EFFECT OF 2008 ICE ENTRAPMENT ON THE ECLIPSE SOUND NARWHAL TOTAL ALLOWABLE LANDED CATCH

Narwhal Monodon monoceros
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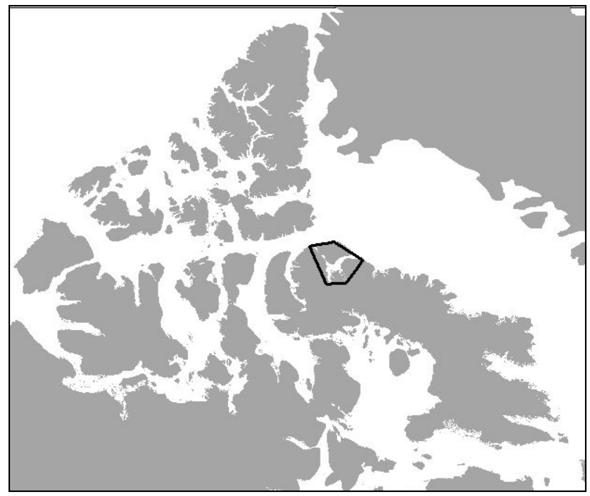

Figure 1. This narwhal stock occupies the Eclipse Sound area in summer, indicated by the black polygon.

Context

In late 2008, an extreme mortality event occurred in the Eclipse Sound area of Baffin Island, Nunavut when more than 629 narwhals were trapped in ice (a "savssat[1]"). Prior to this event, the Nunavut Wildlife Management Board had asked Fisheries and Oceans Canada (DFO) to provide science advice on sustainable levels of harvest for all narwhals and beluga stocks in Nunavut. This advice was provided (DFO 2008) and the current analysis assesses the possible impact of the extreme mortality event on the recommended harvest levels for the Eclipse Sound narwhal stock.

Modelling was used to determine sustainable harvest levels by varying the magnitude of the mortality event over that which could be assumed to be natural mortality. A meeting was held 23 September 2009 by teleconference to review the results of the modelling and provide advice on the impact of the extreme mortality event.

Model results indicate that, even if the entrapment event had caused mortality levels greater than the expected level of natural mortality, the harvest levels need only be reduced by 13 or fewer narwhals to be sustainable. However, if entrapment events of this magnitude were to become more common, the sustainable harvest levels would need to be further revised.

[1] A Greenland word used to describe a group of whales crowded into a small space, trapped by ice forming around them.

This Science Response Report results from the Science Special Response Process of September 23, 2009 on the effect of ice entrapment on the recommendation for Eclipse Sound Narwhal total allowable harvest.

Background

Previous advice on total allowable hunting mortality levels for Canadian Arctic stocks of narwhals were determined using the Potential Biological Removal (PBR) method (DFO 2008). This included advice on catch levels for the Eclipse Sound stock. Given that management control is done more effectively on the landed catch rather than the total removal (landed and lost), sustainable total allowable harvest levels were presented as Total Allowable Landed Catches (TALC) after removal of hunt losses (Richard 2008, DFO 2008). The PBR for the Eclipse Sound stock is 301 narwhals and the TALC is 236 (DFO 2008).

An ice entrapment of more than 629 narwhals occurred in the Eclipse Sound area in November of 2008. Entrapment events of this magnitude are rare in Nunavut, having been recorded only once in the previous century (Heide-Jørgensen et al. 2002a). A majority of hunters interviewed in a local knowledge study reported that narwhals normally leave Eclipse Sound before the winter ice forms (Remnant and Thomas 1992). Thirteen narwhals instrumented with satellite-linked transmitters in the Eclipse Sound area in August 1997-1999 were tracked leaving the area on their southeastern migration between mid-September and mid-October (Dietz et al. 2001, Heide-Jørgensen et al. 2002b). In fact, all but one had left Eclipse Sound and Pond Inlet by 1 October.

Small to medium entrapments resulting in mortality may be major sources of natural mortality for narwhals (Heide-Jørgensen et al. 2002a) but many of these events probably go undetected due to the vast size and remoteness of the narwhal's range, the small size of the savssats and the conditions in which they occur (i.e., darkness). The impact of natural mortality, including normal entrapment events, is already included in the intrinsic rate of population growth used to determine sustainable harvest levels. While a large entrapment such as the one that occurred in November 2008 is rare, because it is so large, there is concern that it will have an impact on the sustainability of the catch from the Eclipse Sound narwhal stock. This analysis assesses whether an adjustment to the proposed TALC for the Eclipse Sound stock is needed following this extreme mortality event to ensure catch levels remain sustainable.

Analysis

Methods

A simple model was used to estimate the difference in TALC required after this large entrapment event to adjust for the population decline.

$$N_{2009} = N_{2008} - H_{2008} - E_{2008}$$

Where: N_{2008} = population size modelled as a lognormal (20,225, Standard Error = 7,285 from Richard et al. 2010[2])

[2] Eclipse Sound narwhal were surveyed in 2004. The modelling assumed a stable population since then.

H_{2008} = hunting mortality from the population in 2008, or the reported landed catch (73, DFO unpubl. data) adjusted for hunting losses ($73 \times 1.28 = 93$, Richard 2008)

E_{2008} = entrapment mortality (629 trapped narwhals which were caught and an unknown number that were lost during the harvest along with others that might have suffocated under the ice and sank before they were caught; Blair Dunn, DFO, pers. comm.)

The annual rate of growth of the population is unknown. To simplify, the growth rate is assumed to be zero, and removed from the equation, because the population is quite large, probably stable in numbers and likely not decreasing given the low hunting rate it is experiencing (~0.5%).

Hunters reported that there were no hunting losses at the entrapment because they harpooned the whales first before dispatching them with a rifle shot (Blair Dunn, DFO, pers. comm.). On the other hand, the actual numbers of animals that suffocated under the ice is unknown. Hunters reported that they caught a large proportion of the entrapped narwhals because they kept holes opened while they removed all the narwhals they could find (Blair Dunn, DFO, pers. comm.). To account for that latter uncertainty, entrapment mortality was modelled using a Uniform distribution between 629 and an assumed upper limit. Because the actual upper limit of animals that died is uncertain, three scenarios were modelled: Uniform (629, 700), Uniform (629, 800), and Uniform (629, 900) to evaluate the sensitivity of results to the assumed upper limit.

The impact of natural mortality, including normal entrapment events, is already included in the intrinsic rate of population growth rate used in PBR. However, since the frequency and magnitude of entrapment events included in the population growth rate are unknown, different levels of entrapment mortality were modelled. Scenarios ranged from entrapment mortality exceeding the base level included in natural mortality by 20% to100%.

The model calculated PBR for the Eclipse Sound stock once the catch and entrapment mortality of each scenario were removed. The PBR is calculated as in Wade (1998) and Wade and Angliss (1997) as follows:

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

Where: N_{Min} = 20th percentile of the log-normal distribution of the estimated population size; equivalent to a lower 60% confidence limit

R_{Max} = maximum rate of increase for the stock. As the maximum rate of increase for the stock is unknown, R_{Max} was set at the default for cetaceans of 0.04. It was then halved ($0.5 \times R_{Max}$) to simulate the effect of logistic density dependent growth.

F_r = recovery factor with values set to reduce the base PBR value to improve the probability of recovery. The recovery factor (F_r) can be set to 0.1 for a critically low stock status, 0.5 for a depleted status and 1.0 for a healthy status (Wade and Angliss 1997). Given the healthy status of this stock, the F_r was set to 1.

PBR was calculated for each scenario. The resulting PBRs were then discounted for the hunt losses (PBR/1.28, Richard 2008) to calculate the revised TALC that would result from each unusual (in excess of base natural) mortality scenario.

Results

Model results indicate that the effect of varying maximum entrapment mortality in the entrapment mortality function is negligible (Table 1). Also, no matter how much the entrapment number was in excess of natural mortality for the chosen scenarios, the TALC need only be reduced by 13 or less from the previously recommended TALC (DFO 2008) to compensate for this event.

Table 1. Revised PBR and TALC resulting from the unusual entrapment mortality scenarios. PBR was calculated after the entrapment event. The sixth column in the table shows the difference between the proposed TALC of 236, which does not consider mortality from the entrapment, and re-calculated TALCs that take into account different proportions of the 2008 entrapment mortality above natural mortality.

Entrapment mortality function (lower limit, upper limit)	Proportion of the 2008 entrapment mortality above the base level of natural mortality	N_{min}	PBR	TALC (after losses)	Difference
Uniform (629, 700)	0%	15,074	301	236	0
	20%	14,858	297	232	-4
	40%	14,732	295	230	-6
	60%	14,605	292	228	-8
	80%	14,479	290	226	-10
	100%	14,353	287	224	-12
Uniform (629, 800)	0%	15,074	301	236	0
	20%	14,848	297	232	-4
	40%	14,712	294	230	-6
	60%	14,577	292	228	-8
	80%	14,441	289	226	-10
	100%	14,305	286	224	-12
Uniform (629, 900)	0%	15,074	301	236	0
	20%	14,839	297	232	-4
	40%	14,694	294	230	-6
	60%	14,548	291	227	-9
	80%	14,403	288	225	-11
	100%	14,258	285	223	-13

Discussion

A majority of hunters interviewed in a local knowledge study reported that narwhals normally leave Eclipse Sound before the winter ice forms (Remnant and Thomas 1992). Tracked narwhals instrumented in the Eclipse Sound area in August 1997-1999 left it between mid-September and mid-October (Dietz et al. 2001, Heide-Jørgensen et al. 2002b) and in fact, most of them had left by 1 October. Why narwhals remained in Eclipse Sound later than usual in 2008 is an enigma. Usually they are much farther down the coast of Baffin Island by November. However, they became trapped when temperatures dropped from -10°C to -40°C overnight and remained at that temperature for several weeks.

Small to medium entrapments resulting in mortality may be major sources of natural mortality for narwhals (Heide-Jørgensen et al. 2002a) but many of these events probably go undetected due to the vast range of narwhals and the fact that smaller ice entrapments are harder to detect than large ones, especially when they are remotely located. An entrapment event of this magnitude is rarely observed and only one of similar size was reported in Nunavut in the last century (Heide-Jørgensen et al. 2002a). This is the first entrapment of this magnitude reported in the Eclipse Sound area. The impact of natural mortality, including normal entrapment events, is already included in the intrinsic rate of population growth rate used in PBR. The model results indicate that the 2008 entrapment mortality event probably had a small effect on this fairly large stock.

The TALC advice provided previously is based on PBR (Wade 1998), a method which is considered conservative and robust to departures from model assumptions and plausible uncertainties (Hammill and Stenson 2007). We conclude that the TALC proposed earlier (DFO 2008) need only be reduced by 13 or fewer narwhals to account for this ice entrapment. If large entrapments such as this one were to become more common in the future then advice on TALC would need to be revisited.

In this analysis, the stock was modelled as if animals of all sex and ages in the population were impacted equally in proportion to their numbers by this entrapment, when in fact the resulting catch from the entrapment shows that there was a preponderance of females, juveniles and calves. Ninety-three tusks were reported sold to the local Co-op store after the entrapment hunt. Assuming that all tusks from this hunt were sold, this suggests that possibly as few as a third of the adults (288) taken by hunters were males and the rest were females. Hunters reported that many males escaped before being entrapped by breaking through the newly-formed ice (7-10 cm thick), using their size and strength. The females apparently lacked the strength and were presumably hampered in their efforts by the calves in their charge (Blair Dunn, DFO, pers. comm.). The highest impact to the population comes from the loss of reproductive females whereas the lowest impact comes from the loss of calves.

There is no way to model this likely bias in the analysis because no information on the sex composition of the stock was available before the incident. Nevertheless, the hunt itself takes more males than females (JCNB 2009), a hunt selection which counteracts to some extent this entrapment sex bias. Finally, the PBR method has been shown by simulation to be robust to departures from assumptions to the parameters used in its calculation (Wade 1998).

Another source of uncertainty is whether these animals were in fact all from the Eclipse Sound stock. Two tagged narwhals from the Admiralty Inlet stock did briefly transit through Eclipse Sound in the autumn of 2003 and the autumn of 2004 but, in both years, had left by mid-October (Dietz et al. 2008). It is not possible to assess whether any narwhals from the Admiralty Inlet stock also came into Eclipse Sound in 2008 and, if so, whether they remained long enough to become entrapped. The analysis presented in this paper assumed that the entrapped narwhals were from the Eclipse Sound stock.

Conclusions

In summary,

- An ice entrapment of over 629 narwhals occurred in the Eclipse Sound area in November of 2008.
- The analysis assesses the impact of this extreme mortality event on the proposed TALC for the Eclipse Sound stock.

- Modelling was used to estimate the difference in TALC that results from this unusual mortality event. Scenarios varied the proportion of the extreme mortality event over that which could be assumed to be natural mortality.
- Model results indicate that, even if mortality from the entire entrapment event was greater than that considered to be natural mortality, the TALC need only be reduced by 13 or fewer narwhals.
- If entrapment events of this magnitude were to become more common, the TALC would need to be further revised.

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