Fisheries and Oceans Canada — Pêches et Océans Canada

Science — Sciences

Canadian Science Advisory Secretariat (CSAS)

Research Document 2013/031

Central and Arctic Region

Estimating total allowable removals for walrus (*Odobenus rosmarus rosmarus*) in Nunavut using the potential biological removal approach

R.E.A. Stewart and J.W. Hamilton

Fisheries and Oceans Canada
Freshwater Institute
501 University Crescent
Winnipeg, MB R3T 2N6
Canada

November 2013

Canada

Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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Published by:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

http://www.dfo-mpo.gc.ca/csas-sccs/
csas-sccs@dfo-mpo.gc.ca

ISSN 1919-5044

Correct citation for this publication:

Stewart, R.E.A., and Hamilton, J.W. 2013. Estimating total allowable removals for walrus (*Odobenus rosmarus rosmarus*) in Nunavut using the potential biological removal approach. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/031. iv + 13 p.

ABSTRACT

DFO Science was asked for advice on sustainable harvest levels for seven stocks of walrus in the Canadian Arctic. No data are available for one stock (south and east Hudson Bay stock) but recent surveys allow calculation of total allowable removal (TAR) levels for the other six stocks. The Potential Biological Removal (PBR) method has been adopted by DFO Science to recommend sustainable levels of removal from marine mammal populations for which there is little information, termed data poor. The results of recent walrus surveys included estimates of the Minimum Counted Population (MCP), as well as adjusted abundance estimates derived using different factors for availability and detectability. The MCP and adjusted abundance estimates were used to estimate levels of TAR (Total Allowable Removal) using the PBR method, noting that all of the estimates are considered negatively biased. The resulting TAR estimates were then compared to recorded landed harvest levels over the last 25 years (about one walrus generation) without adjustments for reporting accuracy or struck-and-lost estimates. For the high Arctic walrus population, it was not possible to partition harvest to the three component stocks but the overall estimated TARs exceeds currently reported landed harvests in Canada. For the central Arctic walrus population, the TAR estimates for the Foxe Basin stocks straddle the lower 95% confidence limit of recent harvest levels, indicating a need for better survey coverage in estimating abundance, and better information on current removals from all sources. Only a small portion of the range of the Hudson Bay-Davis Strait stock has been surveyed, and calculated TAR levels suggest that the local harvest is sustainable. The central Arctic population as a whole lacks sufficient data for a meaningful population estimate and subsequent advice on TARs. Stocks within both the high Arctic and the central Arctic walrus populations are shared with Greenland, and continued collaboration and exchange of harvest data is warranted.

Estimation du total autorisé de prélèvements de morses (*Odobenus rosmarus rosmarus*) au Nunavut à l'aide de la méthode du prélèvement biologique potentiel

RÉSUMÉ

On a demandé l'avis du secteur des Sciences du MPO sur les niveaux de prises durables pour sept stocks de morse de l'Arctique canadien. Pour un de ces stocks (stock du sud et de l'est de la baie de Hudson), on ne dispose pas de données, mais des relevés récents permettent de calculer le total autorisé de prélèvements (TAP) pour les six autres stocks. Le secteur des Sciences du MPO a adopté la méthode du prélèvement biologique potentiel (PBP) pour recommander des niveaux de prélèvement durables au sein de populations de mammifères marins pour lesquelles on manque de données. Les résultats des récents relevés effectuées sur les morses comprenaient des estimations de la population minimale comptée (PMC) ainsi que des estimations ajustées de l'abondance obtenues à partir de divers facteurs tenant compte de la disponibilité et de la détectabilité. La PMC et les estimations ajustées de l'abondance ont permis d'estimer le TAP (total autorisé de prélèvements) au moyen de la méthode du PBP; on considère que toutes ces estimations présentent un biais négatif. Les estimations du TAP calculées ont été alors comparées aux niveaux de prises débarquées enregistrés au cours des 25 dernières années (une génération de morses environ), sans apporter d'ajustements qui tiennent compte de l'exactitude variable des rapports et des taux d'abattage et de perte. Pour les populations de morses du Haut-Arctique, il n'a pas été possible de diviser les prises entre les trois composantes du stock, mais les estimations globales des TAP dépassent la valeur actuelle des débarquements déclarés au Canada. Pour la population de morses du centre de l'Arctique, les estimations du TAP pour les stocks du bassin Foxe se situent autour de la limite inférieure de l'intervalle de confiance à 95 % pour les niveaux de prélèvements récents; il faut donc une meilleure couverture des relevés pour estimer l'abondance et davantage de données sur les prélèvements actuels. On n'a effectué le relevé que d'une petite partie de l'aire de répartition du stock du détroit de Davis et de la baie d'Hudson et les niveaux de TAP calculés laissent penser que la chasse locale est durable. On ne dispose pas de données suffisantes sur l'ensemble du centre de l'Arctique pour obtenir une estimation fiable et formuler un avis sur le TAP. Les stocks de morses du Haut-Arctique et du centre de l'Arctique sont partagés avec le Groenland; par conséquent, une collaboration et un échange continus de données sur les prises s'imposent.

INTRODUCTION

DFO Science was asked to provide walrus population abundance estimates and advice on sustainable harvest levels for seven designated walrus stocks in the Canadian Arctic (Stewart 2008a). These stocks are the Baffin Bay (BB), west Jones Sound (WJS) and Penny Strait-Lancaster Sound (PS-LS) stocks of the high Arctic population (Shafer *et al.* 2013); the north and central Foxe Basin (N-FB, C-FB) stocks and the Hudson Bay-Davis Strait (HB-DS) stock of the central Arctic population (Shafer *et al.* 2013); and the south and east Hudson Bay (S&E-HB) stock (Figure 1). No stock-identification information or recent estimates of population size are available for the S&E-HB stock and it is not considered further.

Surveys have been conducted in recent years for the six remaining walrus stocks to estimate their abundance (Stewart *et al.* 2013a-d). In the case of the HB-DS stock, only a partial estimate of stock size was obtained based on the numbers of walrus summering in Hoare Bay, southeast Baffin Island (Stewart *et al.* 2013c). The N-FB and C-FB stocks have been differentiated on the basis of isotopic differences and morphological differences (DFO 2002, Stewart 2008a) but are indistinguishable during surveys. Here we refer to them collectively as the north and central Foxe Basin walrus (N&C FB). Using colony counts to estimate stock size for walrus is not a well-developed practice. All of the surveys (Stewart *et al.* 2013a-d) employed several approaches to extract as much information as possible from the data.

DFO Science has adopted the Potential Biological Removal (PBR) method to provide sustainable harvest advice for data-poor populations (Stenson *et al.* 2012). Under the Precautionary Approach, walrus are considered data poor. Stewart (2008b) concluded that they were so data poor when he assessed the data that even the PBR method could not generate meaningful estimates of sustainable removals. The purpose of this document is to incorporate results of aerial surveys completed in intervening years to estimate total allowable removal (TAR) levels for each walrus stock using the PBR method.

METHODS

The basic approach in all the surveys was to maximize the number of walrus counted and eliminate those counts which were vulnerable to double-counting by using a time-distance criterion to generate a Minimum Counted Population (MCP) value. The main focus was on haulout sites, but walrus in water and on ice were also counted. These counts inevitably underestimated the total stock size because not all hauled out walrus are visible to observers, and not all walrus are hauled out at the time of the survey. Most surveys were also incomplete in coverage and the number of haulouts contributing to the final estimate was often less than the number observed; even adjusted estimates may underestimate the true numbers.

The MCP includes walrus counted at sea, away from the haulouts, but at-sea coverage was opportunistic only. To estimate the number of walrus at sea, we used the Minimum Counted Population of hauled out walrus (MCP_{HO}).

MCP_{HO}/0.74 – Is the number of walrus hauled out adjusted by the maximum proportion of tagged walrus ever recorded hauled out concurrently in other studies (weighted average indicated in Table 1). It assumes that both surveyors and walrus tend to be at haulout sites in favourable conditions and makes the precautionary assumption that walrus counts were made when the maximum proportion of the population was hauled out.

MCP_{HO}/% tags dry – When satellite tags are active at the time of the survey, the number hauled out can be adjusted to account for walrus at sea using the proportion of functioning tags ‘dry’ at the time of the survey. It has been suggested that the minimum sample size needed is 10 tags (Sharples *et al.* 2009).

$MCP_{HO}/Avg_{time\ dry}$ – When functioning satellite tags transmit information about haulout behaviour, it is possible to adjust walrus counts using the average proportion of a day, or proportion of the survey period that tags register as ‘dry’.

$BC_{HO}/0.74$ – The Bounded Count (BC) adjusts the estimate of the number hauled out for detection and availability. It requires replicate counts and closed populations. None of the studies here had both large numbers of replicates and complete coverage. Bounded Count estimates can be adjusted to account for walrus at sea, again making the precautionary assumption that the maximum proportion of the population is on the haulouts at the time of the survey.

BC_{HO}+at sea – We also examined bounded count estimates augmented with counts of walrus seen at sea but all were <MCP and not considered further.

Table 1. Maximum proportions of satellite tagged walrus hauled out concurrently. Variance for each proportion (p) is the binomial variance (p(1-p)/(n-1) for small samples (Zar 1999). SD = Standard Deviation

Location/ season	Year	Number of tags (dry/total)	Maximum proportion hauled out (SD)	Source
Alaska/ summer	1990	5/6	0.833 (0.17)	Hills 1992
Svalbard/ August	2003 2004	6/9 9/11	0.667 (0.17) 0.818 (0.12)	Lydersen *et al.* 2008, C. Lydersen pers. comm. 2011
Alaska/April	2004 2006	8/12 17/24	0.667 (0.14) 0.708 (0.10)	Udevitz *et al.* 2009, M. Udevitz pers. comm. 2011
NE Greenland/ August	2009	7/8	0.875 (0.13)	Born, unpubl. data
Weighted average		0.743 (52/70)		
Variance SD CV		0.0028 0.053 0.07		

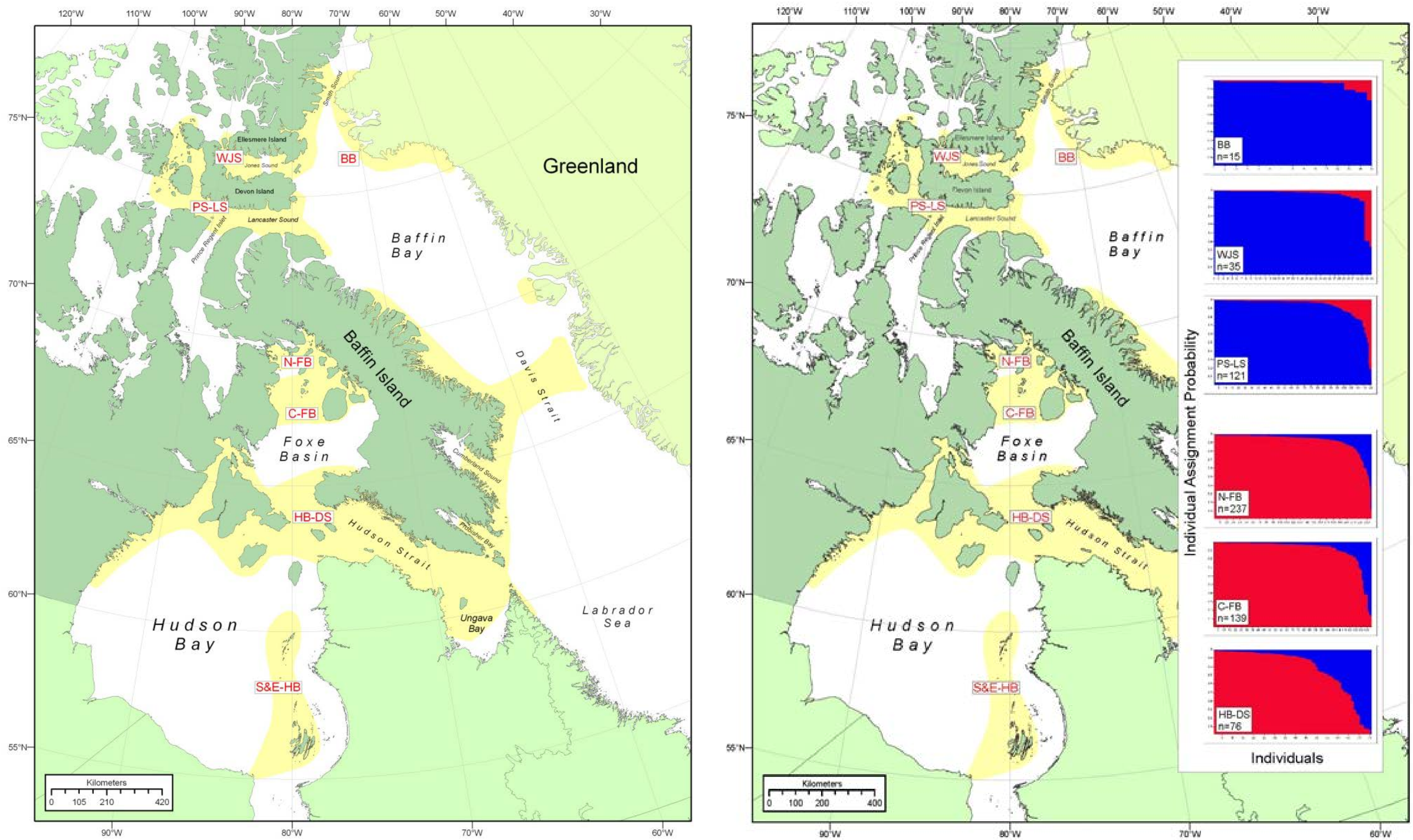

Figure 1. General distribution of walrus stocks in Canada and assignment results of microsatellite DNA analysis placing six of the seven stocks in two clusters (populations) (from Shafer et al. 2013). These two clusters represent the high Arctic and central Arctic populations referred to in this paper.

Potential Biological Removal (PBR) is defined as the maximum number of individuals that can be removed from the populations by all means other than natural mortality to allow the population to attain or maintain its optimal sustainable population size (Wade 1998). It is formulated as follows:

$$PBR = N_{min} \times 0.5 \times R_{max} \times F_R$$

where N_{min} is the estimated minimum population size, R_{max} is maximum net productivity and F_R is a recovery factor. Estimates of population size from Stewart *et al.* (2013a,b,c,d) were used to obtain N_{min} values. The direct counts (MCP) were one estimate of N_{min}. The derived estimates were used to calculate N_{min} following (Wade and Angliss 1997, Wade 1998):

$$N_{min} = N/\exp(0.842 \times (\ln(1+CV^2)))^{0.5}$$

where N is the estimated population size and CV is its associated coefficient of variation.

R_{max} was set at 0.07 as determined for a rapidly growing population of Pacific walrus (Sease and Chapman 1988). Chivers (1999) attained an estimate of 0.08 through modeling but advised that it not be construed as the maximum growth rate for walrus. The recovery factor, F_R was generally set at 0.5 but 1.0 was also used if data suggested the stock was not depleted

We use PBR to estimate the total allowable removals by all means, as a step to estimating sustainable harvest levels. To assist in assessing sustainability, the most recent landed harvest data available (1985-2010) were compared to TAR estimates. This 25-year period is slightly in excess of the generation time of 21 years used by COSEWIC (2006). Harvest data for 1985-1996 are from COSEWIC (2006) after which unpublished DFO data were used. There were discrepancies in reporting years between the two sources and singular harvests levels were used to make reporting years comparable. For example, if routine harvests were about five and both sources reported a harvest of 17 but it was ascribed to year x in one source and year x+1 in the other, that harvest record was assigned to the year in the longest data series and the others re-ordered accordingly.

To progress from estimates of allowable removals to estimates of landed catch requires both accurate harvest statistics and estimates of hunting losses that reflect location, season, and hunting method. In this respect, Stewart's observation (2008, p. 5) is unchanged, i.e., *"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."* Since 2008, industrial development in walrus habitat has increased or is about to increase with concomitant potential for increased human-induced walrus mortality (Stewart *et al.* 2012). PBR, from which TAR is calculated here, includes, by definition, all anthropogenic mortality. Until information is available on hunting mortality (landed and lost), net entanglements, ship strike mortality and other sources of mortality, it is not possible to allocate portions of TAR to individual uses, such as landed harvest or ship-strikes (Stewart *et al.* 2012).

RESULTS

The MCP values and their adjusted estimates are presented in Table 2. Some adjusted estimates were lower than the number of walrus counted (<MCP) and are not presented. TAR estimates varied depending on the method used to estimate stock size (Table 3). Stewart *et al.* (2013a) found no evidence of decline in the WJS and PS-LS stocks so PBR with a recovery factor of 1.0 is also presented for those stocks.

Table 2. Summary of recent walrus population estimates based on different adjustment protocols, with the error term expressed as coefficient of variation (CV). Only estimates which exceeded Maximum Counted Population (MCP) are included. MCP_{HO} = minimum counted population of haulout counts only. BC_{HO} = haulout counts only using the Bounded Count method. See Methods section for additional details (e.g., assumptions) regarding the different adjustment protocols.

Stock(s)	**Year**	**MCP**	**MCP_{HO}/0.74[a]**	**MCP_{HO}/% tags dry[b]**	**$MCP_{HO}/Avg_{time\ dry}$[c]**	**BC_{HO}/0.74[d]**	**Source**
BB	**2009**	571	More than 26% were seen at sea	1,251 (1.00)	1,249 (1.12)		Stewart *et al.* 2013b
WJS	**2008** **2009**	404 388	503 (0.07) <MCP	No concurrent tags		No replicates 470 (1.37)	Stewart *et al.* 2013a
PS-LS	**2007** **2009**	515 557	672 (0.07) 727 (0.07)	No concurrent tags		<MCP 661 (2.08)	Stewart *et al.* 2013a
N&C-FB	**2010** **2011**	3,861 6,043	5,200 (0.07) 8,153 (0.07)	6,480 (0.38) 13,452 (0.43)[†]		No replicates	Stewart *et al.* 2013d
Hoare Bay area of HB-DS	**2007**	1,056	1,420 (0.07)	2,102 (0.58)	2,533 (0.17)	No replicates	Stewart *et al.* 2013c

[a] Counts adjusted by the maximum proportion of tagged walrus ever recorded hauled out concurrently in other studies (Table 1).

[b] Counts adjusted using the proportion of functioning satellite tags 'dry' at the time of the survey.

[c] Counts adjusted using the average proportion of a day, or proportion of the survey period, tagged walruses registered 'dry'.

[d] Counts adjusted by the maximum proportion of tagged walrus ever recorded hauled out concurrently in other studies (Table 1).

[†] This estimate assumes that the tagging data from a single haulout were representative of other haulouts in Foxe Basin, and is based on a count of 4,484. If this assumption is not valid then the best estimate is 10,379 (CV = 0.42).

Table 3. TAR estimates (R_{max} = 0.07, F_R = 0.5) based on counts of walrus and derived estimates of stock size. (TARs in parenthesis used F_R = 1.0 in the PBR calculation if there was evidence of no population decline.) See Table 2 for definitions of the different adjusted counts.

	MCP		**MCP_{HO}/0.74**			**MCP_{HO}/% tags dry**			**MCP_{HO}/$Avg_{time\ dry}$**			**BC_{HO}/0.74**		
Stock(s) & year	**N_{min} = MCP**	**TAR**	**Est (CV)**	**Cal N_{min}**	**TAR**	**Est (CV)**	**Cal N_{min}**	**TAR**	**Est (CV)**	**Cal N_{min}**	**TAR**	**Est (CV)**	**Cal N_{min}**	**TAR**
BB 2009	571	**10**				1,251 (1.00)	621	**11**	1,249 (1.12)	585	**10**			
WJS 2008	404	**7 (14)**	503 (0.07)	474	**8 (17)**								<MCP	
PS-LS 2009	557	**10 (19)**	727 (0.07)	685	**12 (24)**							661 (2.08)	<MCP	
N&C-FB 2011	6,043	**106**	8,153 (0.07)	7,687	**135**	13,452† (0.43)	9,510	**166**						
Hoare Bay area of HB-DS 2007	1,056	**18**	1,420 (0.07)	1,339	**23**	2,102 (0.58)	1,336	**23**	2,533 (0.17)	2,197	**38**			

† This estimate assumes that the tagging data from a single haulout were representative of other haulouts in Foxe Basin. If this assumption is not valid then the best estimate is 10,379 (CV = 0.42) for a TAR of 129.

It was not possible to definitively assign harvests to the WJS, BB and PS-LS stocks. Overall, the total average reported harvest for the high Arctic population in Canada is less than TAR (Table 4, Figure 2). TAR estimates for Foxe Basin based only on MCP were much less than current removals. Adjusted estimates produced TAR estimates of about 135, less than the 25-year average reported harvest (Table 4) although overlapping with the 95% confidence interval (Figure 3). Moreover, if the tag data were indeed representative of walrus haulout behaviour throughout Foxe Basin (Stewart *et al.* 2013d) then TAR would be 166. The TAR estimate for the Hoare Bay area of southeast Baffin Island may be sufficient to support the harvests of local communities but clearly not of the entire range of the HB-DS stock in Canada (Table 4, Figure 4).

Table 4. Calculated annual TAR estimates and reported annual landed harvests in Canada over a 25-year span, averaged for the years in which at least 75% of the communities involved reported harvest data. (SD = standard deviation)

Population	Stock(s)	TAR Range	Current Landed Harvest ± SD (years between 1985 and 2010)	Comments
High Arctic		27-52	14.1 ± 10.1 (22)	
	BB	10-11	9.0 ± 6.7* (17)	* If all Grise Fiord harvest is from BB.
	WJS	7-8 (to 17 if F_R=1)	9.0 ± 6.7* (17)	* If all Grise Fiord harvest is from WJS but only 4 on record.
	PS-LS	10-12 (to 24 if F_R=1)	5.9 ± 4.3* (17)	* If all Arctic Bay, Pond Inlet & Resolute harvests are from PS-LS.
Central Arctic			366.7 ± 85.5 (18)	
	N&C-FB	106-135 (166)	184.5 ± 56.1 (22)	TAR may be as high as 166 depending on how the tag data are interpreted.
	Hoare Bay area of southeast Baffin Island (HB-DS)	18-38	35.8 ± 18.9* (21)	* If all Clyde River, Qikiqtarjuaq, Pangnirtung & Iqaluit harvests are from southeast Baffin Island (Clyde River, Qikiqtarjuaq & Pangnirtung averaged 22 walrus).
	HB-DS		165.7 ± 65.7 (21)	Requires HB-DS stock have about 9,500 walrus for a TAR of 166.

DISCUSSION

There are negative biases in counts for all six stocks due to incomplete coverage and detection: MCP underestimates the total stock size (Stewart et al.). Adjusted estimates are, however, in general agreement with other relevant population estimates. Heide-Jørgensen *et al.* (2012) surveyed Smith Sound and southern Kane Basin in May of 2009 and 2010 and estimated that for the BB stock there were 1,238 (CV = 0.19) and 1,759 (CV 0.29) walrus present in the respective years. These are similar to the estimates of 1,249 (CV = 1.12) and 1,251 (CV = 1.00) (Stewart *et al.* 2013b; Table 2 in this document), but would produce higher TAR estimates of 18-24 as a result of the lower CV. Aerial surveys conducted off West Greenland in spring of 2006, 2008 and 2012 produced population estimates of 1,105 (CV = 0.31) in 2006, 1,137 (CV = 0.48) in 2008 and 1,408 (CV = 0.22) in 2012 (Heide-Jørgensen *et al.* 2013). They are lower than 2,533 (CV = 0.17) estimated for Hoare Bay (Stewart *et al.* 2013c; (Table 2 in this document), suggesting not all the walrus accounted for in the Canadian surveys were available for the Greenland surveys. TAR estimates for the West Greenland portion would be 14-21.

The use of the maximum proportion of tagged walrus hauled out (MCP_{HO}/0.74) is precautionary in that it assumes all surveys were conducted during maximal hauling out. Concurrent tag data (Stewart *et al.* 2013d) and the numbers of walrus counted at sea (Stewart *et al* 2013b) contradict this assumption and these adjusted estimates are also likely underestimates.

Adjusting counts by the proportion of a large (>10) number of tags transmitting concurrently with the survey may be the most robust estimator, but requires more examination of the time periods selected. This has been possible only in Foxe Basin where, in the survey year with the highest count, the tag data applied at only one of 10 haulout sites examined (Stewart *et al* 2013d). If data from these tags were in fact representative of the whole area, the abundance estimate and TAR would change substantially to 13,452 and 166 walrus, respectively. Future analysis of tag data will include examining for coordinated behaviour because the tags were deployed at one site over a short time and did not spread throughout the area (Stewart *et al.* 2013d).

In all cases, changes in ice cover have occurred over the time-frame of the surveys and if ice plays a role in stock delineation, that role is undoubtedly changing.

In addition to the uncertainty associated with size estimates of individual stocks, there is uncertainty in the harvest statistics, both in terms of the accuracy of reported landings and in struck-but-lost removals. There is, as yet, no estimate of the level of reporting. Struck-and-lost rates vary widely (DFO 2013) and should be quantified by community and type of hunt. In Alaska, most struck-and-lost walrus die within a few days (Fay *et al.* 1994).

HIGH ARCTIC POPULATION

Partitioning removals for the three stocks is not straight forward.

West Jones Sound

Stewart *et al.* (2013a) reported no statistical trend in the number of walrus present between 1977 and the 1990s. Grise Fiord may take from the WJS stock although it seems to have been an uncommon occurrence (Priest and Usher 2004). TARs were seven or eight under the default conditions but an argument could be made that the recovery factor could be 1.0, doubling the TAR estimates. Overall, the WJS stock appears lightly exploited.

Penny Strait-Lancaster Sound

Hunters from Arctic Bay, Pond Inlet and Resolute take walrus from the PS-LS stock. Grise Fiord hunters may also hunt this stock if the walrus and hunters converge at the east end of Devon Island. TARs ranged from 10 to 12 under the default conditions but using a recovery factor of 1.0 would double the TAR estimates.

Baffin Bay

Grise Fiord hunters may take walrus from the BB stock if these animals move south in the winter. Hunters from north Baffin Island communities (i.e., Arctic Bay and Pond Inlet) may travel north and also take from the BB stock. TAR estimates are 10-11 for the BB stock.

Whole Population

The TAR estimates for the whole high Arctic population (27-52) exceed the 25-year average (14.1, SD = 10.1) and the upper 95% confidence limit (CL) on a declining reported harvest (Figure 2) in Canada.

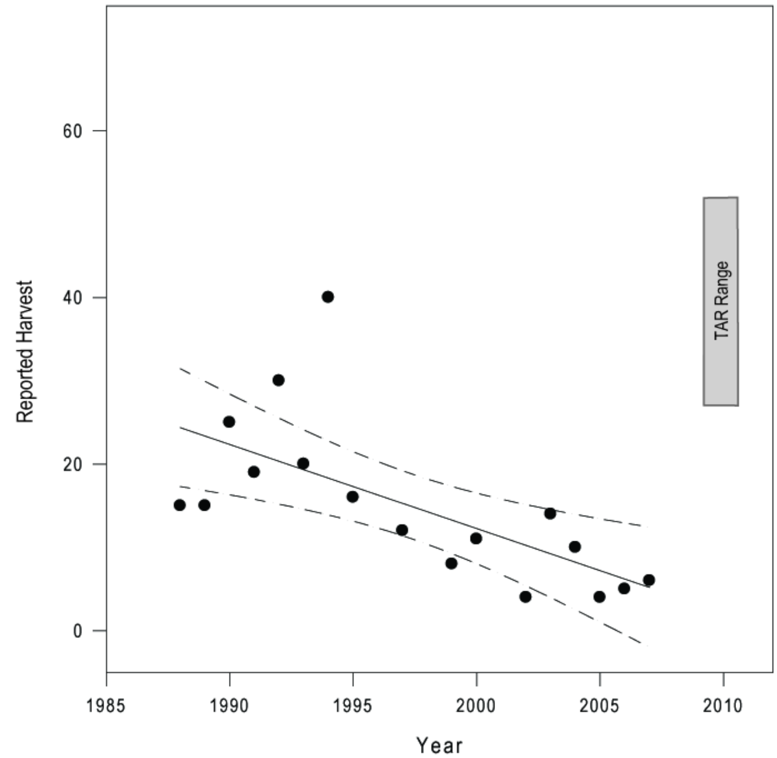

Figure 2. Reported annual harvests from high Arctic communities. Harvest = 2,030 - (1.0 × Yr), N = 17 years, R^2 = 0.44, $F_{1,15}$ = 11.6, P = 0.04. Dashed lines are the upper and lower 95% confidence limits around the mean. The estimated TAR range is identified for comparison.

At least the BB segment of this population is shared with Greenland, which uses a population dynamics model to estimate replacement yield and sets quotas to have a 70% (or higher) probability of population increase (Wiig *et al*. 2013). TAR is designed to allow the population to attain and be maintained at an Optimum Sustainable Population level with 95% probability (Wade and Angliss 1997). With different management objectives underpinning the two approaches, it is not surprising that Greenland identified a different TAR: 68 for the BB stock. Based on older different harvest data which indicated Grise Fiord took about four walrus/year allowed a Greenland quota of 64/year in northwest Greenland (DFO 2013). Clearly further bilateral management is warranted.

CENTRAL ARCTIC POPULATION

Overall, the average annual reported harvest for the entire central Arctic population has been 366.7 (SD = 85.5) walrus in Canada. It has been declining (Harvest = 11,385 – 5.5 × year, n = 18) over the past 25 years but the regression explains little of the variation in the data (R^2 = 0.26). Also, managing at the population level, which assumes all walrus are equally available for harvesting at all locations, could lead to local depletion.

Foxe Basin

TAR estimates ranged from 106 to 135, possibly to 166, and average annual reported harvests are about 185. There is considerable variation in reported harvests among years but no long-term trend (Figure 3). This area is hunted by two communities but walrus move into Foxe Basin from the south in the fall. The extent to which these walrus may be hunted in other areas is unknown.

The facts that the range of TAR estimates intersects the lower 95% CL (Figure 3), that the trend in harvest has remained constant for about 25 years, and that coverage in both survey years was incomplete suggest that the situation bears further monitoring.

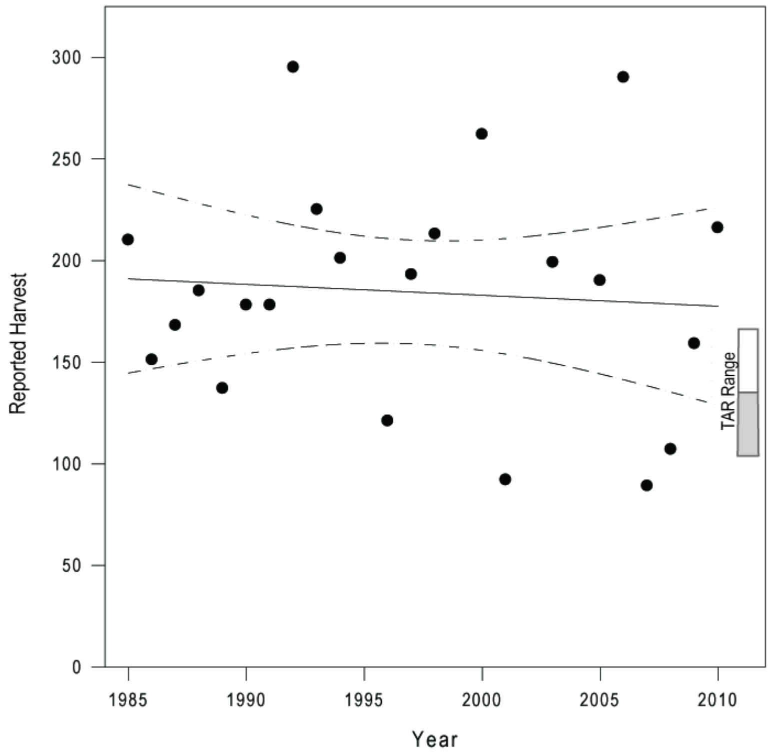

Figure 3. Reported annual harvests from Foxe Basin communities. Harvest = 1,257.9 - (0.5 × Yr), N = 22 years, R^2 = 0.006, $F_{1,20}$ = 0.12, P = 0.73. Dashed lines are the upper and lower 95% confidence limits around the mean. The estimated TAR range is identified for comparison. The grey shaded box is based on surveys in 2010 and 2011. The unshaded box indicates the extended range if tag data were representative (Stewart et al. 2013d).

Hudson Bay-Davis Strait

We have woefully inadequate coverage of this region to estimate the total stock size. Stewart *et al.* (2013c) concluded 2,100 to 2,500 walrus summer in Hoare Bay with TARs of 23-38. Over the past 25 years, the three and four nearest communities have averaged about 22 and 36 landed walrus, respectively. The Greenland government's current science advice for this stock is a quota of 61 animals for West Greenland hunters and 16 (not the 22 or 36 in our dataset) for southeast Baffin Island hunters (DFO 2013).

It has been suggested that there are subunits (Born *et al* 1995), perhaps clinal variation (Stewart 2008a) within the HB-DS stock. There is some evidence of both isotopic (Outridge *et al*. 2003) and genetic clines (Andersen *et al*. 2013). At the moment, it is not possible to partition harvests to those undefined subunits. The annual reported harvest for the HB-DS stock averaged about 166 animals over the past 25 years with a statistically significant decline (Figure 4). An N_{min} of 9,500 is required to support this level of harvest, which is not inconceivable given the large range of the stock. But the entire stock would not be available to support local takes of this magnitude and, again, more information is required on both stock structure and stock size.

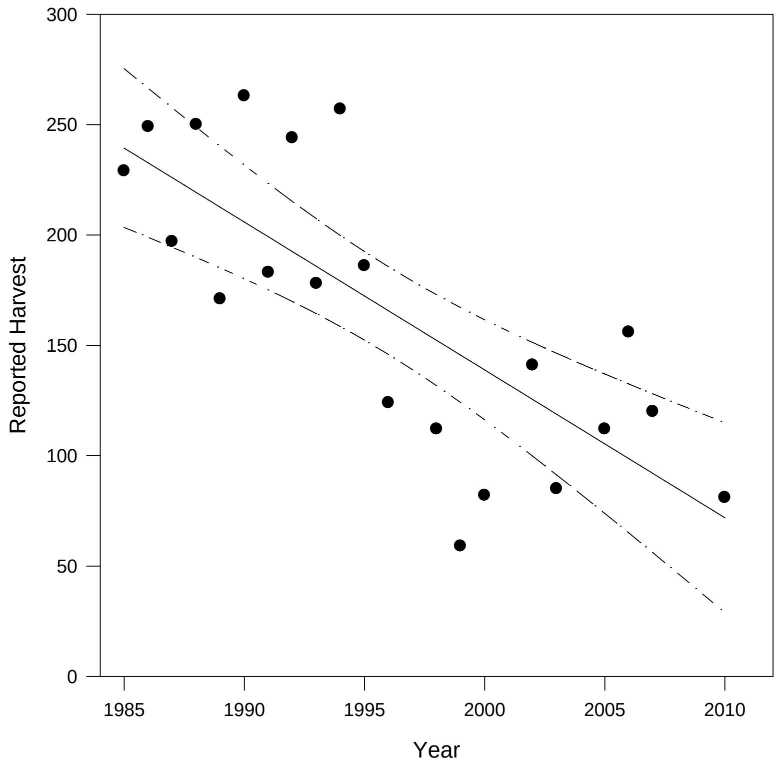

Figure 4. Reported annual harvests from Hudson Bay-Davis Strait communities. Harvest = 13,537.8 - (6.7 × Yr), N = 21 years, R^2 = 0.58, $F_{1,19}$ = 26.44, P <0.001. Dashed lines are the upper and lower 95% confidence limits around the mean.

CONCLUSION

The TAR estimates and Canadian harvests for individual stocks in the high Arctic population are not vastly different. This may change once more information is available on walrus movements and the locations and sizes of hunts within the range of this population. In Foxe Basin, TAR and average harvest levels overlap statistically but more needs to be known about walrus movements within Foxe Basin and between Foxe Basin and areas of HB-DS. Current estimates of total stock size are needed for the HB-DS stock within the central Arctic population. The central Arctic population as a whole lacks sufficient data for a meaningful population estimate and subsequent advice on TARs. The BB stock and the West Greenland/southeast Baffin Island component of the HB-DS stock are clearly shared with Greenland. Bilateral management is required. Stock affinity and current estimates of abundance for the S&E-HB area would help to understand the relationship of walrus in that region to the high Arctic and central Arctic populations.

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