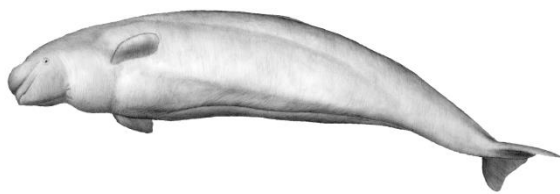




UPDATED GENETIC MIXTURE ANALYSIS OF NUNAVIK BELUGA (*DELPHINAPTERUS LEUCAS*) HARVESTS



G. Kuehl

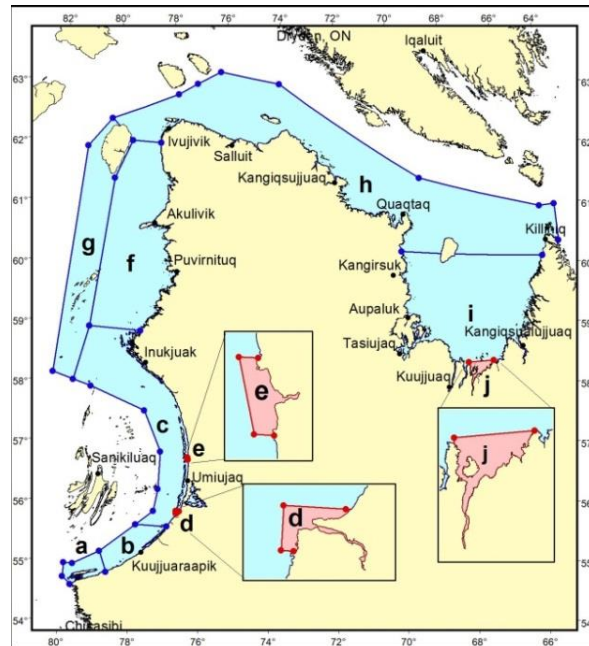


Figure 1. Map of Nunavik communities and boundaries of hunting areas in the 2014–2016 beluga management plan. Areas in red are closed to hunting (d,e,j).

Context

The northern Quebec (Nunavik) beluga hunt targets both summering aggregations and migrating whales from a mixture of stocks, including the eastern Hudson Bay (EHB) and Ungava Bay stocks. Beluga are also observed around the Belcher Islands, which lies in Nunavut. These whales are thought to be a mixture of stocks. There is no established Total Allowable Harvest for Belcher Island hunters. In 2010, the community of Sanikiluaq passed a motion for a voluntary beluga harvest closure from July 1 to September 30, as a conservation measure to protect the EHB stock. In 2012, the closure date was changed to include July 15 to September 30.

Harvesting in Nunavik has been regulated through a combination of area and seasonal closures, and total allowable takes. The Nunavik Marine Region Wildlife Board (NMRWB) has responsibilities for the co-management of Nunavik beluga. In 2014, a new management plan was introduced. This plan relies heavily on the genetic analyses of samples obtained from the hunters to be able to estimate the proportion of EHB whales harvested in each area.

Science was requested to provide advice on: What is the proportion (and associated uncertainty) of EHB beluga present in each of the management zones, based on the most recent genetic information available? What is the best estimate of the proportion (and associated uncertainty) of EHB beluga harvested in Sanikiluaq, both annually and when analyzed based on season? What is the impact of the change in the voluntary closure to July 15th until September 30th, and what is the advice on when the voluntary summer closure in Sanikiluaq would be most effective to conserve EHB beluga?

SUMMARY

- Nunavik hunters harvest beluga from a mixture of stocks currently identified as Western Hudson Bay (WHB), Eastern Hudson Bay (EHB), as well as other non-identified stocks. Animals are also harvested in Ungava Bay, which is believed to contain its own summer stock, but for which no current genetic information is available.
- The 2014-2016 Nunavik beluga harvest management relies on estimating proportion of EHB beluga harvested in newly-defined harvesting areas and seasons.
- Using 1,254 harvest samples collected from 1982 to 2013, the proportions of EHB beluga taken by Nunavik communities and in Sanikiluaq (Nunavut) were estimated with a Genetic Mixture Analysis. These updated analyses confirm that the proportion of EHB beluga in the harvest varies spatially and seasonally.
- Proportions of EHB beluga in well-sampled areas in Hudson Strait remained consistent with previous estimates (with reduced uncertainty). The proportion of EHB beluga in Hudson Strait harvest was 11.7% in the spring (May – August) and 23.6% in the fall (September – January).
- Hunts in the northeastern Hudson Bay in spring and Ungava Bay in fall yielded too few samples to provide meaningful estimates of the proportion of EHB animals in the harvest.
- The updated proportion of EHB beluga harvested in the Belcher Islands (Nunavut) was 2.8% in spring (April 1 – June 30), and 6.5% if spring was extended by two weeks (April 1-14 July). The proportion was 30.6% in summer (July 1 – September 30) and 0% in fall, which confirms that the voluntary summer hunt closure established by the community of Sanikiluaq is an efficient approach to protect the EHB stock. The samples available from July and August, together with expert knowledge, suggest that extending the spring hunt into July may increase the probability of taking EHB beluga. However, this is based on a limited number of samples and so should be interpreted with caution.
- The majority of samples obtained from winter ice entrapments around the Belcher Islands were attributed to the EHB stock. It is unknown whether some EHB beluga remain in southern Hudson Bay in winter, or if the sampled beluga belong to separate, unidentified stocks.

BACKGROUND

Species Biology

Beluga whales have a circumpolar distribution. They are medium-sized toothed whales with an adult length of 350 cm and weigh up to 500–600 kg. Beluga lack a dorsal fin, which is believed to be an adaptation to inhabiting ice covered waters. Mating is thought to occur during winter or early spring. Calves are born after a 14 month gestation and lactation lasts roughly 18 months. Beluga calves spend 2-3 years with their mother, during which time, they perform several seasonal migrations. It has been suggested that this extended parent-offspring association could provide the opportunity for learning migration routes. The calving interval is 3 years. At birth, the calves are brown or dark bluish in colour. The skin becomes lighter in colour as they mature, gradually turning to grey and then to white. Sexual maturity might fall between 8 and 14 years of age, and longevity may be 60+ years.

Across their entire range, beluga whales are known to visit estuaries and river mouths during summer, which has led to the view that they are a shallow water species. However, satellite

telemetry data from the Little Whale and Nastapoka rivers show that beluga regularly move over deeper water, sometimes hundreds of kilometres away, over the course of the summer.

The Harvest

Commercial harvests by the Hudson's Bay Company probably initiated the depletion of beluga stocks in eastern Hudson Bay and Ungava Bay, whereas high subsistence harvests have likely limited the opportunity for stocks to recover. In the 1980's, low estimates of beluga abundance in eastern Hudson Bay and Ungava Bay resulted in limits being placed on harvesting through a combination of Total Allowable Take (TAT) and seasonal and regional closures, including the creation of a permanent sanctuary in southern Ungava Bay at the Whale, Mucalic, Tuctuc and Tunulic rivers (1986), and seasonal closures at the Nastapoka (1990) and Little Whale (1995) rivers in eastern Hudson Bay. Harvesting in the eastern Hudson Bay was closed from 2001 to 2006, and the Nastapoka River (NR) and Little Whale River (LWR) estuaries have remained closed since harvesting resumed in the eastern Hudson Bay area in 2007. The Ungava Bay was entirely closed to hunting during in 2002–2003 and 2005–2006), and the Mucalic has remained closed to hunting since 1986.

In 2014, a 3-year management plan was proposed by the Nunavik Marine Region Wildlife Board (NMRWB) and approved and implemented by DFO. The new plan recognizes that the hunting season extends year-round. It establishes a Total Allowable Take (TAT) for EHB beluga. However, hunters from Nunavik harvest animals from multiple stocks, and genetic studies have indicated that proportions of each stock in the harvest vary spatially and seasonally. The objective of the management plan is to limit the harvest of whales from the EHB and Ungava Bay stocks to prevent further depletion. In the 2014–2016 plan, new hunting areas have been identified (Fig. 1). Harvested whales are assigned a probability of belonging to the EHB stock based on the analysis presented below factoring in when and where the whale was harvested. The total number of EHB whales that have been harvested is then compared to the EHB TAT, over the three years of the plan, to determine if the management objectives have been respected.

Previous advice has shown that there are probably less than 100 whales belonging to the putative Ungava Bay stock at the present time. There is no current genetic material available from these animals; hence they could not be included in this analysis.

Harvesting that occurs around the Belcher Islands (Nunavut) is not regulated by a formal management plan or legal harvest restriction. However, the community of Sanikiluaq has enacted beluga hunting rules, involving since 2010 a closure of the summer beluga harvest in the Belcher Islands (between July 1 and September 30) as a conservation measure in support of EHB beluga recovery. In 2012, the harvest closure start date was changed to July 15.

ASSESSMENT

Stock Structure

According to recent genetic analyses, most beluga in Hudson Bay and Hudson Strait belong to the same breeding population. However, evidence from photo-identification, genetic and contaminant research show that individual beluga exhibit fidelity to specific summer areas. Telemetry studies in Nunavut and Nunavik have supported the concept that Nunavik hunters harvest beluga from a mix of several discrete stocks, designated after these summering areas: north-west-south Hudson Bay (WHB), eastern Hudson Bay (EHB), and Ungava Bay. In the winter, these stocks are found together in Hudson Strait, Ungava Bay, the Labrador Sea and southwest Davis Strait.

Biological Sampling

A tissue sampling (in general, skin) program has been operating on a regular basis in Nunavik since the mid-1990s. Hunters from all 14 Nunavik communities provide skin samples and information on where animals are harvested. Participation rates vary, but samples are generally obtained from around 25-30% of the reported catch. Samples have also been obtained from Nunavut communities. Prior to this analysis, the genetic relationships of individuals caught between 1982 and 2006 in all of Hudson Bay and surrounding areas (e.g., Cumberland Sound, Foxe Basin, northern Hudson Strait) were examined. Here, we focused on Nunavik hunting areas, as well as Sanikiluaq, and added samples collected in these regions between 2007 and 2013. Samples from James Bay and Long Island were not included in this analysis.

Some hunters from communities in Hudson Bay and Ungava Bay travel to other areas (mostly Hudson Strait) to hunt beluga. It is therefore crucial to assign samples to the correct hunting area. Reports from hunters and Uumajuit wardens were used to locate the exact site where each beluga was killed in the new dataset of samples, and to verify information in previous datasets. When the hunting location could not be determined with confidence, samples were removed from the analysis.

Genetic Mixture Analysis

Mitochondrial DNA sequences were obtained from 1,637 samples and categorized into haplotypes. Thanks to increased effort and dedicated sampling programs, 532 new samples from animals harvested between 2007 and 2013 were available from the Nunavik mixed hunt areas, as well as 157 new samples from Sanikiluaq.

Based on mitochondrial DNA haplotypes, a genetic mixture analysis was performed to estimate the proportion of individuals contributed by the different source stocks in areas and periods with potentially mixed stock compositions. In previous studies, material from beluga harvested between 1982 and 2006, from three summering areas, i.e. WHB, EHB and Cumberland Sound, were used as source samples. Based on traditional knowledge and telemetry studies, it is considered extremely unlikely that there is contemporary exchange of individuals between beluga that summer in the Belcher Islands and beluga that summer in Cumberland Sound. Therefore, to minimize confusion, we have performed our analysis using only two source stocks: WHB and EHB.

For this new analysis, the dates and locations for each of the regional harvests were aligned with the new definitions of hunting areas and seasons that are in use since 2014 to manage the Nunavik beluga hunt. We grouped harvest locations into two categories: summering areas (WHB, EHB) and mixed hunt areas in Nunavik coastal waters along the common seasonal migratory corridor (Fig. 1): northeastern Hudson Bay (NEHB), southern Hudson Strait (HS), Ungava Bay (UNG) and Sanikiluaq (SAN). Here, as in previous studies, source samples included beluga hunted in summering areas in July or August. For NEHB, HS and UNG, we pooled samples into two hunting seasons: a “spring” hunt from February 1 to August 31, and a “fall” hunt from September 1 to January 31. We also investigated proportions in the Ungava Bay harvest in the summer (July-August), because Ungava Bay is considered as a potentially distinct summer stock.

For Sanikiluaq, we examined two definitions of the spring hunt: one (“Spring”) bounded by the voluntary closure date in place between 2010 and 2012 (i.e., April 1 to June 30) and the other (“Extended Spring”) using the post-2012 closure date (i.e., April 1 to July 14). There were not enough samples to analyze the 2010-2011 and 2012-2013 harvests individually, and therefore all Sanikiluaq samples from 1982 to 2013 were used.

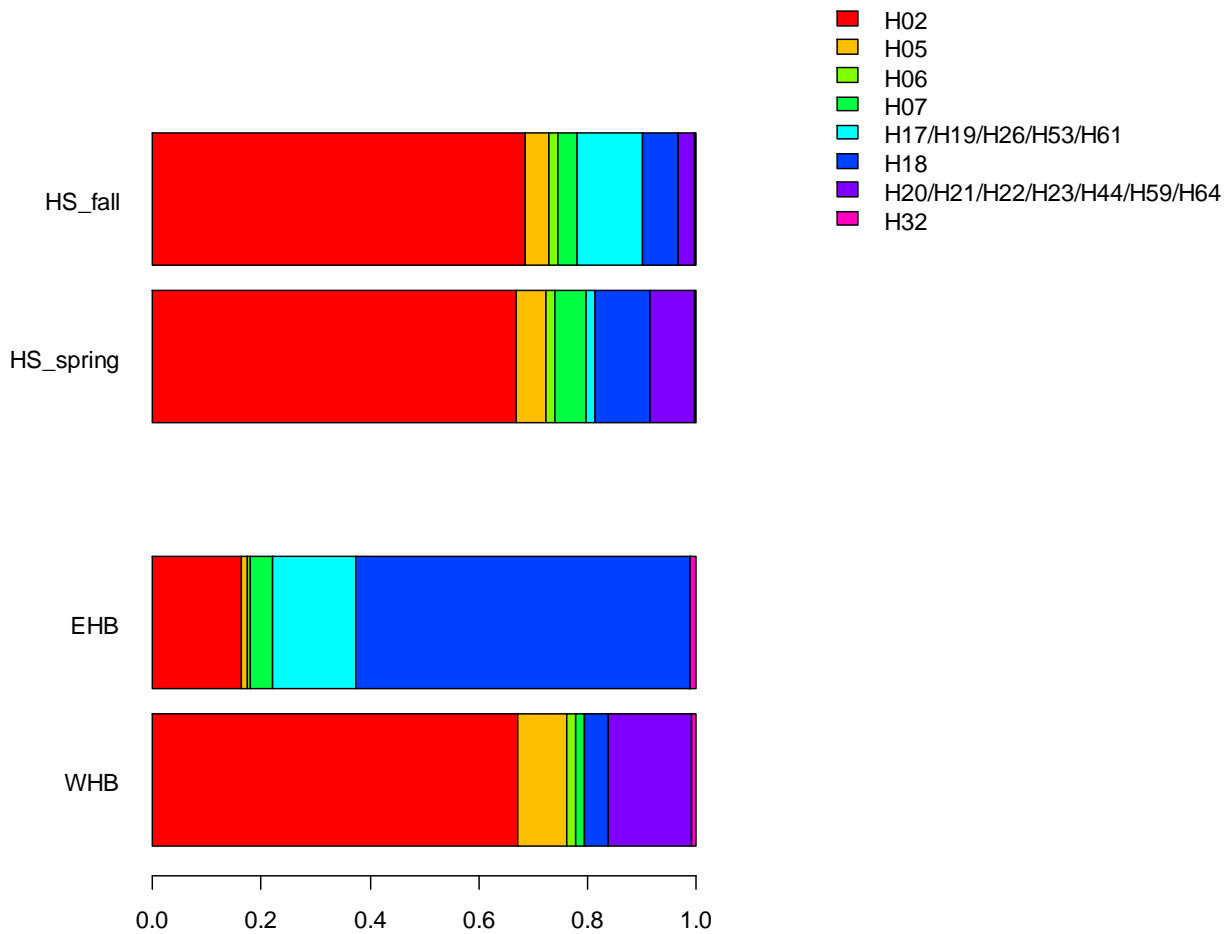


Figure 2. Frequency plot of haplotypes in source areas (bottom, EHB and WHB), and in mixed hunt areas (top). HS_spring and HS_fall: Hudson Strait harvests in spring and fall, respectively. Colour legend shows haplotypes or groups of haplotypes.

The haplotypes frequencies in the Nunavik harvest are shown in Fig. 2, and the estimated proportions of EHB beluga are given in Table 1. Sample size was too small to provide reasonable estimates for the proportion of EHB whales in the harvest for the spring northeastern Hudson Bay and fall Ungava Bay hunts (N=2 and 3 respectively). In the spring hunt, the proportions of EHB beluga were 11.7% for Hudson Strait, and 8.8% for Ungava Bay. In the fall hunt, these proportions were estimated at 33.2 % for northeast Hudson Bay, and 23.6% for Hudson Strait. The proportion of EHB beluga in the Ungava Bay harvest in the summer months only (July – August) was estimated at 4.3%.

In the Sanikiluaq spring harvest (Table 2, Fig. 3), the proportion of EHB beluga was 2.8% for the period April 1 – June 30 and 6.5% for the period April 1 – July 14. The proportion of EHB beluga in the Sanikiluaq summer harvest (July 1 – August 31) was 30.6% while the proportion in the fall hunt was 0.0%. The proportion of EHB beluga in the winter samples was estimated at 39.8%.

**Updated Genetic Mixture Analysis of
Nunavik Beluga Harvests**

Québec Region

Table 1. Percent beluga from each source stock in the harvest of Nunavik mixed hunt areas, based on genetic mixture analysis of mtDNA haplotype distribution. N samples: number of individual samples; N events: number of different hunting dates; WHB: Western Hudson Bay; EHB: Eastern Hudson Bay; 95%CI: 95% confidence interval. ND: not determined (small sample size).

	N samples	N events	WHB	95%CI	EHB	95%CI	Unknown
Spring (February 1 – August 31)							
Hudson Strait	539	252	82.2	76.9-86.6	11.7	8.0-16.4	6.1
NE Hudson Bay	2	1	ND	-	ND	-	ND
Ungava Bay	64	42	83.4	72.5-92.0	8.8	1.9-20.3	7.8
Fall (September 1 – January 31)							
Hudson Strait	318	131	73.3	65.8-80.2	23.6	17.0-30.9	3.2
NE Hudson Bay	19	7	56.3	28.3-82.2	33.2	14.9-54.7	10.5
Ungava Bay	3	3	ND	-	ND	-	ND

Table 2. Percent beluga from each source stock in the Sanikiluaq harvest, based on genetic mixture analysis of mtDNA haplotype distribution. N samples: number of individual samples; N events: number of different hunting dates; WHB: Western Hudson Bay; EHB: Eastern Hudson Bay; 95%CI: 95% confidence interval.

Season	N samples	N events	WHB	95%CI	EHB	95%CI	Unknown
Spring pre-2012 (April 1 – June 30)	191	81	78.9	70.7-86.1	2.8	0.3-7.7	18.3%
Spring post-2012 (April 1 – July 14)	212	92	76.5	68.6-83.6	6.5	2.0-13.3	17.0%
Summer (July 1 – August 31)	29	16	55.7	23.8-85.1	30.6	5.9-64.6	13.8
Fall (September 1 – November 30)	33	24	97.0	89.2-99.9	0.0	-	3.0
Winter (December 1 – March 31)	56	6	28.1	7.8-55.1	39.8	14.8-68.2	32.1

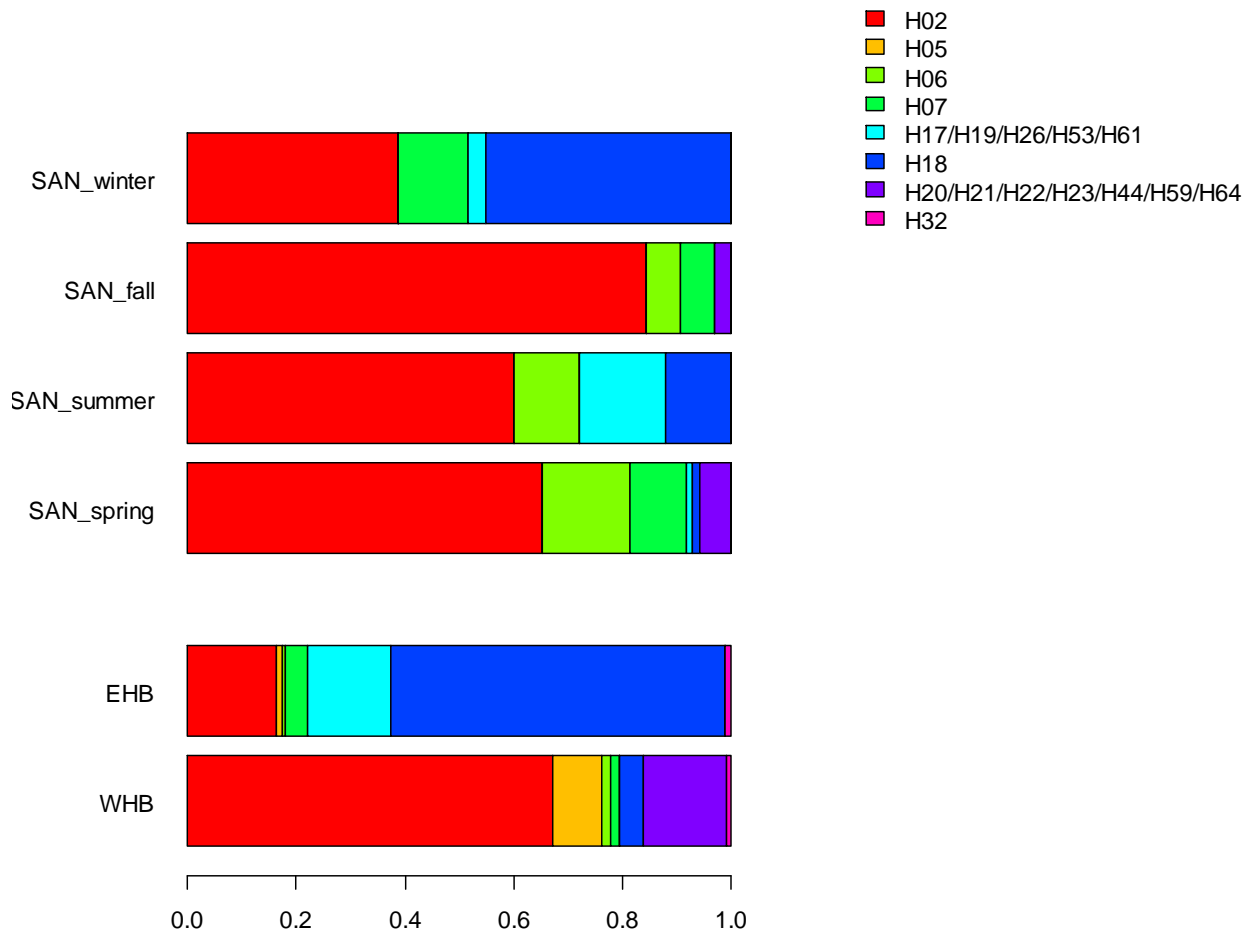


Figure 3. Frequency plot of haplotypes in source areas (bottom, EHB and WHB), and in the Sanikiluaq harvest at different seasons (top). Spring cut-off date is July 14 inclusively. Colour legend shows haplotypes or groups of haplotypes.

Sources of Uncertainty

The new management plan estimates the proportion of EHB animals harvested based on the area that the animals were hunted in, instead of which community they were harvested by. For some areas, the sample sizes remain very small, must be considered highly uncertain and should be used with caution. For example, the sample size in northeast Hudson Bay in spring and in Ungava Bay in the fall were insufficient for inference (N=2 and 3, respectively). In contrast, there is a concentration of hunting effort around Ivujivik and Quaqtuaq because the northeastern Hudson Bay and Ungava Bay communities travel there to perform their harvest. This means that our sampling is heavily biased towards these two hunting sites and may not be representative of beluga mixing in other areas of southern Hudson Strait.

We have grouped the Sanikiluaq samples together, but we do not know from which specific areas around the Belcher Islands these animals have been harvested. Moreover, the number of samples collected in Sanikiluaq between July 1 and 14 inclusively, and in the fall, are also limited which adds to our uncertainty on the proportion of EHB animals harvested in this area at those times.

This analysis as well as previous advice have identified that a large number of whales harvested in Sanikiluaq have a haplotype signature that differs considerably from that of the EHB whales. The stock structure of animals around Sanikiluaq remains uncertain. Furthermore, it is not known if this group is distributed around the Belcher Islands throughout the summer when the aerial surveys are flown. If it is a summer group that is unique to the Belcher Islands area, then this could have important implications for the management of beluga harvesting in this area.

The Sanikiluaq winter dataset includes 49 samples (out of 56) from ice entrapment events that occurred in the Belcher Islands in 2004, 2011 and 2013, and these samples are responsible for the high winter proportion of EHB beluga (~40%). It is still not clear why EHB beluga would remain in southeastern Hudson Bay in winter. It is possible that these individuals are not EHB whales and actually belong to a separate, as yet unidentified beluga stock and it suggests that the stock composition of southeast Hudson Bay beluga is more complex than currently defined.

ADDITIONAL STAKEHOLDER PERSPECTIVES

The Inuit in Nunavik consider beluga whales as an important food resource. There is community concern regarding contaminants and disease agents that could affect the health of beluga or their human consumers. Other global issues of concern include climate change and the resultant changes in sea ice, which might affect whale movements, their food and hunter access to whales. Community consultations raised concerns about the increase in numbers of both small boats and large ships, and how increasing noise might disturb beluga, particularly in nearshore areas.

A wide range of concerns have been expressed about beluga whale abundance. Some people have difficulty understanding and accepting survey estimates, since they have seen large numbers of whales in areas where only small numbers of whales have been seen during the survey period. Several people expressed concern that they were seeing fewer animals than in the past. It is not clear whether changes in sightings are a result of a reduction in beluga abundance, or animals having moved elsewhere. Some communities in EHB have also expressed that there are fewer whales today than during previous years due to high harvest levels. However, other communities particularly in Hudson Strait, feel very strongly that beluga are abundant. Moreover, some hunters disagree with the scientific view that female beluga whales have a calf every three years on average, believing instead that beluga females have a calf every year.

CONCLUSIONS AND ADVICE

These updated analyses align the definitions of hunting areas and seasons with newly established management schemes. Larger sample sizes have yielded more precise estimates of stock identity for harvested beluga. Despite changes made to hunting areas and season dates, proportions of EHB beluga in the Nunavik harvests are consistent with previous estimates. Thus, we recommend that these new estimates should be used for the EHB beluga population model and for management considerations, and that these proportions be updated each time the stock is assessed.

Our results suggest that the proportion of EHB animals taken during the spring hunt in the Sanikiluaq area is low. We now estimate it at 2.8% (95%CI 0.3 – 7.7) for the period April 1 – June 30, and at 6.5% (95%CI 2.0 – 13.3) for the extended period April 1 – July 14. The difference between the “Spring” and “Extended Spring” periods is based on only 21 samples, and thus must be interpreted with caution. The proportion of EHB beluga in the Sanikiluaq harvest in the summer (based on 29 samples) was 30.6%, which confirms that the voluntary harvest closure in summer established by the community of Sanikiluaq is an efficient approach

to protect the EHB stock. Combined with expert knowledge on presumed migratory behavior, these results suggest that extending the spring hunt into July may increase the probability of taking EHB beluga.

Many beluga harvested around the Belcher Islands have a mitochondrial DNA profile that differs from both the EHB and WHB stocks. It is not clear if these animals form their own unique stock. Furthermore, the majority of samples obtained from winter ice entrapments around the Belcher Islands were attributed to the EHB stock. It is unknown whether some EHB beluga do indeed remain in southern Hudson Bay in winter, or if these samples belong to separate, unidentified stocks.

OTHER CONSIDERATIONS

COSEWIC has assessed the EHB stock as Endangered, but no decision has been made by the Government of Canada pending the establishment of a consultation framework with the Nunavik Marine Region Wildlife Board for SARA issues.

SOURCES OF INFORMATION

This Science Advisory Report is from the October 20-24, 2014 Annual Meeting of the National Marine Mammal Peer Review Committee (NMMPRC). Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada \(DFO\) Science Advisory Schedule](#) as they become available.

DFO 2013. [Harvest advice for Nunavik beluga \(*Delphinapterus leucas*\)](#). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2012/076.

Doniol-Valcroze, T., Hammill, M.O., Turgeon, S. & Postma, L.D. 2016. [Updated analysis of genetic mixing among Nunavik beluga summer stocks to inform population models and harvest allocation](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2016/008. iv + 13 p.

Turgeon, J., P. Duchesne, G. Colbeck, L. D. Postma, and M. Hammill. 2012. Spatiotemporal segregation among summer stocks of beluga (*Delphinapterus leucas*) despite nuclear gene flow: implication for the endangered beluga in eastern Hudson Bay (Canada). *Conservation Genetics* 13:419-433.

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