Canadian Journal of Zoology
Revue canadienne de zoologie

**Inuit Knowledge of Beluga Whale (*Delphinapterus leucas*)
Foraging Ecology in Nunavik (Arctic Quebec), Canada**

Journal:	Canadian Journal of Zoology
Manuscript ID	cjz-2015-0259.R1
Manuscript Type:	Article
Date Submitted by the Author:	30-Mar-2016
Complete List of Authors:	Breton-Honeyman, Kaitlin; Trent University, Environmental and Life Sciences; Trent University, Health, Environment, and Indigenous Communities Research Group Hammill, Mike; Maurice Lamontagne Institute, Dept Fisheries & Oceans Canada Furgal, Christopher ; Trent University, Health, Environment, and Indigenous Communities Research Group; Trent University, Indigenous Environmental Studies Program Hickie, Brendan; Trent University, Environmental and Life Sciences Program
Keyword:	Beluga whale, Inuit Knowledge, <i>Delphinapterus leucas</i> , ARCTIC <Habitat, Feeding ecology

SCHOLARONE™
Manuscripts

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

**Inuit Knowledge of Beluga Whale (*Delphinapterus leucas*) Foraging Ecology in
Nunavik (Arctic Quebec), Canada**

K. Breton-Honeyman,^{1,2} M. O. Hammill,³ C. M. Furgal,^{2,4} and B. Hickie¹

kaitlinbh@gmail.com, chrisfurgal@trentu.ca, Mike.Hammill@dfo-mpo.gc.ca,
bhickie@trentu.ca

¹Environmental and Life Sciences Program, Trent University, Peterborough, Ontario,
K9J 7B8

²Health, Environment, and Indigenous Communities Research Group, Trent University,
Peterborough, ON K9J 7B8

³Maurice-Lamontagne Institute, Department of Fisheries and Oceans, Mont-Joli, Québec,
G5H 3Z4

⁴Indigenous Environmental Studies Program, Trent University, Peterborough, ON K9J
7B8

Corresponding Author: Kaitlin Breton-Honeyman, P.O. Box 433, Inukjuak, QC, J0M
1M0, (819) 254-8667 (tel), (819) 254-8816 (fax), kaitlinbh@gmail.com

**Inuit Knowledge of Beluga Whale (*Delphinapterus leucas*) Foraging Ecology in
Nunavik (Arctic Quebec), Canada**

K. Breton-Honeyman, M. O. Hammill, C. M. Furgal, and B. Hickie

Abstract

The beluga whale (*Delphinapterus leucas* (Pallas, 1776)) is expected to be influenced by changes in the environment. In Nunavik, the Arctic region of Quebec, Nunavimmiut (Inuit of Nunavik) have depended on beluga for centuries developing an extensive understanding of the species and its ecology.

Forty semi-directive interviews were conducted with Inuit hunters and Elders from four Nunavik communities, who had a range of 28 to 47 years of beluga hunting experience. Interviews followed an ethnocartographic format and were analyzed using a mixed methods approach. Hunters most commonly reported prey species from the sculpin (*Cottidae*), cod (*Gadidae*), salmon (*Salmonidae*), and crustacean families; regional variations in prey as well as foraging habitat were found. Hunters identified significant changes in body condition (i.e. blubber thickness), which were associated with observations about the seasonality of feeding. The timing of fat accumulation in the late fall and winter coupled with the understanding that Hudson Bay is not known as a productive area suggest alternate hypotheses to feeding for the seasonal movements exhibited by these whales. Inuit Knowledge of beluga foraging ecology presented here provides information on diet composition and seasonality of energy intake of the beluga and can be an important component of monitoring diet composition for this species into the future.

An Inuttitut version of the abstract is available (Appendix A).

Keywords: beluga whales, Inuit Knowledge, *Delphinapterus leucas*, Arctic, feeding ecology

Écologie Alimentaire de la Baleine Béluga (*Delphinapterus leucas*) : Ce qu'on apprend du savoir Inuit au Nunavik (Région arctique du Québec), Canada

K. Breton-Honeyman, M. O. Hammill, C. M. Furgal, et B. Hickie

Résumé

Il est prévu que le béluga (*Delphinapterus leucas* (Pallas, 1776)) sera influencé par des changements dans l'environnement. Au Nunavik, la région arctique du Québec, les Nunavimmiut (Inuits du Nunavik) dépendent sur les bélugas depuis des siècles et ont développé une connaissance approfondi de l'espèce et de son écologie.

Quarante chasseurs et Aînés Inuits, parvenant de quatre communautés du Nunavik et ayant entre 28 et 47 ans d'expérience avec la chasse au béluga, ont participé à des entrevues semi-structurées. Les entrevues ont suivi un format ethnocartographique et les résultats soumis à une analyse d'approche méthodes mixtes. Les espèces de proie du béluga identifiées les plus fréquemment par les chasseurs appartiennent aux familles du chabot (*Cottidae*), de la morue (*Gadidae*), du saumon (*Salmonidae*), et des crustacés; des variations régionales dans les espèces de proie et les habitats fréquentés relativement à la quête de nourriture ont été identifiées. Les chasseurs ont aussi identifié des changements importants dans l'état corporel (ex : l'épaisseur de la couche de graisse), qui étaient associés à leurs observations du cycle saisonnier d'alimentation. Le cycle d'accumulation de graisse à la fin de l'automne et à l'hiver, combinée avec la compréhension que la Baie d'Hudson n'est pas connue comme une région productive, suggère l'existence d'hypothèses alternatives à celle de la quête de nourriture pour

65 expliquer les mouvements saisonniers de ces baleines. Les connaissances Inuites de
66 l'écologie alimentaire du béluga que nous présentons fournissent de l'information sur la
67 composition du régime alimentaire et de l'apport énergétique saisonnier du béluga, et
68 peuvent contribuer un élément important pour la surveillance du régime alimentaire de
69 cette espèce présentement, et dans le futur.

Draft

Introduction

Understanding foraging ecology improves understanding of trophic structure, relationships among species, and knowledge of how species may be affected by environmental and ecosystem change. In the Arctic, changes in the environment are altering food webs, with evidence of dietary shifts in seabirds (Gaston et al. 2003) and pinnipeds (Chambellant et al. 2013; Crawford et al. 2015). These changes increase the urgency of gathering data on foraging ecology to monitor changes or shifts over time, although the opportunity for baseline data has likely already passed (Laidre et al. 2008).

Studying foraging ecology of Arctic cetaceans is inherently challenging given their remote ice-covered environment, the limited time they spend at the surface, their migratory nature, and the cost of research under these conditions. As a result, Arctic wildlife research has generally focused on relatively few locations in the spring and summer seasons (e.g. aerial surveys (Asselin et al. 2012)) (Gagnon and Berteaux 2009).

Beluga whales (*Delphinapterus leucas* (Pallas, 1776)) are medium-sized odontocetes occupying a central role in the Arctic ecosystem. They have a circumpolar distribution and are often associated with seasonally ice-covered waters, but are known to travel through areas of heavy ice cover (Suydam et al. 2001). The absence of a dorsal fin is thought to be an adaptation to ice covered waters (Harington 2008).

Climate change forecasts predict that ice cover in the Arctic will decline, with some areas formerly covered by the multi-year ice pack becoming seasonally ice free (Stroeve et al. 2012). This provides an opportunity for Arctic species, whose distribution is limited by ice, to expand their ranges, while more temperate species are also expected to expand their ranges northwards (Laidre et al. 2008). Monitoring changes in distribution

and foraging ecology among apex predators is one approach to monitoring climate change impacts on the marine ecosystem (e.g. range expansion in northern reaches of species distribution and changes in diet). Beluga are often considered generalist feeders, with regional variations in diet (Loseto et al. 2009; Bailleul et al. 2012; Quakenbush et al. 2015), which may confer diet plasticity allowing them to adapt to these changes. Owing to their wide distribution, and how well beluga are known, this species would appear to be an excellent model to understand the impacts of climate change, because one would expect that ecosystem changes might be reflected in changes in diet as more southerly prey species move north.

Despite the extensive distribution of beluga, and the long history of research on this species, there have been few studies on beluga diet in Canada (e.g. Vladykov 1946; Doan and Douglas 1953; Loseto et al. 2009; Kelley et al. 2010; Marcoux et al. 2012) and elsewhere (Kleinenberg et al. 1964; Tomilin 1967; Seaman et al. 1982; Heide-Horgensen and Teilmann 1994; Quakenbush et al. 2015). Stomach content analyses, largely from harvested whales, provided some of the earliest, and most recent, evidence of prey species (Vladykov 1946; Sergeant 1962, 1973; Quakenbush et al. 2015). Molecular methods such as, fatty acids, stable isotopes, and trace elements have provided indirect evidence for diet, trophic level, habitat use and location, as well as how diet differs by beluga size, sex and reproductive status (Loseto et al. 2007, 2008, 2009; Thiemann et al. 2008; Marcoux et al. 2012). Satellite-linked tagging studies have also increased our understanding of feeding behavior. Dive profiles from tagged beluga have provided data regarding target depth, feeding behaviour, and likely prey choice (Richard et al. 1998, 2001a; Kingsley et al. 2001; Bailleul et al. 2012; Citta et al. 2013; Hauser et al. 2015).

Nunavimmiut (Inuit of Nunavik) have developed an extensive understanding of the beluga whale and its ecology based on a long dependence on beluga, for their cultural, health, and economic well-being that continues today (Van Oostdam et al. 2005). Inuit adults in Nunavik participate in harvesting traditional or country foods, the greatest percentage (81%) of all regions in the Canadian Arctic, with beluga being the most frequently consumed species of marine mammal (Blanchet and Rochette 2008; ITK 2008). Beluga inhabiting Nunavik coastal waters come from several different stocks, some of which are considered endangered (Turgeon et al. 2011).

In the past, Inuit Knowledge (IK) has been considered anecdotal (Krupnik 2009), or used as the basis for hypothesis generation for further scientific inquiry (e.g. Smith and Stirling 1975), and not recognized as a legitimate source of data and knowledge (Simpson 2004). For beluga whales, however, IK has contributed greatly to our understanding of foraging ecology, including seasonal variability, diet, and interactions among species (Kilabuk 1998; Huntington et al. 1999; Mymrin et al. 1999; Huntington 2000; Doidge et al. 2002) and it is clear that IK has great potential to further increase our understanding of the foraging ecology of these animals.

In this paper, we present results from interviews with Inuit hunters and Elders regarding foraging ecology of beluga whales in northern Quebec (Nunavik) Canada. Our purpose was to document knowledge of diet composition and seasonal changes in body condition of beluga whales from interviews to augment existing data. Given the significant challenges to working in the North, such collaborations could be used to develop a long-term program to monitor changes in prey species composition and the effects of those changes as climate warming occurs.

Material and methods

Semi-directive interviews (Huntington 1998) were conducted with expert beluga whale hunters and Elders in the Nunavik communities of Kangiqsualujjuaq, Quaqtaq, Ivujivik, and Kuujjuaraapik (Figure 1) in 2009 and 2010. These Inuit communities range in population from 315 – 1517 and were selected because of their long history of beluga harvesting and to have broad geographic coverage. In each community, a purposeful sampling strategy (Creswell 2009) was used, selecting key interviewees with beluga hunting and ecology expertise in particular. ‘Expert’ was defined by the number of times and years in which a hunter hunted and recognition by community members as an expert/knowledge holder (Davis and Wagner 2003). The structure for the interviews was based on seasonal cycles starting with questions related to the ecology of the species from when beluga are first seen in the year (e.g. spring migration). Throughout the interviews, questions were focused around migration and important habitat areas for different life history traits. Topics included, but were not limited to: migration, body condition, foraging ecology, predation, breeding, calving and behaviour. Particular attention was also given to how any of these aspects have changed according to each participant’s frame of reference. The results presented here are part of an extensive research project – Nunavimmiut Knowledge of Beluga – however, only the information pertaining to feeding ecology is presented here. Interviews also contained a participatory mapping component where participants documented beluga behaviour and habitat use (e.g. foraging locations) by drawing on local and regional maps (Gadamus and Raymond-Yakoubian 2015). A prey species guide, in Inuttitut and English, was also created specifically for the project interviews to allow for more detailed identification of prey

(McLeod et al. 2009). Interviews were conducted in the participants' chosen language via the assistance of an English / Inuttitut interpreter/translator and were audio recorded.

Participants identified prey species, foraging behaviour and locations, and timing of foraging activity through several different observational methods. Prey species were identified both by direct observations of feeding, and observations of stomach contents of killed animals, and indirectly through observations of foraging behaviour. Only species that were confirmed in subsequent discussions with participants are included in the results. Foraging behaviour was identified as the active pursuit of prey, or indirect behaviours such as beluga circling prey and pushing schools of fish together and pushing them towards shore (e.g. capelin (*Mallotus villosus* (Müller, 1776))).

A mixed methods approach for data analyses was taken, using quantitative statistical analyses to further explore the results of qualitative analyses (Creswell 2009). Interviews were first transcribed and the maps of participants' observations of beluga were digitized into a geographic information system, ArcGIS 9.2 (ESRI, 2006). Once interviews were transcribed and verified, they were imported into the qualitative analytical software package NVivo 8 (QSR International, 2008). Thematic content analysis was conducted on the transcripts in that themes were created using the topics from the interview guide as well as other topics that emerged in the interviews (Creswell 2009). Through this process it was possible to consolidate and summarize participants' responses to different topics and determine patterns of responses among participants. In the qualitative presentation of responses the terms 'a couple', 'several', and 'most/majority of' are used consistently throughout the results presentation and refer to

observations and statements that were noted by '2', '3-5', and '50% or more' of the participants, respectively.

Frequencies of participant responses were analyzed by thematic categories to statistically to examine differences among communities. Descriptive statistics were used to illustrate the distribution of participant observations presented in the thematic analysis. Non-parametric statistical tests were prioritized given small sample sizes. For tests that are sensitive to variance, homogeneity of variance was tested prior to analysis. A Kruskal-Wallis test was used to examine differences in participants' age and experience by community and a Wilcoxon matched pairs signed ranks test was used for observations of body condition (i.e. the continuous data). Fisher's Exact test was used for observational count data (e.g. prey species and habitat type) by community. Results were defined as statistically significant at $p < 0.05$. Analyses were performed using JMP 11.0.0 (SAS Institute Inc., USA).

Following the digitization of the maps, common beluga features (e.g. feeding locations) drawn by participants were combined and kernel density estimation was applied to aggregate collective responses and include a source of uncertainty for all features (Worton 1989). Maps presented therefore represent the collective responses from either a specific community or all communities.

Preliminary results were verified and validated (Creswell 2009) with Kangiqsualujjuaq, Quaqtaq, Ivujivik and Kuujjuaraapik participants and final results were reported through meetings open to the whole community during 2010 and 2011. Some topics particularly benefited from validation. For example, changes in blubber thickness were discussed in all of the verification and final reporting meetings and through group

discussions consensus was reached in each community regarding an average blubber thickness and the associated time of year. Similarly, in some cases the consensus around stomach fullness was developed either during the verification or final reporting workshops.

Results

Participant Information

A total of 40 participants were interviewed in 4 communities. Participants had a median age of 63 years (range 34 – 86 years old) (Table 1). The age of the participants was not statistically different between communities (Kruskal-Wallis, $df = 3$, $\chi^2 = 5.40$, $p = 0.14$). The majority of participants were male; less than 20% were female. The median time that participants had spent in their hunting-area was 61 years and ranged between 48 years in Ivujivik to 67 years in Kangiqsualujjuaq. No difference in length of interviewee experience was observed between communities (Kruskal-Wallis, $df = 3$, $\chi^2 = 5.07$, $p = 0.17$). The majority of participants noted that they began hunting beluga when they were young teenagers, but had followed older hunters for years prior to actually hunting. Therefore each participant had, on average, over 40 years of experience in his or her area. On average 86% of the participants were active hunters, with the lowest proportion in Kangiqsualujjuaq (73%, $n = 11$) and the highest proportion in Ivujivik (100%, $n = 8$).

The size of community beluga hunting areas (i.e. all individual beluga hunting areas combined) varied between communities. Hunters in Ivujivik and Quaqtaq identified the smallest hunting areas, while Kangiqsualujjuaq and Kuujjuaraapik hunters used larger areas (Table 1). For all communities with the exception of Kuujjuaraapik, the

feeding areas were larger than the beluga hunting areas. The time of year beluga are observed varied by community. While all communities observed beluga throughout the year, Quaqtaq and Ivujivik hunters observed large numbers during the spring and fall migrations, whereas Kuujjuaraapik hunters observed whales intermittently throughout the summer. Kangiqsualujjuaq hunters observed beluga during the spring and fall migrations, though to a lesser extent than Quaqtaq and Ivujivik, and also intermittently throughout the summer.

Prey Species

Nunavimmiut identified a diverse range of fish and invertebrate prey species (Table 2; Figure 2). Participants were able to identify prey to either the genus or species level, depending on the experience of the participant, the level of digestion of stomach contents, and the conditions during harvest. To increase sample sizes, prey species were grouped by family for comparison among communities. A full list of species identified is included in Table 2. Sculpin (*Cottidae*), cod (*Gadidae*), salmon (*Salmonidae*) and crustaceans were more frequently reported by participants as known beluga prey than smelt (*Osmeridae*), sandlance (*Ammodytidae*) and herring (*Clupeidae*). Sculpins, cods, and crustaceans were identified in all communities. Two fish species, shorthorn sculpin (*Myoxocephalus scorpius* (L., 1758)) and Greenland cod (*Gadus ogac* (Richardson, 1836)), were identified as beluga prey in all communities. Direct observation of beluga feeding on sculpins and cod was identified by 55% and 53% of all participants, respectively. Although no significant difference was found among communities for sculpins or cod, they were more commonly reported in Ivujivik (75% for both species) and Kuujjuaraapik (70% and 60% of participants respectively). Capelin was identified in

all communities, except Quaqtaq, which reported sand lance (*Ammodytes sp.*). It was thought that it was likely American sand lance (*Ammodytes americanus* (DeKay, 1842)) based on the type of behaviours observed (i.e. close to shore). Sand lance are present when the ice first breaks up and very early in the summer, the middle of July, as well as on the beach in August. Capelin was reported by 24% of the participants from the other three communities with no significant regional variation. Participants in Ivujivik and Kuujjuaraapik said that capelin is among the most important prey items for beluga and Ivujivik hunters noted the particular importance of capelin during the fall when they are present in large schools. Kuujjuaraapik and Kangiqsualujjuaq participants also observed new species of fish in their areas due to warming waters but did not identify the species. “Ya, there was usually the fish that usually are from this area that I used to see inside the stomach, but nowadays with the warming of the... Arctic we’re starting to have different fish inside their stomach” (Willie Tooktoo).

Some regional differences were reported. For example, there was significant variation in the reporting of *Salmonidae* within Nunavik (see Table 2). Hunters in Kangiqsualujjuaq (73% of participants) and Quaqtaq (55% of participants) reported Arctic char (*Salvelinus alpinus alpinus* (L., 1758)) more frequently than Ivujivik or Kuujjuaraapik hunters (Fisher’s Exact test, $p = 0.00002$). One participant in Ivujivik reported Arctic char but this could not be confirmed though other participants agreed that it was possible. “Dolly varden” (*Salvelinus malma malma* (Walbaum, 1792)) was identified as a beluga prey in both Kangiqsualujjuaq and Kuujjuaraapik but the current known distribution of this species makes this unlikely (Scott and Crossman 1973). It is more likely that it was an Arctic char and brook trout (*Salvelinus fontinalis* (Mitchill,

1814)) hybrid (Hammar et al. 1991; Glemet et al. 1998). Quaqlaq hunters noted that shorthorn sculpin, Arctic char, and shrimp are the most common beluga prey, particularly in the winter. Hunters in Kuujjuaraapik noted that there are two types of whitefish (*Coregonus*), inshore and offshore, and that both types are important beluga prey species.

High seasonal variability in beluga prey occurred for Arctic char, capelin, and sand lance. Participants in both Quaqlaq and Ivujivik, however, observed that location accounted for more variation in beluga diet than season.

Foraging Habitats and Locations

Hunters identified beluga feeding locations throughout Nunavik coastal waters. Sixty-five percent of participants spoke about specific habitat types, noting that beluga forage in rivers, bays, onshore, and offshore (Table 3) and identified these foraging areas on maps (Figure 3 a-d). Rivers were reported much more often as feeding locations (73%) throughout Nunavik, while bays (31%), shores (23%), and offshore areas (12%) were identified less frequently (Table 3).

There is regional variation in habitats used for foraging (Table 3). Participants from Kangiqsualujjuag, Quaqlaq and Kuujjuaraapik who discussed habitat types mentioned rivers significantly more often than participants in Ivujivik, where rivers were not mentioned in the context of foraging locations. Ivujivik hunters mentioned bays more frequently than Kuujjuaraapik hunters, who did not mention bays at all (Fisher's Exact test, $p = 0.005$). Ivujivik and Quaqlaq participants similarly reported that beluga feed along the shore or coast near their communities (40 and 43%, respectively). Feeding along shore, particularly as beluga arrive, was also mentioned in Kuujjuaraapik specifically in relation to feeding on capelin. Quaqlaq hunters who discussed foraging

habitats said that beluga feed in offshore areas (29%) (see Figure 3 a-d for all feeding locations identified), though this was not significantly different from other communities. It was also noted, particularly in Quaqtaq and Kuujjuaraapik, that beluga move between inshore and offshore areas, probably associated with tide-related feeding opportunities. “*At the low tide they would go down, feed off shore and high tide they would come in again*” (Alec Tuckatuck). Strong currents and upwellings are important for feeding. “*Beluga depend on currents very much for feeding*” (David Okpik). The noted association with currents was particularly common in Kangiqsualujjuaq and was reported by 55% of participants.

In August and September, Arctic char and Atlantic salmon (*Salmo salar* (L., 1758)) migrate upriver giving rivers greater importance as foraging habitat. Communities along Hudson Strait, however, observed less feeding during this time. Quaqtaq participants reported that beluga do not feed while they are migrating, particularly during the spring migration, and feed mainly in their wintering, but also their summering areas. Beluga that remain in Hudson Strait during the summer are observed feeding in rivers, particularly those southeast of Kangiqsujuaq. They are reported to be most likely feeding on sand lance and Arctic char. Winter feeding was noted to take place in Hudson Strait and by Killiniq at the tip of the Quebec – Labrador peninsula (Figure 1).

Several hunters in Kangiqsualujjuaq (27%) and two in Quaqtaq (18%) noted differences in foraging associated with gender or reproductive status. In Kangiqsualujjuaq, participants reported that males generally feed farther offshore than females and calves. During the final reporting meeting in Quaqtaq females were reported

to often leave their calves at the river mouths of known ‘good char rivers’ during the summer while they feed on char. Also in Quaqtaq, a hunter reported females exhibiting cooperative feeding behaviour by these rivers to feed their calves.

One time a bunch of us we were watching a calf being fed by the parent whales.

During the month of July we were going fishing here and we saw a calf there (in the rivers near Kangiqsujuaq, Innangajuit – char river). We stopped for lunch and we saw a whole bunch of whales coming from the ocean into the bay. They were coming in this way and there were calves here, beluga calves. When they were coming we didn’t notice any unusual activity, but then a few minutes later we started finding out they’re drawing in a school of Arctic char fish right to their calf. And they circled and just let the calf eat from that. And every time the pool of fish tried to get away they were diverting them right to where the calf was. It was something else. The most unusual moment I have watched in the beluga, how they worked together. And these were about maybe five, six whales working together bringing in the pool of Char fish! We were witnessing very clearly what was happening there. (Harry Okpik)

Seasonality of Foraging

Participants also spoke about the time of year beluga forage in their hunting areas. All communities agreed that beluga feed intensively during the winter and less so during the summer. “All year ‘round even in the winter time the beluga are here in the open water. All over around here they’re going like back and forth the whole winter... in Hudson Strait. They’re feeding and they gain weight around here” (Quitsaq Tarriasuk). Feeding during the late summer (July and August) was mainly observed for communities with large runs of fish nearby, such as Kangiqsualujjuaq and Kuujjuaraapik. “They wait

for the blueberries to turn blue and they come along to the mouth of the river. That's when the fish come in." (Sappa Fleming). While some participants reported that there is some feeding occurring during migration, others from each of the communities which observed beluga during migration said that beluga are feeding very little during that time. Observations of feeding during migration were frequent in Quaqtaq (73%). It was also noted that there is more feeding during the fall than the spring migration.

In addition to prey identification, hunters observations of stomach contents provided indirect observations about the amount of feeding. Hunters in all communities looked in beluga stomachs (73% of all participants), and although it varied by community this variation was not significant (Table 4). The percentages reported represent the number of hunters interviewed who have looked at beluga stomachs but most hunters have done so on many occasions. In the past, when beluga stomachs were used as floats for harpoons, Nunavimmiut observed stomach contents more commonly. For those communities observing beluga stomachs during their migration most observed them to be quite full during the spring migration and quite empty during the fall migration (Table 4).

Body Condition

Participants were asked about the general body condition of beluga, specifically blubber and skin, with attention to seasonal variation and overall beluga health. There were individuals in each community who observed pattern of beluga being fattest in late winter and early spring and thinnest during the fall. In Quaqtaq and Ivujivik the pattern was strong and reported by 100% and 75% of participants, respectively. In Kangiqsualujjuaq and Kuujjuaraapik the pattern was less noticeable, reported by 55% and 10% of participants, respectively. Given the strength of this pattern in the Hudson Strait

communities, participants from Quaqtaq and Ivujivik were further asked if they could quantify the change in blubber thickness by estimating average thickness at the same location (behind the head on the dorsal side) at different times of the year. Based on the estimates that hunters from Quaqtaq and Ivujivik provided, beluga lose 5 cm (median) of blubber thickness between the spring and the fall (Wilcoxon signed rank matched-pair test, $S = -33.00$, $n = 11$, $p = 0.001$). The median spring blubber thickness reported was 11 cm (range: 6.3-20 cm) and the median fall blubber thickness reported was 4 cm (range: 1-9 cm) (Figure 4). During the final reporting meeting in Quaqtaq it was cautioned that there can be considerable variation between whales, and that blubber thickness is dependent on other factors such as size and whether it is a migratory or resident whale. Observations of these changes from all communities are summarized in Table 5.

Observations of body condition were associated with whether beluga float or sink when killed. Beluga usually float in the late winter and spring, when they have thick blubber, and sink in the fall when they are thinner (Kangihsualujjuaq, 45%, Quaqtaq, 45% and Ivujivik, 34%). *“That’s (March) when they don’t sink anymore. Like if you shoot them they’ll float. Blubber is so thick they don’t sink”* (Joshua Annanack). When discussing fall hunting it was frequently stated that a different hunting approach is necessary to retrieve beluga, such as hunting in shallow waters or with a heavy hook. It was emphasized, especially during the final reporting trip, that it is important to not oversimplify this pattern of weight change because there are beluga that do not follow this and will sink in the spring or float in the fall and in general, blubber thickness is more variable in the fall. Several interviewees also noted an overall trend, saying that beluga are fatter than they used to be, particularly in the fall. Hunters in Ivujivik associated

these changes in body condition with behavioral changes, noting that beluga are more 'skittish' (i.e. cautious) in the fall. Similar behavioural observations were made by Kuujjuaraapik hunters but were associated with moulting rather than changes in body condition.

In Quaqtac, two participants discussed the characteristics of blubber, noting that the blubber is yellower, oilier (containing more liquid), and denser in the spring. The changes in the characteristics of the blubber were also discussed in the final reporting meeting and it was noted that beluga have more oil in the summertime but are not necessarily more fat and that beluga fat is more dense in the spring than in the fall. In the final reporting meeting it was added that grey whales (i.e. juveniles) tend to be very oily.

Discussion

Using a mixed methods approach provided an effective way to analyse IK to add to the existing knowledge base regarding beluga whale diet composition, foraging time and location, and seasonal changes in body condition in Nunavik waters.

Participants had, on average, 40 years of beluga hunting experience within their hunting areas, thus differences among communities, in diet, condition and behaviour are likely reflecting real differences in regional or seasonal activity. When whales are nearby communities also impacts hunters' observations and varies regionally. For example, although all communities reported some observations of beluga throughout the year the two Hudson Strait communities (Quaqtac and Ivujivik) primarily observe beluga during their spring and fall migration whereas Kangiqsualujjuac hunters observe a migration of fewer animals and travel to both Quaqtac and Killiniq for hunting during the larger

migration. All communities observe beluga throughout the summer though the observations are sporadic in all communities except Kuujjuaraapik, which sees beluga throughout the summer.

Prey Species

In total, 21 species were identified as beluga prey by hunters, with sculpin, cod, salmon, trout, whitefish and crustaceans dominating diets, which was similar to that described in earlier unpublished traditional ecological knowledge studies from this region (McDonald et al. 1997; Doidge et al. 2002; Lee et al. 2002). According to scientific studies of more northern populations such as the Beaufort Sea, Cumberland Sound, and Greenland (Heide-Jorgensen and Teilmann 1994; Loseto et al. 2009; Marcoux et al. 2012; Table 6), beluga in Nunavik consumed sculpin, cod, salmon and crustaceans more often than Arctic cod (*Boreogadus saida* (Lepechin, 1774)) (Table 2). Arctic cod was identified as beluga prey by Salluit hunters in a previous TEK study (Lee et al. 2002), but only a single hunter from both Kangiqsualujjuaq and Ivujivik mentioned Arctic cod during this study. Hunters did not indicate a change in diet related to cod and the regional differences are more likely related to a north-south cline in prey availability. Capelin, which was identified in all but one community, and qualitatively described as a dominant prey species, has also been identified as dominant prey for Western Hudson Bay beluga (Kelley et al. 2010), as well as in beluga from the St. Lawrence River Estuary (Vladykov 1946). One of the predictions of climate change is that there will be fewer northern prey species, such as Arctic cod, and more temperate species, such as capelin, may replace them. However, it is not known whether capelin has always been an important prey species for beluga in eastern Hudson Bay or whether that is a recent shift

as has been shown for thick-billed murres (*Uria lomvia* (L., 1758)) in northern Hudson Bay (Gaston et al. 2003) and hypothesized for the Cumberland Sound beluga (Marcoux et al. 2012) and ringed seal (*Pusa hispida* (Schreber, 1775)) populations (Chambellant et al. 2013). Although the observed importance of capelin could suggest that temperate species may be moving in with warming sea temperatures, Watts and Draper (1986) documented beluga preying upon capelin in western Hudson Bay over 30 years ago indicating that capelin is not a new arrival, at least on that coast of the bay. Hunters in the more southern communities (i.e. Kangiqsualujjuaq and Kuujjaraapik) noted that they are observing new types of fish though there were few other noted changes in prey. This suggests it may be related to the latitudinal gradient though there are alternate possibilities (e.g. species introductions).

Regional differences characterized beluga diet in Nunavik, with only two species, Greenland cod and shorthorn sculpin, reported throughout the region (Arctic char was the most reported prey in Kangiqsualujjuaq and capelin was qualitatively described as dominant in Ivujivik and Kuujjaraapik). The greatest abundance of *Salmonidae* species (7), was reported in Kangiqsualujjuaq, which is also the area where many of the salmonid species distributions overlap (Scott and Crossman 1973). Other populations of beluga inhabiting the same latitude, such as Cook Inlet and Bristol Bay beluga, also feed on a variety of salmonids; at least 3 of the 5 and all of the different species of salmon found in that area, respectively (Hobbs et al. 2008; Goetz et al. 2012; Quakenbush et al. 2015). In other communities, for example Ivujivik, no hunters reported observations of beluga preying on salmonids, though it was noted that beluga could be preying upon Arctic char. For a species to become a common prey item two things must occur; beluga and prey

must regularly overlap in space and time. For a fish species to be a known prey item, in this study, the beluga either needed to be harvested or observed feeding. Therefore, what we can learn about diet using IK depends on the overlap in the distribution and timing of beluga and potential prey species, the hunter observations and timing of the harvest. Though Arctic char are distributed throughout Nunavik and were historically present in Great Whale River (Scott and Crossman 1973), during more recent sampling along Hudson Bay, char were not found south of the Innuksuac River (Morin et al. 1980). This may explain why char were not reported beluga prey by Kuujjuarapik hunters or it may be related to the time of year beluga are present in Eastern Hudson Bay. In the more eastern communities, Quaqtaq and Kangiqsualujjuaq, beluga are observed during their fall migration at the same time of year there are large river runs of anadromous fish (Scott and Crossman 1973), likely leading to the dominance of char reported. However there were participants who specifically noted that changes in location account for more change in beluga diet than season, though it is difficult to disentangle the two factors given beluga's strong seasonal movements.

Foraging Habitats and Locations

Hunters have observed beluga using a range of habitats (e.g. rivers, bays, offshore, and nearshore) for foraging throughout Nunavik, with rivers identified most by participants from all communities, except for Iuvjivik. Rivers, particularly in the fall, are likely important due to anadromous fish runs (e.g. Southeast Baffin and Alaskan beluga populations for Arctic char and salmon, respectively) (Kilabuk 1998; Huntington et al. 1999) therefore community location likely influences reported habitat use. For example, in Iuvjivik, where there are few large rivers, hunters reported beluga foraging in bays

more commonly than hunters in Kuujjuarapik, where there are several large rivers. The observation of beluga feeding along the shore in most of the communities likely coincides with capelin spawning (late June – August in the North Atlantic) (Davoren and Montevecchi 2003) and also when sand lance are nearshore (late summer) (participants and Robards and Piatt 1999). The observation, particularly by Quaqtaq participants, that beluga are feeding in offshore areas is also corroborated by telemetry data for this beluga population and others (Richard et al. 2001*b*; Bailleul et al. 2012). For example, in Lewis et al. (2009) beluga whales spent 76% of their time in areas greater than 15 kilometers from shore and traveled to deep-water troughs (600m) in the Labrador Sea in the winter, most likely associated with foraging activities. Observations of movement between offshore and inshore areas are thought to be associated with feeding by Nunavimmiut, which has also been hypothesized for these and other populations by biologists (Richard et al. 2001*a*; Bailleul et al. 2012). Tagging studies in the western Arctic have shown that beluga travel into pack ice much greater distances from shore than previously thought (Suydam et al. 2001; Citta et al. 2013; Hauser et al. 2014), supporting the argument that beluga may be using heavy pack ice, perhaps for predator avoidance in addition to feeding. These tagging studies and interviewee observations support that beluga use offshore habitats as well as estuarine and coastal areas.

Hunters in half of the communities referenced gender and reproductive status when discussing habitat use for foraging. For example, Kangiqsuluajjuaq hunters noted that males generally feed farther offshore and on larger fish than females and calves. Segregation based on gender, size and reproductive status has also been documented in the Beaufort Sea (Loseto et al. 2006).

Seasonality of Feeding

Hunters shared observations of beluga foraging throughout the year and participating communities agreed that feeding activity peaks during the winter. This comes from direct observations of feeding, when Inuit used to hunt beluga during the winter. This practice is less common now due to changes in the environment and management regulations. Feeding in the winter is also inferred from observation that beluga gain mass during the winter. Though many populations of beluga feed most intensively during the spring and summer (e.g. Alaskan stocks) there are other populations for which fall and winter are the seasons of greatest foraging activity (e.g. Koski et al. 2002) (Mosnier et al. 2010). In communities near migration routes, interviewees reported that beluga feed very little while they migrate, particularly during the spring. Interviewees reported that feeding activity is less intense in summer, and that it increases in fall. These observations are similar for those of High Arctic beluga where very little feeding activity was observed in summer estuarine areas (Koski et al. 2002). Participants also noted seasonal fluctuations in prey, particularly for those prey species that have stages in their life cycle that bring them closer to shore or into rivers (e.g. Arctic char, capelin, and sandlance). Interviewees also noted seasonal fluctuations in habitat use (e.g. importance of river during the fall).

Seasonal observations of foraging activity are also supported by the examination of stomach contents, which was common practice among the majority of hunters interviewed (73%). Variation in the practice was related to community differences in harvest conditions. For example the spring harvest in Quaqtaq is usually done from the ice edge where time is limited and therefore fewer people look at stomach contents. In

the verification and final workshops with participants, consensus was developed and generally indicated that beluga migrating in the spring have fuller stomachs while in the fall more stomachs were empty, which participants thought was reflective of the amount of feeding that took place prior to migration.

Body Condition

The annual changes in body condition suggest that beluga go through a considerable seasonal change in blubber thickness, gaining in the winter and losing throughout the rest of the year, primarily during migrations. Hunters from Kuujjuaraapik, thought the reduction in blubber thickness after moulting was due to high energy expenditures during breeding and calving. To quantify the changes, Quaqtaq and Ivujivik hunters reported blubber thickness during spring and fall migrations and a matched paired analysis was performed. The timing of fat accumulation coupled with the understanding that Hudson Bay is not known as a productive region (Stewart and Lockhart 2005), indicates that there are likely other factors for the migration into Hudson Bay and lends support to alternate hypotheses. For example the elevated temperatures and low salinity conditions of estuaries in Hudson Bay provide conditions for moulting (St Aubin et al. 1990; Koski et al. 2002). Alternately, this movement could be related to predator avoidance, given that killer whales (*Orcinus orca* (L., 1758)) have only recently become more numerous in Hudson Bay (Higdon and Ferguson 2009; Hammill 2013).

Seasonal differences in body condition have been observed in Baffin Island populations of beluga (Kilabuk 1998) and Alaskan hunters also noted similar observations of beluga being fattest in the spring (the 'winter coat') and thinnest in the fall (Huntington et al. 1999). This seasonal pattern also parallels other marine mammals

such as polar bears (*Ursus maritimus* (Phipps, 1774)) which have the highest adipose stores at the end of the winter (Derocher et al. 2004). Given the pervasiveness of the loss in mass, hunters inferred that it is related to the energetic cost of migration and the lack of foraging in the summer, though given the significant cost of lactation for females (Matthews and Ferguson 2015), the change may be related to multiple factors. For example, the warmer waters of the summering areas require less blubber for thermoregulation and therefore beluga do not forage as extensively at that time of year. The changes related to lactation may account for some of the individual variation (but only in females) observed by hunters. These seasonal changes in body condition have potentially significant implications for bioenergetics (e.g. energy budget, heat loss and feeding rate).

Some caution is needed when interpreting the quantitative results. The methodological approach (i.e. semi-directive interviews) meant that although participants spoke to the same general topics they did not necessarily speak to the same points. In many cases analysis was done on all responses received regardless of whether they were the result of a specific question. For example, because participants were not consistently and specifically asked about whether beluga float or sink when harvested at different times of the year the proportion of participants who would have contributed to that topic was under-represented.

Although we were able to quantify much of the information collected, in some instances observations were not particularly supported by quantitative results but were strongly supported by the qualitative. For example, capelin was only reported by 24% of participants overall, participants in the Hudson Bay communities clearly emphasized their

importance as beluga prey. This qualifying of the quantitative results, and vice-versa, speaks to the importance and strength of a mixed methods approach (Fetters et al. 2013). Results were greatly improved by the verification and validation process conducted in workshops. By reviewing the information that had been collected during the interviews we were able to correct, clarify and further describe results. Finally, these results can only truly represent the participating hunters' experiences and knowledge, and not the community's knowledge as a whole and any extrapolation needs to be done with caution.

Inuit Knowledge provides a complementary approach to other dietary methods (i.e. stomach contents, stable isotope and fatty acid analysis); each approach is limited by the realities of methodology and the challenges of research in the Arctic (Bowen and Iverson 2012). The year-round and long-term nature of the observations and experiences that hunters shared about beluga whale foraging ecology adds considerably to beluga whale foraging ecology literature, specifically contributions regarding diet composition, foraging behaviour, locations, and seasonal body changes in condition. Documentation of Nunavik IK of foraging ecology also provides reference data that can be used for monitoring and detecting change, as well as for the conservation of this species by providing information that can be used to develop mitigation measures for industrial activity such as commercial fisheries and marine development (Gavrilchuk and Lesage 2014). This study demonstrates that IK can greatly add to current knowledge and be incorporated into long-term monitoring programs (that identify prey in stomachs and listen to local hunters) to monitor for changes in the marine ecosystem (e.g. appearance of more temperate species). More specifically, the information on diet can contribute to a

circumpolar spatial model of diet composition for beluga whales able to monitor latitudinal and temporal shifts in prey. With the communities as monitoring sites and the hunters as researchers a cost effective, efficient, and experienced monitoring program could be developed.

Acknowledgements

First and foremost the authors gratefully acknowledge the forty expert hunters and Elders who made this work possible - Kuujjuaraapik: Jobie Abraham, Jimmy Paul Angutiguluk, Betsy K. Crow, Alec Fleming, Louisa Fleming, Sappa Fleming, Willie Tooktoo, Alec Tuckatuck, Moses Weetaltuk, Caroline Weetaltuk; Ivujivik: Moses Ainalik, Peter Ainalik, Sirqualuk Ainalik, Jimmy Audlaluk, Lucassie Kanarjuaq, Charlie Paningajak, Quitsaq Tarriasuk, Saviarjuk Usuarjuk; Quaqtaq: Susie Aloupa, George Angnatuk, Peter Aupaluk, Willie Jararuse, Louisa Kulula, Harry Okpik, David Okpik, Charlie Okpik, David Oovaut, Johnny Oovaut, Eva Tukkiakpik; Kangisualujjuaq: Johnny G. Annanack, Joshua Annanack, Bobby Baron, Christina Baron, Willie Emudluk, Tommy George Etok, Tivi (David) Etok, Lucas Etok, Willie Etok, Paul Jararuse, Tommy Unatweenuk. The authors also wish to thank the late Dr. Bill Doidge who was instrumental in this project. This manuscript was greatly improved by regional reviews by Gregor Gilbert (Makivik Corporation) and Mark O'Connor (Nunavik Marine Region Wildlife Board (NMRWB)), and comments and suggestions from Lori Quakenbush and an anonymous reviewer. We also thank Kristeen McTavish and Sarah Aloupa for translation, Matt Toll for assistance with mapping, and Melanie Lemire for statistical advice. An earlier version of this paper was presented at the 19th Biannual Conference on the Biology of Marine Mammals in

2011. KBH thanks the Garfield Weston Foundation, NSERC, and Canadian Scholarship Trust Foundation for support during her graduate work. We thank International Polar Year, Northern Scientific Training Program, Department of Fisheries and Oceans, and Trent University for funding support.

References

- Asselin, N.C., Barber, D.G., Richard, P.R., and Ferguson, S.H. 2012. Occurrence, distribution and behaviour of beluga (*Delphinapterus leucas*) and bowhead (*Balaena mysticetus*) whales at the Franklin Bay ice edge in June 2008. *Arctic*, **65**(2): 121-132. doi: 10.14430/arctic4194.
- Bailleul, F., Lesage, V., Power, M., Doidge, D.W., and Hammill, M.O. 2012. Differences in diving and movement patterns of two groups of beluga whales in a changing Arctic environment reveal discrete populations. *Endanger. Species Res.* **17**: 27-41. doi: 10.3354/esr00420.
- Blanchet, C., and Rochette, L. 2008. Nutrition and food consumption among the Inuit of Nunavik. Nunavik Inuit Health Survey 2004, Qanuippitaa? How are we? Quebec: Institut national de santé publique du Québec (INSPQ) & Nunavik Regional Board of Health and Social Services (NRBHSS). Available from <http://www.inspq.qc.ca> [accessed 6 October 2015].
- Bowen, W.D., and Iverson S.J. 2012. Methods of estimating marine mammal diets: a review of validation experiments and sources of bias and uncertainty. *Mar. Mamm. Sci.* **29**(4): 719-754. doi: 10.1111/j.1748-7692.2012.00604.x

- 643 Chambellant, M., Stirling, I., and Ferguson, S.H. 2013. Temporal variation in western
644 Hudson Bay ringed seal *Phoca hispida* diet in relation to environment. Mar.
645 Ecol. Prog. Ser. **481**: 269-287. doi: 10.3354/meps10134.
- 646 Citta J.J., Suydam R.S., Quakenbush L.T., Frost K.J., and O'Corry-Crowe G.M. 2013.
647 Dive behavior of eastern Chukchi beluga whales (*Delphinapterus leucas*), 1998-
648 2008. Arctic, **66**: 389-406. doi: 10.14430/arctic4326
- 649 Crawford J.A., Quakenbush L.T., and Citta J.J. 2015. A comparison of ringed and
650 bearded seal diet, condition and productivity between historical (1975-1984) and
651 recent (2003-2012) periods in the Alaskan Bering and Chukchi seas. Prog.
652 Oceanogr. **136**:133-150. doi:10.1016/j.pocean.2015.05.011.
- 653 Creswell, J.W. 2007. Qualitative inquiry and research design: Choosing among five
654 approaches (3rd ed.). Sage Publications, Los Angeles, C.A.
- 655 Creswell, J. W. 2009. Research design: Qualitative, quantitative, and mixed methods
656 approaches. 3rd ed. Sage Publications, Los Angeles, C.A.
- 657 Davis, A., and Wagner, J.R. 2003. Who knows? On the importance of identifying
658 "expert" when researching local ecological knowledge. Hum. Ecol. **31**(3): 463-
659 489. doi: 10.1023/A:1025075923297.
- 660 Davoren, G.K., and Montevecchi, W.A. 2003. Signals from seabirds indicate changing
661 biology of capelin stocks. Mar. Ecol. Prog. Ser. **258**: 253-261. doi:
662 [10.3354/meps258253](https://doi.org/10.3354/meps258253).
- 663 Derocher, A.E., Lunn, N.J., and Stirling, I. 2004. Polar bears in a warming climate.
664 Integr. Comp. Biol. **44**: 163-176. doi: [10.1093/icb/44.2.163](https://doi.org/10.1093/icb/44.2.163).
- 665 Doan K.H., and Douglas C.W.. 1953. Beluga of the Churchill region of Hudson Bay. Bull.

- 666 Fish. Res. Board Canada **98**: 1–27.
- 667 Doidge, W., Adams, W., and Burgy, C. 2002. Traditional ecological knowledge of beluga
668 whales in Nunavik: Interviews from Puvirnituk, Umiujaq and Kuujjuaraapik.
669 Makivik Corporation, Kuujjuaq. pp. 20-20. Available from [http://waves-](http://waves-vagues.dfo-mpo.gc.ca)
670 [vagues.dfo-mpo.gc.ca](http://waves-vagues.dfo-mpo.gc.ca) [accessed 6 October 2015].
- 671 Fetters, M.D., Curry, L.A., and Creswell, J.W. 2013. Achieving integration in mixed
672 methods designs - Principles and practices. Health Serv. Res. **48**(6): 2134-2156.
673 doi: 10.1111/1475-6773.12117.
- 674 Gadamus, L., and Raymond-Yakoubian, J. 2015. Qualitative participatory mapping of
675 seal and walrus harvest and habitat areas: Documenting Indigenous knowledge,
676 perserving local values, and discouraging map misuse. Int. J. Appl. Geospatial
677 Res. **6**(1): 76-93. doi: 10.4018/ijagr.2015010105.
- 678 Gagnon, C.A., and Berteaux, D. 2009. Integrating traditional ecological knowledge and
679 ecological science: A question of scale. Ecol. Soc. **14**(2): 19[online]. URL:
680 <http://www.ecologyandsociety.org/vol14/iss2/art19/>.
- 681 Gaston, A.J., Woo, K., and Hipfner, J.M. 2003. Trends in forage fish populations in
682 northern Hudson Bay since 1981, as determined from the diet of nestling thick-
683 billed murre, *Uria lomvia*. Arctic, **56**(3): 227-233. doi: [10.14430/arctic618](https://doi.org/10.14430/arctic618).
- 684 Gavrilchuk, K., and Lesage, V. 2014. Large-scale marine development projects
685 infrastructure (mineral, oil and gas) proposed for Canada's North. Can. Tech.
686 Rep. Fish. Aquat. Sci. 3069: pp. viii + 84. Available from
687 [http://publications.gc.ca/collections/collection_2014/mpo-dfo/Fs97-6-3069-](http://publications.gc.ca/collections/collection_2014/mpo-dfo/Fs97-6-3069-eng.pdf)
688 [eng.pdf](http://publications.gc.ca/collections/collection_2014/mpo-dfo/Fs97-6-3069-eng.pdf) [accessed 6 October 2015].

- 689 Glémet, H., Blier, P., and Bernatchez, L. 1998. Geographical extent of Arctic char
690 (*Salvelinus alpinus*) mtDNA introgression in brook char populations (*S.*
691 *fontinalis*) from eastern Québec, Canada. Mol. Ecol. 7: 1655-1662. doi:
692 [10.1046/j.1365-294x.1998.00494.x](https://doi.org/10.1046/j.1365-294x.1998.00494.x).
- 693 Goetz, K.T., Montgomery, R.A., Ver Hoef, J.M., Hobbs, R.C., and Johnson, D.S. 2012.
694 Identifying essential summer habitat of the endangered beluga whale
695 *Delphinapterus leucas* in Cook Inlet, Alaska. Endanger. Species Res. 16: 135-
696 147. doi: 10.3354/esr00394.
- 697 Hammar, J., Dempson, J.B., and Verspoor, E. 1991. Natural hybridization between Arctic
698 char (*Salvelinus alpinus*) and brook trout (*S. fontinalis*): Evidence from northern
699 Labrador. Can. J. Fish. Aquat. Sci. 48(8): 1437-1445. doi: [10.1139/f91-171](https://doi.org/10.1139/f91-171).
- 700 Hammill, M.O. 2013. Effects of climate warming on Arctic marine mammals in Hudson
701 Bay: Living on the edge? In Responses of Arctic Marine Ecosystems to Climate
702 Change. Edited by F.J. Mueter, D.M.S. Dickson, H.P. Huntington, J.R. Irvine,
703 E.A. Logerwell, S.A. MacLean, L.T. Quakenbush, and C. Rosa. Alaska Sea
704 Grant, University of Alaska Fairbanks. pp. 021-038. doi:
705 [10.4027/ramecc.2013.02](https://doi.org/10.4027/ramecc.2013.02).
- 706 Harington, C.R. 2008. The evolution of Arctic marine mammals. Ecol. Appl.
707 18(2)Supplement: S23-S40. doi: doi:10.1890/06-0624.1.
- 708 Hauser D., Laidre K., Parker-Stetter S., Horne J., Suydam R., and Richard P. 2015.
709 Regional diving behavior of Pacific Arctic beluga whales *Delphinapterus leucas*
710 and possible associations with prey. Mar. Ecol. Prog. Ser. 541:245–264.
711 doi:10.3354/meps11530.

- 712 Hauser D.D.W, Laidre K.L., Suydam R.S., and Richard P.R. 2014. Population-specific
713 home ranges and migration timing of Pacific Arctic beluga whales
714 (*Delphinapterus leucas*). Polar Biol. **37**:1171–1183. doi:10.1007/s00300-014-
715 1510-1.
- 716 Heide-Jørgensen, M.P., and Teilmann, J. 1994. Growth, reproduction, age structure, and
717 feeding habits of white whales (*Delphinapterus leucas*) in West Greenland
718 waters. Meddelelser om Grønland, Biosci. **39**: 195-212.
- 719 Higdon, J.W., and Ferguson, S.H. 2009. Loss of Arctic sea ice causing punctuated change
720 in sightings of killer whales (*Orcinus orca*) over the past century. Ecol. Appl.
721 **9**(5): 1365-1375. doi: 10.1890/07-1941.1.
- 722 Hobbs, R.C., Sheldon, K.E.W., Rugh, D.J., and Norman, S.A. 2008. 2008 status review
723 and extinction risk assessment of Cook Inlet belugas (*Delphinapterus leucas*).
724 AFSC Processed Rep. 2008-02, 116 p. Alaska Fish. Sci. Cent., NOAA, Natl.
725 Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.
- 726 Huntington, H.P. 1998. Observations on the utility of the semi-directive interview for
727 documenting traditional ecological knowledge. Arctic, **51**(3): 237-242. doi:
728 <http://dx.doi.org/10.14430/arctic1065>.
- 729 Huntington, H.P. 2000. Traditional knowledge of the ecology of belugas, *Delphinapterus*
730 *leucas*, in Cook Inlet, Alaska. Mar. Fish. Rev. **62**(3): 134-140.
- 731 Huntington, H.P., and the Communities of Buckland, Elim, Koyuk, Point Lay, and
732 Shaktoolik, E. 1999. Traditional knowledge of the ecology of beluga whales
733 (*Delphinapterus leucas*) in the eastern Chukchi and northern Bering Seas,
734 Alaska. Arctic, **52**(1): 49-61. doi: [10.14430/arctic909](https://doi.org/10.14430/arctic909).

- 735 Inuit Tapiriit Kanatami (ITK). 2008. Inuit in Canada: A Statistical Profile. Available from
736 <https://www.itk.ca/publication/inuit-statistical-profile> [accessed 7 October
737 2015].
- 738 Kelley, T.C., Loseto, L.L., Stewart, R.E.A., Yurkowski, M., and Ferguson, S.H. 2010.
739 Importance of eating capelin: Unique dietary habits of Hudson Bay beluga. *In* A
740 Little Less Arctic: Top Predators in the World's Largest Northern Inland Sea,
741 Hudson Bay. S.H.Ferguson, L.L. Loseto, and M.L. Mallory. Springer
742 Netherlands, Dordrecht. pp. 53-70. doi: 10.1007/978-90-481-9121-5_3
- 743 Kilabuk, P. 1998. A study of Inuit knowledge of the Southeast Baffin beluga. The
744 Southeast Baffin Beluga Management Committee. pp. 74. Available from
745 <http://www.nwmb.com/en/resources/publications> [accessed 6 October 2015].
- 746 Kingsley, M.C.S., Gosselin, S., and Sleno, G.A. 2001. Movements and dive behaviour of
747 belugas in northern Quebec. *Arctic*, **54**(3): 262-275. doi: [10.14430/arctic786](https://doi.org/10.14430/arctic786).
- 748 Kleinenberg S.E., Yablokov A.V., Bel'kovich V.M., and Tarasevich M.N. 1964. *Beluga*
749 *(Delphinapterus leucas): Investigation of the species*. Moscow Tra. Nauk SSSR,
750 Jerusalem.
- 751 Koski, W.R., Davis, R.A., and Finley, K.J. 2002. Distribution and abundance of Canadian
752 High Arctic belugas, 1974-1979. *NAMMCO Sci. Publ.* **4**: 87-126. doi:
753 [10.7557/3.2839](https://doi.org/10.7557/3.2839).
- 754 Krupnik, I. 2009. "The Way We See It Coming": Building the Legacy of Indigenous
755 Observations in IPY 2007 – 2008. *In* Smithsonian at the Poles: Contributions to
756 International Polar Year Science. *Edited by* I. Krupnik, M. Lang, and S.
757 Millereds. Smithsonian Institution Scholarly Press. pp. 129–142

- 758 Laidre, K.L., Stirling, I., Lowry, L.F., Wiig, Ø., Heide-Jorgensen, M.P., and Ferguson,
759 S.H. 2008. Quantifying the sensitivity of Arctic marine mammals to climate-
760 induced habitat change. *Ecol. Appl.* **18**(2)Supplement: S97-S125. doi:
761 [10.1890/06-0546.1](https://doi.org/10.1890/06-0546.1).
- 762 Lee, D., Doidge, W., Burgy, C., and Adams, W. 2002. Traditional ecological knowledge
763 in relation to the management of beluga whales in Nunavik Phase I. Interviews
764 at Kangirsuk, Salluit and Inukjuak. Makivik Corporation. Kuujjuaq. Quebec
765 J0M 1C0. pp. 16p + Appendix of 18 maps.
- 766 Lemire, M., Kwan, M., Laouan-Sidi A.E., Muckle, G., Pirkle, C., Ayotte, P., and
767 Dewailly, E. 2015. Local country food sources of methylmercury, selenium and
768 omega-3 fatty acids in Nunavik, Northern Quebec. *Sci. Total Environ.* **509**-
769 **510**:248–259. doi:10.1016/j.scitotenv.2014.07.102.
- 770 Lewis, A.E., Hammill, M.O., Power, M., Doidge, D.W., and Lesage, V. 2009. Movement
771 and aggregation of eastern Hudson Bay beluga whales (*Delphinapterus leucas*):
772 A comparison of patterns found through satellite telemetry and Nunavik
773 traditional ecological knowledge. *Arctic*, **62**(1): 13-24. doi: 10.14430/arctic109.
- 774 Loseto, L.L., Richard, P., Stern, G.A., Orr, J., and Ferguson, S.H. 2006. Segregation of
775 Beaufort Sea beluga whales during the open-water season. *Can. J. Zool.* **84**(12):
776 1743-1751. doi:10.1139/Z06-160.
- 777 Loseto, L.L., Stern, G.A., Connelly, T.L., Deibel, D., Gemmill, B., Prokopowicz, A.,
778 Fortier, L., and Ferguson, S.H. 2009. Summer diet of beluga whales inferred by
779 fatty acid analysis of the eastern Beaufort Sea food web. *J. Exp. Mar. Bio. Ecol.*
780 **374**(1): 12-18. doi: DOI: 10.1016/j.jembe.2009.03.015.

- 781 Loseto, L.L.L., Stern, G.A.A., Deibel, D., Connelly, T.L.L., Prokopowicz, A., Lean,
782 D.R.S., Fortier, L., and Ferguson, S.H. 2007. Linking mercury exposure to
783 habitat and feeding behaviour in Beaufort Sea beluga whales. *J. Mar. Syst.* **74**:
784 1012-1024. doi: 10.1016/j.jmarsys.2007.10.004.
- 785 Loseto, L.L.L., Stern, G.A.A., and Ferguson, S.H. 2008. Size and biomagnification: How
786 habitat selection explains beluga mercury levels. *Environ. Sci. Technol.* **42**:
787 3982-3988. doi: 10.1021/es7024388.
- 788 Marcoux, M., McMeans, B.C., Fisk, A.T., and Ferguson, S.H. 2012. Composition and
789 temporal variation in the diet of beluga whales, derived from stable isotopes.
790 *Mar. Ecol. Prog. Ser.* **471**: 283-291. doi: 10.3354/meps10029.
- 791 Matthews, C.J.D., and Ferguson, S.H. 2015. Weaning age variation in beluga whales
792 (*Delphinapterus leucas*). *J. of Mammal.* **96**(2): 425-437. doi:
793 10.1093/jmammal/gyv046.
- 794 McDonald, M., Arragutainaq, L., and Novalinga, Z. (eds.). 1997. Voices from the bay:
795 Traditional ecological knowledge of Inuit and Cree in the Hudson Bay
796 bioregion. Canadian Arctic Resource Committee, Environmental Committee of
797 Municipality of Sanikiluaq, Ottawa/Sanikiluaq. pp. 98.
- 798 McLeod, B.A., Furgal, C.M., Doidge, W., and Hammill, M.O. 2009. A field guide to prey
799 of beluga (*Delphinapterus leucas*) of the Canadian Arctic. Makivik Corporation.
800 Kuujjuaq, Quebec J0M 1C0.
- 801 Morin, R., Dodson, J., and Power, G. 1980. Estuarine fish communities of the eastern
802 James-Hudson Bay coast. *Environ. Biol. Fishes* **5**(2): 135-141. doi:
803 10.1007/bf02391620.

- 804 Mosnier, A., Lesage, V., Gosselin, J.F., Lemieux Lefebvre, S., Hammill, M.O., and
805 Doniol-Valcroze, T. 2010. Information relevant to the documentation of habitat
806 use by St. Lawrence beluga (*Delphinapterus leucas*), and quantification of
807 habitat quality. DFO Can. Sci. Advis. Sec., Res. Doc. 2009/098. pp. iv + 35.
- 808 Mymrin, N.I., The communities of Novoe Chaplino, Sireniki, Uelen, and Yankrakinnot,
809 and Huntington, H.P. 1999. Traditional knowledge of the ecology of beluga
810 whales (*Delphinapterus leucas*) in the northern Bering Sea, Chukotka, Russia.
811 Arctic, **52**(1): 62-70. doi: 10.14430/arctic910.
- 812 Quakenbush L.T., Suydam R.S., Bryan A.L., Lowry L.F., Frost K.J., and Mahoney B.A.
813 2015. Diet of beluga whales, *Delphinapterus leucas*, in Alaska from stomach
814 contents, March–November. Mar. Fish. Rev. **77**: 70–84.
815 doi:10.7755/MFR.77.1.7.
- 816 Richard, P.R., Heide-Jørgensen, M.P., Orr, J.R., Dietz, R., and Smith, T.G. 2001a.
817 Summer and autumn movements and habitat use by belugas in the Canadian
818 High Arctic and adjacent areas. Arctic, **54**(3): 207-222. doi: 10.14430/arctic782.
- 819 Richard, P.R., Heide-Jørgensen, M.P., and St. Aubin, D. 1998. Fall movements of
820 belugas (*Delphinapterus leucas*) with satellite-linked transmitters in Lancaster
821 Sound, Jones Sound, and northern Baffin Bay. Arctic, **51**(1): 5-16. doi:
822 10.14430/arctic1040
- 823 Richard, P.R., Martin, A.R., and Orr, J.R. 2001b. Summer and autumn movements of
824 belugas of the Eastern Beaufort Sea stock. Arctic, **54**(3): 223-236. doi:
825 10.14430/arctic783.

- 826 Robards, M.D., and Piatt, J.F. 1999. Biology of the genus *Ammodytes*, the sand lances. *In*
827 Sand lance: A review of biology and predator relations and annotated bibli-
828 ography. *Edited by* M.D. Robards, M.F. Willson, R.H. Armstrong, and J.F. Piatt.
829 1999. Res. Pap. PNW-RP-521. Portland, OR: U.S. Department of Agriculture,
830 Forest Service, Pacific Northwest Research Station. pp. 1-16.
- 831 Scott, W.B., and Crossman, E.J. 1973. Freshwater fishes of Canada. Bull. Fish. Res.
832 Board Can., Ottawa, Canada.
- 833 Seaman GA, Lowry LF, Frost KJ. 1982. Foods of belukha whales (*Delphinapterus*
834 *leucas*) in western Alaska. *Cetology*, **44**: 1–19.
- 835 Sergeant, D.E. 1962. The Biology and Hunting of Beluga or White Whales in the
836 Canadin Arctic. Fish. Res. Board Can. Arctic Unit, Montreal, Que. Circ. 8: pp.
837 13. Available from <http://publications.gc.ca/site/eng/447887/publication.html>
838 [accessed 7 October 2015].
- 839 Sergeant, D.E. 1973. Biology of white whales (*Delphinapterus leucas*) in western
840 Hudson Bay. J. Fish. Res. Board Canada **30**(8): 1065-1090. doi: 10.1139/f73-
841 178.
- 842 Simpson, L.R. 2004. Anticolonial Strategies for the Recovery and of Indigenous
843 Maintenance Knowledge. *Am. Indian Q.* **28**(3&4): 373–384. doi:
844 10.1353/aiq.2004.0107.
- 845 Smith, T.G., and Stirling, I. 1975. The breeding habitat of the ringed seal (*Phoca*
846 *hispida*). The birth lair and associated structures. *Can. J. Zool.* **53**(9):
847 1297-1305. doi: 10.1139/z75-155.

- 848 St Aubin, D.J., Smith, T.G., and Geraci, J.R. 1990. Seasonal epidermal molt in beluga
849 whales, *Delphinapterus leucas*. Can. J. Zool. **68**: 359-367. doi: 10.1139/z90-051.
- 850 Stewart, D.B., and Lockhart, W.L. 2005. An overview of the Hudson Bay marine
851 ecosystem. Canadian Technical Report of Fisheries and Aquatic Sciences no.
852 2586. pp. vi + 487.
- 853 Stroeve, J.C., Serreze, M.C., Holland, M.M., Kay, J.E., Malanik, J., and Barrett, A.P.
854 2012. The Arctic's rapidly shrinking sea ice cover: A research synthesis. Clim.
855 Change **110**: 1005-1027. doi: 10.1007/s10584-011-0101-1.
- 856 Suydam, R.S., Lowry, L.F., Frost, K.J., O'Corry-Crowe, G.M., and Pikok, D.Jr. 2001.
857 Satellite tracking of eastern Chukchi Sea beluga whales into the Arctic Ocean.
858 Arctic, **54**(3): 237-243. doi: 10.14430/arctic784.
- 859 Thiemann, G.W., Iverson, S.J., and Stirling, I. 2008. Variation in blubber fatty acid
860 composition among marine mammals in the Canadian Arctic. Mar. Mammal Sci.
861 **24**(1): 91-111. doi: 10.1111/j.1748-7692.2007.00165.x.
- 862 Tomilin AG. 1967. Mammals of the U.S.S.R. and adjacent countries. Cetacea, **9**: 666–
863 696.
- 864 Turgeon, J., Duchesne, P., Colbeck, G.J., Postma, L.D., and Hammill, M.O. 2011.
865 Spatiotemporal segregation among summer stocks of beluga (*Delphinapterus*
866 *leucas*) despite nuclear gene flow: implication for the endangered belugas in
867 eastern Hudson Bay (Canada). Conserv. Genet. **13**(2): 419-433. doi:
868 10.1007/s10592-011-0294-x.

- 869 Vladykov, V.D. 1946. Études sur les mammifères aquatiques IV: Nourriture du marsouin
870 blanc ou béluga (*Delphinapterus leucas*) du fleuve St-Laurent. Département des
871 Pêcheries, Québec, QC.
- 872 Watts, P.D., and Draper, B.A. 1986. Note on the behavior of beluga whales feeding on
873 capelin. Arct. Alp. Res. **18**(4): 439-439. doi: 10.2307/1551093
- 874 Worton, B.J. 1989. Kernel methods for estimating the utilization distribution in home-
875 range studies. Ecology, **70**(1): 164-168. doi: 10.2307/1938423.
- 876

Draft

Table 1: Summary statistics for participants in beluga interviews conducted in Kangiqsualujjuaq, Quaqtaq, Ivujvik, and Kuujjuaraapik*.

Community	Kangiqsualujjuaq (n = 11)	Quaqtaq (n = 11)	Ivujvik (n = 8)	Kuujjuaraapik (n = 10)	All (n = 40)
Age † (y)	69.7 (49-86) ^a	64.5 (34-84) ^a	53.5 (35-76) ^a	57.3 (39-77) ^a	61.3 (34-86)
Male (n, %)	10 (91%)	8 (73%)	8 (100%)	7 (70%)	33 (83%)
Number of interviews with interpretation (n, %)	8 (73%)	6 (55%)	5 (63%)	4 (40%)	23 (58%)
Current hunter (n, %)	8 (73%) ^a	10 (91%) ^a	8 (100%) ^a	8 (80%) ^a	34 (86%)
Time spent in hunting- area † (y)	67.2 (49-86) ^a	60.7 (24-84) ^a	48.0 (22-76) ^a	53.2 (11-84) ^a	57.3 (11-86)
Community beluga hunting area (km ²)	1,966	490	183	4,374	-
Size of foraging habitat (km ²)	3,114	821	331	1,504	-

* Different letters represent statistically significant differences between communities (Each pair Wilcoxon test or Fisher Exact test).

† Mean, range.

Table 2: Percentages of participants that identified prey species to the family taxonomic level during initial interviews and later validated. All prey identified to species are listed by family, with the exception of cod. *

	Kangiqsualujjuaq (<i>n</i> = 11)	Quaqtaq (<i>n</i> = 11)	Ivujivik (<i>n</i> = 8)	Kuujuaraapik (<i>n</i> = 10)
Sculpin (<i>Cottidae</i>)	4 (36%)	5 (45%)	6 (75%)	7 (70%)
Shorthorn sculpin (<i>Myoxocephalus</i> <i>scorpius</i>), Arctic sculpin (<i>Myoxocephalus</i> <i>scorpioides</i>), Spatulate sculpin (<i>Icelus spatula</i>), Fourhorn sculpin (<i>Trigloopsis quadricornis</i>), Slimy sculpin (<i>Cottus</i> <i>cognatus</i>)				
Cod (<i>Gadidae</i>)	4 (36%)	5 (45%)	6 (75%)	6 (60%)
Arctic cod (<i>Boreogadus</i> <i>saida</i>)	1 (9%)	0 (0%)	1 (13%)	0 (0%)
Greenland cod / Rock cod (<i>Gadus ogac</i>), Atlantic cod (<i>Gadus</i> <i>morhua</i>)	4 (36%)	3 (27%)	3 (38%)	2 (20%)
Salmon, trout, and whitefish (<i>Salmonidae</i>)	9 (82%) ^a	6 (55%) ^{ab}	0 (0%) ^c	2 (20%) ^{cb}
Arctic char (<i>Salvelinus</i> <i>alpinus alpinus</i>), Atlantic				

Salmon (<i>Salmo salar</i>), Dolly Varden (<i>Salvelinus malma malma</i>), Brook Trout (<i>Salvelinus fontinalis</i>), Lake Trout (<i>Salvelinus namaycush</i>), Arctic cisco (<i>Coregonus autumnalis</i>)				
Shrimps and Crabs (Crustaceans) Grey sand shrimp (<i>Crangon septemspinosus</i>), Sars shrimp (<i>Sabinea sarsii</i>), Striped pink shrimp / Aesop shrimp (<i>Pandalus montagui</i>), Snow crab (<i>Chionoecetes opilio</i>)	5 (45%)	4 (36%)	4 (50%)	1 (10%)
Smelts (<i>Osmeridae</i>) Capelin (<i>Mallotus villosus</i>)	4 (36%)	0 (0%)	2 (25%)	2 (20%)
Sandlance (<i>Ammodytidae</i>)	0 (0%)	3 (27%)	0 (0%)	0 (0%)
Herring (<i>Clupeidae</i>) (<i>Clupea harengus harengus</i>)	2 (18%)	0 (0%)	0 (0%)	0 (0%)

* Different letters represent statistically significant differences between communities (Fisher’s Exact test)

887 **Other prey:** Lumpsucker, Squid, Seaweed, Plankton, Sea Urchins

888

Draft

889 Table 3: Percentage of participants who discussed foraging habitat, and particular habitat
890 types (as a proportion of the respondent group) (n, %). *

	Kangiqsualujjuaq (n = 11)	Quaqtaq (n = 11)	Ivujivik (n = 8)	Kuujjuaraapik (n = 10)	All participants (n = 40)
Participants who discussed foraging habitats	5 (45%)	7 (64%)	5 (63%)	9 (90%)	26 (65%)
Rivers†	5 (100%) ^a	6 (86%) ^a	0 (0%) ^b	8 (89%) ^a	19 (73%) ^c
Bay†	1 (20%) ^{ab}	3 (43%) ^{ab}	4 (80%) ^a	0 (0%) ^b	8 (31%) ^d
Shore	0 (0%)	3 (43%)	2 (40%)	1 (11%)	6 (23%) ^d
Offshore	1 (20%)	2 (29%)	0 (0%)	0 (0%)	3 (12%) ^d

891 * Different letters represent statistically significant differences between habitats or between communities (Fisher's Exact test)

892 † Indicates those habitat types for which there is statistical difference

893

894

895 Table 4: Observations of Stomach contents (n, %).

	Kangiqsualujjuaq (n = 11)	Quaqtaq (n = 11)	Ivujivik (n = 8)	Kuujuaraapik (n = 10)
Participants	9 (82%)	5 (45%)	6 (75%)	9 (90%)
who look at stomach contents (%)				
Quantity of stomach contents	Often empty, Spring - can have some contents Fall - quite empty,	Spring - fairly full Fall - quite empty	Spring - quite full Fall – empty (though more variable)	Summer – ¼- ½ full, though can be empty

896

897

898 Table 5: Participants’ observations of changes in blubber thickness at different times of
899 the year.

	Time of the Year	Estimated Blubber Thickness (cm)	Time of the Year	Estimated Blubber Thickness (cm)	Notes
Kangiqualujuaq					Describe a change in blubber thickness between seasons but not reflected as a measurable difference
Quaqtaq	Spring migration (end of April – mid July)	12	Fall migration (beginning of Sept- Dec)	5	Based on measurements around the back of the neck
Ivujivik	Spring migration (end of May – mid July)	7	Fall migration (Oct – Dec)	1-4	

Kuujjuaraapik	Arrival	7.5 – 10	Departure	5 – 7.5
	(June)		(September	
			–	
			November)	

900

901

Draft

902 Table 6: Dominant prey species for beluga populations by latitude and method.

Region	St. Lawrence River	Western Hudson Bay	Nunavik Coastal Waters	Cook Inlet and Bristol Bay	Southeast Baffin	Cumberland Sound	Beaufort Sea	West Greenland (Upernavik)
Latitude	45-50°	55-60°	55-65°	60-65°	60-70°	65-70°	65-75°	70-75°
Method	Stomach content identification	Observation; fatty acid analysis	Inuit Knowledge	Stomach contents identification	Inuit Knowledge	Stable isotope analysis	Fatty acid analysis	Stomach content identification
Dominant Prey Species	Sand lance (<i>Ammodytes americanus</i>) and Capelin (<i>Mallotus villosus</i>)* (Vladykov 1946)	Capelin (Kelley et al. 2010; Watts and Draper 1986)	Sculpin (<i>Cottidae</i>), Cod (<i>Gadidae</i>), Salmon (<i>Salmonidae</i>), and Crustaceans † (this study)	Salmon ‡ (Hobbs et al. 2008; Quakenbush et al. 2015)	Arctic cod (<i>Boreogadus saida</i>), turbot (<i>Scophthalmus maximus</i>), Arctic char (<i>Salvelinus alpinus alpinus</i>), Invertebrates, shrimp (Kilabuk 1998)	Arctic cod and Capelin (Marcoux et al. 2012)	Arctic cod (Loseto et al. 2009)	Arctic cod and polar cod (<i>Actogadus glacialis</i>) (Heide- Jorgensen and Teilmann 1994)

903 * Two most commonly found fish species identified in stomach contents

904 † Family groups of species reported most frequently

905 ‡ Greatest percentage frequency

Draft

Figure 1: Map of Nunavik highlighting participating communities - Kuujjuaraapik, Ivujivik, Quaqtaq, and Kangiqsualujjuaq - Killiniq, as well as beluga spring migration (light blue – major migration, dark blue – lesser migration). Note that fall migration is in the reverse direction (adapted from Science of the Total Environment vol. 509-510: Lemire, M., Kwan, M., Laouan-Sidi A.E., Muckle, G., Pirkle, C., Ayotte, P., and Dewailly, E. Local country food sources of methylmercury, selenium and omega-3 fatty acids in Nunavik, Northern Quebec. pp. 248-259, Copyright 2015, with permission from Elsevier).

Figure 2: Reporting of beluga prey species by family group from all participants¹.

¹ Different letters represent statistically significant differences between family groups (Fisher's Exact test)

Figures 3a-d: Maps showing Nunavimmiut identified feeding areas for a) Kuujjuaraapik, b) Ivujivik, c) Quaqtaq, and d) Kangiqsualujjuaq. Colour intensity represents kernel density estimation of commonality of reported observations. **NOTE: THIS MAP IS NOT TO BE REPRODUCED IN ANY WAY, WHOLE OR IN PART. INFORMATION PRESENTED ON THIS MAP ONLY REPRESENTS THAT COLLECTED FROM PARTICIPANTS TO THIS STUDY FROM THE 4 COMMUNITIES INCLUDED. IT DOES NOT REPRESENT ALL NUNAVIMMIUT KNOWLEDGE OF BELUGA FORAGING LOCATIONS FOR THIS REGION.**

Figure 4: Beluga blubber thickness (cm), showing quantiles (red), in spring and fall as reported by hunters in Quaqtaq and Ivujivik.

Figure 1: Map of Nunavik highlighting participating communities - Kuujjuaraapik, Ivujivik, Quaqtaq, and Kangiqsualujuaq - Killiniq, as well as beluga spring migration (light blue – major migration, dark blue – lesser migration). Note that fall migration is in the reverse direction (adapted from Science of the Total Environment vol. 509-510: Lemire, M., Kwan, M., Laouan-Sidi A.E., Muckle, G., Pirkle, C., Ayotte, P., and Dewailly, E. Local country food sources of methylmercury, selenium and omega-3 fatty acids in Nunavik, Northern Quebec. pp. 248-259, Copyright 2015, with permission from Elsevier).

178x194mm (300 x 300 DPI)

(b)

(c)

(a)

(d)

Draft

ዲፍፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን
ፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን
ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን
ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን
ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን
ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን
ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን ዲፍራክሽን

Draft