

REPORT FROM SURVEYS TO ASSESS HOODED AND HARP SEAL PUP PRODUCTION IN THE GREENLAND SEA PACK-ICE IN MARCH-APRIL 2007

Compiled by

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SUMMARY

In the period 14 March to 3 April 2007 aerial surveys were performed in the Greenland Sea pack-ice (the West Ice), to assess the pup production of the Greenland Sea populations of hooded (*Cystophora cristata*) and harp (*Pagophilus groenlandicus*) seals. Two fixed-wing twin-engined aircrafts, stationed in Constable Pynt (East-Greenland), Akureyri (Iceland), and the Jan Mayen island, were used for reconnaissance flights and photographic surveys along transects over the whelping areas. A helicopter, operated from the applied expedition vessel (M/V "Nordsyssel") also flew reconnaissance flights, and was subsequently used for other purposes, such as monitoring the distribution of seal patches and age-staging of the pups.

The reconnaissance surveys were flown by the helicopter (14 – 24 March) and the fixed-wing aircrafts (21 March – 3 April) in an area along the eastern ice edge between 66°55' and 75°30'N. Obviously, the ice cover was narrow and the edge close to the Greenland coast in 2007, and all surveyed areas were overlaying the continental shelf (300 - 400 m depth). The reconnaissance surveys were adapted to the actual ice configuration, usually flown at altitudes ranging from 160 - 300 m. Repeated systematic east-west transects spacing 10 nm (sometimes 5 nm apart) were flown from the eastern ice edge and usually 20-30 nautical miles (sometimes longer) over the drift ice to the west. The reconnaissance surveys detected no apparent hooded seal whelping concentrations, only scattered hooded seal families and, subsequently, solitary bluebacks over a relatively large area ranging from 72°00'N and

73°51'N. Scattered harp seal whelping was observed in the same area, whereas a more concentrated harp seal whelping patch was observed to the east of the scattered hooded seals between 73°00'N and 73°40'N.

One aircraft was equipped with a Leica RC 30 camera with a motion compensation mechanism shooting AGFA Pan 400 black-and-white film. The second aircraft was fitted with a Vexcel Ultra Cam D digital camera, which provided multichannel images (Red Green Blue Infrared).

On 27 March, a total of 19 photo transects, spacing 5 nautical miles, were flown using both aircrafts in the area between 72° 00'N / 18° 35' - 16° 49' W and 73° 30'N / 15° 40' - 13° W. The survey covered the entire area of scattered whelping hooded seals, including also scattered whelping harp seals in the northern parts of the covered area. The survey was conducted with low-density photographic effort where two photos were shot per 1 nm along each line, resulting in a total of 1136 photos.

On 29 March, the area between 73° 03'N / 15° 42' - 14° 42' W and 73° 33'N / 15° 20' - 13° 50' W was covered using both aircrafts simultaneously in a high-density coverage of the concentrated patch of whelping harp seals. A total of 16 photo transects, spacing 2 nm, were flown with cameras operated to ensure about 80-90 % coverage of the area along each transect line, resulting in a total of 1987 photos shot.

A second, smaller harp seal whelping concentration was covered in another high-density coverage on 3 April in the area between 71° 22'N / 17° 40' - 18° W and 71° 30'N / 17° 27' - 17° 46' W. Five photo transects, spacing 2 nm, were run with 80-90 % coverage of the area along each transect line, resulting in a total of 264 photos shot.

Only very few whelping hooded and harp seals were observed outside the surveyed whelping areas. The results from the aerial surveys will be used to estimate the 2007 hooded and harp seal pup production in the West Ice. Subsequently, the status of the stocks will be assessed by fitting population models to the pup production estimates.

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, using aerial photographically or visually based strip transect methods, have been recommended and used to determine population size of harp (*Pagophilus groenlandicus*) and hooded (*Cystophora cristata*) seals both in the northwest Atlantic (Bowen et al., 1987; Hammill et al., 1992; Stenson et al., 1993; 1997; 2002; 2003), in the Greenland Sea (Øritsland and Øien, 1995; Haug et al., 2006; ICES, 2006a; Salberg et al. 2007), and in the White Sea (Potelov et al., 2003; ICES, 2006b). 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 2006a, b; Hammill and Stenson, 2007; Skaug et al., 2007).

Harp seal pup production was assessed in the Greenland Sea in 2002 (Haug et al. 2006), hooded seals in 2005 (Salberg et al. 2007). Preferably, abundance estimates of hunted seal stocks should be obtained no less than every 5 year, and surveys and associated data that are more than 8 years old are too old to be considered recent (ICES 2006b). Therefore, the plan was to conduct new surveys to obtain data necessary for estimation of the abundance of harp seals of the Greenland Sea stock in 2007. However, the low pup production estimate obtained for hooded seals in the area in the 2005 survey caused so serious concerns that ICES has advised Norway to stop the hooded seal catch from 2007 on, and recommended that a new hooded seal survey be carried out already in 2007 (ICES 2006a). This recommendation was the prime reason for the present survey, conducted in the Greenland Sea in March/April 2007. In addition to revisit all areas historically used by hooded seals for breeding purposes in the Greenland Sea (see Salberg et al. 2007), also new areas to the north and south of these areas were covered with reconnaissance flights during the survey. In addition to the abundance estimation, using aerial survey techniques as described in Salberg et al. (2007), also a number of animals of various ages were killed for scientific biological sampling to obtain updated information on reproductive rates and health status of hooded seals.

If possible, it was a secondary goal to obtain also a new abundance estimate for harp seals in the area during the same survey. Evidently, given the available logistical resources and the priority of hooded seals, the possibilities to obtain a harp seal pup production estimate would require that harp seal breeding occurred within the same main areas as the hooded seal breeding. During the survey, it proved possible to obtain data on the pup production of both harp and hooded seals in the Greenland Sea in 2007. In addition to give a short review of the status of the two seal populations in question, the present report review the activities on the ship bound part of the survey (including all activities using the ship borne helicopter) and details from the activities of two aircrafts used for reconnaissance and photographic surveys.

2 STATUS OF THE SEAL STOCKS

2.1 HOODED SEALS

Two (possibly three) stocks of hooded seals are assumed to inhabit the North Atlantic Ocean (Sergeant 1974; Kovacs and Lavigne 1986). Whelping occurs east of Newfoundland and in the Gulf of St. Lawrence (the Northwest Atlantic stocks), whereas a possible separate whelping stock of hooded seals occurs in the Davis Strait between Greenland and Arctic Canada. Furthermore, hooded seals whelp in the Greenland Sea off the east coast of Greenland (the West Ice stock). It has proved impossible to detect significant genetic differences (allozymes and DNA) between hooded seals from the West Ice and from the Northwest Atlantic (Sundt et al. 1994; Coltman et al. 2007). Thus, a hypothesis that there is some degree of intermixing between the stocks cannot be rejected. The stocks are, however, managed separately. In general, results from satellite tagging programs indicate that hooded seals tagged in the West Ice during breeding and after moult, remain within the Greenland, Norwegian and Icelandic Sea for the majority of the year (Folkow and Blix 1995, 1999; Folkow et al. 1996). Recaptures of seals, tagged as pups in the West Ice, are consistent with the satellite tagging results (ICES 1999).

The Greenland Sea stock of hooded seals has been subject to commercial exploitation for centuries (Iversen 1927; Sergeant 1966; Nakken 1988; ICES 2006a). The hunt increased substantially after 1920, and after a 5 year pause in the sealing operations during World War II, the postwar annual catches quickly rose to levels higher than the stock could sustain, and some regulatory measures (mainly to reduce effort) were taken in 1958 (Rasmussen 1957, 1960; Øritsland 1959; Sergeant 1966). The total annual catches have subsequently followed a decreasing trend, primarily due to reduction in catch effort, and quotas were imposed in 1971 (Kovacs and Lavigne 1986; ICES 2006a).

Knowledge of possible variations in the abundance of Greenland Sea hooded seals is rather restricted. As judged both from catch per unit of 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; Øritsland and Øien 1995). Aerial surveys to estimate the hooded seal pup production were attempted, however with rather little success, in the Greenland Sea both in 1959 (Øritsland 1959; Rasmussen 1960) and in 1994 (Øritsland and Øien 1995). More successful aerial surveys suggested a minimum pup production of c. 24 000 (s.e. = 4 600, cv = 19.0%) in 1997 (ICES 1998, 1999). New aerial surveys to assess the Greenland Sea hooded seal pup production were conducted in 2005. Using the same methodology as in the 1997 survey, the results from the 2005 survey suggested a current hooded seal pup production in the Greenland Sea of 15 200 (s.e. = 3 790, cv = 24.9%) (Salberg et al. 2007). While the 1997 estimate was a minimum estimate, not corrected for the temporal distribution of births or pups born outside of the whelping patches, the more current estimate was corrected both for readers error and the temporal distribution of births. Thus, the results seem to indicate that

the 2005 pup production of hooded seals in the Greenland Sea is considerably lower than in 1997.

Incorporating available pup production estimates into a population model indicates that Greenland Sea hooded seals underwent a substantial decrease in population abundance from the late 1940s and up to the early 1980s (ICES 2006a). In the most recent two decades, the stock appears to have stabilized at a low level, approximately 71 400 (95% C.I. 38 400-104 400) 1+ animals in 2006, which may be only 10-15% of the level observed 60 years ago. The modelling exercises included the two pup estimates as well as available information about age at maturity and estimates of natural mortality and natality. Changes in size of harvested seal populations are often attributed to hunting pressure. However, in the past 25 years, the average annual catch level has remained less than 5 000 animals (almost exclusively pups), which is below the level that has been assumed to stabilize the population at its current size (ICES 2004). Annual removals by Greenland hunters from the Northeast Atlantic stock were between 3 and 67 animals per year (ICES 2006a). It seems unlikely, therefore, that recent hunting pressure alone could cause a stock decline.

2. 2 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). 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). 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 hundreds 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 modeling, the 1988 pup production was projected to have been within the range of 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 (s.e. = 5 400, cv = 8.0 %) (ICES, 2001). Aerial surveys performed in 1991 suggested a minimum pup production in this year in excess of 55 000 (Øritsland and Øien, 1995). New aerial surveys conducted 11 years later (in 2002, see Haug et al., 2006) yielded an estimate of 98 500 (s.e. = 16 800, cv = 17.0%). Incorporating available pup production estimates in a population model suggested population growth after 1970 and a current (2005) population size of 620 000 (95% CI 418 000 – 823 000) seals (ICES 2006b).

3 LOGISTICS AND METHODS

3.1. Ship, aircrafts and personell

The ice-strengthened expedition vessel M/V "Nordsyssel" (length 71.6 m, 760 gross tonnes, 2x1560 hp machine engines, classification ICE 1A Super; owned by Rana Ship Management AS, Mo i Rana, Norway) was used for operations in the Greenland Sea drift ice. The ship was equipped with a helicopter platform 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; Haug et al., 2006; Salberg et al. 2007). The helicopter was fitted with a satellite navigation system (GPS) and radar altimeter. Approximately 80 hours were flown over the ice during the survey.

In addition to crews on the ship and helicopter, the boat based part of the expedition included a scientific personell of 11 persons. Onboard M/S "Nordsyssel", Tore Haug (IMR, expedition leader), Lotta Lindblom (IMR), Carlos das Neves (National Veterinary Institute, Tromsø, Norway), Michael Polterman (IMR), Nils Erik Skavberg (IMR) and Tor Arne Øigård (IMR) had the pup assessments and biological sampling from hooded seals taken for scientific purposes as their primary occupation during the survey. Erik Born (Greenland Institute of Natural Resources, Nuuk, Greenland), Øystein Wiig (University of Oslo, Norway) and Rune Dietz (Danish Polar Centre, Copenhagen, Denmark) participated in the boat based part of the

expedition primarily to deploy satellite linked tags on, and collect samples for analyses of pollutants from, polar bears (*Ursus maritimus*) in the study area.

Two fixed-wing twin engine Piper Navajo aircrafts (LN-NPZ and LN-NAB, operated by Blom Geomatics, Norway) were used to conduct reconnaissance and photographic surveys. The aircraft LN-NPZ operated over the drift ice during the period 21 March – 3 April, and LN-NAB in the period 24 March - 3 April. The aircrafts were mainly based at Constable Pynt airport (50 km north of Scoresbysund, East Greenland), but the airports in Akureyri (Iceland) and on the island Jan Mayen (Norway) were also used. In addition to the pilot and one operator/copilot on each aircraft, Kjell Tormod Nilssen and Kjell-Arne Fagerheim (both from IMR) operated on the LN-NPZ and LN-NAB aircrafts, respectively.

3.2 Reconnaissance surveys

The distribution and configuration of the drifting pack ice throughout the survey period is given in Figs 1-5. Obviously, the ice cover was very close to the East Greenland coast in 2007, and all surveyed areas were generally over the continental shelf (300-400 m depth). Whelping seals (concentrations as well as scattered seals) were located using fixed-wing and helicopter reconnaissance surveys of areas historically used by hooded and harp seals in the Greenland Sea, mainly the pack ice areas along the eastern coast of Greenland between 66°55'N / 25°30'W and 75°30'N / 9°23'W (see Figs 6 and 7). The reconnaissance flights were adapted to the actual ice-configuration during the survey period. Survey altitudes were 160-300 m. Due to ice drift and a range of pupping dates (mid to late March, see Rasmussen, 1960; Øritsland, 1964; Øritsland and Øien, 1995; ICES, 1998; Haug et al., 2006, Salberg et al., 2007), most areas were surveyed repeatedly to minimize the chance of missing whelping concentrations. Colour markers, VHF transmitters and one satellite based Argos calib were deployed in major whelping concentrations to facilitate relocation and to monitor ice drift (see Fig. 8).

M/S "Nordsyssel" met the ice edge at 72°28'N / 16°55'W on 14 March. The ship moved and drifted southwestwards and was at 71°40'N / 18°48'W on 16 March, then moved northwards again and stayed within an area between 72°30'-73°15'N and 15°00'-16°30'W during the period 19 – 30 March. Helicopter reconnaissance flights were flown between 14 and 24 March in areas between 71°28'N - 73°57'N and 13°27'W - 19°00'W as repeated systematic east-west transects from the ice edge in the east and into more close drift ice. The length of the transects were approximately 10-30 nm and they were usually spaced 5 nm apart, modified according to the actual ice configurations during the surveys. "Nordsyssel" left the ice on 30 March.

The reconnaissance fixed-wing surveys had the capacity to cover larger areas than the helicopter surveys, and were used in order to cover the entire area of potential hooded and harp seal whelping in the West Ice. These surveys were usually flown at altitudes between 200-300 m, but due to low cloud base in some short periods surveys were also flown at lower altitudes. Repeated systematic east-west transects normally spacing 10 nm were flown from the eastern ice edge and usually 20-30 nm (sometimes longer) over the drift ice to the west. Transects were usually ended in the west when the ice conditions changed to be very dense, with no water between the ice flows and increased snow coverage on the ice. Along the eastern ice edge, also some additional transects were flown in order to cover tongues of drift

ice stretching to the east. In areas where seals were concentrated, transects spaced from 1 nm to 5 nm.

3.3 Visual surveys

Visual surveys using the helicopter were not conducted in 2007 due to the scattered distribution of whelping over large areas.

3.4 Photographic surveys

The LN-NPZ aircraft was equipped with a Leica RC 30 camera with a motion compensation mechanism shooting AGFA X100 colour film. The camera was fitted with a 15,3 cm lens, and photographic surveys were conducted at altitudes of approximately 250 m (800 ft) for hooded seals and 190 m (600 ft) for harp seals. The LN-NAB was equipped with a Vexcel Ultra Cam D digital camera, which provides multichannel images (Red Green Blue Infrared). The digital camera was operated at altitudes of approximately 310 m (1000 ft) for both harp and hooded seals. Both cameras were operated in order to cover about 80-90 % of the area along each transect line spacing 2 nm over areas characterized as more concentrated whelping patches. In areas with scattered whelping 2 photos per 1 nm were shot along each transect line spacing 5 nm.

LN-NPZ was fitted with radar altimeter, while LN-NAB was fitted with barometric altimeter to obtain correct altitude. Altitudes based on the GPS navigation systems were logged along the transect lines, and later used to correct the altitudes on all photos. The altitudes on each photo were estimated using bilinear interpolation based on the geoid model EGM96 (see <http://cdis.gsfc.nasa.gov/926/egm96/nasatm.html>). Correct transect spacing were maintained using GPS.

3.5 Temporal distribution of births

To correct the estimates of abundance for hooded seal pups that had left the ice or were not yet born at the time of the survey, it was necessary to estimate the distribution of births over the pupping season. This was done by using information on the proportion of pups in each of four distinct age-dependent stages. These arbitrary, but easily recognizable age categories were based on pelage color and condition, overall appearance, and muscular coordination, as described for northwest Atlantic hooded seals by Bowen et al. (1987) and Stenson & Myers (1988), and used in the 2005 survey in the Greenland Sea by Salberg et al. (2007):

0. Unborn: Parturent females.
1. Newborn: Skin in loose folds along flanks, fur saturated to wet, entire pelage with yellowish hue, awkward body movements. Mother present. Often associated with wet placentas and blood stained snow.
2. Thin blueback: Pup dry, ventrum white, neck well defined, trunk conical in shape. Mother present. Mainly 1-2 days old.
3. Fat blueback: Ventrum white, neck not distinguishable, trunk fusiform in shape. Mother present. Mainly 2-4 days old.
4. Solitary blueback: As in fat blueback, but mother not present. Mainly 4 days or older.

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.

A similar procedure was followed for harp seals where information on the proportion of pups in each of seven distinct age-dependent stages were used to assess the temporal distribution of births. 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 yellow 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).

3.6 Animals taken for scientific purposes

A total of 47 hooded seals were killed, examined and sampled for scientific purposes during the survey:

DAY	LATITUDE	LONGITUDE	NO. ANIMALS
22-03-2007	72°32'00"N	16°06'00"W	8
23-03-2007	73°13'00"N	15°16'00"W	9
24-03-2007	73°14'00"N	15°15'00"W	10
26-03-2007	73°04'00"N	15°32'00"W	12
27-03-2007	73°01'00"N	15°22'00"W	6
28-03-2007	72°43'00"N	16°01'00"W	1
TOTAL			47

The animals were shot in the head according to existing sealing regulations and brought onboard immediately. Biometric measurements were taken: weight, total length, girth over flipper, maximum girth, blubber thickness on the back and on the chest. This information will be used for comparative purposes (with previous sampling of hooded seals from the regular

hunt). Furthermore this data will be correlated to the analysis of organ tissue samples as well to reproductive studies.

The following tissues were sampled for the study of bacteriological, virological diseases as well as pollutants contamination, and endocrinal parameters: Adrenal gland, mammary gland, thyroid gland, reproductive organs, liver, kidney, spleen, muscle, feces, blubber and lesions when found. Samples were either frozen at -20° Celsius or put in formalin.

Liver and kidney samples were collected from all animals for the study of distemper virus (PDV).

Blood was collected at the beginning of the skinning process, usually directly from the jugular artery. Blood was collected in Venoject EDTA tubes (2 per animal) and centrifuged at 1500g for 15 min. Sera was collected and frozen at 20°C.

The thoracic was usually open for the inspection of lungs and heart. The skin was also inspected for lesions.

Additional sampling from selected animals included:

- Three lung tissue samples were collected from animals 20, 22 and 38. The lung presented some areas of paler white color denser to palpation. No signals of edema, parasite or pus were found.
- One liver sample was taken from animal 42. Liver presented some yellow areas on the surface. When cut these areas were slightly yellow as well in tissue bellow. No evidence of edema, parasites, pus or other pathological identities.
- One milk sample was collected from animal 27 to study the composition of the milk sample.
- 5 heads were sampled for the study of prion diseases in marine mammals. Responsible: Morten Tryland, National Veterinary Institute, Tromsø, Norway.
- A small muscle sample was sampled for the screening of *Brucella spp.* Responsible: Morten Tryland, National Veterinary Institute, Tromsø, Norway.
- A skin with blubber of an adult animal was collected for Christian Lyndersen, Norwegian Polar Institute, Tromsø.
- Female seal's heads were collected for meorphometric studies. Responsible: Øystein Wiig, University of Oslo.

4 PRELIMINARY RESULTS

4.1 Identification of whelping areas

The helicopter reconnaissance flights were flown between 14 and 24 March in areas between 71°28'N - 73°57'N and 13°27'W - 19°00'W as repeated systematic east-west transects from the ice edge in the east and into more close drift ice (Fig. 6). During the period 14-17 March, the reconnaissance flights covered areas between 71°28'N and 72°28'N where only scattered solitary hooded seals (adults and immatures) were observed in the northmost parts of the surveyed areas. Scattered family groups of breeding hooded seals were observed during reconnaissance flights on 19 March in areas between 72°40'N and 73°05'N. New reconnaissance surveys on 21 and 22 March confirmed the occurrence of scattered hooded seal whelping over a large area between 72°25'N and 73°30'N, and an additional survey on 24 March similarly confirmed scattered whelping as far north as to 73°57'N. The reconnaissance surveys detected no apparent hooded seal whelping concentrations, only scattered hooded seal families and, subsequently, solitary bluebacks over a relatively large area. Staging surveys with the helicopter on 26 and 28 March confirmed this picture and revealed that the main area of scattered hooded seal whelping was between 72°00'N and 73°30'N.

Reconnaissance surveys using the fixed wing aircrafts over the drift ice were attempted on 13 and 16 March, but both had to be interrupted due to fog. After a period (13-20 March) of poor weather conditions, reconnaissance surveys were successfully carried out in the period 21 March to 3 April. Nine reconnaissance surveys were flown by the aircrafts covering the eastern parts of the drift ice between approximately 66° 55'N / 25°30'W and 75° 30'N / 09°20'W (Fig.7). The information obtained from these fixed-wing surveys confirmed the helicopter survey observations in that whelping hooded seals were mainly observed in the area between 72° 00' N / 18° 35'W - 16° 49'W and north to 73° 51' - 56'N / 14° 25'W - 13° 45'W. Only a few scattered bluebacks and hooded seal families (a total of 19 bluebacks) were observed south of 72° N, mainly in the areas between 71°20'N/18 ° W and 72° N / 18 ° - 19 ° W (Fig. 9).

Harp seal breeding was observed in the northeastern part of the scattered hooded seal area, in some cases close to the ice edge, between 73°15'N and 73°57'N during reconnaissance flights on 22 (helicopter) and 24 March (helicopter and fixed-wing aircrafts), and on a helicopter staging flight (targetting hooded seal pups) on 26 March. A new helicopter staging flight (now targetting harp seals) on 27 March confirmed scattered distribution of groups of breeding harp seals between 73°15'N and 73°40'N, whereas a similar staging survey and fixed-wing reconnaissance surveys on 28 March found substantially increased number of harp seals, virtually a concentrated whelping patch, in these areas.

Based on the observations made 28 March, staging of the larger and more concentrated patch of harp seals was carried out with the helicopter between 73°07'N and 73°35'N on 29 March. These staging flights also detected scattered hooded seal families and solitary pups (bluebacks) to the west of, to some extent also within, the harp seal breeding patch.

The ice drift varied in the survey period, but could be as much as 15-20 nm per day in a

south-southwesterly direction, as seen from the satellite based calib deployed on the ice (Fig. 8). It was, therefore, assumed that both the harp seal whelping patch, and the scattered hooded seal whelping animals that occurred west of the harp seals, all observed north of $73^{\circ}07'N$ on 29 March, were different from and independent of all whelping seals observed before that date. A combined reconnaissance and staging survey flown by the helicopter on 30 March confirmed this.

During search for polar bears, the helicopter also surveyed areas closer to the Greenland shore. Usually, no seal whelping activities were observed during these excursions. However, on one polar bear survey on 30 March, polar bears were observed to feed on groups of both hooded seals (mainly solitary bluebacks) and harp seal pups at approximately $72^{\circ}24'N / 18^{\circ}00'W$.

Two small patches of whelping harp seals were observed by the fixed-wing aircrafts on 2 April. The smallest patch was located between $72^{\circ}23'-24'N / 17^{\circ}50' - 18^{\circ}10' W$. The second patch was observed further south in the area around $71^{\circ}38'N / 17^{\circ}50'W$ (Fig. 7).

4.2 Temporal distribution of births

Estimations of the proportion of pups in each developmental stage were obtained from both hooded and harp seals in both the low-density and high-density areas of seals. The low-density pupping area was covered with systematic east-west staging transects (spaced 2-5 nautical miles apart) on 21, 23, 26, 27 and 28 March, whereas the high-density pupping area was covered with similar transects (all spaced 5 nautical miles apart) on 29 and 30 March (Tables 1 and 2).

4.3 Photographic surveys

The helicopter based on M/V "Polarsyssel", was used to define the geographic range of the whelping patches prior to the fixed-wing aircraft photographic surveys. Cameras were turned on when seals were observed on a transect line. Cameras turned off when the transect line ended at the eastern ice edge, or when no seals were observed for an extended period along the line to the west.

On 27 March, the area between $72^{\circ}00'N / 18^{\circ}35' - 16^{\circ}49' W$ and $73^{\circ}30'N / 15^{\circ}40' - 13^{\circ}W$ was photographed in order to cover almost the entire area of whelping hooded seals (Fig. 9). However, whelping harp seals also occurred in the northern parts of the covered area. A total of 19 transects spacing 5 nm were flown. Two photos per 1 nm were shot along each line, resulting in a total of 1136 photos (Table 3). The aircraft LN-NPZ first photographed the transects 1-11 during one survey, while the other aircraft LN-NAB stayed on ground due to technical problems. After a stop of about three and a half hour, both aircrafts were used to photograph the transects 12-19 (Table 3).

On 29 March, the area between $73^{\circ}03'N / 15^{\circ}42' - 14^{\circ}42' W$ and $73^{\circ}33'N / 15^{\circ}20' - 13^{\circ}50' W$ was photographed using both aircrafts simultaneously in order to cover the largest patch of whelping harp seals (Fig. 9). A total of 16 transects spacing 2 nm were flown. Both cameras were operated in order to cover about 80-90 % of the area along each transect line, resulting in a total of 1987 photos shot (Table 4).

On 3 April, the area between 71° 22'N / 17° 40' - 18° W and 71° 30'N / 17° 27' - 17° 46' W was photographed in order to cover the southernmost harp seal whelping patch using LN-NAB (Fig. 9). Five transects spacing 2 nm were photographed in order to cover 80-90 % of the area along each transect line, resulting in a total of 264 photos shot (Table 5).

Attempt at finding the small harp seal whelping patch observed on 2 April was done on 3 April, but with negative result due to fog.

A total of 74 hours were flown by both fixed-wing aircrafts, including the transport flights between the airports (Constable Pynt, Akureyri and Jan Mayen) and the surveyed areas.

4.4 Biological sampling of hooded seals

All examined hooded seals seemed to be in good health condition. No strange behavioral events were recorded. Hooded seals occurred very scattered on the ice and no big concentrations were found during the expedition. Regarding harp seals, apart from the two dead animals taken from the ice, animals seemed healthy and didn't show either any strange behavior. Unlike hooded seals, large patches of harp seals were identified with mothers and pups, these mostly still in the white coat stage.

Besides the studies already planned with the samples gathered in this expedition it would be interesting to conduct investigation on the changes at reproductive level during the last years: changes in organ size, hormone levels etc Further studies on bacterial and viral diseases in seals, like herpes, morbilli and distemper viruses would be of high interest as well.

4.5 Other observations

Two dead harp seal pups were found in the ice 29 March. On the first, there was some evidence of feces frozen as well and blood on the nose and mouth. The pup had a clear white fur on the top side exposed to the wind and was still yellow on the other side. First analysis points to a death after birth. Also for the second pup there was some evidence of feces. This pup was only frozen in the lower body and head and the chest was still at body temperature. Eyes still contained liquid humor, and the pup had a clear white fur. First analysis points to a death after birth. Other dead harp seal pups were seen in the ice both from the boat as well from the helicopter survey on 30 March. Once again they were young pups, yellow and white. Two dead harp seal pups were collected and frozen. Responsible: Siri Knudsen and Carlos das Neves, National Veterinary Institute.

A total of 19 narwhals (*Monodon monoceros*) were observed in open leads within the drifting ice in the survey area of the helicopter.

4.6 Polar bears

During the survey, available helicopter time (in total 32 hours) was used to search for polar bears in the survey area. The purpose of this research was to anesthetize bears for deployment of satellite tags and to collect samples for studies of pollutants. In total, 16 bears

were sampled. Of these 12 (6 adult females, 1 subadult female, 1 two-year-old female and 4 adult males) were fitted with satellite tags.

5 CONCLUDING REMARKS

The survey used methods comparable with previous surveys performed for harp and hooded seal assessments in the northwest Atlantic (Bowen et al., 1987; Hammill et al., 1992; Stenson et al., 1993; 1997; 2002; 2003), in the Greenland Sea (Øritsland and Øien, 1995; ICES, 1998; Haug et al., 2006; Salberg et al., 2007) and in the White Sea (ICES, 1999; 2001; 2004; Potelov et al., 2003). Extensive reconnaissance of all likely areas were conducted to locate whelping hooded seals, and results from the visual and photographic surveys will be used to estimate the 2007 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 2007 surveys will be used to estimate the hooded and harp seal pup productions and to assess the present status of Greenland Sea hooded seals. Presumably, the obtained results will indicate whether the apparent low level of hooded seal pup production observed in 2005 (see Salberg et al., 2007) still prevail. Also, data from the survey will make comparisons of harp seal pup production between 2002 (Haug et al., 2006) and 2007 feasible.

Hooded seals are usually found in more moderate densities than harp seals (Lavigne and Kovacs 1988), and over a large, unstable habitat. The accuracy of estimates obtained from aerial surveys is dependent on the degree to which the possible sources of error are minimized. In assessing the relative importance of different sources of bias in estimating seal abundance from aerial surveys, (Myers and Bowen 1989) concluded that the greatest source of bias arose from missing whelping concentrations. The extensive reconnaissance surveys conducted of all areas historically used by hooded seals in the Greenland Sea reduced the likelihood of missing major whelping concentrations in 2007. In previous hooded seal surveys the surveyed areas have traditionally consisted of two strata types: (1) whelping concentrations where both visual and photographic surveys were conducted with high-density coverage, and (2) scattered pups outside the whelping concentrations which were covered with low-density photographic surveys only (Bowen et al. 1987; Stenson et al. 1997). In the 2005 Greenland Sea survey hooded seal whelping occurred in three well defined concentrations, but it was not possible to run an additional low-density coverage survey of scattered pups outside these whelping concentrations. Owing to this, the total estimate presented is slightly negatively biased. In 2007, all pupping of hooded seals occurred scattered with no major patches of concentrated breeding. This will increase the uncertainty in the estimate obtained (see Bowen et al. 1987) – it remains to see how the new estimate compares with the 2005 estimate.

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7 REFERENCES

- Borisov, V.I. 1966. Some data of the serological analysis of *Pagophilus groenlandicus* Erxleben colonies. *Zoologicheskii Zhurnal*, 45: 1890-1892. (In Russian, with English summary)
- Bowen, W.D., Myers, R.A., and Hay, K. 1987. Abundance estimation of a dispersed, dynamic population: hooded seals (*Cystophora cristata*) in the Northwest Atlantic. *Can. J. Fish. Aquat. Sci.* 44: 282-295.
- Coltman, D. W. Stenson, G., Hammill, M. O., Haug, T., Davis, C. S., and Fulton, T. L. 2007. Panmictic population structure in the hooded seal (*Cystophora cristata*). *Molecular Ecology* 16: 1639-1648.
- Folkow, L.P. and Blix, A.S. 1995. Distribution and diving behaviour of hooded seals. Pp 193–202 in Blix, A.S., Walløe, L. and Ulltang, Ø. (eds). *Whales, seals, fish and man*. Elsevier Science B.V., Amsterdam.
- Folkow, L.P. and Blix, A.S. 1999. Diving behaviour of hooded seals (*Cystophora cristata*) in the Greenland and Norwegian Seas. *Polar Biol.* 22: 61–74.
- Folkow, L.P., Mårtensson, P.E. and Blix, A.S. 1996. Annual distribution of hooded seals (*Cystophora cristata*) in the Greenland and Norwegian Seas. – *Polar Biol.* 16: 179–189.
- Hammill, M.O. and Stenson, G.B. 2007. Application of the Precautionary Approach and conservation reference points to the management of Atlantic seals. *ICES J. Mar. Sci.* 64: in press.
- Hammill, M.O., Stenson, G. B., and Myers, R. A. 1992. Hooded seal pup production in the Gulf of St. Lawrence. *Can. J. Fish. Aquat. Sci.* 49: 2546-2550.
- Haug, T., Stenson, G.B., Corkeron, P.J. and Nilssen, K.T. 2006. Estimation of harp seal (*Pagophilus groenlandicus*) pup production in the North Atlantic completed: Results from surveys in the Greenland Sea in 2002. *ICES J. Mar. Sci.* 63: 95-104.

- Healey, B.P. and Stenson, G.B. 2000. Estimating pup production and population size of the northwest Atlantic harp seal (*Phoca groenlandica*). Canadian Stock Assessment Secretariat, Research Document 2000/081: 28 pp.
- ICES 1998. Report of the Joint ICES/NAFO Working Group on Harp and Hooded Seals, ICES Headquarters, 28 August-3 September 1997. ICES CM 1998 / Assess: 3: 35 pp.
- ICES 1999. Report of the Joint ICES/NAFO Working Group on Harp and Hooded Seals, Tromsø, Norway, 29 September-2 October 1998. ICES CM 1999 / ACFM: 7: 33 pp.
- ICES 2001. Report of the Joint ICES/NAFO Working Group on Harp and Hooded Seals, ICES Headquarters, 2-6 October 2000. ICES CM 2001 / ACFM: 8: 40 pp.
- ICES 2004. Report of the Joint ICES/NAFO Working Group on Harp and Hooded Seals, Arkhangelsk, Russia, 2-6 September 2003. ICES CM 2004, ACFM: 6: 53 pp.
- ICES 2006a. Report of the Joint ICES/NAFO Working Group on Harp and Hooded Seals, ICES Headquarter, Copenhagen, Denmark, 12-16 June 2006. ICES CM 2006, ACFM: 32: 32 pp.
- ICES 2006b. Report of the Joint ICES/NAFO Working Group on Harp and Hooded Seals, St. John's, Newfoundland, Canada, 30 August-3 September 2005. ICES CM 2006, ACFM: 6: 52 pp.
- Iversen, T. 1927. Drivis og selfangst. Årsber. vedk. Norges Fiskerier 1927(2): 1-84. (In Norwegian)
- Kovacs, K.M. and Lavigne, D.M. 1986. *Cystophora cristata*. Mammalian Species 258: 1-9.
- Meisfjord, J. and Nævdal, G. 1994. Using isoelectric focusing to discern enzyme variation in northeast Atlantic stocks of the harp seal (*Phoca groenlandica*). Hereditas 121: 273-281.
- Meisfjord, J. and Sundt, G. 1996. Genetic variation between populations of the harp seal, *Phoca groenlandica*. ICES J. Mar. Sci. 53: 89-95.
- Møller, D.G., Nævdal, G. and Valen, A. 1966. Report on serological work in population studies. Fisken Hav. 1966: 1-17. (In Norwegian, with English summary)
- Myers, R.A. and Bowen, W.D. 1989. Estimating bias in aerial surveys of harp seal pup production. J. Wildl. Manage. 53: 361-372.
- Nævdal, G. 1966. Protein polymorphism used for identification of harp seal populations. Årbok Univ. Bergen (Matematisk Naturvitenskapelig Serie), 9: 1-20.
- Nævdal, G. 1969. Blood protein polymorphism in harp seals off eastern Canada. J.Fish. Res. Bd Can. 26: 1397-1399.

- Nævdal, G. 1971. Serological studies on marine mammals. Rapp. Proc.-verb. Réun., Cons. Int. l'Explor. Mer 161: 136-138.
- Nakken, O. 1988. Fangsthistorikk. Fiskets Gang 74(6/7): 14-15. (In Norwegian)
- Øien, N. and Øritsland, T. 1995. Use of mark-recapture experiments to monitor seal populations subject to catching. Pp 35-45 in Blix, A.S., Walløe, L. and Ulltang, Ø. (eds). Whales, seals, fish and man. Elsevier Science B.V.
- Øritsland, T. 1959. Klappmyss. Fauna 12 (2): 70–90. (In Norwegian)
- Øritsland, T. 1964. Klappmysshunnens forplantingsbiologi. – Fisken og Havet 1964 (1): 1–15. (In Norwegian)
- Øritsland, T. and Øien, N. 1995. Aerial surveys of harp and hooded seal pups in the Greenland Sea pack ice. Pp 77-87 in Blix, A.S., Walløe, L. and Ulltang, Ø. (eds). Whales, seals, fish and man. Elsevier Science B.V.
- Perry, E.A., Stenson, G.B., Bartlett, S.E., Davidson, W.S. and Carr, S.M. 2000. DNA sequence analysis identifies genetically distinguishable populations of harp seals (*Pagophilus groenlandicus*) in the northwest and northeast Atlantic. Mar. Biol. 137: 53-58.
- Perry, E.A. and Terhune, J.M. 1999. Variations in harp seal underwater vocalisations among three breeding locations. J. Zool., London 249: 181-186.
- Potelov, V.A., Golikov, A.P. and Bondarev, V.A. 2003. Estimated pup production of harp seals *Pagophilus groenlandicus* in the White Sea, Russia, in 2000. ICES J. Mar. Sci. 60: 1012-1017.
- Rasmussen, B. 1957. Exploitation and protection of the east Greenland seal herds. Norsk Hvalfangsttid 46: 45–59.
- Rasmussen, B. 1960. Om klappmyssbestanden i det nordlige Atlanterhav. Fisken og Havet 1960 (1): 1–23. (In Norwegian)
- Salberg, A.-B., Haug, T., Nilssen, K.T. 2007. Estimation of hooded seal (*Cystophora cristata*) pup production in the Greenland Sea pack ice during the 2005 whelping season. Polar Biol: in subm.
- Sergeant, D.E. 1966. Exploitation and conservation of harp and hooded seals. Polar Record 12 (80): 541–551.
- Sergeant, D.E. 1974. A rediscovered whelping population of hooded seals *Cystophora cristata* Erxleben, and its possible relationship with other populations. Polarforschung 44: 1–7.
- Sergeant, D.E. 1991. Harp seals, man and ice. Can. Spec. Publ. Fish. Aquat. Sci. 114: 1-153.

- Skaug, H.J., Frimannslund, L. and Øien, N. 2007. Historical population assessment of Barents Sea harp seals (*Pagophilus groenlandicus*). ICES J. Mar. Sci. 64: in press.
- Stenson, G.B., Hammill, M.O., Kingsley, M.C.S., Sjare, B., Warren, W.G. and Myers, R.A. 2002. Is there evidence of increased pup production in northwest Atlantic harp seals, *Pagophilus groenlandicus* ? ICES J. Mar. Sci. 59: 81-92.
- Stenson, G.B. and Myers, R.A. 1988. Accuracy of pup classifications and its effect on population estimates in the hooded seals (*Cystophora cristata*). Can. J. Fish. Aquat. Sci. 45: 715-719.
- Stenson, G.B., Myers, R.A., Hammill, M.O., Ni, I.-H., Warren, W.G. and Kingsley, M.C.S. 1993. Pup production of harp seals, *Phoca groenlandica*, in the northwest Atlantic. Can. J. Fish. Aquat. Sci. 50: 2429-2439.
- Stenson, G.B., Myers, R.A., Ni, I.-H. and Warren, W.G. 1997. Pup production and population growth of hooded seals, *Cystophora cristata*, near Newfoundland, Canada. Can. J. Fish. Aquat. Sci. 54 (Supplement 1):209-216.
- Stenson, G. B., Rivest, L.P., Hammill, M. O., Gosselin, J. F., and Sjare, B. 2003. Estimating pup production of harp seals, *Pagophilus groenlandicus*, in the Northwest Atlantic. Mar. Mamm. Sci. 19: 141-160.
- Stewart, R.E.A. and Lavigne, D.M. 1980. Neonatal growth of northwest Atlantic harp seals (*Pagophilus groenlandicus*). J. Mammol. 61: 670-680.
- Sundt, R.C., Dahle, G. and Nævdal, G. 1994. Genetic variation in the hooded seal, *Cystophora cristata*, based on enzyme polymorphism and multi-locus DNA fingerprinting. Hereditas 121: 147-155.
- Ulltang, Ø. and Øien, N. 1988. Bestandsutvikling og status for grønlandssel og klappmyss. Fiskets Gang 74: 8-10. (In Norwegian)
- Yablokov, A.V. and Sergeant, D.E. 1963. Cranial variation in the harp seal (*Pagophilus groenlandicus* Erxleben 1777). Zool. Zhurn. 42: 1857-1865. (In Russian, with English summary).

Table 1. Numbers of hooded seal pups in individual age dependent stages in the whelping area between 72°00' - 73°25'N and 14°00'W / 17°40'W in the Greenland Sea during March 2007.

Date	Stages					Total
	Parturient Females	Newborn	Thin blueback	Fat blueback	Solitary blueback	
March 21	2	2	44	2	1	51
March 23	6	4	135	114	7	161
March 26	2	0	81	256	51	390
March 28	0	0	5	33	16	54
March 30	0	0	12	80	17	109

Table 2. Numbers of harp seal pups in individual age dependent stages in the whelping area between 72°00' - 73°25'N and 14°00'W / 17°40'W in the Greenland Sea ("Patch A") and in whelping patch B during March 2007.

Date	Patch	Stage							Total
		New	Yellow	Thin white	Fat white	Grey coat	Ragged jacket	Beater	
Mar 27	A	1	0	17	79	0	0	0	97
Mar 28		1	0	48	126	2	0	0	177
Mar 29	B	0	0	78	434	0	0	0	512
Mar 30		2	1	24	324	8	0	0	359

Table 3. East-west transects (spaced 5 nm apart) flown during a fixed-wing photographic survey of hooded seal pupping areas in the Greenland Sea drift ice on 27 March 2007 (positions = deg.,min.). LN-NPZ photographed transects 1-15 (colour film; altitude 800 ft), and LN-NAB (shaded) covered transects 16-19 (digital photo; altitude 1000 ft).

Transect	Time	Start			End		Photo num.	Total
		Lat. N	Lon. W	Lon. W	Start	End		
1	11:13	72,00	16,49	18,30	1597	1657	61	
2	11:30	72,05	18,23	16,31	1669	1731	63	
3	11:46	72,10	16,31	18,14	1743	1795	53	
4	12:03	72,15	18,12	16,27	1796	1853	58	
5	12:19	72,20	16,22	17,46	1854	1901	48	
6	12:32	72,25	17,42	16,14	1902	1950	49	
7	12:46	72,30	16,10	17,32	1951	1996	46	
8	13:01	72,35	17,07	16,02	1997	2033	37	
9	13:12	72,40	15,55	17,03	2034	2070	37	
10a	13:22	72,45	16,58	16,04	2071	2099	29	
10b*	13:38	72,45	15,33	14,37	2101	2132	32	
11	13:48	72,50	14,37	16,35	2133	2197	65	
12	17:16	72,55	16,35	14,45	2205	2262	58	
13	17:32	73,00	14,57	16,34	2263	2314	52	
14	17:45	73,05	16,33	14,52	2315	2369	55	
15	17:59	73,10	14,52	16,35	2371	2425	55	
16	17:19	73,15	16,30	14,17	7	71	65	
17	17:37	73,20	14,30	16,10	72	133	62	
18	17:53	73,25	16,08	12,59	134	251	118	
19	18:20	73,30	13,00	15,40	252	344	93	
Sum photo							1136	

* Changed film; continued photographing to the east after open water between photo 2099 and 2101

Table 4. East-west transects (spaced 2 nm apart) flown during a fixed-wing photographic survey of harp seal pupping areas (including smaller areas of hooded seal pupping) in the Greenland Sea drift ice on 29 March 2007 (positions = deg.,min.). LN-NPZ photographed transects 1-10 (colour film; altitude c. 600 ft), and LN-NAB (shaded) covered transects 21-26 (digital photo; altitude c. 1000 ft).

Transect	Time	Lat. N	Start		End		Photo num.	Total
			Lon. W	Lon. W	Start	End		
1	14:57	73,03	15,42	14,43	2441	2502	62	
2	15:07	73,05	14,52	15,42	2503	2563	61	
3a	15:16	73,07	15,40	14,44	2564	2603	40	
3b*	15:33	73,07	14,38	15,00	2604	2623	20	
4	15:42	73,09	14,34	15,25	2624	2667	44	
5	15:50	73,11	15,15	14,25	2668	2711	44	
6	15:59	73,13	14,20	15,15	2712	2758	47	
7	16:07	73,15	15,11	14,20	2759	2800	42	
8	16:16	73,17	14,18	15,11	2801	2847	47	
9	16:24	73,19	15,07	13,29	2858	2930	73	
10	16:40	73,21	13,41	15,16	2931	3010	80	
21	14:57	73,23	15,20	13,50	345	561	217	
22	15:10	73,25	13,50	15,20	562	825	264	
23	15:25	73,27	15,20	13,50	826	1037	263	
24	15:38	73,29	13,50	15,20	1038	1303	263	
25	15:53	73,31	15,20	13,50	1304	1511	208	
26	16:06	73,33	13,50	15,20	1512	1774	263	
Sum photo							1987	

* Changed film; continued photographing from the ice eastern edge to the west; some overlapping photos between 73,07 N / 14,44-15,00 W

Table 5. East-west transects (spaced 2 nm apart) flown during a fixed-wing photographic survey, using LN-NAB (digital photo; altitude c. 1000 ft), of harp seal pupping areas in the Greenland Sea drift ice on 3 April 2007 (positions = deg.,min.).

Transect	Time	Lat. N	Start	End	Photo num.		Total
			Lon. W	Lon. W	Start	End	
1	12:52	71,22	17,40	18,00	1775	1825	51
2	12:57	71,24	18,00	17,40	1826	1873	48
3	13:02	71,26	17,40	18,00	1874	1921	48
4a	13:07	71,28	18,00	17,40	1922	1965	44
4b	13:14	71,28	17,40	17,27	1966	1993	28
5	13.17	71,30	17,27	17,46	1994	2038	45
Sum photo							264

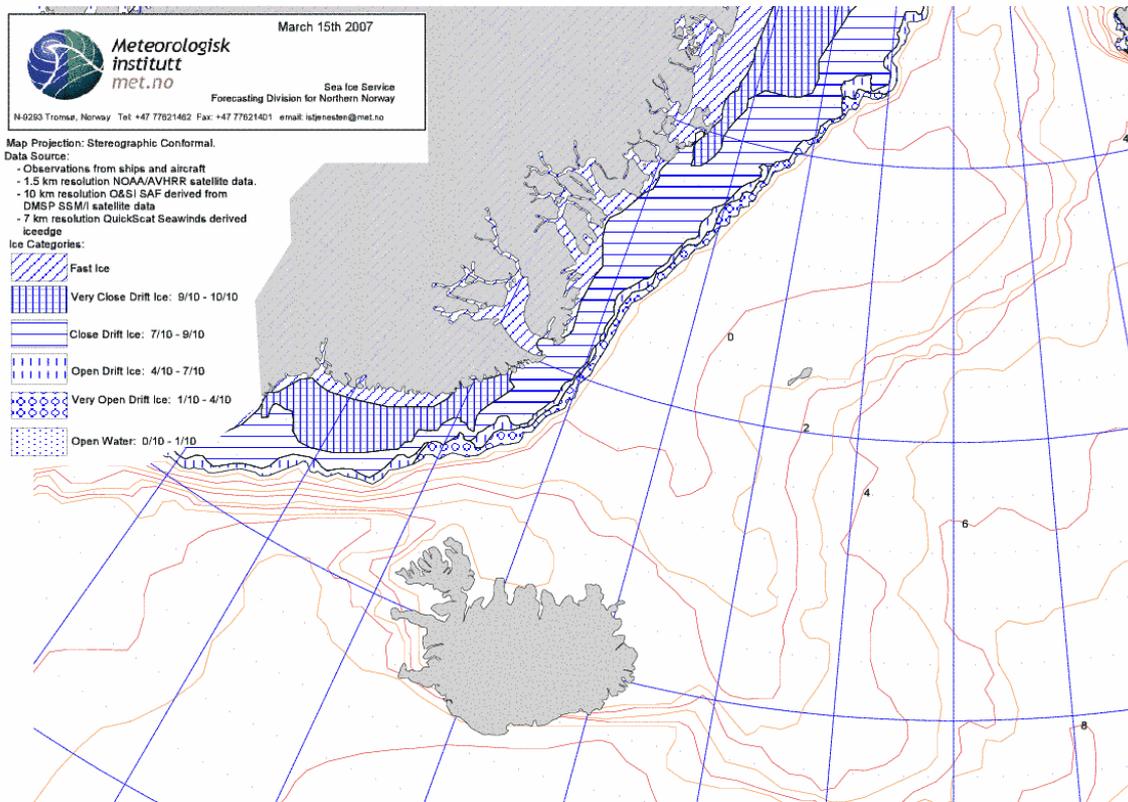


Fig. 1. Drift ice distribution on 15 March 2007 in the Greenland Sea.

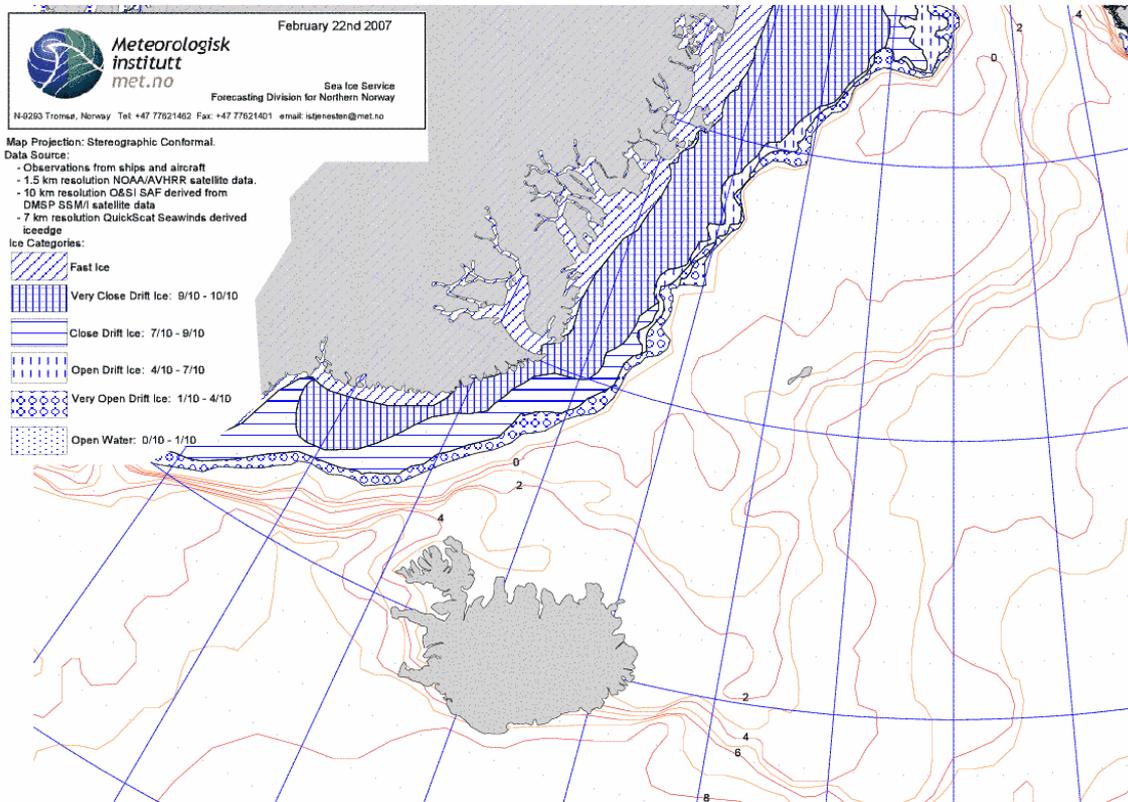


Fig. 2. Drift ice distribution on 22 March 2007 in the Greenland Sea.

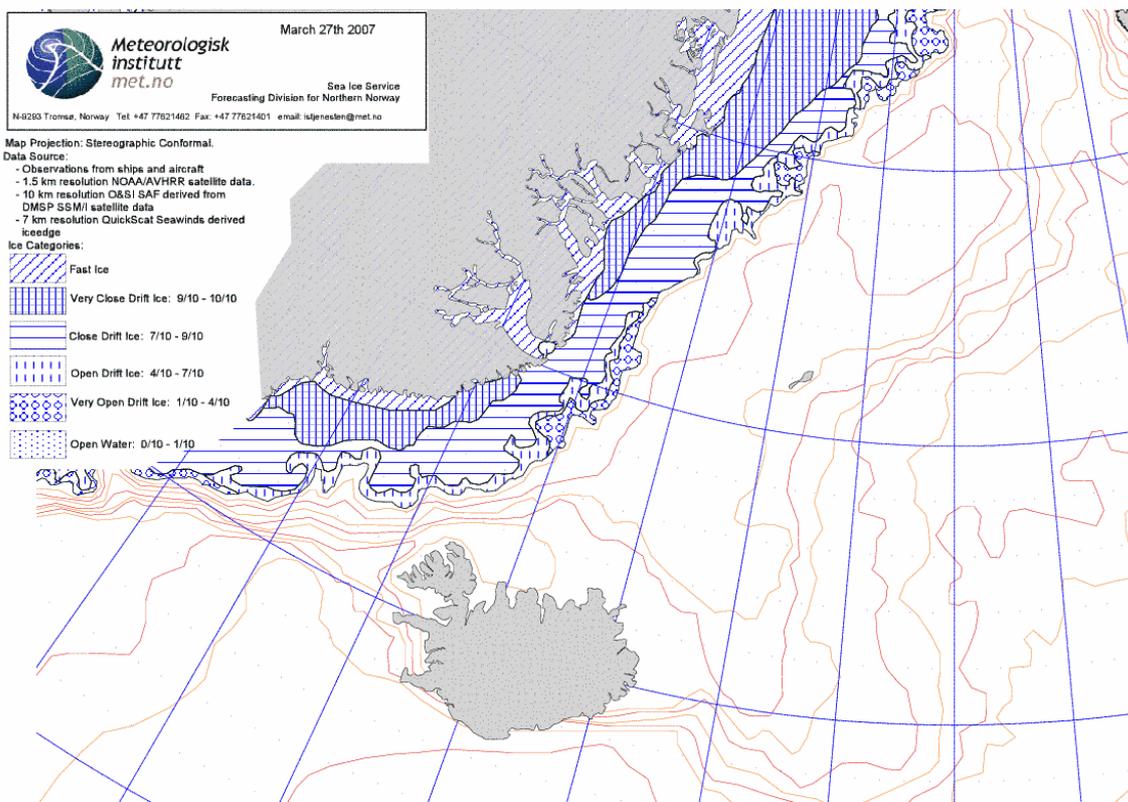


Fig. 3. Drift ice distribution on 27 March 2007 in the Greenland Sea.

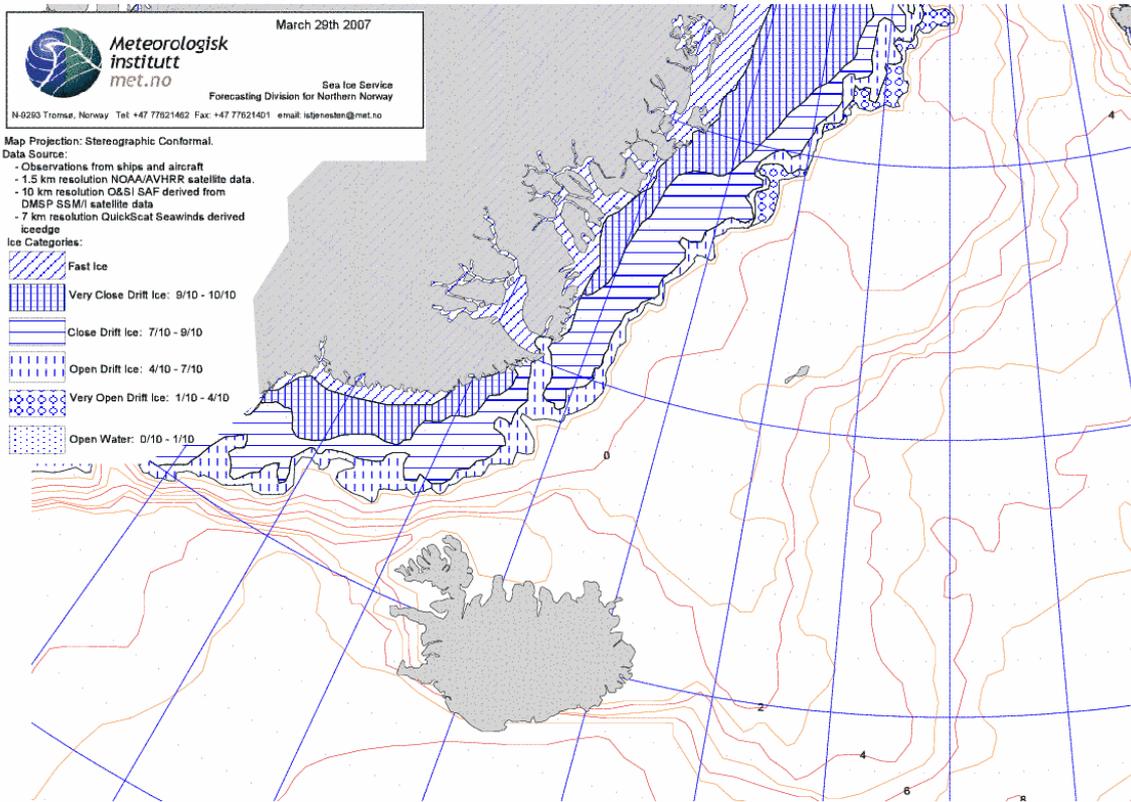


Fig. 4. Drift ice distribution on 29 March 2007 in the Greenland Sea.

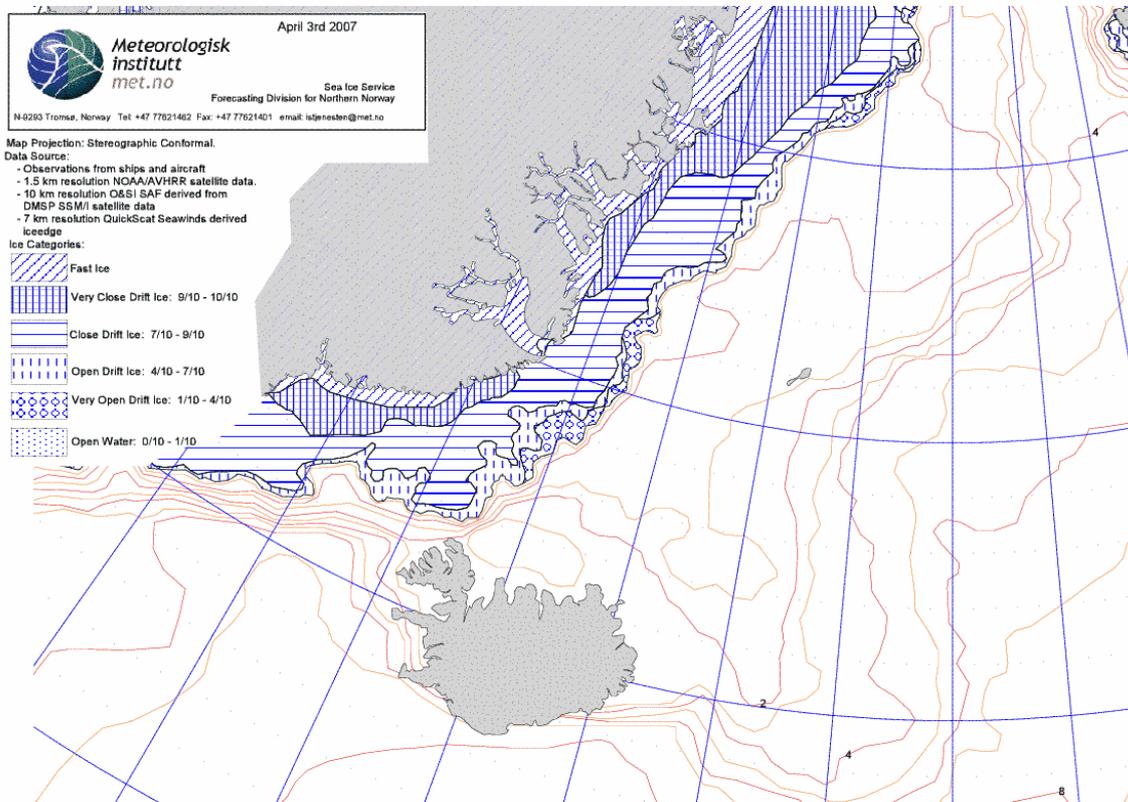


Fig. 5. Drift ice distribution on 3 April 2007 in the Greenland Sea.

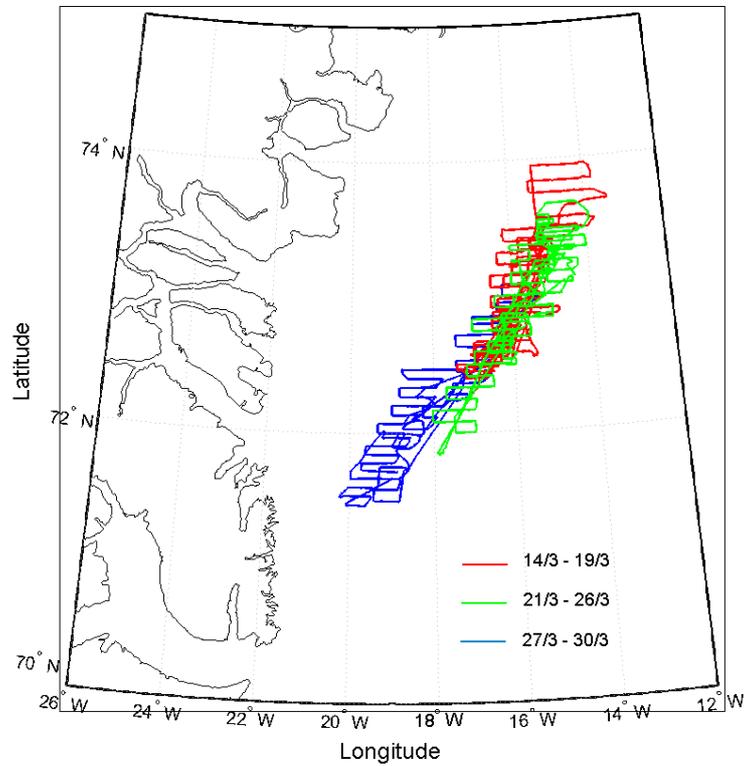


Fig. 6. Reconnaissance surveys conducted by helicopter over the drift ice in the Greenland Sea during the hooded and harp seal pup production surveys in March 2007. Transect lines are shown for three consecutive periods: 14 – 19 March (red), 21 – 26 March (green) and 27 – 30 March (blue).

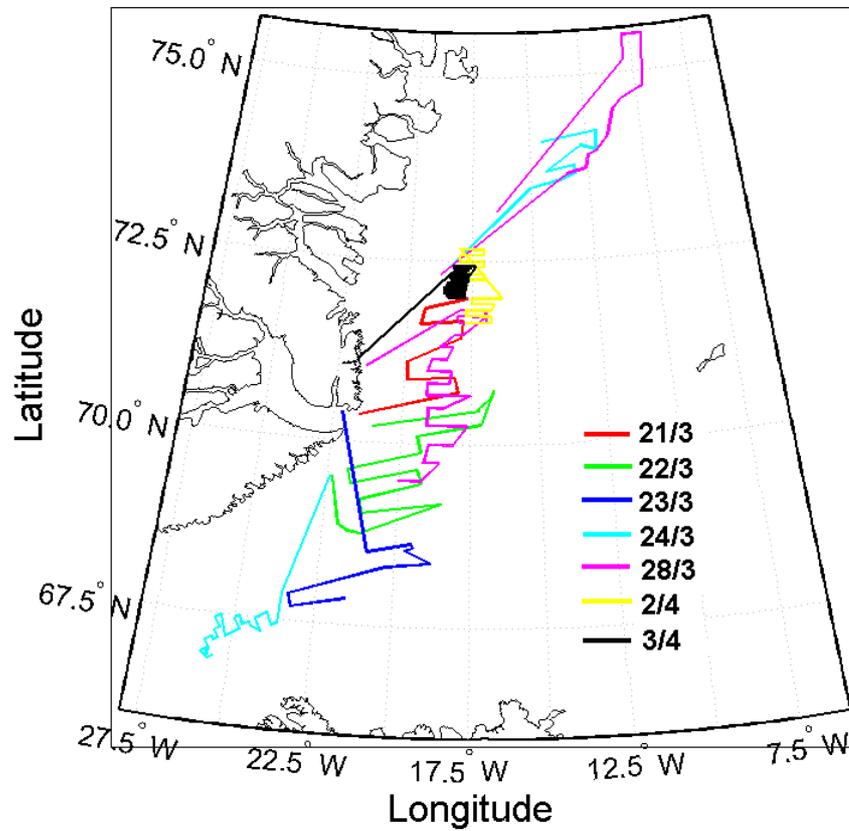


Fig. 7. Reconnaissance surveys conducted by using the fixed-wing aircrafts LN-NPZ and LN-NAB over the drift ice in the Greenland Sea during the period 21 March – 3 April 2007.

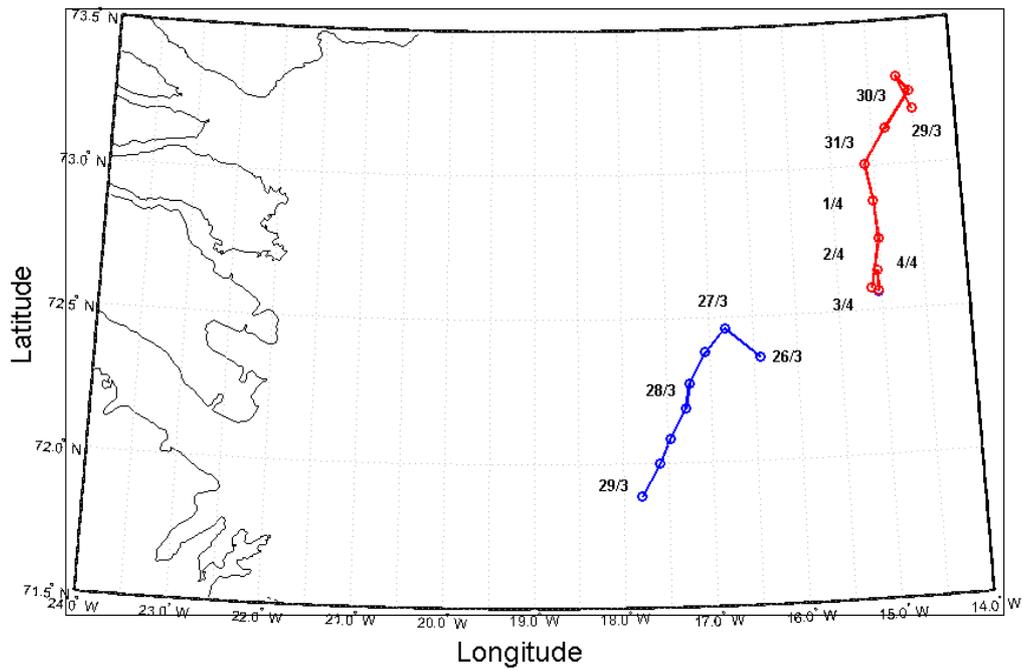


Fig. 8. Ice drift in the Greenland Sea during the last part of the survey period, as observed from a satellite based calib deployed on the ice 26 March. The calib was moved northwards on 29 March, and no signals were received after 4 April.

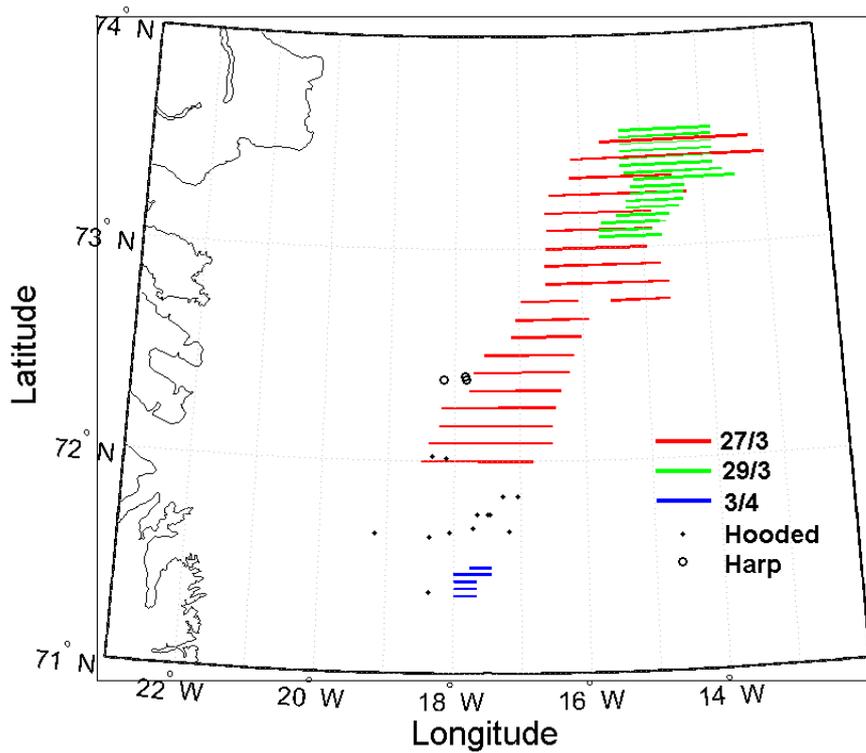


Fig. 9. Fixed-wing photographic surveys covering the hooded seal whelping area on 27 March (red), and the harp seal whelping patches on 29 March (green) and on 3 April (blue). Observations of bluebacks and hooded seal families • and harp seal whelping ○ not covered by photos are given.