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ABUNDANCE OF THE BAFFIN BAY POPULATION OF ATLANTIC WALRUS (*ODOBENUS ROSMARUS ROSMARUS*) DURING SUMMER, 2009

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Abstract

A group of Atlantic walrus (*Odobenus rosmarus rosmarus*) is found year round in the North Water polynya area (NOW) between NW Greenland and eastern Ellesmere Island. The current understanding is that this population - denoted the Baffin Bay (BB) population - has only little exchange with walruses in neighboring areas in West Greenland and the Canadian High Arctic. The BB population is hunted for subsistence purpose in the Qaanaaq area (NW Greenland) bordering the NOW polynya to the east. Perhaps some walruses from this population are also taken at the entrance to Jones Sound by Canadian Inuit. During summer the Qaanaaq area is virtually devoid of walruses and at this time of the year they can be found along the coast and in the fjords of eastern Ellesmere Island (Canada). To determine the abundance of BB walruses in the NOW area, aerial surveys were conducted on 9 and 20 August 2009 along eastern Ellesmere Island. Walruses were observed on the ice and in water primarily in the Buchanan Bay and Princess Marie Bay areas. Data on haul-out and at surface activity obtained from three walruses (1 F, 2 M) that were monitored with satellite-linked transmitters in the area simultaneous with the aerial surveys were used to adjust estimates of abundance for walruses that were not hauled out or were not at the water surface during the surveys. Adjusting the number of walruses on ice for those that were not hauled out, the estimate of abundance of the BB population in the NOW area during August 2009 is 1616 (90% CI: 968-2704). An alternative estimate based on a correction of walruses that were not at the water surface during the survey is 1233 walruses. The surveys did not cover all potential walrus summering habitat along eastern Ellesmere Island. Hence, these estimates of abundance indicate that at least 1500 walruses summered in the NOW area during 2009.

Introduction

Atlantic walruses (*Odobenus rosmarus rosmarus*) occur year-round in the North Water polynya (NOW) in northern Baffin Bay, Smith Sound and Kane Basin between NW Greenland and Ellesmere Island in Canada (Born et al. 1995). During April the NOW extends from ca. 76° 30´ N (eastern Devon Island) to 79° N and may cover 70,000-80,000 km^2 (Stirling & Cleator 1981). Walruses winter in several places in the NOW area but can more predictably be found at Coburg Island at the entrance to Jones Sound and the Qaanaaq area in NW Greenland (Born et al. 1995, Stewart 2008). However, during summer or the open water season the distribution of walruses in the NOW area is more restricted and basically confined to the eastern coast of Ellesmere Island (Canada). Walruses that have wintered in the eastern parts of the NOW (i.e. in the Qaanaaq area of NW Greenland) migrate west in June-July to summer along the coasts and in the fjords of Ellesmere Island only ca. 40 km across the Smith Sound from Greenland. Hence, walruses are absent during the open water season or summer in Greenland waters, except for a few stragglers. Sometime in the fall they reappear in the Qaanaaq area (Born 1987, Born et al. 1995 and references therein).

A review of available information on distribution, movement studied by satellite telemetry, genetics and Pb-isotope signatures lead the North Atlantic Marine Mammal Commission (NAMMCO 2006) and Stewart (2008) to the tentative conclusion that walruses in the North Water area constitute a demographically distinct population which has only limited connection with neighboring groups of walruses in the Canadian Arctic Archipelago to the west and western Greenland further south. Previously, walruses in the NOW were regarded as being a part of a population with a larger range covering also the Canadian Arctic archipelago (Born et al. 1995 and references therein). This larger population was referred to as “the North Water” or “Baffin Bay-Eastern Canadian Arctic population” (Born et al. 1995, NAMMCO 1995, 2006). However, as a consequence of the review by NAMMCO (2006) the North Water population was subdivided into three stocks: (1) Baffin Bay, (2) West Jones Sound, and (3) Penny Strait-Lancaster Sound. This subdivision was adopted by Stewart (2008). In the following we use the terminology suggested by NAMMCO and refer to walruses that occur in the North Water area in northern Baffin Bay, Smith Sound and Kane Basin as “the Baffin Bay (BB) population”.

Walruses are hunted for subsistence purposes in the Qaanaaq area where they always have been a cornerstone in the subsistence economy of the hunting culture (Vibe 1950, Born 1987). During the 1990s the catch of an average of 136 walruses/year was reported in the Qaanaaq area (Witting & Born 2005). Furthermore walruses are also hunted by the people living in Jones Sound (Born et al. 1995; Priest & Usher 2004). It cannot be precluded that some of the walruses taken in Jones Sound are from the BB population.

Since 1976 several attempts have been made to estimate the number of walruses in the Baffin Bay population. However, information on numbers of walruses in the North Water and adjacent areas has been collected in different seasons and in different years.

Both aerial surveys and ship-borne surveys have been used and the entire range has not always been covered.

An aerial survey conducted in 1999 corrected for walruses not seen (i.e. at sea and/or submerged) resulted in an estimate of ca. 1000 walruses for “the North Water” or “Baffin Bay-Eastern Canadian Arctic population” (Witting & Born 2005). However, to account for walruses potentially present in un-surveyed areas, another 500 animals was added, and furthermore it was suggested that the estimate of 1500 probably was negatively biased (Ibid.). This abundance estimate was, however, found by NAMMCO (2006) to be problematic given the new putative stock areas, since most of the abundance estimate in the North Water area was a "guesstimate" due to incomplete survey coverage.

In 2005 the NAMMCO working group on walruses (NAMMCO 2006) concluded that there was no indication that these combined stocks (i.e. Baffin Bay, West Jones Sound, and Penny Strait-Lancaster Sound) were large enough to support the current harvest levels and therefore expressed concern that current harvests probably were not sustainable.

Aerial surveys that were conducted jointly by the Department of Fisheries and Oceans (DFO, Canada) and the Greenland Institute of Natural Resources (GINR, Greenland) in 1999 and 2008 to estimate the number of BB-walruses in the NOW region resulted in only very few observation of walruses (Dunn 2000, Stewart unpublished).

To provide an estimate of the Baffin Bay walrus population aerial surveys were conducted over the walruses summering areas along eastern Ellesmere Island in August 2009. In this paper we present an estimate of abundance. We use data on haul-out and diving activity collected simultaneous with the survey to correct the abundance estimate so that it includes the fraction of the population that was not detected either because the walruses were not hauled-out or were submerged.

Material and methods

Field work

Instrumentation and data collection from walruses

Not all walrus in the area at the time of a survey will be hauled out, and of those at sea, not all will be near the surface where they can be seen. To obtain estimates of the total abundance of walruses, we estimated the number of walruses that were not available to be detected by the observers either because they were not hauled out and were submerged.

Information on “haul-out” and “at surface time” was obtained from activity measurements from the saltwater switch (SWS) of satellite-linked transmitters (SLT) that were deployed during 12-14 July 2009 on walruses that were either swimming or resting on ice floes in southern Kane Basin at ca. 79° N. The field team cooperated with experienced walrus hunters from the Qaanaaq area in NW Greenland using small skiffs for transportation.

Nine ca. 60 g SPOT-5 "match box" SLTs (Wildlife Computers, Redmond, Washington, USA) were deployed on the walruses using a CO_2-powered rifle (Dan-Inject, www.dan-inject.com) or traditional harpoons used by the Greenlandic Inuit when hunting walruses. All SLTs were attached to the tough skin of the walruses using a ca. 6.5 cm long harpoon head-like stain-less steel anchor developed by Mikkels Værksted ("Mikkel´s Workshop"; www.mikkelvillum.com). Main target site was the medial back thorax region but in several cases the tags were placed in other parts.

By accident two tags were placed on the same individual. Hence, in total 8 different walruses that all were judged to be 5+ years old were instrumented (3 F, 4 M, 1 unidentified). The 8 animals were tagged in three events on 12 (n=3), 13 (n=1) and 14 (n=4) July 2009. Female walrus 3758 which was judged to be 5 years old based on tusk size and body dimensions was together with another female and two young when instrumented. Walrus 4188 (ca. 12 years) and 8375 (ca. 15 years) were both in mixed groups. During 9 and 20 August 2009, when aerial surveys were flown along eastern Ellesmere Island, these three transmitters (3758, 4188, 8375) functioned and collected behavioral data.

Information on walrus behaviour in this area was also obtained from one walrus instrumented with a SPOT-5 satellite tag on 19 June 2008, in cooperation with walrus hunters from the Qaanaaq area in the drift ice off Cape Inglefield (78° 34´ N) Smith Sund in NW Greenland. The satellite tag was placed on an adult female # 83304 (estimated age: 6-8 years) with a calf.

The SLTs had a transmission rate of 45 s in water and 90 s when the walrus was hauled out. They were programmed to transmit continuously between 7 and 22 GMT (GMT 3 h ahead of local time in NW Greenland) when the SWS was dry with a maximum allowance of 150 transmissions per day. Duty cycle was every day in June-December.

The internal system of the SLTs continuously checked the status of the SWS ("dry" vs. "wet") every 0.25 sec and recorded the activity of the SWS in 60-min intervals. This information was stored in "timelines" (TIM) that show what percentage of each 60-min interval the SLT was dry. Percentage of "dry"-time/h was given in a total of thirteen increments ranging from "0%" (every measurement was wet) to "100%" (every measurement was dry). Two increments were 5% (i.e. >0-<5%; ≥95-<100%) and nine increments between >5% and <95% SWS dry were 10%. TIMs with information on haul-out activity during 24 h were transmitted along with the "time-at-temperature" histograms (Wildlife Computers 2006).

Aerial surveys, 2009

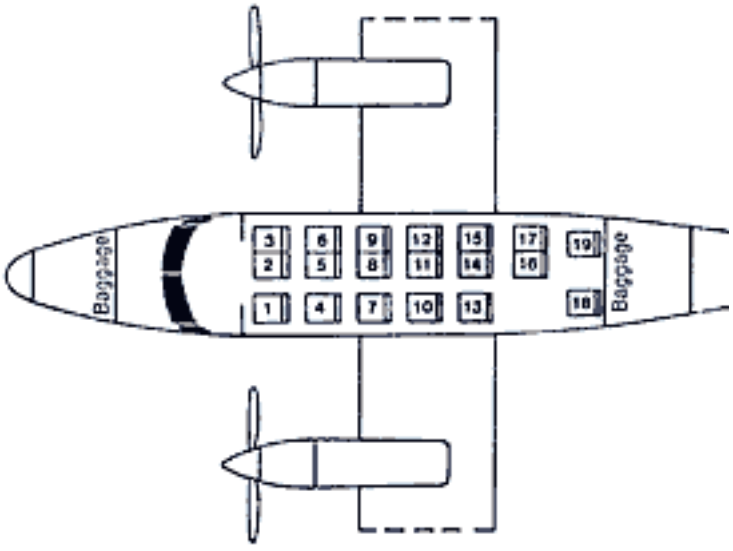
On 9 and 20 August 2009, aerial surveys were conducted along a section of the coast of eastern Ellesmere Island. Based on scientific and Inuit (Grise Fiord) information, the survey focused on the coast and fjords between Cape Wilkes (80° 11´ N, 70° 07´W), at the NE mouth of John Richardson Bay and Cape Herschel (78° 35´ N 74° 37´W), south of Pim Island on 9 August covering approximately 1170 km of survey effort. On 20 August, the

coast between Cape Herschel and Cape Prescott (79° 35´ N, 74° 26´ W), approximately 800 km was surveyed (Fig. 1). The area north of Cape Prescott was not surveyed on 20 August due to flight restrictions. Twenty-three of 208 walrus had been seen in this area on 9 August but were excluded from the 20 August counts due to the potential for double-counting.

A DeHavilland DH6 Twin Otter was used for the surveys that were flown between 12 and 17 h local time. Target altitude and speed were 200 to 250 m ASL (650-800 feet) and 210 kph (110 knots), respectively, but the aircraft would slow down to facilitate counting of groups of walruses. All surveys were flown about 400 m from the shoreline. On 20 August, two primary observers on opposite sides of the aircraft in the rear-most port seat (18, see below), equipped with a bubble window, and the second last starboard seat (17). Secondary observers sat in seats 4 and 13. When a large concentration of walrus was sighted and if time allowed, an observer would change sides of the aircraft to maximize the number of digital photos available. The pilot and co-pilot also relayed sightings.

When walrus were seen on ice or in the water, the numbers were estimated independently by each observer and oblique aerial photographs were taken whenever possible. Digital photographs were taken of major concentrations using a Canon EOS 30D or 40D and a EFS17-85 mm or 70-300 mm zoom lens, with image stabilizer, for later counting.

During the surveys it was noted whether the walruses were hauled out on ice or were in the water.



Analysis of data

Haul-out and diving activity

For analysis of haul-out time we defined a walrus to be hauled out if the SWS showed ≥70% "dry" during a 60-min interval. On average, intervals with "≥70%-<100% dry" constituted ca. 7% of all 60-min intervals and usually occurred at the beginning or end of a continuous series of "100% dry" intervals (i.e. at the beginning or end of a haul-out period). To determine % of time in water all ≥70% dry intervals were subtracted from the total sum of 60-min intervals during August. Subsequently, % of time per day at water´s surface (i.e. % of time when SWS was dry) was calculated for this "in water time".

Hence, for each animal we determined the percentage of time per hour and day (1) hauled out and at the water´s surface during August and during the survey "window" between 12 and 17 h local time.

The duration of a single haul-out period was defined as the time elapsed between the beginning and the end of a continuous series of "≥70% dry" intervals. "Extended" haul-out period was defined as a haul-out period ≥2 hours.

Following identification of extended haul-out periods the locations received during each individual haul-out period were identified by comparing time of the haul-out period with time of reception of high quality re-locations (LC:2 and 3, cf. www.argos-system.org). In this manner the exact location (and substrate: ice vs. land) of haul-outs locations was determined.

Estimating the number of walruses not available for detection

Based on information from the three tagged animals we established a correction factor to account for the proportion of animals that were not hauled out or were submerged. The proportion of time spent on ice was calculated as the mean of individual haul-out times with its variance.

Analyses of haul-out patterns

Haul-out percentages were first square root and then arcsine transformed prior to statistical analyses in order to approach the assumptions of normal errors and constant variance as recommended in e.g. Zar (1996).

To test for differences in haul-out in relation to time of day, the mean haul-out percentage per hour was calculated and the 24 hours were subsequently divided into four 6-h intervals beginning at 24 h local time.

To describe the diurnal pattern, polynomial regression analyses were employed. The first order hour term in the regression model is equivalent to a linear relationship, the second order to a quadratic (second-power) and the third to a cubic (third-power)

relationship etc. Terms were added to the polynomial regression models until no longer significant at the 5% level.

The software Microsoft Excell-2007 and free software "R" (R Development Core Team 2008) were used for the calculations.

Counting of number of walruses

Data included visual estimates from airborne observers as well as aerial photographs. Regression analysis (SigmaStat® v 3.11) was used to assess between-observer counts of photos taken from aircrafts and boats in the Canadian High Arctic during 1998-2008 and along Baffin Island during 2007-2008. These analyses indicated that there was little inter-observer variation (Stewart et al. working paper, this meeting). Hence, numbers of walrus in photographs from eastern Ellesmere Island 2009 were counted by one observer (REAS). When there were data of more than one type available for a site, aerial photo-count was preferred for aerial estimate. On each photo individual walruses were identified, marked digitally and tallied. Counts on a series representing a group or an entire haul-out photographed from several angles were then evaluated for a final estimate of number of animals on that particular location. All images were examined in Adobe Photoshop®.

Aerial surveys

The number of walruses observed during the 2009-survey was summed for each survey day. Haul-out information from the instrumented animals in 2009 was applied to the total count to account for walruses not hauled out during the surveys.

Variation associated with the estimate of abundance was: cv(N)=sqrt(cv(number of walruses)^2 + cv(haul-out correction factor)^2). Confidence limits were calculated based on the assumption of log-normal distribution with lower limit=N/V and upper limit=N$*$V and V=exp(z $*$ sqrt(ln(1+varN/N^2))) (Buckland et al. 2001); where N is the abundance of walruses and the factor z varied with the desired confidence limits (90%) and the degrees of freedom.

Results

Movement and general distribution

In 2009, five walruses gave signals after deployment of the satellite tags. One stopped the day after deployment whereas the other moved into Buchanan Bay where 8374 stopped on 4 August. The three instrumented walruses which were still transmitting exploited shallow waters close to the coast in Buchanan Bay and Princess Marie Bay during August (Fig. 2). The female walrus instrumented in northern Smith Sund on 19 June 2008 also moved

directly from the C. Inglefield area to Buchanan Bay where it stayed until transmission stop 10 days later (Fig. 3).

The position of good quality locations (LC2 and 3; cf. Harris et al. 1990) indicated that the walruses did not use any terrestrial haul-outs in these areas during July and August and apparently only used ice for hauling out. When the aerial survey was conducted in 2009, the three walruses that were still transmitting were in Princess Marie Bay and tributary fjords.

During the surveys walruses were primarily found in Buchanan Bay and tributary fjords on 20th August (Fig. 1). As in previous years (1999, 2008) no walrus were found on land.

Diurnal haul-out patterns

There was no difference in haul-out pattern between July and August (ANOVA, haulout time interval and month interaction, p=0.15). The mean haul-out percentage of the 18-24 h block was significantly higher than the other 3 (Tukey, p adjusted = 0.05). The walruses preferred to haul out during the evening and curve fitting by polynomial regression to the diurnal pattern of haul-out resulted in a quartic (forth-order) regression (Figure 4).

In August the duration of extended (>2 h) haul-out sessions on ice ranged between 16.1 (sd=7.2, n= 7 periods) and 21.2 h (sd=36.7, n=11) among the three walruses. The overall mean of duration of on ice haul-out periods was 18.3 h (sd=21.7, range: 2-130 h, n=32); Table 1.

Adjusting for walruses on the ice

During August 2009, "≥70-100% dry SWS" readings constituted 32% of all 1 h readings (n_{total} = 1848 h). Of these, "≥70-85% dry" readings constituted 2.1% (or 6.3% of all ≥70-100% readings), Fig. 5).

On average, the three instrumented walruses hauled out for 32.1% of each day (sd=10.6, range: 21.6-42.7%, n=3) during August (Table 2).

To establish a correction factor for walruses on ice we used the haul-out time between 12 and 17 h local time during August when the aerial surveys were conducted. During this survey window, the three walruses hauled out for an average of 25.8% (sd=14.5, range: 13.0-41.6, n=3) of the time (Table 3). We would therefore expect, on average, that about 25% of the walrus in the survey area were on ice at the time of the survey. Hence, theoretically the number of walruses observed on ice can be multiplied by 1/0.258 or 3.88 (cv=0.32) to account for walruses that were hauled out during the aerial survey. According to the information on the activity of the SWS none of the three instrumented walruses were hauled out when the surveys were conducted between 12 and 17 h local time on 9 and 20 August.

Adjusting for walruses in water

When in the water during August three walruses spent an average of 17.4% (sd=1.9, range: 16.3-19.6, n=3) of the time at the surface (Table 1). Between 12 and 17 h local time in August the walruses spent an average of 18.8% of the time (sd=4.3, range: 15.1-23.5%, n=3) at the water´s surface (Table 2) resulting in a surface:subsurface ratio of 1:5.3 walruses (i.e. the number at the water surface must be multiplied by 5.3 to include the proportion that was submerged).

Aerial surveys and estimate of abundance

When the coast of eastern Ellesmere Island was surveyed on 9 August 2009 a total of 208 walruses were seen. However, during a survey of most of the same coastline on 20 August a total of 571 were observed. Of these 417 (73%) were hauled out on ice and 154 (27%) were in the water (walruses that obviously were scared into the water by the noise of the aircraft are included in the "on ice" count). Judging from the photos the groups consisted of adults of both sexes and young.

When we apply the availability index for walruses on ice during 12 and 17 h local in August (0.258, cv=0.32) to the numbers that were on the ice on 20 August an estimated 1616 (cv=0.32, 90% CI: 968-2704) walruses were present in the survey area. If we alternatively apply the estimate of the surface:subsurface ratio (5.3, cv=0.13) to the numbers seen swimming (n=154) an estimated 816 (cv=0.13) walruses were in the water in the survey area on 20 August. To this number walruses on ice (n=417) must be added bringing the total estimate to ca. 1233 walruses.

Hence, the survey indicates that ca. 1500 walruses were present in this section of eastern Ellesmere Island in August 2009.

Discussion

Movement and distribution

During summer or the open water season walruses in the NOW area are primarily found along the coast of Ellesmere Island. According to the Inuit of the Qaanaaq area some walruses, predominantly males, may migrate along the coast of Inglefield Land (Greenland) to summer off the Humboldt Glacier in eastern Kane Basin. However, there are no indications that in any year significant numbers summer there (Born et al. 1995). We therefore chose to estimate the abundance of walruses during summer by conducting an aerial survey along eastern Ellesmere Island in August when they are virtually absent from Greenland.

The walruses that were tracked by use of satellite telemetry moved from Kane Basin into the Buchanan Bay-Princess Marie Bay region. The occurrence of walruses from June-

July until formation of new shore-fast ice in Buchanan Bay and its tributary fiords and in Princess Marie Bay appears to be fairly regular (Born et al. 1995).

However in some years walruses have been observed along coast of Ellesmere Island between Buchanan Bay and the entrance to Jones Sound. On this stretch of coast walruses have been observed in July-August in Baird Inlet, Talbot Inlet west of Cape Faraday and in Goding Bay (Born et al. 1995 and references therein). When these bays were inspected from a distance in 2008 and 2009 walruses were not observed. The bays were full of drift ice and we likely would have seen large walrus groups had they been there - though likely not a few individuals. The walruses that were tracked in 2008 and 2009 indicate that during those years the main summering areas were Buchanan Bay and Princess Marie Bay and tributary fjords. We believe that the 2009 aerial survey covered the main summering areas for walrus in the Smith Sound-Kane Basin region (the NOW area). However, it cannot be excluded that groups of walruses were missed during the survey because they occurred south of the survey area. For this reason our estimate of abundance in 2009 may be negatively biased.

Inuit from Grise Fiord have reported groups of walrus estimated to be 100+ on the ice east of Starnes Fiord (roughly 76° 20' N, 81° 30' W) in August of both 2008 and 2009. These animals were not found during aerial surveys of the area in either year. Indeed in 2009 there was no ice in area. The presence of walrus in this area was noted in the mid-1990s and one of us (REAS) partook in a walrus hunt near Starnes Fiord in the late 1970's. The nearest over-wintering population is at Coburg Island but the relationship of these summering walrus to those in West Jones Sound and on east Ellesmere Island remains unclear.

Diurnal haul-out rhythm

We found a diurnal variation in haul-out rhythm with a tendency to haul-out during evening and mid night. The locations indicated that the three walruses that were monitored only hauled out on ice. To our knowledge only few studies have provided information about haul-out behavior of walruses when using only ice as a resting platform. A study of 43 walruses that were monitored with satellite transmitters in the Bering Sea region during April also showed a diurnal cycle with highest haul-out values in the evening (Udevitz et al. 2009).

Generally the tendency to haul out is influenced by weather conditions - and is in particular negatively affected by low temperature and high wind speeds (i.e. wind chill) and precipitation (Salter 1979, Hills 1992, Born & Knutsen 1997, Udevitz et al. 2009). We have not been able to obtain weather data from any weather station in the Kane Basin region. This prevents us from pursuing in detail how or to what extend weather factors influenced on the haul-out behavior of the instrumented walruses in this study. Data from Grise Fiord in Jones Sound or Qaanaaq town in NW Greenland were considered not be useful for our study because these sites are too far away to be representative of the situation in the Buchanan Bay and Princess Marie Bay areas. However, judging from data from Qaanaaq

town it appears that during August generally the entire Smith Sound-Kane Basin region had stable high pressure conditions with <5 m/sec wind, mean temperature around 7 °C and >1010 hPa. Moreover, the decision to commit to survey east Ellesmere from Resolute Bay (some 690 km away) was based on real-time satellite imagery showing clear skies in the survey area. During the 20 August survey, skies were clear or had only high overcast, winds were calm, and temperatures in the 5-10 °C range.

Haul-out and at surface time

We found that the instrumented walruses generally hauled out for 32.1% of the day during August. Due to the diurnal haul-out pattern the percentage of time spent on the ice during the survey window (12-17 h local time) was only ca. 25.8%.

Jay et al. (2006) and Udevitz et al. (2009) who used basically the same type of transmitters as used in the present study considered a walrus to be hauled out if the percentage of dry time for a given interval was ≥85%. In our study we decided that a walrus was hauled out if a 1 h interval showed ≥70% dry. Interval with "≥70-<85%"constituted 2.1% of all 1 h intervals (6.3% of all ≥70-100% increments). If we had used the same haul-out threshold as Jay et al. (2006) and Udevitz et al. (2009) (i.e. ≥85%) our estimate of mean haul-out time in August would have been ca. 6% lower, or 30.1%. One may argue that intervals with even lower % dry than 70% may represent a walrus being hauled out and not at the water surface. In the present study interval with "≥50-<85%"constituted 3.4% of all 1 h intervals (10.0% of all ≥50-100% increments). Therefore, if we had included also ≥50-<70% dry intervals, our estimate of mean haul-out time in August would have been 33.3%. This suggests that analyses of haul-out percentage (and consequently correction factor) are relatively insensitive to which haul-out threshold value is chosen.

Studies of the haul-out activity of free-ranging walruses have mainly been conducted during summer. They have shown a remarkable consistency in mean fraction of time spent out of the water between 23-25% (Jay et al. 2001, Lydersen et al. 2008) and 30-35% (Hills 1992, Born & Knutsen 1997, Acquarone et al. 2006, Born & Acquarone 2007).

For the estimate of the number of walruses in the Baffin Bay population we used 25.8% of the time on ice to obtain a correction factor for those not hauling out. Apparently, a fair proportion of the walruses that summer in the Buchanan Bay –Princess Marie Bay is females and young. A haul-out percentage of 25.8% falls well within the range found by Hills & Gilbert (1994) for 15 female Pacific walruses that were monitored with SLTs in the Bering Sea-Chuckchi Sea area. These researchers reported that female walruses spent 56-89% of the time in water (i.e. hauled out for 11-44% of the time).

In August the walruses in our study spent an average of 17.4% of the time at the surface. During the survey window at-surface percentage was 18.8. Direct observations indicate that during travelling and feeding walruses are at the water surface for 11 to 24% of the time (Fay 1982, Born & Knutsen 1997 and references therein). Fay et al. (1997) summarized information on at surface time and found that walruses on average spend ca. 16% of the time at the surface during various behaviours. However, at surface times may

vary substantially among studies. At Svalbard during summer, Wiig et al. (1993 found that about 24% of the time was spent between 0 and 2 m. In contrast, Jay et al. (2001) found that four Pacific walruses equipped with time-depth-recorders (TDR) when at sea spent ca. 40% of the time between 0 and 2 m during summer. Using TDRs and SLDRs to study walrus activity during late July-August at Svalbard, Gjertz et al. (2001) found that nine walruses spent ca. 83% of their time in water of which 39% was spent between 0 and 2 m depth, and 44% of the time below 2 m (Ibid.).

Estimates of abundance and comparison with previous surveys

We estimated that around 1500 walruses summered in the Buchanan Bay and Princess Marie Bay areas in 2009. Aerial surveys conducted in recent years to specifically enumerate the number of walruses summering in the NOW area resulted in fewer observations. On 11 August 1999, the coast of eastern Ellesmere Island between Cape Faraday (77° 53´ N) and Cape Albert (79° 01´ N) including Buchanan Bay and tributary fjords was surveyed. On this day also the southern coast of Makinson Inlet was surveyed. Only 5 walruses were observed in the Buchanan Bay area (Dunn 2000). A survey conducted on 23 August 2008 covering the same area as 20 August 2009 resulted in the observation of a total of 74 walruses (Stewart unpublished). This and the 2009-surveys show that numbers can be highly variable even in the same sector of Ellesmere Island. Similar between year and within year variability was also noted in the surveys of the Canadian Arctic archipelago surveys (Stewart et al. working paper, this meeting).

Information about numbers of walruses in the NOW and adjacent areas has been collected during summer in previous years. Both aerial surveys and ship-borne surveys have been used and the entire range has not always been covered. Hence any numbers must be treated with caution.

Observations cited in Born et al. (1995) indicate that Buchanan Bay and tributary fjords are an important summering area for walruses in the Baffin Bay population. When the ice dam between Pim Island in Canada and Cape Inglefield (78° 34´ N) in northern Smith Sound-southern Kane Basin dissolves walruses can move into the Buchanan Bay area. Royal Canadian Mounted Police (RCMP) game reports from Alexandra Fjord refer to a herd of 500-800 in Flagler Bay in summer 1956 and a group of 400, mainly females with calves, near Cape Sabine (78° 43´ N) on eastern Pim Island in early September 1962 (unpublished RCMP game reports cited in Born et al. 1995). In July 1978 Schledermann (1978, 1980) saw about 300 walruses in the Flagler Bay polynya in western Buchanan Bay. In 1979 at least 250 walruses were observed in the Buchanan Bay area (Schledermann 1980). These estimates of numbers in Buchanan Bay were considered to be conservative (K. McCullough *in litt*. 1988). During an aerial reconnaissance on 31 August 1985 an estimated 300 walruses were observed in Buchanan Bay (Born unpublish.) where on 21 August 1988 a minimum of 171 walruses were present (Born & Knutsen 1988).

Riewe (1992:39,154) indicated that "thousands" of walruses were found along the east coast of Bache Peninsula and also that the population scattered along the east coast of

Ellesmere Island in summer represents the third greatest concentration of walruses in Canada (after the Southampton Island and northern Foxe Basin areas). The basis, however, for the statements by Riewe (1992) is not clear. Moreover, there are no methods of calibrating any of these previous visual estimates with our own or with our photographic counts.

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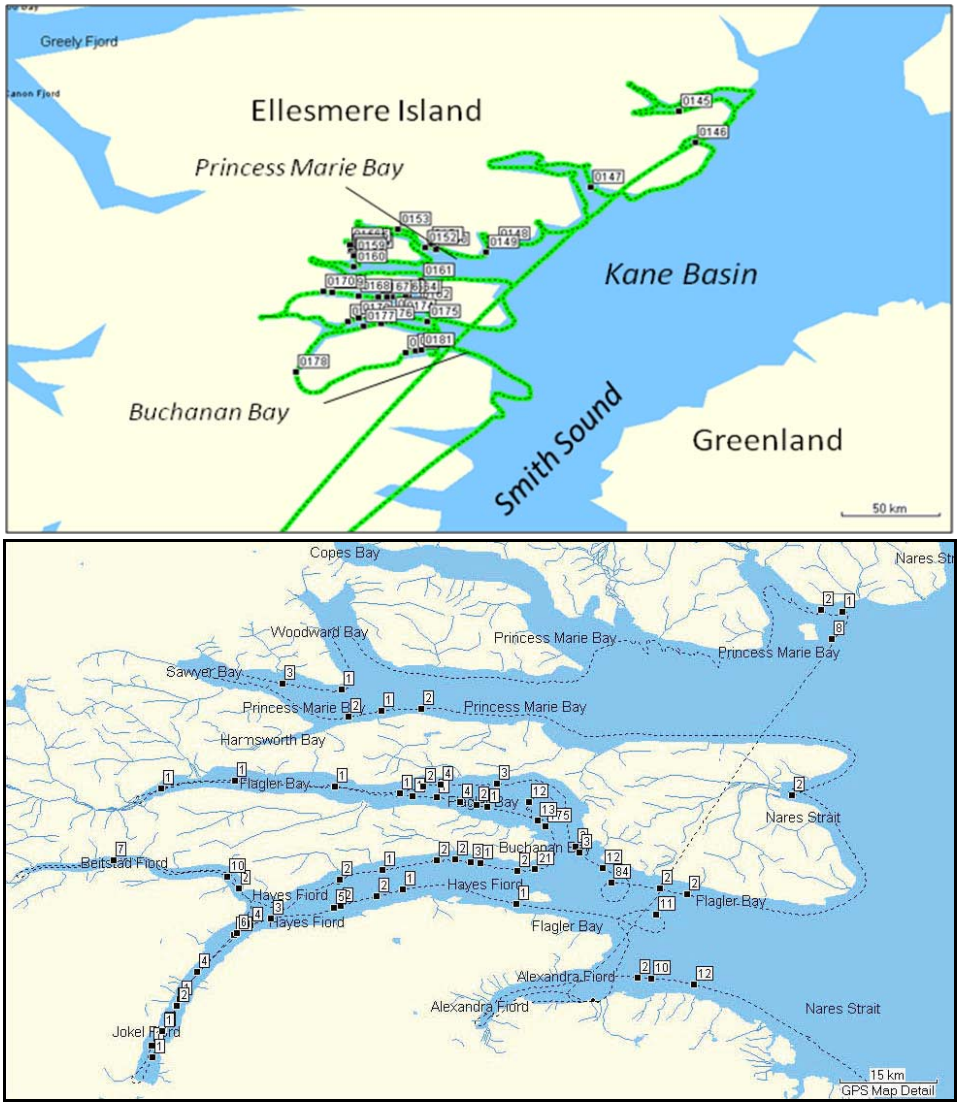

Fig. 1: Survey routes flown during 9 (A) and 20 (B) August 2009 along eastern Ellesmere Island in order to count walruses in the BB population. (A) Waypoints indicate where walruses were observed. (B) "Raw" counts are shown. Raw means they are the raw observations without checking for redundant counts. Some observations which did not get a way point are not shown.

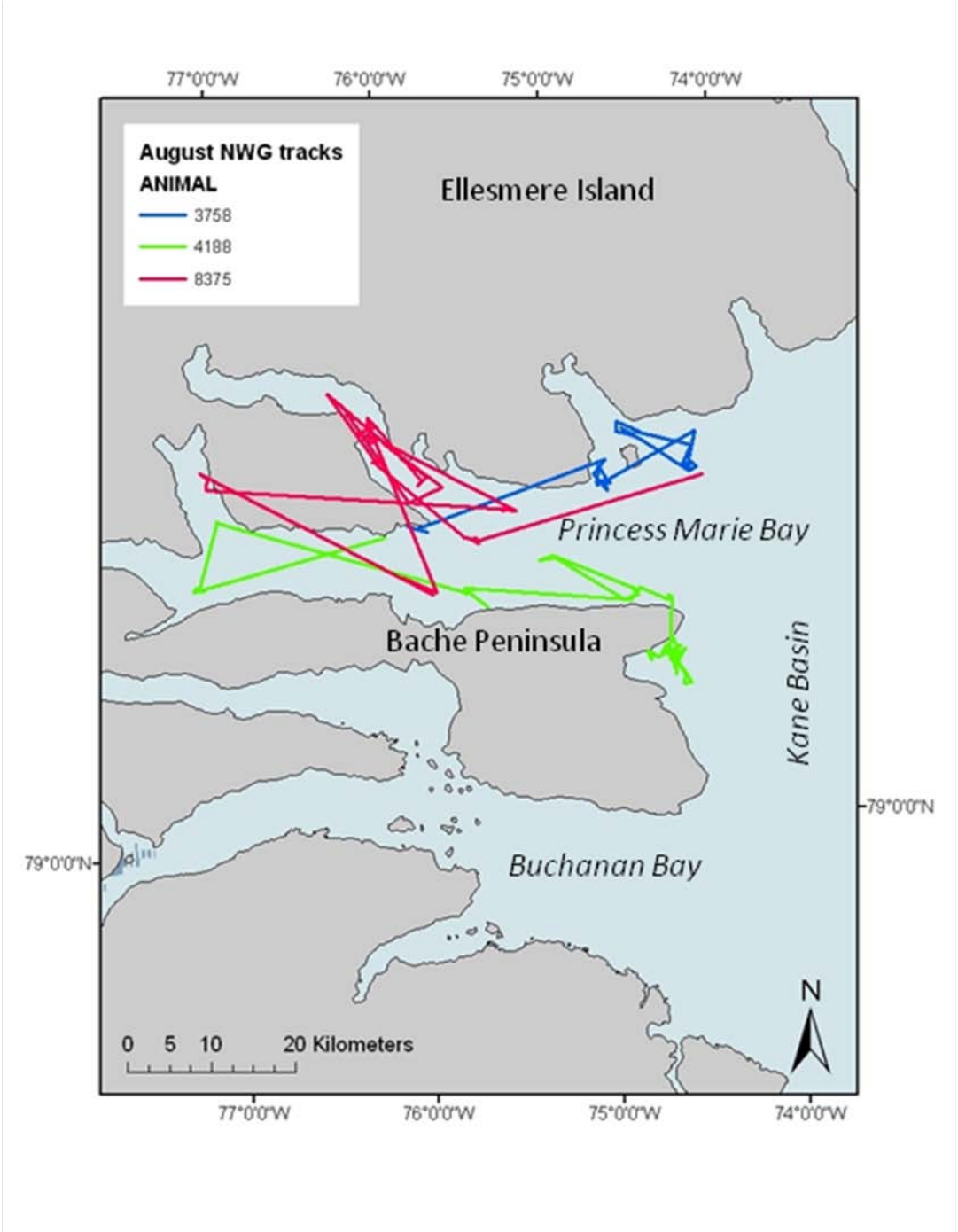

Fig. 2: Movement in August 2009 of three walruses (2 M, 1 F) that transmitted data on location and behaviour during the aerial surveys. The walruses were monitored with satelllite-linjed transmitters and only locations of quality 2 and 3 were used for mapping their movement.

Fig. 3: An adult female walrus (83304) that was tagged at Cape Inglefield with a satellite transmitter on 19 June 2008 moved directly from the C. Inglefield area to Buchanan Bay on eastern Ellesmere Island. In June 2008 there was very little ice in Kane Basin and no ice dam between Cape Inglefield and Pim Island.

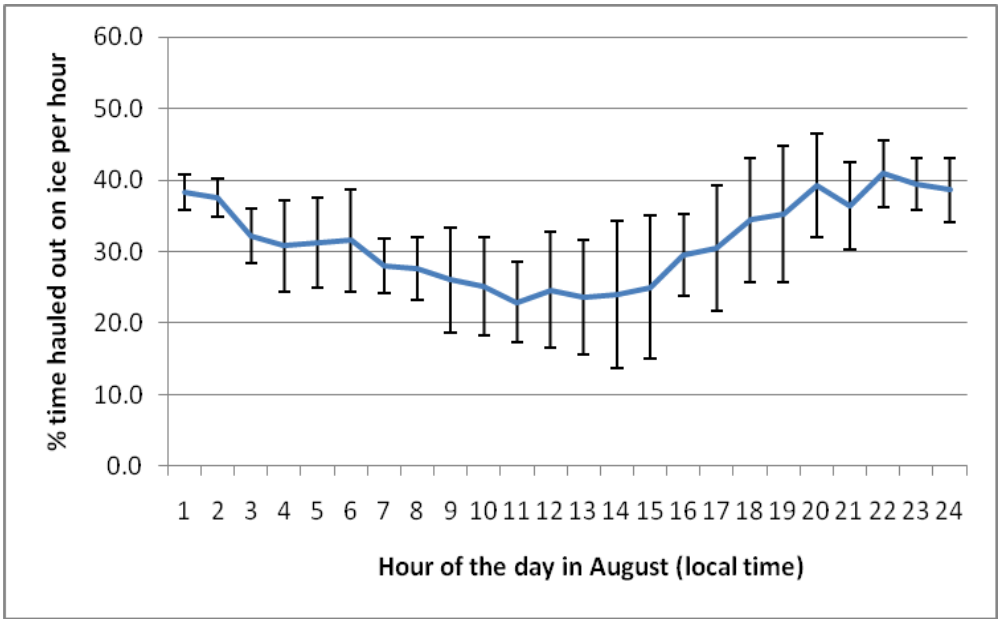

Fig. 4: Diurnal haul-out pattern on ice in August 2009 of three walruses (2 M, 1 F) that were monitored by use of satellite transmitters in the Kane Basin region. Error bars are ± SE.

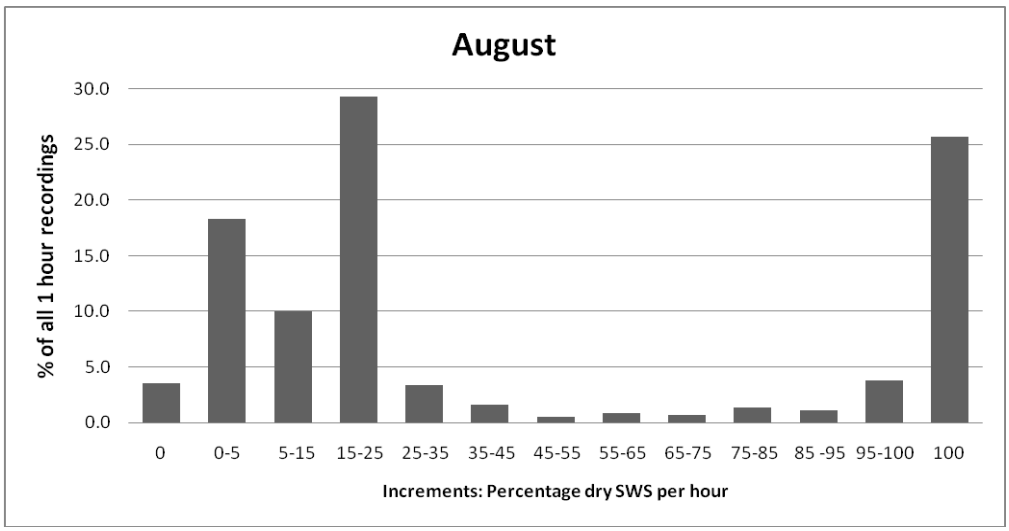

Fig. 5: Distribution during August 2009 of recordings of the activity of the saltwater switch in 1 h intervals given by "% dry per hour categories". Data are from the satellite transmitters on three walruses in the Kane Basin region (n_{total} =1848 hours).

Table 1: Duration of unaborted haulout on ice of three walruses that were monitored with satellite transmitters during August 2009 in the Kane Basin region. Duration of extended haulout period (i.e. ≥2 h) are also shown. "Unarborted" haulouts were haulout that were not terminated due to a break in the data data string (i.e. due to missing timelines for some days.

Month 2009	Animal ID	Sex	Duration of unaborted haulout periods				Duration of extended haulout periods			
			Mean (h)	SD (h)	Min-max (h)	N	Mean (h)	SD (h)	Min-max (h)	N
Aug.	3758	F	17.2	7.4	3-29	14	17.2	7.4	3-29	14
	4188	M	12.8	9.1	1-24	9	16.1	7.2	2-24	7
	8375	M	15.8	32.3	1-130	15	21.2	36.7	4-130	11

Table 2: Daily mean haulout, in water and at surface time for three walruses that were monitored with satellite transmitters during August 2009 in the Kane Basin region.

Month 2009	Animal ID	Sex	Days with records	% Time hauled out	SD	% Time in water	% Time at sea surface	SD	% Time exposed
Aug.	3758	F	29	32.0	26.8	68.0	16.4	4.7	48.4
	4188	M	23	21.6	21.6	78.4	16.3	9.2	37.9
	8375	M	25	42.7	34.5	57.3	19.6	8.9	62.3
			Mean	**32.1**		Mean	**17.4**	Mean	**49.5**
			SD	10.6		SD	1.9	SD	12.2

Table 3: Daily mean haulout, in water and at surface time during 12-17 local time for three walruses that were monitored with satellite transmitters during August 2009 in the Kane Basin region.

Month 2009	Animal ID	Sex	Days with records during survey	Mean time hauled out per day 12-17 local time (%)	SD	% Time in water	Mean time at surface per day 12-17 local time (%)	SD	Total time exposed per day (%)
Aug.	3758	F	29	22.8	31.9	77.2	15.1	4.9	37.9
	4188	M	23	13.0	25.3	87.0	17.9	10.6	30.9
	8375	M	25	41.6	46.5	58.4	23.5	13.9	65.1
			Mean	**25.8**		Mean	**18.8**	Mean	**44.6**
			SD	14.5		SD	4.3	SD	18.1