Estimates of Minimum Population Size for Walrus near Southeast Baffin Island, Nunavut

Robert EA Stewart[1], Erik W Born[2], Rune Dietz[3] and Anna K Ryan[1]

[1] *Department of Fisheries and Oceans, Freshwater Institute, 501 University Crescent, Winnipeg, Manitoba R3T 2N6, Canada*
[2] *Greenland Institute of Natural Resources, P.O. Box 570, DK-3900 Nuuk, Greenland*
[3] *Department of Bioscience, Aarhus University, P.O. Box 358, DK-4000 Roskilde, Denmark*

ABSTRACT

To support management objectives in Canada and Greenland, joint research between the Department of Fisheries and Oceans and Greenland Institute of Natural Resources was begun in 2005. Direct counts were used to determine the Minimum Counted Population (MCP) in summer around SE Baffin Island. Aerial surveys examined the coast from roughly the Saddleback Island in northern Hudson Strait to Isabella Bay on eastern Baffin Island but concentrated on the area between Loks Land and Cape Dyer. The maximum count was obtained on 3–4 September 2007 during boat surveys. The MCP ranged from 716 (in 2006) to 1,056 (2007). Using the largest MCP adjusted with published maximum estimates of the proportion of walrus hauled out concurrently, we estimated 1,420 (95% CI: 1,219–1,622) walrus were present. In addition, four walrus had been fitted with satellite relayed data logger tags prior to the maximum counts in 2007. Using the simple proportion of 'tags dry' on 3 September to adjust counts on 3 and 4 September 2007 provided an estimate of 2,102 (CI=MCP-4,482). Using the proportion of time dry immediately preceding the survey to adjust the maximum count produced an estimate of 2,502 (CI=1,660–3,345) walrus were present in Hoare Bay. We conclude approximately 2,100–2,500 walrus were present in Hoare Bay in late summer 2007. This number is a negatively biased estimator of the population of walrus around SE Baffin Island and in the Hudson Bay–Davis Strait stock as a whole. Broader survey coverage in a short period and more detailed information on the movement of walrus between Greenland and Canada and the summer dispersal of these animals within Canada are required to improve population estimates.

INTRODUCTION

Atlantic walrus (*Odobenus rosmarus rosmarus*) occur in Canada in seven stocks (Fig. 1), two of which are shared with Greenland (Born et al. 1995, NAMMCO 2006, Stewart 2008, Andersen et al. 2009, 2014, Dietz et al. 2014). The Hudson Bay–Davis Strait (HB-DS) stock, part of the central-Arctic population of walrus in Canada (Shafer et al. 2014) ranges from West Greenland to eastern Baffin Island and into Hudson Strait, although it is thought the occupancy range in this region has diminished in modern history (COSEWIC 2006). Walrus in this stock are hunted in both Canada and Greenland (Born et al. 1995, Priest and Usher 2004) but there is only limited information on the size of the population that supports these harvests.

Here we report on surveys designed to obtain current estimates of the Minimum Counted Population (MCP; Stewart et al. 2014) of walrus in the SE Baffin area in late summer. The survey area concentrated on SE Baffin as the most likely area where walrus arriving from Greenland would be hunted, an assumption subsequently borne out by tracking data (Dietz et al. 2014).

METHODS

The scientific literature (e.g., Born et al. 1995), Inuit *qaujimaningit*, or IQ, (e.g., Riewe 1992, local participation) and other traditional knowledge (e.g., Arctic researchers) were used to identify former, current, and potential haul out sites between roughly the Saddleback Island in northern Hudson Strait to Isabella Bay on eastern Baffin Island (Fig. 2, Table 1). These sites, but primarily those between Loks Land and Cape Dyer were examined repeatedly each year (Fig. 3) in the season when maximum numbers were expected to occur based on IQ. In 2007, major haulouts were also examined at surface level during a boat-based research (Dietz et al. 2014).

The surveyed area (Fig. 2) included the main area of occupancy of walrus tagged in West Greenland and in the SE Baffin study area in 2007 (Fig. 4 of Dietz et al. 2014). It also included the 37 presumed active haulout sites illustrated by Born et al. (1995: Figs. 10 and 16). Several of these are adjacent to each other, for example three on Kertaluk Island (Fig. 2) which is about 10 km long. We therefore collapsed some sites resulting in 25 identified areas, to which we added two sites (Clephane Bay and Anna's Skerries) and Government of Nunavut (GN) researchers added another (Moonshine Fiord, E. Peacock, *in lit*. 2007; Table 1). Without precise coordinates for presumed haulout sites, when we searched the area within 5 km of its nominal coordinates at a suitable altitude and with appropriate visibility and saw no walrus, we assumed that we observed the intended site and recorded a 0 count (Table 1). When walrus were seen, we revised the coordinates for the haulout site as required.

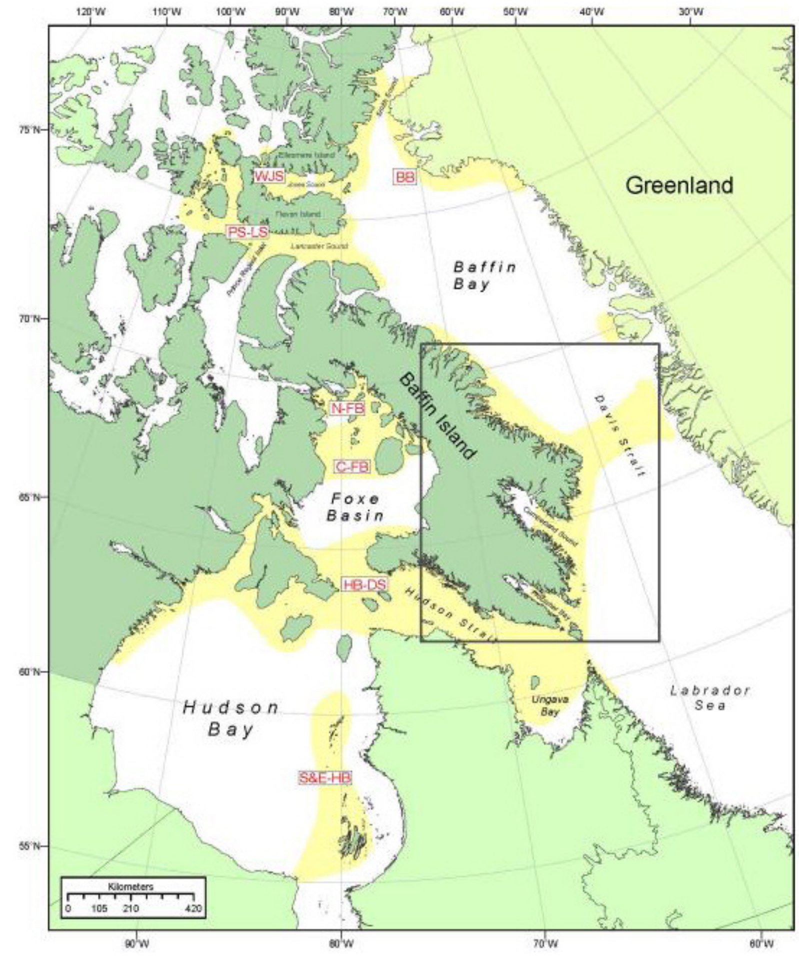

Fig. 1. Generalized distribution of walrus stocks in Canada and western Greenland (after Shafer et al. 2014). Stock designations as used here (Stewart 2008) are: BB: Baffin Bay; PS-LS: Penny Strait–Lancaster Sound; WJS: West Jones Sound; N-FB and C-FB: North and Central Foxe Basin; HB-DS: Hudson Bay–Davis Strait; SE-HB: South and East Hudson Bay.

In 2005, aerial surveys were conducted using a Messerschmitt-Bolkow-Blohm (BO-105-CBS) helicopter based on the Canadian Coast Guard (CCG) icebreaker *Henry Larsen*. The helicopter flew with a target altitude ~150 m above sea level (ASL) and a searching speed of approximately 185 km/h, reduced when counting at haulouts. Three observers occupied the front left and two rear positions. Flying time was constrained by other operational responsibilities of the icebreaker and surveys were flown on 21, 26, 28 and 29 August.

A de Havilland Canada DHC-6 Twin Otter was used to fly surveys on 25–26 July, 28–29 August, and 26–27 September 2006, on 16 August, 17 September, and 15 October 2007, and 6, 8, 9 and 11 September, 2008. Target altitude was 300 m ASL, at about 210 km/h. There were at least two observers, one on each side, on all flights, but usually also a third observer. The flight crew also contributed observations. When walrus were seen, the numbers were estimated independently by each observer and oblique aerial photographs were taken when possible.

In 2005, it was possible to land at one haulout site (Angijak Island) and to observe the walrus form a vantage point slightly above the site (Fig. 4). In 2007, as part of tagging studies (Dietz et al. 2014) several of the known SE Baffin haulouts were visited by boat. Surface level estimates were made from a vantage point on land above the haulout, and from boats, sometimes below the lowest walrus on shore according to the stage of the tide.

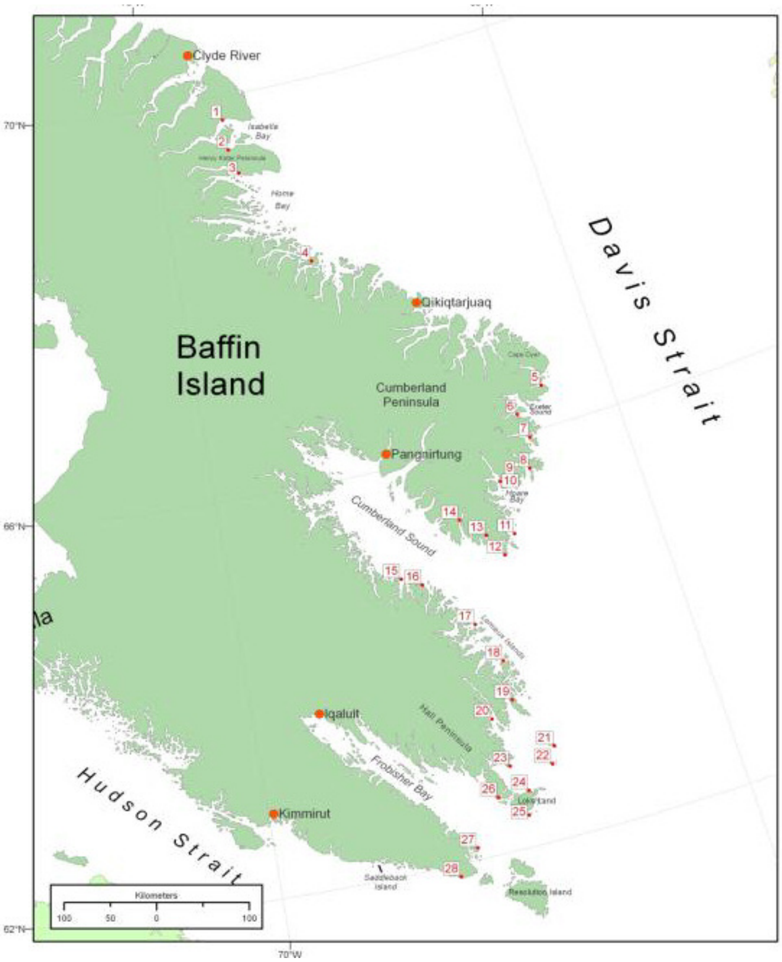

Fig. 2. *The survey area. Place names used in text. Clephane Skerries comprises two sites about 1 km apart. At Angijak Islands, walrus haul out at four places less than a kilometre apart, sometime concurrently (see Fig. 4). Only the main site is illustrated due to limitations of scale.*

For each walrus encounter, a visual estimate was made by all observers. Ultimately only two visual estimates were used: one of “40+” recorded and one of “200+”, both recorded independently by two observers. Otherwise, walrus on land were photographed using digital cameras (Canon EOS 30D or 40D and EFS17-85 mm or 70–300 mm zoom lens with image stabilizer). Cameras were synchronized with a GPS used to record tracks and sightings. Photographs from each encounter were examined in Adobe PhotoShop® CS2 and modified in size, contrast, and brightness to produce the clearest image for counting. Coloured dots were super-imposed on each enumerated walrus and the image re-examined for missed animals. If the walrus reacted to the aircraft, the reactions were: first, becoming more alert, second moving towards the water, and third, entering the sea. The first two facilitated counting as more heads were up and the distance between walruses increased. The third reduced counts as walrus disappeared. A full series of photos was examined and the peak counts were used. A comparison of counts by two authors (REAS and EWB) of walruses on photos revealed that their individual counts were nearly identical (R2=0.97; EW =0.01(SE=0.78) + 0.97(SE=0.02)*REAS) (Stewart et al. 2014) and only counts made by REAS were used. If data of more than one type were available we prioritized inclusion in descending order of (1) aerial photo-count (2) aerial estimate (3) surface photo-count and (4) surface estimate.

Surveys of adjoining areas were often separated by a few days. Six walrus that were tagged in West Greenland between 2005 and 2008 migrated across Davis Strait to SE Baffin (Dietz et al. 2014). They travelled an average of 45.3 km/d (SD=8.5) during the migration, similar to the 40 km/d criterion of Stewart (2008). We used 45 km/d as the criterion to reject counts that were not sufficiently separated in time and space to preclude double-counting that may have resulted from animals moving between haulouts in the interval between counts. Distances were estimated using the graphic display of Garmin MapSource® (version 6.16.3), estimating the shortest sea-route on the image and rounded to the nearest 5 km. Retained daily counts were summed to produce an annual MCP.

Identification to sex and age

From selected photos of sufficient quality we attempted to estimate the age and sex composition of the walrus herds. For groups of walrus for which multiple photos were available, all were used to view the group from different perspectives to obtain both the maximum count and to identify the most for age and sex. In one instance, there was partial overlap of several images of a large group and an average was calculated from all these images.

Walruses were classified based on sex and approximate age based on physical appearance. For consistency, classifications were made by only one author (EWB). Atlantic walrus females become sexually mature (1^{st} ovulation) at ca. 6 years of age (Born 2001) at which age tusk length usually is ca. 15 cm (Fay 1982, Born unpublished data). If an animal had (1) slender and usually parallel or converging tusks with a length ≥15 cm, (2) a small head and slender neck relative to body size, and (3) was lacking skin lumps (“bosses”) on neck and thorax, it was regarded as being an adult female. Individuals with (1) stout and >15 cm long and diverging tusks, (2) relatively massive head and neck, and (3) “bosses” on shoulder and thorax were categorised as adult males. Tusk lengths used for categorisation of age were: (1) no tusks (and dark and small body size) = calf of the year, (2) visible part of the tusks <15 cm = subadult of both sexes, (3) tusks ≥ 15–30 cm long = adult female or male and (4) tusks > 30 cm slender = old female and stout = old male. Estimation of the external length of tusks was made semi-quantitatively based on their relative size compared to head size and muzzle width. We also noted if the animals were relaxed (mostly recumbent) or alert (many heads up).

Adjusting Counts

Coverage was insufficient to calculate meaningful densities or robust bounded count estimates

(Stewart et al. 2014). It is unlikely that 100% of the population is hauled out at one time and concomitant radio tag data may provide information on the proportion of the population hauled out at the time of the survey (Huber et al. 2001). In 2007, custom-designed Satellite Relayed Data Logger (SRDL), developed specifically for walrus, were deployed on six adult walruses (4 M and 2 F), that hauled out on small islands off Cumberland Peninsula (SE Baffin Island) in late August–early September (see Dietz et al. 2014 for details). Four satellite tags were deployed at SE Baffin sites on Angijak Island on 25 August (2 males) and on small islands (Clephane Skerries) at the mouth of Clephane Bay on 30 August (2 females) at two sites roughly 75 and 110 km north of Anna's Skerries, where the single large count was made on 3 September 2007. Walruses which have been chemically immobilized may show drowsiness for some hours after they have woken up (Born, Dietz, Stewart pers. observations). Following Born and Knutsen (1997), we therefore excluded data on behaviour that were collected the first 24 h post drugging.

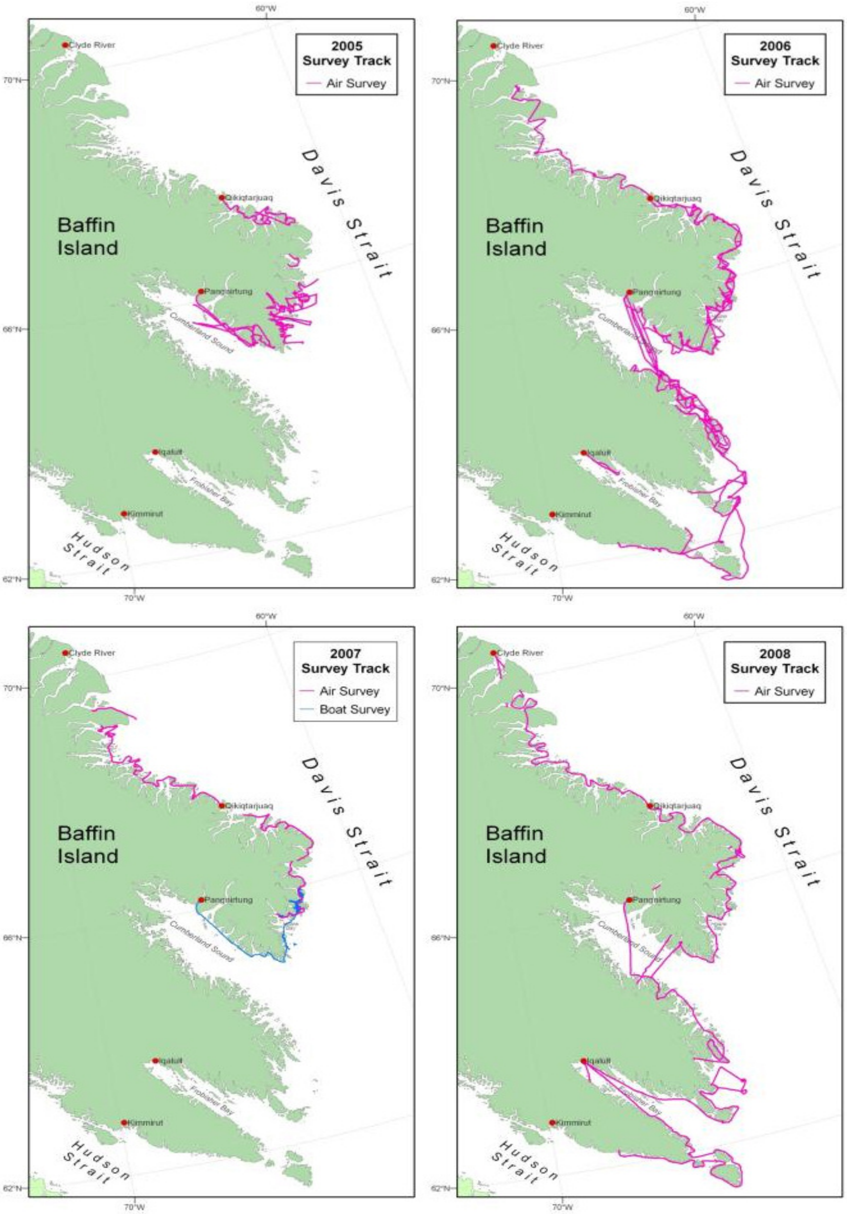

Fig. 3. *Survey routes in 2005–2008. All were aerial surveys except as indicated in 2007.*

Fig. 4. Two occupied haulouts at the Angijaq site. Walrus in the foreground are on a rocky islet adjacent to a small island. Walrus in the background are on a rocky spit separated from the island behind it only at high tide. A third small rock in the background is also used. (photo credit: REA Stewart)

The SRDL collected data on the time walruses were hauled out, permitting calculation of an adjustment factor that incorporates the fraction of the population which was not present at the haul-outs during boat-based and aerial surveys. The configuration of the SRDLs was similar to that used for studies of walruses at Svalbard, described in Lydersen et al. (2008). The basic software and hardware in these SRDLs were the same as in previous SRDLs deployed (Fedak et al. 2002, Dietz et al. 2014), except that they had no speed or temperature sensors.

The SRDLs continually monitor the data their sensors are collecting (surface sensor, depth sensor, and time interactions) and group the animals' activities into three different states: diving, hauled out, and at surface. For this study, only the summary statistic "hauled out" was used. Behaviour was classified as hauled out when the tag had been dry for at least 10 minutes and this state ended when wet-dry sensors indicate wet for more than 40 seconds. The individual and population-specific haul-out fraction was calculated as the average proportion of time spent hauled out across all days of records in August, September and October using up to six tags. Haul-out fractions on specific survey dates in September were also calculated as was the raw proportion of tags reporting 'dry' on the days of the survey. The software Microsoft Excel 2007® and software "R" version 2.12.1 (R Development Core Team 2010) were used for the analyses.

To be most useful in adjusting survey counts, tagged animals should have sufficient time to return to undisturbed activities, tags should be present in proportion to age and sex class sizes (Ries et al. 1998, Härkönen and Harding 2001), and should include at least 10 tagged animals (Sharples et al. 2009). While we allowed 24 h for walrus behaviour to return to a pre-tagging state we have not specifically tested this assumption. At the time of the 3 September count, four SRDLs were active, reporting on two males and two females so the recommendations for large and proportional sample sizes were not met. Two of four functioning tags on 3 September were disturbed in the process of making our survey so we used data from only that day, from midnight to 1200 h to reflect undisturbed animals on 3 and 4 September. Stewart et al. (2014) examined the maximum proportion of tags concurrently reporting 'dry' in several studies representing various seasons and habitats. Combined, these datasets indicated the maximum proportion hauled out, HO_{max} was 0.74 (SD = 0.05) and we have used that value here to adjust the count in 2007, as well as in 2005, 2006, and 2008 when there were no concurrent tag data. The binomial variance (p(1-p)/(n-1)) for small samples (Zar 1999) associated with proportional data from the tags was combined

Fig. 5. Some haulout sites are small islets. As shown this one, referred to as Gordon's Rock, was occupied by about 20 walrus on 26 August 2005. Maximum count at this site was 58 in 2006. (photo credit: REA Stewart)

with any variance associate with the count or estimate following Thompson and Seber (1994) as per Stewart et al. (2014). The lower 95% confidence limit was the MCP if the calculated lower confidence limit was less than the MCP.

RESULTS

The proportion of possible haulout sites observed varied among years. It was low in 2005 (6/28, 21%) and ranged from about 86% to 89% in subsequent years (Table 1). However, due to the large area and generally poor flying conditions, hence long periods between observations, only 10 (36%), 3 (11%), and 17 (61%) of 28 haulout sites contributed to MCP estimates in 2006–2008, respectively.

The 2005 helicopter survey covered approximately 3,000 km of coastline, but found only two occupied haulouts on a single day. On 26 August, we observed a few walrus on a tiny rock (Gordon's Rock, Figs. 2 and 5) near Kekertuk Island in Hoare Bay and three larger groups, within sight of each other near Angijak Island. In 2006, approximately the same areas were surveyed in late July, August and September. Monthly counts (not corrected for duplicates) at haulouts increased into September with about 100 seen in July, over 400 seen in August, and 700 in September. Based on the 2006 results, the survey period was shifted to August–October 2007. The maximum aerial total count (473) was obtained in October; the September total (1,269) included almost 890 walruses recorded in a boat survey on 3 September. Within a year, the uncorrected total number of walrus counted on haulouts, and the number of walrus seen adjusted for the numbers of haulouts surveyed, were highest in September (Table 2), but the difference between August and September was not significant (*t*-test, $p > 0.05$, n=3). Across years, there was greater variation in August than in September. The survey in 2008 was limited to September for logistic reasons. The Minimum Counted Population (MCP) estimates ranged from 766 in 2006 to 1,056 in 2007 (Table 1).

Sex and age

We examined 39 images of 21 groups comprised of 3 to 456 walrus. The proportion of walrus in a group that could be confidently assigned age and sex categories was significantly larger in groups of alert walrus (63.5%) compared to recumbent walrus (17.5%; X^2= 404, 1 d.f, P << 0.001) but the proportion of calves detected did not differ (X^2=0.4, 1 d.f, P > 0.50). Overall, 24% of 2,542 walrus were assigned to age and sex classes. Of those 620 animals, 12.1% were calves, 39.0% subadults of both sexes, 42.7% adult females, and 6.1% adult males. The calf to adult female ratio was 75:265 or 0.28:1.

Adjusting Counts

Three approaches were used to apply data on haulout patterns to adjust numbers counted at haulout sites for the proportion of the population not hauled out at the time of counting, on the assumption that all walrus are never hauled out concurrently: 1) the average time that four undisturbed walruses spent hauled out in the 12 hours immediately preceding the September 2007 survey based on SRDL data; 2) the proportion of SRDLs indicating the walrus bearing them were hauled out at the time of the largest count (3 September 2007); and 3) a broad-scale estimate of the maximum proportion of walrus hauled out concurrently (0.74). Overall, tagged walrus were hauled out 24.9% of the time between 27 August and 31 October 2007 (range 9.7–34.2% per day; Table 3a).

Location data received the morning of 3 September 2007 (Table 3b) placed two of the four tagged walruses near Anna’s Skerries; one was photographed there asleep on the haulout several times

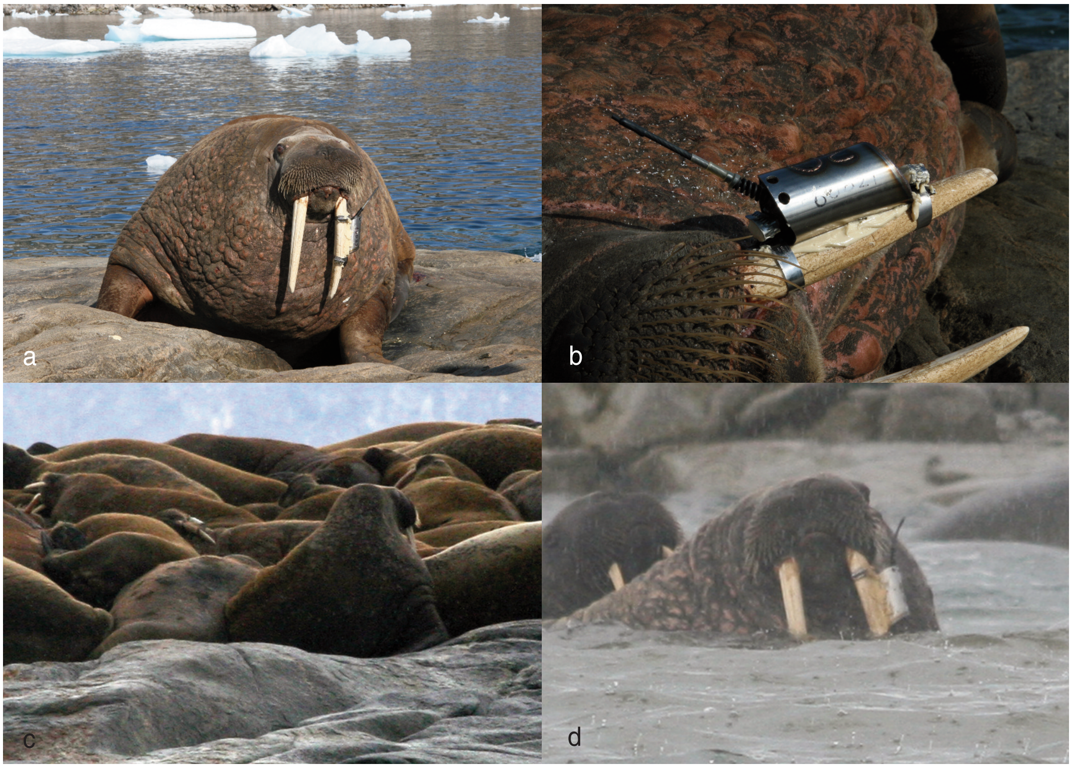

Fig. 6. *Adult male walruses wearing tags 60021 and 60022 were both tagged on 25 August 2007. They were the only males equipped with a SRDL before 3 September. (a) 60022 at the time of deployment. (b) 60021 at the time of deployment. Compare the position of the clamp bolts relative to the tag and the extension of the adhesive onto the tag between 60021 and 60022. (c) Walrus 60022 asleep on south side of Anna’s Skerries, about 1400 h on 3 September 2007. (d) Walrus 60022 in water on north side of haulout, about 1430 h on 3 September 2007. (photo credits: REA Stewart)*

Table 1. Maximum walrus counts at haulout sites around SE Baffin, surveyed in 2005–2009 and estimated MCP, including observations made at sea. All counts are based on aerial photographs except those indicated with 'V' which were aerial visual estimates, and Anna's Skerries (2007), for which we used surface level photographs. Counts (parenthetically if a count other than the maximum count was used in MCP) and dates in **bold** contributed to MCP. Map key refers to Figure 2.

Site	Map Key	Year			
		2005	2006	2007	2008
Isabella Bay North	1		0		0
Isabella Bay South	2		0	0	0
Alexander Bay	3		0	0	0
Kertaluk Island	4		0	0	
Moonshine Fiord	5		**0***	0	**0**
Exeter Sound	6	0	**63**	**86**	**0**
Clephane Skerries†	7		**106**	115	**265**
Angijak Island	8	**745**	**226**	179 **(78)**	**139**
Gordon's Rock†	9	**21**	**58**	40v	
Touak Fiord	10	**0**	97	0	**0**
Ujuktuk Fiord (Abraham Bay)	14	0	0	0	**0**
Aktijartuka Fiord	13	0			
Anna's Skerries†	11		400v **(200v)**	**887**	**338**
Ptarmigan Fiord	15		0	0	**0**
Cape Mercy	12		**0**	**0**	**0**
Sulut Bay	16		0	0	**0**
Leybourne Islands	17		0	0	0
Lemieux Islands	18		0	144	0
Brevoort Island	19		0	0	0
Corelius Grinnell Bay	20		*		
Lady Franklin Island	21		0	0	213
Cape Farrington	23			0	0
Monumental Island	22		48*	188	0
Frobisher Bay	26			0	0
Loks Land	24		0	0	0
Lupton Channel	25		0	0	0
Kendall Strait	27		0	0	0
Gabriel Strait	28		0	0	0
Total seen at Haulouts		766	1,198	1,639	955
Number of Haulouts		6	24	25	24
Total Coverage		0.214	0.857	0.893	0.857
Counts at HO used in MCP		766	701	1,051	955
HO in MCP estimate		3	10	3	17
Coverage in MCP		0.107	0.357	0.107	0.607
At sea		0	15	5	33
MCP		766	716	1,056	988
Dates of maximum counts		26 Aug	25 Jul, 29 Aug 26, 27 Sep	16 Aug 3, 4, 17 Sep 15,16 Oct	6, 8 Sep

† Some haulouts are on inconspicuous bits of rock and not associated with any unique name of a body of water. Hubris aside, here we use the colloquial names that were applied for ease of reference in the field. We defer to any more official toponymy should one apply.

*In 2006, GN observers estimated 600–700 walrus hauled out in Cornelius Grinnell Bay, 1000–1500 hauled out near Monumental Island, and 200–300 hauled out in Moonshine Fiord.

between 1355 h when we arrived and 1430 h after the group had been disturbed (Fig. 6) to permit additional tagging. Of the other two, one hauled out at a distant site in the evening and the other did not haulout on 3 September. The average proportion of 12 hour periods available to haulout was 0.415 (SD=0.07, n=48 tag-hours). The derived adjustment factor from the simple proportion (p) of 'tags-dry' preceding the count was 0.50 (SD=0.29, n=4). We also considered using only the 2 undisturbed tags for 4 September but the average pre-survey time hauled out was similar (47%), the proportion of tags dry at the survey time (1 of 2) and the contribution of the count relatively small (86) that reducing the sample to only 2 tags was unwarranted. For all years, we applied abroad-scale adjustment of HO_{max} = 0.74 ±0.05 representing the maximum proportion of the population hauled out at one time (Stewart et al. 2014).

Using concurrent tag data and the MCP (1,056) from 3 and 4 September 2007 the three adjustment factors produced different estimates (Table 4). Assuming the maximum proportion of the population was hauled out at the time of counting yielded a lower estimate (1,420) than using the concurrent tag data, either the proportion of tags dry (2,102) or the proportion of time dry (2,502). Across years, adjusted for the maximum proportion hauled out based on broad-scale telemetry data (0.74), estimates ranged from 947 in 2006 to 1,420 in 2007 (Table 4).

DISCUSSION

The coast of SE Baffin is a challenging area in which to conduct aerial surveys, especially in late summer/early autumn. The weather deteriorates from July into October. In August and September, about 40 of the 61 days were characterized by > 8/10 cloud cover and 15–20% have visibilities less than 9 km (Cape Dyer, 1971–2000 average, http://www.climate.weatheroffice.ec.gc.ca/climate_ normals/index_e.html, accessed 6 Nov. 2009). Such conditions contributed to the low number of replicates and the small number of haulouts in some MCP estimates. It was not possible to return to a site or to observe adjacent sites in a period short enough to preclude possible double-counting. Coverage is therefore incomplete.

Some previously reported haulouts were not identified with sufficient precision to determine if walrus hauled out nearby were occupying the same or a slightly different location. Some reported haulouts were identified and observed but no walrus were present. These include all four on eastern Baffin Island identified in Born et al. (1995: Fig. 10): Isabella Bay, Alexander Bay, Home Bay and Ketaluk Island. Similarly, no walrus were seen in Gabriel or Kendall straits, Lipton Channel, Loks Land, Cape Farrington or the several sites west of Cape Mercy illustrated in Born et al. (1995: Fig. 16). Most of these sites are rocky shore and would show little evidence of recent occupation. Cornelius Grinnell Bay and Cape Colby were both observed during our surveys and

Fig. 7. *The vantage point for the large count at Anna's Skerries on 3 September 2007 was below the herd. Cleary walrus are hidden from view by animals in front of them and the count is an underestimate. (photo credit: REA Stewart)*

found empty, but walrus were seen ashore during the GN bear surveys and we cannot conclude that the others have been abandoned.

Researchers for the Government of Nunavut conducting polar bear (*Ursus maritimus*) surveys off SE Baffin in 2006 reported (E. Peacock GN, *in litt*. August 2007):

- 150–200 walrus swimming in Butterfly Bay on 9 September;
- an estimated 600–700 walrus were hauled out on Enchantress Island in Cornelius Grinnell Bay on 11 September;
- an estimated 1,000–1,500 walrus hauled out near Monumental Island on 18 September;
- 6 walrus swimming and hauled out in the Lemieux islands on 29 September; and
- 200–300 walrus hauled out on the south side of Moonshine Fiord on 9 October,

as well as other smaller numbers of swimming walrus. Distances among these locations are sufficiently short that the observations on 9 and 11 September may be subsumed by the Monumental Island estimate on 18 September. We observed 48 walrus at Monumental Island on 26 September and, although visual estimates by the GN observers have not been calibrated against ours, they clearly saw many more walrus. However, based on dates and distances, none of these estimates excludes the others and they cannot be added to our counts in late September 2006. The haulouts at Enchantress Island and Moonshine Fiord are however newly reported, precise locations.

From late August to the end of October in this study, tagged walrus were hauled out approximately 25% of the sampling time (Table 3a). This is consistent with other reports of walrus hauling onto land. Born and Knutsen (1997) found that walrus in Northeast Greenland hauled out for 29.3% of the sampling time overall, using both ice and land in August and September. At Svalbard, the average periods spend hauled out and at sea were 20 and 56 h (Gjertz et al. 2001) and 29.8 and 85.6 h (Lydersen et al. 2008) or, respectively, 35.7% and 34.8% of the sampling periods in late July and August. As at Svalbard where the average duration of a haulout bouts were 20–30 h (Gjertz et al. 2001, Lydersen et al. 2008), haulout bouts average 11 h on ice and 38 h on land in Northeast Greenland (Born and Knutsen 1997). The amount of time hauled out on ice is less than on land: about 15% of the sampling time, with durations of 9 h (Udevitz et al. 2009). Haulout duration was longer, about 18 h in August near eastern Ellesmere Island (Stewart et al. 2014) than in Alaska in April (about 9 h, Udevitz et al. 2009). Applying the long-term mean of 25% to a 24 h period creates an apparent paradox: on average a walrus would be hauled out 6–7 h per day (25–30%) on land, for an average duration of 20–40 h. This contradiction arises because average tag data represent all weather conditions, some of which are not conducive to

Table 2. Monthly maximum counts recorded, not corrected for possible double-counting [and number of haulouts observed].

Year	Maximum Count / number of haulouts			
	July	August	September	October
2005		766 [8]		
2006	97 [15]	400 [19]	701 [20]	
2007		144 [24]	1,269 [12]	473 [17]
2008			955 [27]	
Average (SD)		436.7 (312.6)	975.0 (284.5)	
Average count/HO (SD)		40.9 (48.1)	58.3 (40.7)	

hauling out or surveys (Olesiuk et al. 1990, Udevitz et al. 2009). Once a walrus is hauled out and available to be counted, it is likely to remain hauled out and available for the entire survey day. And, because walrus tend to haul out when other walruses haul out (Fay and Ray 1968, Salter 1979, Born and Knutsen 1997, Lydersen et al. 2008, Udevitz et al. 2009), their average probability of being counted is not well represented by their longer term average of time hauled out. Instead we used the percentage of time spent 'dry' in the 12 hours immediately preceding our survey (0.42 SD = 0.07, Table 3b) as a proxy for the proportion of walrus hauled out. However, this factor is based on only 12 hours of data from four tags with high variation. Moreover, MCP counts are based on maximum counts and attempting to adjust them using average behaviour may be inappropriate. Therefore, we did not use the long-term average of time hauled out from our tags to adjust counts.

Table 3. Haulout behaviour recorded by Satellite Relayed Data Logger (SRDL) tags. A) Monthly averages of percentage time hauled out and duration of haulout periods for six walrus. The day of tagging and day after, and parts of days when we disturbed walrus are not included in summary statistics. B) Percentage of 12 undisturbed hours spent ashore on 3 September 2007 (0:00-12:00 local time) indicated by four SRDLs.

a)

Month 2007	SRDL #	Sex	Dates	Percent of Day Hauled out				Days Monitored
				Mean	SD	Min.	Max.	
Aug	60021	M	27–31	26.9	22.6	0.0	61.5	5
	60022	M	27–31	9.7	16.6	0.4	39.3	5
Sept	60021	M	2–27	27.4	40.1	0.0	100.0	25
	60022	M	1–30	21.4	33.8	0.0	100.0	30
	60023	F	1–30	31.6	42.1	0.0	100.0	29
	60024	F	1–30	23.3	26.8	0.0	75.4	30
	60026	M	5–15	24.6	41.8	0.0	98.1	11
	60027	M	5–30	21.5	32.0	0.0	100.0	24
Oct	60021	M	1–10	29.7	38.3	0.0	100.0	10
	60022	M	1–25	21.3	36.5	0.0	100.0	20
	60023	F	1–27	28.3	36.7	0.0	100.0	25
	60024	F	1–30	23.7	36.4	0.0	100.0	30
	60027	M	1–7	34.2	40.6	1.6	86.1	4

b)

SRDL#	Sex	Proportion of time Hauled Out*	Location	Comment
60021	M	0.661	Anna's Skerries	not seen during count;
60022	M	1.0	Anna's Skerries	seen on Anna's Skerries ~14:00 and in water ~14:30 during count
60023	F	0.0	Exeter Sound	
60024	F	0.0	na	
Mean		0.415		
N (h)		48		
SD		0.072		

* Calculated from 00:00 h to 12:00 h local time on 3 September and 00:00 to 17:00 h on 4 September.

The assumption that the maximum proportion of the population was hauled out at the time of our survey is not supported by our small sample of concurrent tags. Two of four tags were hauled out at the time of the survey rather than 3 as predicted by assuming that $HO_{max} = 0.74$ applied.

Minimum Counted Population (MCP) estimates ranged from 716 in 2006 to 1,056 in 2007. The count in 2007 relied heavily on observations made from a boat near a large group of walrus on a rocky islet from a vantage point below the walrus herd (Fig. 7). It is undoubtedly an underestimate of the numbers of walrus present and the derived estimates are thought to be negatively biased. The adjusted counts using concurrent tag data in 2007 were 2,102 (CI=1,056–4,482, cv=0 .58) and 2,502 (CI=1,670–3,396) which we consider our best estimates of the number of walrus present in Hoare Bay in August/September 2007.

Some walrus summering in the survey area wintered off west Greenland (Dietz et al. 2014). Walrus also winter in Cumberland Sound and other areas around south Baffin Island (Riewe 1992, Born et al. 1995, DFO 2002, Stewart 2008). Walrus sampled in Hoare Bay were not genetically differentiated from those in Hudson Strait and West Greenland (Andersen et al. 2009, 2014). Witting and Born (2005) used surveys conducted in March 1990 and April 1991 to estimate an over wintering population in West Greenland of 938 (cv=0.48). Although their model predicted extirpation by 2000, the authors noted had not happened. Heide-Jørgensen et al. (2014) conducted aerial surveys of walrus in spring 2006, 2008 and 2012 in West Greenland. Their adjusted estimates of walrus abundance were 1,105 (*cv*=0.31, 95% CI=610–2,002) in 2006, 1,137 (*cv*=0.48, CI=468–2,758) in 2008 and 1,408 (*cv*=0.22, CI=922–2,150) in 2012. These are not significantly different than most of our estimates although adjusting by the percentage of time spent dry (2007 adjustment c, Table 4) appears higher.

There is movement between the West Greenland and Hoare Bay survey areas (Dietz et al. 2014) as well as between Hoare Bay and areas to the south, east, west and north of Hoare Bay (Dietz et al. 2014, Pangnirtung Hunters and Trappers Association, pers. comm.). Walrus winter in local Canadian waters as well as in West Greenland and it is reasonable to assume some of them summer in the Hoare Bay area. One would then expect higher estimates in Hoare Bay in summer than in West Greenland in winter.

Table 4. MCP (hauled out plus at sea) and MCPHO (only hauled out) adjusted using three adjustment factors: (a) broad-scale telemetry studies and in 2007, (b) the proportion of tags hauled out on survey days; and (c) concurrent telemetry data of the proportion of time hauled out (Table 3b). (Final estimates may vary from the products of data presented because significant figures were carried through the calculations and rounded at the end.)

Year	MCP	At sea	MCP_{HO}	Adjustment ± SD	Estimate	SD (cv)	95% CL	#HO in MCP
2005	766	0	766	(a) 0.74+0.05	1,035	75.4 (0.07)	887–1,183	3
2006	716	15	701	(a) 0.74+0.05	947	69.2 (0.07)	812–1,083	12
2007	1056	5	1051	(a) 0.74+0.05	1,420	103.8 (0.07)	1,219–1,622	4
				(b) 0.50+0.29	2,102	1,214 (0.58)	MCP–4,482	
				(c) 0.42+0.07	2,502	430 (0.17)	1660–3,345	
2008	988	33	955	(a) 0.74+0.05	1,291	93.6 (0.07)	1107–1,474	21

Our estimate of 2,100–2,500 walrus in Hoare Bay is an underestimate of the SE Baffin population. To avoid double-counting, it relied on only four haulout sites out of 25 examined in 2007 and of approximately 30 in the survey area, thereby excluding almost 600 animals seen at other times. Moreover, the survey area from Isabella Bay to Gabriel Strait did not include the entire range of genetically similar walrus distributed from western Hudson Strait to West Greenland (Andersen et al. 2009, 2014). There remains a need for more complete coverage of the entire Hudson Bay–Davis Strait stock range.

Haulout surveys in the late 1970s reported a few to hundreds of animals, with 600–700 near Lady Franklin Island (Born et al. 1995 and references therein). These surveys may be the basis of Richard and Campbell's (1988, Fig. 5) estimate of "1,000+" However, there appears to have been no correction for potential double-counting between surveys within a year, survey effort is difficult to assess, and the location data are too imprecise to be able to identify specific haulouts observed (e.g., Maclaren Marex 1979). Without these ancillary data it is impossible to asses a trend in population size.

CONCLUSION

The maximum count of walrus in the SE Baffin area was recorded during a boat survey on 3–4 September 2007. Using the maximum counts of 1,056 we estimated 2,100–2,500 walrus summer in Hoare Bay, on 3 key haul-out sites out of a total of 28 known haul-out sites of South East Baffin Island. Adjusting the same data using only 4 tags that transmitted concurrently with the maximum count generated an estimate of about 2,500. The maximum count, however, is likely negatively biased due to the low vantage point of observers. It is also not clear what proportion of HS-DS stock is represented by these estimates of walrus numbers in Hoare Bay in the summer. The estimates are best viewed as a partial survey and index of the numbers present in Hoare Bay in the summer.

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