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Central and Arctic Region

Canadian Science Advisory Secretariat
Science Advisory Report 2020/051

ESTIMATED ABUNDANCE AND TOTAL ALLOWABLE LANDED CATCH FOR THE ECLIPSE SOUND NARWHAL STOCK

*Narwhal (*Monodon monoceros*)*

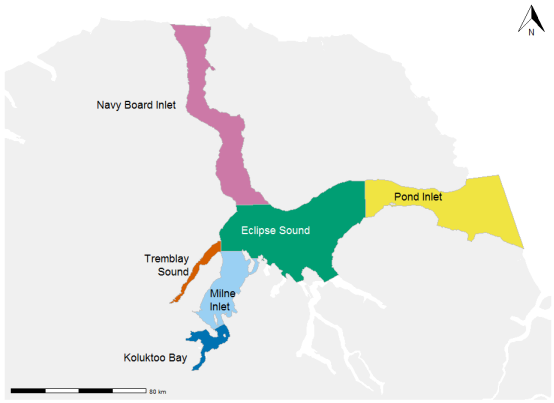

Figure 1. Map of study area showing the strata.

Context:

The Inuit subsistence harvest of narwhal is a key fishery for DFO Central and Arctic Region. In the Nunavut Settlement Area, updated science and documented management approaches are required for the sustainable management of the fishery. The Nunavut Wildlife Management Board (NWMB) has the authority to establish/modify levels of Total Allowable Harvest. Fisheries and Oceans Canada (DFO), in close collaboration with co-management partners, has implemented an Integrated Fisheries Management Plan for narwhals, which also recognizes that domestic management measures must also conform to the Convention on International Trade in Endangered Species (CITES) requirements for international trade.

The Nunavut Agreement requires that restrictions or limitations on Inuit harvesting can only be made to the extent necessary to affect a valid conservation purpose. An aerial survey for Eclipse Sound narwhals was conducted in 2013, which provided the basis for DFO Fisheries Management to recommend a reduction of the existing Total Allowable Harvest. However, uncertainty about the movement of narwhals between summer management areas has made it difficult to interpret the resulting abundance estimate. Since then, additional aerial survey information has become available (e.g., DFO 2016 aerial survey, LGL Ltd. aerial survey data) that may enhance our understanding of Eclipse Sound narwhal abundance. Resource Management has requested DFO Science to evaluate the usefulness of the LGL survey for estimating abundance, review the data collected in the 2016 DFO aerial survey, and using appropriate data sets, provide an estimate of abundance and associated Total Allowable Landed Catch (TALC) recommendations for the Eclipse Sound narwhal stock.

October 2020

SUMMARY

- Aerial photographic surveys were flown by DFO in August 2016 to estimate the abundance of the Eclipse Sound narwhal stock. Sightings in the fiords were analysed using density surface modelling, while sightings in other strata were analysed using a strip transect design.
- On August 7, 9 and 10, 2016 all survey strata were covered. These data were analysed to provide a corrected total abundance estimate of 12,039 narwhals (Coefficient of Variation [CV] = 0.23).
- DFO also obtained data from visual surveys of the Eclipse Sound narwhal stock conducted by the environmental consulting company LGL Environmental Research Associates in 2013–2015 to evaluate the impact of shipping in narwhal distribution. These data were evaluated to assess their suitability for estimating abundance of Eclipse Sound narwhals.
- The LGL data were not considered suitable for estimating stock abundance for a number of reasons, including: 1) incomplete coverage of the survey area; 2) the high proportions of sightings missing perpendicular distances required to estimate narwhal abundance; and, 3) failure of fiord survey design to meet distance analysis assumptions.
- Harvest advice was generated using the Potential Biological Removal (PBR) method. Using the 2016 DFO survey results and a recovery factor of 0.75, the estimated PBR is 150 narwhals. The PBR estimate includes all sources of human-caused mortality, such as landings, struck and lost, non-reporting, and bycatch.
- The PBR value was adjusted to account for the current estimate of narwhal hunting losses (28%), resulting in a Total Allowable Landed Catch (TALC) of 117 narwhals for the Eclipse Sound stock.

INTRODUCTION

The Baffin Bay narwhal (*Monodon monoceros*) population is the largest of Canada's two narwhal populations, numbering approximately 140,000 individuals. During summer, Baffin Bay narwhals are distributed in fiords and inlets of northeastern Canada and western Greenland, with individuals typically showing site fidelity to a given region during the post-calving period. These regional summer aggregations form the basis of independently managed stocks in Canada and Greenland, where narwhals are subject to subsistence hunts. In Canadian waters, there are four defined Baffin Bay narwhal stocks; Somerset Island, Admiralty Inlet, Eclipse Sound, and East Baffin Island, and two putative stocks, Smith and Jones sounds.

The Eclipse Sound narwhal stock was surveyed by Fisheries and Oceans Canada (DFO) in 2004 and 2013, resulting in abundance estimates of 20,225 (CV = 0.36) and 10,489 (CV = 0.24) respectively. In contrast, the 2013 estimate for the neighboring Admiralty Inlet stock (35,043; CV = 0.42; DFO 2015) was higher than its previous survey estimate in 2010 (18,049; CV = 0.23; DFO 2012), which has raised questions about mixing of animals between the two adjacent summering stocks. Supporting evidence has been inconclusive because, while most narwhals tagged in the Eclipse Sound area typically remain in the region throughout the summer and return after overwintering in Baffin Bay some anomalous movement behaviour has been reported. For example, one narwhal tagged in Tremblay Sound in 2010 returned to summer in Admiralty Inlet in August 2011. In addition, nearly half of Eclipse Sound narwhals tagged in 2009 and 2010 left the Eclipse Sound area in late August and traveled into areas occupied by the Admiralty Inlet (and Somerset Island) stocks further west.

Additional abundance estimates of Eclipse Sound narwhals are required for assessment of interannual variation in abundance, and to provide additional data for modelling stock abundance trajectories. To that end, DFO conducted a third aerial survey of the stock in August 2016 in order to provide an updated abundance estimate and TALC for the stock. In addition, DFO has been provided aerial survey data, collected by the environmental consulting company LGL Environmental Research Associates in 2013, 2014, and 2015. LGL was hired by the mining company Baffinland Iron Mines Corporation to assess potential impacts of shipping iron ore from Baffinland's Mary River Project on narwhals in the area.

METHODS

LGL Surveys

Aerial surveys were flown in 2013, 2014 and 2015 by LGL Environmental Research Associates (thereafter LGL) using the same protocol, aircraft type, and observer set-up each year. Surveys were conducted roughly bi-weekly over much of the open-water season (early August to mid-September or later), although coverage differed among years.

Initial assessments of the LGL temporal and spatial coverage led to the exclusion of the 2013 data from subsequent analysis because of inconsistent spatial coverage. The only surveys to cover the entire area in 2013 were conducted in mid-October, after Eclipse Sound narwhals (and stocks further west that may pass through the Eclipse Sound region) have begun their eastward migration to Baffin Bay.

Survey coverage in 2014 was largely similar to that of DFO surveys in terms of spatial extent, and included the early to mid-August period when DFO conducts its surveys. The 2015 surveys omitted Navy Board Inlet and the eastern fiord strata, strata that are typically included in DFO surveys (Figure 1). Although similar in spatial extent and timing to DFO surveys, a majority of observation data in both survey years were missing perpendicular distances required to conduct distance sampling analysis. In addition, the single non-linear fiord transects violated several assumptions of distance sampling analysis, as well as the alternative density surface modeling (i.e., they did not span a sufficient range of environmental factors to allow for density and abundance modelling). Finally, the lack of dual-observer data prevented correction of near-surface abundance estimates for perception bias. Therefore, it was decided that these data could not be used to provide abundance estimates comparable to DFO surveys.

DFO Survey

Aerial surveys to estimate abundance of narwhals were conducted by DFO in August 2016 to cover the extent of the Eclipse Sound narwhal summer stock range. The survey was entirely photographic and included six (6) strata (Figure 1). The Pond Inlet, Eclipse Sound, Navy Board Inlet and Milne Inlet strata were designed as systematic line surveys (non fjord strata). The Tremblay Sound and Koluktoo Bay strata (fjord strata) were surveyed using multiple non-linear transects.

A photo analyst counted narwhals in the aerial photos for August 7, 9, and 10.

The strip transect method was used to estimate abundance in the non fjord strata. The density of narwhals was calculated by adding the number of narwhals in each photo and dividing by the surface water area covered by the photos. The abundance in each strata was estimated by multiplying the density of each strata by its area.

For the fiord strata, density and abundance were estimated using spatial modeling. The number of narwhals seen in the photos was modelled using Generalized Additive Models that included distance from shore and distance from the mouth of the fiord as variables. The best model for each fiord was selected based on Akaike Information Criterion and used to predict the abundance of narwhals across the entire fiord.

Surface estimates were corrected for narwhals that could not be seen on the photos (i.e., those that were not within 2 m of the surface of the water at the time of the survey) using a correction factor of 3.18 (CV = 0.107) obtained previously.

Recommended Total Allowable Landed Catch (TALC)

The Potential Biological Removal (PBR) method, corrected to include hunting losses (i.e., animals that are struck and lost), was used to calculate the recommended Total Allowable Landed Catch (TALC):

$$TALC = \frac{PBR}{LRC}$$

where:

$$PBR = 0.5 * R_{max} * N_{min} * F_r$$

LRC is the hunting loss rate correction and is equal to 1.28 (Standard Error [SE] = 0.15; R_{max} is the maximum rate of increase for the stock (which is unknown, so the default for cetaceans of 0.04 was used), N_{min} is the 20th percentile of the log-normal distribution of N, and F_r is the recovery factor. Here, we used $F_r = 0.75$ because the stock is abundant, but with limited data and an unknown trend not considered to be declining which is consistent with the approach agreed to by DFO.

RESULTS

Strata abundance estimates are provided in Table 1. No narwhals were observed in the Navy Board Inlet in August 10 or the Pond Inlet strata on August 10. The estimate for the Eclipse Sound stratum on August 9 was of 6,118 (CV = 0.40). The abundance estimate for the Milne Inlet stratum was 2,713 (CV = 0.40) narwhals on August 10.

There were two estimates of the Tremblay Sound strata. The abundance estimate was of 1,437 (CV = 0.21) on August 7 and 1,148 (CV = 0.22) on August 9. The average of the two surveys (weighted by the inverse of the variance) is 1,293 (CV = 0.14) narwhals. For Koluktoo Bay, the number of narwhals estimated was 1,914 (CV = 0.15) on August 10.

Based upon these surveys, the total abundance in 2016 was estimated at 12,039 narwhals with a 95% confidence interval of 7,768–18,660. The TALC was estimated to be 117 narwhals (based upon a PBR of 150).

Table 1. Narwhal abundance per strata

Strata	Date	Area (km^2)	Area covered by photos (%)	Surface estimates	Abundance (corrected)	Coefficient of variation
Tremblay Sound	Aug 7	155	44.18	453	1,437	0.21
Tremblay Sound	Aug 9	155	45.55	361	1,148	0.22
Average				**407**	**1,294**	**0.14**
Eclipse Sound	Aug 9	2,937	18.61	1,924	6,118	0.40
Koluktoo Bay	Aug 10	236	41.16	602	1,914	0.15
Milne Inlet	Aug 10	752	18.40	853	2,713	0.40
TOTAL				**3,786**	**12,039**	**0.23**

Sources of Uncertainty

- The instantaneous availability bias correction factor used for this survey was based on the diving behaviour of 24 narwhals equipped with satellite transmitters on their summering grounds between 2009 and 2012. Seven narwhals were tagged in Admiralty Inlet and 17 were tagged in Eclipse Sound. For this study, we assumed that the behaviour of the tagged narwhals was representative of the narwhals observed during the 2016 aerial surveys. However, narwhal diving behaviour is variable and might be affected by predator/prey interactions (e.g., killer whales), tourism (e.g., cruise ships), social behaviour (e.g. group size) and anthropogenic development (e.g., port construction, shipping). It is possible that differences in these factors between the two regions where narwhals were tagged, or among survey and tagging years, introduce bias in the availability-adjusted abundance estimates. This requires further examination incorporating all of the available data on diving behaviour of narwhal.
- The availability correction used for the 2016 survey assumes that narwhals can be detected within 2 m of the surface. This depth could be affected by changes in environmental conditions such as sea state or water clarity. This may have introduced uncertainty that has not been captured in the variance estimate.
- The estimate of total abundance is based on the sum of the abundances of the strata surveyed over a period of four days. We assume that the movement of narwhals among strata is random, which would produce unbiased abundance estimates. However, we could not assess whether directed movements among strata occurred during the survey interval, which would introduce bias to the abundance estimates.
- The likelihood that animals moved among strata that were surveyed on different days means that the sum of the stratum estimates has “additional” variance, which could not be estimated from the data; not including this additional variance results in an underestimation of the variance of the total estimate. Inclusion of this additional variance would result in a lower N_{min} and therefore a lower estimate of PBR and TALC.
- Narwhal sightings were extremely clustered throughout the survey area which increases uncertainty in the abundance estimate.

- Based on satellite telemetry data, connectivity between the Admiralty Inlet and Eclipse Sound summering stocks remains a source of uncertainty.

CONCLUSIONS AND ADVICE

- The LGL surveys from 2013 to 2015 were not considered appropriate for estimating stock abundance.
- The 2016 DFO aerial survey of the Eclipse Sound narwhal stock produced an abundance estimate of 12,039 (95% C.I. 7,768–18,660) narwhals.
- Harvest advice was generated using the Potential Biological Removal (PBR) method. Using the 2016 DFO survey results and a recovery factor of 0.75, the estimated PBR is 150 narwhals.
- The Total Allowable Landed Catch (TALC) was estimated to be 117 narwhals using the estimated PBR minus other sources of mortality not included in the reported catch (e.g., struck and lost, non-reported harvest and other human related mortality).
- Abundance estimates were improved by implementing new survey protocol (100 % photographic) and analysis techniques to address specific challenges associated with narwhal surveys. However, the use of photographs extended the time required for analysis.

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SOURCES OF INFORMATION

This Science Advisory Report is from the February 26 – March 2, 2018 National Marine Mammal Peer Review meeting on Estimated abundance of the Eclipse Sound narwhal stock from the 2016 aerial photographic survey. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

DFO. 2012. Abundance and total allowable landed catch for the Admiralty Inlet narwhal stock in 2010. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2012/048.

DFO. 2015. Abundance estimates of narwhal stocks in the Canadian High Arctic in 2013. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2015/046.

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