Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

Central and Arctic Region

Canadian Science Advisory Secretariat
Science Advisory Report 2019/024

SUSTAINABLE HARVEST ADVICE FOR CUMBERLAND SOUND BELUGA BASED ON THE 2017 AERIAL SURVEY AND MODELLED ABUNDANCE ESTIMATES

*Beluga (*Delphinapterus leucas*) in Clearwater Fiord.*

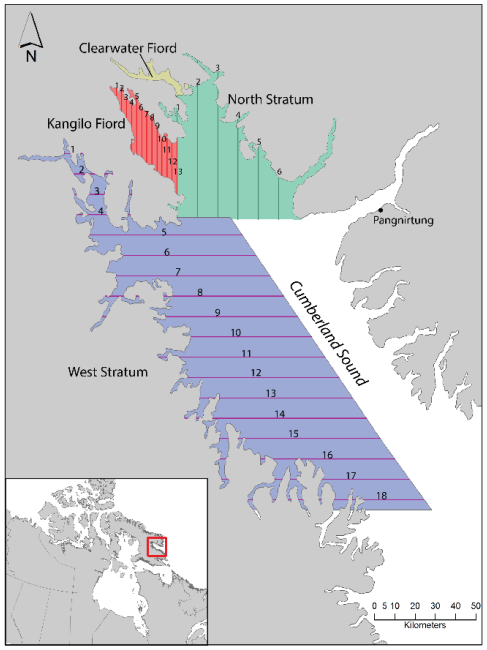

Figure 1. Map indicating the four strata surveyed in the visual and photographic aerial survey in Cumberland Sound in 2017.

Context:

The Cumberland Sound Beluga (CSB) population was listed in 2017 as 'Threatened' on Schedule 1 of the Species at Risk Act*. Continued research and monitoring of the population are required to ensure sustainability of the Inuit subsistence harvest. DFO Fisheries Management (FM) has requested Science Advice on an updated population abundance estimate and sustainable harvest level recommendation for the CSB population.*

An aerial survey of Cumberland Sound was conducted in summer 2017. This request is a re-submission from 2010-2013.

The two parts of this request reflect recommendations contained in DFO (2013):

1) Provide a population abundance estimate based on the aerial survey of CSB in 2017 and sustainable harvest level recommendation for the 2019 harvest year.

2) Complete the Bayesian population dynamic modeling of the 2009 to 2017 aerial survey results, and if supported by this analysis, provide an updated population abundance estimate and sustainable harvest level recommendation for CSB.

May 2019

SUMMARY

- Cumberland Sound Beluga (CSB) are harvested by hunters from the hamlet of Pangnirtung. Since 2002 the quota for CSB has been 41 animals a year. An assessment in 2016 indicated this harvest was not sustainable.
- Two aerial surveys to estimate CSB abundance were flown in 2017. The estimated average abundance from the two surveys was 1,381 (95% Confidence Interval (CI): 1,270–1,502) belugas.
- To estimate current abundance and determine trends in population dynamics a population model was fit to the series of survey estimates from 1990–2017 and reported annual harvests from 1960–2017.
- Accounting for recent trends and survey estimates the model estimated a 2018 abundance of 1,090 (95% CI: 617–1,864) belugas.
- The addition of the 2017 abundance and harvest information makes it possible to provide advice on sustainable harvest levels from the population model.
- The model estimated that a Total Allowable Landed Catch (TALC) of 0, 14, or 20 beluga per year would result in a 0%, 25%, and 50% probability of decline, respectively, in the CSB population in ten years.
- Under the current quota the model estimated a 96% probability of population decline in ten years.

INTRODUCTION

Genetic and satellite telemetry data suggest Cumberland Sound beluga (CSB) (*Delphinapterus leucas*) whales form a distinct genetic population that remain within the sound year-round. The population was commercially hunted until 1939 and a subsistence harvest has been regulated since the 1980s with a current quota of 41 beluga per year. A population of 1,151 (95% CI: 760–1,744) beluga was estimated from the 2014 aerial survey (DFO 2016). The Pangnirtung HTA raised concerns about the 2014 survey design; therefore, a modified survey design was flown in July and August 2017 to update the CSB abundance estimate. A stochastic stock-production model, that assumes density dependence acts on the population growth rate, was fitted by Markov Chain Monte Carlo (MCMC) Bayesian methods to aerial survey (1990–2017) and reported harvest data (1960–2017). Here we present the results from the 2017 aerial survey and population dynamics model.

Species Biology

Belugas have a circumpolar distribution. They are medium-sized toothed whales with adults growing to 3 to 5 m, depending on the population, and reaching weights up to 1,900 kg. Belugas 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 three 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, belugas 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

and aerial survey data have shown that beluga can undertake regular trips to and from estuaries, sometimes hundreds of kilometres away, over the course of the summer.

ASSESSMENT

2017 Survey

Visual and photographic aerial surveys were conducted from 29 July to 12 August, 2017 (Figure 1). Survey abundance estimates were adjusted for diving animals that are not visible at the surface, known as availability bias. Availability bias was calculated from three tagged CSB in 2006–2007 and was either 2.06 when beluga were in clear water or 4.46 when beluga were in murky water. Perception bias results because some observers may miss whales even if they are visible. This was calculated using a double observer platform during the 2017 visual survey and the estimated adjustment factor was 1.05.

The first aerial survey was flown from 29 July to 3 August and estimated 1,749 (95% CI: 755–4,049) beluga. The second survey, flown 4–12 August, estimated 1,379 (95% CI: 1,267–1,500) CSB (Table 1). The second survey was more precise since the majority of animals were in Clearwater Fiord and captured in the photographic survey. A weighted average estimate of 1,381 (95% CI: 1,270–1,502) from the two surveys was used as input into the population model (Table 1).

Table 1. Total population abundance estimates from two surveys flown from 29 July to 3 August and 4-12 August, that included visual and photographic strata. The average of the two surveys was weighted by the variances.

Strata	Date Flown	Beaufort Sea State	Survey	Estimate	CV (%)	95% CI
Survey 1						
Clearwater Fiord	29 July		Photographic	301		
North	3 Aug	1	Visual	0		
Kangilo Fiord	3 Aug	2	Visual	0		
West	1–2 Aug	2–4	Visual	1,448		
TOTAL				**1,749**	**42.27**	**755–4,049**
Survey 2						
West	4 Aug	1	Visual	83		
North	5 Aug	1	Visual	0		
Kangilo Fiord	5 Aug	1	Visual	11		
Clearwater Fiord	4, 7, 8, and 12 Aug	0–1	Photographic	1,286		
TOTAL				**1,379**	**4.31**	**1,267–1,500**
AVERAGE				**1,381**	**4.29**	**1,270–1,502**

Assessment Model

The method to assess sustainable harvest depends on where a stock lies along a Data Poor-Data Rich continuum. For stocks where there is a poor understanding of abundance, trends and dynamics of the population (i.e., Data Poor), harvest levels have been set using the Potential Biological Removal (PBR) method. However, for stocks where we have a greater understanding

of their population dynamics it is possible to use a population model to generate advice regarding sustainable harvest levels. The modelling approach makes greater use of all available information with respect to the dynamics of beluga populations, harvest data, and multiple abundance indices and, thus, is preferable for data-rich populations. The addition of the 2017 abundance and harvest information makes it possible to provide advice on sustainable harvest levels for CSB using a population model under this data-rich approach.

A population model, fit to the series of survey estimates from 1990–2017 and reported annual harvests from 1960–2017, estimated a population of 2,884 (95% CI: 1,849–3,725) in 1960, which declined to 1,090 (95% CI: 617–1,864) in 2018 (Figure 2). Maximum growth rate for the population was estimated as 3% per year and the estimated carrying capacity was 7,875 animals.

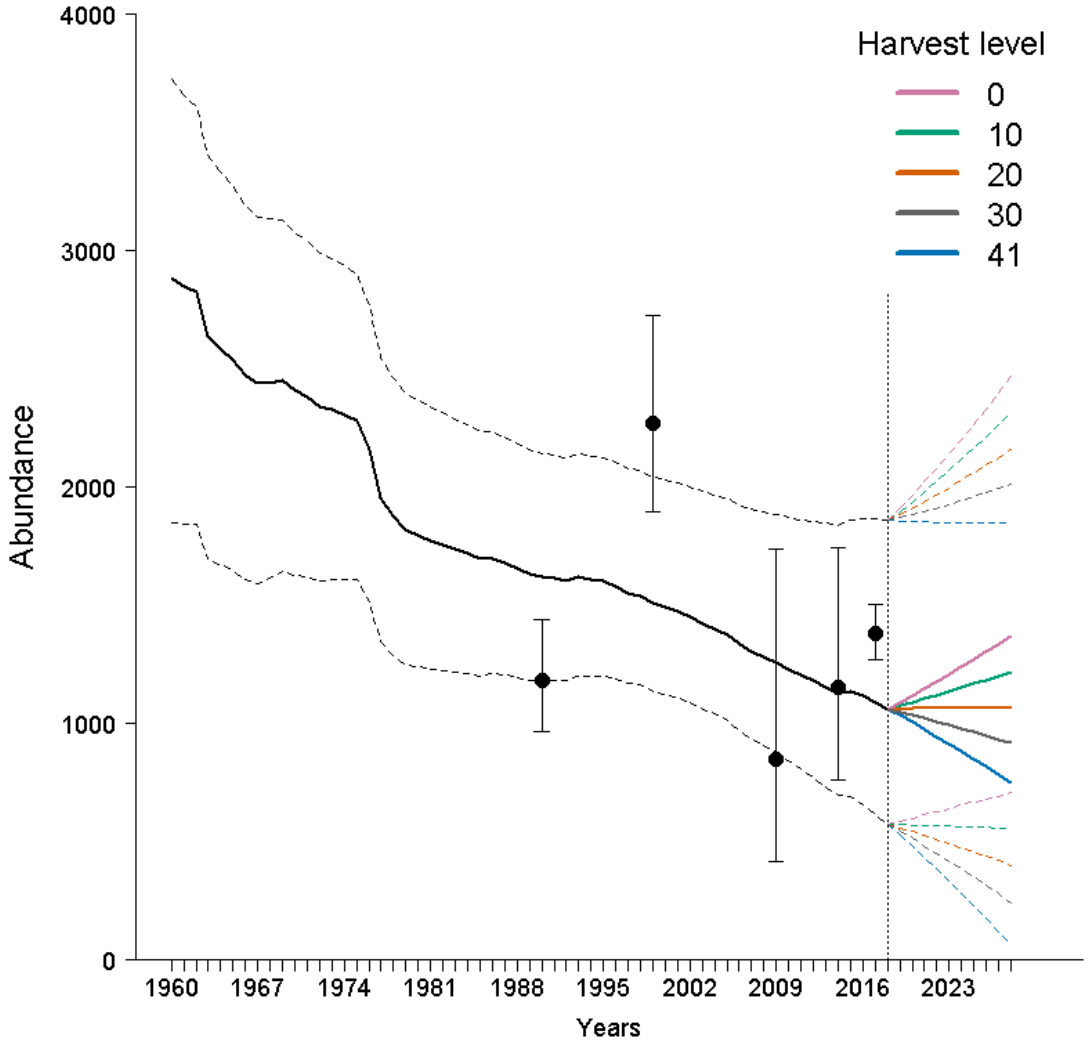

Figure 2. Estimated changes in abundance of CSB determined after fitting the population model to abundance estimates from aerial surveys flown between 1990–2017. The solid line indicates the median estimate and dotted lines represent the 95% Credibility Intervals. Beyond 2018 indicates future population projections at annual harvests of 0, 10, 20, 30, and 41 belugas.

The model predicts that a TALC of 0, 14, or 20 beluga per year would result in a 0%, 25%, and 50% probability of decline in the CSB population in ten years (Figure 3, Table 2), assuming animals are taken in proportion to the population sex and age structure.

Table 2. Percent probability (P) that the population, subjected to different levels of annual landed catch, will decrease in 10 years.

Landed Catch	P (%)
0	0.1
5	1.2
8	5.7
9	8.0
10	10.8
11	13.9
12	17.3
13	20.9
14	24.8
15	28.7
20	49.5
30	82.5
41	95.7

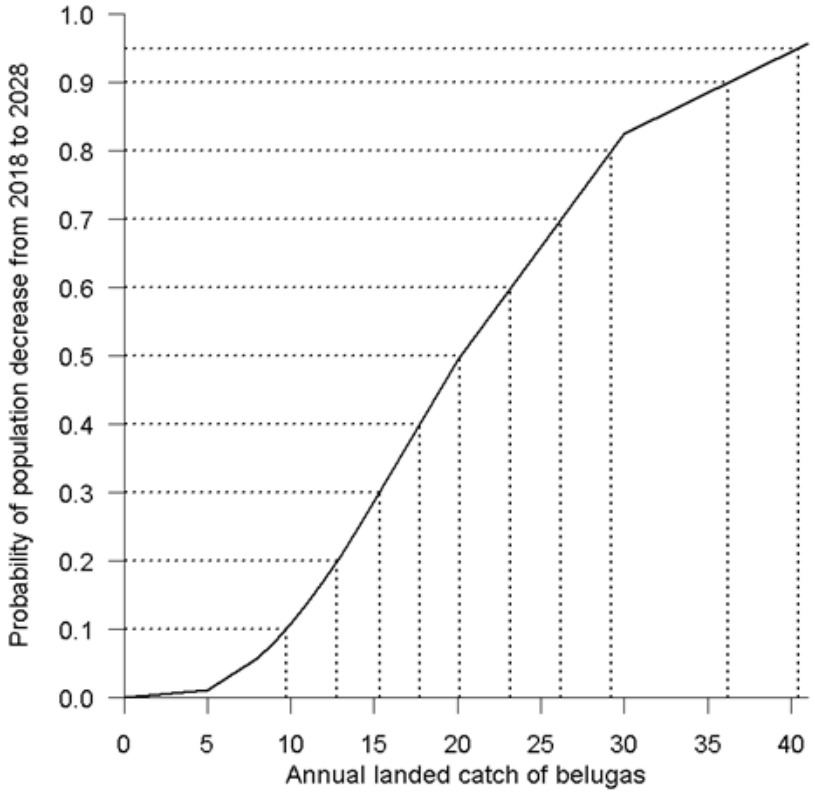

Figure 3. Probability of the Cumberland Sound Beluga stock decreasing from the 2018 abundance estimate in 10 years of harvest, estimated by the population model as a function of the landed catch of belugas every year. Dotted lines indicate levels of harvest (x-axis) corresponding to the probability of decline (y-axis).

Potential Biological Removal

For comparison with previous advice, we also calculated a Potential Biological Removal (PBR) following Wade (1998):

$$PBR = N_{Min} \times 0.5 \times R_{Max} \times F_R$$

Where, N_{Min} is the value of the 20th percentile of the population size. Considered a conservative estimate of the population size.

R_{Max} is the maximum rate of population increase. The default for cetaceans is 0.04.

F_R is a recovery factor set to 0.1 for a threatened declining stock (Hammill et al. 2017).

Based upon the 2018 model estimate of N_{Min} (917), PBR was estimated to be two belugas and the TALC, one beluga, using the model estimate for a struck and lost and non-reporting rate of 36%.

Sources of Uncertainty

The availability bias correction factors used to adjust the survey estimates for animals that are not visible are the best values currently available for CSB; however, they are derived from only three whales tagged in 2006–2007. These factors have been applied to the entire time series of aerial survey estimates. Additional beluga, preferably tagged spatially and temporally to coincide with the survey, would result in a better understanding of beluga behaviour. A large sample of tagged whales would also improve our understanding of diving behaviour in different environmental conditions and habitats.

With respect to the CSB stock, there is considerable uncertainty with harvest removals. For example, in years when CSB harvests were not reported (2004, 2005, 2008 to 2010, 2012 to 2014), it was assumed that the entire quota of 41 animals had been taken. There is insufficient information to evaluate the direction and magnitude of this uncertainty.

Since actual struck and lost rates are not known, they are estimated by the model within a range of plausible values. However, there is little data to inform this parameter, and thus the choice of prior distribution has a large impact on the estimated value. Moreover, the application of a single struck and lost rate over the entire catch series may also be inappropriate.

The values of growth rate and carrying capacity are unknown and were estimated by the model from within realistic ranges. Effort should be made to obtain demographic information for this population over time.

CONCLUSIONS AND ADVICE

The addition of the 2017 abundance and harvest information makes it possible to provide advice on sustainable harvest levels using a population model. The population model indicated an estimated stock abundance of 1,090 belugas (95% CI: 617–1,864) in 2018. Assuming an annual catch equal to the current quota of 41 CSB will lead to a decline (96% probability) in the stock over the coming 10 years. The model predicts a TALC of 0, 14, or 20 beluga per year would result in a 0%, 25%, and 50% probability of decline in the CSB population in 10 years. Figure 3 provides the probability of a population decline at a range of harvests. A longer time series of survey estimates (and a survey interval that allows for measurable changes [e.g., 5 years]), improved survey correction factors, improved harvest reporting (including struck and lost), and independent estimation of demographic parameters would help to reduce uncertainty associated with the abundance estimates and population trend. As this population has moved

into a data-rich state, model-based assessments should be developed that incorporate limit-reference points that will enable the development of harvest control rules for sustainable harvest under the DFO precautionary framework.

APPENDIX 1. LIST OF MEETING PARTICIPANTS

Name	Organization/Affiliation
Christine Abraham	DFO – Science, National Capital Region
Nell den Heyer	DFO – Science, Maritimes Region
Thomas Doniol-Valcroze	DFO – Science, Pacific Region
Steve Ferguson	DFO – Science, Central and Arctic Region
Katherine Gavrilchuk	DFO – Science, Pacific Region
Jean-Francois Gosselin	DFO – Science, Quebec Region
Mike Hammill	DFO – Science, Quebec Region
Valerie Harvey	DFO – Science, Quebec Region
Shelley Lang	DFO – Science, Pacific Region
Jack Lawson	DFO – Science, Newfoundland and Labrador Region
Veronique Lesage	DFO – Science, Quebec Region
Marianne Marcoux	DFO – Science, Central and Arctic Region
Cory Matthews	DFO – Science, Central and Arctic Region
Hilary Moors-Murphy	DFO – Science, Maritimes Region
Sean MacChonnachie	DFO – Science, Pacific Region
Arnaud Mosnier	DFO – Science, Quebec Region
Simon Nadeau	DFO – Science, National Capital Region
Linda Nichol	DFO – Science, Pacific Region
Lianne Postma	DFO – Science, Central and Arctic Region
Stephanie Ratelle	DFO – Science, Gulf Region
Joy Stanistreet	DFO – Science, Maritimes Region
Garry Stenson (Chair)	DFO – Science, Newfoundland and Labrador Region
Sheila Thornton	DFO – Science, Pacific Region
Strahan Tucker	DFO – Science, Pacific Region
Cortney Watt	DFO – Science, Central and Arctic Region
Julie Deault	DFO – Species at Risk, National Capital Region
Christie McMillan	DFO – Species at Risk, Pacific Region
Patt Hall	DFO – Fisheries Management, Central and Arctic Region
Jennie Ryman	DFO – Fisheries Management, Central and Arctic Region
Robert Suydam	Alaska North Slope Borough, Department of Wildlife Management

Name	Organization/Affiliation
Rodd Hobbs	Retired – National Oceanic and Atmospheric Administration
Jordan Hoffman	Nunavut Wildlife Management Board
David Lee	Nunavut Tunngavik Incorporated
Mark Basterfield	Nunavik Marine Region Wildlife Board
Gregor Gilbert	Makivik Corporation
Micheal Ferguson	Qikitqtaaluk Wildlife Board
Qovik Netser	Kivalliq Wildlife Board

SOURCES OF INFORMATION

This Science Advisory Report is from the February 11–15, 2019 Cumberland Sound Beluga Survey 2017 – Population Abundance Estimate. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

DFO. 2013. Advice on size and trend of the Cumberland Sound beluga whale population, 1990 to 2009. Can. Sci. Advis. Sec. Sci. Advis. Rep. 2013/003.

DFO. 2016. Status of beluga (*Delphinapterus leucas*) in Cumberland Sound, Nunavut. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/037.

Hammill, M.O., Stenson, G.B., and Doniol-Valcroze, T. 2017. A management framework for Nunavik beluga. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/060. v + 34 p.

THIS REPORT IS AVAILABLE FROM THE:

Center for Science Advice (CSA)
Central and Arctic Region
Fisheries and Oceans Canada
501 University Crescent
Winnipeg, Manitoba R3T 2N6

Telephone: 204-983-5131
E-Mail: xcna-csa-cas@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

ISSN 1919-5087

Correct Citation for this Publication:

DFO. 2019. Sustainable harvest advice for Cumberland Sound beluga based on the 2017 aerial survey and modelled abundance estimates. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2019/024.

Aussi disponible en français :

MPO. 2019 Avis sur la capture durable de bélugas de la population de la baie Cumberland selon un relevé aérien mené en 2017 et des estimations d'abondance modélisées. Secr. can. de consult. sci. du MPO, Avis sci. 2019/024.