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AERIAL AND VISUAL SURVEYS TO ESTIMATE HARP SEAL PUP PRODUCTION IN THE GREENLAND SEA

by

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Abstract

In March-April 1991 a combined expedition using fixed-wing aircraft and ship-borne helicopter was carried out to estimate harp seal pup production in the Greenland Sea (the *West Ice*). Photographs were taken from the fixed-wing aircraft and analysed from counts made on negatives. Visual surveys were made from helicopter using funnel-shaped shades to limit the search strip. Three separate breeding patches of harp seals were surveyed by either or both of the methods, making direct comparisons between the methods possible. Abundance estimates calculated from the basic data are given for these patches. Bearing in mind that neither survey covered all known patches, the photographic estimate of surveyed areas was about 40,000 pups, and the visual estimate of surveyed patches about 60,000 pups. Both these estimates have an inherent negative bias caused by the fact that known patches were not included (which may account for at least -10%); neither have scattered pups between patches nor the temporal distribution of births been taken into consideration. A specific problem of the photographic survey are the errors made during reading and interpretation of the photographs. These aspects were investigated by reading negatives under slightly different conditions, and parallel reading of negatives and printed copies, which apparently have differing properties with respect to readability definitions of harp seal pups. By these two procedures it was demonstrated that counts increased by 3.2% and 5.5%, respectively. Conclusively, it is recognized that the aerial survey results in general are consistent with pup production estimates based on mark-recapture experiments conducted over the last 15 years.

Introduction

Harp seals (*Phoca groenlandia*) are widely distributed in the northern North Atlantic. Three main breeding populations are recognized, primarily by the areas where they congregate to breed and moult; one in the Northwest Atlantic (Newfoundland), one in the Greenland Sea (the *West Ice)*, and one in the White Sea. Since the mid 1980s, Norwegian investigations to estimate abundance have focused on the *West Ice* population. Due to obvious difficulties in analysing mark-recapture data collected through a number of years from this population (*Øien and Øritsland, 1992*), more direct methods, that is aerial surveys, have been attempted in recent years, despite the logistical constraints involved. In 1991, a combined photographic and visual aerial survey was conducted in the *West Ice* harp seal breeding lairs to estimate the pup production. In this paper we describe some of the problems encountered during the survey and analyses of the data collected.

Materials and methods

Narrative

The survey was carried out on a combined expedition using fixed-wing aircraft and ship-borne helicopter during the *West Ice* harp seal breeding season in March-April 1991. The expedition vessel, *'Polarsyssel'*, a combined icebreaker and sealer with the helicopter on board, left Tromsø on 12 March 1991. After landing of fuel, equipment and the observer for the fixed-wing aircraft on Jan Mayen Island on 15 March, the ship arrived in the pack-ice at 71°N, 18°W on 16 March. From this position the ship and the helicopter, an AS 350 B1 Ecureuil, were engaged in search, taggings and surveys towards 75°N, 3°W for 28 days until departure from the ice on 12 April. By then the helicopter had logged a total of 75.6 hours in the air. *'Polarsyssel'* returned to Tromsø on 15 April after a total of 35 days at sea. The aircraft, a Partenavia P68TC Observer with long-range fuel tanks, arrived at Jan Mayen on 15 March and was available for search flights and photographic surveys for 26 days until it returned to Norway on 10 April. Its operations were impeded by unsuitable or highly unstable weather conditions for 16 days. A total of seven reconnaissance flights and three photosurveys were completed over the pack-ice between 71°N, 18°W and 74°N, 3°W. The aircraft logged a total of 46.1 flight-hours, including transits between Jan Mayen and the pack-ice, during the period it was based on Jan Mayen.

Navigation onboard the aircraft was based on Loran C, onboard the helicopter on GPS (Global Positioning System); both were equipped with gyro compass and radio-direction-finder, and survey altitudes were determined from barometer for the aircraft and by radar altimeter for the helicopter.

Reconnaissance flights

The area of interest for searching of breeding lairs includes the drift ice in the Greenland Sea between 71°N and 75°N, bounded by the open sea and consolidated older ice. Reconnaissance flights with the *Partenavia* from the Jan Mayen base was usually conducted at altitudes of 600 to 1,000 feet, depending on weather conditions and visibility. Generally, ice conditions were characterised by young ice which covered extensive areas between strips and patches of older ice. Furthermore, currents and changing winds led to rapid rearrangements of the ice, and during the last week in March the ice drifted towards ENE, contrary to the usual drift towards SSW. Search flights by the helicopter were made in a systematic way from *'Polarsyssel'*,

mostly at survey altitudes of 300-500 feet (91-152 m).

Stage determinations of pups

To obtain information on the temporal distribution of births, classified counts of pups in stages of development (age) were made by the helicopter flown at low altitudes at intervals throughout the survey period from 22 March to 12 April . The classifications were based on the descriptions given by *Stewart and Lavigne (1980)*, but with a few of their classes combined. Thus, for harp seals the following classes were used: 1) Newborn and yellowcoats, 2) thin whitecoats, 3) fat whitecoats, 4) graycoats, 5) ragged-jackets and 6) beaters (Table 1). The classified counts included a total of 4,711 pups.

Visual surveys

Visual surveys for estimation of abundance of harp seal pups were flown with the helicopter at an altitude of 200 feet (61 m) above the ice surface at a ground speed of 30 knots (56 km/h) and with two observers, one on each side. Observations were made through removable funnel-shaped shades installed within the compartment, one on each side of the helicopter. The strip width was defined as the width of the limited view of the observer holding his head tightly towards the eye-opening of the shade. The observations were read into tape recorders connected to a timing device for easy grouping of data. The strip widths were estimated to be 30 m and 19 m to the left and right hand sides, respectively, at the survey altitude of 200 feet. Transects were preferably run directly towards the prevailing wind direction to ensure strip width consistency.

Photographic survey

Photographic surveys were conducted from the *Partenavia* using a Wild RC20 camera with a 153 mm lens for maximum area coverage, and a Vinten F95 camera with a 350 mm lens intended for calibration. The Wild camera was operated with Agfa Aviphot Pan 200 film, partly also with Pan 150, while Ilford HP5-film was used with the Vinten camera. We had technical problems with the Vinten camera, and therefore no results based on that camera are presented here. The flight altitudes during surveys were 400-600 feet (122-183 m), and transects were flown in a systematic manner with intended equal spacing between legs based on the time available to cover the area of interest.

Analyses of photographic material

All counts from photographic material were made by a single reader who also had extensive experience from field work. Abundance estimates have been based on counts made from negatives. The negatives were mounted on a light table (Bretford Acculight Model 6000 Still Picture Projector), covered with a transparent sheet with a grid of nine squares to facilitate reading, and examined using a magnifying lens (Zeiss, 10X).

A subsample of 20 frames was selected for further investigations; the numbers of adult harp seals and pups counted in each frame ranged from 3 to27 and from 6 to 34, respectively. The first experiment was to count seals on negatives under grids of (i) nine squares and (ii) 81 squares, where each square corresponded to the viewing field of the magnifying lens. The second experiment was to count adults and pups under the small grid squares on (i) negatives and (ii) positive prints of these negatives.

Analyses of the data

The numbers of pups in the surveyed breeding patches and the associated coefficients of variation (c.v.) were estimated by the strip sampling method for unequal-sized units described

by Caughley (1977), and log-based 95% confidence intervals are given following *Buckland (1992)*. Areas of the surveyed patches have been calculated as the area bounded by the transect endpoints.

Results

Distribution of harp seals

Scattered harp seals with pups were recorded throughout the area between 71°N 18°W and 75°N 3°W, over a distance of about 350 nautical miles (650 km), with the largest concentrations towards northeast in this area. Four separate patches, labeled G I - G IV, of breeding harp seals were identified (Fig. 1). The first one, G I, was found during a helicopter search on 22 March and at that time the patch covered an area of 1.0 x 4.2 nautical miles (14.4 km^2), stretched out in an east-west direction. This patch drifted in an easterly direction and was resighted and recognized by tagged pups and colour-marked ice floes; by 29 March it was found about 45 nautical miles (83 km) to the east of where it was first discovered.

The Soviet research vessel '*Varzuga*' found a minor harp seal breeding patch G II on 22 March. '*Varzuga*' conducted a visual shipboard survey and reported an estimate of 3,800 pups based on ten transects.

On 26 March, the *Partenavia* found an area (G III) of scattered harp seals with a few small dense concentrations over a distance of about 36 nautical miles (67 km).

The definitly largest harp seal breeding concentration, G IV, was located by the helicopter during a search on 30 March. At that time, Ice conditions were relatively stable at that time, and the extension of the patch was estimated to be approximately 135 nautical $miles^2$ (463 km^2).

Temporal distribution of births

The data collected on developmental stages of pups were collected from the patches G I (22 March-30 March) and G IV (31 March-12 April). Representatives of the late stage 5 were observed only towards the end of the period and beaters (stage 6) were not recorded at all. In the patch G IV newborn pups were not observed, and only a few thin whitecoats were recorded. The proportional counts are given in Fig. 2.

Visual surveys

At the time of detection, two parallel transects were flown in the longitudinal east-west direction of the relatively small patch G I. While the first transect was run contrary to the wind direction, the second transect was flown with the wind, which made it difficult to avoid an oblique positioning of the helicopter relative to the transect line, which might have implied a distortion of the estimated strip width. The visual survey estimate for G I has therefore been calculated based on the first transect only, using the two observers as replicates. In breeding lair G IV, seven transects of equal lengths were placed randomly among the available south-north integer minute longitudes in a survey on 31 March. The area coverage was 2.1%. Estimates of harp seal pup production based on visual counts in these two breeding lairs are given in Table 2.

Photographic surveys

The patch G I drifted rapidly towards ENE and dispersed over a much larger area. A

photographic survey of the patch was not possible until 25 March due to poor weather, and at that time the recognizable part of the patch covered an area of approximately 101 km^2. Six transects were flown at an average altitude of 149m with a total of 556 exposures. Patch G III was surveyed by interval photography on three transects with about one nautical mile between each of 106 exposures in total. The average flight altitude was 209 m. A total of 735 exposures were taken during seven transects covering the lair G IV. Average flight altitude was 139 m, and area coverage was 6.9%.

Estimates and counts from photographic material

Estimates of harp seal pup production based on the counts from negatives taken through the surveys of three patches are given in Table 3.

The results from reading the subsample of 20 frames under varying conditions are given in Tables 4 and 5. They indicate that the counts of adult seals are not very sensitive to the method used, while the pup counts are. A small grid size increased the total count in the sample by 3.2%. Moreover, reading of negatives generally resulted in higher counts than reading of positive prints, although the prints added to the interpretation of images. This experiment indicates that an increase of 5.5% could be expected in number of pups not detected on the negatives but identified on the positive prints.

Discussion

A basic problem inherent in aerial surveys of breeding patches of icebreeding seals, is to obtain a full coverage of their areal distribution at the time. Most of the pups are born in breeding concentrations of fairly high densities and varying sizes, but some pups are also born outside these patches. The latter are thought to be a relatively minor problem, but the failure to detect breeding patches may introduce serious biases into the estimates. During the 1991 survey, three of the four recognized patches were photographed, one of them (G I) only in an inadequate way. The omission of the patch G II, which the Russian vessel *'Varzuga'* had estimated to contain 3,800 pups, introduces a bias alone of approximately -10% in the photographic estimate, and the omission of patch G III a bias of a similar size in the visual estimate. The difficult ice conditions in recent years in the *West Ice* with the ice edge exeptionally far from the Jan Mayen base, make it difficult to fully utilize flight time for search. The prevailing ice conditions made it unfeasible to carry out ground truthing experiments in 1991 to investigate bias problems associated with the availability of pups for observation; for example pups hidden beneath ice ridges or difficult to se due to poor contrast.

Births are distributed over a period of time. This implies that an estimate of pup production based on a snapshot aerial survey may represent only a fraction of the total production. A model for the availability of harp seal pups through the breeding season has been suggested by *Myers and Bowen (1989)* based on experience from the Northwest Atlantic population. The method assumes that data are collected both on stage duration and stage proportions over time. However, their results with regard to harp seal pups are encouraging, since they indicate that surveys conducted approximately 5-15 days after the start of pupping will need only minor corrections (in the order of 3%) due to unavailability. The data collected during the *West Ice* survey (Fig. 2) indicate that harp seal births may have started around 20 March in 1991. If the *Myer and Bowen (1989)* results are applicable to our survey, the visual (22 March) and photographic (25 March) surveys of patch G I may have a larger negative bias than the others due to unavailability.

When comparing the basic estimates from the visual and photographic surveys for the patches G I and G IV (Tables 2 and 3), it is seen that the visual estimates tend to be higher. The patch G I was surveyed on different days by the helicopter and the aircraft, and it is believed that the photographic survey did not cover the patch completely. Patch G IV was, however, surveyed at virtually the same time by both methods, making them quite comparable. Although the point estimates cannot be separated as judged by their 95% confidence intervals, it is worth noting that with 1/3 the coverage, the visual survey has an estimate of c.v. about half of that from the photographic survey for this patch.

Although both visual and photographic surveys have problems in common, it could also be mentioned that with a visual strip width and helicopter speed adjusted to the pup density to ensure easy counting, the eye may have a higher and more reliable detection probability than the interpretation of photographs after the survey. With photographs the inevitable problem is whether pups are correctly identified, and whether all pups are detected. The present study indicates that this is not the case, but an elaborate reading process as well as reading both negatives and positive prints might increase the information gained from a photographic survey.

It is, however, encouraging that the aerial survey estimates of pup production seem to be consistent with those derived from mark-recapture experiments in the *West Ice* over the past 15 years *(Øien and Øritsland, 1992)*. These data sets therefore could be integrated to get a better understanding of the dynamics of this population.

Acknowledgments

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References

Buckland, S.T. 1992. Proposal for standard presentation of abundance estimates. ***Rep.int.Whal.Commn 42:235.***

Caughley, G. 1977. Analysis of vertebrate ppulations. ***John Wiley & Sons, London.***

Myers, R.A. and Bowen, W.D. 1989. Estimating bias in aerial surveys of harp seal pup production. ***J.Wildl.Mgmt. 53(2):361-372.***

Øien, N. and Øritsland, T. 1992. Using mark-recapture methods to estimate pup production of harp seals (Phoca groenlandica) in the Greenland Sea. ***ICES C.M. 1992/N:10-Ref.D.***

Stewart, R.E.A. and Lavigne, D.M. 1980. Neonatal growth of Northwest Atlantic harp seals, *Pagophilus groenlandicus. J. Mamm., 61(4):670-680.*

Table 1: Criteria used for classification of of harp seal pups according to develpmental stages.

Stage	Criterion
1	Newborn: body lean (concave), neck distinct, coat yellowish
2	thin whitecoat: body lean, neck distinct, coat white
3	fat whitecoat: body rounded, neck not discernible, coat white
4	early moulter: body rounded, dark hairs visible through the white coat, or white coat shedded in small patches or both
5	ragged jacket: body rounded, neck discernible, white coat shedded in large patches (1/3 of body surface or more)
6	beater: moulted, no white hair left on the body

Table 2: Estimates of numbers of harp seal pups on the ice in three breeding patches in the West Ice in 1991, based on visual surveys from helicopter (patches 01 and 04) and ship (patch 02: Russian estimate from *'Varzuga'*).

Patch	Date	Estimate	95% confidence interval	c.v.
01	22 March	7,100	6,100-8,200	0.075
02	22 March	3,800		
04	31 March	52,500	38,500-71,600	0.159
Combined		63,400		

Table 3: Estimates of numbers of harp seal pups on the ice in three breeding patches in the West Ice in 1991, based on photographic surveys.

Patch	Date	Estimate	95% confidence interval	c.v.
01	25 March	2,021	1,570 - 2,600	0.128
03	28 March	5,905	4,040 - 8,630	0.195
04	31 March	31,917	18,900 - 53,800	0.271
Combined		39,843	23,800 - 66,700	0.268

Table 4: Reading of 20 selected negatives from the photographic survey to compare readings under a large cell grid size and a small cell grid size. The ranges of pups and adults counted per photo were 6-34 and 3-27, respectively. All observations were plotted on foils to facilitate comparisons.

	Pups	Adults
a.Large grid size (3x3)	442	273
b.Small grid size (9x9)	456	274
a > b	3	1
b > a	10	2
a = b	7	17

Table 5: Reading of 20 selected negatives from the photographic survey to compare readings of negatives and positive prints. The ranges of pups and adults counted per photo were 6-34 and 3-27, respectively. All observations were plotted on foils to facilitate comparisons. Readings were made under small cell size grid.

	Pups	Adults
a.Negatives	456	274
b.Positive prints	432	276
a > b	15	1
b > a	4	2
a = b	1	17
Detected on negatives only	49	1
Detected on positiv prints only	25	3

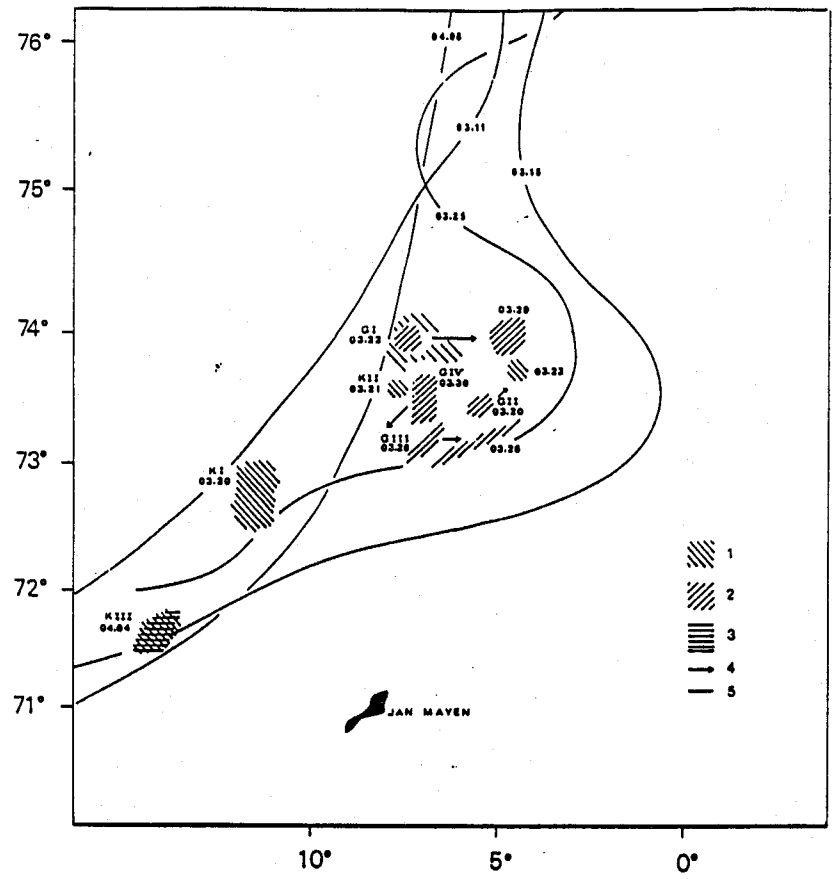

Fig 1. Ice limits and the distribution of breeding harp and hooded seals, recorded by ship-borne helicopter and spotting aircraft in the West Ice 16 March to 12 April 1991: 1) Hooded seal breeding lair; 2) harp seal breeding lair; 3) scattered breeding hooded seals; 4) drift; 5) ice limit.

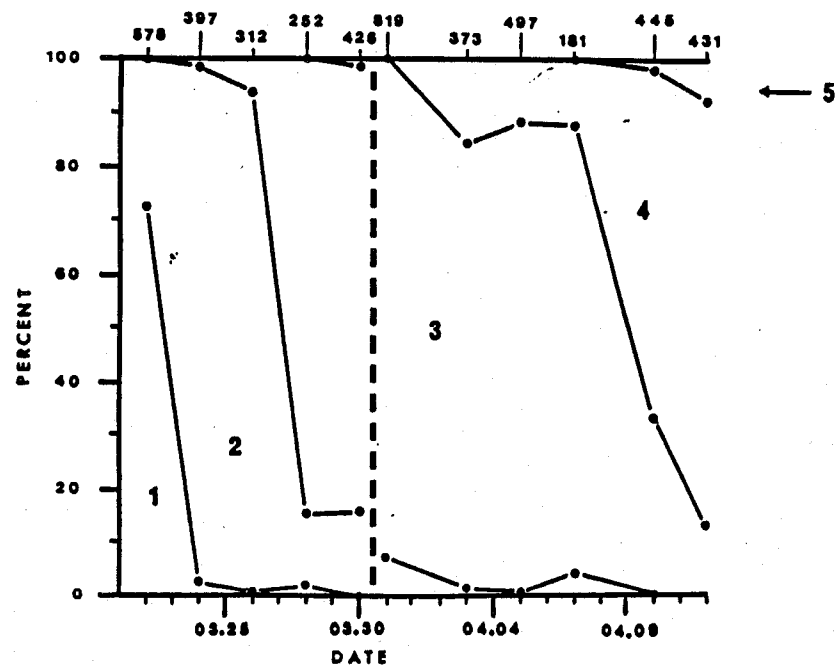

Fig 2. The relative distribution of harp seal pup developmental stages by date, classified in the West Ice 22 March to 12 April 1991. Sample sizes for each of the counts are given along the upper horizontal axis. Stages were determined according to criteria listed in the text.