaska Natives are taught by their Elders to be humble about hunting, especially polar bear hunting. Thus, they rarely announce that they plan to hunt bears, but will instead mention their intent to "look around." In some cases, opportunities for polar bear hunting are disregarded when hunters are in the midst of other important and time-intensive subsistence activities, such as hunting for seals or walrus (*Odobenus rosmarus*).

Hunting polar bears is hard work, as is processing a harvested bear. Hunters in several villages said that interest in bear hunting is declining, as fewer people are willing to take on the tasks involved. Polar bear meat is a delicacy for Elders, but many of the younger generation avoid it because of its intense flavor and the risk of trichinosis. However, in years of unusually high local polar bear abundance, more community members develop a taste for the meat, which in

turn can lead to increased hunting efforts. While there are fewer active polar bear hunters today than in the past, polar bear hunting—and especially catching one's first bear—remains materially and symbolically important to the communities included in this study.

Seasonal Movements and Local Distribution

Hunters see a pulse of polar bear arrival in late fall and winter, as freeze-up occurs, and another during bears' migration north in the spring. Historically, hunters associated the arrival of polar bears with winds and currents from the north, as well as with the seasonal appearance of blue icebergs, or pack ice, carried by these winds. Across the study area, bears and bear tracks are seen close to the coast and on barrier islands in the weeks immediately following their arrival; by March, they are also commonly encountered farther out on the ice. In spring, hunters observe bears in marginal areas of sea ice and pressure ridges, where seals are abundant. Later in the spring, polar bears can be found around open leads, which have been forming closer to the shoreline in recent years. Bears become temporarily abundant around villages and whaling sites during spring, as they are attracted to the byproducts of subsistence activities, such as whale carcasses, seal oil, and old meat that is discarded when people clean out their ice cellars.

Summer sightings are relatively rare. Point Lay and Point Hope hunters occasionally observe polar bears during the summer, both inland and along the coast. Some hunters in Point Hope have noticed that these summer sightings are becoming more common. On St. Lawrence Island, if the ice retreats too quickly, bears may remain on the island over the summer, as happened to a large number of bears in 2003. Some of these remaining bears move inland, spending time in the highlands. However, hunters on St. Lawrence Island note that a few bears may remain in the area into the summer even in years of exceptionally good ice.

Local Abundance

Local abundance can vary significantly for one village between any two consecutive years. Furthermore, reports of local abundance and trends over time varied considerably from one village to another. Most hunters interviewed said that despite variation in local abundance on the scale of years and decades, overall, there are as many bears now as there have always been, and that changes in abundance are cyclical. Many hunters believe that decreased local abundance reflects the fact that polar bears have moved in search of seals and better ice habitat, rather than indicating an overall decline in the CS population. We summarize trends in the local abundance of polar bears from the 1940s to 2012 for each village in Table 1.

TABLE 1. Abundance of polar bears over time by village, south to north. Darker shading corresponds to greater local abundance of polar bears, relative to other periods for that community (no comparisons of relative abundance from one community to the next were attempted). Consistent shading indicates no change over time.

Village	1940s	1950s	1960s	1970s	1980s	1990s	2000s	2010–12
Gambell	Light	Dark	Dark	Dark	Dark	Dark	Dark	Dark
Savoonga	Light	Light	Light	Light	Light	Light	Light	Light
King Island	Light	Light	Light	Light	Light	Light	Light	Light
Wales	Light	Light	Light	Light	Light	Light	Light	Light
Shishmaref	Light	Light	Light	Light	Light	Light	Light	Light
Point Hope	Light	Light	Light	Light	Light	Light	Light	Light
Point Lay	Light	Light	Light	Light	Light	Light	Light	Light

Body Condition

Hunters in all villages (except King Island, which did not provide information on body condition) said that the majority of bears observed in the area are in good condition, being fat, healthy, and large. Gambell hunters said that bears that remain on the island after the sea ice melts in spring nonetheless remain in good condition in most years. While the presence of bears on St. Lawrence Island over the summer is not a new phenomenon, the trend in the number of bears exhibiting this behavior in recent years is unclear. Bears that over-summer have been seen eating salmonberries (*Rubus chamaemorus*) and black crowberries (*Empetrum nigrum*) (also known locally as cloudberries and blackberries). A family group of bears observed on St. Lawrence Island in August 2010 appeared healthy.

Bears are sometimes encountered within village boundaries. The condition of these bears varies: some are fat, and some are skinny. Hunters say that many of the bears that venture directly into town are simply young, curious, and inexperienced, rather than starving. They suggest that bears may be coming into villages for three reasons: because they have been orphaned and lack knowledge of how to survive, because diminished—and sometimes absent—shorefast ice brings polar bear habitat closer to the village, and because bigger bears may be forcing weaker or younger bears into marginal habitat.

Demographics

While there appear to be local patterns of polar bear distribution and abundance by sex, no consistent patterns are apparent across the study area. Male and female bears are encountered in roughly equal proportions on St. Lawrence Island. In the Wales area, females arrive first in December, and males come about two weeks later. Males are more common around Shishmaref and Point Lay. Family groups observed by hunters usually include one or two cubs. Families with three cubs are less common, but some hunters reported that these larger family groups were more common in the 1970s. Hunters did not distinguish between cubs-of-the-year and older cubs; therefore, the term “cubs” is used throughout the paper to refer to any dependent young bears.

In Gambell, sightings of females with cubs have increased since the 1990s. Mothers and cubs in the area are reported to be in good condition.

Feeding

In wintertime around most villages, polar bears feed out on the sea ice, where they are observed jumping, presumably to break the ice and access a seal underneath. Gambell hunters said that bearded seals (*Erignathus barbatus*) are polar bears' favorite prey. Wales hunters added ringed seals (*Phoca hispida*) and spotted seals (*Phoca largha*) to the list of polar bears' primary foods. Usually bears eat only the blubber of seals; only young or particularly hungry bears eat the seal meat as well. In all villages, hunters generally agreed that ice seal populations have remained stable and abundant over the last decade.

It is not uncommon for polar bears to hunt for beluga whales (*Delphinapterus leucas*) in this region. Hunters have observed polar bears waiting by the water with one forepaw raised, ready to strike a beluga, and have also known bears to jump on top of beluga whales in the water before hauling them out onto the ice. In the Shishmaref area, bears have been seen preying on beluga whales trapped in small openings in the ice. As they do with seals, bears usually eat only the beluga's blubber. Younger bears, as well as other animals (including, on occasion, people), scavenge the rest of the carcass.

Throughout the study area, hunters reported that polar bears are more likely to scavenge on carcasses of walrus than to kill them, although hunters on St. Lawrence Island have observed bears actively hunting for walruses. Carcasses of walrus, beluga whale, bowhead whale (*Balaena mysticetus*), and gray whale (*Eschrichtius robustus*) wash up on shore in the summer and fall and later become frozen in the shorefast ice, providing an important food source for bears in the region. Polar bears are commonly found scavenging along shorelines from December to March.

Concentrations of carcasses can lead to large congregations of polar bears. In Savoonga, hunters tell stories about dozens of bears congregating at Pugughileq Camp in the 1800s and early 1900s. In the 1970s and 1980s, large groups of bears were observed scavenging on walrus on Punguk

Island. More recently, Ikpek Inlet, located approximately 65 km southwest of Shishmaref, has become a place where bears are known to scavenge on walrus carcasses in the fall and winter. Overall, hunters reported declines in the availability of marine mammal carcasses along the coast, citing two possible causes. First, when ice fails to form or remain along the coast, as in recent years, the carcasses that usually freeze into shorefast ice are dispersed. Second, some hunters, as in Wales, attributed local declines in polar bear sightings to the decrease in walrus carcasses following enforcement action against subsistence hunting in the early 1990s.

The stomach contents of harvested bears provide information about feeding habits. Many hunters avoid eating or even touching the internal organs of polar bears, especially the liver, which is regarded as dangerous and unhealthy. Those who do look in the bears' stomachs usually find only seal oil. Younger bears tend to have a greater diversity of things in their stomachs, including meat, skin, and bones. On occasion, hunters have found items of trash in bears' stomachs, including aluminum foil, a juice container, and a bottle cap. Hunters in Wales say that bears are far more likely to have trash in their stomachs now than in the past.

Hunters emphasized the range and flexibility of the polar bear diet. When occasional polar bears remain on land during summer, they eat a wide variety of plants and animals. On St. Lawrence Island in summer, for example, they have been observed eating fish, murre (*Uria* spp.) eggs, greens, and berries. In Point Lay, bears are known to target caribou in late spring.

Dens

Hunters recognize that polar bears make both temporary "resting" dens and winter-long reproductive dens. On St. Lawrence Island, dens of both kinds are very rare, although well-known stories exist about hunters catching bears in dens in the 1940s and 1950s, leading some hunters to suggest that denning may have been more common on the island at that time. At present, dens and associated tracks are found in snowdrifts on the southwestern coast of St. Lawrence Island, but it is not known which kind of dens these are.

During years of light snowfall, hunters say that bears travel deeper into valleys and along creek beds to find deeper snow for denning. No Shishmaref or King Island hunters had encountered a polar bear den in their hunting areas. The terrain around Shishmaref is too flat to allow snowbanks to build up, resulting in a lack of denning habitat; however, one hunter had seen a temporary den in snow next to a sea-ice pressure ridge.

Dens are also scarce in the immediate vicinity of Point Hope, though hunters occasionally see temporary dens while they are out hunting. One reproductive den was located on a hill near the village about 10 years ago (early 2000s), but no other permanent dens have been reported nearby since. More distant areas known as likely denning

sites include Cape Dyer (located approximately 48 km north of Point Hope), Cape Lisburne (approximately 72 km north of Point Hope), and Cape Thompson (approximately 40 km southeast of Point Hope). At Cape Thompson, sightings of female bears are also common.

Dens have been observed in February and March around Point Lay, where high snowdrifts pile up against bluffs and riverbanks. Within the last decade, reproductive dens have been observed in an inlet about 16 km north of Point Lay. Other denning areas include the north side of Tungak Creek, between Cape Beaufort and Kasegaluk Lagoon, and south of Utokok River, near a shelter cabin about 40 km from Point Lay. The bluffs along Icy Cape are also known as a denning area because hunters sometimes see den openings there, as well as the occasional cub.

Polar Bear Characteristics

Hunters recognize polar bears as extremely smart animals, with the ability to sense the presence of humans. According to some hunters, bears can sense fear and seem to be able to read people's thoughts, so they are very difficult to outsmart. Experienced polar bear hunters warn younger hunters that polar bears are left-handed, which makes it more dangerous to approach them from that side. Hunters must also be wary of bears that have just come out of the water, as their wet and frozen fur can become nearly bulletproof. In addition to regular polar bears, hunters recognize a special category of "king bears," which measure upwards of 3.5 m in length. King bears are said to be recognizable by black marks on their shoulders; sometimes they also lack fur on their legs. According to the old stories, king bears are almost impossible to kill.

Hunters view bears as social animals whose survival depends on learning hunting skills. Cubs learn how to survive as polar bears only through a long period of learning from their mothers. Hunters in Point Lay recognize that cubs need to learn hunting techniques from their mothers and should not be disturbed as they are doing so. Similarly, hunters in Wales and Shishmaref stress the importance of not killing cubs or mother bears. Hunters in Wales believe that when bears are orphaned at a young age, they do not learn how to fend for themselves, a problem which can even affect subsequent generations of bears in negative ways. Some say that the effects of the sport-hunting era, which ended in the early 1970s, continue to reverberate through the local polar bear population in this way. According to hunters, this lack of knowledge about how to survive causes young bears to come into villages to scavenge on trash, and they can become a threat to community members.

Polar Bear Habitat

Changing sea ice has been the most notable alteration to polar bear habitat in recent decades. Hunters have observed the most change in sea ice since the 1990s, although they first noticed changes in ice conditions as early as the 1970s

and 1980s. Freeze-up is now occurring up to a month later in fall, and breakup is coming up to a month earlier in spring. Hunters believe that changing ice conditions are affecting the distribution of bears and the timing of their seasonal migrations, though not necessarily their overall numbers. When the ice is thin, hunters say that bears simply go elsewhere in search of seals.

One of the most prominent observations made by hunters about polar bear habitat regards “blue icebergs,” which used to arrive from the north in the fall, and which brought polar bears and other game to the area. In recent years, these icebergs have failed to arrive, and hunters make a connection between the absence of this ice and the delayed arrival of polar bears in the region. Pack ice is associated with abundant seals, and so the lack of blue icebergs coming from the north in fall has resulted in reduced prey for bears (and thus, fewer bear sightings).

Shorefast ice is now less extensive than it used to be and is more easily dispersed by wind, resulting in periods of open water along the coast. When pressure ridges form, they are much smaller than those that hunters remember from the past. Shorefast ice on St. Lawrence Island is less common than it used to be and does not last as long; this trend has intensified since 2006. Point Hope hunters have noticed similar changes along the coast between Point Hope and Kotzebue. The reduced extent of shorefast ice around Point Hope now means that spring whaling camps are closer to the village than before, which in turn brings bears that scavenge on whale remains closer to the village. Overall, ice conditions are more variable and harder to predict than in the past.

Interactions between Polar Bears and Grizzly Bears

Although not an intended topic of the study, grizzly bear (*Ursus arctos*) and polar bear interactions were observed by some hunters. Like polar bears, grizzly bears scavenge on marine mammal carcasses, though not in wintertime. In Point Hope, there were more grizzly bears seen in 2012 than ever before, but polar bears replace them in fall and winter, and the two species have not been observed interacting. In Point Lay, in contrast, grizzly bears and polar bears occasionally overlap. Grizzly bears may be seen in Point Lay as early as springtime, but more often are seen between July and September. Hunters say that grizzly bears are scared of polar bears on the ice, but on land, polar bears are scared of grizzly bears. Overall, however, they suggest that grizzly bears are dominant in these interactions.

DISCUSSION

Previous studies of polar bear habitat use in the Chukchi and northern Bering Seas have focused primarily on identifying the types of ice habitats selected by polar bears and bear movement patterns (Garner et al., 1990; Arthur et al., 1996; Durner et al., 2009). In our study, subsistence hunters

provide the first information on potential changes in CS polar bear seasonal movement, habitat use, local abundance, and distribution in response to sea ice changes. Here, we analyze the results presented above, bringing them into dialogue with current understanding of polar bear biology and ecology as reflected in the scientific literature.

Hunters testified that freeze-up is occurring later in the fall, and breakup is occurring earlier in the spring in the Chukchi and Bering Seas. In our study area, shorefast ice is thinner, does not extend as far from land as it once did, and is prone to frequent and unpredictable dispersal by wind. When ice ridges form, they are smaller than those observed in the past. Icebergs (or fragments of multiyear ice), which used to arrive from the north, are now rarely seen. Interestingly, this observation has parallels in IQ gathered in the Inuvialuit Settlement Region (Slavik, 2010, 2013); in Baffin Bay (Dowsley, 2005), where communities noticed a decline in the presence of icebergs in the 10–15 year period preceding that study; and in Gjoa Haven, Nunavut, where icebergs were largely absent by 2002 (Keith et al., 2005).

Given these ice changes, it is hardly surprising that hunters in most communities described changes in the local abundance and distribution of polar bears, as well as in the timing of their seasonal movements. A comparison of results between the present study and Kalxdorff (1997) shows that in three communities (Wales, Shishmaref, and Point Lay), the fall arrival of bears now occurs later, in January rather than December. It is not clear whether lack of multiyear ice is the primary cause of delayed arrival of polar bears in the area, as suggested by some hunters, or whether these phenomena simply co-occur.

Kalxdorff’s (1997) report, which focused on polar bear habitat use, does not provide a point of historical comparison regarding polar bear body condition. However, in our study, hunters were virtually unanimous in reporting that there has been no noticeable change in bear body condition over recent decades. Bears across the region appear to be in relatively good physical condition. These reports coincide with a recent study that observed no change in body condition and reproductive indices between polar bears captured in this region in 1986–94 and those captured in 2008–11 (Rode et al., 2014).

Bears that come directly into the village and whaling camps are more likely to be in poor condition than those that do not. Rather than linking the presence of these occasional skinny bears to a lack of feeding habitat and food due to ice loss, hunters tend to see these bears as young and inexperienced. Their lack of knowledge about how to survive is sometimes interpreted as a legacy of over-hunting prior to the 1970s, during which time many bears were orphaned before their mothers could teach them how to hunt. In this and other observations, hunters highlight the importance of considering both large-scale climate change and local socio-political factors affecting polar bear populations.

Hunters frequently spoke of a special class of “king bears,” unusually large and powerful male polar bears that

have been known to hunters for many generations, and which can still be found today. These reports converge with Western scientific observations that body masses and skull widths of adult males in the Chukchi Sea are among the highest of any reported for polar bears in the spring (Manning, 1971; Rode et al., 2014), including perhaps the largest male ever weighed in the spring, at 632 kg (USFWS, unpubl. data). Thus, adult males in this population can be of particularly large size. However, TK collected in Nunavut indicates that bears of this special class are also recognized there, where they are known as *nanurluit* (Keith et al., 2005), suggesting that the presence of extremely large male bears is not unique or limited to the CS population.

Differences in local abundance of polar bears exist both between villages and within the same village from year to year, suggesting that local abundance is dynamic, and that the number of bears observed in any given area is subject to highly localized factors. Kalxdorff's (1997) report does not provide a historical baseline of TK regarding local abundance. Nonetheless, hunters in our study were able to provide information on overall trends in abundance for each village, and some patterns emerged across the study area. Hunters described a period of reduced polar bear abundance during the sport-hunting era prior to passage of the Marine Mammal Protection Act in 1972. Local abundance then appears to have increased. Broadly speaking, this upward trend extended into the 1980s, before dropping off in the early 1990s. In some communities, the trend was discernible as early as the late 1980s. Since that time, there has been a noticeable downward trend in local abundance in some communities on the shores of the Chukchi and Bering Seas. Hunters attribute these declines in local abundance to poor sea ice conditions along the coast.

The downward trend in local abundance in some communities could be representative of an overall decline in CS population-level abundance; alternatively, it could indicate a redistribution of bears, as suggested by some hunters in our study. While a lack of change in body condition would suggest that bears are obtaining adequate food resources, the CS population could still be declining through harvest in Alaska, poaching on the Russian side, or other direct sources of mortality (Amstrup et al., 2006; Monnett and Gleason, 2006). Hunters tended to interpret the decline as evidence of redistribution as bears seek out food and habitat elsewhere, rather than as an overall reduction in population numbers, a view they share with Inuvialuit polar bear hunters in Sachs Harbour, Northwest Territories (Slavik, 2013), and IQ holders in Gjoa Haven, Nunavut (Keith et al., 2005), where declining local abundance is likewise understood as evidence of polar bear mobility. There are important exceptions to the downward trend in local abundance in our study area, such as the relative abundance of bears in several communities in 2012, a year noted for thicker ice, particularly near Point Hope. The overall trend in the Chukchi Sea polar bear population remains unknown.

Hunters in this study indicated that ringed and bearded seals continue to be polar bears' preferred prey (Kalxdorff,

1997), and this view is similarly supported by diet estimates for this population based on fatty acid analyses of tissue samples from captured bears (Rode et al., 2014). Additionally, hunters reported stable ringed and bearded seal populations, which were also reported by Quakenbush et al. (2011a, b) on the basis of body condition and reproductive data collected from harvested seals. Spotted seal consumption was not identified from tissue analyses, but the spotted seal was identified by hunters as an important prey species. This result could suggest limitations of the fatty acid technique, such as samples representing only a limited, seasonal dietary window, or an inability of this technique to adequately differentiate consumption of some species. Fatty acid analyses supported consumption of beluga whale (Rode et al., 2014), which hunters report are actively preyed upon by polar bears.

Hunters consistently reported that polar bears scavenge on carcasses of beluga whales, bowhead whales, gray whales, and walrus, which is consistent with fatty acid analyses of polar bear tissues except that gray whales were not detected as part of polar bear diets using fatty acids (Rode et al., 2014). A comparison of Kalxdorff's (1997) data with data from our study, however, strongly suggests reduced opportunities for bears to scavenge on ice-bound marine-mammal carcasses as a result of fragile or absent shorefast ice conditions. Some hunters believe that the lack of carcasses—and the resulting absence of bears—is due not only to changes in the ice, but also to enforcement action against illegal levels of subsistence walrus hunting in the early 1990s, which reduced the number of carcasses washing up on shore. Whether or not one shares this particular interpretation, such insights suggest that human action is very much part of the local ecosystem in north and northwest Alaska and may reshape polar bear habitat on fine scales and in unexpected ways. Polar bears also scavenge on trash from human settlements. Testimony of hunters in Wales suggests that bears are far more likely to have trash in their stomachs now than in the past, which could indicate that this kind of scavenging is increasing.

Summer land use reported by hunters in this study parallels long-term observations of summer land use by polar bears in this population on Wrangel and Herald Islands in Russia (Kochnev, 2002; Ovsyanikov and Menyushina, 2010). Use of terrestrial foods by polar bears in the summer has commonly been reported in the literature for a number of populations (Russell, 1975; Derocher et al., 1993; Rockwell and Gormezano, 2009). Lemelin et al. (2010) and Kakekaspan et al. (2010) documented Cree observations of polar bears hunting beavers, and Slavik (2013) documented observations of polar bears scavenging on muskoxen, caribou, and grass in the Inuvialuit Settlement Region. Use of terrestrial foods was also previously reported for the CS population in Alaska (Kalxdorff, 1997). The number of bears observed on land in western Alaska was not ascertained from interviews, but appeared to be relatively low. However, summertime land use and terrestrial feeding by at least some bears in this population appears to be common.

Hunters did not consider this to be a novel or growing phenomenon. Rather, they see it as an example of polar bears' usual ability to exist in diverse habitats.

Our study suggests that a greater diversity of terrestrial foods is consumed by CS bears than previously documented. Kalxdorff's (1997) study showed that bears eat crabs, clams, squirrels (*Spermophilus parryii*), seaweed, and birds on St. Lawrence Island. Our study added fish, caribou, eggs, crowberries, salmonberries, and "greens" to the list of terrestrial foods that bears have been observed eating in the region. The primary techniques used to estimate polar bear diets require identifying and including in statistical models all the potential prey items (Hilderbrand et al., 1996; Iverson et al., 2004). Thus, hunter reports provide critical information that is needed to inform quantified dietary estimates.

Several studies have suggested that terrestrial food resources are insufficient to meet the total energy requirements of a large proportion of a polar bear population (Hobson and Stirling, 1997; Rode et al., 2010) because foraging efficiency, energy density, and availability are low for most terrestrial foods. However, these land-based food resources may contribute calories, reducing loss of mass and body fat when sea ice, and therefore, ice seals, are unavailable (Rockwell and Gormezano, 2009), or they may help maintain mass for some individuals depending on body size and resource abundance (Welch et al., 1997; Rode et al., 2001; Dyck and Kebreab, 2009). Condition of bears on land may be a combination of their access to seals while on the ice prior to the summer ice minimum (Ovsyanikov and Menyushina, 2010) and access to alternative foods while on shore.

Hunters from the four most southerly villages in our study reported few or no denning observations; the denning that does occur in this region is contingent on accumulation of adequately deep snowdrifts. As in Kalxdorff's (1997) study, St. Lawrence Island in particular had a paucity of dens. Stories about hunters catching bears in dens in the 1940s and 1950s led some hunters to suggest that dens may have been more common on the island at that time. However, these stories could also simply reflect the fact that when bears were hunted in dens, hunters sought out and observed dens more frequently. Like any other way of knowing, TK has limitations. TK is created and practiced through subsistence activities on the land. When patterns of subsistence use change, the kinds of knowledge that people cultivate also changes, making comparisons difficult.

However, the reported lack of dens in the study area today is consistent with previous scientific studies showing that polar bears in the Chukchi Sea den on land or near shore in western Alaska infrequently. Documentation of land-based denning in western Alaska based on radio-tracked bears has been rare (Lentfer and Hensel, 1980; Garner et al., 1990). The majority of denning by the Chukchi subpopulation is believed to occur on Wrangel and Herald Islands (Garner et al., 1994), with some additional denning on the Chukotkan coast.

Reproductive denning was reported more frequently around Point Lay, and Point Lay hunters named Cape Beaufort as a well-known denning area in both Kalxdorff's (1997) study and our own. While hunters were not able in all cases to classify dens definitively as reproductive (as opposed to temporary resting dens) (Ferguson et al., 2000), they drew on the presence of cub tracks near dens, as well as location in previously known maternal denning areas, as indications that a particular den was likely to be reproductive. Point Lay is located in an area known to overlap with the Southern Beaufort Sea polar bear population, which has increasingly denned on land in recent years (Fischbach et al., 2007) and is known to den in this region (Amstrup and Gardner, 1994).

Although we were not seeking information on interspecific interactions of polar bears, hunters offered observations of interactions between grizzly and polar bears that parallel recent observations on Alaska's North Slope. On the North Slope, polar bears interact with grizzly bears primarily at subsistence-harvested bowhead whale carcasses (Miller et al., 2006). Grizzly bears have also been observed consuming seals on the ice off the Alaska North Slope and Northwest Territories coasts (R. Shideler, pers. comm. 2012; E. Richardson, pers. comm. 2013). As was similarly observed by hunters in this study, grizzly bears at marine mammal carcasses in the fall are aggressive towards polar bears and tend to outcompete them for food resources (Miller et al., 2006).

Human use of polar bears may be decreasing in many communities because of synergistic ecological and social factors. The effect of lack of bears around many villages is compounded by hunters' tendency to lose interest in polar bear hunting when they perceive that there are fewer bears around. The price of gasoline does not appear to overwhelmingly influence levels of polar bear hunting, perhaps because bears are often hunted opportunistically in the course of other subsistence activities. However, polar bear hunting is costly in other ways; it is difficult and time-consuming and is often done in the coldest, darkest time of year. Processing polar bears is also hard work and historically has been the responsibility of women. In terms of both hunting and processing, many people may no longer be inclined to take part in this activity, especially as the preference for eating polar bear meat is increasingly restricted to Elders.

There are fewer active polar bear hunters today, and the average number of bears hunted per active hunter has decreased compared to previous generations. Hunter reports in this study mirror harvest records collected by the USFWS, which similarly demonstrate a general decline in polar bear harvest by communities in the Chukchi and northern Bering Seas since the 1980s (USFWS, unpubl. data). However, our study shows that this trend is temporarily reversed in years when polar bears are unusually abundant in the vicinity of the village, as occurred in Point Hope in 2012. When more bears are present, interest in bear hunting also grows. In turn, more community

members—especially youth—acquire a taste for polar bear meat and a willingness to put effort into polar bear hunting in the future.

In our study, TK and previous scientific studies about the CS polar bear population are in concordance on many matters, such as the continued good condition of polar bears in the CS range, the existence of particularly large male bears in this population, dietary preferences, and the continued lack of denning in this area. Because of the difficulty of studying CS polar bears through conventional field methods, and because accurate knowledge of the population is central to successful implementation of the voluntary hunting quota under the U.S.-Russia Agreement, these are important points of convergence.

Moving beyond concordance, hunters also provided information about local abundance that is complementary to research on larger scales (Huntington et al., 2004; Gagnon and Berteaux, 2009), but which could not have been gained in any other way. Given the highly variable patterns of local bear abundance and distribution, this study demonstrates the importance of analyzing the effects of Arctic sea ice loss on polar bears at fine spatial scales. This study included most of the Alaska Native communities located within the range of the CS population. Future research should extend this community cluster approach (Dowsley, 2009) to studying polar bears by coordinating and integrating TK collected in communities on both the Alaskan and Russian sides of the CS range.

In this study, we worked against the tendency to extract TK as data without accounting for the way in which TK holders contextualize and interpret that data (Cruikshank, 2005). Indeed, we believe that these local interpretations are powerful for their ability to identify linkages, generate hypotheses, and open up avenues of continued research. In the case of polar bears on the Bering and Chukchi Seas, some potential hypotheses are that lack of multiyear icebergs is connected to the delayed arrival of polar bears, that disruption of polar bear family groups may be a factor pushing young or hungry bears into human settlements, and that CS polar bears may eat a wider range of terrestrial foods than was previously thought.

CONCLUSIONS

Polar bear hunters in communities along Alaska's northern Bering Sea and Chukchi Sea coast have observed changes in polar bear distribution, timing of seasonal movement patterns, and local abundance in recent years. In all communities except Point Hope, there has been either stability or decline in local abundance since the 1980s and 1990s. However, abundance has fluctuated dramatically in recent years, making patterns difficult to identify and future abundance difficult to predict.

Large blue "icebergs," or pieces of multiyear ice, used to arrive from the north in the late fall and winter and provided polar bear feeding habitat, but now are rarely seen.

Shorefast ice is less extensive and is easily broken up and dispersed by wind. As a result, there are fewer ice-bound marine mammal carcasses for polar bears to feed on over the winter. Overall, hunters find both ice conditions and the presence of bears from year to year to be increasingly unpredictable. Polar bears' fall migration into the study area is occurring several weeks later than it used to in at least three communities. Over-summering by some bears occurs, but this does not appear to be a new phenomenon.

Despite these changes, bears have remained in good physical condition throughout the study area. With the exception of reduced winter scavenging opportunities, feeding behavior appears to be unchanged. However, our study expanded the list of terrestrial foods that polar bears have been observed to eat in the region during the summer. In general, hunters described a high degree of flexibility in polar bears' ability to adapt and survive amidst difficult and changing environmental conditions. Although polar bears remain symbolically and materially important to coastal communities of this region, hunters did express a decline in interest and effort to hunt polar bears for a variety of reasons.

In Iñupiaq and Siberian Yupik culture, it is important for hunters to avoid speculating about the future. The future is unknown, and because of this, it is believed that one should be humble about one's abilities to predict what will happen, and not expect any one particular outcome over another. Following these cultural norms, hunters caution that the ultimate impact of ice loss on polar bears is not yet fully clear. The great respect that people hold for polar bears grows in part out of the species' ability to find clever ways of adapting and surviving amidst very difficult conditions. It is this respect for polar bears that leaves hunters with a degree of optimism about the polar bears' future.

ACKNOWLEDGEMENTS

This project was initiated through the vision and determination of the Alaska Nanuq Commission (ANC) and the U.S. Fish and Wildlife Service (USFWS). The ANC's relationships with hunters and local communities made this study possible. All interviews, data collection, and data summarization were conducted by the ANC. Funding was provided by the National Fish and Wildlife Foundation and the USFWS.

The ANC is indebted to all participants who generously shared their knowledge about polar bears with us. For full acknowledgement of individual hunters' contributions, see Voorhees and Sparks (2012), available online at <http://thealaskananuqcommission.org>. The support of tribal councils in each village made this research possible. We also thank ANC village commissioners, who went out of their way to facilitate our communication with hunters.

The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the USFWS.

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