

Participatory assessment of aklak (Grizzly bear, *Ursus arctos*) abundance and distribution in the Kivalliq Region, Nunavut

Final Report, ECCC contract # 3000713560

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January 2025

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Abstract

Aklak (grizzly bear, *Ursus arctos*) are viewed by residents of the Kivalliq region, Nunavut, as increasing in abundance across the region. We used semi-structured interviews and participatory mapping exercises to elicit narratives of encounters, estimates of spatial distribution and abundance, and knowledge of aklak ecology from Inuit hunters and elders. Participants uniformly emphasized an increase in the relative abundance of aklak across the Kivalliq region since the beginning of the twentieth century, with rare encounters prior to the 1960s but frequent encounters from the 1990s onward. Participants emphasized that aklak were not historically abundant in the Kivalliq, suggesting a range expansion rather than a population in recovery. The distribution of aklak was primarily inland, where encounters frequently occurred along lakes and rivers; however, sightings in coastal areas have become more common. Aklak densities were calculated from both interview data alone and interview data plus DNA sampling grid hits (Awan et al. 2019) using inverse distance weighting and Empirical Bayesian Kriging (2.88-4.07 bears/1000km²) for a total abundance of 1081-1515 bears in the study area. Both estimates are within the 95% CI range estimated previously by Awan et al. (2019) of 2.1-6.1 bears/1000km² and are similar to other previous studies in similar habitat. Further exploration of this new estimation method would be useful. The socio-ecological context of the Kivalliq is not analogous to other regions in Canada, and study participants emphasized that management policies and practices for aklak should be distinctive to the region's context.

Résumé

Selon les résidents de la région de Kivalliq, au Nunavut, l'abondance d'aklaks (grizzli, *Ursus arctos*) a augmenté dans l'ensemble de la région. Nous avons eu recours à des entrevues semi-structurées et à des exercices de cartographie participative pour obtenir de chasseurs inuits et d'âînés des récits de rencontres, des estimations de la répartition spatiale et de l'abondance et des connaissances du milieu écologique de l'aklak. Les participants ont rapporté de façon unanime une augmentation de l'abondance relative de l'aklak dans l'ensemble de la région de Kivalliq depuis le début du vingtième siècle, les rencontres ayant été rares avant les années 1960, mais fréquentes depuis les années 1990. Les participants ont insisté pour dire que l'aklak n'a jamais été abondant dans les environs de Kivalliq, ce qui suggère une expansion de l'aire de répartition plutôt qu'une population en voie de rétablissement. La répartition de l'aklak se limitait surtout à l'intérieur des terres, et les rencontres se produisaient fréquemment le long des lacs et des rivières; cependant, les observations dans les zones côtières sont devenues plus fréquentes. Les densités ont été calculées à partir des données recueillies lors des entrevues elles-mêmes et des données tirées des entrevues en plus des occurrences de la grille d'échantillonnage de l'ADN (Awan et coll. 2019) en utilisant la pondération de la distance inverse et le krigeage bayésien empirique (2,88 à 4,07 ours/1 000 km²) pour une abondance totale de 1 081 à 1 515 ours dans la zone étudiée. Les deux estimations se situent dans l'IC de 95 % estimée précédemment par Awan et coll. (2019) de 2,1 à 6,1 ours/1 000 km² et sont similaires à celles des autres

études semblables pour un habitat semblable. Un approfondissement de cette nouvelle méthode d'estimation serait utile. Le contexte socioécologique de Kivalliq ne s'apparente en rien aux autres régions du Canada, et les participants de l'étude ont souligné que les politiques et pratiques en matière de gestion de l'aklak devraient être adaptées au contexte particulier de la région.

- Atuqhugit qitqani inuit aklaklu hilait atuqtaujut kuukap uvalu tahiitlu.
- Angunnahuaknirmun aklak tautukhimajunik uumajunik ilaujunik pihimajunik amigaitilaangit angiklivalialiqnun.
- Qaffiutilaangit pittailijakhaillu aklak angunahuarniq ihumagijaungittut akhuraaluk piiqtaulimaittuqluuniit nunamiknit.
- Qaffiunigit aklak nunaujarmit Inuit takujainik nalaumajunik nanijaujunik hivuanit ilituqhaunmit naunajagaujut DNA-nik aklak amiqmit mitquinik qiuknik napaqutinik atuliqhimajut nunami.
- Inuit atuqhimaatqangit anguniarniq, angunahuarniq, pirlukhutiklu tuktu, iqhitaatqaujut amigairjumiqtumit nunami amigaitni, atuqattaqhugit amiqhaat pirujat igluqpannuallu qajangnaqhivaktut pittailiplugillu hapkuat pirujat.
- Havaanga aklak inuuhiqmut-pijuj nunanga Kivallirmi avikturhimajuq aadlangajuq aadlanit aviktuqhimajunit Kaanatami.
- Amigaiqpalianigit atuqtait, ilaujut takuvaktut aklak-mik nuutqaqtitiniganik inuuhiqmi inuujuhiqmilu atuqtumik, ukuagugituq aalatqiit ihariagijauniginik angunahuarutikharnik nuutqaqtitijutinik.

Plain language summary

- Study objective: elicit local knowledge of aklak abundance, distribution and ecology in the Kivalliq region and use insights from Inuit Qaujimagatuqangit (IQ) to complement existing scientific data to inform wildlife management practices.
- In 2022-2023, locally hired Inuit research assistants conducted interviews in Arviat and Baker Lake (Qamani'tuaq), with workshops held in early 2023. Additionally, previous interviews provided by the Baker Lake Hunters and Trappers Organization (HTO) were included in the analysis. Both Baker Lake (Qamani'tuaq) and Arviat participants attested to increases in human encounters with aklak across the Kivalliq region since at least the 1990s and perhaps as early as the 1960s.
- Encounters between humans and aklak tend to occur along rivers and lakeshores.
- The harvest of aklak is viewed as sustainable by participants as the population is increasing.
- Quotas and restrictions on aklak harvest are considered not pragmatic or desirable by community members.
- The number of aklak from mapping Inuit observations aligns with findings from a previous study that sampled DNA from aklak hair snagged on wooden tripod posts deployed on the land.

- Inuit practices around hunting, harvesting, and caching caribou, are threatened by an increase in aklak abundance, as more frequent encounters with aklak scavenging caches and cabins pose safety risks and disrupt these practices.
- The role of aklak in the socio-ecological landscape of the Kivalliq region is distinct from that in other regions in Canada.
- With increasing encounters, participants view aklak as a disruption to the socio-ecological system, rather than as a species in need of conservation interventions.

Résumé en langage simple

- Objectif de l'étude : recueillir des connaissances locales sur l'abondance de l'aklak, sa répartition et son milieu écologique dans la région de Kivalliq et tirer parti des perspectives issues de l'Inuit Qaujimagatuqangit (IQ) pour bonifier les données scientifiques actuelles afin d'orienter les pratiques en matière de gestion des espèces sauvages.
- En 2022-2023, des assistants de recherche inuits embauchés localement ont mené des entrevues à Arviat et à Baker Lake (Qamani'tuaq) et ont animé des ateliers au début de 2023. De plus, des entrevues réalisées précédemment par l'organisation de chasseurs et de trappeurs (OCT) de Baker Lake ont été incluses dans l'analyse. Les participants de Baker Lake (Qamani'tuaq) et d'Arviat ont tous confirmé une augmentation du nombre d'humains ayant rencontré un aklak dans l'ensemble de la région de Kivalliq depuis au moins les années 1990, et peut-être même depuis les années 1960.
- Les rencontres entre un humain et un aklak ont tendance à se produire le long des lacs et des rivières.
- La récolte de l'aklak est perçue comme étant durable par les participants puisque la population augmente.
- Selon les membres des collectivités, les quotas et les restrictions visant la récolte de l'aklak ne sont ni pragmatiques ni souhaitables.
- Le nombre de spécimens de l'aklak, d'après la cartographie tirée des observations inuites, est conforme aux conclusions d'une étude précédente qui avait prélevé des échantillons d'ADN des poils de l'aklak accrochés à des trépieds en bois déployés dans les terres.
- Les pratiques inuites en matière de chasse, de récolte et de cache pour le caribou, sont menacées par une augmentation de l'abondance de l'aklak, puisque les rencontres plus fréquentes avec l'aklak détruisant les caches et les cabanes présentent un risque pour la sécurité et perturbent ces pratiques.
- Le rôle de l'aklak dans le paysage socioécologique de la région de Kivalliq est différent de celui qu'il joue dans d'autres régions du Canada.

- En raison de l'augmentation des rencontres avec l'aklak, les participants le perçoivent comme une perturbation du milieu socioécologique et non comme une espèce devant faire l'objet d'efforts de conservation.

Background

Members of the HTOs of Baker Lake (Qamani'tuaq) and Arviat have shared that they have witnessed an increase in aklak⁷ abundance in the Kivalliq region for approximately the last fifty years (Clark and Slocombe 2011; Lokken et al. 2019). Community members have expressed concerns about human-wildlife conflict, as aklak cause damage to hunting cabins, dig up caches of caribou meat, and can pose risks to community safety (Nirlungayuk 2011; Manning 2022).

Climate change is impacting northern wildlife population dynamics (Humphries et al. 2004) and Indigenous communities are well-positioned to observe and interpret these changes (Etiendem et al. 2020; Henri et al. 2020; Jessen et al. 2022; Tomaselli et al. 2018). Furthermore, as pointed out by McLoughlin and Stenhouse (2021, 51), more information is needed to understand how climate change may be contributing to improved ecological conditions for aklak and shaping the dynamics of their range expansion in this region. The increasing population in the Kivalliq region provides a contrast to other areas in Canada with the implication that management strategies for this region ought to significantly differ from other regions (McLoughlin and Stenhouse 2021, 48-51).

Like all communities in Nunavut, the hamlets of Arviat and Baker Lake were formed as a result of Canadian government-driven relocations of Inuit people in the 1950s and 1960s (Tester and Kulchyski 2011). Arviat is now home to descendants of the Paallirmiut, who traditionally hunted in both inland and coastal areas, and Ihalmiut, whose territories lay inland near Ennadai Lake. Qamani'tuaq is home to eleven Inuit groups, including the coastal Utkuhiksalingmiut, Qaingningmiut, Paallirmiut, Natsilingmiut, Killirnirmiut, Iluilirmiut, Hanuniqtuurmiut and the inland Harvaqtuurmiut, Haningajurmiut, Akilirmiut, and Ahiarmiut. The latter inland-oriented groups were known in the ethnographic literature as the Caribou Inuit due to their inland orientation and reliance on terrestrial mammals like caribou for subsistence (Tester and Kulchyski 2011). Inuit culture is deeply rooted in hunting, with knowledge of wildlife behaviour and distribution vital for Inuit survival.

Many of the Elders interviewed for this study were born on the land before the settlement of the hamlets and are fluent in their group's particular dialect of Inuktitut. Thus, they have access to knowledge gained from both their own long experiences on the land and knowledge passed on through oral traditions. Arviat, the southernmost mainland community in Nunavut, and Baker Lake, the only inland community. Prior to forced relocation in the 1950s, many of the Elders in the Kivalliq were members of inland-oriented Inuit groups. This is in contrast to other communities in Nunavut, which are coastal and oriented towards marine resources (while also still using inland resources). All participants asserted that aklak were more likely to be found inland, therefore community members in Baker Lake and Arviat have greater familiarity with the inland areas where aklak are more often found. Historically, aklak encounters were rare, but they were still known to Inuit communities: *“living and seeing with grizzly bears have always been in part of Inuit life”* (Norman Attungala, Baker Lake 2003).

⁷ The terms “aklak” and “grizzly bear” will be used interchangeably throughout this report.

Objectives

The overall purpose of this study is to estimate grizzly bear abundance and distribution in the Kivalliq region by consulting Inuit Qaujimajatuqangit on aklak with existing scientific data and presenting the findings in ways that inform grizzly bear co-management. These two biological parameters are identified as monitoring priorities in the Co-Management Plan (Government of Nunavut 2017, 14).

Objectives of this study were to:

1. Generate estimates of grizzly bear abundance and changes in distribution through participatory exercises with HTO members in Arviat and Baker Lake.
2. Document Inuit observations and understanding of grizzly bear population trends, distribution, ecology, and the social, economic, cultural, and biological aspects of coexisting with grizzly bears— (including perceptions of risk, hunting practices, predation on caribou, human-bear conflicts, and effects of climate change).
3. Compare new data with past data from Baker Lake, specifically HTO's 2002 interviews (if available), Clark's 2003 interviews, and Loken's 2014 TUNDRA interviews to identify changes and shifts in social tolerance for grizzlies in the region.

Methods

Individual semi-structured interviews

Semi-structured interviews were selected as appropriate given the cross-cultural context of research, small sample size, and our research goal to both elicit and respect Inuit Qaujimagatuqangit. Semi-structured interviews were conducted locally in Baker Lake (n=6) and Arviat (n=16). Questions revolved around participant observations of aklak abundance, distribution, ecology, and conflict with humans. Individual interviews were conducted by Emil Arnalak in Arviat and Russell Toolooktook in Baker Lake from April 2022 to February 2023 a local community member in either English or Inuktitut, based on participant preference, with most conducted in Inuktitut. Interviews were translated by local research assistant, Emil Arnalak, while Dr. Lauren Harding transcribed those conducted in English. Inuktitut interviews of 2002 from Baker Lake are still undergoing translation at the time of this report.

In addition to the data from community-based interviews in 2023, this study includes past interviews conducted in Qamani'tuaq in 2002 by Natasha Thorpe with Golder & Associates, translated by Lizzie Iblauk (n=1), and interviews conducted by Douglas Clark during his doctoral research in 2003 (n=12; Clark and Slocombe 2011). More interviews are undergoing translation, which once received will expand the temporal range and scope of our data set from Qamani'tuaq. NVivo software was used to conduct thematic analysis, identifying key themes and observations that emerged from the qualitative interview data.

Participatory mapping

Participatory mapping was a key method used in this study to capture Inuit knowledge and perceptions of aklak distribution. During each individual interview participants used markers to draw on a topographic map with a clear overlay to mark locations where they had encountered aklak and indicating areas where they believed aklak were likely or unlikely to be found (Figure 1). Standard topographic maps were used as base maps, and spatial categories emerged through dialogue with the participants and were not pre-determined by researchers. This approach aligns with established participatory mapping methods that seek to represent local perceptions of the landscape and allow for the cultural contextualization of data when possible and appropriate (Ernoul et al. 2018; Riddell et al. 2022; Robinson et al. 2016). The maps also provided a useful tool for the elicitation of place-based qualitative data. Qualitative spatial data was collected and marked on the map throughout the interview process, including areas of human-wildlife conflict (i.e., cabin break-ins) and known denning sites. The map overlays were digitized and integrated into spatial database by a geospatial analyst at Caslys Consulting (B.C.), ensuring the data was aligned with the geospatial framework of the study.



FIGURE 1. EXAMPLE OF PARTICIPATORY MAPPING EXERCISE.

Focus groups

The second phase of data collection employed focus groups and proportional piling methods to validate initial findings and gain deeper insights into aklak distribution and abundance. Focus group interviews were conducted in Arviat (n=6) and Baker Lake (n=2) in February 2023 during a community visit by Dr. Harding. In addition to the continued collection and confirmation of qualitative data on aklak, a second participatory mapping exercise was carried out oriented towards capturing relative abundance and spatial distribution.

Using proportional piling methods, participants collectively estimated aklak density on a topographic map (Figure 2), placing beads to represent relative abundance categories of 'few' or 'many'. Photographs of estimated aklak density from the group interviews was combined with participatory mapping data from individual interviews. A second proportional piling method was attempted in Arviat to graph change in population over time, but participants rejected this method in favour of a narrative approach to discuss changing abundance. Focus group sessions were recorded, transcribed, and thematically analyzed using NVivo software.

Proportional piling has been used effectively for estimating abundance of wildlife that congregate in groups like ungulates (Tomaselli et al. 2018) but may not be an effective method for estimating abundance of wildlife species like aklak which are encountered sporadically and individually. However, this method remains useful for this study as it enables participants to convey their perceptions of relative abundance across the landscape, offering valuable qualitative insights into aklak distribution patterns.

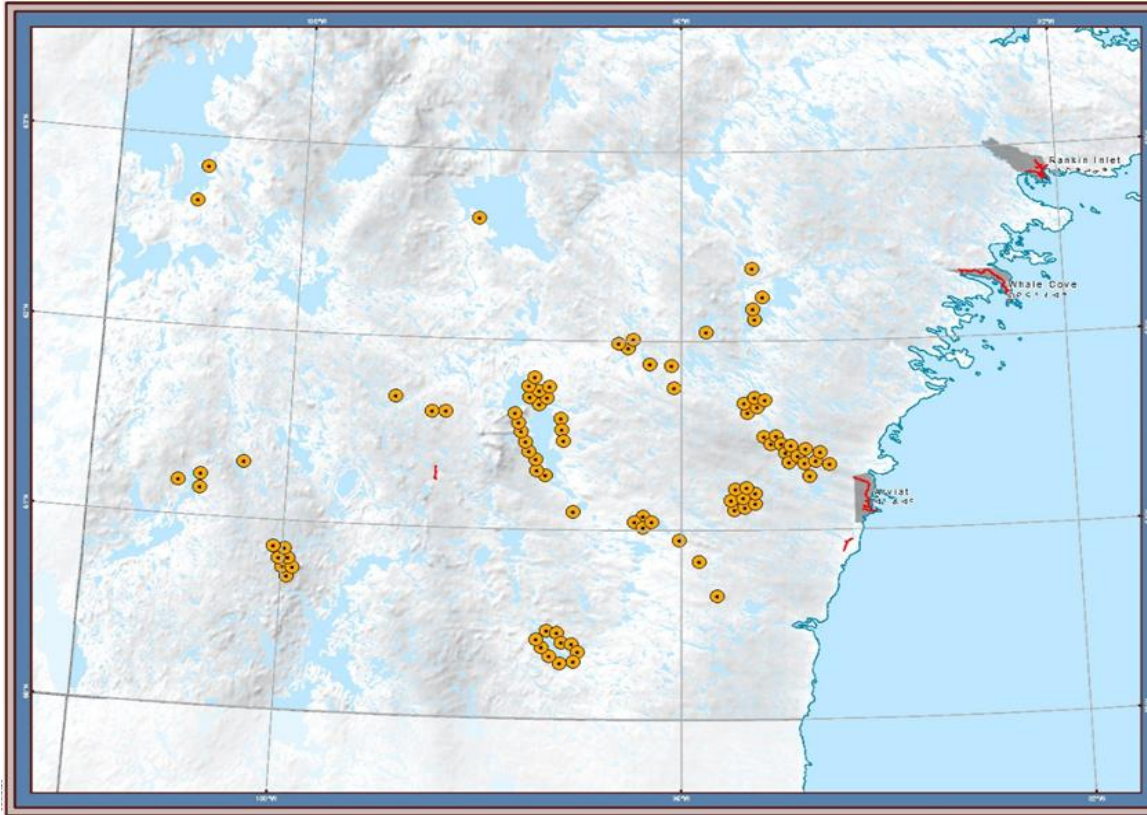


FIGURE 2. ARVIAT FOCUS GROUP PROPORTIONAL PILING EXERCISE.

Recruitment and participation

A list of potential participants in each community was created by the Government of Nunavut (GN) Department of Environment (ENV) and HTO board, who were then invited to give interviews in the wildlife office. This study faced several delays due to the need for face-to-face interviews, which were difficult to conduct during the COVID-19 pandemic. Focus group interview participation in Arviat was moderate with ten participants and participation in Baker Lake was low with two participants. The latter may be attributed to poor weather conditions, as it was communicated to the researchers that several Elders did not want to leave their homes in the high winds and low temperatures (windchill of -67 degrees Celsius) present during the one day allocated for the focus group.

Community validation

Several strategies have been employed in this study to ensure that participant contributions are accurately represented. This includes the use of a local interviewer in each community, which helps preserve the linguistic and cultural context of knowledge communication, as well as the fact that participants were invited from a list of acknowledged community experts generated by the GN, ENV and Inuit HTO.

Prior to visiting Arviat and Baker Lake, Harding reviewed the collected interviews and prepared a list of clarifying questions for focus group participants. During the focus groups, these questions were asked to

clarify or expand on statements from the semi-structured interviews, as well as to better understand whether there was any disagreement or consensus among participants on the major themes that emerged. It should be noted that, as an 'outsider,' Dr. Harding was unlikely to observe dissenting opinions or internal community conflicts during the short interactions she had with participants. At the same time, a second attempt at community validation will occur when the contents of this report are shared with both participants and the wider community in Arviat and Baker Lake. We hope to circulate the contents of the final report in both English and Inuktitut and make use of digital storytelling tools to disseminate the study results in forms that are accessible and culturally appropriate.

Inuit Qaujimajatuqangit in this study context

This study explicitly engaged with Inuit Qaujimajatuqangit (IQ), in keeping with the Government of Nunavut's objective to integrate Inuit values across government programs and services. This approach also supports the specific goal of using IQ as expressed in the GN's Grizzly Bear Co-Management Plan (Government of Nunavut 2017).

The term Inuit Qaujimajatuqangit encompasses all aspects of traditional Inuit culture including values, worldview, language, social organization, knowledge, life skills, perceptions and expectations (Wenzel 2004, 240). It is a purposefully holistic and fluid concept, reflecting the intertwining of values, tradition, skill, and knowledge in Inuit expertise, as well as the continued expansion of Inuit knowledge through lived experience (Greene 2021, 198). It cannot simply be equated with "traditional ecological knowledge" (TEK) as it includes knowledge disseminated through ongoing oral traditions, knowledge accumulated through personal experience, and the interpretation of knowledge through the lens of Inuit values (Greene 2021, 207; Oosten and Miller 2018). Furthermore, IQ is relational, meaning the social relationship between speaker and listener influences its content and so cannot be separated from the social context in which it is articulated (Tester and Irniq 2008). For wildlife management, it is important to recognize that, for Inuit people, relations with non-human animals are both social and subsistence-based (Laugrand and Oosten 2022; Rasing 2018, 6-8).

It should be noted that IQ, as a formalized concept, has "predominately pertained to the interface between foreign-imposed non-Inuit governance and Inuit culture" (Greene 2021, 209). As such, our interpretation of IQ and the articulation of Qaujimajatuqangit by our research participants are artefacts of cross-cultural encounters. What this means is that we, as the authors of this study, are not attempting to conclusively represent IQ on aklak, but rather are collaboratively articulating knowledge on aklak that study participants considered useful, important, and of interest to non-Inuit researchers, policy makers, co-management and conservation practitioners.

Much of the interview data was collected in Inuktitut and the process of translation can impact the interpretation of qualitative data, especially in a cross-cultural context (Hennink 2008, 21). We wish to acknowledge these barriers to interpretation, but also highlight our attempts to counter it with community validation, as this reflexivity and transparency is key to scholarly rigor in qualitative methodologies (Hennink 2008, 22).

An important methodological consideration in this research is our efforts to address to what Pfeifer (2018, 29) has termed the 'credibility gap,' where Inuit knowledge "does not have [the same] credibility compared to Western academic knowledge". Pfeifer argues that there is a need to recognize Inuit knowledge and everyday practices on the land as "a qualitative mode of inquiry producing scientific

evidence” and Inuit communities (hunters/harvesters/knowledge keepers) as equally valid references as those esteemed by academic publication standards (Pfeifer 2018, 31). This is particularly important given the impetus to decolonize research relations and the proven insights of Indigenous science in understanding complex socio-ecological systems (Reid et al. 2022; Turner et al. 2022). While the interview data collected in this study is descriptive and qualitative, it provides important insights that can:

1. be investigated quantitatively (below),
2. complement existing scientific data, and
3. direct future research priorities.

Furthermore, Inuit Qaujimagatuqangit is useful for managers attempting to understand temporal and spatial patterns in wildlife harvest, establish baselines to understand the rapid change happening in Arctic ecosystems, and understand community impacts of ecological change (Etiendem et al. 2020).

Quantitative abundance assessment methods

Defining the study area

The study area was defined by the geographic extent of all mapped data collected during the interview process (Figure 3). It includes the southern portion of Nunavut, with its northern boundary set by drawing a horizontal line from east to west at the latitude of the northernmost mapped interview observation.

Abundance estimation process

Data overview

The purpose of this segment of the project was to estimate the total number of aklak within the study area using knowledge collected on physical maps during interviews with community members and hunters. In addition to this primary data source, we incorporated two additional datasets on aklak locations within the study area for the period of interest. The first was derived from a DNA capture-recapture study conducted in 2016 and 2017 (Awan et al. 2019), and the second comprised GN, ENV harvest data spanning from 2008 to 2023. While all datasets fell within the defined study area, the coverage of aklak locations within each dataset differed. Figure 4 displays the distribution of each of the three datasets across and within the study area, with the DNA capture-recapture study represented by blocks, while the other two datasets are depicted as points.



FIGURE 3. THE STUDY AREA IS DELINEATED BY THE GREEN BOUNDARY, WITH ITS SOUTHERN EDGE DEFINED BY NUNAVUT BORDER AND ITS NORTHERN LIMIT EXTENDING TO THE NORTHERNMOST INTERVIEW DATAPPOINT.

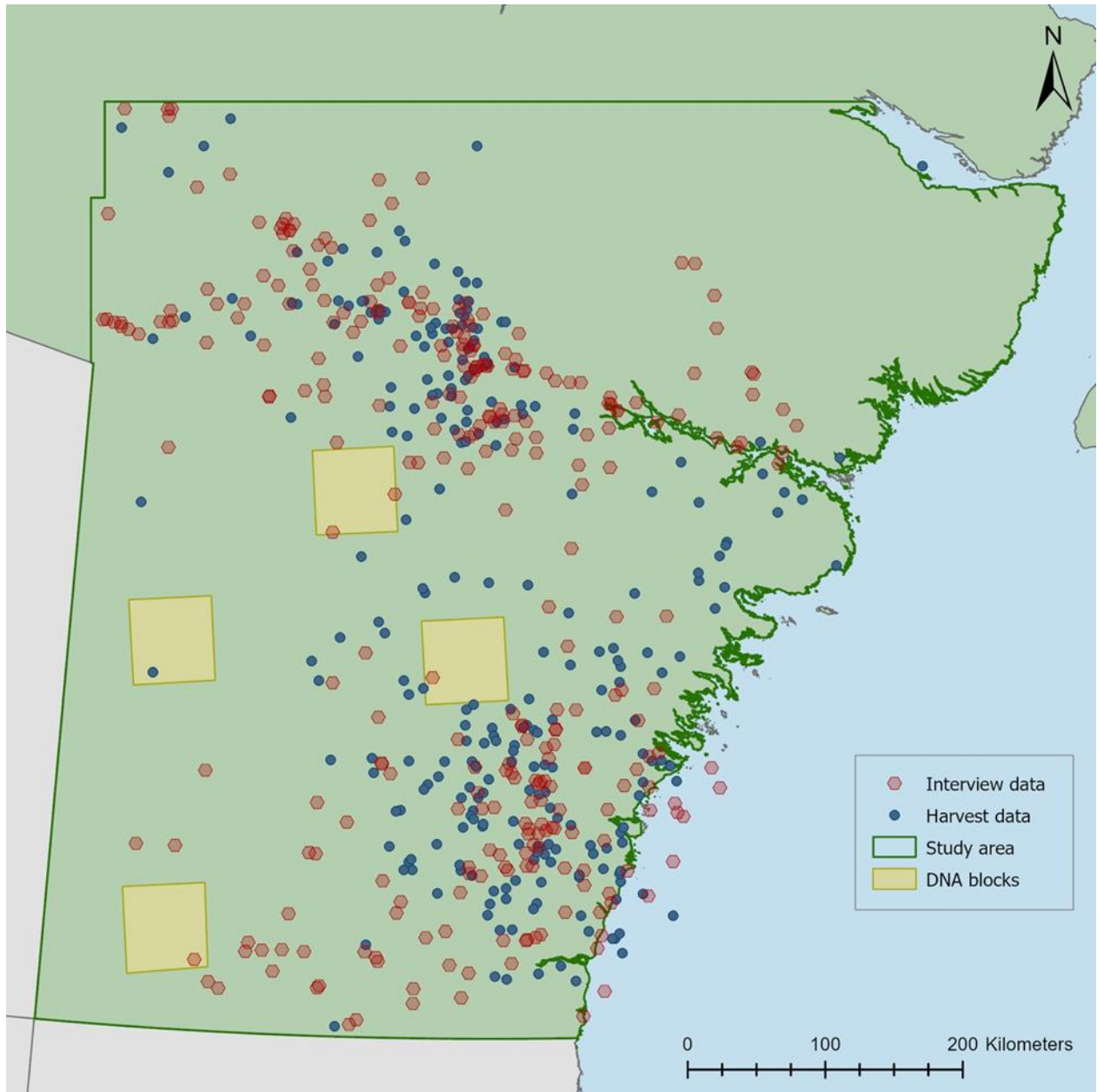


FIGURE 4. THE DISTRIBUTION OF THE THREE INPUT DATASETS, INCLUDING ALL INTERVIEW DATAPPOINTS, HARVEST DATA, AND THE STUDY BLOCKS USED FROM THE AWAN ET AL. (2019) MARK-RECAPTURE STUDY.

Notably, data collected based on people's reported land use practices (the interview data and harvest data) largely overlaps, while data collected by Awan et al. (2019) using DNA capture-recapture does not intersect with the distribution of the other two datasets. Based on the distributions of the datasets, we identified the DNA study data as having the potential to complement the interview data in the spatial interpolation process. We determined that the harvest data was likely to overlap with the interview data not only in spatial extent, but also in individual aklak sightings (as interviewees reported places where aklak were harvested as well as observed in other contexts). Therefore, while the harvest data was not appropriate for use in the spatial interpolation process, it could be used as an alternative data source for abundance estimation via spatial interpolation.

Cleaning and processing interview data

The first step in the abundance estimation process involved cleaning and processing the interview data. All interview data were digitized using ArcGIS Pro software and saved into a geodatabase. Data points were digitized in two ways. First, vector shapefiles were created to accurately capture all map elements added by participants, including point, line, or polygon features. This required that interview data were digitized and saved into three separate feature classes (point, line, and polygon) depending on the feature type. Attribute tables were used to ascribe additional data to each feature, including an anonymized participant code; a description of the feature class (point, line, or polygon); and any comments that were added to the map for contextualization along with the feature. Second, all datapoints were compiled into a single feature class. This required that line and polygon features were transformed into points by calculating the centroid of each shape. Once all datapoints were compiled into a single feature class, the attribute table was exported, and data processing continued using Microsoft Excel.

The original maps produced in the interviews were consulted along with the feature comments to further categorize the data in Microsoft Excel. First, features were categorized according to whether they identified aklak signs, sightings, or something else (e.g., some participants noted typical aklak travel routes or geological features like eskers). Signs were further categorized by type, and columns were created to account for temporal data, including one for the year that the observation was made and one for the season (e.g., spring, summer, fall, or winter). Finally, a numeric column was created to store an estimate of the number of bears seen for each datapoint that constituted a sighting. For datapoints that suggested sightings but did not explicitly provide information about the number of aklak seen, conservative estimates were made using proxies (Table 1). Because the interviews produced qualitative data, we were conscientious in assigning numeric values to non-quantitative data points, including by keeping track of all assumptions with the justifications that informed decision-making in assigning proxy values throughout this process. Data points containing locations of aklak sightings (and locations of aklak signs that were "counted" as sightings) were taken forward for use in the spatial interpolation process.

Importantly, interviewees consistently observed that the abundance and locations of grizzly bears in the region had notably changed during the decade of the 1990s. As we are interested in recent aklak abundance, we removed aklak sightings made prior to the year 1990 from the dataset to be used for interpolation.

Using the single feature class containing all spatial data collected in interviews, we applied a kernel density calculation in ArcGIS Pro to produce a raster that contained information about the density of interview observations across the study area. The raster was classified using natural breaks into ten

classes, and the bottom three classes (areas with the lowest observation density) were removed. The resulting area represented our “observation zone,” which was used to differentiate between regions of the study area for which there was substantial local knowledge about aklak abundance and regions for which aklak abundance was largely unknown to local populations. In essence, the observation zone represents participants’ land use patterns. The goal of the abundance estimation process thus requires using data contained in the observation zone (or “known” regions) to project aklak distribution in the areas of the study area outside of the observation zone (the “unknown” regions) using spatial interpolation, and then summing aklak abundance inside and outside the observation zone to produce a total abundance estimate within the study area.

TABLE 1. PROCESS FOR ASCRIBING PROXY VALUES TO AKLAK SIGHTINGS WITHOUT A DISCRETE NUMBER NOTED.

Key Words	Proxy	Number Used	Justification
grizzly with cubs; family; bear with cubs	Yes	3	Cub of the year litter size average: 2.23. Yearling litter size average: 1.86. Two-year-old litter size average: 1.85. Average family grouping will thus contain 3 bears (1 mother, 2 cubs). (McLoughlin and Messier, 2001).
lots of; more; grizzly area; grizzlies like it here; core area; main area	Yes	3	More than one sighting, but no quantity given. No mention of cubs or family. Presumably sightings were made separately, but interviewee includes a descriptor that suggests a number higher than two.
cubs	Yes	2	Cub of the year litter size average: 2.23. Yearling litter size average: 1.86. Two-year-old litter size average: 1.85. (McLoughlin and Messier, 2001).
grizzlies; sightings	Yes	2	More than one sighting, but no quantity given. No mention of cubs or family. Presumably sightings were made separately.
den	Yes	1	Grizzlies may dig multiple dens but only use one, so there is a chance that not all dens seen indicate a bear. In any given year a female of cub-bearing age (typically 5-8 years of age) will have an average of 1.5 cubs with her. Thus, the average number of bears per den can be rounded down to one (McLoughlin and Messier, 2001).
digging; tracks	Yes	1	Signs that clearly indicated grizzly presence were counted as sightings.
less; fewer; don’t see	No	0	When interviewees indicated a lack of sightings, no sightings were counted.
cabins; smoke	No	0	Some datapoints referred to things other than grizzly signs or sightings.

Refining input data for spatial interpolation

The application of spatial interpolation strategies is limited by the format of the input data. To maximize our ability to apply various spatial interpolation strategies, we set some parameters on the format of our input data. Due to the nature of the interview approach and the scale of the maps used, the spatial

precision of participant observations was limited. We created grid using the “Create Fishnet” tool in ArcGIS Pro that spanned the study area, aggregated the sightings within each grid cell, and then used grid centroids containing total number of aklak sightings within each 100 km² cell (10km by 10km) as the input dataset for the interpolation process (Figure 5). Values were only ascribed to those grid cells that overlapped with the observation zone; cells within the observation zone that did not contain sightings made by interviewees were ascribed a value of zero. Cells that fell outside of the observation zone were only ascribed a value if there were sightings recorded. We chose a grid cell size of 10 x 10 km for two reasons. First, because participant observations can be expected to demonstrate precision within approximately 10 km. Second, because the DNA study data, which we planned to use to complement the interview data in spatial interpolation calculations, was collected and reported on at 10 km intervals within each study block (sampling grid). This allowed us to seamlessly integrate the data collected via DNA capture into the grid within the grid cells that overlapped with the DNA study blocks. Grid cells that fell outside the interview observation zone and the DNA study blocks were not ascribed to any numeric values (null), to be populated based on the results of the spatial interpolation processes. After sighting data from interviews and DNA study data was ascribed to the relevant grid cells, the centroid of each grid cell with an ascribed value was exported into a point feature class to be used as input data for the spatial interpolation.

Exploring weighting variables

Before applying spatial interpolation, we explored whether there were potential variables that could be used to increase the accuracy of the abundance estimation by weighting the spatial interpolation. In their study examining grizzly bear habitat factors in the northwestern United States, Sells et al. (2023) used a normalized difference vegetation index (NDVI) to indicate abundance of food, while Chetkiewicz and Boyce (2009) found that greenness positively correlates with grizzly population in Canadian Rocky Mountains. NDVI is a metric used to quantify vegetation health and density using aerial imaging and sensor data. We determined that it would be worthwhile to explore whether a correlation exists in Nunavut between NDVI and aklak distribution by conducting geostatistical analyses using our various data sources on aklak presence. We decided to test for correlation between aklak sightings and NDVI within the observation zone, under the premise that if a correlation existed within the “known” regions of the study area, we could use NDVI data in the “unknown” to predict abundance outside of the observation zone more accurately.

We collected NDVI data from two sources: one raster dataset containing average NDVI values over the months of June, July, and August from 2016–2020 from Google Earth Engine (Earth Engine Data Catalog, 2024), and another containing trends in NDVI values between 1984–2012 (where significant negative values represent browning and significant positive values represent greening) from NASA’s Distributed Active Archive Center for Biogeochemical Dynamics (NASA Earth Data, 2019). Both data products had a resolution of 30 m and were collected by different generations of the LANDSAT satellites.

The NDVI raster files were added to ArcGIS Pro, and the datasets were cleaned by removing outlier values. The pixel values were aggregated to the 10 x 10 km grid cells by calculating the mean value within each cell to match the degree of precision of our data on aklak sighting. Three statistical tests were used to determine whether there was a correlation between NDVI and aklak abundance: local bivariate analysis in ArcGIS Pro, and Spearman and Pearson correlation tests in SPSS. All tests were run multiple times to assess the correlation between both NDVI datasets with all three data sources

(interviews, DNA capture, and harvest), within their respective observation zones. We reran the local bivariate analysis test with a wide range of neighbour parameters.

There were no significant correlations between NDVI and any of the datasets, or between NDVI change and any of the datasets. Therefore, we did not take NDVI forward as a weighting variable for spatial interpolation.

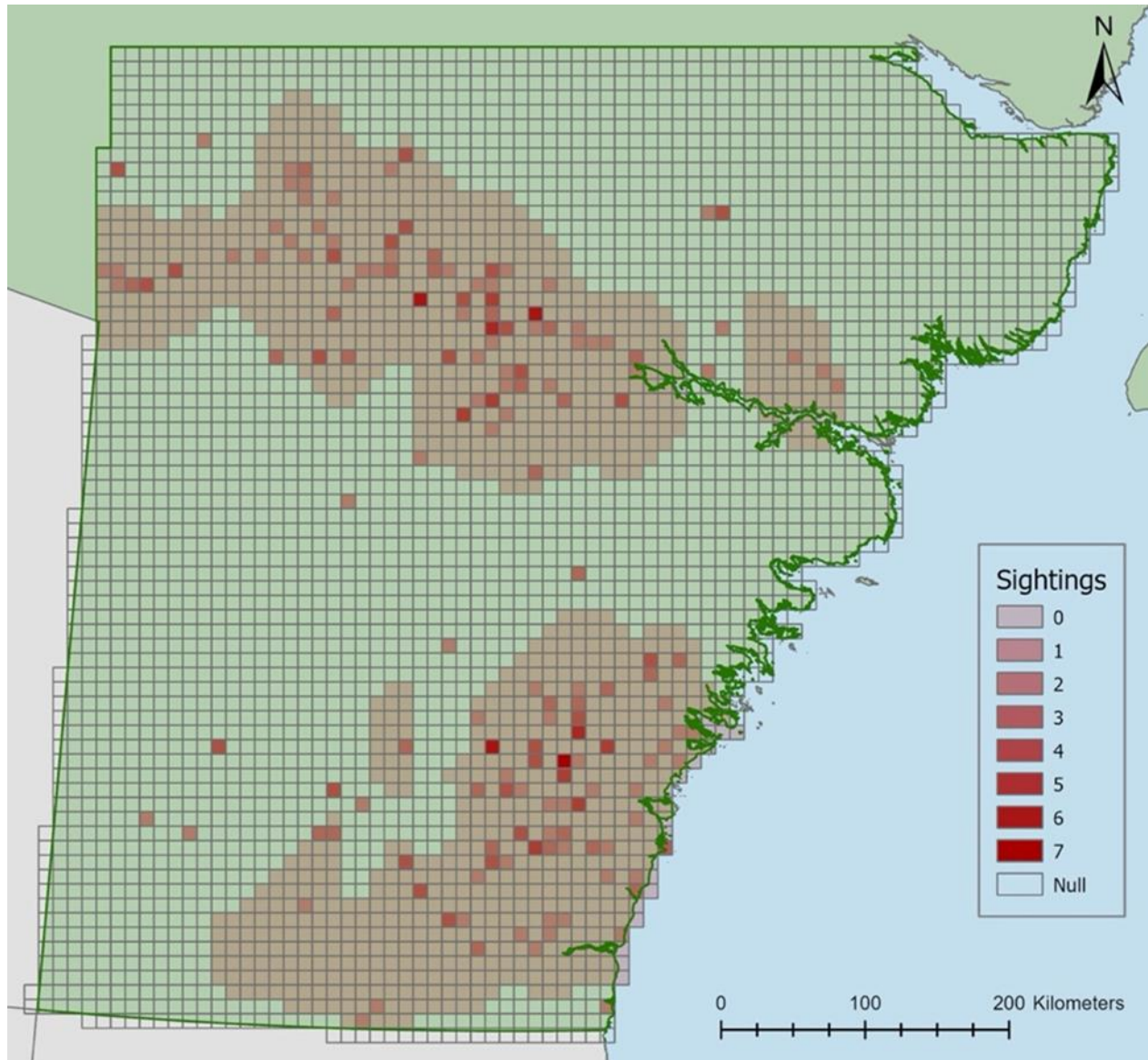


FIGURE 5. 10X10 KM GRID OVERLAID ONTO THE STUDY AREA, SHOWING THE GRID CELLS THAT INTERSECTED WITH THE OBSERVATION ZONE IN RED, WITH GRID CELLS CONTAINING OBSERVATIONS IN DARKER VALUES PROPORTIONAL TO THE NUMBER OF SIGHTINGS IN THAT AREA.

Interpolation strategies and total abundance calculation

Two interpolation strategies were applied: Inverse Distance Weighted (IDW) interpolation and Empirical Bayesian Kriging (EBK). Both interpolation processes function on the fundamental geographic premise that “everything is related to everything else, but near things are more related than distant things” (sometimes known as “Tobler’s First Law of Geography”) (Tobler 1970, 236). Both interpolation strategies were applied using the interview dataset alone (signs and sightings of aklak after 1990) as the input data, as well as using the interview dataset combined with the DNA study capture locations as input data. As discussed previously, the DNA capture locations offered spatial complementarity to the interview and harvest observation zones, allowing for a more spatially robust input dataset. Table 2 shows the parameters set for each interpolation method. For EBK, additional model parameters limited the maximum number of points in each local model to 100, the local model area overlap factor to 1, and the number of simulated semivariograms to 100. All interpolation calculations were done within the study area boundaries.

TABLE 2. PARAMETERS USED FOR INVERSE DISTANCE WEIGHTING AND EMPIRICAL BAYESIAN KRIGING INTERPOLATION PROCESSES.

Interpolation Method	Power	Search Neighbourhood	Max Neighbours	Min Neighbours
IDW	2	Standard	15	10
EBK	N/A	Standard circular	15	10

Both processes output continuous (floating point) raster files, with a single non-integer value ascribed to each cell. Based on our input dataset, the value ascribed to a given cell essentially represents the likelihood of aklak being observed in a discrete location at a given time. Because our input values were either zeros or positive integers, the majority of cell values in the output rasters ranged from zero to one. Total abundance was calculated by summing all cell values across the study area.

Results

Participant observation of changes in aklak abundance and distribution

This section summarizes the key themes reported by participants, including factors influencing aklak movement patterns and perceived population growth. The results are organized by descriptive codes that emerged from thematic analysis.

Relative abundance of aklak has rapidly increased since at least the 1990s:

Both Baker Lake (Qamani'tuaq) and Arviat participants attested to increases in human encounters with aklak across the Kivalliq region. Aklak are a known species within Inuit Qaujimagatuqangit, but prior to the mid-20th century encounters with aklak were rare. Aklak are viewed as increasing in abundance and distribution across the Kivalliq since at least the 1990s and perhaps as early as the 1960s. While one participant suggested that hunting may be limiting further population growth, all other translated interviews (n=18) indicated that the population is increasing rather than stable.

“There were not much grizzlies before the 1990s that I know of. I started catching grizzlies around the year 2000.” (Ken Avaala, Baker Lake 2022)

Aklak prefer inland habitats, particularly around lakes, rivers, wetlands, and eskers:

While aklak are found everywhere in the Kivalliq mainland, encounters between humans and aklak tend to occur along rivers and lakeshores inland. In contrast to data the study authors collected in Northern Manitoba (Clark et al. 2022), participants in the Kivalliq all indicated that aklak were more likely to be found inland, but that there were more found near the coast than in the past.

“I think the coast is where is where you would rarely see grizzly bears, along the whole coast.” (Joe Savikataaq, Arviat, 2022)

“I think there’s grizzlies all over the tundra. They’re hardly close to the Hudson’s Bay, they’re mostly inland.” (Ken Avaala, Baker Lake, 2022)

“They follow the rivers more for the fish.” (Ken Avaala, Baker Lake, 2022)

Climate change is expanding aklak habitat northward:

Study participants perceive the rise in aklak populations in the Kivalliq as driven by climate change, rather than a sign of natural abundance. For example, one participant described changes in habitat and vegetation as bringing aklak further north:

“It is probably from what they had eaten. I think that their vegetations are starting to be different compared to in the past. It is from global warming that their behaviour is changing and where there vegetations are changing and it’s affecting them from the changes and the growing population of grizzly bears are improving.” (Norman Attungala, Baker Lake 2003)

“We’re beginning to see some animals and birds that we were unheard of in earlier days. Just I think that probably has a lot to do with what is known as global warming you know, you know, you know as it warms up. It’s not just the grizzlies that are beginning to move up here. So, I don’t know, I guess it’s hot. I believe that has a lot to do with it. They’re just moving up and realizing that they can survive up here. But like I said, it’s just not the grizzlies increasing, everything is increasing all your birds, mammals, even moose, we’re even beginning to see moose. So that’s probably it, they’re just moving up, and probably will continue to do so.” (Hugh Ikoe, Baker Lake, 2023)

Habitat destruction is driving wildlife north:

Participants in Arviat described wildfires in regions south of Nunavut as causing aklak to migrate into the Kivalliq. They described aklak as disliking smoke, and as moving in Nunavut to avoid the smoke from wildfires in Saskatchewan, Manitoba, and the Northwest Territories.

“They are all over the world, they are in the world, in land, everywhere, but in white man’s land, but the trees are on fire, right now, they have really increased.” (Paul Kablutsiak, Arviat, 2022)

Participant observations of aklak ecology

Participant observations highlight aklak adaptability, intelligence, and ecological roles, offering valuable insights into their diet, habitat, and interactions with humans in the Kivalliq region.

Defending scavenged food:

Inuit caches are well-designed to keep out common scavengers like the Arctic fox, but participants noted that the traditional way of building a cache would not keep out aklak due to its size, strength and digging ability. When aklak dig up a cache, they will stay nearby and defend it:

“they don’t finish it in one day, they make a bed, look like this, I seen one, by the willow, they sleep there and the next day they start eating again.” (Alex Iglookyouak, Baker Lake, 2003)

Hiding from humans:

Participants described aklak as tricky, and as having the ability to hide themselves well despite their large size. Participants in Arviat spoke of how aklak were known to make a whistling noise, while Baker Lake participants did not have this attribute included in their traditional knowledge. Participants from both communities emphasized that traditional knowledge warned Inuit to be alert and wary if they suspect an aklak was around, as it could hide from humans. One participant described that in his own experience and from knowledge passed on to him by elders, he knew that aklak:

“...pretend to run away and they look at you from someplace else.” (Tom Mannik, Baker Lake, 2003)

Known to scavenge carcasses as well as hunt:

One participant observed aklak following wolf tracks and stated that the aklak intended to steal carcasses from wolves. See also Gunther and Smith (2004) for similar observations in Yellowstone National Park.

Known to den from November to April/May:

Females with cubs were observed to leave their dens later than males. One report of a winter-active aklak (February) from Baker Lake (focus group 2023) that was caught by a hunter and was very thin.

Regular diet includes bird eggs, geese, fish, caribou, musk-ox, and ground squirrel:

One participant observed an aklak attempting to drown a muskox. Muskox were also observed fleeing from aklak.

“The muskox did not form a defensive circle, as they usually do, but ran and ran and ran.” (Joe Savikataaq, Arviat, 2022)

Diggings for sik-sik (Arctic ground squirrel) were commonly observed.

“Seems like loader had been there, part of it, maybe after ground squirrels.” (Ryan St. John, Arviat, 2022)

Observed feeding on vegetation:

“They also like to be in the damp hummock in the land I guess they like plants that are moist. We mostly see them in the flatlands around hummock area.” (Norman Attungala, Baker Lake, 2003)

“I shot a grizzly bear and there was nothing but berries inside its stomach.” (Tony Uluadluak, Arviat, 2022)

Sexual dimorphism:

Females were known to be smaller than males, and one participant noted that the hind leg tracks of females were more triangular in shape.

“You can tell by its size, their body, or by claws, yes, and by the face.” (Daniel Kablutsiak, Arviat, 2022)

Observations of bears congregating in groups:

One participant described encountering five adult bears at one time, which may indicate the presence of an abundant and attractive food source.

Behavioural plasticity, intelligence, individual agency:

“All grizzly bears are different. Some will come attack a person, a human being, or some other grizzly bears run away.” (Emily Alerk, Baker Lake, 2003)

“The way of living in their habitat is similar to us humans. We hunt where we can find food and we go to the hunting area and start having cabins there because we will know we will get what we want or because of way the land makes us feel or go to the place that we used to live, it is same as the animals they know where to get food, where to stay from their comfort zone. It is parallel living where an animal stays where they can find food just like humans do. They do not talk or communicate like humans do but they know what they eat, they know where to get food, they know what to do to get food and they know how the weather will be.” (Norman Attungala, Baker Lake, 2003)

Maternal investment:

Participants noted that female aklak usually bore two cubs, with three being rare. It was described how aklak, like caribou, did not have cubs every season but waited at least two years between litters.

Avoiding conflict with humans:

“Like grizzly, if it is not grizzly, it will flee, if it is a fox, it sees, that it is not a fox, it will flee. Animals were like that.” (Dorothy Aglukark, Arviat, 2022)

“The woman was going to face a grizzly, head on. She is petrified, the grizzly bear will have no match along with her carried child. Using Inuit Knowledge, she was told not to move and do not speak, when we see a large animal. I know this for a fact, because I have been told about this. She remembers this. “I will just stop, stop walking, just being still.” She was being quiet along with her child, making sure she does not speak. Grizzly bear, there, was just coming. She was just like that, it just crossed by. She survived. She did not move even though the grizzly bear crossed very close by.” (Dorothy Aglukark, Arviat, 2022)

Inuit taxonomy based on colour and behaviour:

Different types of aklak were described by participating Elders.

“He says there are three types of grizzlies. There [are] the brown ones. And the one that looked like ground squirrels, and the dark ones. The ones that look like ground squirrels, they're the mean ones, the vicious ones.” (Arviat focus group 2023)

This taxonomic distinction differs from the Linnaean system used by biologists but as Polfus et al. (2016) found for caribou, Indigenous taxonomies can encompass features identifiable through focused scientific investigation. Phenotypic plasticity characterizes *Ursus arctos* across its circumpolar range and the history of taxonomic classifications of this species is a dynamic one that is not yet settled (Kitchener 2010). We therefore recommend that any future genomic research on grizzlies in the Kivalliq specifically look for population substructure. Moreover, knowledge about behavioural variation, whatever its potential relationship with physiognomy, is important for understanding and reducing human-wildlife conflict.

Participant attitudes towards aklak

The increasing abundance of aklak in the Kivalliq poses challenges to intangible cultural heritage, particularly Inuit practices surrounding hunting, harvesting, and caching caribou (Bortolotto 2007; Lenzerini 2011; UNESCO 2003). In February 2023, Hugh Ikoe of Baker Lake described how his family would make caches of caribou meat every season. He described how, in the past, wolves, foxes and wolverines might destroy up to a few of his family's caches, but the last time his family cached caribou meat, every single cache was destroyed by aklak. He stressed that this was a loss of approximately 15 caches full of caribou meat, which was significant to his community both financially—due to the time, fuel and labour invested—and culturally, as cached caribou is viewed as the most culturally important food for inland Inuit groups.

“When a grizzly bear finds a piruyaq (caribou meat cache) it thinks that it belongs to the grizzly bear. The bear can become aggressive to a person who went to go get its catch and starts to attack the person. What I heard and seen before is when a grizzly bear finds a caribou caches it will think that the food it his and will protect what it is find from any animal or from any human.” (Norman Attungala, Baker Lake, 2003)

“The only reason why we survived up here you know, far in native country, is that it's cool enough that we can cache it [meat]. That was the only way to survive, bury it with rocks. And it will not go bad. You have to cache as much are you can, because if you didn't you're facing certain starvation, which did happen in 1958. Lot of people starved to death.” (Hugh Ikoe, Baker Lake, 2023)

“So that [caching meat] was very much part of our culture. You know, we have to cache but today we can't. As you've probably heard, we can't do it anymore because of the grizzlies. This caching was such a part of our culture because it was like sausage, you know, like Italian or Ukrainian, everybody makes a sausage and everybody loved it, whether you are polish or German everybody made their own sausage and that. To us, it was the same thing. [Word for cached caribou in Inukitut] had a certain taste of its own. So basically, I called it our sausage. It was very much part of our culture. We would like to keep it but now you can't have cache anymore.” (Hugh Ikoe, Baker Lake, 2023)

Participants also noted that it was more dangerous to camp in tents out on the land, and that many people were now scared to camp without a hard-sided cabin. Concerns about keeping young children and family members safe while camping out on the land were expressed in both communities. Some participants stated they no longer felt safe camping in inland areas once considered safe due to the absence of polar bears, as the increasing presence of aklak has changed this.

The harvest of aklak is viewed as sustainable by study participants as the population is generally viewed to be increasing. Quotas and restrictions on aklak harvest are not pragmatic or desirable for community members. Hunters who harvested intentionally rather than opportunistically did so in the spring, when aklak had just emerged from their dens. While aklak meat and pelts would be used when harvested, aklak were not a preferred food source. The harvest of aklak was viewed similarly to pest control. While some community members would hunt aklak in the spring, most aklak were harvested after a conflict with human. Participants characterized aklak negatively, using terms such as aggressive, dangerous, and nuisance as descriptors.

Geography of aklak observations

- **Higher observed density inland than in coastal areas.** This contrasts our data from northern Manitoba (Clark et al. 2022), suggesting either an observation bias in that data or different habitat preferences. Behavioural differences may also play a role, as all confirmed grizzly bear observations in northern Manitoba are of lone adult bears, often males, indicating a dispersing population at the edge of its range (Clark et al. 2022), rather than an established breeding population, as in the Kivalliq. Further investigation into this difference would be worthwhile.
- **Concentration of encounters around river corridors, lakeshores, and wetlands.** Participatory mapping exercises revealed most encounters with aklak occurred near lakes and rivers. While this may be due to the use of bodies of water as landmarks, it also was noted by participants that aklak preferred vegetation in wetter areas and with trees over the open tundra.
- **No differences noted in sex distribution of aklak.** Participants communicated no other observations about sex-specific space use differences and answered negatively when asked if they knew of any differences in distribution between sexes.

Quantitative assessment of aklak abundance

Cleaning and processing data

For those datapoints with temporal data included, observations made by participants spanned from the 1950s to the present. Total aklak sightings by interviewees since 1990 was 296. Figure 6 shows the distribution of sightings made by interviewees categorized by time period (pre-1990s, during the 1990s, and after 2000). Aklak sighting density within the 122,900km² observation zone (based on interview data alone) was 2.41 bears/1000km². While the observation zone does not overlap with the study area used in the DNA capture study (Awan et al. 2019), we compared this result to the DNA study findings, which estimated a population density of 3.5/1000km² within a 95% confidence interval of 2.1–6.1 bears/1000km².

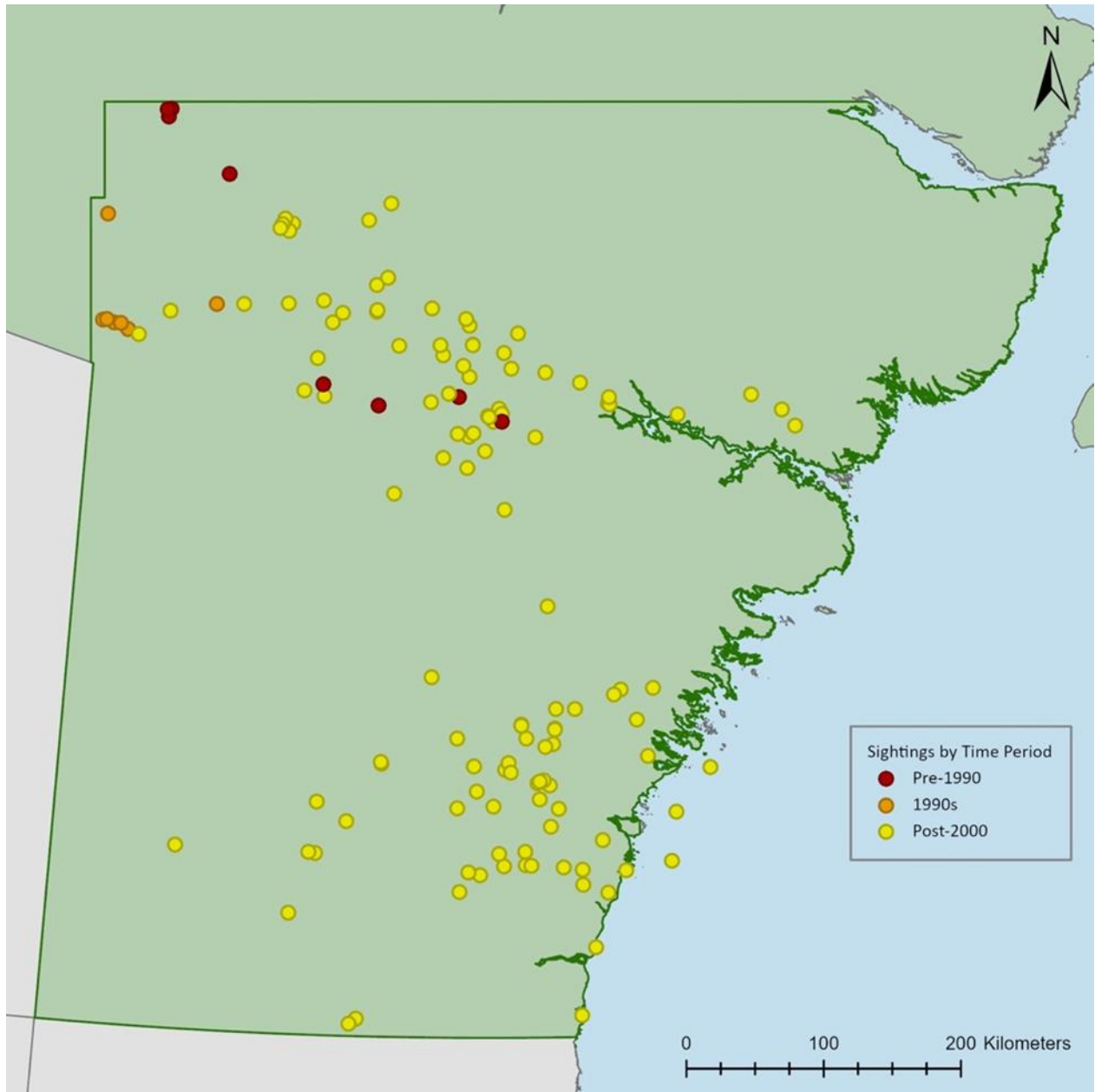


FIGURE 6. SIGHTINGS REPORTED BY PARTICIPANTS CATEGORIZED ACCORDING TO TIME PERIOD.

Spatial interpolation and total abundance

Figures 7 and 8 show the raster outputs for the IDW and EBK interpolation processes, respectively. The results of the interpolation using only the interview dataset as input are displayed in map A (on the left), while the results using the interview and DNA recapture study datasets as input are displayed in map B (on the right). Table 3 shows a selection of summary statistics from each of the four output rasters. Table 4 summarizes the abundance estimation results from the two spatial interpolation processes, including a total abundance estimate within the 371,600km² study area, and a density estimate of aklak per square kilometer within the study area. 95% confidence intervals were calculated for density and

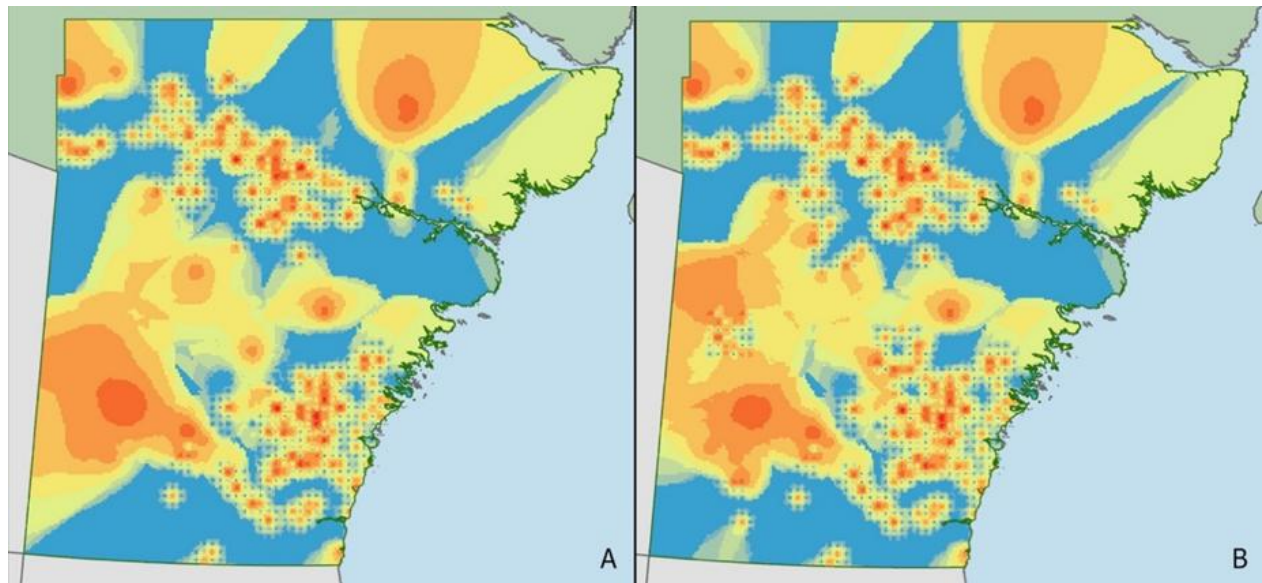


FIGURE 7. RESULTS OF INVERSE DISTANCE WEIGHTING SPATIAL INTERPOLATION, USING INTERVIEW DATA ONLY AS INPUT (MAP A) AND INTERVIEWED DATA COMBINED WITH DNA MARK RECAPTURE STUDY DATA (AWAN ET AL. 2019) AS INPUT (MAP B).

abundance using SPSS and are also shown in those tables.

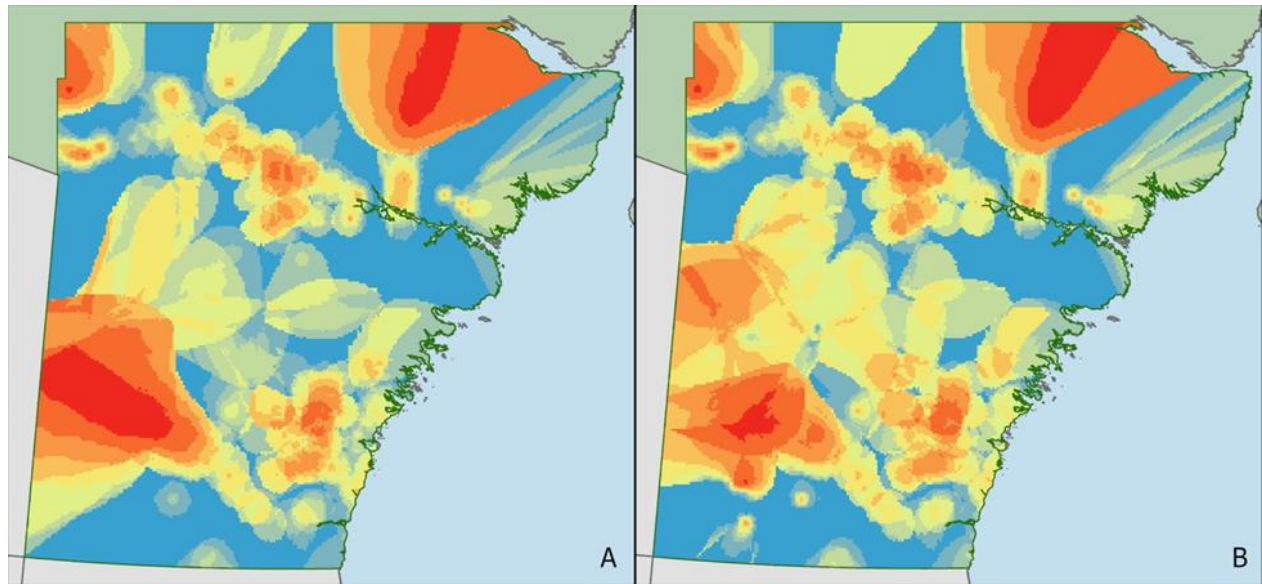


FIGURE 8. RESULTS OF EMPIRICAL BAYESIAN KRIGING SPATIAL INTERPOLATION USING INTERVIEW DATA ONLY AS INPUT (MAP A) AND INTERVIEW DATA COMBINED WITH DNA MARK RECAPTURE STUDY DATA (AWAN ET AL. 2019) AS INPUT (MAP B).

TABLE 3. SUMMARY DENSITY (BEARS/1000KM²) STATISTICS FROM EACH OF THE FOUR OUTPUT RASTER DATASETS.

Input Data	Inverse Distance Weighting		Empirical Bayesian Kriging	
	<i>Interview</i>	<i>Interview and DNA</i>	<i>Interview</i>	<i>Interview and DNA</i>
Maximum	3.93	3.93	2.58	2.21
Minimum	0	0	-0.05	-0.04
Mean	0.29	0.29	0.41	0.36
Mean 95% CI				
Lower	0.28	0.28	0.39	0.35
Upper	0.30	0.30	0.43	0.38
Median	0.14	0.14	0.18	0.21
Standard Deviation	0.41	0.39	0.54	0.43

TABLE 4. ESTIMATED ABUNDANCE OF AKLAK WITHIN THE STUDY AREA USING INVERSE DISTANCE WEIGHTING AND EMPIRICAL BAYESIAN KRIGING.

Input Data	Inverse Distance Weighting		Empirical Bayesian Kriging	
	<i>Interview</i>	<i>Interview and DNA</i>	<i>Interview</i>	<i>Interview and DNA</i>
Total	1081	1073	1515	1351
95% CI				
Lower	1032	1027	1450	1300
Upper	1130	1120	1580	1404
Aklak per 1000 km²	2.91	2.88	4.07	3.64
95% CI				
Lower	2.77	2.76	3.90	3.50
Upper	3.04	3.01	4.25	3.78

Conclusions

Aklak distribution, abundance, and implications

Mapped observations precisely indicate the southward spread of aklak observations since the 1990s, with the earliest documented observations from the region of the Thelon Game Sanctuary (Figure 6). Inuit Qaujimagatuqangit strongly suggests that aklak are undergoing a population increase and subsequent range expansion across the Kivalliq region that began decades ago. This situation is distinctive from other regions in Canada where grizzly bear populations are increasingly under threat from habitat destruction or are in recovery from a population decline (McLoughlin and Stenhouse 2021). Study participants are aware of this difference and recommend that management strategies should account for the unique social and ecological contexts that aklak experience in the Kivalliq region.

Quantitative estimation of aklak abundance

The estimated aklak densities from both interview data (2.91-4.07 bears/1000km²) and interview data plus DNA grid hits (2.88-3.64 bears/1000km²) are all within the 95% CI range estimated for our study area by Awan et al. (2019) of 2.1-6.1 bears/1000km². Our estimates are also consistent with results from previous studies in similar habitats: 3.5 bears/1000km² in the 1990s from the nearest other grizzly bear study area in Nunavut/NWT, which adjoins the Kivalliq (McLoughlin and Messier 2001); 5.2 – 6.7 bears/1000km² from the same area in 2012-2014 (Barrueto et al. 2023); and 5 to 6.6 bears/1000km² from the Kitikmeot region, Nunavut (Awan et al. 2023; Dumond et al. 2015). Further, they are even consistent with estimates at the lower range of the large-scale habitat- and mortality-based density projections by Mowat et al. (2013) and 3.9 bears/1000km² extrapolated from abundance estimates for the Arctic Coastal Plains grizzly bear zone by Banci et al. (1994). Such similarities with these geographically broader estimates are not unexpected, assuming that the habitat productivity/home range size relationships for grizzlies described elsewhere hold here too (McLoughlin et al. 2003).

While these similarities are promising it would be premature to consider it definitive validation of our study (or those other ones), for several reasons. First, our estimates are based on cumulative observations over 33 years, so it is not yet clear how comparable they are to those generated from short-duration mark-recapture studies. Nonetheless, the lack of change over two decades between the estimates in McLoughlin and Messier's original study area, despite industrial development there, suggests such comparisons may not be *a priori* invalid. Second, Awan et al. (2019) provided only provisional estimates, recommending a much larger sampling effort for greater accuracy and reliability. Third, recalling that our initial plan for abundance estimation was to use proportional piling exercises, we lack a theoretical framework for explaining how these observational data actually indicate abundance. Besides further methodological development (discussed below), it will be necessary to build such a framework, which should itself be done in a participatory way. Participants' observations about the limited applicability of proportional piling for solitary animals shows both the need and the value of further Inuit involvement in such research.

Aklak ecology

Participants provided detailed observations of aklak food habits and interspecific interactions, habitat selection, litter size and timing, and denning. Unsurprisingly, Inuit observations correspond with findings

from scientific studies conducted in similar Arctic habitats (e.g. Arthur et al. 2017; Edwards et al. 2009, 2011; Gau et al. 2002; McLoughlin et al. 1999, 2002; Reynolds et al. 1987; Young and McCabe 1998).

We were surprised that neither NDVI nor NDVI change explained the spatial distribution of aklak observations given its strong predictive value for grizzly bears elsewhere (e.g. Apps et al. 2016; Mowat et al. 2013). While it's possible that NDVI might have stronger explanatory power at larger spatial scales, it's also possible that the species' range expansion in the region may not necessarily be driven by vegetation productivity, or perhaps not directly. Since Gau et al. (2002) found grizzlies adjacent to our area were predominantly carnivorous (on caribou), such a habit could explain the lack of dependence on vegetation productivity as measured by NDVI. Petzold and Goward (1988) demonstrated that NDVI doesn't accurately measure lichen productivity, indicating that if aklak distribution was governed by caribou – which are dependent on lichens – NDVI measures could well be insufficient to detect it. Consequently, more precise insights into what aklak eat in the Kivalliq, and whether their diet is comparable to other parts of the species' Arctic range, would be helpful.

Recommendations for further investigation

An important area for further inquiry is the investigation of solutions to the problem of caribou cache destruction by aklak. As noted above, aklak were viewed as the primary reason that Inuit were no longer able to cache caribou meat, a practice which is viewed by community members as vital to Inuit culture. If a way could be found to deter aklak from digging up caribou caches this could allow the practice of caching meat to continue and support Inuit cultural continuity. Participants also expressed a desire to deter aklak from entering their camps and cabins, particularly at night. Deterring bears from damaging property is a primary issue in reducing human-bear conflict across species and ecosystems. Further investigation into what deterrence methods are feasible, affordable, accessible, and efficient in remote communities in the Kivalliq region would be welcomed by communities.

Improving methods for estimating density and abundance from participatory mapping would be benefit aklak co-management and help bridge traditional and local knowledge with broader wildlife management goals. As Mowat et al. (2013) noted, conducting detailed abundance estimations is not feasible for most regions due to high costs and competing priorities. Since the cost of this project was considerably less than a mark-recapture field study, the potential benefits of fully and appropriately utilizing this kind of data are substantial. To be clear, this line of methodological inquiry is not a question of scientifically judging the reliability of IQ about aklak, which would be epistemologically inappropriate even if it was possible (Brook and McLachlan 2005). Rather, what's required is understanding of how comparable this observation-based approach to grizzly bear density and abundance estimation is to other established methods which use different information inputs. For example, many observations mapped by our participants were associated with lakes and rivers. Awan et al. (2019) sampled lakeshores specifically (as well as grids) where they detected a high number of individuals. They were concerned this could lead to erroneous density/abundance estimation, yet that doesn't appear to be the case with our data despite the same spatial associations.

Implications for co-management and planning

Unique situation of “threats” in the Kivalliq

Study results suggest that the positioning of aklak in the socio-ecological context of the Kivalliq region is not analogous to other regions in Canada as the threat they pose to Inuit food systems is the paramount concern of communities facing human-aklak conflict and the abundance and distribution of aklak is increasing. Aklak are perceived as a threat to the existing socio-ecological system, rather than as a species under threat and in need of protection.

Need for extended deterrence strategies

While harvest was presented as a primary means for reducing conflict with aklak, strategies for reducing encounters through deterrence and preventing habituation were also suggested by participants as something they'd like to know more about. Participants expressed a desire for strategies to deter aklak from damaging property and for more community education about the importance of proper food storage and garbage disposal. Participants were resigned to the increased presence of aklak on their territories, stating *“they're here to stay”* (Hugh Ikoe, Baker Lake, 2023). Participants expected aklak to continue to be a problem for the foreseeable future.

Participants do not desire a quota system and are skeptical of Canadian science-based wildlife management

Participants were uniformly adamant that a hunting quota system should not be reinstated for grizzly bears, and that Inuit should have the ability to judge for themselves the best course of action according to the conditions of a particular encounter. As noted previously, participants described aklak as varying in behaviour and temperament, which means that it was highly dependent on the individual bear and the specific context of the encounter whether lethal action was deemed necessary or not. Participants emphasized aklak intelligence and agency, and how during an encounter aklak also assessed the situation and decided on a course of action. It was emphasized that generalized rules and regulations such as quota systems are not responsive to the unique conditions of each aklak-human encounter. As stated by one participant commenting on the previous quota system: *“when a grizzly bear is going to be dangerous it will not think of the legislation”* (Simeon Mikkingwak, Baker Lake, 2003).

Participants in Clark's 2003 interviews indicated they believed the quota system was instated to protect bears due to concerns of low bear populations. Even though there is no longer a quota system, our data from 2022 suggests that community members continue to perceive the goal of aklak management to be an aklak population increase. For example, participants stated that in the past the government was *“trying to get more grizzlies”* (Avaala 2022). This was consistent with data from the 2003 interviews conducted by Dr. Douglas Clark. Participants expressed the view wildlife management regulations are designed to protect wildlife, not prevent human-wildlife conflict or protect Inuit communities and culture. Participants are aware that their cultural attitudes towards aklak differs from those of conservationists from southern Canada, where grizzly bears may be viewed with reverence (Harding 2014) or as cultural keystone species (Clark et al. 2021). It is important that non-Inuit managers and Conservation Officers are aware of the views expressed by participants that aklak are increasing partially due to protections introduced by a colonial government.

"...they are increasing in our land. When they could be caught, I am alright with it, and if they were able to catch the cubs too, I would be okay with it." (Ludovic Onerk, Arviat, 2022)

"...we hunters, inside, one hundred miles, radius, are stabilizers of grizzly bears, like, we will not make them increase." (Daniel Kablutsiak, Arviat, 2022)

"It's right, if it is caught. There seems to be many grizzly bears, if they are caught, it is alright." (Dudley Copland, Arviat, 2022)

"No! I do not want it [the lack of a harvest quota] changed. If they do, your cache, your cache had been taken again on September. They keep saying that, I want them shot down. What good is it if they try and keep them alive? What good is it?" (Paul Kablutsiak, Arviat, 2022)

"The thing I don't like about the grizzly is that it has completely taken away a very important part of our culture. Caching caribou is our culture. And what made it that way was at some point we were told that don't kill them, don't kill the grizzly or you're gonna go to jail and some people did." (Hugh Ikoe, 2023)

Methodological recommendations for future wildlife research involving Inuit Qaujimagatungit

A more effective interview context for future studies involving qualitative data collection and IQ could be achieved by implementing the following approaches:

1. It is recommended that future interviews take place in a community setting other than the wildlife office. While Conservation Officers were supportive of this research, the association between the wildlife office and government oversight of hunting, particularly given the politically complex history of wildlife regulation in Nunavut, may have influenced some participants' willingness to engage fully.
2. Interview questions should be translated into Inuktitut in consultation with speakers of multiple dialects before interviews take place, pre-emptively addressing issues of dialect difference and translation that came up during the interview process.
3. Community validation would ideally take place over several days, to accommodate changing local conditions (adverse weather, overlapping community events) that affect participation.
4. Simultaneous translation was found to be more efficient than post-interview translation, with the researcher, interviewer/translator, and participant creating a dialogue discussing the meaning of participant statements as issues came up.
5. Greater involvement of community members in research design (question creation), data analysis, and the communication of results is recommended for future studies. While efforts were made in this study, the pandemic presented multiple barriers. Given the accessibility of the methods and the community's interest for intergenerational knowledge transfer, the potential for capacity building is considerable (Greene and Zawadski 2022). This would require more involvement in the research process from community educators and organizations as facilitators.

Dissemination of study results

One of the challenges of this project is the cross-cultural context of the communication of not only the study data, but also the results. We have found throughout the data collection process that topographic maps are excellent tools for eliciting qualitative data from participants. Disseminating the study results to the community, which is an imperative for ethical research practice with Indigenous communities, can be a challenge given the bilingual and cross-cultural context. Maps are a valuable cross-cultural communication tool, complementing written reports and oral presentations. The digitized maps generated from the participatory mapping exercises can be uploaded onto a digital platform, along with participant descriptions, to create a 'storymap' interface (e.g. Kopatz et al. 2021). This approach locates study results within the landscape, emphasizing place-specific context, community connections to the conservation area, and the experiential elements integral to Inuit Qaujimagatuqangit.

Acknowledgements

We thank participants in Arviat and Baker Lake for their participation, hospitality, and insights. Special thanks are due to Emil Arnalak and Russell Toolooktook for their dedicated work conducting and translating interviews. We would like to acknowledge the expertise of the following interview participants and community members, both from a previous 2003 study conducted by Douglas Clark and our 2022-2024 study. We are grateful for their generosity in sharing their knowledge.

Baker Lake (Qamani'tuaq):

Barney Aaruaq
David Aksawnee
Emily Alerk
Norman Attungala
John Avaala
Ken Avaala
Harold Etegoyuk
Timothy Evviuk
Alex Iglookyouak
Hugh Ikoe
Joedee Joedee
Tom Mannik
Simeon Mikkingwak
Joe Niego
David Owingayak
Philip Putumiraqtuq
Joan Scottie
Hugh Tularialik

Arviat:

Dorothy Aglukark
Peter Alareak

Thomas Siatalaaq Alikaswa
Darryl Baker
Dudley Copland
Joe Savikataaq
Leo Ikakhik
Louis Irkok
Cedric Manik
Arden Nibgoarsi
Ludovic Onerk Isumatardjuak
Daniel Kablutsiak
Paul Kablutsiak
Joe Savikataaq
Dominic Sinnisiak
Jordan St.John
Tony Uluadluak

Local interviews were carried out by Emil Arnalak in Arviat and Russell Toolooktook, Department of Environment, Government of Nunavut in Baker Lake. This research was supported by the community-based Hunters and Trappers' Organizations of Arviat and Baker Lake. Research was funded by the MITACS postdoctoral research Elevate program, in partnership with Environment and Climate Change Canada and the Churchill Northern Studies Centre. Research design and the facilitation of this project is credited to Douglas Clark of the University of Saskatchewan and Malik Awan, Department of Environment, Government of Nunavut. We'd also like to thank Jason Shaw of Caslys Consulting and the Canadian Hub for Applied and Social Research (CHASR) for their work with map conversion and spatial data analysis. Finally, we thank John Ringrose and Jonathan Pynn, GN ENV, for their comments on an earlier draft of the manuscript.

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