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Can We Calculate Total Allowable Harvests for Walrus Using Potential Biological Removal?

Pouvons-nous calculer les prélèvements totaux admissibles pour le morse au moyen du prélèvement biologique potentiel?

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ABSTRACT

DFO was asked by the Nunavut Wildlife Management Board to provide advice on Total Allowable Harvest (TAH) levels for walrus in Nunavut. Given the lack of information available, Potential Biological Removal (PBR) methods were explored, using a generic hunting loss-rate of 30% to convert PBR to landed TAH. Except for West Jones Sound, there were no estimates of population size made within the past 5 years and none of the existing estimates included the entire stock. It is not possible to provide valid scientific advice on TAH for most walrus stocks in Nunavut. Current estimates of minimum population size and hunting losses are required.

RÉSUMÉ

Le Conseil de gestion des ressources fauniques du Nunavut a demandé au MPO de formuler un avis sur les taux des prélèvements totaux admissibles pour le morse au Nunavut. Faute d'information disponible, des méthodes d'établissement des prélèvements totaux admissibles ont été analysées au moyen d'un taux de perte générique attribuable à la chasse de 30 % pour convertir le PBP en prélèvements totaux admissibles débarqués. Sauf pour l'ouest du détroit de Jones, aucune estimation de l'effectif de la population n'a été réalisée ces cinq dernières années et aucune des estimations actuelles n'incluent le stock en entier. Il n'est pas possible de formuler un avis scientifique valable sur les prélèvements totaux admissibles pour la plupart des stocks de morses au Nunavut. Des estimations à jour de l'effectif minimal de la population et des pertes dues à la chasse sont nécessaires.

INTRODUCTION

Fisheries and Aquaculture Management (FAM) has requested that Science provide advice on Total Allowable Harvest (TAH) levels for marine mammal stocks in Nunavut. This advice will be used by the Nunavut Wildlife Management Board to establish TAH for Nunavut walrus, beluga and narwhal stocks. The advice will also be used in the development of management plans for Nunavut marine mammal stocks. FAM is initiating the development of a management plan for walrus in Foxe Basin.

The Department of Fisheries and Oceans deems "scientific uncertainty" as insufficient reason to forego estimating allowable harvest levels under the precautionary principle (DFO 2007). Certainly "doing nothing" is accepting the status quo, which may not be precautionary. However there is a distinction between "scientific uncertainty" which is the scientific error about an estimated number and the "absence of knowledge" which means there is no estimate. This interpretation appears supported by the Precautionary Approach guidelines provided: "In data deficient cases, priority should go to monitoring the stock and establishing data time series to support the identification of an LRP [Limit Reference Point]" (DFO 2007, page 3). A strong case can be made to consider walrus to be data deficient.

I have explored our ability to calculate Total Allowable Harvests (TAH) for various Canadian walrus stocks using the Potential Biological Removal (PBR) algorithm. I chose this approach because it requires few assumptions and input parameters. These calculations are made in an exploratory fashion only and their results should be considered speculative, at best. It is imperative that the required data are obtained to allow reliable estimates of PBR.

METHODS

PBR

The definition of PBR arises in the American Marine Mammal Protection Act (MMPA) amendments of 1994 (quoted in Wade 1998):

"(20) The term 'potential biological removal level' means the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population. The potential biological removal level is the product of the following factors:

(A) The minimum population estimate of the stock.
(B) One-half the maximum theoretical or estimated net productivity rate of the stock at a small population size.
(C) A recovery factor of between 0.1 and 1.0.''

$$PBR = N_{min}*0.5* R_{max} *F_R \qquad [1]$$

"(27) The term 'minimum population estimate' means an estimate of the number of animals in a stock that - (A) is based on the best available scientific information on abundance, incorporating the precision and variability associated with such information; and (B) provides reasonable assurance that the stock size is equal to or greater than the estimate."

N_{min} is the estimate of minimum population size. Taylor (1993) found that using the central population estimator depleted most stocks below the Maximum Net Productivity Level (MNPL) over 100 years but using the lower 2-tailed 95% CL resulted in all simulated populations greatly exceeding MNPL over the same time. Wade (1998) concluded that the 20th percentile (the lower 60% log-normal confidence limit) of the abundance estimate was the intermediate percentile that would be just sufficient to result in a high probability that populations would be above MNPL.

For most walrus stocks, there are no estimates of abundance from quantitative surveys, hence no associated information on precision and variability (measures of uncertainty). Therefore I emphasized part (B) of the MMPA definition of N_{min} in selecting a starting number.

Multiplying R_{max} by 0.5 is thought to be conservative because it is less than or equal to R_{MNPL} if MNPL is greater than or equal to 50% of K (Wade 1998). There are insufficient data to calculate rates of increase for Atlantic walrus. Sease and Chapman (1988) determined R_{max} for the rapidly growing Pacific walrus population between 1958 and 1975 as 0.07. Wade (1998) used 0.04 for whales and 0.12 for pinnipeds although the age of maturity for walrus and the calving interval are more like odontocetes of similar size. I used a range of 0.04-0.07.

F_R can be used to address potential biases caused by uncertainty about some important factors, such as stock boundaries (Wade 1998). The greater the uncertainty, the lower F_R value that should be used. Wade found that a value of 0.5 allowed recovery of depleted stocks in virtually all simulations and cautioned against raising it from this default value without strong supporting evidence. I used 0.5.

PBR carries some assumptions that may not be valid for walrus stocks.

1. The management goal is the Optimum Sustainable Population level. This may not be the management goal for every walrus stock; indeed there may not be management goals stated for every walrus stock. Any other calculations of TAH however also presume some un-stated management goal which may be “stable at current levels.” Such a management goal may not be precautionary.
2. The stock is depleted. Again this may not be the case for all walrus stocks. A depleted stock should achieve more than ½ R_{max} but if the stock is not depleted, then ½ R_{max} may not be precautionary (Wade 1998) in as much as it may over-estimate the true R_{max}.

To convert PBR to TAH requires accounting for unreported kills and killed but lost walrus: TAH = PBR/[1/(1-(lost+unreported))]. There is no correction available for non-reporting. Hunting loss rates are thought to range from 20 to 30% (Witting and Born 2004 who applied 25%), or 30% (NAMMCO 2006). I used 30%.

Using generic values for R_{max}, F_R, and losses plus unreported harvest, the only data required are estimates of N_{min} for each stock.

<u>Stock definitions</u>

Born *et al*. (1995) proposed 5 stocks for walrus in Canada but NAMMCO (2006) accepted new data as evidence for 8 stocks (Table 1, Fig. 1). These 8 have recently been sanctioned by DFO-HQ for use in developing a Walrus Management Plan (P. Hall, pers. Comm., 2007). It is precautionary to assume more stocks than to assume fewer.

Estimates of N_{min}

Baffin Bay

Witting and Born (2004) used joint DFO-Greenland Institute of Natural Resources (GINR) counts (n = 452) from 1999 to estimate ~1000 for the old Northwater area (including WJS and PS-LS) but only 5 of the 452 walrus counted were in the area of the current Baffin Bay designation. Proportionally this would mean the Baffin Bay stock was (5/452)*1000 = 11 animals if Witting and Born's adjustments are applied. NAMMCO (2006) accepted no population estimate.

Estimated harvest in 1999 was >100. Annual landed harvest 1996-2001 was about 110 animals (NAMMCO 2006). In 2007, Grise Fiord reported local decline.

There are no data upon which to base PBR calculations.

Western Jones Sound

Counts were made at haulouts in 1977, 1998-2001,2003-04 (Table 2; Stewart *et al*. in prep). Counts are biased down by an unknown amount due to incomplete coverage of known haulouts, unknown haulouts, and animals at sea. Some "at sea" counts were made only some years but are of limited coverage and not adjusted for submerged animals. Animals seen at sea are included in total counts of minimum known alive. These counts are highly variable both among and within years. Since 1998, the average count was 146, the median was 154. The maximum count was used as the estimate of known-alive.

There is virtually no harvest: 4 walrus were reported taken in a single hunt between 1996 and 2001, inclusive (Priest and Usher 2004).

The stock size may be 200-500 and I used 200 as N_{min}.

Penny Strait-Lancaster Sound

Counts were made at haulouts in 1977, 1998-2001, 2003-04 (Table 2; Stewart *et al*. in prep). Counts are biased down by an unknown amount due to incomplete coverage of known haulouts, unknown haulouts, and animals at sea. Some "at sea" counts were made only some years but are of limited coverage and not adjusted for submerged animals. Animals at sea are included in total counts of minimum known alive. These counts are highly variable both among and within years. Since 1998, the average count was 171, the median was 122. There are no data for south side of Lancaster Sound. Witting and Born (2004) guessed 500 for the whole stock. The maximum survey count was used as the estimate of known-alive.

Average harvest 1996-2001 = 8 (NAMMCO 2006).

The stock could be 450 -1000. I used 450 as N_{min}.

Northern Foxe Basin

There is no stock-specific abundance estimate but there is a 20 year-old estimate for the Foxe Basin population = 5500 (95% CI 2700-11,200; Richard 1993). In the absence of any information on proportional distribution of this population into harvested stocks, I assumed equal sharing with the southern Foxe Basin stock.

Recent annual harvests are approximately 130 (COSEWIC 2006).

Stock size perhaps is 1500-6000, using 0.5*95% CL of the survey estimate. I used 1500 as N_{min} which may be overly conservative (Taylor 1993) but protects against errors associated with the age of the estimate and the simplistic nature of this calculation.

Southern Foxe Basin

The rationale and numbers in the estimate are the same as for Northern Foxe Basin, i.e. N_{min}. = 1500. Recent average harvests are about 80/year (COSEWIC 2006).

Northern Hudson Bay – Davis Strait (W Greenland)

There are no concurrent estimates of stock size. COSEWIC (2006) summarized available data (Table 3).

The Canadian harvest averaged about 150/yr until 1997 when it declined to 68/ yr 1997-2002 (COSEWIC 2006), although the validity of the latter number is uncertain (COSEWIC 2006). Another estimate for 1996-2001 was 170/year (NAMMCO 2006) to which some proportion, perhaps all, of the west Greenland harvest (1996-2001 = 158; NAMMCO 2006) should be added (sum approximately 230).

The best available estimate of N_{min} is about 3500 but there is considerable uncertainty in this value.

South and East Hudson Bay

Using mostly Ontario Ministry of Natural Resources unpublished data, the recent estimate is ~ 300 (COSEWIC 2006) but it is unclear if this is an estimate of minimum known alive or an extrapolation to total population size.

The average annual harvest in 1996-2001 was 8-10 (COSEWIC 2006, NAMMCO 2006).

I used the point estimate of 300 as N_{min}.

Maritimes

There are occasional sightings but the stock is officially extirpated. There is no harvest. No further analysis is presented here.

RESULTS AND DISCUSSION

Calculation of PBR, hence TAH, is sensitive to the estimate of R_{max}. There are no data to choose among the options used for any walrus stock and results (Table 4) are presented for a range of probable R_{max} values.

DFO (2007) noted the need to assess scientific uncertainly. Without statistical estimates, I have tried to assess, qualitatively, the probability that our estimate may be in error and the probability of a stock decline. In all cases it is highly likely that the hunting loss rate is in error. It was calculated several years ago on the basis of limited data. This uncertainty affects the calculation of TAH but not the estimation of PBR. Harvest data are also out of date, incomplete, or both.

Baffin Bay

If the minimum population size is about 100, the TAH is 1, well below the current annual harvest, regardless of the value used for R_{max}. The Hunters and Trappers Association in Grise Fiord indicated in January 2007 that there has been a decline in walrus numbers around their community, but did not indicate that walrus had disappeared completely. Therefore a TAH of 1, based on data from 1999, is inconsistent with an annual harvest of about 100 since 1999.

The probability of being wrong is high. Calculated TAH_{1999} has been exceeded 100-fold for about 8 years though the stock would have been extirpated quickly at that harvest rate. There are no estimates of stock size, no quantitative data by which to assess the observed trend, uncertain stock definition, and the possibility of unreported harvest, which may be large in Greenland. The risk of decline seems high because there has been an observed decline, there is an international hunt, and there is little monitoring.

Western Jones Sound

Minimum-known-alive estimates vary widely among years but using 200 generates a TAH of 1-2 depending on R_{max} (Table 4), within the range of reported harvest up to 2001.

The probability of being wrong is moderate due to the variability in haulout counts which may be related to the proportion of the stock hauled out (compared to the proportion at sea) at any survey time. While the risk of decline may be low because there is no significant harvest, with the decline in walrus numbers near Grise Fiord, diminishing ice in Jones Sound, and generally an increase in boating capability in Nunavut, hunting pressure could increase, and may have done so since 2001.

Penny Strait-Lancaster Sound

The estimated TAH ranged from 3 to 6 based on N_{min} of 450. Current reported harvest averages 8/year. This TAH is an under-estimate for the whole area because there are at least 6 haulouts known historically on the south side of Lancaster Sound and adjacent waters that have not been examined for several decades.

The probability of being wrong is high because abundance, stock boundaries, harvest levels, and the effects of diminishing ice coverage (increase hunting access, increase vessel traffic) are poorly known.

Qualitatively, the risk of decline may be low to moderate because the estimated harvest is small and the population may be larger than the data suggest.

Northern and Southern Foxe Basin

If the data available were used to calculate a TAH, it would be the same for both north and south stocks due to the way the data were partitioned. TAH would range from 11 to 18 (Table 4), well below the current estimated harvests (about 130 and 80 respectively). Indeed, one might expect there to be very few walrus left now since the TAH estimates are based on data collected in 1988-1990. The data available are inappropriate to calculate a TAH.

The probability of being wrong is high because abundance, stock boundaries, and real harvest levels are poorly known. The proportion of the population estimate that should be assigned to each stock is unknown. Qualitatively, the risk of decline seems moderately high because the harvest is large, and because there may be soon an dramatic increase in ship traffic in the area (new iron mine).

Northern Hudson Bay – Davis Strait (W Greenland)

Estimated TAHs would be 25 to 44 (Table 4) and are greatly exceeded by estimated annual harvest of about 230, but the data are inadequate to calculate a TAH.

The probability of being wrong is high because abundance, stock boundaries, and real harvest levels are poorly known. It is unclear how hunting in West Greenland might affect walrus numbers at SE Baffin Island and farther west. Qualitatively, the risk of decline is high because of the large international harvest. While N_{min} may be under-estimated, it would require a minimum population estimate of about 13,000, a high R_{max}, and no hunting losses to support the current reported removals.

South and East Hudson Bay

Based on N_{min} = 300 the calculated TAH was 2-4 compared to a reported annual harvest of 8-10, but the data are insufficient to support such a calculation.

The probability of being wrong is high because abundance, stock boundaries, and real harvest levels are poorly known. The risk of decline may be moderate because the Ontario coast may serve as a refugium from the small harvest.

CONCLUSIONS

With the exception of West Jones Sound, the minimum population numbers used here have inadequate or no scientific underpinning. Some of the N_{min} estimates are clearly wrong because current removals should have extirpated the stocks several years ago and they have not.

There is cause for concern for all walrus stocks in Canada. Inuit communities have identified local declines. The limited data available indicate harvests exceed PBR. We need better data. Walrus occupy remote areas, occur in widely dispersed groups, and are difficult to count. Additional resources, both time and money, and the continued assistance and cooperation of co-management groups are required to obtain the essential information.

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Table 1. Relationship of walrus stocks in Canada as identified by Born *et al.* (1995) and by NAMMCO 2006

Born *et al*. (1995) Designation	NAMMCO (2006) Designation
Northwater	Baffin Bay West Jones Sound Penny Strait – Lancaster Sound
Foxe Basin	Northern Foxe Basin Southern Foxe Basin
Hudson Bay-Davis Strait	Hudson Bay-Davis Strait
South and East Hudson Bay	South and East Hudson Bay
Maritimes	Maritimes

Table 2. Maximum counts of walrus and number of haulouts examined to generate those counts during coastline surveys in the Western Jones Sound area and the Penny Strait – Lancaster Sound area.

Year	Western Jones Sound		Penny Strait – Lancaster Sound	
	Maximum daily count	Haul outs examined (max = 8)	Maximum daily count	Haul outs examined (max = 22)
1977	293	5	565	10
1998	179	8	195	12
1999	108	5	457	14
2000	203	5	122	12
2001	173	7	22	1
2002	no data		no data	
2003	129	6	92	5
2004	154	2	34	3
2005	no data		no data	
2006	76	3	273	8

Table 3. Estimated walrus numbers in the Northern Hudson Bay – Davis Strait area, as summarized by COSEWIC (2006).

Year	Area	Estimate	COSEWIC citation
Mid-1990s	Western Hudson Bay	More than in the past	Born *et al.* 1995
Late 1980s	Northern Hudson Bay	>1400*	Richard 1993
Mid 1980s	Hudson Strait (north side)	500-1000*	Orr & Rebizant 1987
1960	Akpatok Island	1000-2000	Currie 1963
recent	Hudson Strait (south side)	?	
Late 1970s	Southeast Baffin Island	~1000	McLaren Marex 1979, 1980a,b
~1990	Entire stock	5000-6000	Richard & Campbell (1988) Born *et al.* (1995)
2006-2007	Southeast Baffin Island	>1500*	DFO/GINR ongoing studies
1990-1991 (winter)	West Greenland	~500 (not corrected)	Born *et al.* 1994

* summed to generate minimum estimate

Table 4. Best estimates of N_{min} for each walrus stock in Nunavut, PBR (at different estimates of R_{max}) and TAH = PBR/(1/(1-.3))

Stock	N_{min}	PBR at R_{max}				TAH at R_{max}				Comments
		0.04	0.05	0.06	0.07	0.04	0.05	0.06	0.07	
Baffin Bay	nd									No data available
West Jones Sound	200	2	2.5	3	3.5	1	2	2	3	MKA (2000)
Penny Strait – Lancaster Sound	450	4.5	5.6	6.8	7.9	3	4	5	6	MKA (1999); underestimate because there is no coverage on southern Lancaster Sound
Northern Foxe Basin	1500?									N_{min} is based on ½ the lower 95% CI of a 20 year old, incomplete estimate for the combined Foxe Basin stocks and too uncertain to generate harvest advice.
Southern Foxe Basin	1500?									N_{min} is based on ½ the lower 95% CI of a 20 year old, incomplete estimate for the combined Foxe Basin stocks and too uncertain to generate harvest advice..
Hudson Bay-Davis Strait	3500?									N_{min} is based on a combination of incomplete estimates spanning approximately 30 years and too uncertain to generate harvest advice.
South and East Hudson Bay	300									N_{min} is based on unpublished third-party data from only one haulout site and too uncertain to generate harvest advice.

MKA = minimum know alive (year) based on counts at haulout sites (Stewart *et al*. in prep.)

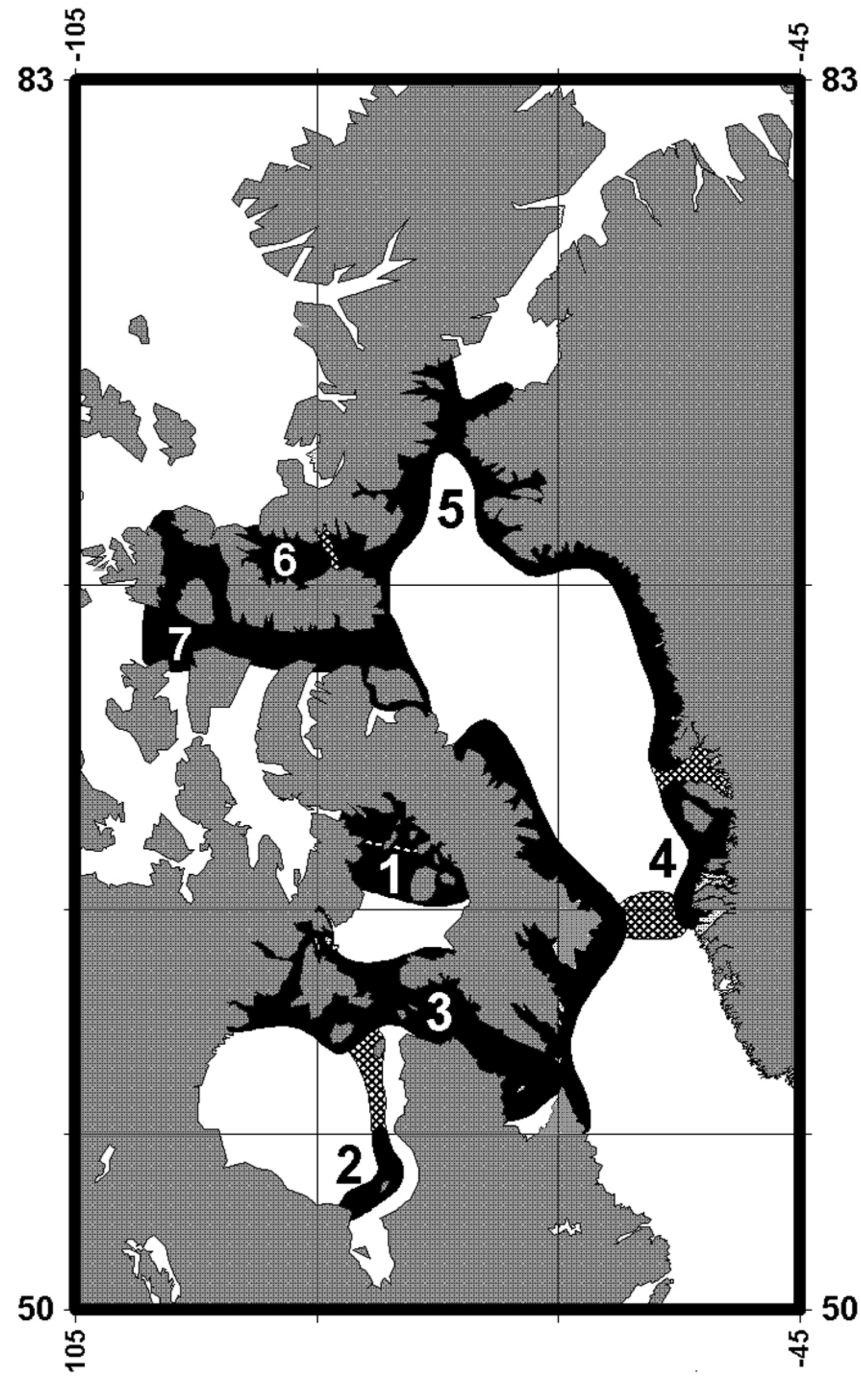

Fig. 1. Walrus stocks in Canadian and adjacent waters (figure after NAMMCO 2006). Boundaries are approximate. Hatching indicates areas of possible stock affiliation. Stocks are: 1) Foxe Basin, dashed line divides N and S areas; 2) South and East Hudson Bay; 3) N. Hudson Bay- Hudson Strait - N. Labrador - S.E. Baffin Island; 4) Central West Greenland; 5) Baffin Bay; 6) West Jones Sound; 7) Penny Strait – Lancaster Sound.