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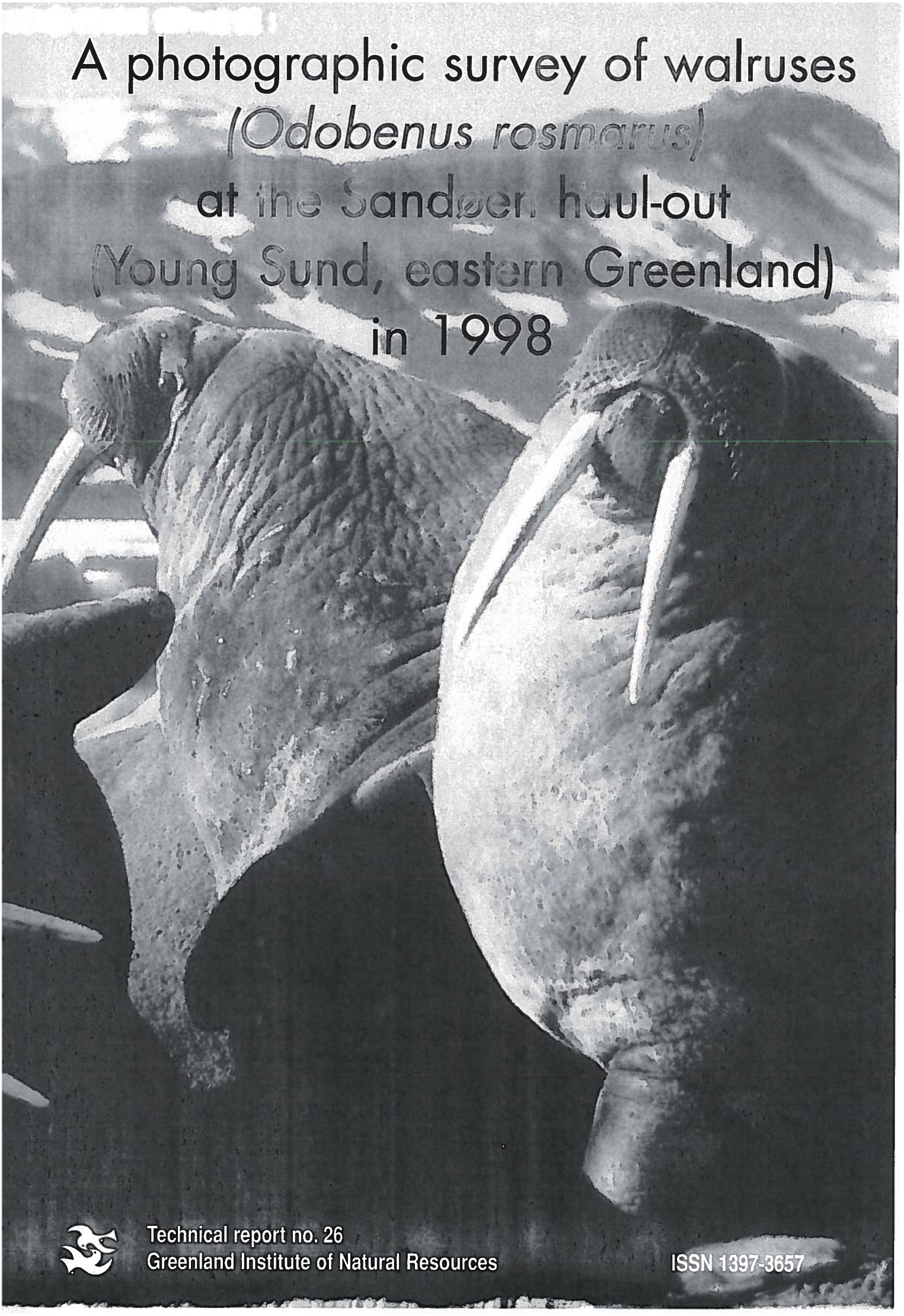

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Authors: E.W. Born and T.B. Berg

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Tlf.: (+299) 32 10 95
Fax.: (+299) 32 59 57

A photographic survey of walruses (*Odobenus rosmarus*) at the Sandøen haul-out (Young Sund, eastern Greenland) in 1998

by

E.W. Born[1] and T.B. Berg[2]

[1] Greenland Institute of Natural Resources, P.O. Box 570, DK-3900 Nuuk, Greenland
[2] Danish Polar Center, Strandgade 100H, DK-1401 Copenhagen, Denmark

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Abstract

During 26 July - 26 August 1998 an automatic camera was used for photographing walruses (*Odobenus rosmarus*) at a terrestrial haul-out in eastern Greenland (*i.e.* the Sandøen, 74° 15′ 30″ N, 20° 18′ 00″ W, in Young Sund). The objectives of the study were (1) to determine the feasibility of using time-lapse photography for recording of walruses at a haul-out and (2) to determine the numbers hauling out on one of only two terrestrial sites in Greenland where walruses regularly haul out. During the study period a photo was taken at six hours intervals of the southern tip of Sandøen where the walruses usually haul out. On average the estimates of the numbers obtained from analysis of the photos by a person experienced in observing walruses were 16% higher than those obtained by a less experienced observer. On 26 July a total of 28 walruses were counted by researchers on the site whereas a maximum of 16 were estimated from photos taken later the same day. Maximum count was 18 on 29 July. After 5 August the numbers hauling out decreased substantially. It is unclear whether this decline represented natural behavior or was a reaction to human-induced disturbance. It is concluded that registration of walruses by use of an automatic camera is feasible provided that (1) the camera is placed sufficiently high to ensure that all walruses in a herd are detectable and (2) that some direct counts *in situ* are made to verify the accuracy of the photographic registration.

Naalisagaq

1998-imi juulip 26-aniit aggustip 26-anut Tunumi Young Sundimi Sandømi (74° 15′ 30″ Av, 20° 18′ 00″ Ki) aarrit amerlassusaat naatsorsorniarlugit assiliissut immineq ingerlasoq atorneqarpoq. Siunertaavoq nalilissallugu (1) aarrit qassimaffianni immineq ingerlasumik assiliinerup atorluarsinnaassusia, aamma (2) Kalaallit Nunaanni maanna qassimaffiit atorneqartut marluusut aappaanni aarrit amerlassusaat nalilissallugu. Nalunaaquttapakunnerini arfinilinni assiliiviup Sandøp kujataatungaa aarrit sikoqanngiffiup nalaani qassimaffigikkajugaat assilisarpaa. Inuk misissuinermik misilittagaqartoq misilittagaqanngitsuminngarnit assit najoqqutaralugit aarrinik 16%-inik amerlanerusunik kisitsivoq. Juulip 26-ani Sandømi aarrit ataatsimoortut 28-usut kisinneqarput, ullorli taanna asseq najoqqutaralugu amerlanerpaamik uumasut 16-it kisinneqarlutik. Assini aarrit kisinneqartut amerlanerpaat 18-iupput, juulip 29-ani. Aggustip 5-anniit uumasut ikileriangaatsiarput. Erseqqissumik ilisimaneqanngilaq nalinginnaasumik pissuteqartumik nikinnerunersoq imaluunniit tamaani inuit najuunnerannit akornusersorneqarnermik peqquteqarnersoq. Immineq ingerlasumik assiliiviup aarrinik nalunaarsuinera periaasiuvoq atorluarneqarsinnaasoq uku naammassineqarpata, (1) assiliivik nunamit qutsinnerusumut inissinneqassasoq uumasut tamarmik takuneqarsinnaassallutik aamma (2) nalunaarsuinerup nalaani sumiiffimmi kisitsinerit arlallit ingerlanneqassasut amerlassutsit assimi takuneqartut piviusumi amerlassutsinut sanilliunneqarsinnaaqqullugit.

Resumé

Fra d. 26. juli til og med d. 26. august 1998 anvendtes et digitalt kamera til at registrere antallet af hvalrosser på Sandøen (74° 15′ 30″ N, 20° 18′ 00″ W) i Young Sund i Østgrønland. Formålet var at vurdere (1) anvendeligheden af automatisk foto-registrering på en landgangsplads for hvalrosser, og (2) antallet af hvalrosser på den ene af kun to tilbageværende landgangspladser i Grønland. Hver 6. time tog kameraet et foto af den sydlige del af Sandøen, hvor hvalrosserne sædvanligvis ligger på land i åbentvandssæsonen. En person med erfaring i observationer af hvalros talte i gennemsnit 16% flere hvalrosser på fotogra-

fierne end en mere uerfaren. Den 26. juli optaltes i alt 28 dyr i flokken på Sandøen, mens der på et foto fra samme dag optaltes maksimalt 16 dyr. Det største antal hvalrosser, der optaltes på fotografierne, var 18 stk. den 29. juli. Efter den 5. august faldt antallet af dyr markant. Det er ikke klart, om denne nedgang repræsenterede en naturlig variation eller var en reaktion på forstyrrelse pga. menneskelig aktivitet i området. Automatisk fotoregistrering af hvalrosser er en anvendelig metode forudsat, (1) at kameraet befinder sig så højt over jordens overflade, at alle dyr i en gruppe kan ses, og (2) at der i løbet af registreringsperioden foretages nogle optællinger på stedet for at klarlægge forholdet mellem antallet der ses på fotografierne og det egentlige antal.

Introduction

During summer walruses are dependent on having access to a platform (*i.e.* ice or land) for hauling out and resting. During the season with minimum ice cover (August-September) they usually haul out at terrestrial sites (*e.g.* Salter, 1979; Born and Knutsen, 1997). Apparently walruses forage intensively during the short inshore season (*e.g.* Born and Knutsen, 1990, 1992), and therefore terrestrial haul-outs are situated in close proximity to shallow-water foraging areas (*cf.* Born *et al.*, 1995).

Although that walruses have been observed on land in several places in eastern Greenland there are only two terrestrial sites where they regularly haul out during summer: Sandøen (74° 15′ N) at the entrance to Young Sund and Lille Snenæs (76° 52′ N) in Dove Bugt (Born *et al.*, 1997); Fig. 1. Both these sites, which in fact are the only terrestrial haul-outs in the whole of Greenland, are situated close to good walrus foraging habitats within the National Park of North and East Greenland (Born and Knutsen, 1997; Born *et al.*, 1997; Rysgaard *et al.*, 1998).

Walruses in eastern Greenland belong to a genetically separate entity (Andersen *et al.*, 1998) which is estimated to number about 1000 individuals (Born *et al.*, 1997). During the period 1952 - 1995 the number of walruses observed at Lille Snenæs increased by about 5% per year, perhaps reflecting an overall population growth since the partial protection of walruses in 1956. A similar, but non-significant trend, was indicated by observations made at Sandøen (Born *et al.*, 1997). Due to their habit of using the same terrestrial sites each year trends in a walrus population may therefore be detected from annual counts at haul-outs.

Since 1993 the Young Sund area has been focus of a study to determine the influence of climatic factors on the productivity of the marine, arctic ecosystem including benthic communities (*e.g.* Rysgaard *et al.*, 1998). Walruses predate on the benthic fauna in the Young Sund area and therefore their role as consumers has to be determined quantitatively. The number of walruses in this area may possibly be determined from studies at the Sandøen haul-out.

However, various factors (*e.g.* weather conditions) cause the number of walruses at a haul-out on any particular day to fluctuate (*e.g.* Hills, 1992; Born and Knutsen, 1997). Hence, to obtain a representative estimate of the number of animals using the haul-out in a particular season it has to be surveyed continuously. However, for practical and economical reasons this may not be possible in which case automatic photographic surveillance may be feasible. In Greenland this method has previously (1995 - 1997) been used to determine the numbers and the haul-out activity of a small group of harbor seals (*Phoca vitulina*) at Kangerlussuaq (Søndre Strømfjord) in western Greenland (Lisborg and Teilmann, 1999).

During 26 July - 26 August 1998 time-lapse photography was used to record the numbers and the haul out activity of walruses on Sandøen. In this report we present the results of this study.

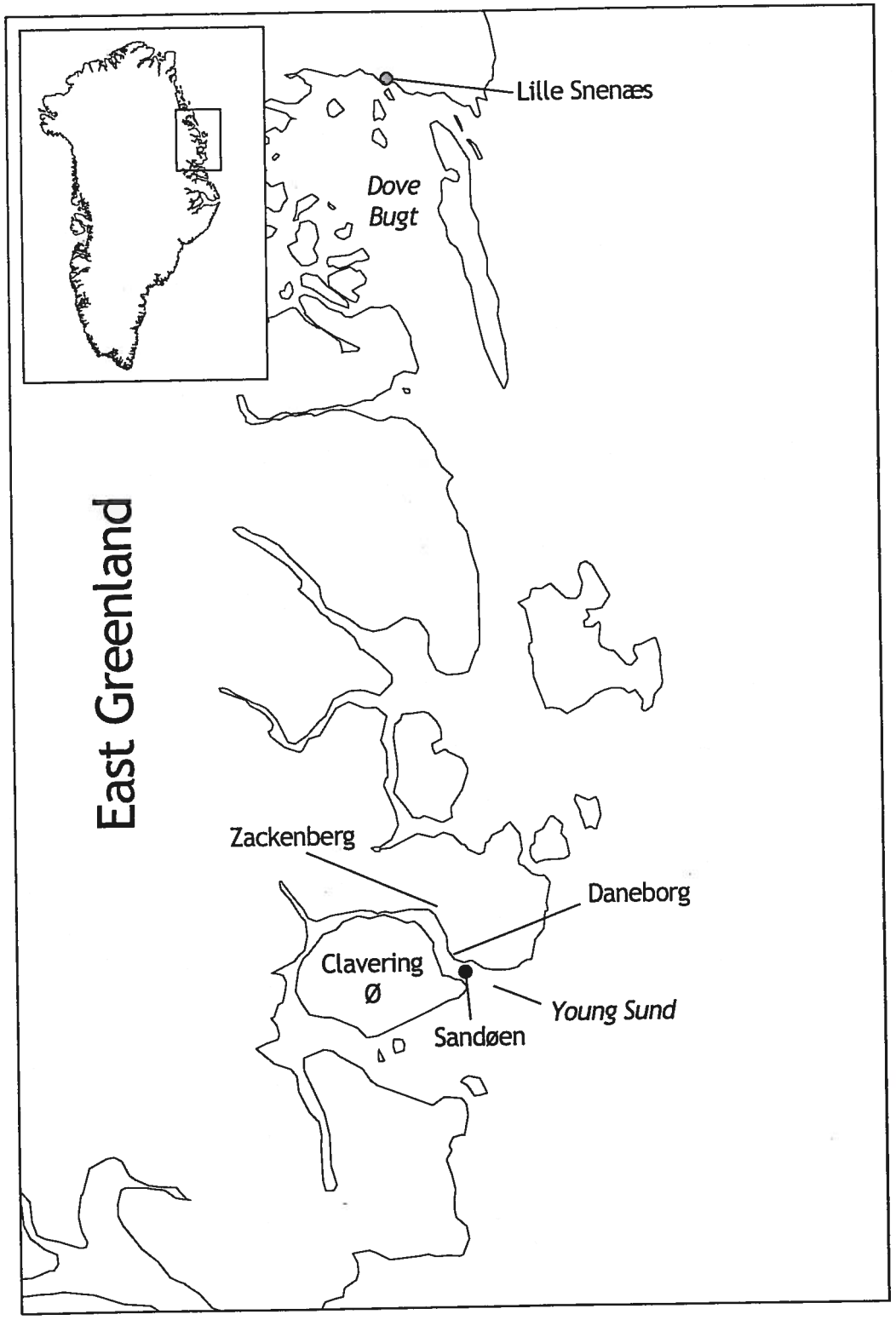

Fig. 1. Location of Sandøen (74° 15′ N, 20° 18′ W) in Young Sund and Lille Snenæs (76° 52′ N, 19° 38′ W) in Dove Bugt. These are the only regularly used terrestrial walrus haul-outs in Greenland.

Material and methods

Collection of data in the field

Between 00 h (local time) on 26 July and 06 h on 26 August 1998 walruses were photographed by use of an automatic camera which was placed on Sandøen ("Sand Island"; 74° 15′ 30″ N, 20° 18′ 00″ W) about 6 km SE of the Daneborg military detachment (fig. 1). This island is approximately 1.3 km long and 0.5 km wide and is flat (highest elevation about 4 m above maximum tide mark). The beaches, which consist of relatively fine-grained sand, are particularly low on the southern tip of Sandøen.

A digital camera (Kodak DS-50 with a 28 - 80 mm lens, default setting at 35 mm) was placed on the southern tip of the Sandøen where walruses regularly haul out between July and September (*cf.* Born *et al.*, 1997). The camera was encased in a box of transparent plastic to protect it from rain and wind and was mounted on a 1.60 m high tripod. Power was provided via a rechargeable 12 V battery which was charged by two small solar panels that were placed on the top of the box. The camera was equipped with a 30Mb PCMCA-card allowing for 360 digital photos to be stored. The camera was programmed to take one photo at 6 h intervals (00, 06, 12 and 18 h local time = UTC/GMT).

The camera pointed southwest overlooking that part of the beach where walruses hauled out on 26 July, and where drag marks and other signs indicated that they had hauled out recently. Using the body length of a walrus (ca. 3 m) as a scale it was estimated that about 75 m from the camera the photographs covered an about 100 m wide zone (including some sea) (Plate I, A). Judged from the photos the camera was able to register walruses on land out to a distance of about 150 m.

Using PhotoEnhancer for Kodak (Version 2.1) the pictures were saved in JPEG-format at maximum size on a Windows-based computer.

Weather information (wind speed and direction, and temperature) recorded at 3 h intervals at Daneborg was obtained from the Danish Meteorological Institute (DMI, Copenhagen). Walruses on land are sensitive to the cooling caused by a combination of wind and low temperatures ("wind chill") (*e.g.* Born and Knutsen, 1997). Indices of wind chill (kcal/m²/h) were obtained by comparing wind speed scaled to 1 m elevation (Steadman, 1971) and temperature with the normogram in Consolazio *et al.* (1963 *fide* Blix and Steen, 1979). For situations with bright sunshine (*i.e.* 0 octas cloud cover) the wind chill index was reduced by 200 kcal/m²/h (Siple and Passel, 1945; *fide* Osczevski, 1995).

Data analyses

The photos were studied at 200 x magnification on a 14"color screen of a PC (Altima Supreme II) and were categorized as either "bad", "medium", or "good" according to their technical qualities (*i.e.* brightness, sharpness, contrast, color) by an observer (= Reader 1) experienced in observations of walruses on land. In addition to the technical quality of the photo, several other factors may influence the reliability of an estimate of numbers in a herd of walruses. The estimates may be influenced by whether (1) the herd is "tight" or "loose" (*i.e.* whether individual animals are more or less easy to discriminate or some might be concealed behind others), (2) individual body contours are blurred due to reduced visibility caused by for example fog, and (3) the walruses are far away. Therefore Reader 1 evaluated the counting circumstances and provided each photo with a qualifier (low, medium, high) indicating how reliable an estimate was likely to be.

In addition to the number of animals the following information was extracted during analysis of the photos: Cloud cover (octas), precipitation or fog, sea state (Beaufort), ice

cover (%), presence or absence of stranded ice hummocks potentially blocking access to the haul-out.

Numbers of walruses were counted twice by Reader 1 with the replicate count being "blind". Where discrepancies existed between the first and the second estimate, the photo in question was counted a third time in order to reach a final estimate of the number of walruses. The photos were also "blind"-read by an observer (= Reader 2) with experience in observations of various wildlife in Greenland, but not in observations of walruses in particular. Photos, where the estimates by the two readers differed by 2 or more animals, were reanalyzed by Reader 1 who decided a final estimate of numbers.

A mean percent error difference in numbers estimated by Reader 1 and Reader 2 was calculated with analogy to Calvert and Ramsay (1998):

$$\% \text{ difference} = \frac{\frac{\Sigma N - K}{A}}{K} (100)$$

Where A = Reader 2's estimate of numbers hauled out, K = Reader 1's estimate, and N = number of photos analyzed.

There was an apparent drop in number of hauled out walruses after 5 August (Results). For tests for differences in weather conditions before and after this date cloud cover was divided into only two categories: 0 - 5/8 (= "clear sky or scattered") and 6-8/8 (= overcast). Ice cover was categorized: (1) "less than 10%" and (2) "10% or more".

Statistical analyses were made by use of the statistical software SAS (1990) and StatView (1997). The difference between replicate estimates were tested by using one-way analysis of variance (ANOVA) for categories of technical quality of the photos, and the reliability of the numerical estimate. Similar tests were made to detect differences in numbers hauled out per 6 h intervals. The ANOVA was followed by Fisher PLSD-tests for differences in mean values. Polynomial regression analyses were used to describe the curve on numbers hauling out per day during the total period, and simple regression analyses to test for trends during sub-periods. Comparisons of estimates of numbers obtained by the two readers were made using paired t-tests, and differences in frequency of weather conditions by sub-periods were detected by use of χ^2-tests.

Results

During the entire study period the camera functioned without any technical problems despite that there were days with high winds and rain.

Quality of the estimates

Of a total of 126 photos taken, 23, 30 and 73 were categorized as being technically of "bad", "medium" and "good" quality, respectively. From all photos it was attempted to estimate the number of walruses. A total of 31, 37 and 58 estimates of numbers were categorized as being of "low", "medium" and "high" reliability, respectively.

The two "blind" readings made by Reader 1 differed significantly ($t = 5.26$, $p < 0.01$, $df = 125$). This difference was not related to the technical quality of the photo ($F = 0.49$, $p = 0.61$, $df = 123/2$) but, and less surprising, to the qualifier assigned to the reliability of

numerical estimates. The difference between the first and the second estimate was substantially smaller ($F = 5.10$, $p < 0.01$, $df = 123/2$) in the best category (mean: 0.237 walrus, sd = 0.94, n = 58) than in the two other categories of reliability where the mean difference averaged about 1 walrus.

The estimates of numbers obtained by the two readers also differed significantly ($t = 6.12$, $p < 0.01$, $df = 125$). Overall, Reader 1's estimates were 16% higher than those of the other reader (fig. 2). The differences between the two readers' estimates were not related to the technical quality of the photos ($F = 0.34$, $p = 0.72$, $df = 123/2$) but to the reliability of the estimates - "counting circumstances" ($F = 9.74$, $p < 0.01$, $df = 123/2$). The difference in the best quality was significantly lower (mean = 0.271 walrus, sd = 1.06, n = 59) than in the other two categories of reliability (mean difference >/= 1 walrus). However, of 46 estimates with 0 walruses, 40 were categorized as being of "high" reliability whereas for the other estimates (n = 80), which involved one or more animals, only 19 were of the best quality. If all "0 walrus" cases were omitted from the analysis the difference by reliability was no longer significant ($F = 1.66$, $p = 0.20$, $df = 77/2$).

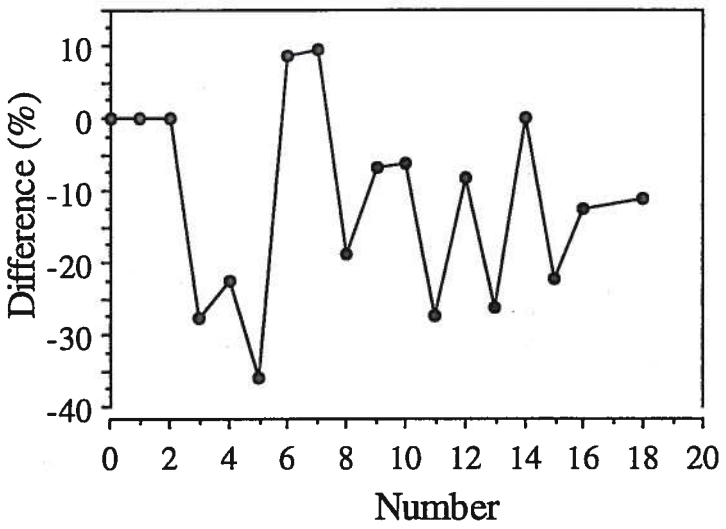

Fig. 2. Mean error difference (see Materials and methods) between an unexperienced "reader's" and an experienced reader's (Reader 2/ Reader 1) estimates of number of walruses at the Sandøen haul-out in eastern Greenland in 1998.

Numbers hauled out

Despite the uncertainties associated with estimating the actual numbers, trends in numbers hauled out were apparent.

The number of walruses decreased during the study period. Generally, more walruses hauled out prior to than after 5 August. After this date the numbers remained low and there were several periods where the walruses did not haul out on land (fig. 3). After stepwise addition of terms, optimum fit ($r^2 = 0.81$) between numbers hauling out (per interval) and day was obtained by a quartic polynomial regression model ($Y = 10.77 + 1.50X - 0.30X^2 + 0.014X^3 - 0.0002X^4$); a quintic expression did not provide a significant improvement of the model.

The highest number was 18 counted on 29 July (day 4). In connection with placing of the camera on 26 July a total of 28 walruses were counted in the herd whereas the estimate of numbers obtained from photographs taken later that day was 16 (fig. 3).

Although a decrease in numbers occurred between 26 July and 5 August (day 12) (r^2 = 0.13; t = 15.0, $p < 0.01$, n = 46) the numbers hauling out were relatively high (mean = 11.3 animals, sd = 2.88, n = 44, range: 5 - 18 animals) compared with the numbers later. After 5 August the decrease in numbers continued (r^2 = 0.17; t = 5.83, $p < 0.01$, n = 80). Furthermore, during this period there were no walruses on 57% of the photos (47 of 82) in contrast to the situation prior to 6 August where there were no "0" recordings (fig. 3). Between 6 and 26 August numbers hauled out were below seven except in one case (mean number on the beach was 1.5 walrus, sd = 1.93, n = 82, range: 0 - 7).

During the study period the walruses hauled out at three sites within the view of camera. Until 6 h on 7 August the herd hauled out at the same site which was used when the camera was placed (Site 1; Plate 1 A and B). Then followed a period where walruses were absent from the beach. At 00 h on 8 August a group of seven animals hauled out on the beach about 50 m south of the first site (site 2; Plate 1 C and D). After another period without walruses (from 21 August 12 h) two walruses were back on the beach at 12 h on 23 August on a third site about 25 m north of Site 1 (Plate 1 E and F).

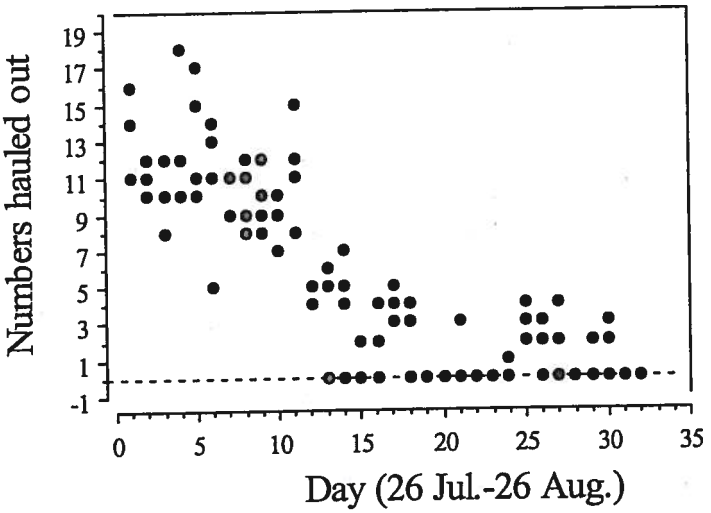

Fig. 3. Numbers of walruses hauled out per 6 h interval at Sandøen (eastern Greenland) during the period 26 July – 26 August 1998 (n = 126 photos). The numbers were low after 5 August (= day 11).

Diurnal haul out activity

Between 26 July and 5 August, when relatively many walruses hauled out, the number per 6 h interval differed significantly ($F = 4.45$, $p < 0.01$, df = 40/3). Lowest numbers (mean = 9.5) were present during afternoon (i.e. 18 h). The numbers increased until noon (mean = 13.1) when significantly more animals were hauled out ($p < 0.01$) than during the afternoon. After 5 August there was also this tendency of fewest walruses hauling out during the afternoon, but the differences between numbers per interval were not statistically significant ($p > 0.05$).

Weather conditions

Weather conditions may influence the number of hauled out walruses (*e.g.* Pankratov, 1982; Hills, 1992; Born and Knutsen, 1997). The clear temporal tendency in the numbers hauling out prevented that more sophisticated statistical analyses as for example multiple regression analyses be carried out to determine the relative influence of various environmental factors on numbers. Furthermore, the data were insufficient to carry out time series analyses (*cf.* for example Hills, 1992). Instead, to determine whether change in weather influenced the numbers on land simple comparisons were made of frequency of various weather parameters before and after the decrease of walruses on 5 - 6 August.

During the study period the daily mean temperatures (*i.e.* mean of recordings at 00, 06, 12 and 18 h) increased gradually from about 4 °C to about 6 °C. This increase, which was significant ($t = 6.90$, $p < 0.01$, $r^2 = 0.08$, $n = 94$), was particularly pronounced during day hours (*i.e.* at 12 and 18). Furthermore, the temperatures were significantly higher (Fisher's PLSD test, $p < 0.01$) during the day (mean = 5.2 °C, sd = 2.3, n = 60) than during the "night" (00 and 06 h; mean = 3.1 °C, sd = 1.7, n = 37).

The estimates of sea-state (*i.e.* index of wind force) obtained from the photos were positively correlated with wind force recorded at Daneborg ($r^2 = 0.169$, $p < 0.001$, $n = 97$). During 43% of the time (n = 100 recordings when a photo was also taken) it was calm (*i.e.* </= 1.78 m/s according to Eagan, 1964; *fide* Osczevski, 1995), and for 84% of the time the wind force was below 5 m/s (about 3 Beaufort). On 27 July and on 5, 7, 8 and 14 - 17 August there were periods with wind force above 7 m/s. For 48% of the time the winds came from E-SE (*i.e.* onshore winds at the haul-out). The frequency of periods with onshore winds was higher prior to than after 6 August ($\chi^2 = 7.85$, $p < 0.01$, $df = 1$).

Wind chill varied between 175 and 950 kcal/m²/h (mean = 639 kcal/m²/h, sd = 164) and showed no trend during the study period ($r^2 = 0.007$, $p = 0.40$, $n = 97$). There was no difference in mean wind chill ($t = -1.39$, $p = 0.167$, $df = 95$) or in frequencies of periods with comparatively high wind chill values (*i.e.* = or >700 kcal/m²/h) ($\chi^2 = 1.43$, $p = 0.23$, $df = 1$) before and after 6 August. Furthermore, there were no differences in average wind chill during the four periods of the day (Fisher's PLSD test, $p > 0.05$).

The frequency of periods with overcast ($\chi^2 = 2.80$, $p = 0.09$, $df = 1$) or fog ($\chi^2 = 1.48$, $p = 0.22$, $df = 1$) did not differ significantly before and after 6 August. However, periods with rain was only experienced after 5 August (on 8, 13 - 15, 17 and 21 August). On 10 - 12 and 14 August ice hummocks were stranded on the beach apparently without preventing the walruses from hauling out. The ice cover seen on the photos consisted of a mixture of floes of 1-year-old fjord ice, floes of thick multi-year ice likely from the Greenland Sea. Judged from the photos the ice in the vicinity of Sandøen decreased during the study period; the ice cover was significantly less after 6 August ($\chi^2 = 44.480$, $p = 0.001$, $df = 1$).

Discussion

The walruses regularly haul out on the southern tip of Sandøen, but in a few cases a limited number of animals have been observed on land in other places of the island (Born *et al.*, 1997; Berg and Forchammer, 1997). There are no reports about walruses choosing other parts of the island in 1998. It may be speculated that the walruses chose to haul out at other terrestrial sites in the area. From other years there are observations of walruses on land on the southern shores of Clavering Ø (about 30 km straight line distance from Sandøen) but regularly used haul-outs are not found within hundreds of km of Sandøen (Born *et al.*, 1997).

In a previous study instances of inter-seasonal movement of individual walruses from the Lille Snenæs haul-out to Sandøen has been demonstrated. Two individually recognizable walruses that initially were registered at Lille Snenæs were photographed in subsequent years on Sandøen and at Clavering Ø, respectively (Born *et al.*, 1997). However, whether *intra*-seasonal movements in the opposite direction may also occur, is not known.

Apparently walruses are very conservative in their choice of sites for terrestrial rests and the same "traditional" haul-outs are occupied each year (*cf.* Born *et al.*, 1995). According to Fay (1982:25), who quoted several authors, walruses that are confronted with the choice of land or ice as a resting place, tend to prefer ice. At Lille Snenæs the walruses regularly hauled out on land despite the presence of ice (Born and Knutsen, 1997). In some cases walruses were observed hauling out on ice in Young Sund in 1998. For example, on 26 August two walruses were seen on an ice floe outside Daneborg (T.B. Berg, unpublished data). However, judged from the photos the ice cover around Sandøen almost disappeared after 6 August indicating that less ice became available for hauling out. Hence, one might have expected an increased use of the terrestrial haul out, rather than the opposite.

In the only case where numbers obtained from direct observation could be compared with estimates from counting on a photo the direct count was higher by a factor of 1.75. This indicates that the counts obtained from the photos may some times grossly underestimate the numbers actually present. The most obvious explanation for this discrepancy is that some walruses in a tight group are concealed behind other individuals. Clearly, in future studies the camera has to be placed at a sufficiently high elevation to ensure detection of all individuals in the herd.

The precision of the estimates of the numbers on a photo varied. On the photos it was often difficult to determine whether a part of a body or a limb belonged to one or another individual in the group. Reader 1's previous experience from counting walruses likely explains why his estimates generally were higher than those of the other reader. The difficulty of obtaining an estimate of numbers in a group of walruses also exists when counting them in the nature. To obtain an estimate during direct observations of a group of walruses it is often necessary for the observer to get a different view of the herd or/and to wait for some movement in the group (E.W. Born, unpublished data).

Apart from these problems, there is also a fundamental uncertainty associated with determination of the actual numbers using the beach during the season. Based on observations of walruses that could be individually recognized it was concluded that the number of walruses occurring at the beach of Lille Snenæs on the "maximum-count day" was only 50% and 87%, respectively, of the actual numbers using the haul-out during August 1989 and 1990 (Born and Knutsen, 1997; Born *et al.*, 1997). Comparable proportions on peak days have been estimated at 76% and 83% in two different studies at Round Island in

Alaska (*cf.* Hills, 1992). Fourty-seven and 48 walruses were observed at Sandøen in 1991 and 1994, respectively (Born *et al.*, 1997; S. Rysgaard, pers. comm. 1999), indicating that the maximum counts of 20 - 30 animals reported in most years (Born *et al.*, 1997; Berg, 1998) represents only a fraction of the group of walruses using the haul-out.

After 5 August the numbers hauled out dropped markedly and remained low during the remainder of the study period. Walruses have not been studied systematically at Sandøen before and therefore the seasonal trend at this site is not known. Numbers reported between 1976 and 1994 by various field teams making sporadic visits to the island during the period 23 July - 31 August have been highly variable (range: 0 to 40 animals) with no apparent relationship between numbers and date of observation (Born *et al.*, 1997). Nevertheless the decrease observed in this study is surprising. At the Lille Snenæs haul-out observations during three seasons showed that the numbers increased during August (Maagaard, 1990; Born and Knutsen, 1997; Born *et al.*, 1997). A seasonal increase in numbers has also been observed at other haul-outs (*e.g.* Hills, 1992).

Pankratov (1982) found that the maximum wind speed at which walruses remained on a haul-out was about 7 m per second (approximately 4 Beaufort; Anon., 1995). On Sandøen walruses hauled out at winds speeds above 7 m/s, also before 6 August. Temperatures were highest during the day whereas wind-chill showed no diurnal trend. Hence, during the study period the weather conditions did not deteriorate markedly. Thus bad weather likely did not cause the drop in numbers after 5 August.

The photos indicated that at Sandøen the lowest numbers were found during the afternoon (*i.e.* at 18 h local). With analogy to haul out patterns in other Arctic seals (*e.g.* Finley, 1979) it might be expected that walruses tend to haul out during afternoon and evening when the incoming radiation generally is highest. On Bathurst Island in the Canadian High Arctic Salter (1979) found a tendency for walruses to haul out on the beach between about 6 and 18 h local time, and at Lille Snenæs walruses tended to haul out during afternoon and evening (Born and Knutsen, 1997).

During the study period there were several potential sources of disturbance either not far from or on the island. It can not be excluded that disturbance from human activities caused the numbers to decline during the study period. Disturbance, which likely was concentrated during work hours during the day, may also explain the drop in numbers during the afternoon.

Sandøen is situated relatively close to the Daneborg military detachment. Additionally, research stations are situated at Daneborg and at Zackenberg about 27 km west of Sandøen. In connection with the supply of these stations some ship (ocean going cargo ship, rubber dinghies with outboard engine, small-type fishing vessel) and air traffic (DeHavilland Twin-Otter and various small type helicopters) occurred in the vicinity of Sandøen during July - August 1998. During this period, photographers, tourists and researchers made several visits to the island. It has not been possible to obtain specific information about all these activities. However, between 10 July and 26 August an Ecureul helicopter made 10 flights in the Daneborg area none of which were reported by the pilots to get closer than about 5 km from Sandøen. Six of these flights were made during the period 6 to 26 August (E.W. Born, unpublished data). Between 4 and 7 August a cargo ship visited Daneborg and the ship's Hughes 500 helicopter made several local flights (T.B. Berg, unpublished). We do not know whether this helicopter got close to the walrus haul-out or not. However, on 6 August (7?) an unidentified helicopter flew over the hauled out walruses causing them to flee into the water (M. Elander, *in litt.* 1998).

Noise from small type-fixed winged aircraft and helicopters may induce escape response in hauled out pinnipeds (*cf.* Richardson *et al.*, 1995; Born *et al.*, 1995, 1999). Salter (1979) found that walruses on land reacted when a Bell 206 helicopter was about 8 km away and escaped into the water when it was about 1.3 km away. At the Lille Snenæs haul-out walruses went into the water when a Hughes 500 helicopter was about 1.5 km away upwind (Born and Knutsen, 1990). Walruses usually do not react to small boats with outboard engines before these are less than about 0.4 km away (Salter, 1979; Fay, 1981). However, drowsy walruses can sometimes be approached slowly to within 10 - 20 m in small skiffs with outboard engines (Born *et al.*, 1995). The type of reaction and the distance at which reaction is induced are related to the walruses' previous experience with noise and partial habituation may occur (*cf.* Richardson *et al.*, 1995; Born *et al.*, 1995).

With the purpose of filming walruses a team of photographers visited Sandøen and the surrounding waters several times during the period 5 to 23 August. The filming activities were reported not to cause the walruses to flee into the water (M. Elander, *in litt.* 1998). Judged from photos taken by the film crew, some of their activities brought them in close contact with walruses (< 1 m) both on land and in the water at the haul-out.

Furthermore, researchers and tourists operated in the area by use of dinghies powered with out-board engines. There is no information to quantify the potential disturbance made by these activities, which in some cases probably happened close to the island. At 6 h on 24 August five people (likely tourists) walked up close to a group of three hauled out walruses (Plate I, F).

This information indicates that during the study period the behavior of the walruses may have been influenced by various human activities, and that this activity around and at the island was intensified around 5 - 6 August.

Wildlife regulations offer walruses in these areas some protection also from disturbance. Taking effect from 1 June 1951, a decree from the Ministry for State Affairs gave protection to walruses north of 74° 24' N (Anon., 1950). By the same decree, Sandøen and a 300 m zone around the island became a game reserve to which access was prohibited. These regulations were amended in 1956 (Anon., 1956). When the National Park of North and Northeast Greenland was established in 1974 (Anon., 1976) this particular protection of Sandøen became no longer in force (*e.g.* Anon., 1987). However, the regulations still offer the Sandøen haul-out some protection. Air-traffic regulations in the National Park prohibit flying below 500 m. Furthermore, it is prohibited to disturb or provoke mammals and birds (Anon., 1987).

Concluding remarks

Our study indicated that use of a time-lapse camera is feasible for determination of walrus numbers and haul out activity. However, it appears essential that the camera be placed so that all animals in a herd can be detected. Furthermore, placing a second camera with a different angle of view may improve the method. Some direct counts *in situ* are needed to verify the accuracy of the photographic registration.

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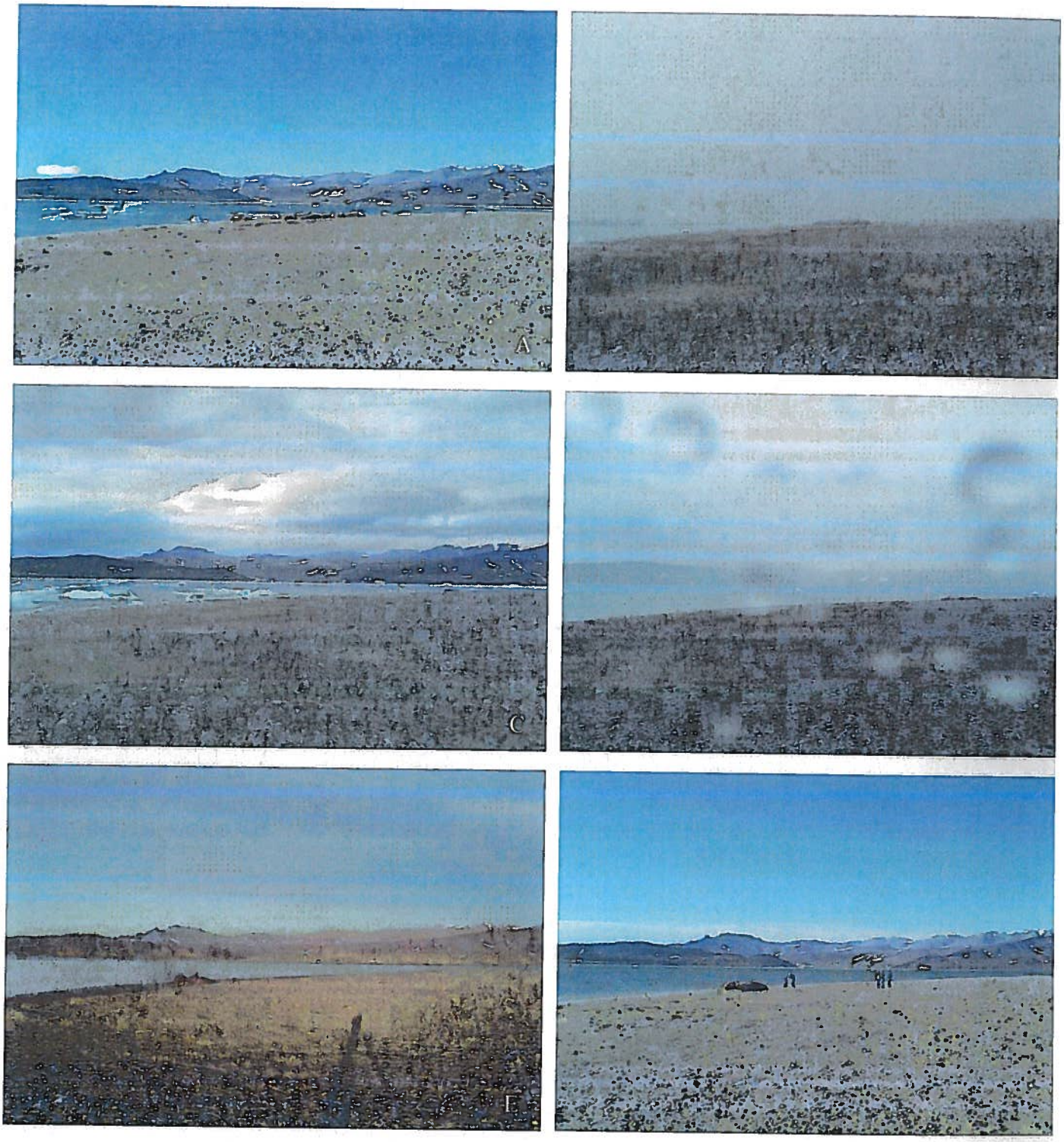

Plate 1 - Examples of photos taken by a time-lapse digital camera on Sandøen (Young Sund, eastern Greenland), 26 July - 26 August 1998.

A: 2 Aug. 06 h local. Haul-out site 1: Count (Reader 1: 13; Reader 2: 11, Final: 11). Photo quality: 3; count quality: 3. **B:** 27 Jul. 6 h. Site 1: Count (R1: 12; R2: 10; Final: 12). Photo quality: 2; count quality: 2. **C:** 15 Aug. 6 h. Site 2: Count (R1: 3; R2: 3; Final: 3). Photo quality: 2; count quality: 1. **D:** 8 Aug. 6 h. Site 2: Count (R1: 7; R2: 6; Final: 7). Photo quality: 3; count quality: 2. Rain drops on the lens. **E:** 24 Aug. 0 h. Site 3: Count (R1: 2; R2: 2; Final: 2). Photo quality: 3; count quality: 3. The shadow of the camera and the tripod is seen. **F:** 24 Aug. 6 h. Site 3: Count (R1: 3; R2: 3; Final: 3). Photo quality: 3; count quality: 3. Five people are seen close to where the walruses haul out.