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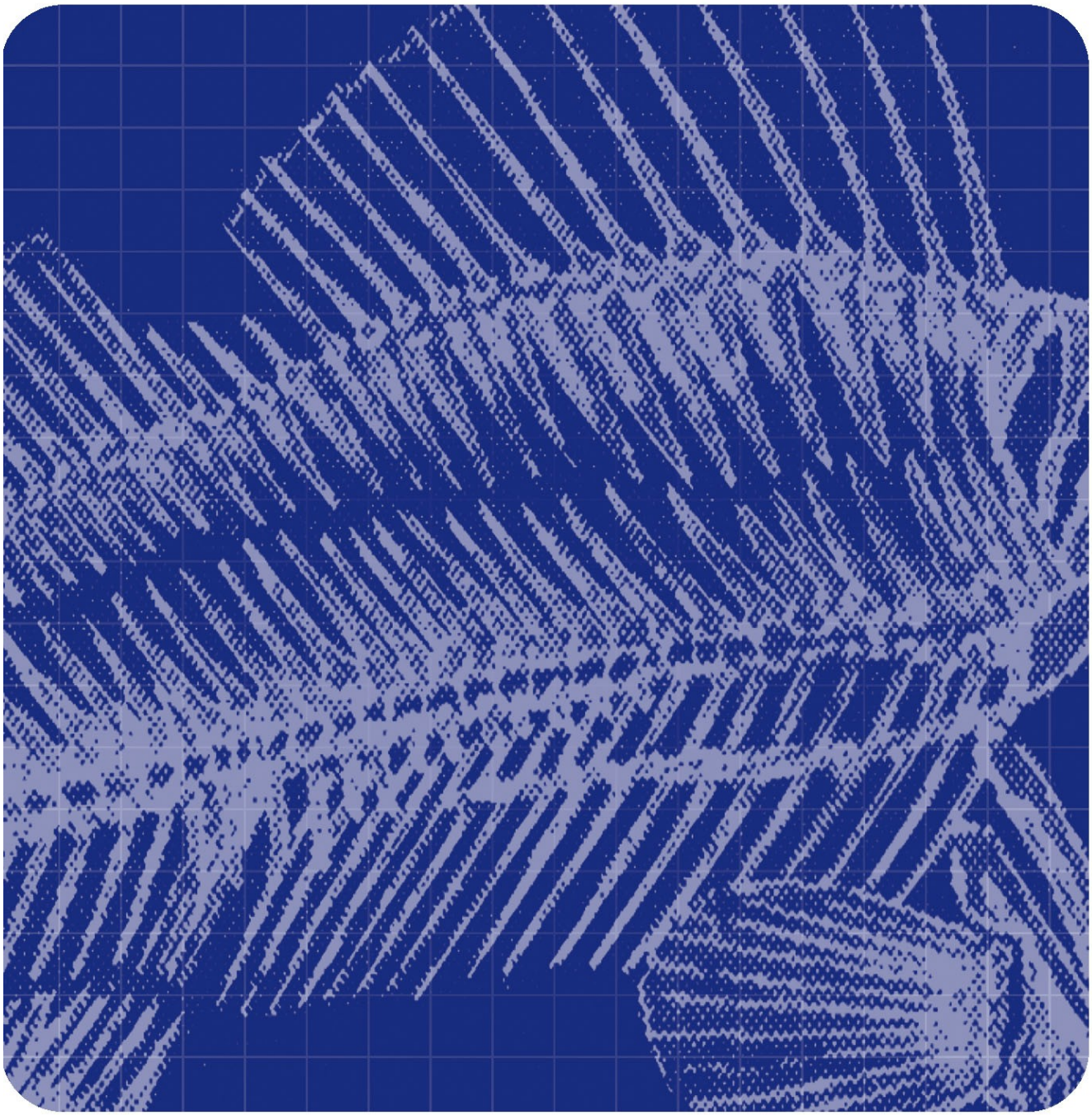
Report from aerial surveys of ice breeding seals in the Greenland Sea pack-ice during the 2002 whelping season

Tore Haug, Peter Corkeron, Kjell T. Nilssen and Garry B. Stenson



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Summary:

In the period 14 March to 6 April 2002 aerial surveys were performed in the Greenland Sea pack-ice (the West Ice), to asssess the pup production of the Greenland Sea population of harp seals *Pagophilus groenlandicus* and, if possible, hooded seals *Cystophora cristata*. One fixed-wing twin-engined aircraft (stationed in Scoresbysound, Greenland, but permitted also to use the Jan Mayen island as base) was used for reconaissance flights and photographic surveys along transects over the whelping patches once they had been located and identified. A helicopter, stationed on and operated from the applied research vessel (R/V"Lance"), assisted in the reconnaissance flights, and subsequently flew visual transect surveys over the whelping patches. The helicopter was also used for other purposes, such as age-stageing (also performed along transects over the patches) and tagging of the pups. Logistical restrictions and the unusually wide distribution of the hooded seal pups made it impossible to survey both species simultaneously, and therefore hooded seal pup production was not assessed. Three harp seal breeding patches were located and surveyed. The results from the aerial surveys will be used to estimate the 2002 harp seal pup production. Subsequently, the status of the stock will be assessed by fitting population models to the pup production estimate.

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1 INTRODUCTION

Due to uncertainties in the assumptions required when estimating abundance from catch-at-age data, sequential population models and mark-recapture data, independent estimates of pup production have been recommended (e.g., ICES, 1992; 1993; 1994; NAFO, 1995) and used to determine population size of harp *Pagophilus groenlandicus* and hooded *Cystophora cristata* seals both in the northwest Atlantic (Hammill et al., 1992; Stenson et al., 1993; 1997; 2002a; b), in the Greenland Sea (Øritsland and Øien, 1995; ICES, 1998; 1999), and in the White Sea (ICES 1999; 2001; Potelov et al., in subm). The status of the stocks are subsequently assessed by fitting population models to the independent estimates of pup production (e..g. Healey and Stenson, 2000; ICES 2001). It is recommended that the comprehensive aerial surveys needed to provide estimates of current pup production should be conducted periodically, and that efforts should be made to ensure comparability of survey results (ICES, 1994; NAFO, 1995). In the Greenland Sea, harp and hooded seals were surveyed aerially in 1991 (Øritsland and Øien, 1995) and 1997 (ICES, 1998; 1999), respectively. Although not formally established, it has been argued that the period between surveys should not exceed 4-5 years. For this reason, new aerial surveys to asssess the status of the Greenland Sea population of harp seals and, if possible, hooded seals during their whelping period (March-April) were coducted in 2002. During field work it soon became evident that logistical restrictions in combination with unusually scattered and wide distribution of the hooded seal pups made it impossible to survey both species simultaneously. Therefore, the survey focussed on harp seals.

Three stocks of harp seals inhabit the North Atlantic Ocean (Sergeant ,1991). Whelping occurs east of Newfoundland and in the Gulf of St.Lawrence (the Northwest Atlantic stock), off the east coast of Greenland (the Greenland Sea or West Ice stock), and in the White Sea (the Barents Sea / White Sea stock). Relationships among the three North Atlantic populations of harp seals have been examined in studies of cranial measurements (Yablokov and Sergeant 1963), underwater vocalizations (Perry and Terhune 1999), serum transferrins (Møller et al., 1966; Nævdal, 1966; 1969; 1971), blood serum proteins (Borisov, 1966), allozymes (Meisfjord and Nævdal 1994) and DNA (Meisfjord and Sundt, 1996; Perry et al. 2000). These studies have revealed significant differences between the Northwest Atlantic stock on one side and the Greenland Sea and Barents Sea harp seal stocks on the other, while no evidence of difference between the two latter was observed. Although tagging experiments suggest that mixing of immature animals between the West Ice and Barents Sea stocks may occur, there is no evidence of mixing on the breeding grounds (Øien & Øritsland 1995). The two stocks are managed separately.

The Greenland Sea stocks of harp seals have been subject to commercial exploitation for centuries (Iversen, 1927; Nakken, 1988; Sergeant, 1991). The Greenland Sea hunt started as an offshoot of the Spitsbergen hunt for bowhead whales (*Balaena mysticetus*) in the late 17th century. Knowledge of the Greenland Sea catches in the 18th and the first two-thirds of the 19th century, performed by Dutch, British, German and Danish ships, is poor. Norwegian sealers appeared for the first time in the Greanland Sea in 1846, and have subsequently participated with increased effort. Exploitation levels reached a historical maximum in the 1870s and 1880s when annual catches of harp seals (pups and adults) varied between 50 000 and 120 000 (Iversen, 1927). This assumed overexploitation probably drove the stock to an all time low, and the competition for a limited supply of seals in the 1870s resulted in the disappearance of all non-Norwegian fleets (Sergeant 1991). It was evident that the catch levels in the 1870s were higher than the stock could sustain, and some regulatory measures

(mainly designed to protect adult females) were taken in 1876 (Iversen, 1927). In the first decades of the 20th century the annual harp seal catches varied between 10 000 and 20 000 animals, whereas an increase to around 40 000 seals per year occurred in the 1930s (Iversen, 1927; Sergeant 1991). After a 5 year pause in the sealing operations during World War II, total annual catches quickly rose to a postwar maximum of about 70 000 in 1948, but then followed a decreasing trend until quotas were imposed in 1971 (Sergeant 1991, ICES 2001). From 1955 to 1994 a minor part of the catches were taken by the Soviet Union / Russia, and the total annual catches have varied between a few hundereds to about 17 000 from 1971 to present (ICES 2001).

Available knowledge of both previous and present abundance of Greenland Sea harp seals is rather restricted. As judged both from catch per unit effort analyses and mark-recapture pup production estimates, it has been assumed that the stock has increased ever since the early 1960s, but evidence of the level of increase has been rather imprecise (Ulltang and Øien, 1988; Øien and Øritsland, 1995). During the period 1977-1991, about 17 000 harp seal pups were tagged in a comprehensive mark-recapture experiment in the Greenland Sea (Øien and Øritsland, 1995). From this experiment, a pup production of 40 000 – 50 000 was assumed in 1980, and by modelling the 1988 pup production was projected to have been within the area 53 000 – 69 000, which would imply a stock of one year old and older (1+) animals within a range of 230 000- 290 000 (Ulltang and Øien, 1988). Updates of the mark-recapture based pup production estimates indicated a pup production in 1991 of 67 300 (95% CI 56 400-78 113) (NAFO, 1995). Aerial surveys performed in 1991 suggested a minimum pup production in this year in excess of 55 000 (Øritsland and Øien, 1995). A new population model, based on original reproductive parameters (see Frie et al. in subm) and tuned to available pup production estimates (Øien and Øritsland, 1995; Øritsland and Øien, 1995), gave a projected 2000 pup production estimate of 76 700 (95% CI 48 000 – 105 000) and a total size of the 1+ population of 361 000 with a 95% confidence interval ranging between 210 000 and 629 000 animals (ICES, 2001).

The present study was carried out with the Marine Resource Section of the Norwegian Institute of Fisheries and Aquaculture (NIFA), Tromsø, Norway, as responsible institution. The methodology used was to conduct aerial surveys of seal pups in the Greenland Sea pack-ice during the whelping period (March/April) in 2002. The techniques used were similar to those developed and used previously for determining population size for harp and hooded seals in the northwest Atlantic (Hammill et al., 1992; Stenson et al., 1993; 1997; 2002a; b) and in the Greenland Sea (Øritsland and Øien, 1995; ICES, 1998; 1999), and for harp seals in the White Sea (ICES 1999; 2001; Potelov et al., in subm). In addition to the abundance estimation, behavioural studies of harp seals were conducted, and a few animals (5 harp seal pups, and 3 adult hooded seals and 4 hooded seal pups) were taken for other scientific purposes including genetic studies.

2 LOGISTICS AND METHODS

2.1 Ship, aircrafts and personell

The ice-strengthened expedition vessel R/V"Lance" (length 60.8 m, 458 gross tonnes, 3200 hp machine engine, classification ICE-1A) owned by the Norwegian Polar Institute, Tromsø, was used for operations in the Greeland Sea drift ice. The ship was equipped with a landing platform for helicopter and equipment in compliance with relevant requirements for helicopter operations.

An Ecureuil AS 350 B1 helicopter (owned by Airlift AS, Bygstad, Norway) was chartered for the expedition. This helicopter type has previously proved useful in similar operations in the Greenland Sea pack ice, both with regard to ease of handling and stowage onboard the ship and because of flight range (Øritsland and Øien 1995). The helicopter was fitted with a satellite navigation system (GPS) and radar altimeter. Approximately 63 hours were flown over the ice during the survey.

A fixed-wing twin engine PA31 Piper Navajo aircraft, operated by Fotonor AS, Sandefjord, Norway, was based in Constable Pynt, East-Greenland, but was also granted permission to use the airport on the Jan Mayen Island. The Navajo was fitted with GPS to ensure accurate navigation, and it was equipped with a gyro mounted Leica RC 30 camera with 15,3 cm lens for vertical photography. A total of 54 hours were flown over the ice during the survey.

In addition to the ship, helicopter and aircraft crews, the expedition included a scientific personell of 11 persons. Onboard R/V"Lance", Tore Haug (NIFA, expedition leader), Ivan Ahlqvist (NIFA), Bjørn Bergflødt (Institute of Marine Research, Bergen), Peter Corkeron (NIFA), Lotta Lindblom (NIFA), Nils Erik Skavberg (NIFA) and Garry Stenson (guest scientist from Department of Fisheries and Oceans, St.John's, Newfoundland, Canada) had the pup assessments as their primary occupation during the survey. Contributions to the pup assessment work was also received from Callan Duck, participating guest scientist from the Sea Mammal Research Unit, University of St.Andrews, Scotland, and Sofie Van Parijs and student Ilse van Opzeeland (Norwegian College of Fishery Science, University of Tromsø, Norway). The latter two participated in the expedition primarily to collect data for studies of acoustic and more general behaviour of the Greenland Sea harp seals. Kjell T. Nilssen (NIFA) was the responsible scientist for all surveys performed with the fixed-wing twin engine aircraft.

2.2 Reconnaissance surveys

Whelping concentrations were located using fixed-wing and helicopter reconnaissance surveys of areas historically used by harp and hooded seals in the Greenland Sea, mainly the pack ice areas along the eastern coast of Greenland between 67°30' and 74°40'N. The reconnaissance flights were adapted to the actual ice-confuguration during the surveys. Survey altitude were between 800-1000 ft. Due to ice drift and a range of pupping dates (mid to late March, see Øritsland and Øien, 1995), most areas were surveyed repeatedly to minimize the chance of missing whelping concentrations. Color markers and VHF transmitters were deployed in major whelping concentrations to facilitate relocation and to monitor ice drift.

Reconnaissance flights using the fixed-wing aircraft were generally flown as repeated systematic east-west transects from the ice edge in the east and into more close drift ice. The length of the trancects were approximately 30 nm and they were usually spaced 10 nm apart, modified according to the actual ice configurations during the surveys (Fig. 1). In the period 14-16 March, daily reconnaissance flights were performed along the ice edge between 70º32'N and 73ºN, and at longitudes varying from 9º52'W to16º50'W. After some technical problems with the aircraft, new reconnaissance flights were conducted on 20 March (along ice edge between 73º20'N - 74º40'N, and 10º51'W - 14º00'W), 21 March (along ice edge from 71º53'N / 13º00'W and southwestwards to 69º05'N / 15º50'W), 22 March (further southwestwards along ice edge from 69º17'N / 16º47'W to 67º33'N / 19º51'W), and 23 March (along ice edge from 69º37'N / 15º39'W and northwards to 71º13'N / 12º08'). Also fixed-wing aircraft based reconnaissance survey was conducted on 30 March in a zig-zag pattern following the ice edge between 71º54'N / 14º02'W and north to 74º31'N / 13º10'W, and then southwards more to the west in a zig-zag pattern at longitudes varying from 13º30'W to15º59'W. On 5 April a reconnaissance survey was flown from 70º01'N / 16º52'W in a zig-zag pattern along the ice edge southwest to 68º42'N / 19º41'W.

R/V"Lance" met the ice edge at 71º21'N / 12º14'W on 15 March. The ship moved northwards, and helicopter reconnassance flights were started from position 72º23'N / 13º34'W on 17 March. During the period 17 – 23 March the helicopter was used to fly reconnaissance flights in areas between 71º10'N - 73º19'N and 11º38'W - 16º50'W. A new helicopter-based reconnaissance survey was conducted on 29 March between 71º14'N - 72º32'N and 13º59'W - 15º20'W. "Lance" left the ice on 2 April.

2.3 Photographic surveys

Fixed-wing aerial photographic surveys were flown using the Piper Navajo fitted with the gyro mounted Leica RC 30 camera with 15,3 cm lens for vertical photography. AGFA PAN 200 aerographic black-and-white film was used. The surveys were mainly conducted at an altitude of 620 ft but during surveys in difficult weather (including fog) photos were also taken at altitudes varying from 620 ft to 450 ft. The images covered areas of 284.1 x 284.1m or 206.2 x 206.2m per photo at altitudes of 620ft and 450 ft, respectively. Along the transects photos were taken at intervals separated sufficiently to avoid overlap. The camera was turned on when seals were observed on a transect line. Camera was turned off if no seals were observed for an extended period along a transect, and turned on when seals were encountered again. The photography on a transect line was finished when no seals were observed. Correct altitude and transect spacing were maintained using radar altimeter and satellite navigation system (GPS).

2.4 Visual surveys

The number of pups present within the identified whelping patches were estimated by conducting systematic visual strip transect surveys, flown using the ship based helicopter at an altitude of 100 ft. Observers, seated in the left and rear seats, counted all pups within a 30-35 m wide strip on each side of the aircraft. Each pup observation was recorded directly into a GPS-connected lap-top which ensured that all observations were linked to positions. Each transect began before a navigator, seated in the front, encountered seals and was terminated after the last seal was observed. The survey ended when no seals were seen on transect and

were not observed outside the survey area, ensured by the third observer (with forward view) in the helicopter. The direction of and spacing between transects depended on orientation and size of the concentration. The subsequent data analyses was the same as used for the photographic surveys, assuming complete coverage along a transect (see Stenson et al., 1993).

2.5 Temporal distribution of births

To correct the estimates of abundance for pups that had left the ice or were not yet born at the time of the survey (Myers and Bowen, 1989; Stenson et al., 1993; 2002 a; b), it was necessary to estimate the distribution of births over the pupping season. For harp seals this was done using information on the proportion of pups in each of seven distinct age-dependent stages. These arbitrary but easily recognisable descriptive age categories were based on pelage color and condition, overall appearance, and muscular coordination, as described for the northwest Atlantic harp seals by Stewart & Lavigne (1980):

1. Newborn: Pup still wet, bright yelow colour often present. Often associated with wet placentas and blood stained snow.

2. Yellowcoat: Pup dry, yellow amniotic stain still persistent on pelt. The pup is lean and moving awkwardly.

3. Thin whitecoat: Amniotic stain faded, pup with visible neck and often conical in shape, pelage white.

4. Fat whitecoat: Visibly fatter, neck not visible, cylindrical in shape, pelage still white.

5. Graycoat: Darker juvenile pelt begin to grow in under the white lanugo giving a gray cast to the pelt, ”salt-and-pepper”-look in later stages.

6. Ragged-jackets: Lanugo shed in patches, at least a handful from torso (nose, tail and flippers do not count).

7. Beaters: Fully moulted, weaned pups (a handful of lanugo may remain).

Prior to the survey, classifications of pup stages were standardized among observers to ensure consistency. To determine the proportion of pups in each stage on a given day, random samples of pups were obtained by flying a series of transects over the patch. Pups were classified from the helicopter hovering just above the animals. The spacing between transects depended on the size of the actual patch. Repeated classifications were obtained from each patch several days apart. Methods used to model the stage transitions are given in Myers and Bowen (1989) and in Stenson et al. (1993; 2002b).

Experiments where individual harp seal pups, tagged as yellowcoats, were followed over a period of several days to ascertain average duration of the various stages (see Kovacs and lavigne 1985) were conducted in the breeding patches. Paint sprayed on the lanugo of the tagged pups was used to facilitate resightings.

2.6 Tagging of pups

Although mark-recapture experiments as a tool to estimate pup production of harvested populations involve many uncertainties and problems, they have been used to estimate harp and hooded seal pup production as a valuable supplement to direct methods such as aerial surveys. (Bowen and Sergeant, 1983; Øien and Øritsland, 1995). During the present survey, harp seal pups were tagged with numbered, Dalton roto-tags through the webbing of one of the hind flippers.

3 PRELIMINARY RESULTS

3.1 Identification of whelping areas

Two harp seal whelping concentrations, one small and one large, apparently in the very beginning of formation, were observed during fixed-wing reconnaissance flight on 15 March in areas between 72º37'N - 72º43'N and 10º03'W / 12º22'W. Based on ice drift the two whelping concentrations were relocated during helicopter reconnaissance flights. A small patch (Patch A) was found on 17 March at an approximate mean position of 72º14'N / 12º43'W. A VHF transmitter was immediately deployed in the patch to monitor movements which was generally in a southwesterly direction. On 30 March, this patch was relocated at 70º52'N / 14º11'W.

A larger harp seal concentration (Patch B) was located on 20 March in approximate position of 72º10'N / 13º10'W. A VHF transmitter was deployed in this patch two days later, then in position 72º33'N / 13º15'W. Patch B was increasing in size when it was located, and on 23 March it occupied areas between 72º25'N - 72º35'N and 13º10'W - 14º10'N. The drift of Patch B was also to the southwest, and on 31 March the Patch B VHF transmitter had moved to position 70º54'N / 16º02'W.

On 5 April, a third harp seal whelping concentration (Patch C) was observed during fixed-wing reconnaissance flight between 69º00'N / 19º52'W and 69º11'N / 19º35'W.

Scattered hooded seal whelping was observed over most of the area surveyed during reconnaissance flights, from 72º40'N / 12º00'W in the north and southwards to 68º35'N / 16º08'W. During the earliest reconnaissance flights, observations suggested that more well defined whelping patches were about to start (many newborn and thin bluebacks) in a few particular areas; 71º20'N - 71º42'N and 13º26'W - 15º08'W (14 March), 70º41'N - 71º03'N and 14º50'W - 15º54'N (21 March), 69º37'N - 69º56'N and 14º58'W - 15º4'W (21 March), and 72º25'N - 72º30'N and 12º20'W - 13º20'W (22 March). The latter was located close to harp seal breeding Patch B. However, none of these areas developed into well defined concentrations and instead consisted of scattered groups of breeding hooded seals. This was also confirmed from three Norwegian sealers ("Harmoni", "Polarfangst" and Polarsyssel") that were hunting weaned bluebacks from 20 March. The wide distribution of scattered groups and lack of well defined whelping concentrations of hooded seals made it impossible to survey both harp and hooded seals during the 2002 breeding season. For this reason the survey focussed on harp seals.

3.2 Visual surveys

Systematic visual strip transect surveys were flown over harp seal Patch A on 20 March (Fig. 2). The whelping concentration then occupied an area between approximately 71º41'N - 71º50'N and 11º40'W - 12º50'W. Eighteen east-west transects were flown spaced 0.5 nautical mile apart. A total of 277 harp seal pups were counted on transects within a 64 m wide strip (Table 1).

Harp seal Patch B was surveyed on 28 March when the patch occupied an area between approximately 71º13'N - 71º43'N and 14º38'W - 16º30'W (Fig. 2). Sixteen east-west

transects were flown spaced 2 nautical miles apart. In total, 1416 pups were counted on the 64 m wide transect strip (Table 2).

Visual surveys were not flown over harp seal Patch C.

3.3 Photographic surveys

Harp seal whelping Patch A was not surveyed with photographic strip transects.

An incomplete photographic strip transect survey of Patch B (then approximately occupying an area between 71º26'N - 71º50'N and 14º50'W - 16º30'W) was attempted on 27 March. The plane flew 18 east-west transects spaced mainly 1 nautical mile apart, but was unable to cover the southern areas (south of 71º33'N) of the patch due to fog and lack of available flight time. A total of 475 exposures were taken (Table 3). A survey of the entire Patch B concentration (now occupying an area between 70º52'N - 71º25'N and 14º44'W - 16º38'W) was successfully completed 29 March (Fig. 3). Twenty transects were flown in an east-west direction, spaced 2 nautical miles apart (Table 4). A total of 533 exposures were taken.

The harp seal whelping Patch C was surveyed with photographic strip transects on 6 April in relatively difficult weather conditions due to fog (Fig. 3). However, 15 east-west transects, spaced 1 nautical mile apart, were flown over the whelping patch (which covered an area between 68º59'N - 69º14'N and 19º04'W - 19º49'W). A total of 326 exposures were taken (Table 5).

All images will be analysed as described in Stenson et al. (1993; 2002a, b).

3.4 Temporal distribution of births

Estimation of the proportion of pups in each developmental stage were obtained from both whelping concentrations. Systematic east-west staging transects (spaced 1-3 nautical miles apart) were flown over Patch A on 17, 19, 21 and 30 March, and over Patch B on 22, 24, 27, 29 March and on 2 April (Table 6). Prior to the pup estimation surveys (visual as well as photographic) newborns (stage 1) were absent while yellowcoats (stage 2) occurred in low numbers in the patches. No newborn were observed after the surveys were flown. The majority of pups present during and immediately after the estimation survey periods were thin whitecoats (stage 3) in patch A and fat whitecoats (stage 4) in patch B. In Patch C, no staging was performed.

3.5 Duration of pup stages

Starting on 23 March in Patch B, 39 individual stage 2 (yellow) harp seal pups were tagged with numbered, Dalton roto-tags through the webbing of one of the hind flippers. Attempts were made to followindividual seals over several days to ascertain average duration of the various stages. It appeared difficult to resight individual pups, and 80 additional pups, tagged either as thin whitecoats (stage 3) or fat whitecoats (stage 4) and subsequently resighted, were also included in the experiment. On 31 March, 91 of these pups had been resighted once, 15

pups resighted twice, 11 pups resighted three times and 2 pups resighted six times. Analyses to identify the duration of the various stages of Greenland Sea harp seal pups are under way.

3.6 Tagging of pups

Tagging of pups with numbered, Dalton roto-tags through the webbing of one of the hind flippers were mainly restricted to Patch B where 1378 pups were tagged (of which 1314 were sexed: 628 (47.8%) females and 686 (52.2%) males). Only 31 pups were tagged in Patch A.

3.7 Pup vocalizations

Recordings were made of pup calls on 96 occasions. Ten pups were recorded on at least two occasions.

4 CONCLUDING REMARKS

The survey used methods comparable with previous surveys performed for harp seal assessments in the northwest Atlantic in 1990, 1994 and 1999 (Stenson et al., 1993; 2002a; b), in the Greenland Sea in 1991 (Øritsland and Øien, 1995) and in the White Seaa in 1998 and 2000 (ICES, 1999; 2001; Potelov et al., in subm). Extensive reconnaissance of all likely areas were conducted to locate whelping harp seals, and results from the visual and photographic surveys will be used to estimate the 2002 pup production. Results from the staging analyses will be used to correct the survey results for any pups that may have been missed due to the temporal distribution of births.

The results from the 2002 surveys will be used to assess the present status of Greenland Sea harp seals, and to determine if there is evidence of increased pup production in this population. The latter can be done by comparing the 2002 results with those obtained by Øritsland and Øien (1995) in 1991, when methods similar to those applied in 2002 were used.

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Table 1. Number of harp seal pups counted on east-west transects obtained during a helicopter flown visual survey of the Patch A whelping concentration in the Greenland Sea on 20 March 2002.

Transect	Latitude	Longitude start	Longitude finish	Pups counted
1	71°41N	12°9.978	12°46.765	1
2	71°41.5N	12°10.482	12°46.133	6
3	71°42N	12°10.62	12°43.417	6
4	71°42.5N	12°43.442	12°10.943	7
5	71°43N	12°43.743	12°9.916	10
6	71°43.5N	12°10.744	12°36.554	32
7	71°44N	12°40.303	12°8.279	22
8	71°44.5N	12°8.29	12°33.443	18
9	71°45N	12°31.498	12°7.06	25
10	71°45.5N	12°7.684	12°26.771	6
11	71°46N	12°28.837	12°6.741	2
12	71°46.5N	11°46.265	12°17.99	56
13	71°47N	12°16.532	11°45.381	46
14	71°47.5N	11°45.932	12°17.873	23
15	71°48N	12°16.256	11°45.873	9
16	71°48.5N	11°42.592	12°17.096	6
17	71°49N	12°16.246	11°45.901	2
18	71°49.5N	11°47.561	12°18.793	0

Table 2. Number of harp seal pups counted on east-west transects obtained during a helicopter flown visual survey of the Patch B whelping concentration in the Greenland Sea on 28 March 2002.

Transect	Latitude	Longitude start	Longitude finish	Pups counted
1	71°15N	16°29.709W	16°6.996W	64
2	71°13N	16°1.209W	16°10.821W	34
3	71°17N	16°30.737W	15°53.404W	108
4	71°19N	15°32.564W	16°26.242W	9
5	71°21N	16°18.593W	15°14.101W	34
6	71°23N	15°19.665W	16°6.306W	134
7	71°25N	16°5.082W	15°16.306W	40
8	71°27N	15°14.329W	15°58.328W	322
9	71°29N	15°56.295W	15°9.218W	343
10	71°31N	15°5.76W	15°49.373W	142
11	71°33N	15°49.695W	14°38.432W	118
12	71°35N	14°39.523W	15°23.483W	51
13	71°37N	15°17.913W	14°35.023W	15
14	71°39N	14°39.46W	15°14.677W	0
15	71°41N	15°10.935W	14°38.146W	2

Table 3. Number of exposures taken on east-west transects during a fixed-wing survey of the harp seal Patch B whelping concentration in the Greenland Sea on 27 March 2002. It was not possible to cover the southern areas (south of 71º33'N) due to fog and lack of available light time. A total of 475 exposures were taken.

Transect	Latitude	Long.(W) start	Long.(W) finish	N.of expos.
1	71°50.0N	14° 51	15°11	25
2	71°47.0N	14°59	14°47	19
3	71°48.5N	14°50	15°12	26
4	71°46.4N	15°09	14°51	21
5	71°45.8N	14°51	15°17	29
6	71°45.2N	15°10	14°50	17
7	71°44.6N	15°01	15°14	14
8	71°43.6N	15°08	15°00	11
9	71°42.6N	15°00	15°16	19
10	71°41.6N	15°18	14°51	34
11	71°40.6N	14°57	15°37	45
12	71°39.6N	15°36	15°07	16
13	71°38.6N	15°07	15°45	39
14	71°37.6N	15°46	15°17	27
15	71°36.6N	15°20	15°52	26
16	71°35.6N	15°45	15°17	20
17	71°34.6N	15°35	15°57	23
18	71°33.6N	15°59	15°26	64

Table 4. Number of exposures taken on east-west transects during a complete fixed-wing survey of the harp seal Patch B whelping concentration in the Greenland Sea on 29 March 2002. A total of 533 exposures were taken.

Transect	Latitude	Long.(W) start	Long.(W) finish	N.of expos.
1	70°49N	16° 38	16°30	10
2	70°51N	16°35	16°46	14
3	70°53N	16°38	16°20	22
4	70°55N	16°24	16°37	15
5	70°57N	16°34	16°02	37
6	70°59N	15°58	16°30	18
7	71°01N	16°33	16°02	29
8	71°03N	15°47	16°12	24
9	71°05N	16°01	15°30	39
10	71°07N	15°37	16°16	44
11	71°09N	16°03	15°08	57
12	71°11N	15°12	15°51	23
13	71°13N	15°49	15°06	49
14	71°15N	15°10	15°48	37
15	71°17N	15°25	14°52	47
16	71°19N	14°58	15°17	18
17	71°21N	15°11	14°54	19
18	71°23N	14°42	15°07	23
19	71°25N	14°56	14°44	8
20	71°27N	14°54	15°08	0

Table 5. Number of exposures taken on east-west transects during a complete fixed-wing survey of the harp seal Patch C whelping concentration in the Greenland Sea on 6 April 2002. A total of 326 exposures were taken.

Transect	Latitude	Long.(W) start	Long.(W) finish	N.of expos.
1	69°11N	19° 11	19°37	33
2	69°09N	19°34	19°12	26
3	69°07N	19°15	19°40	19
4	69°05N	19°36	19°16	24
5	69°03N	19°22	19°49	25
6	69°01N	19°42	19°26	17
7	68°59N	19°42	19°47	5
8	69°02N	19°51	19°30	28
9	69°04N	19°25	19°42	20
10	69°06N	19°42	19°14	33
11	69°08N	19°13	19°41	23
12	69°10N	19°35	19°11	25
13	69°12N	19°15	19°33	14
14	69°13N	19°19	19°04	16
15	69°14N	19°07	19°24	18

Table 6. Numbers of harp seal pups in individual age dependent stages in two whelping patches (A and B) in the Greenland Sea during March/April 2002.

Date	Patch	Stage							Total
		New	Yellow	Thin white	Fat white	Grey coat	Ragged jacket	Beater	
Mar 17	A	0	18	73	0	0	0	0	91
19		0	3	144	0	0	0	0	147
21		0	2	256	23	0	0	0	281
30		0	0	4	24	60	0	0	88
Mar 22	B	54	303	1513	0	0	0	0	1870
24		1	81	879	7	0	1	0	969
27		4	28	424	1135	111	2	0	1704
29		0	4	122	810	32	1	0	969
April 2		0	0	1	38	711	3	0	753

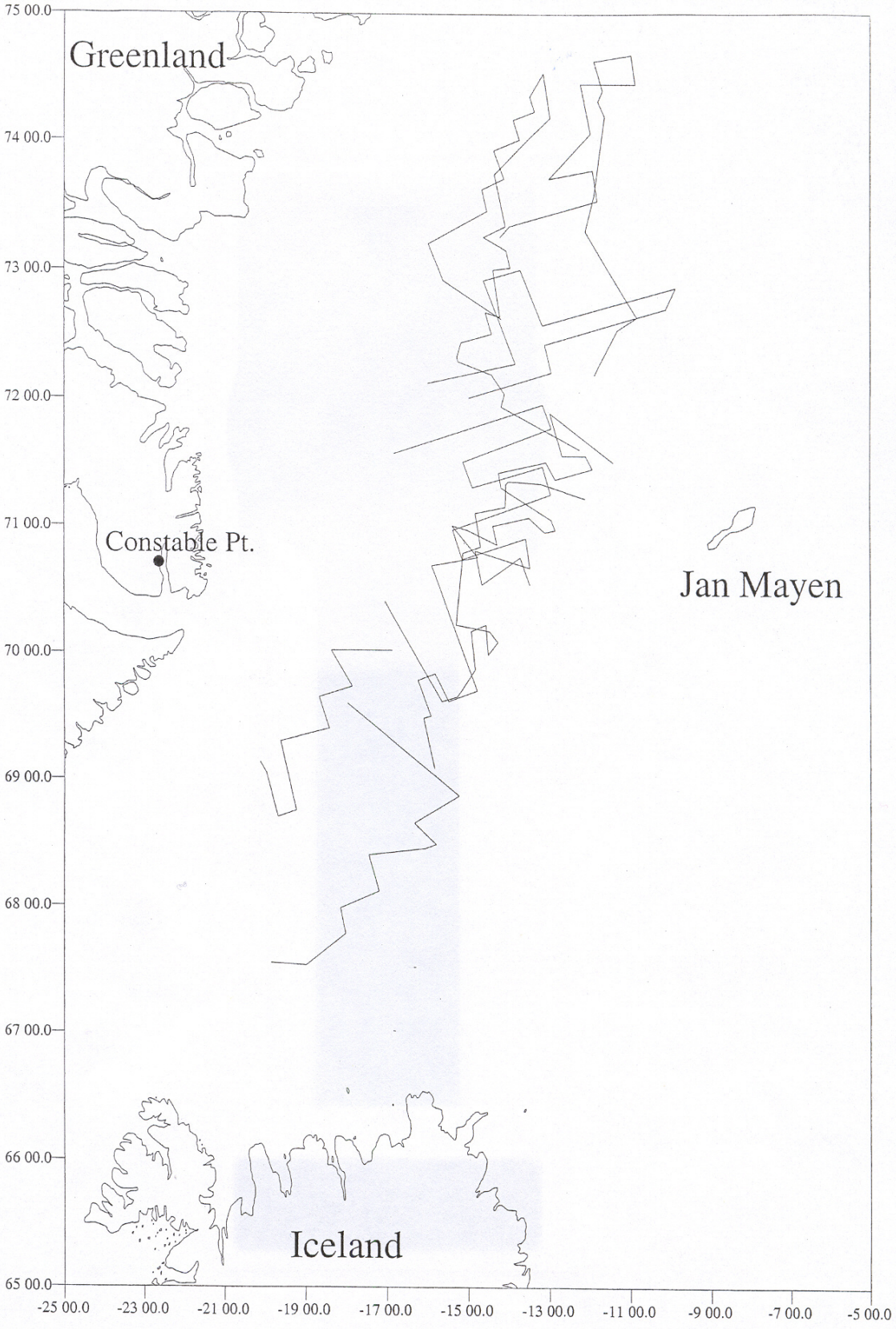

Fig. 1. *Fixed-wing reconnaissance surveys flown in the Greenland Sea from 14 March to 5 April 2002.*

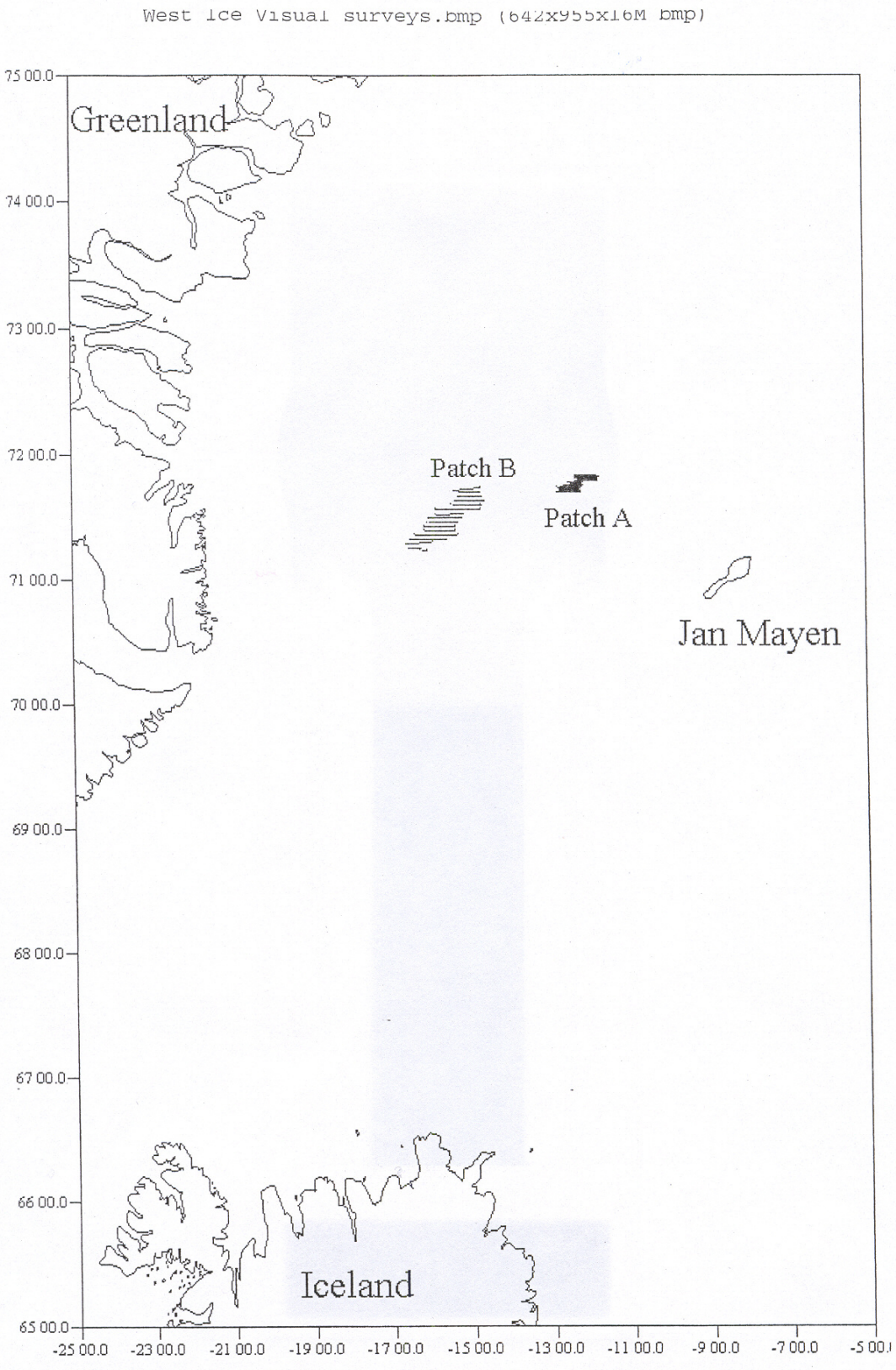

Fig. 2. *Visual survey transects flown by helicopter over harp seal whelping patches A (20 March 2002) and B (28 March 2002) in the Greenland Sea.*

West Ice Photo surveys.jpg (642x955x16M jpeg)

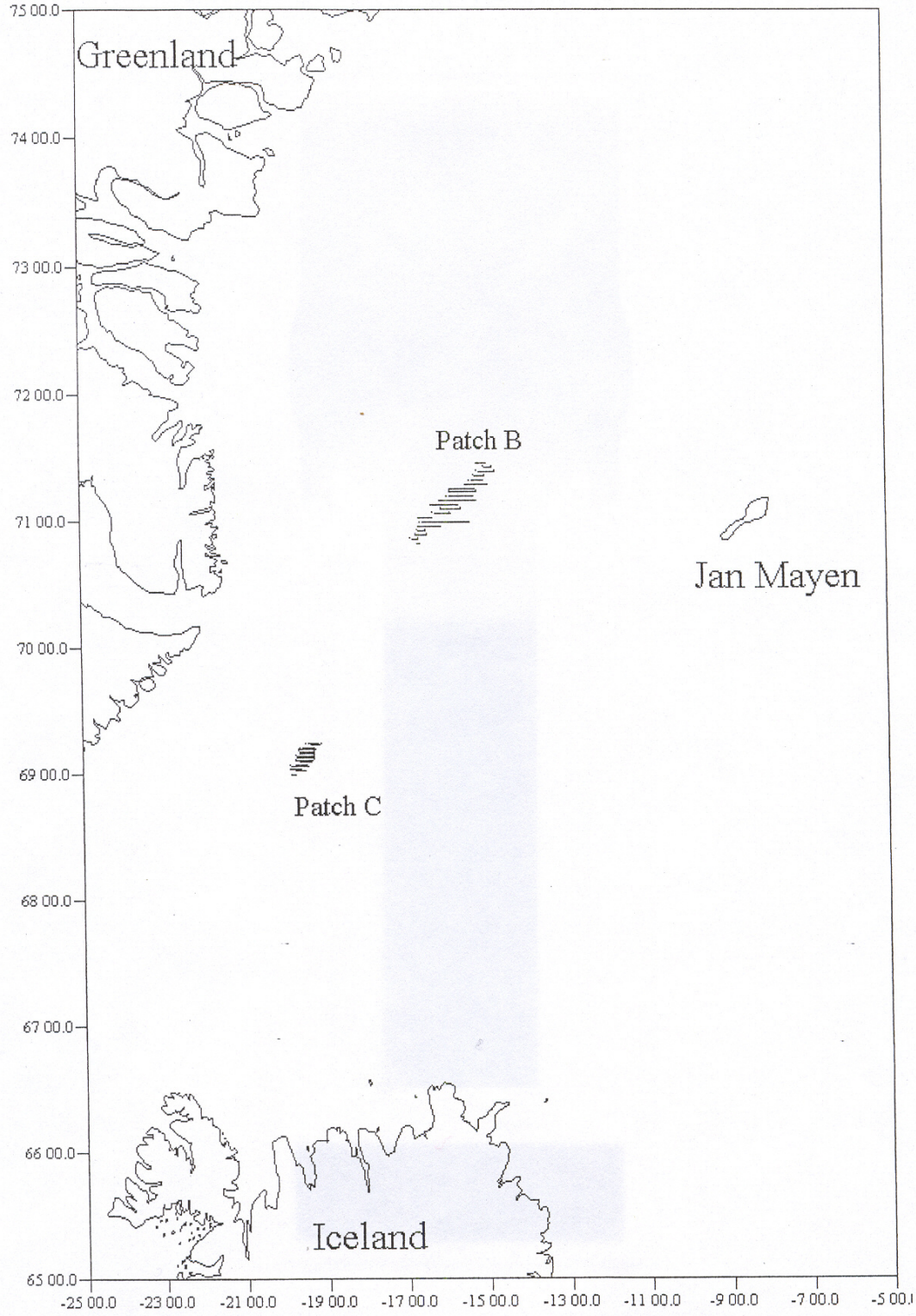

Fig. 3. *Photographic survey transects flown by fixed-wing aircraft over harp seal whelping patches B (29 March 2002) and C (6 April 2002) in the Greenland Sea.*

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