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REPORT FROM SURVEYS TO ASSESS HARP AND HOODED SEAL PUP PRODUCTION IN THE GREENLAND SEA PACK-ICE IN 2018

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Harp seal breeding patch in the West Ice in 2018. (Photo: O.L.B. Iden).

SUMMARY

In the period 18–31 March 2018 aerial surveys were performed in the Greenland Sea pack-ice (the West Ice), to assess the pup production of the Greenland Sea populations of harp *(Pagophilus groenlandicus)* and hooded (*Cystophora cristata)* seals. One fixed-wing aircraft, stationed in Akureyri (Iceland), was used for reconaissance flights and photographic surveys along transects over the whelping areas. A helicopter, operated from the expedition vessel (KV ”Svalbard”) also flew reconnaissance flights, and was subsequently used for monitoring the distribution of seal patches and age-stageing of the pups.

The reconnaissance surveys were flown by the helicopter (18–22 March) and the fixed-wing aircraft (18–31 March) in an area along the eastern ice edge between 68°40’and 74°47’N. The ice cover was narrow and the edge closer to the Greenland coast in 2018 compared to previous survey years. The reconnaissance surveys were adapted to the actual ice configuration, usually flown at altitudes ranging from 160–300 m, depending on weather conditions. Repeated systematic east-west transects with a 10 nm spacing (sometimes 5 nm) were flown from the eastern ice edge and usually 20-30 nautical miles (sometimes longer) over the drift ice to the west.

Harp seal breeding was first observed from the fixed-wing on 18 March at approximately 74º00’N / 13º47’W, along with scattered hooded seal families further south. On 21 March, however, a large patch (considered to be the same patch as observed on 18 March) containing whelping harp and hooded seals was discovered in an area between 72º25’N and 72º35’N; 14º30’W and 16º00’W. Colour markers and satellite-based GPS beacons were deployed on ice floes north, east and south of the patch. The ship and helicopter had to depart from the ice on 24 March, but the fixed-wing aircraft continued to conduct reconnaissance surveys in the area. Based on observations made during these surveys, and information on localization of the identified whelping patches obtained from the ice-deployed GPS beacons, photographic surveys were conducted on 27 and 28 March. Subsequent reconnaissance surveys were conducted during 29–31 March to ensure that all whelping patches had been covered by the photographic surveys.

On 27 March, two photographic surveys were flown to cover the entire whelping patch area which was a little more than 60 nm in south-north direction. Due to fog in the northwestern areas, these areas had to be re-visited with new transect surveys the following day (28 March). To define the transect lines for this second survey day, data from the ice-deployed GPS beacons were used to account for the ice drift between the two days.

In total, 5104 photos were taken during the surveys (3016 photos on 27 March; 2088 photos on 28 March). Results from the aerial surveys will be used to estimate the 2018 harp and hooded seal pup production in the West Ice. Subsequently, the status of the stocks will be assessed by incorporating the pup production estimates into population models.

1 INTRODUCTION

Independent estimates of pup production, using aerial photo or visually based strip transect surveys, have been recommended and used to determine population size of harp (*Pagophilus groenlandicus*) and hooded (*Cystophora cristata*) seals in the northwest Atlantic (Bowen et al., 1987; Hammill et al., 1992; Stenson et al., 1993; 1997; 2002; 2003; 2005; 2006; 2010), in the Greenland Sea (Øritsland and Øien, 1995; Haug et al., 2006; ICES, 2006a; Salberg et al. 2008; Øigård et al 2010, 2014a, 2014b), and in the White Sea (Potelov et al., 2003; ICES, 2016). The status of the stocks is subsequently assessed by fitting population models to the independent estimates of pup production (e.g. Healey and Stenson, 2000; Hammill and Stenson, 2007; Skaug et al., 2007; Øigård et al. 2014a, 2014b).

Both harp and hooded seal pup production was last assessed in the Greenland Sea in 2012 (Øigård et al. 2014a, 2014b). The ICES management of harp and hooded seals is based on a situation where these populations can be defined as "data rich" (ICES 2006b). Data rich stocks should have data available for estimating abundance where a time series of at least three abundance estimates should be available spanning a period of 10-15, years with surveys separated by 2-5 years. The most recent abundance estimates should be prepared from surveys and supporting data (e.g., birth and mortality estimates) that are no more than 5 years old. The original plan was to conduct a new survey of the Greenland Sea harp and hooded seal stocks in 2017, to ensure these stocks met the data rich criterion. However, – due to practical logistical issues this survey was postponed to 2018. The survey techniques applied were as decribed in Øigård et al. (2014a, 2014b).

The harp seal was the prime target species for the surveys, since this population is still hunted. Hooded seals have been protected since 2007 due to the low pup production numbers in recent decades (ICES 2006a; 2016) – to assess the effect of protection on the pup production, more than 5 years are needed due to the usually 4-5 years age at maturity observed in hooded seals (see Frie et al. 2012). One secondary goal of this latest survey was therefore to obtain a new abundance estimate for hooded seals in the area. Given restricted logistical resources and the priority of harp seals, the possibility of obtaining a hooded seal pup production estimate would require that hooded seal breeding occurred within the same main areas as the harp seal breeding. This turned out to be the case for this survey, and pup production estimates for both harp and hooded seals in the Greenland Sea will be provided for the 2018 season. In addition to providing a short review of the status of the Greenland Sea harp and hooded seal populations, the present report reviews the activities on the ship-based part of the survey, including helicopter reconnaissance and pup staging surveys. Also, reconnaissance and photographic surveys using a fixed wing, Twin Otter, based in Akureyri (Iceland) and Constable Pynt (Greenland) are described.

2 STATUS OF THE SEAL STOCKS

2.1 HARP SEALS

Three stocks of harp seals inhabit the North Atlantic Ocean (Sergeant 1991). Whelping occurs east of Newfoundland and in the Gulf of StLawrence (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 Carr et al. (2015) found evidence of differenciation between the two latter. In late summer (July-August) seals from the Grenland Sea stock migrate into feeding grounds in the northern Barents Sea where they mingle with the Barents Sea stock before they return (in November-December) and spend the winter off south-east Greenland in the Denmark Strait (Folkow et al. 2004; Nordøy et al. 2008). 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, 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 hiatus 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 some 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, 2016).

Available knowledge of both previous and present abundance of Greenland Sea harp 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; 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. 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). Results from aerial surveys suggested a minimum pup production in 1991 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%), whereas the most recent estimates were 110 530 (s.e. = 27 680, cv = 25%) in 2007 (Øigård et al., 2010) and 89 590 (s.e. = 12 310, cv = 13.7%) in 2012 (Øigård et al. 2014a). Incorporating

available pup production estimates in a population model suggested population growth since 1970 and a current population size of 650 300 (95% CI = 471 200–829 300) seals (ICES, 2016).

2.2 HOODED SEALS

Two stocks of hooded seals are assumed to inhabit the North Atlantic Ocean (Sergeant, 1974; Kovacs and Lavigne, 1986). Whelping occurs east of Newfoundland, in the Gulf of StLawrence and in the Davis Strait between Greenland and Arctic Canada (the Northwest Atlantic stocks). Furthermore, hooded seals whelp in the Greenland Sea off the east coast of Greenland (the West Ice stock). So far no significant genetic differenciation (allozymes and DNA) have been found between hooded seals from the West Ice and from the Northwest Atlantic (Sundt et al., 1994; Coltman et al., 2007). Thus, while some degree of intermixing between the stocks must be assumed, the stocks are managed separately. In general, results from satellite telemetry programs indicate that hooded seals tagged in the West Ice during breeding and after moult remain within the Greenland, Norwegian and Icelandic Seas for the majority of the year (Folkow and Blix 1995, 1999; Folkow et al., 1996, Vacquie-Garcia et al., 2017). Recaptures of seals tagged as pups in the West Ice are consistent with these 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. Quotas were imposed in 1971, and except for a few animals taken for scientific purposes and by local Greenland hunters, the stock has been completely protected since 2007 (Kovacs and Lavigne, 1986; ICES, 2006a, 2016).

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, with rather limited 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, 2007 and 2012. Using the same methodology as in the 1997 survey, the results from the 2005 survey suggested a hooded seal pup production in the Greenland Sea of 15 200 (s.e. = 3 790, cv = 24.9%) (Salberg et al., 2008). The 2007 and 2012 surveys resulted in pup production of 16 140 (s.e. = 2 140, cv = 13.3%) and 13 655 (s.e. = 1 900, cv = 13.9%), respectively (Øigård et al., 2010, 2014b). 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 2005, 2007 and 2012 estimates were corrected both for readers' error and the temporal distribution of births. Thus, the results since 2005 indicated that pup production of hooded seals in the Greenland Sea were considerably lower than in 1997.

The historical data on pregnancy rates that are available for this population are unreliable. Hence, the population model was run assuming a range of pregnancy rates, in addition to one model run using the original model assuming constant reproduction rates. All model runs indicated a decrease in population abundance from the late 1940s and to the early 1980s. The most recent estimate for the total population is 80 460 (95% CI = 59 020–101 900), which may be less than only 10% of the population level observed 70 years ago (ICES, 2016). Changes in size of harvested seal populations are often attributed to hunting pressure. However, during the periods 1982-2007, the average annual catch level has remained less than 5 000 animals (almost exclusively pups), and from 2007 there has been no hooded seal hunt in the Geenland Sea (ICES 2016). Annual removals by Greenland hunters from the Northeast Atlantic stock were reported to be between 3 and 67 animals per year (ICES 2006). It therefore seems unlikely that recent hunting pressure alone could cause a stock decline.

3 LOGISTICS AND METHODS

3.1. Ship, aircraft and personell

The ice-strengthened Norwegian Coast Guard vessel KV ”Svalbard” was used for operations in the Greeland Sea drift ice. The ship has helicopter platform and hangar, and was equipped in compliance with relevant requirements for helicopter operations.

Fig. 1. KV Svalbard in the West Ice (Photo: T. Haug)

An Ecureuil AS 350 B2 helicopter (owned and operated by Airlift AS, Bygstad, Norway) was chartered for the expedition. This helicopter type has previously proved suitable in similar operations in the Greenland Sea pack ice (Øritsland and Øien, 1995; Haug et al., 2006; Salberg et al., 2008; Øigård et al. 2010, 2014a, 2014b). The helicopter was fitted with GPS and radar altimeter. Approximately 27 hours were flown over the ice during the survey.

Fig. 2. The helicopter on an ice floe in the West Ice. (Photo: T. Haug)

The scientific crew on the ship was Tore Haug (IMR, expedition leader), Martin Biuw (IMR), Lotta Lindblom (IMR), Martin Kristiansen (IMR) and Garry Stenson (DFO, Canada). Localization of breeding patches and stageing of pups were the primary goal during the helicopter surveys.

A fixed-wing Twin Otter aircraft (TF-POF, operated by Norlandair, Akureyri, Iceland) was used for reconnaissance and photographic surveys. The aircraft was fitted with an extra fuel tank, which made it possible to remain airborne for up to 7 hours. In addition to communication and GPS systems, the Twin Otter was fitted with radar altimeter and a camera for vertical photos. The aircraft operated over the drift ice east of the Greenland coast from 68°40'N / 24°50'W to 74°47'N / 13°58'W during the period 18-30 March. The aircraft was based in Akyreyri (Iceland) and at Constable Pynt airport (Nerlerit Inaat, 50 km north of Scoresbysund, East Greenland). Kjell T. Nilssen (IMR, leading the fixed-wing surveys) and Michael Poltermann (IMR) operated on the Twin Otter, which had two pilots (Nordlandair) and one camera operator (Terratec, Norway). Approximately 54 hours were flown (total airborne).

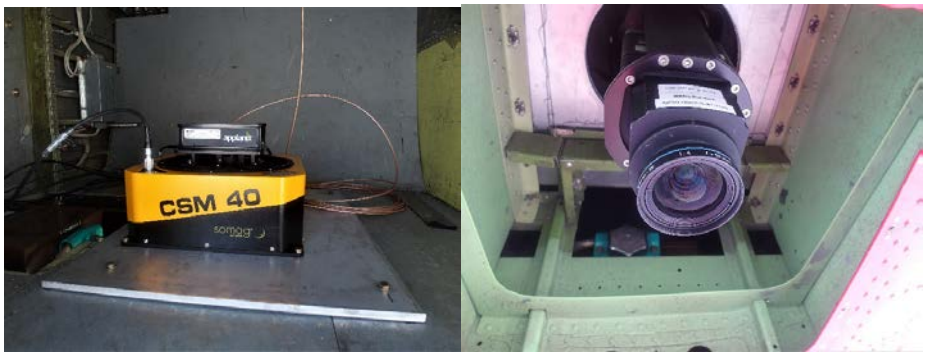

Fig. 3. The Twin Otter at Constable Pynt, East Greenland, with mounted camera and lense underneath the aircraft. (Photo: M. Poltermann)

3.2 Reconnaissance surveys

The distribution and configuration of the drifting pack-ice in the survey period (here represented with the situation as observed on 22 March) is given in Fig. 5. The ice cover in 2018 was considerably less, with the edge of the pack ice situated closer to the East Greenland coast than during the surveys in 2007 (Øigård et al. 2010) and 2012 (Øigård et al. 2014a, 2014b). In addition to revisiting all areas historically used by harp and hooded seals for breeding purposes in the Greenland Sea (see Haug et al. 2006; Salberg et al. 2008; Øigård et al. 2010, 2014a, 2014b), reconnaissance flights also covered areas to the north and south of these historical core areas, to account for potential distributional changes over time. Reconnaissance flights were flown at an altitude of 160-300 m, and transects were adapted to the actual ice-configuration during the survey period, with the ice edge generally delineating the eastern end and areas of fast ice or large ice sheets making up the western end. Due to the significant southward ice drift occurring in the region, and a pupping period often spanning several weeks (mid to late March, see Rasmussen, 1960; Øritsland, 1964; Øritsland and Øien, 1995; ICES, 1998; Haug et al., 2006, Salberg et al., 2008; Øigård et al., 2010, 2014a, 2014b),

most areas were surveyed repeatedly to minimize the chance of missing whelping concentrations. Colour markers and 5 satellite based GPS beacons were deployed in and around the major whelping concentrations to facilitate relocation and to monitor ice drift (see Fig. 4).

Fig. 4. Deployment of satellite based beacons on an ice floe in the West Ice (Photo: T. Haug)

The vessel encountered the ice edge at 72º30'N / 17º55'W on 17 March, and maintained its position relative to the edge between 72º20'N and 72º35' N until 21 March, subsequently moving northwards to 72º52'N / 18º37'W, and further to the northeast to position 73º14'N / 16º28'W. Due to restricted time of vessel availability for the survey, KV "Svalbard" started moving southwards through a large whelping patch of both harp and hooded seals on March 23rd. At the assumed southern edge of this patch, a beacon was deployed on the ice from the vessel (position to72º19'N / 17º39'W), whereafter the vessel left the ice and returned to Norway.

Helicopter reconnaissance flights were flown from the ship between 18 and 22 March in areas between 71º25'N and 73º40'N, as repeated systematic east-west transects from the ice edge in the east and into more close drift ice to the west (Fig. 5). Transects were usually spaced 5 nm apart, with a length of 10-30 nm, and were modified according to the actual ice distribution during the individual survey flights.

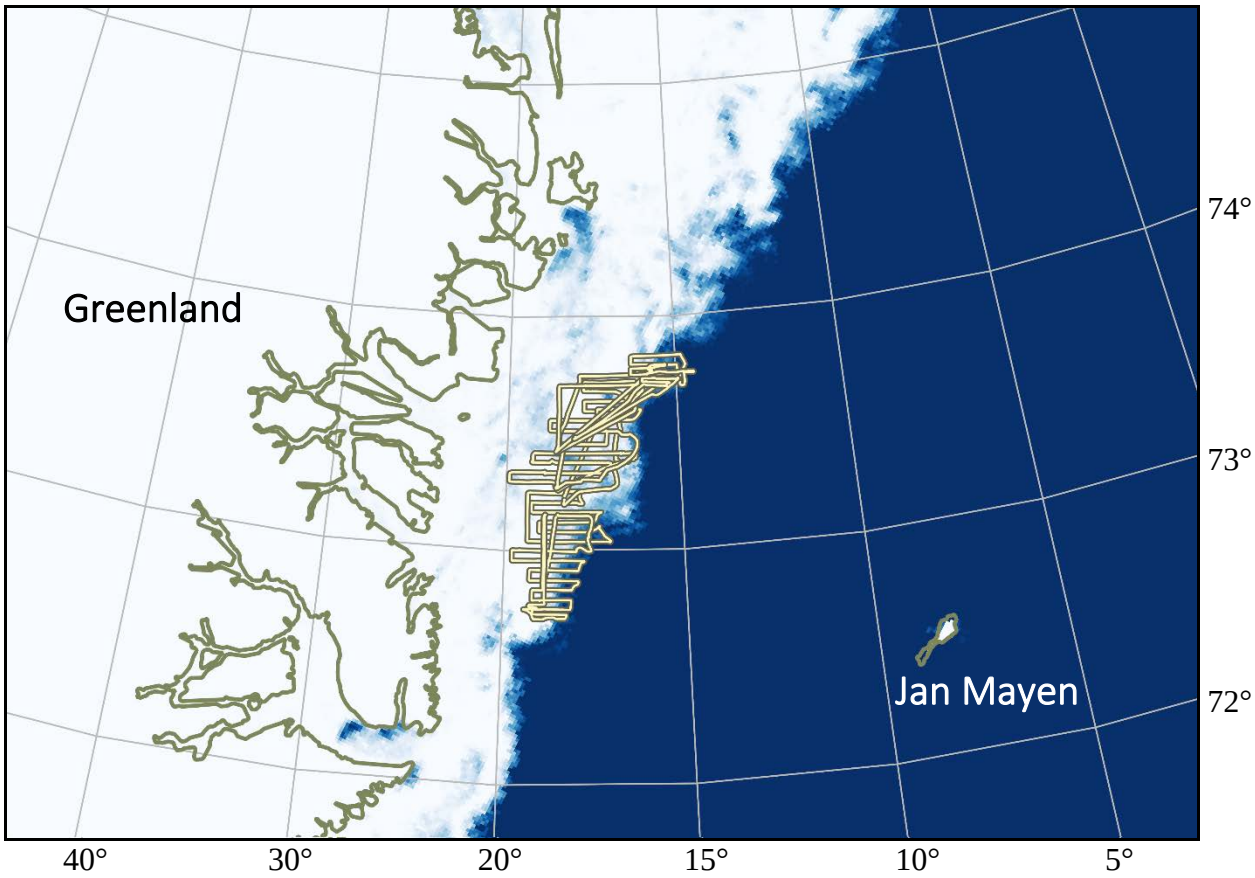

Fig. 5. Helicopter flight tracks conducted during reconnaissance surveys from KV Svalbard on 18-22 March, 2018. The background image shows the sea ice concentration on 22 March (taken from the AMSR2 Sea Ice Concentration product, Spreen et al., 2008).

The Twin Otter had ability to conduct reconnaissance surveys covering much larger areas than the helicopter, and was used to cover potential seal whelping areas within the drift ice outside of the historical core area, from from 68°40'N/24°50'W to 74°47'N/ 13°58'W during the period 18-30 March. These reconnaissance flights also followed east-west transects usually spaced 10 nm, but spacing was decreased to 5 nm in areas where seals were observed. In the north, reconnaissance was flown more in relation to ice distribution (also covering some areas of open water), and occasionally restricted due to fog banks covering parts of the area (see Fig. 6).

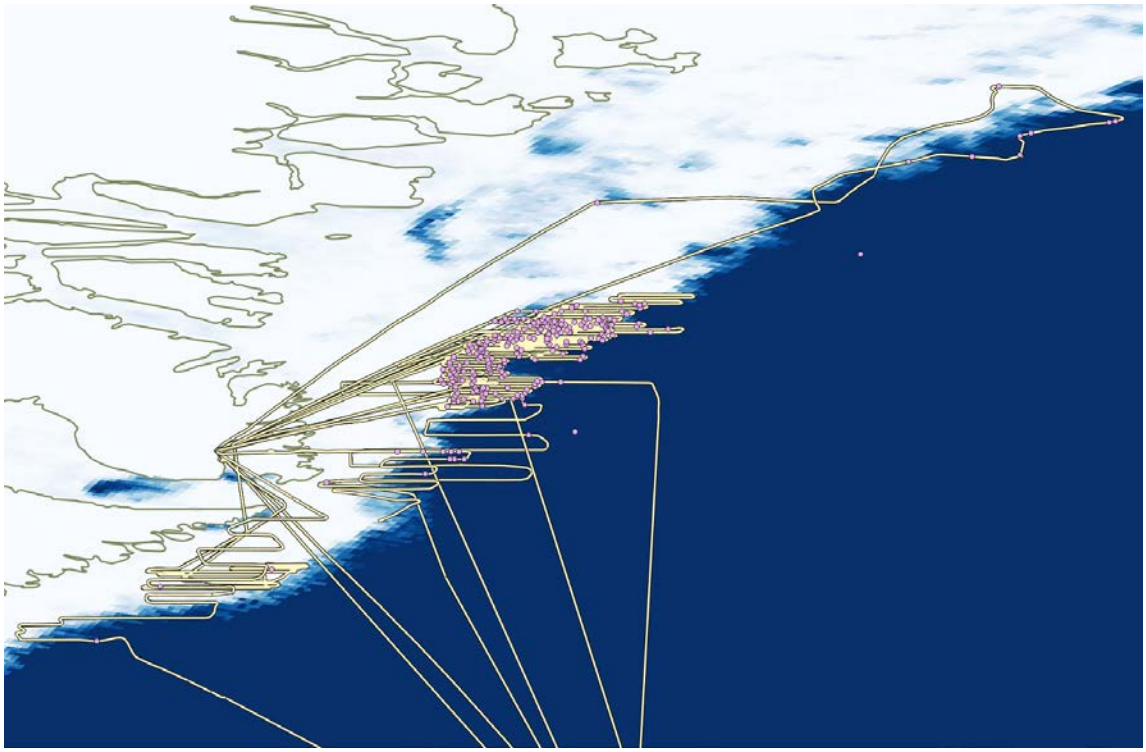

Fig. 6. Areas covered during aircraft reconnaissance surveys over the West Ice during the period 18 -31 March. Pink spots indicate seal observations.

3.3 Visual surveys

Because KV ”Svalbard“ had to leave the drift ice early in the seal whelping season (on 23 March), no visual assessment surveys of pup production were conducted from the helicopter in 2018.

3.4 Photographic surveys

The Twin Otter was equipped with a digital camera (Phase One IXU-RS-1000 / Lens: Rodenstock 50 mm f/4.0). Images were taken at an altitude that was kept at 1100 ft (335 m) using a radar altimeter, and at a flight speed of approximately 130 knots. The camera was operated to cover 80-90 % of the area along each transect line, with deliberate spacing between adjacent images to avoid overlap and the potential for double counting. The image footprint was 347m (cross track) x 260 m (flight direction), with a pixel ground resolution of approximately 29 mm.

3.5 Temporal distribution of births

To correct the estimates of abundance for seal pups that were not yet born or had already left the ice at the time of the survey, it is necessary to estimate the distribution of births over the pupping season. This is done by using information on the proportion of pups in distinct age-dependent stages. These arbitrary but easily recognisable descriptive age categories were based on pelage color and condition, overall appearance, and muscular coordination (see Stewart & Lavigne, 1980; Bowen et al. 1987; Stenson & Myers, 1988; Øigård et al., 2014a, 2014b).

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 at low altitude. Pups were classified from the helicopter hovering just above the animals. The spacing between transects depended on the size of the actual patch. Usually, at least two and ideally three repeated classifications are obtained from each patch several days apart. Unfortunately, due to the restricted ship-time available, only one stageing bout (on 21 March) was possible during the 2018 survey. To compensate for this, we will attempt to stage the pups in the survey photographstaken 6 and 7 days after the helicopter-based stageing. This second stageing, though less precise than the one done visually from the helicopter, may allow us to determine the changes in stage composition between the visual stageing and the days images were taken, and thereby to correct the abundance estimates accordingly.

4 PRELIMINARY RESULTS

4.1 Identification of whelping areas

Reconnaissance fligths were conducted on 18 and 19 March in areas along the ice edge between position 72º35'N and 74º47'N using both the Twin Otter (18 March only) and the helicopter (Figs 5 and 6). Some harp seal breeding was observed from the Twin Otter on 18 March in approximately 74º00'N / 13º47'W, otherwise the picture was dominated by scattered hooded seals, a few of them females with pups (Fig. 7).

The Twin Otter flew reconnaissance flights along the ice edge from 73º 30'N to 74º 47'N on 18 March and from 70º26'N to 71º30'N on 19 March, whereas the helicopter covered the area between 71º25'N to 72º20'N on 20 March. Both harp and hooded seal whelping was observed by the fixed-wing in a patch thought to be about 300 animals in approximately 74º00'N / 13º47'W on 18 March. No harp seals were seen on the fixed-wing survy in the southern part of the area, although scattered hooded seal families (defined as adult female and pup, accompanied by adult male waiting to breed) were observed. An area with more concentraterd hooded seal families was observed from the helicopter between 71º25'N and 71º33'N (Fig. 7), and a beacon was deployed in position 71º30'N / 19º06'W at 1500 hrs Norwegian time (Fig. 8) to follow the drift of this possible emerging patch.

During helicopter reconnaissance flights on 21 March a large patch of whelping harp and hooded seals was located between 72º25'N and 72º35'N; 14º30'W and 16º00'W. There were signs suggesting that the patch extended considerably southwards from this area, but colour marker and sattellite based GPS beacons were deployed on ice floes in the assumed northern (position73º32'N / 15º43'W) and eastern (position73º27'N / 14º56'W) ends. The eastern beacon was deployed in more loose ice where breeding harp seals were observed on strips of more dense ice. Subsequent helicopter stageing flights in the patch confirmed that breeding seals were distributed more south than initially assumed, and another GPS beacon was deployed in position73º13'N / 16º33'W on 22 March.

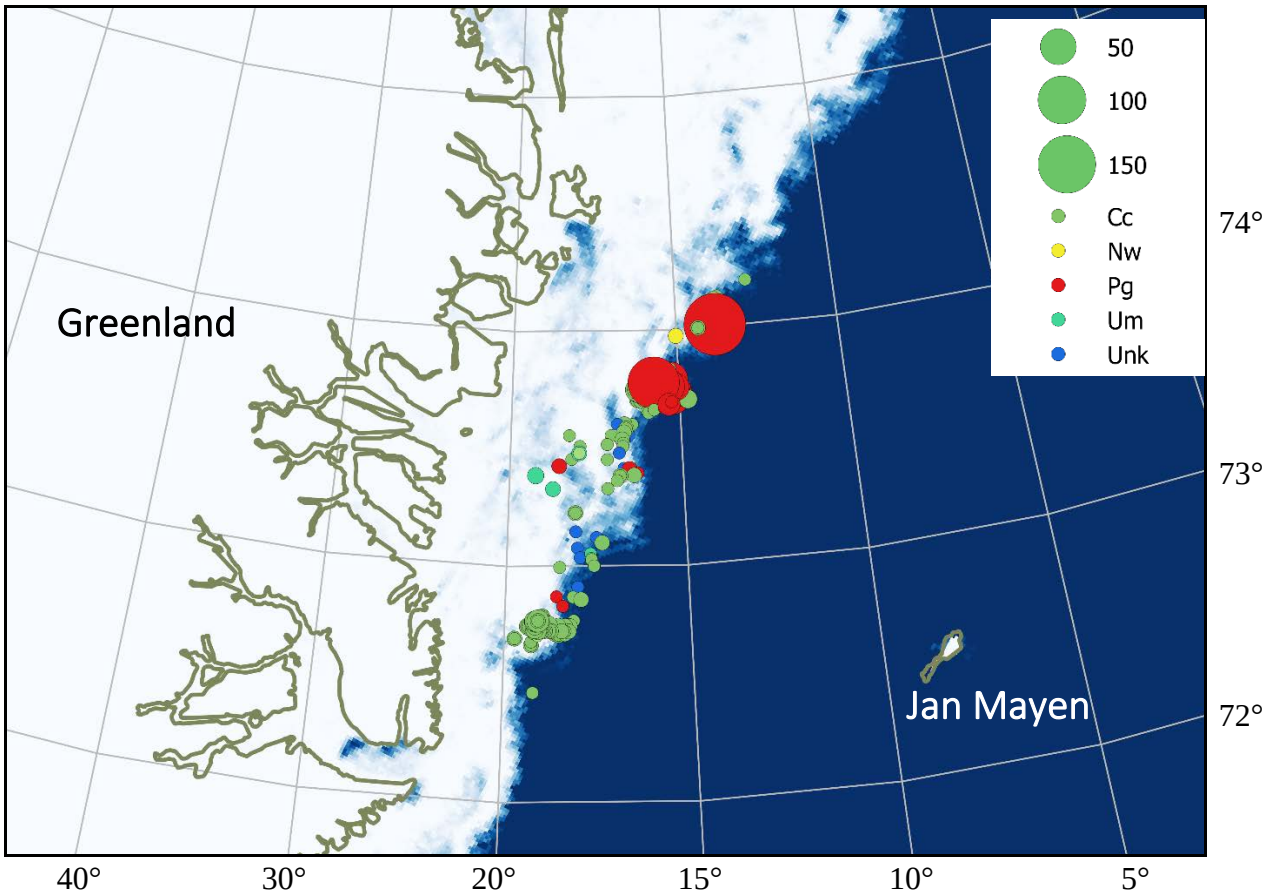

Fig. 7. Seal sightings obtained during reconnaissance flights conducted by helicopter from KV Svalbard and by airplane from Iceland on 18-22 March 2018. Opportunistic sightings of other marine mammals are also shown. Points are coloured by species (Cc=Hooded seals, Nw=Narwhal, Pg=Harp seals, Um=Polar bear, Unk=Unknown seal species). The size of the dots represents the relative abundance. The background image shows the sea ice concentration on 22 March (taken from the AMSR2 Sea Ice Concentration product, Spreen et al., 2008).

On 23 March, the weather and visibility conditions prevented helicopter operations. The vessel was therefore used to localize the north-south distribution of the patch. Apparently, the northern end was now at position 72º52'N / 16º40'W, which was close to the northernmost GPS beacon. Harp seals dominated this northern part of the patch (down to ca position 72º22'N / 17º20'W) – south of this there were mostly hooded seals. The remaining GPS beacon was deployed in the assumed southern end of the patch in position 72º19'N / 17º39'W, before KV "Svalbard" left the ice to return to Norway.

The fixed-wing aircraft continued to conduct reconnaissance surveys after the vessel had left the ice. Based on observations made during these surveys, and information on localization of the identified whelping patches obtained from the ice-deployed GPS beacons, photographic surveys were conducted on 27 and 28 March. Subsequent reconnaissance surveys were conducted during 29–31 March to ensure that all whelping patches had been covered by the photographic surveys.

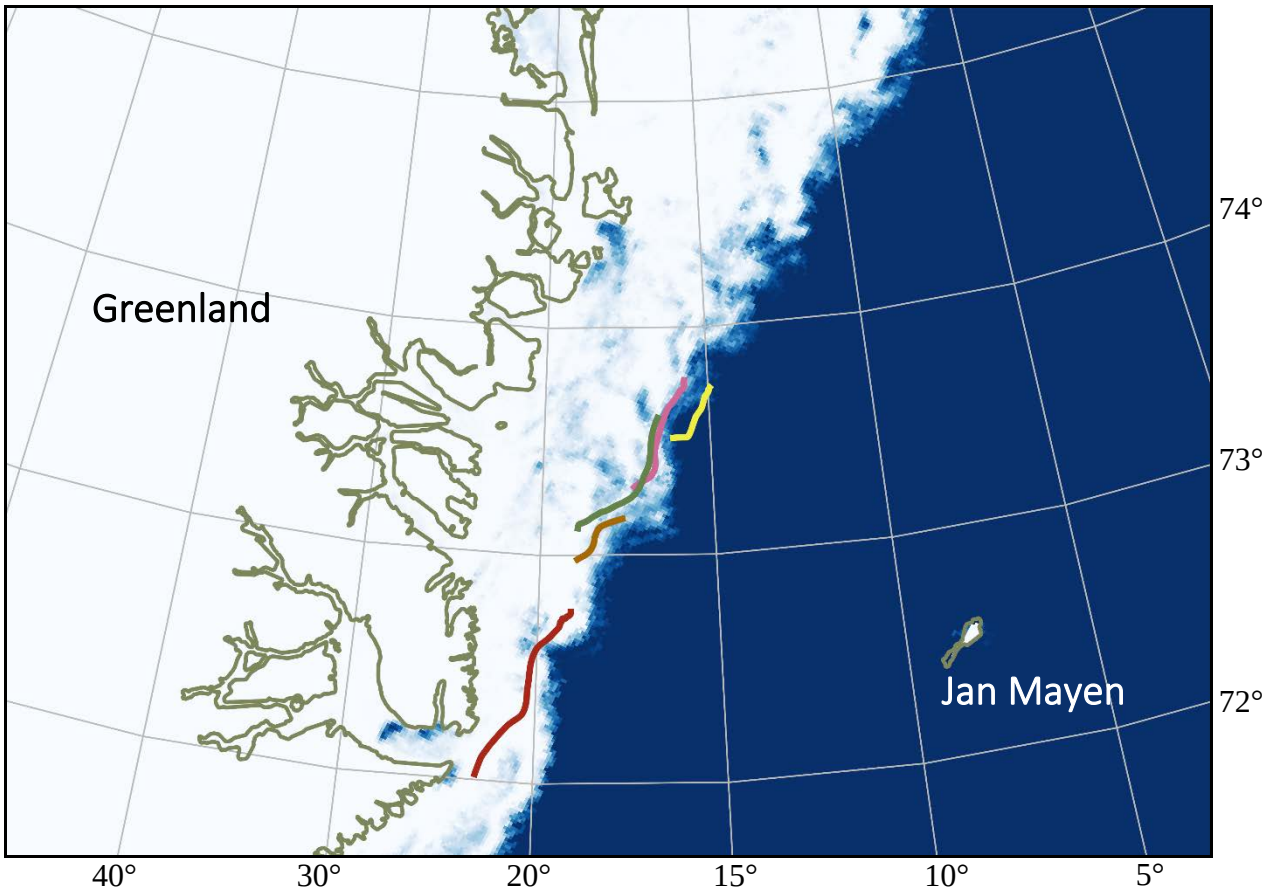

Fig. 8. Tracks of five GPS/Idirium tracking devices deployed by helicopter from KV Svalbard on ice floes around the main seal concentrations 18-24 March 2018. The tracks illustrated the ice drift up to and including March 24. The background image shows the sea ice concentration on 22 March (taken from the AMSR2 Sea Ice Concentration product, Spreen et al., 2008).

The ice drift varied throughout 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 GPS beacons deployed on the ice (Fig. 8). However, in the period 27-28 March, when the photo suveys were conducted, the ice drift seemed to be in a more southeasterly direction. This must be investigated more precisely to assess potential overlap between photo surveys on two separate days.

4.2 Temporal distribution of births

Estimations of the proportion of pups in each developmental stage were obtained from harp and hooded seals in the large northern patch on 21 March. The patch was covered with systematic east-west staging transects spaced 1-2 nautical miles apart (Fig 9 and 10). The high proportion of thin pups suggested that this date represented a relatively early stage of the pupping period.

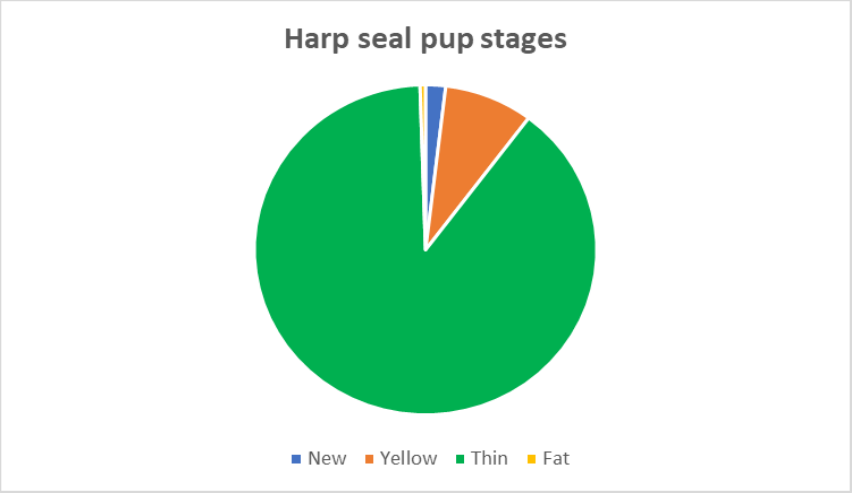

Fig. 9. Distribution of harp seal pups in individual age dependent stages in the whelping patch on 21 March 2018.

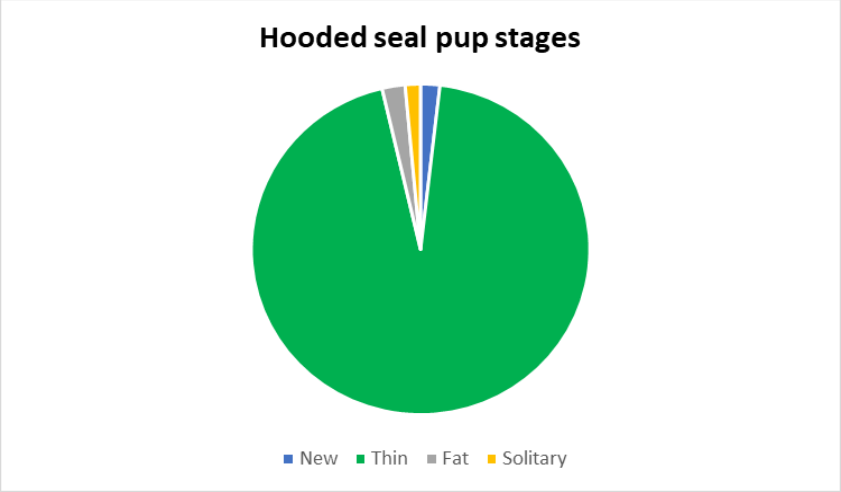

Fig. 10. Distribution of hooded seal pups in individual age dependent stages in the whelping patch on 21 March 2018.

4.3 Photographic surveys

The ship and helicopter were used to define the geographic range of the whelping patches prior to the fixed-wing aircraft photographic survey. The GPS beacons deployed on the ice was used to guide the aircraft to the patches, since the ship and helicopter were forced to depart from the ice prior to the optimal time for the photographic surveys.

Two surveys with a total of 35 transect lines were flown on 27 March in east-west/west-east directions, starting at the southern end of the whelping patch at 71°15’N with a distance between the two first lines spacing 3 nm. The distance between the transect lines between of 71°18’N and 72°22’N was 2 nm (see Fig.11). In total 3016 images were taken during the two surveys on this day.

Due to fog in the northwestern parts of the area surveyed on 27 March, this area of the patchwas re-photographed on 28 March. Based on the ice drift displayed by the satellite

beacons (approximately 10 nm from north to south since the day before), this repeat survey was conducted in an area slightly offset towards the south relative to the area that was missed during the previous day (between 71°30'N and 72°12'N). Transect lines were separated by 2 nm between 71° 30' N and 71° 52' N. Between 71°52'N and72°12'N, where seals were most abundant, the distance between transect lines was reduced to 1nm, and the total patch between 71°52'N and 72°12'N was covered (both to the east and the west).

A total of 35 east-west/west-east transect lines were flown on 28 March (see Fig. 12), and 2088 images were taken.

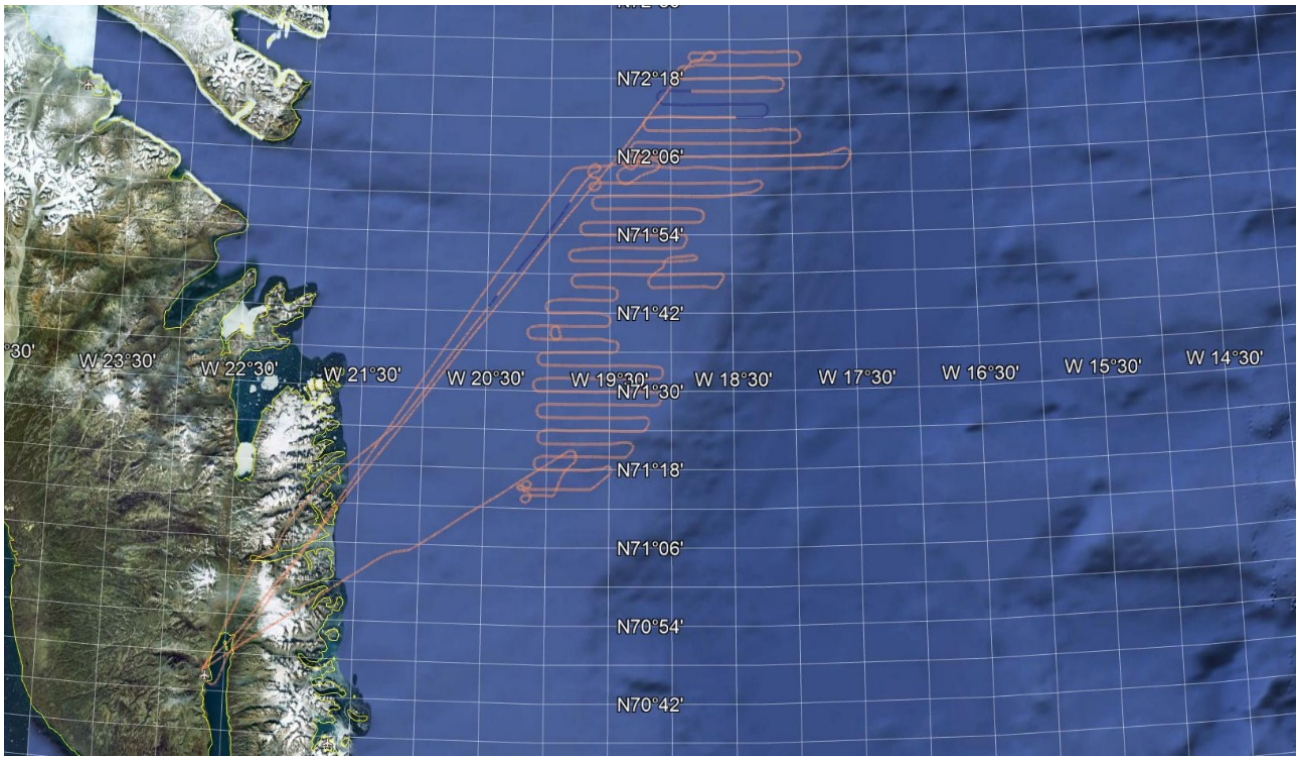

Fig. 11. Track lines from two aerial photographic survey transects, covering the entire area and conducted on 27 March in the West Ice. Spacing between transects were 2 nm.

4.5 Other observations

Tracks of polar bears were observed on several occasions, and several bears were seen both from the helicopter and the vessel. Two narwhals (*Monodon monoceros*) were observed in open leads within the drifting ice in the survey area of the fixed-wing.

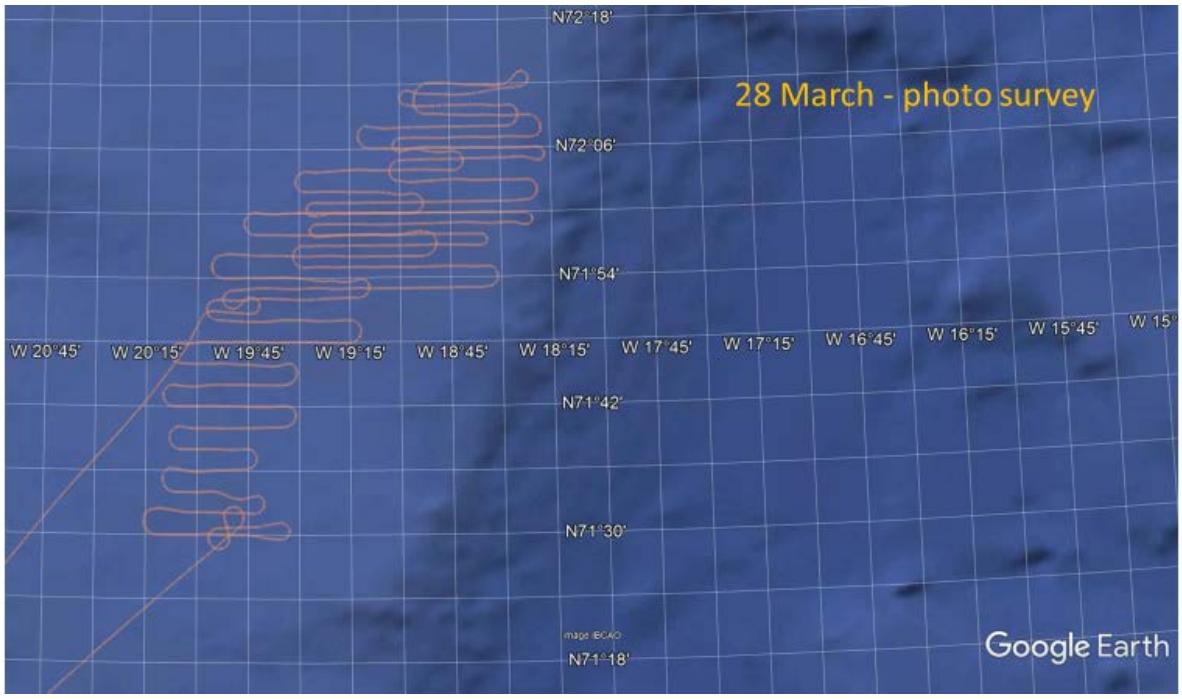

Fig. 12. Track lines from one aerial photographic survey transects, covering the northern area and conducted on 28 March in the West Ice. Spacing between transects were 2 nm. In the northmost area the coverage was made double in that extra transects were run and photographed in between the first lines.

5 CONCLUDING REMARKS

The survey used methods which are 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; 2005; 2006; 2010), in the Greenland Sea (Øritsland and Øien, 1995; ICES, 1998; Haug et al., 2006; Salberg et al., 2007; Øigård et al., 2010, 2014a, 2014b) and in the White Sea (ICES, 1999; 2001; 2004; 2011; Potelov et al., 2003). Extensive reconnaissance of all likely areas was conducted to locate whelping harp and hooded seals, and results from the photographic surveys will be used to estimate the 2018 pup production of both species.

The results from the 2018 surveys will be used to assess the present status of Greenland Sea harp and hooded seals. As in 2012, all pupping of hooded seals occurred scattered throughout the area, with no major patches of concentrated breeding. The results from the complete analysis of the data from this survey will be sufficient to indicate whether or not the apparent low level of hooded seal pup production observed in 2005 and 2007 (see Salberg et al., 2008; Øigård et al., 2010, 2014b) still prevail. Also, data from the survey will facilitate comparisons of present harp seal pup production with observations made in 2002 (Haug et al., 2006), 2007 and 2012 (Øigård et al., 2010, 2014a).

The ice conditions in 2018 were characterized by much more open drift ice and large areas with completely open waters compared to all previous survey years. North of 74°47'N there were large areas of open water as far north, and to some extent also as far west, as could be observed from the aircraft. For this reason, but also due to much fog in the area, no search

was conducted north of this latitude. No whelping has ever been observed north of 75°N during previous surveys in the West Ice, and we are therefore confident that no major breeding patches were missed during this year's survey.

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