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Abundance estimate of the Hudson Bay–Davis Strait walrus (*Odobenus rosmarus rosmarus*) stock from aerial surveys flown in September 2017

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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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ABSTRACT

From September 1st to 17th, 2017, three planes conducted an aerial photographic survey to estimate the abundance of walrus from the Hudson Bay–Davis Strait stock (HBDS). Most of the distribution range of this stock was covered, including the eastern, southern and southwestern coasts of Baffin Island, Hudson Strait, Southampton Island and the northwestern coast of Hudson Bay. A total of 13,375 walrus were counted within the HBDS distribution area, including 1,179 individuals along the east coast of Baffin Island and 12,196 in Hudson Strait and northern Hudson Bay. Correcting raw counts using the mean proportion of hauled out animals obtained from the literature (P = 0.3) resulted in an abundance estimate of 44,582 animals (95% CI = 19,485–102,004). This abundance estimate is considerably larger than the estimate of the last survey conducted in 2014 (i.e., 7,100 animals [95% CI = 2,500–20,400]). However, the 2014 survey coverage did not include the HBDS range along the east coast of Baffin Island and part of northwestern Hudson Bay overflown in 2017. Considering only the area in common between the two surveys still results in a large difference, with 11,554 walruses detected in 2017 and a population estimate of 38,514 (95% CI = 15,091–98,290) individuals. Walrus haulout behaviour and possible exchange from other stocks/regions (e.g., Foxe Basin) are among the hypotheses proposed to explain this difference.

INTRODUCTION

Two genetically distinct populations of Atlantic walrus (*Odobenus rosmarus rosmarus*) occur in the Canadian Arctic (Shafer et al. 2014). The Central Arctic population, whose range encompasses Hudson Bay, Hudson Strait, Foxe Basin, and Davis Strait comprises four largely discrete management stocks based on genetics, distribution, growth patterns, and stable lead isotope ratios: Hudson Bay–Davis Strait (HBDS), South and East Hudson Bay, North Foxe Basin, and Central Foxe Basin, with the latter two managed as one unit (Figure 1; Stewart 2008). Walrus are hunted by Inuit for food and other products throughout their range in Canada, and smaller numbers are taken in limited sports hunts (Stewart et al. 2014, Matthews et al. 2018). Walrus from both populations are also hunted in West Greenland (Born et al. 1994), where they occur primarily in winter (Dietz et al. 2014, Heide-Jørgensen et al. 2017).

The range of the HBDS walrus stock spans 1,500 km from northwestern Hudson Bay through Hudson Strait, and runs along the eastern coast of Baffin Island up to 180 km northwest of Clyde River (Stewart 2008). An unknown portion of this stock undertake seasonal movements between southeastern Baffin Island in summer and the coast of Central West Greenland in winter (Dietz et al. 2014). The HBDS stock has never been surveyed throughout its entire range at one time. A partial survey of the stock covering northern Hudson Bay and Hudson Strait was conducted in September 2014 (Hammill et al. 2016). A total of 2,144 walruses were counted at terrestrial haulout sites, producing an abundance estimate of 7,100 (95% Confidence Interval = 2,500–20,400) after accounting for the proportion of animals estimated to have been at sea during the survey (Hammill et al. 2016). Different sections of the east Baffin coast have been surveyed several times between 2005 and 2008 and estimates ranged from 947 (95% CI = 812–1,083) to 2,502 (95% CI = 1,660 to 3,345) walruses in the area (Stewart et al. 2014a). These partial survey estimates have not been added to estimate overall stock abundance because of concerns about potential walrus movements between areas (see Andersen et al. 2014).

In September 2017, Fisheries and Oceans Canada (DFO) completed a more comprehensive survey of the HBDS walrus stock. A coastal photographic survey was flown using three aircraft that simultaneously surveyed known terrestrial haul-out sites and adjoining coastline in northern Hudson Bay, Hudson Strait, and the eastern coast of Baffin Island. Walrus counts from aerial photographs were adjusted to account for the proportion of walruses that were hauled out to estimate stock abundance.

MATERIALS AND METHODS

SURVEY AREA AND PROTOCOL

The survey area included most of the HBDS walrus stock distribution area in Canada (Figure 1 and 2), with the exception of the area north of Clyde River (Baffin Island), northeast Labrador, and West Greenland. Locations of known walrus haulout sites were obtained from previous surveys and discussions with Inuit hunters (Orr and Rebizant 1987, Born et al. 1995, Reeves 1995, Gaston and Ouellet 1997, Hammill et al. 2016). A coastal survey was planned to fly over these sites, as well as the coastline and islands between sites to detect new or previously unknown haulout sites. Three deHavilland Twin Otter 300 aircraft simultaneously covered either:

1. The eastern coast of Baffin Island,
2. Southern Baffin Island, Southampton Island, and the northwestern part of the Hudson Bay, or

3. The south coast and large islands (Nottingham, Salisbury, and Mills Islands) of Hudson Strait, as well as the northern part of Hudson Bay (Mansell, Coats, and Walrus islands).

The survey was conducted from September 1st–17th, based on suggestions received during previous community consultations (Hammill et al. 2016).

Aircraft were flown at a target altitude of 1000 feet (305 m) and a speed of 100 knots (185 km/h). Each aircraft was equipped with two Nikon D800 camera with Zeiss 35 mm lens, installed in the belly of the aircraft, and aimed to the right and left of the track line at an angle of 27.2° from the nadir, resulting in an image swath of 425 m on each side of the aircraft. The camera system, controlled by a laptop computer, was set to take one image every 3 seconds, leading to an overlap of ~17% between successive photos. The flightpath was continually adjusted to keep the coastline in the camera field of view.

The survey crew consisted of two observers stationed on each side of the aircraft looking through bubble windows located at the second seat row. Additional local observers, when available, sat in the last seat row bubble window on the shoreward side to enhance walrus detection. One of the main observers also acted as navigator/camera operator during the flight.

The position and altitude of the aircraft were recorded every second with GPS devices (Garmin GPSMap78s and Bad Elf GPS pro) connected to the navigation system and the cameras. GPS information was directly embedded in each photo, allowing georeferencing of the observations. If walruses were spotted, the observer recorded the time of the sighting and an estimate of the number of animals detected. When photographic coverage of the area where the walruses were seen was incomplete, the aircraft circled back and flew over the area again.

PHOTO ANALYSIS

Owing to the large number of images taken during the survey, a triage approach was used to select the photographs to be examined for walruses. First, walrus were counted in photographs taken at times observers had reported seeing animals. Next, photographs taken at previously known haulout sites were scanned even if no observation was recorded during the survey. Starting with the photograph taken either at the time of the observation or at the haulout site, photograph readers counted every walrus visible on the current image and on the previous and next 10 photos. If a walrus was detected in one of these images, the previous and next 10 photographs were checked, and so on, until no new walruses were detected. The process was repeated for each observation and known haulout site. Three readers processed the photographs (I.S., R.M., P.R.); however, ~95 % were read by one reader (I.S.). Due to time constraints and the large number of photographs to be read, multiple counts by different readers could not be completed, and inter-reader variability was not assessed.

COUNT ANALYSIS

Even with three aircraft, the large area to be covered and poor weather conditions did not allow the survey to be completed in a short timeframe. Walrus movements into or out of areas surveyed on different days could therefore have resulted in animals being counted twice or missed. Information about site fidelity and walrus movements in Canadian waters, particularly potential movements among haulout sites, is lacking. We considered that animals were able to move randomly among haulout sites, and counts conducted at the same site but separated by more than 24 hours were considered independent. Multiple counts resulting from the repositioning of the aircraft to ensure optimal coverage of a haulout site were not considered to be independent, and the highest count was kept in those cases.

The number of walrus observed during the survey provides an estimate of the hauled out population. The proportion of the total population occurring at haulout sites at the time of the survey is unknown (Stewart et al. 2013, 2014a, 2014b), and some animals hauled out may have been missed. The latter point was considered negligible as counts were obtained from photos and detection was considered equal to 1 (Stewart et al. 2014b, Hammill et al. 2016).

Generally, three methods have been used to estimate walrus abundance in combination with adjustment factors considering the haulout behaviour (e.g., Johnson et al. 2007, Stewart and Hamilton 2013, Stewart et al. 2014b). The Simple Count (SC) is simply a total of hauled out animals or a mean of the counts if several surveys covered the area. The Minimum Counted Population (MCP) retains only the highest count for the calculations. Finally, the Bounded Count (BC) assumes counts are random samples from a uniform distribution between 0 and the total number of individuals that haul out at a given site, and that the difference between the true number and a count is the same as the difference between the largest count and the next largest count (Johnson et al. 2007). Doniol-Valcroze et al. (2016) tested these methods using a framework considering virtual populations with known size and mimicking the overdispersion of counts due to the correlated haulout behaviour of walruses. They concluded that the SC method using mean counts corrected by the average proportion of time hauled-out provides a reliable and unbiased estimator. Following this, when a haulout site was covered by several surveys separated by more than 24 hours, the counts were averaged. The population estimate was then obtained by dividing the mean number of walruses recorded at each site (C_{mean}) by the estimated proportion of the population hauled out (P):

$$\hat{N} = \frac{C_{mean}}{P}$$

where *P* = 0.30, the average of published values (Table 1 in Hammill et al. 2016).

Doniol-Valcroze et al. (2016) also suggested a formula for the variance of the Simple Count taking into account the relationship between the haulout behaviour of walruses and the variability in observed counts. If k is considered to be the number of counts, then:

$$var(\hat{N}) = \hat{N} \times \frac{1-P}{k\,P} \times \sigma^2$$

where σ^2 (the overdispersion factor) is equal to:

$$\sigma^2 = 1 + (\hat{N} - 1) \times rho$$

with rho being the correlation factor among walrus.

The latter was estimated to 0.26 (95% CI = 0.140–0.362) from a Bayesian model using the framework developed by Doniol-Valcroze et al. (2016) and considering Mansfield and St. Aubin (1991) data consisting of multiple counts obtained from daily aerial surveys over Walrus Island area (Figure 2) in 1976 and 1977 (Figure A1). Interestingly, the model also estimated a mean proportion of hauled out animals of 0.31 (95% CI = 0.175–0.402), supporting the average haul-out proportion obtained from the literature. The 95% Confidence limits around the population estimate were calculated considering a log-normal distribution.

RESULTS

A large majority (249/257) of the haulout sites identified in the study area were surveyed (Figure 3). Eight sites were not surveyed due to poor weather conditions or logistic constraints. Among the 249 surveyed haulout sites, 55 were considered active as walruses were observed in their vicinity (i.e., < 22.5 km from the site; Figure 3). Only three new haulout sites (defined as

> 22.5 km from a known haulout site; 53.5, 57, and 65 km respectively) were identified. Two were located in the mainland part of Nunavut, north of Southampton Island, and one was in the southwestern part of Baffin Island (~190 km west of Cape Dorset).

More than 195,000 photos were taken during the survey; however, our triage approach limited the number of examined photos to approximately 18,000, of which 94.5% were read by one reader (I.S.). A total of 34,713 walruses were counted at 52 locations, including animals at haulout sites surveyed several times, and those that may have moved between sites between surveys.

Four haulout sites were surveyed twice and one was surveyed three times with an interval greater than 24 hours between overflights (Table 2). Following the Simple Count approach, the mean of the counts was calculated for each of these haulouts. Walrus Island was overflown four times, however these multiple counts were obtained on the same day and only the largest count was retained.

While not included in the planned survey area, a large count of 804 walruses was recorded on September 16th in the southwestern part of Foxe Basin. These walruses were considered to belong to the Foxe Basin stock (Figure 1; Stewart 2008; Figure A2), and were not included in the final count for the HBDS stock.

This resulted in a total count of 13,375 walrus within the HBDS distribution area, including 1,179 individuals along the east coast of Baffin Island and 12,196 in Hudson Strait and northern Hudson Bay.

The 2017 walrus survey covered a larger area than the 2014 survey. It included the east coast of Baffin Island, which was not considered in 2014, and covered a larger portion of the northwestern part of Hudson Bay. However, contrary to the 2014 survey, the eastern Hudson Bay was not surveyed in 2017. Considering only counts in the area covered by both surveys resulted in a total of 11,554 walruses observed in 2017.

Correcting raw counts using the mean proportion of animals hauled out resulted in an estimate of 44,582 (SE = 19,698) walruses for the HBDS stock. Likewise, a population of 38,514 (SE = 19,514) walruses was estimated to occur in the area in common with the 2014 aerial survey.

DISCUSSION

The clumped distribution of walrus, in addition to an unknown and highly variable fraction of the population hauled out at any time and unknown rates of movements among haulout sites, make their enumeration particularly complex (Mansfield and St. Aubin 1991, Lydersen et al. 2008, Stewart et al. 2014a, Doniol-Valcroze et al. 2016). This survey is the first to cover most of the range of the HBDS stock in such a short time frame. A large proportion (97%) of the haulout sites identified previously were visited to increase our efficiency and enumerate the largest part of the population. A large part of the southern coast of Baffin Island was not surveyed as originally intended due to bad weather (Figure 2), but neither Inuit knowledge nor previous surveys identified important haulout sites in this area, reducing the likelihood that large numbers of walruses were missed.

Previous comparisons have shown good agreement between visual counts and concurrent photographic counts of walrus at low density (Mansfield and St. Aubin 1991, Stewart et al. 2014, Hammill et al. 2016). However, visual observers are generally overwhelmed when the density of walruses is high (group size > 30; Stewart et al. 2014b), resulting in negatively biased visual estimates. The large groups of several hundred to several thousand walrus as recorded on

Walrus, Nottingham or Trinity islands (Figure 2 and 3; Table 2) underlines the importance of using photographic counts.

The HBDS stock abundance estimate of 44,582 (95%CI = 19,485–102,004; 13,375 counted) is particularly large compared to the 7,100 animals (95% CI = 2,500–20,400; 2,144 counted) estimated in 2014 using a similar survey setup and analysis. The area surveyed in 2014, however, excluded the eastern coast of Baffin Island (1,179 animals counted in 2017) and some of the western coast of Hudson Bay covered in 2017 (642 animals in the area not covered in 2014). Nevertheless, considering only the area in common between the two surveys still results in a large, but not statistically significant, difference, with 11,554 walruses detected in 2017 and a population estimate of 38,514 (95% CI = 15,091–98,290) individuals. Walrus Island alone had counts of over 7,000 walruses in 2017, compared to ~2,600 in 2014 and 1,373–2,900 during periodic surveys from 1954–1990 (Hammill et al. 2016 and references therein). The productivity of walrus cannot explain by itself such a difference in abundance estimates separated by just three years, as the annual growth rate for this species under favourable environmental conditions with no food limitations is considered to be around 7% (Tavrovski 1971, Sease and Chapman 1988, Witting and Born 2005).

In analysing the counts from this survey, we have assumed walrus movements among haulout sites (if any occurred) surveyed on separate days were random, such that the counts would not introduce bias in the final estimate. Previous DFO surveys (Stewart et al. 2014b, Hammill et al. 2016) have considered that walrus movements among haulout sites could be directional, which could bias estimates as animals could be counted multiple times, and used a daily travel distance of 45 km (Stewart et al. 2014b) as a criterion to assess whether counts at different haulout sites were independent. Hammill et al. (2016) determined that, with the exception of only five animals spotted at a location within 85 km of haulout sites surveyed two days previously, no adjacent haulout sites surveyed in 2014 were close enough to have allowed for any walrus movements among them. Therefore, whether walrus movements were considered to be directional or random had no bearing on the estimate from that survey. However, in 2017, Nottingham, Salisbury, and Mills Islands and the southwestern coast of Baffin Island were surveyed multiple times from September 7 to 17 (Table 2), enough time to have allowed walrus to move between the sites. Assuming any such movements were directed, rather than random as we have done here, and discarding counts at subsequent sites that could have represented individuals that were counted more than once, would have resulted in a count of 12,601 walruses for HBDS area. Although this count is lower than our count of 13,378 walruses assuming random movements among sites (in which case multiple counts of same sites were averaged, rather than discarded), the magnitude of the difference (< 10 %) is not great enough to account for the relatively large difference in counts between the 2017 and 2014 surveys.

The proportion of a walrus population hauled out at terrestrial sites can vary substantially within and among years (Lydersen et al. 2008, Udevitz et al. 2009, Stewart et al. 2014b), and large variability in the numbers of walrus hauled out at specific sites has previously been observed in our study area (Figure A1; Mansfield and St. Aubin 1991, Hammill et al. 2016). Haulout proportions range from 0% to a theoretical maximum of 74% (Stewart et al. 2014) of the population (but see Doniol-Valcroze et al. 2016 for the impact of the population size and walrus correlated haulout behaviour on this maximum). It is possible that counts from the 2014 and 2017 surveys represent the low and high extremes of this range, respectively. While this would be consistent with the results observed, it is an unlikely explanation, as haulout proportions would be expected to converge to a long-term average over the 17-day duration of the survey (individual walruses haul out for ~1–2 days on average; Born and Knutsen 1997). Other studies have shown regional synchronicity in walrus haulout behavior that appears to be weather-driven (Fay and Ray 1968, Lydersen et al. 2008, Stewart et al. 2014b), with numbers hauled out negatively correlated with precipitation, wind direction, and wind speed, and positively correlated with air temperature (Salter 1979, Born and Knutsen 1997, Lydersen et al. 2008). Observations obtained during the 2014 survey may have resulted from such relationship. Indeed, counts over Walrus Island changed dramatically from 248 on September 11 to 2,579 individuals on September 16 while weather readings at the Coral Harbour airport located ~100 km from Walrus Island showed that wind speed was 100 km/h on September 10, subsequently reducing to 35–55 km/h between September 11 and 15 then falling below 30 km/h on September 16. Wind speeds at a weather station located at Nottingham Island during the 2017 survey do not show any noticeable prolonged periods of either favorable or poor conditions for hauling out (although interestingly, wind speeds on September 10 [50 km/h] were higher than on September 17 [10 km/h], which is the reverse pattern of the count totals at haulouts in that area on those two dates; Figure 4). Ideally, survey-specific adjustment factors would be developed from walrus haulout patterns determined using satellite tags or stationary cameras set up to monitor haulout activity over the duration of the survey. Unfortunately, walruses were not satellite tagged during either the 2017 or 2014 surveys, and the camera system at a Nottingham Island haulout site did not capture the primary area occupied by walruses.

The difference between 2014 and 2017 counts could also reflect a shift in distribution of walrus in Canadian waters. The east coast of Baffin Island was not covered in 2014 and one could argue that a large number of animals may have been present in this area at this time and later redistributed in 2017. However, our 2017 count and abundance estimate for this area (1,201 and 4,003 [95% CI = 1.201–15,443], respectively) are also higher than the count and minimum estimate (1,051 and ~2,500 [95% CI = 1,660–3,345], respectively) for the same area in 2007 (Stewart et al. 2014a). Another explanation for the different counts between the two surveys is the possible inclusion of a large number of animals from other walrus stocks in the 2017 counts. Movement of walrus from the south and east Hudson Bay stock, estimated at 200 individuals (95% CL = 70–570), would not have had a large impact on the HBDS survey results. However, the Foxe Basin (FB) stock, estimated to have at least 8,200 to 10,400 animals (Stewart et al. 2013), could have contributed significantly to the difference. The spatial limit separating the FB and HBDS stocks is not clear. The map presented by Hammill et al. (2016; Figure 1) showed that both FB and HBDS stocks share a common boundary in the southern part of Foxe Basin. Stewart (2008), however, suggested that the two stocks are clearly separated, with FB walruses located in the northern part of Foxe Basin near the communities of Igloolik and Hall Beach, and HBDS walruses hunted in the northwestern part of their range mainly found further south, close to Naujaat (previously called Repulse Bay; Figure 1 in this study and Figure 5 and 6 in Stewart 2008). In this study, we considered the 804 walruses detected near Cape Wilson (located in between these two areas) to belong to the FB stock; however, more information is needed to ensure these numbers were assigned to the correct stock. A genetic study from Shafer et al. (2014) found that FB and HBDS stocks were only moderately differentiated, suggesting these stocks may not be completely isolated. Members of the Hunters and Trappers Association in Hall Beach believe that FB walruses may undertake long-distance movements into northern Hudson Bay and Hudson Strait (personal communication to CJDM). The movement of animals between Greenland and Canada (e.g., Dietz et al. 2014) underlines that this species is capable of undertaking long-distance movements, therefore the possibility of movement/exchange between the HBDS and Foxe Basin stocks is quite possible.

Finally, walrus at a majority of the haulout sites exhibited a flight response to the approaching aircraft, with sometimes a large part of hauled out walruses entering the water by the time the aircraft was directly overhead and photographing the haulout site. A second or third flyover was occasionally necessary to clearly capture walruses on photos, increasing the proportion of animals in water. Although previous walrus surveys have excluded walrus in water from their counts as the adjustment factor later applied to estimate abundance should account for those animals, that was not an option in cases where it was clear that the majority of walruses in the water had been hauled out. However, in counting all the walruses in the immediate water around the terrestrial site, we inevitably included an unknown number of walrus that had already been in the water in our counts. This would impart a positive bias in our estimates, as the counts were adjusted by the proportion of animals assumed to be hauled out (0.30), thereby effectively double-counting animals that were already in the water. While we cannot estimate the size of this positive bias, the largest counts in the survey were obtained on Walrus Island, where 95% and 80% of the counted walrus were on land during the first and second pass, respectively. The 7,000+ animals counted at this site make up over half the entire stock count, thereby limiting the effect discussed above. Moreover, the most recent survey of the HBDS stock in 2014 followed the same protocol as we have here (Hammill et al. 2016), and so the large difference between the abundance estimates of the two surveys is unlikely related to this issue. To avoid including animals that were already in the water in the counts, a maximum distance from a haulout site beyond which counting should be stopped should be decided upon. However, the application of this approach is challenging as, in several cases, the land is not visible on the photos and not all land is a potential haulout site. In future aerial surveys, the altitude at which aircraft are flown should balance the needs of acquiring photos of suitable resolution to discern individual walruses while causing minimal disturbance.

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TABLES

Table 1. Site, survey dates and photographic counts of walrus detected in the area covered by both the 2017 and the 2014 surveys.

Site	Count	Date
Walrus Island, Pass 1	7,294	2017-09-06
Walrus Island, Pass 2	7,207	2017-09-06
Walrus Island, Pass 3	4,493	2017-09-06
Walrus Island, Pass 4	6,753	2017-09-06
Coats	7	2017-09-06
Southwest Baffin Island (Site 1)	23	2017-09-07
Southwest Baffin Island (Site 2)	867	2017-09-07
Southwest Baffin Island (Site 3)	1,135	2017-09-07
Hudson Strait – Maiden Island, Pinnacle Islands	16	2017-09-16
Hudson Strait – Wales Island	2	2017-09-16
Hudson Strait – Nottingham, Pass 1	1,120	2017-09-10
Hudson Strait – Nottingham, Pass 2	1,933	2017-09-17
Hudson Strait – Salisbury, Pass 1	39	2017-09-10
Hudson Strait – Salisbury, Pass 2	122	2017-09-17
Hudson Strait – Very little island east of Salisbury, Pass 1	77	2017-09-10
Hudson Strait – Very little island east of Salisbury, Pass 2	744	2017-09-17
Hudson Strait – Mills, Pass 1	24	2017-09-10
Hudson Strait – Mills, Pass 2	3	2017-09-17
Hudson Strait – Mills Island (in water), Pass 3	8	2017-09-07
East Southampton	9	2017-09-06
Northeast Southampton	1	2017-09-14
Northwestern Hudson Bay – Uglialuk Islands	127	2017-09-15
Northwestern Hudson Bay – NW tip of Ile Vansittart (Nagjuttuuq)	44	2017-09-11

Table 2. Site, survey dates and photographic counts of walrus detected.

East Baffin Bay

Site	Count	Date
East Monumental Island	6	2017-09-11
80 km west of Monumental Island	3	2017-09-11
Islands south east Allen Island – North West Rogers Island, Pass 1	221	2017-09-11
Islands south east Allen Island – North West Rogers Island, Pass 2	312	2017-09-16
Tip Breevort Island	8	2017-09-11
Lemieux Islands	1	2017-09-11
West Hozier Islands	205	2017-09-08
Island located west of Leybourne Island	2	2017-09-08
Ujuktuk fjord	4	2017-09-05
Aktijartuka Fjord	37	2017-09-05
Cumberland sound North	1	2017-09-06
Little islands – Northeast Leopold island (not Prince Leopold)	351	2017-09-06
Between Ilikok Island and Muingmak Island	2	2017-09-06
North Kekertaluk Island	3	2017-09-06
Between Kekertaluq and Kekertuq Islands	3	2017-09-06
Kekertuq Island	97	2017-09-11
Akuglek Island	24	2017-09-11
Clefane Bay entrance	101	2017-09-11
Exeter sound	62	2017-09-11
Kekertaluq Island	2	2017-09-17

Hudson Strait and Northern Hudson Bay

Site	Count	Date
Hudson Strait - Maiden Island, Pinnacle Islands	16	2017-09-16
Hudson Strait - Wales Island	2	2017-09-16
Hudson Strait – Nottingham, Pass 1	1,120	2017-09-10
Hudson Strait – Nottingham, Pass 2	1,933	2017-09-17
Hudson Strait – Salisbury, Pass 1	39	2017-09-10
Hudson Strait – Salisbury, Pass 2	122	2017-09-17
Hudson Strait – Very little island east of Salisbury, Pass 1	77	2017-09-10
Hudson Strait – Very little island east of Salisbury, Pass 2	744	2017-09-17
Hudson Strait – Mills Island, Pass 1	24	2017-09-10
Hudson Strait – Mills Island, Pass 2	3	2017-09-17
Hudson Strait – Mills Island, Pass 3	8	2017-09-07
Baffin Island – Kingait – Trinity Islands	1,120	2017-09-07
Baffin Island – Kingait – Outside Schooner Harbour	3	2017-09-07
Baffin Island – Kingait – Alarvittuq	12	2017-09-07
Baffin Island – Nuvujuaq – Little Island SW Finnie Bay	867	2017-09-07
Baffin Island – Nuvujuaq – Qikiqtakutaak	22	2017-09-07
Baffin Island – Nuvujuaq – Ulliit	1	2017-09-07
Coats Island	7	2017-09-06

Site	Count	Date
Walrus Island, Pass 1	7,294	2017-09-06
Walrus Island, Pass 2	7,207	2017-09-06
Walrus Island, Pass 3	4,493	2017-09-06
Walrus Island, Pass 4	6,753	2017-09-06
East Southampton – East Stanley Harbour	9	2017-09-06
North Southampton – Duke of York Bay – Nias Island	1	2017-09-14
Northwestern Hudson Bay – Fairway island	7	2017-09-15
Northwestern Hudson Bay – Ikaariarvik reef	357	2017-09-14
Northwestern Hudson Bay – Uglialuk Islands	127	2017-09-15
Northwestern Hudson Bay – NW tip of Ile Vansittart (Nagjuttuuq)	44	2017-09-11
Northwestern Hudson Bay – Itirjuk (site 1)	5	2017-09-11
Northwestern Hudson Bay – Itirjuk (site 2)	9	2017-09-11
Northwestern Hudson Bay – Moyle bay	261	2017-09-11
Northwestern Hudson Bay – East Moyle Bay	3	2017-09-13
Northwestern Hudson Bay – Big island W of Owlitteeweek Island – Cap Wilson	804	2017-09-16

FIGURES

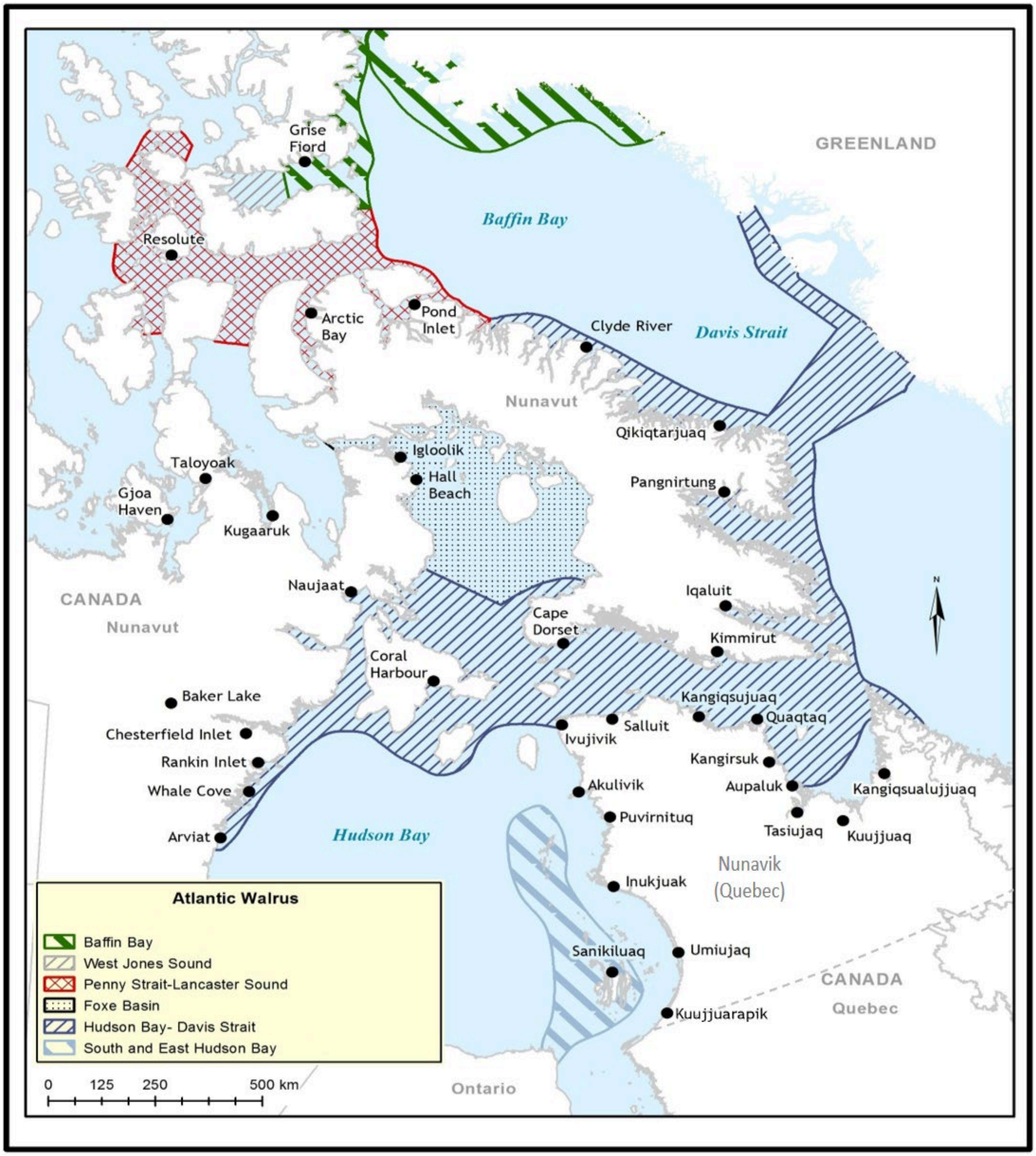

Figure 1. Range of Atlantic walrus stocks in the eastern Canadian Arctic. Map from Hammill et al. 2016. The stock of concern in the current survey is the Hudson Bay–Davis Strait stock.

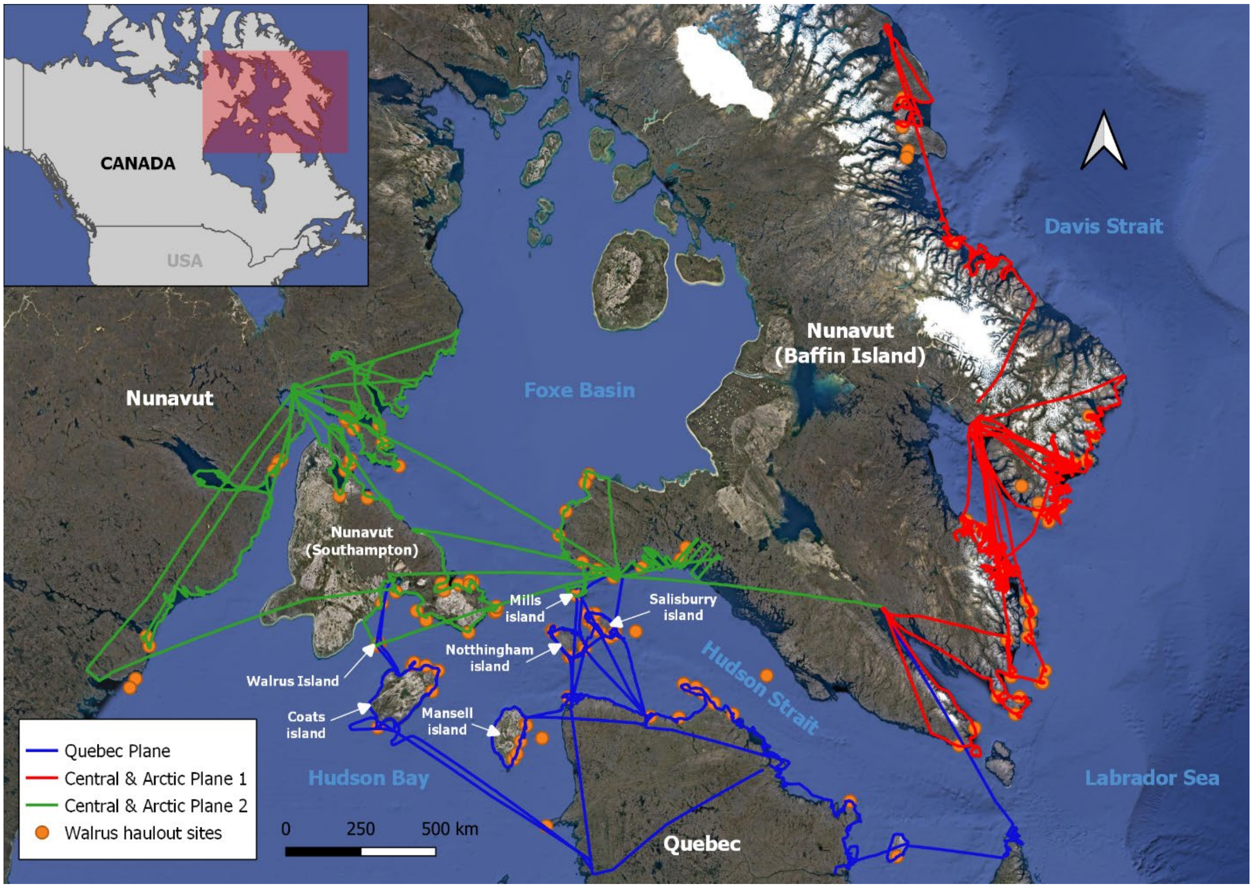

Figure 2. Survey tracks flown by the three aircraft during September 2017 along with locations of known walrus haulout sites obtained from previous surveys and discussions with Inuit hunters.

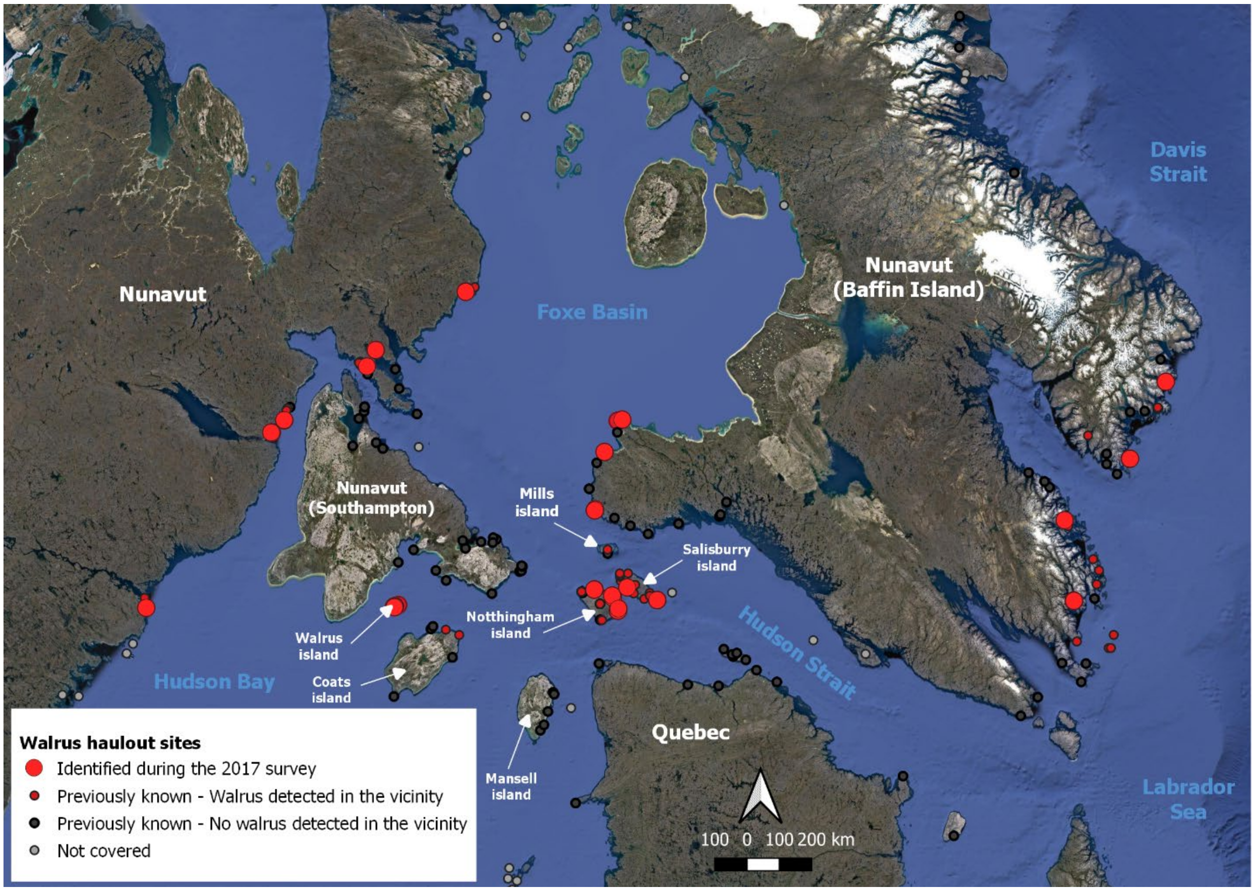

Figure 3. Location of new and previously known walrus haulout sites along with their use as observed during the 2017 survey. The vicinity of a haulout site was defined as a range of 22.5 km around it, considering that a walrus can travel 45 km/d (Stewart et al. 2014b) and thus can move back and forth to the haulout in the same day. Haulout sites identified during the survey correspond to locations where walrus were seen on land on the photographs.

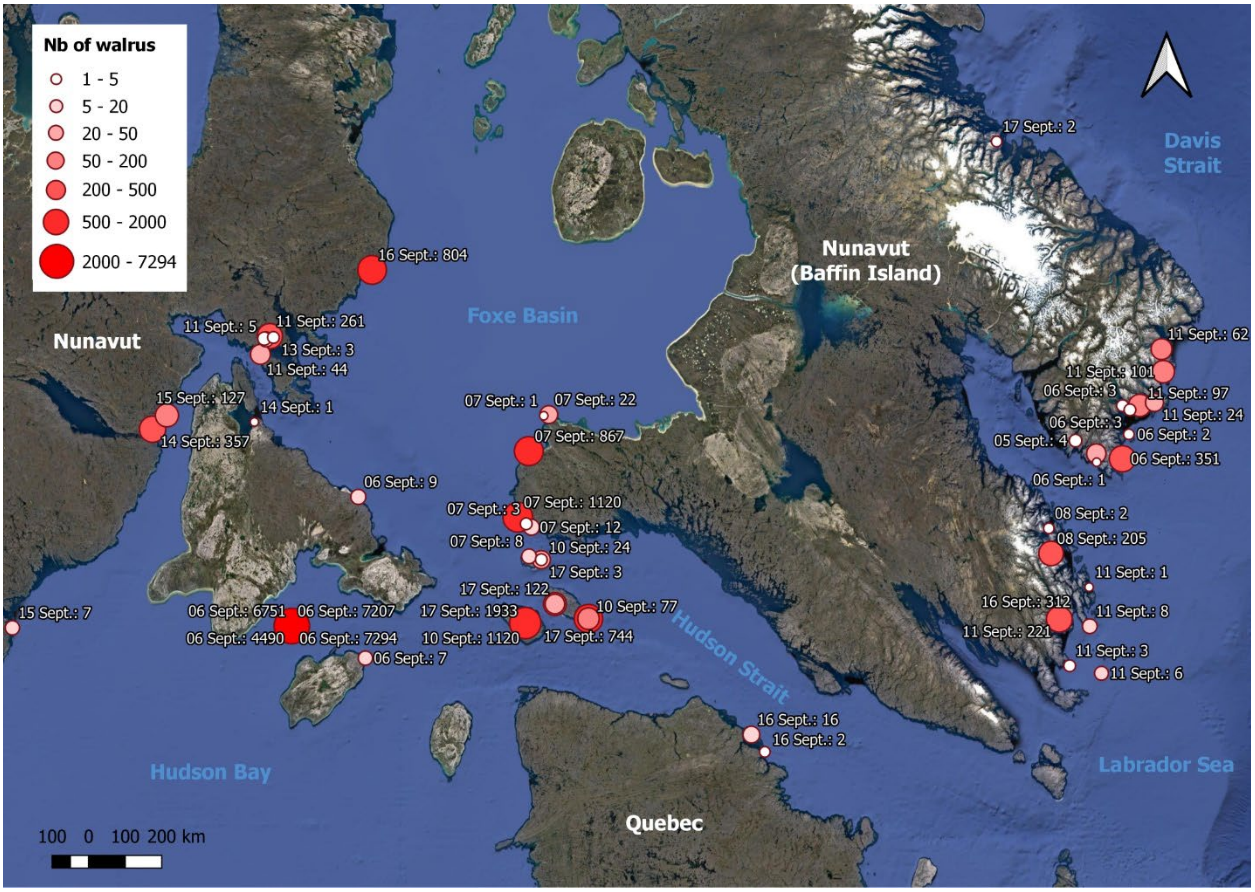

Figure 4. Counts of walrus obtained from the photographs taken during the September 2017 walrus survey.

APPENDIX

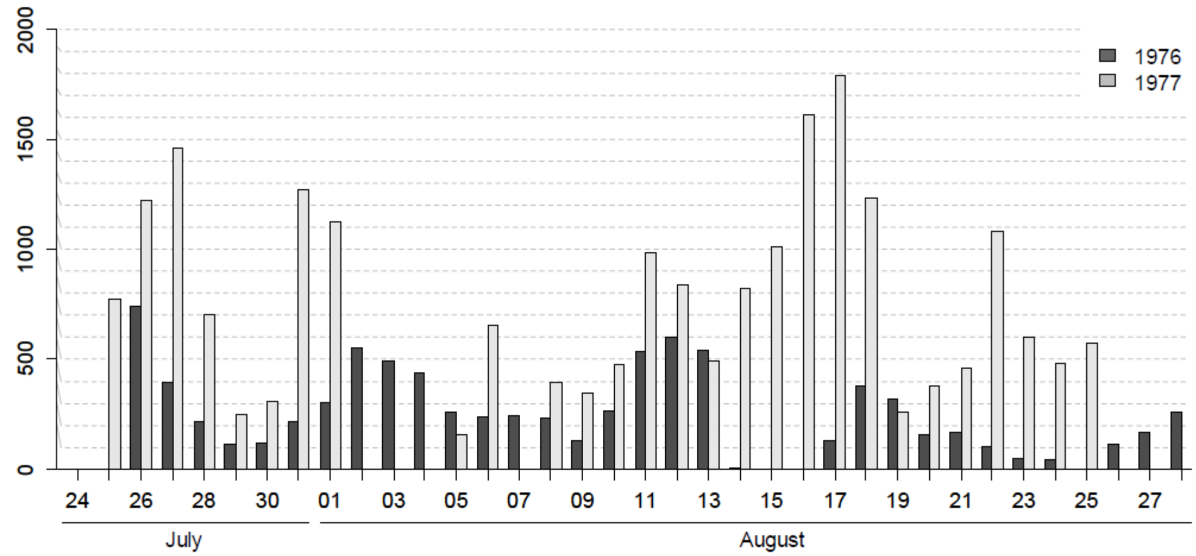

Figure A1. Maximum daily counts recorded at a haulout site on eastern Coats Island in 1976 and 1977 from Mansfield and St. Aubin (1991). In Doniol-Valcroze et al. 2016.

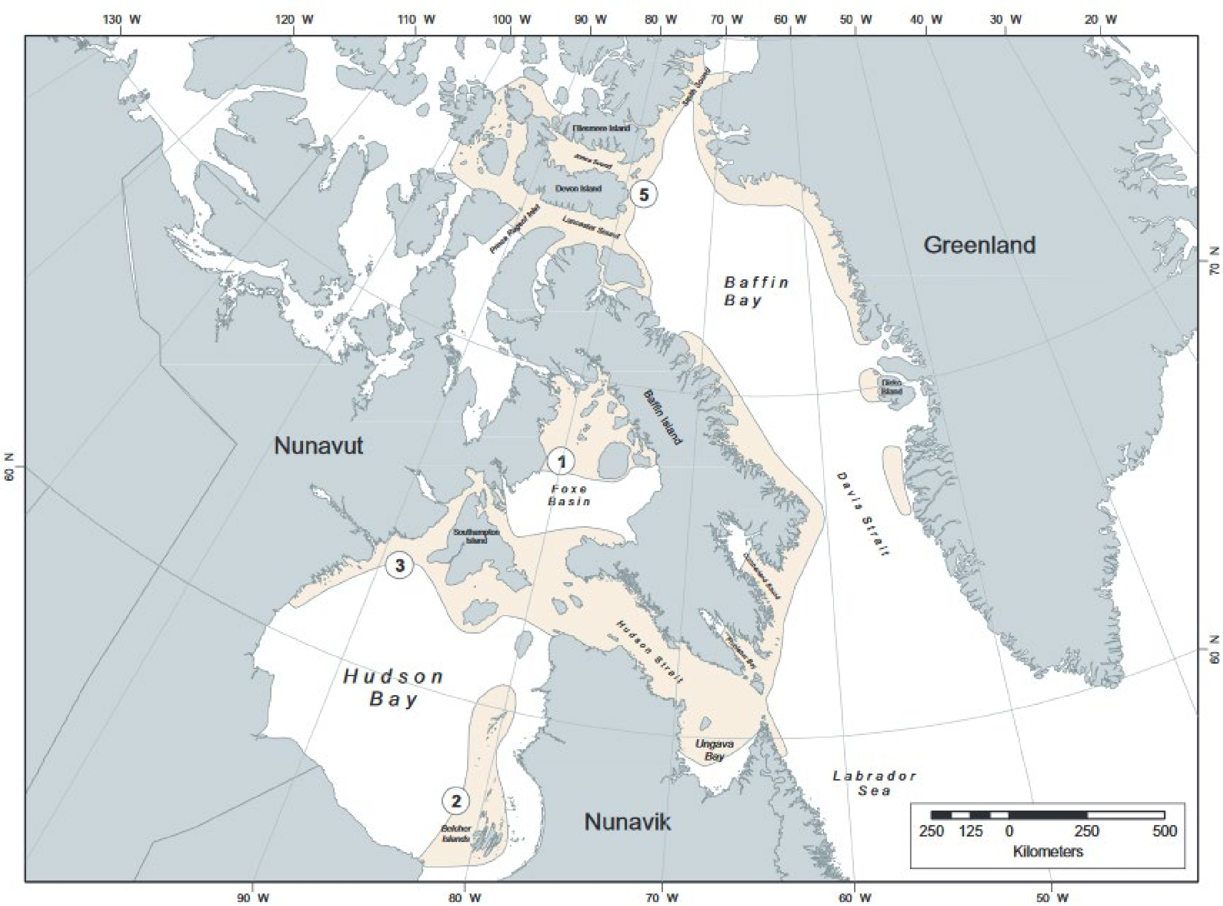

Figure A2. Range of putative walrus stocks in Canada (redrawn from Born et al 1995 in Stewart 2008).