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National Capital Region

Canadian Science Advisory Secretariat
Science Advisory Report 2022/024

HARVEST ADVICE FOR EASTERN HUDSON BAY AND JAMES BAY BELUGA (*DELPHINAPTERUS LEUCAS*)

Beluga Whales (Delphinapterus leucas). Photo by V. Lesage (DFO)

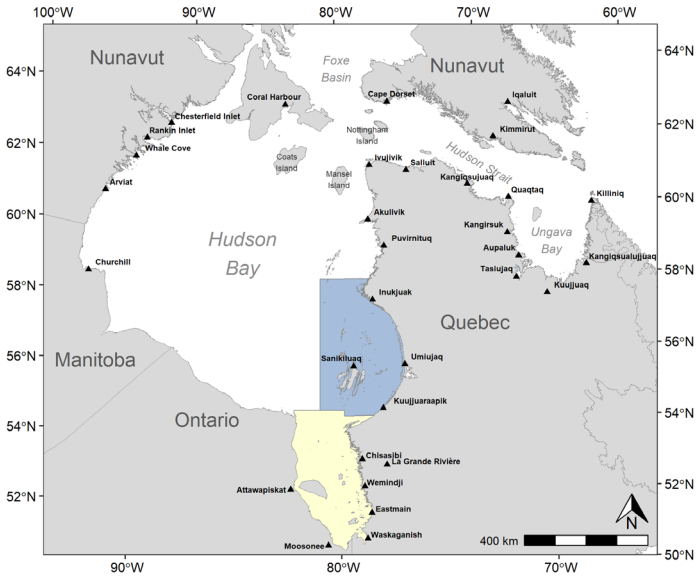

Figure 1. Map of James Bay-Hudson Bay-Hudson Strait-Ungava Bay (Hudson Bay-Strait Complex) showing communities. The blue area delimits the summer distribution of the Belcher Island-Eastern Hudson Bay (BEL-EHB) beluga stock. The yellow area delimits the summer distribution of the James Bay population. Sanikiluaq is a community on the Belcher Islands (Nunavut).

Context:

*Hunters living in northern Quebec (Nunavik) harvest beluga (*Delphinapterus leucas*) from at least four populations that comprise the Hudson Bay-Strait complex that have different migratory patterns: the eastern Hudson Bay (EHB) and western Hudson Bay (WHB) populations summer on each coast of Hudson Bay, overwinter together in Hudson Strait and the Labrador Sea. The Ungava Bay (UNG) population has an undefined migratory pathway but likely overwinters with the Hudson Bay populations. A separate population of beluga summers in James Bay (JAM) and overwinters there or moves into an area of loose ice where James Bay and Hudson Bay meet. In 2020, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated WHB and James Bay beluga as Not at Risk, EHB beluga as Threatened, and UNG beluga as Endangered.*

Harvesting of EHB beluga by Nunavik communities is managed under a multi-year management plan developed by the Nunavik Marine Region Wildlife Board and the Eeyou Marine Region Wildlife Board and approved by the Minister of Fisheries and Oceans. The current management objective is to ensure a 50% or greater probability of maintaining a stable stock of 3,400 individuals after five years. To meet this objective, harvesting is limited through a combination of non-quota (regional and seasonal closures) and quota limitations.

June 2022

Canada

Management of beluga in Nunavik relies on the estimation of abundance of beluga in their summering aggregations, and on an understanding of stock composition of the harvest, which varies both seasonally and spatially. EHB and JAM beluga were previously surveyed in July-August 2015. A new survey of these two areas was flown in July-August 2021.

Objectives

The objectives of the peer review meeting were:

- *Review the 2021 aerial survey methods, results and estimate the EHB and JAM abundance.*
- *Review the population model for EHB beluga and provide advice on sustainable harvest to ensure that the probability of a decline in abundance from 3,400 animals does not exceed 50% during the next five years, taking into account the season and area of the hunt, as well as the genetic mixture of stocks.*
- *Estimate the maximum number of beluga from EHB that can be harvested at various probability of increase over 10 years.*
- *Determine whether a population model can be fitted to the JAM abundance estimates and used to provide harvest advice*
- *Determine how harvest composition varies with time within and between seasons using an accepted genetics approach;*
- *Provide Potential Biological Removal (PBR) levels for EHB, JAM and if possible, UNG.*

This information will also support the Department in meeting requirements for an updated assessment of Nunavik beluga stocks as required under the U.S. Marine Mammal Protection Act bycatch provisions (in the case that EHB or JAM beluga are ever identified as bycatch).

SUMMARY

- A genetic re-analysis of nearly 3000 beluga samples from the Hudson Bay-Strait complex reaffirmed the existence of four populations (WHB, EHB, JAM, Cumberland Sound), and distinguished a new population in the Belcher Islands (BEL).
- The BEL and EHB populations overlap genetically and in summer distribution, making it impossible to distinguish animals belonging to these two populations either in the harvest or during the aerial abundance surveys. Therefore, these two populations were combined for the purposes of stock assessment to form a BEL-EHB stock.
- Total harvest in Nunavik averaged 344 beluga/year during 2016-2021. Three hundred and sixty-six beluga were harvested in 2021-2022.
- The new genetic analysis was used to adjust the harvest time series which increased the proportion of the newly defined BEL-EHB stock in the total harvest. The greatest changes in proportions were observed in the Hudson Strait Fall, Northeastern Hudson Bay Fall and Sanikiluaq (Belcher Island, Nunavut) harvests.
- In Hudson Strait, the proportion of BEL-EHB beluga in the harvest is higher in Fall, than during Spring. In October and early November, the proportion of BEL-EHB beluga in the harvest is approximately 50%, but this proportion declined to approximately 10% by the 3rd week of November.
- Using the new proportions and the newly defined BEL-EHB stock, an average of 95 beluga were removed annually from the BEL-EHB stock between 2016-2021 by Nunavik hunters. An estimated 139 BEL-EHB beluga were harvested in 2020-21.
- In Sanikiluaq, using these new proportions and the newly defined BEL-EHB stock, an average of 24 animals were removed annually from the BEL-EHB stock between 2016-2021. An estimated 19 BEL-EHB beluga were harvested in 2020-21.

- As in the past, visual line-transect surveys were flown in July-August 2021 to estimate beluga abundance in eastern Hudson and James Bays. Ungava Bay was not surveyed.
- New survey-specific correction factors were developed for availability and perception bias and applied to the time series.
- Survey corrected abundance estimates were 16,300 (95% CI=9,800-27,200) for James Bay and 2,300 (95% CI=1,300-4,200) (rounded to the nearest 100) for the BEL-EHB stock.
- The 2021 BEL-EHB abundance estimate is the lowest in the time series and has the smallest confidence interval.
- A population model was fitted to the aerial survey estimates, considering reported harvests and the proportion of BEL-EHB stock animals in the harvests, to provide information on abundance trends and sustainable harvest levels.
- For the BEL-EHB stock, the model estimated a 2015 abundance of 3,500 animals declining to 2,700 (95% CI=1,500-3,700) beluga in 2021 for an average rate of decline of 4%/year.
- An alternative BEL-EHB model run assumed a 2021 survey coefficient of variation of 48%. This run provided an abundance estimate of 3,900 in 2015, declining to 3,200 (95% CI=1,600-4,600) beluga in 2021 for an average rate of decline of 3% per year.
- The decline is associated with a combination of the Total Allowable Take (TAT) being exceeded and an under-estimate of the proportion of BEL-EHB stock animals in the harvest.
- In James Bay, the model estimated a 2021 abundance of 19,200 (95% CI=12,500-25,100) in 2021. The population has levelled off since the last assessment. The Potential Biological Removal for this population would be 335 beluga per year.
- For the BEL-EHB stock, the management objective is to ensure a 50% probability that the stock will be at or above the 2015 abundance estimate of 3,400 animals after 5 years and 10 years. The model estimates that harvest levels of 0 and 20 beluga respectively would respect this objective. In the alternative model run, assuming a 2021 survey coefficient of variation of 48%, harvests of 48 and 65 beluga would respect the management objective after 5 and 10 years respectively.
- However, since the last assessment, new availability and perception bias corrections have been applied and there is a new survey estimate of abundance. Together these changes result in different estimates of abundance in 2015 of 3,500 or 3,900 animals depending on model scenario. To respect the new benchmarks (3,500 or 3,900), harvest levels need to be reduced to 0-65 BEL-EHB beluga depending on the model scenario, and time frame. The Potential Biological Removal is 5 animals/year assuming a Recovery factor of 0.1.

BACKGROUND

Beluga whales are medium-sized toothed whales and have a circumpolar distribution. Mating occurs 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. Sexual maturity is thought to occur between 8 and 14 years of age, and longevity may be 60+ years. Beluga social and migratory behaviour is complex. Some animals are resident throughout the year, while others undertake significant seasonal migrations.

The Harvest

James Bay population (JAM)

Historically, efforts to develop commercial whaling in James Bay were not successful and removals appear to have been insignificant. Consequently, the JAM population was never depleted to the extent seen elsewhere. Significant habitat changes have occurred through very large-scale hydroelectric developments on the east side of James Bay, but their long-term impacts are not known. In recent times, there has been limited hunting. Reported removals in 2021 were 41 belugas (Figure 2).

Belcher Island and Eastern Hudson Bay (BEL-EHB) stock

Commercial harvests in the 19th century initiated the depletion of beluga in eastern Hudson Bay. Subsequent subsistence harvests may have limited recovery. In the 1980's, limits were placed on harvesting through a combination of Total Allowable Takes (TAT) and regional and seasonal closures at the Nastapoka and Little Whale Rivers. Harvesting in eastern Hudson Bay was closed from 2001 to 2006, and the Nastapoka and Little Whale Rivers estuaries have remained closed since harvesting resumed in 2007.

A total of 366 beluga were reported harvested by Nunavik including 41 animals from the Long Island area during the 2021-22 season (Figure 2). Another 30 animals were harvested in Sanikiluaq (Nunavut) (Figure 2). The 2021 harvest in Nunavik was above the annual average of 344 animals taken during 2016-2021.

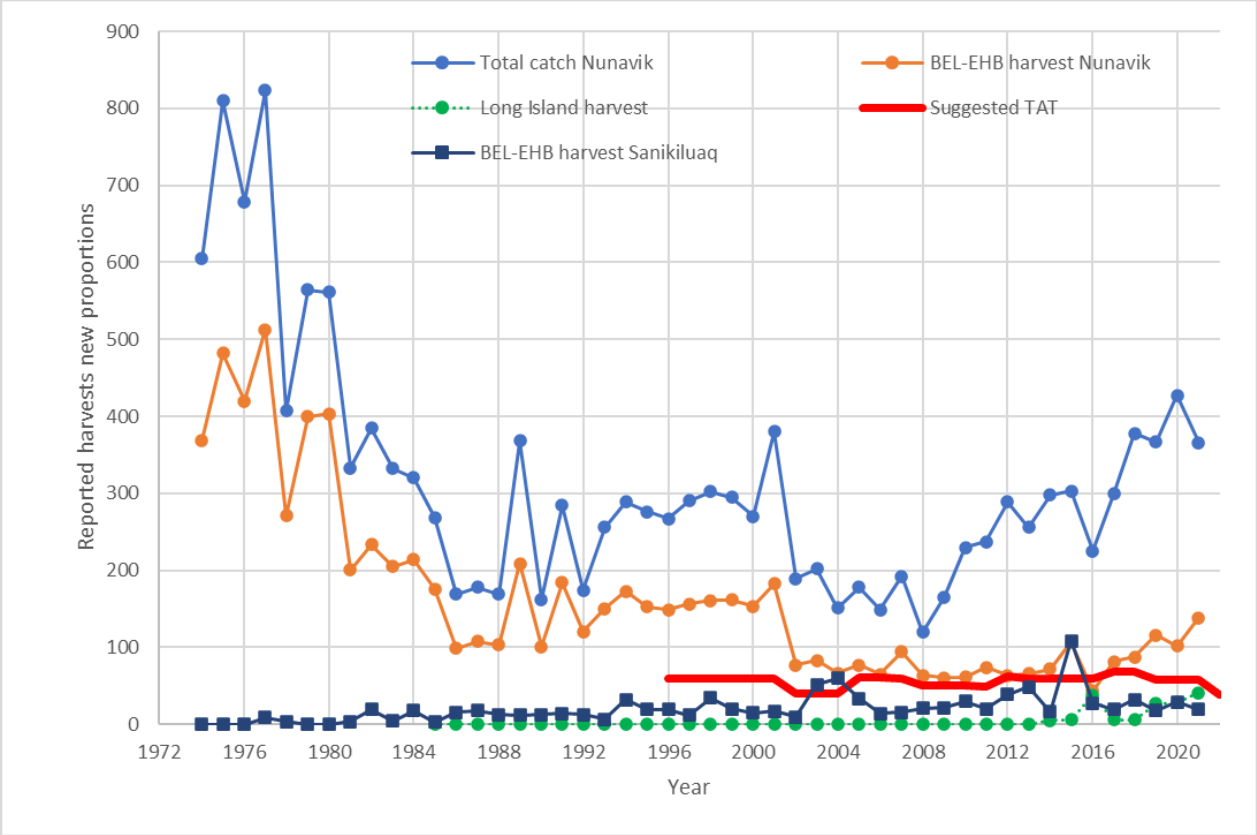

Figure 2. Total reported harvest of beluga in Nunavik (blue circles), estimated landed harvest of the BEL-EHB stock in Nunavik (orange), estimated landed harvest of BEL-EHB stock animals in Sanikiluaq (Nunavut; blue squares), and reported landings from Long Island area (green). The BEL-EHB landings are based on reported harvest for the area and the proportions from the genetic mixture analysis. The red line represents the recommended Total Allowable Take (TAT) of BEL-EHB animals. The average beluga harvest and BEL-EHB beluga harvest in Nunavik were 344 and 95 respectively between 2016-2021.

ASSESSMENT

Stock structure

The population structure of beluga summering aggregations in the Hudson Bay-Strait Complex was characterized using a long sequence of the mitochondrial DNA (mtDNA) control region (615 nucleotides). The analysis detected a WHB and an EHB population and confirmed previous results using short haplotypes (234 nucleotides). The long haplotypes also confirmed the presence of the James Bay (JAM), and Cumberland Sound (CSB) populations, and identified a new Belcher Island (BEL) population (Figure 3).

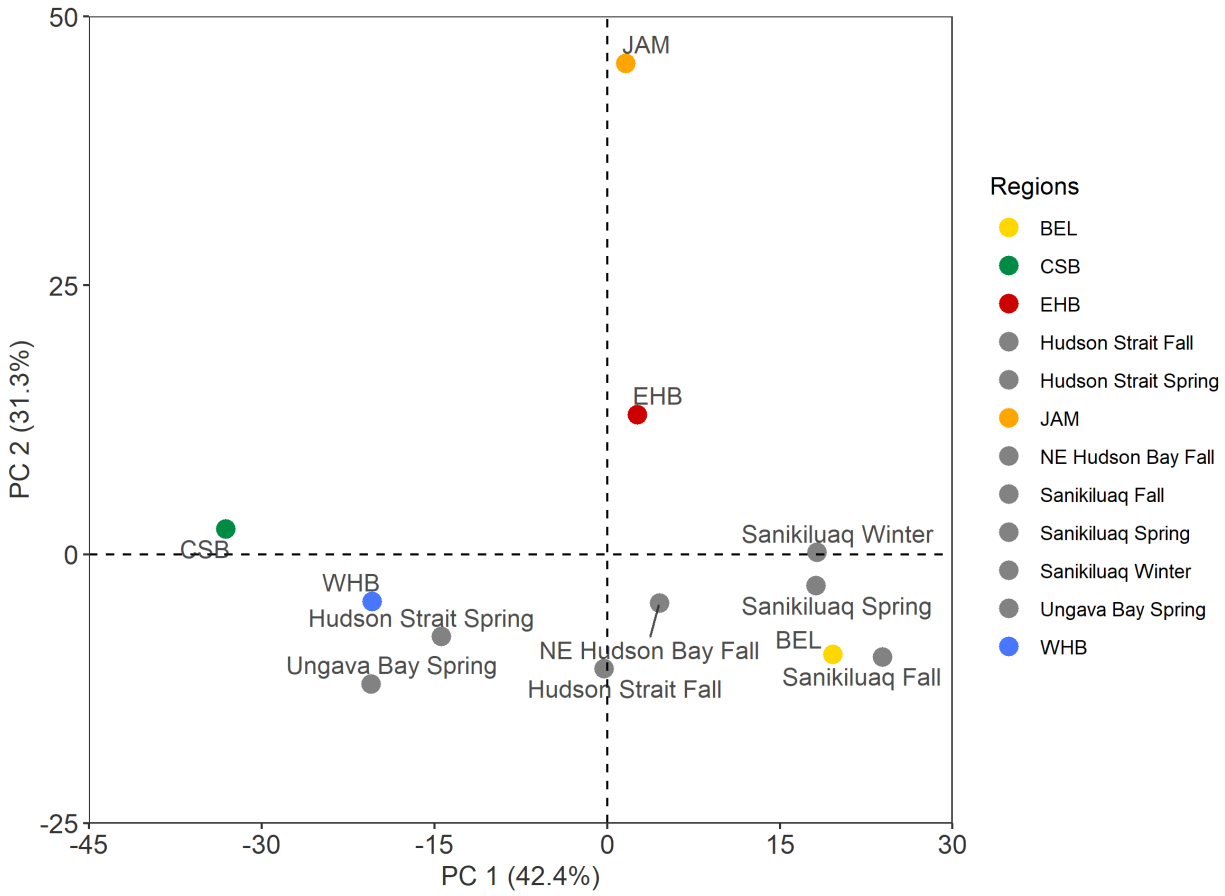

Figure 3. Principal component analysis (PCA) using haplotype frequencies of the long haplotype (615 nucleotides) for the mitochondrial DNA control region for beluga from five populations (in colours; WHB, JAM, EHB, BEL, CSB) and from harvests from Nunavik or Sanikiluaq management units (in grey). The distance between populations or management units reflects the scale of difference in genetic composition.

Based on the new analysis, individuals from BEL were identified as forming a population or distinct evolutionary unit. In previous analyses with the short haplotype, the BEL population was grouped with the WHB population, mostly due to haplotype sharing. However, the long haplotype analysis showed that the most abundant haplotype from the western haplogroup differed between the two populations. BEL did not share its two most abundant haplotypes with EHB, although they shared non-abundant haplotypes belonging to the eastern haplogroup.

Self-assignment rates were poor (19.7%) for the BEL population and acceptable (69.4%) for the EHB population when considering five populations. This is attributed to sharing between the two populations of multiple non-abundant haplotypes from the eastern haplogroup. The EHB and BEL summering individuals were combined to form a BEL-EHB stock, which considerably improved the self-assignment rates (84.7%). Thus, four genetic groups should be considered in genetic mixture analyses, namely WHB, JAM and CSB populations and the BEL-EHB stock.

The proportion of BEL-EHB beluga harvested in the different management areas and during the spring (February 1-August 31) and fall (1 September-January 31) harvest seasons is estimated using beluga tissue samples obtained from the subsistence harvest. In Sanikiluaq, the harvest is

divided into four seasons: Spring (April 1-June 30), Summer (July 1-August 31), Fall (September 1-November 30) and Winter (December 1-March 31) (Table 1).

Table 1. Genetic mixture analysis of the BEL-EHB proportion harvested in Nunavik and Sanikiluaq management units. NE Hudson Bay: Northeast Hudson Bay; Ns: number of samples; Nv: number of different hunt days (events); P: proportion; 95% CI: 95% confidence interval. [1]proportions from Hudson Strait in spring used due to insufficient samples or hunt events; [2]proportions from Hudson Strait in fall used due to insufficient samples or events. Samples analysed were collected between 1994-2021.

Management units	Ns/Nv	BEL-EHB stock (%)	
		P	95% CI
Nunavik			
Spring			
Hudson Strait	824/364	12.3	8.6-16.5
NE Hudson Bay[1]	2/1	12.3	8.6-16.5
Ungava Bay	143/87	4.7	0.8-11.8
Fall			
Hudson Strait	512/202	44.0	35.1-53.0
NE Hudson Bay	45/19	50.1	23.9-76.2
Ungava Bay[2]	6/6	44.0	35.1-53.0
Sanikiluaq			
Spring	229/99	62.8	51.5-73.4
Fall	49/35	61.0	35.1-83.9
Winter	76/11	39.9	13.0-70.8

Hunters have indicated that the BEL-EHB stock of whales migrate earlier through Hudson Strait than do animals from the WHB population. This possibility was examined by a seasonal analysis of the population/stock composition of the harvest (Table 2). Proportions of the BEL-EHB stock were high in October and early November, but declined after mid-November to 10.4% late in the month.

Table 2. Genetic mixture analysis of the BEL-EHB stock proportion harvested in Hudson Strait throughout the year. Ns: number of samples; Nv: number of different hunt days (events); P: proportion; 95% CI: 95% confidence interval; ND: not determined (number of samples or hunt days < 10). Samples analysed were collected between 1994-2021.

Period	Ns/Nv	BEL-EHB stock (%)	
		P	95% CI
May	6/6	ND	-
June	577/230	12.4	7.9-17.7
July	223/114	11.0	5.6-18.0
August	18/14	13.7	0.0-57.4
September	26/7	ND	-
October	223/104	47.3	34.7-60.1
November	263/91	45.1	33.0-57.6
Nov. 1-10	167/62	51.5	39.0-63.9

Period	Ns/Nv	BEL-EHB stock (%)	
		P	95% CI
Nov. 11-20	96/29	33.9	13.9-57.6
Nov. 21-30	49/13	10.4	0.9-29.5

Aerial surveys

Visual line-transect surveys flown in July-August 2021 covered James Bay and the eastern Hudson Bay from the coastline to 81°W of longitude, which is 60 km west of the Belcher Islands (Figure 1). Coastal surveys were flown on three occasions to search for groups of beluga along the coastline and within estuaries. In eastern Hudson Bay, the Little Whale and Nastapoka Rivers were specifically targeted and visited every time a transit was passing by (while on transit between lines or between transects and the airports), weather permitting.

In 2021, no surveys were flown in Ungava Bay nor in the west of Hudson Bay.

Table 3. Aerial survey abundance and standard error (SE) estimates for the BEL-EHB stock, and the Western Hudson Bay (WHB), James Bay (JAM) and Ungava Bay (UB) beluga populations from aerial surveys. Indices have been corrected for availability and precision bias.

Year	BEL-EHB estimate (SE)	WHB estimate (SE) [1]	JAM estimate (SE)	UNG
1985	6,967 (3,240)	-	6,477 (2,727)	*
1987	-	31,124 (6967)	-	-
1993	4,061 (1,961)	-	12,497 (4,549)	*
2001	4,430 (2,428)	-	27,373 (10,046)	*
2004	7,153 (3,276)	51,761 (15,875)	13,226 (5,383)	-
2008	4,164 (2,265)	-	38,191 (27,307)	*
2011	5,060 (2,879)	-	24,085 (9,851)	-
2015	8,205 (4,053)	54,473 (5,329)	23,036 (7,602)	-
2021	2,315 (734)	-	16,349 (4,332)	-
-	-	-	-	<100

[1] last surveyed in 2015.
* No beluga have been seen on transect in Ungava Bay. Most recent estimate for UNG population is less than 100 animals

The surveys flown in James and eastern Hudson Bays were corrected 1) for animals not detected because the animals were below the surface when the plane flew overhead (availability bias), and 2) for whales at the surface but missed by the observers as the plane flew overhead (perception bias). The estimated abundance of the JAM population in 2021 from the aerial surveys was 16,300 (95% CI=9,800-27,200, rounded to the nearest 100) (Figure 4).

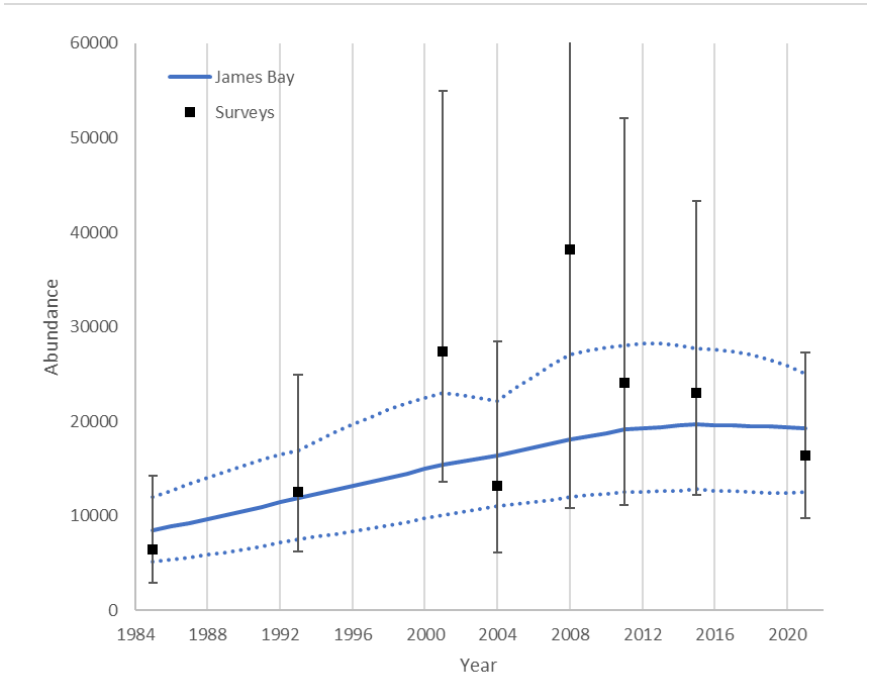

Figure 4. Aerial survey and model abundance estimates of James Bay beluga and 95% credibility intervals during 1985-2021.

The estimated abundance of the BEL-EHB stock from the aerial survey was 2,300 (95% CI=1200-3400)(Table 3; Figure 4). Of note, during three coastal surveys of the Nastapoka River estuary (6, 17, 20 August) no beluga were observed; whereas 200-300 beluga were observed during three of the six visits to Little Whale River (July 27, August 6, 12, **15**, **16**, 17; flights with sightings in bold).

Modeling abundance of beluga and impact of harvests

A population model incorporating updated information on harvest statistics and stock composition was fitted to the JAM population and the BEL-EHB stock aerial survey estimates of abundance (Figures 4,5). Animals harvested near Long Island were assigned as harvested from the JAM population (Figure 2).

Fitting the model to the JAM population resulted in an abundance estimate of 8,500 (95% CI=5,100-12,000) in 1985, increasing to 19,700 in 2015 before leveling off to 19,200 (95% CI=12,500-25,100) in 2021 (Figure 4). Fitting the model to the BEL-EHB stock, estimated a population of 8,500 (95% CI=5,200-12,900) in 1974, declining to 2700 (95% CI=1,500-3,700) in 2021 (Figure 5). The rate of decline has increased from an annual average of 1.3% between 2004 and 2014, to an annual average of 4% between 2015 and 2021. The 2021 aerial survey estimate was much lower and more precise than previous surveys. This survey had a major impact on current abundance and trend of this stock. To understand the impact of this survey on the model, a second run reduced the weight of this survey when fitting the model by increasing the survey coefficient of variation from 32% to 48%. The model was then fitted with the new 2021 aerial survey estimate. This resulted in a 2021 abundance estimate of 3,200 (95%= 1,600-4,600) (Figure 5). The rate of decline in the population under this scenario increased from less than 1% per year between 2004- 2014, to 3% per year between 2015-2021. The decline is associated with a combination of high harvests that have exceeded the TAT over multiple years and an under-estimate of the proportion of BEL-EHB stock animals in those harvests.

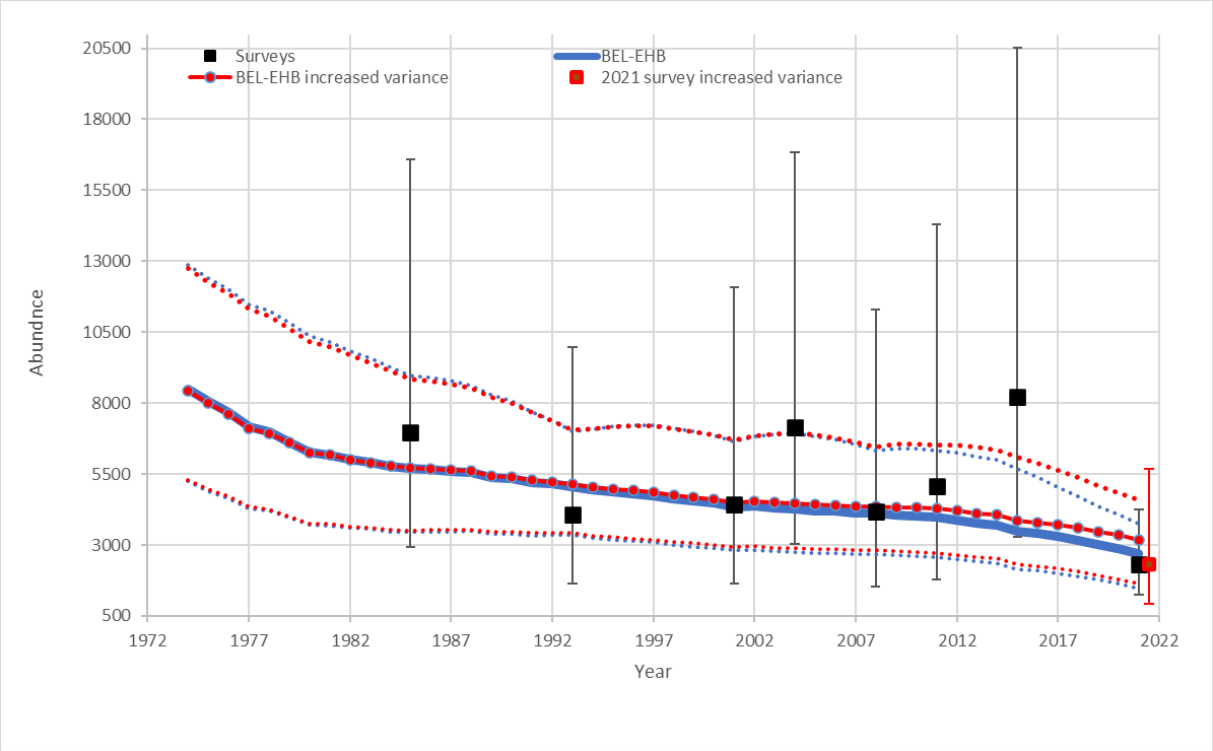

Figure 5. Aerial survey (black) with 95% confidence intervals, population model estimates of BEL-EHB beluga abundance and 95% credibility intervals during 1974-2021. Two model runs were completed. The first fitted to the aerial survey time series (blue). The second run fitted to the aerial survey time series (black squares) with an increase of the coefficient of variation around the 2021 survey estimate from 32% to 48% (red square).

Harvest advice

No management objective has been identified for the JAM population. The Potential Biological Removal would be 335 beluga, with an N_{min} of 16,800 beluga and a Recovery Factor of 1.

The management objective for BEL-EHB beluga is to maintain the stock at 3,400 animals or greater over five years. Harvest levels are set to ensure that the probability of decline from harvesting does not exceed 50%. Over a five year timeframe, there should be no harvests of BEL-EHB beluga to respect this management objective. Over a 10 year timeframe, a harvest of 20 BEL-EHB beluga would respect this management objective. However, the benchmark of 3,400 is based on model runs completed after the 2015 survey and estimates not corrected using the same availability and perception bias correction factors as used in this assessment. Fitting the model to the new availability and perception bias corrections and the 2021 survey estimate results in a 2015 estimate of 3,500 beluga. To meet the management objectives over five years, no harvests of BEL-EHB animals should be allowed, using a benchmark of 3,500 beluga. If a 10 year timeframe is used, the reported harvests should not exceed 18 beluga (Figure 6).

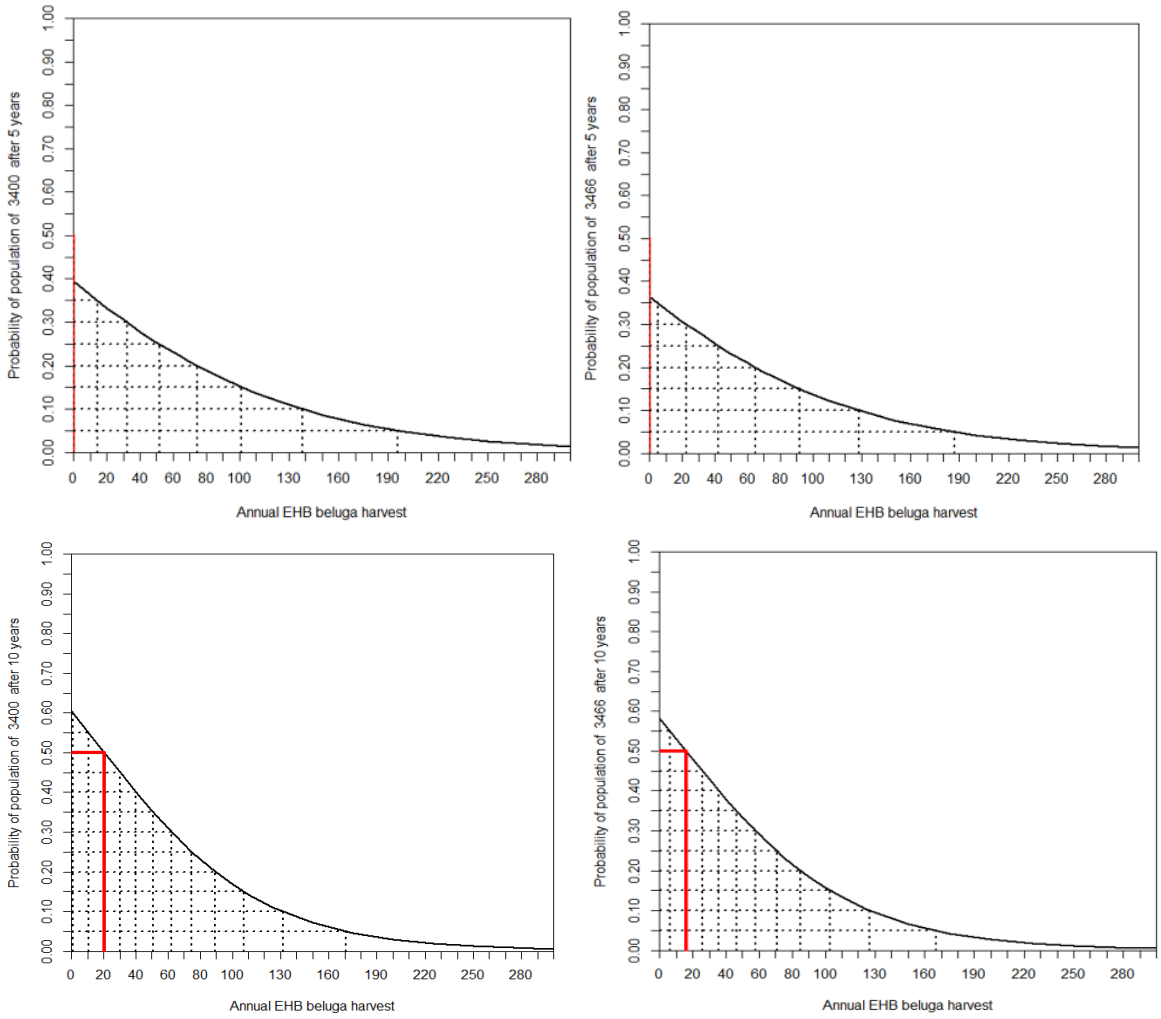

Figure 6. Probability (y-axis) that the BEL-EHB stock would be greater than 3,400 animals (based on the estimated 2015 abundance after the last survey) or estimated abundance of 3,500 (rounded to the nearest 100) beluga in 2015 using the most recent survey and correction factors over 5 years (top row), or 10 years (bottom row). X-axis is the reported harvest. Red line is harvest that results in a probability of decline of 50%.

Fitting the model with the increased coefficient of variation of 48% applied to the 2021 survey results in a 2015 abundance estimate of 3,900. If evaluated over five years no harvests should be allowed using the benchmark of 3,900 animals. Using a benchmark of 3,400 animals, a harvest of 48 BEL-EBH would respect the management objective. Over 10 years, a harvest of 65 BEL-EHB beluga would respect the 3,400 benchmark, while a harvest of 34 animals would respect the 3,900 animal benchmark (Figure 7). The Potential Biological Removal for the BEL-EHB stock is 5 animals/year assuming a Recovery Factor of 0.1.

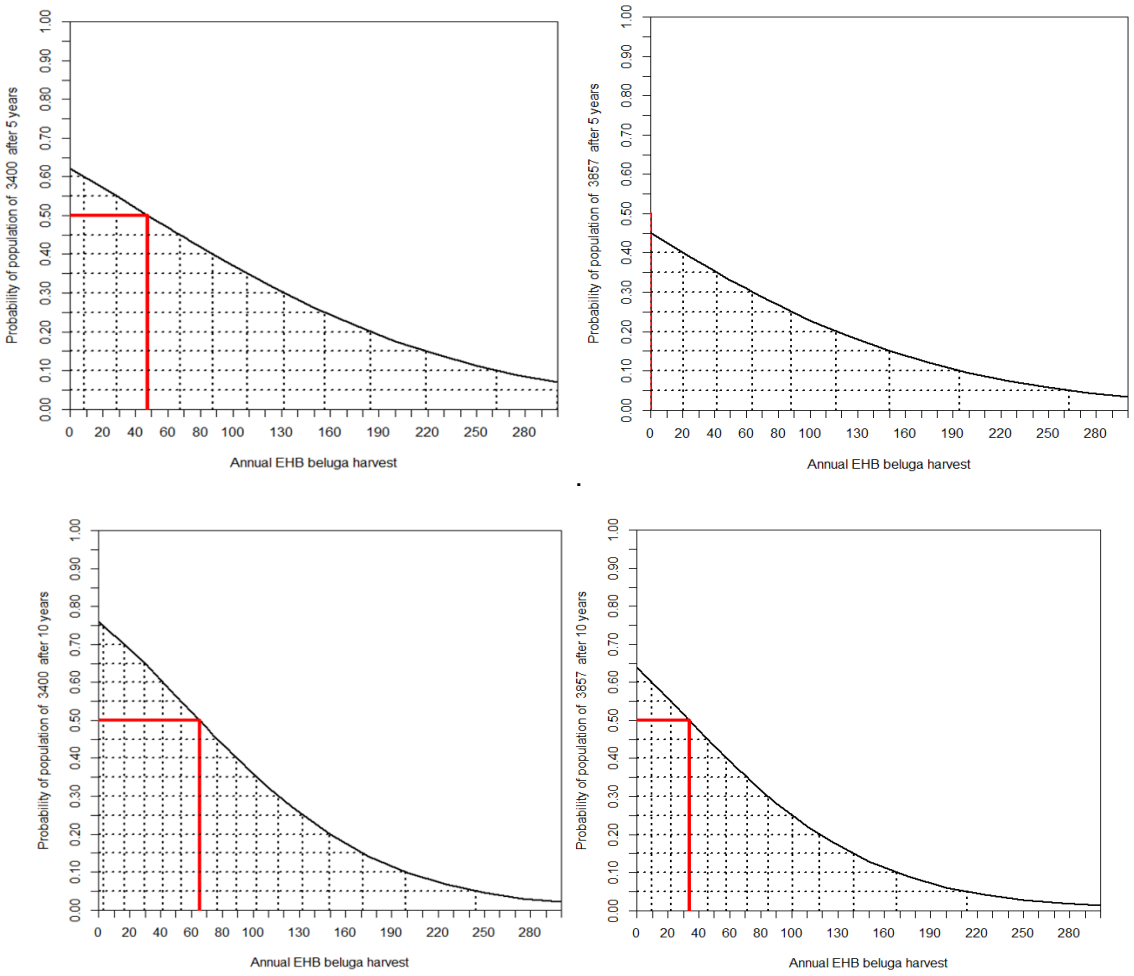

Figure 7. Probability (y-axis) that the BEL-EHB stock would be greater than 3,400 animals (left) or estimated abundance of 3,900 beluga in 2015 using the most recent corrected estimates assuming a 2021 survey coefficient of 48% (right), over a period of 5 years (top) or 10 years (bottom). Red line shows the harvest level (x-axis) with a 50% probability of being above the benchmark.

Sources of Uncertainty

Aerial survey estimates for beluga are known to be highly variable. The 2021 aerial survey estimate was very low, and more precise than normally associated with surveys of this species. Much of this variability is associated with group size, and whether large groups were encountered, or not, and how often. Factors affecting group size are poorly understood, but may be related to social behaviour, bathymetry, local foraging conditions, and population size. Given the relatively few surveys that have been completed of this stock, our understanding of current trend is quite sensitive to changes in the last survey estimate used in the model.

New availability bias correction factors were developed using telemetry dive data from 2003 and 2004. New perception bias correction factors were developed from surveys flown in 2015 and 2021. Assuming no major changes in either correction factor, the six aerial survey estimates flown between 1985 and 2011 were adjusted using the same correction factors. Inter-annual variability in either correction factor will affect our survey estimates.

The new genetic analyses have improved our understanding of beluga stock structure in the Hudson Bay-Strait complex. Nevertheless, uncertainty remains due to an absence or limited samples from beluga observed along the Ontario coast of Hudson Bay, northwest James Bay and from the southern Ungava Bay (Mucalic river). Additional samples are needed from the Belcher Island and from the eastern Hudson Bay region, which would improve the genetic characterization of reference populations.

The genetic analyses identified two populations, the Belcher Island and Eastern Hudson Bay populations, that are harvested in the eastern Hudson Bay area and in Hudson Strait. However, there is uncertainty in the seasonal distribution, level of mixing between the two populations and relative abundance of each population. The current survey flies over the area where animals from both populations summer and thus can only provide a combined estimate of the two groups. Thus, the abundance of each population belonging to this stock is not known.

Field observations of animals struck and killed, but not recovered, or non-reported is an important source of uncertainty.

CONCLUSIONS AND ADVICE

The genetic re-analysis of past beluga samples recognized a new population in the Belcher Islands which is indistinguishable in their distribution from EHB beluga during summer.

The JAM population increased to as high as 19,700 in 2015 and has since levelled off to an estimated 19,200 individuals in 2021.

The BEL-EHB stock of beluga is declining. Harvest levels for the EHB stock have consistently exceeded recommended levels. The BEL-EHB stock has declined from 3,500-3,900 animals after the 2015 survey, to a current abundance estimate of approximately 2,700-3,200 animals depending on the model scenario. If there is to be a recovery in this stock, harvest levels need to be reduced to 0-65 BEL-EHB belugas, depending on the scenario, management framework and time frame adopted.

OTHER CONSIDERATIONS

Beluga often travel in groups. Clustering of harvests each year may increase the risk of removing entire family units, which could affect genetic diversity as well as the transfer of knowledge of migration routes to future generations. This transmission of information is hypothesized to be the mechanism for retaining site fidelity. Harvest levels have been set to maintain a 50% probability of no population decline over a five or 10 year period. This approach does not allow for rebuilding of the stock and does not include any buffer to accommodate uncertainty in assessment estimates, harvest composition, unusual mortality events, or environmental variability. A small population can exhibit lowered growth rates at low abundance levels (i.e. Allee effects) that can worsen declining trends.

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SOURCES OF INFORMATION

This Science Advisory Report is from the February 14-18, 2022 Annual Meeting of the National Marine Mammal Peer Review Committee (NMMPRC) on Population status assessment for beluga stocks in Nunavik (northern Quebec). Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

DFO. 2020. 2020 Harvest Advice for Eastern Hudson Bay Beluga (*Delphinapterus leucas*). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2020/031.

Wade, P. 1998. Calculating limits to the allowable human-caused mortality of cetaceans and pinnipeds. Mar. Mamm. Sci. 14:1-37.

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