WORKING GROUP ON ABUNDANCE ESTIMATE
Copenhagen, October 16-18, 2016
REPORT

1. CHAIRMAN WELCOME AND OPENING REMARKS

Daniel Pike welcomed the participants (Appendix 2) to the meeting and thanked everyone for their attendance. He reminded the participants that the WG will review abundance estimates generated from the NASS2015 and any surveys that have occurred since then, for use in assessments by NAMMCO.

2. ADOPTION OF AGENDA

The agenda was adopted (Appendix 3).

3. APPOINTMENT OF RAPPORTEURS

Prewitt was nominated as rapporteur, with help from participants as needed.

4. REVIEW OF AVAILABLE DOCUMENTS AND REPORTS

Pike reviewed the documents available to the meeting (Appendix 4). Six working papers were available, as well as several background documents.

5. FIN WHALES

5.1 Shipboard Iceland/Faroes

Pike presented SC/23/AE/04 which gives abundance estimates for fin whales from the Icelandic and Faroese NASS2015 shipboard surveys.

The Icelandic and Faroese components of the sixth North Atlantic Sightings Survey (NASS) was conducted between 10 June – 10 August 2015 (Gunnlaugsson and Vikingsson 2015). Three vessels covered a large area of the northern North Atlantic, similar to the earlier NASS, but for the first time applying fully independent double platform observer (IO) mode. The fin whale was a target species in all areas. Realized effort and fin whale sightings are shown in Fig 1. In addition to stratum and total abundance estimates, regional estimates, each of which includes a combination of the original strata, were required for population modelling purposes. These included estimates east and west of 18° W, which required the division of stratum FW into W (FW_W) and E (FW_E) sections. A contiguous area north and east of Iceland around Jan Mayen Island was covered simultaneously by a Norwegian vessel as a part of an annual cyclic mosaic survey (see section 5.2). One of the Icelandic survey vessels was conducting coincident fisheries surveys and some observation effort was on transit transects aligned with expected high fin whale density, so analyses were performed both including and excluding these data. Rejecting this compromised effort, the total corrected estimate for the survey area using all fin whale sightings was 40,788 (cv 0.17, 95% CI 28,476 to 58,423). Restricting to high and medium confidence sightings using the same effort reduced the total estimate to 35,605 (cv 0.18, 95% CI 24,615 to 51,505). While overall abundance over the entire survey area is not directly comparable between NASS as coverage has varied between surveys, the numbers seen here are the highest of any NASS in the Central North Atlantic. Compared to the most recent previous survey conducted in 2007, increases were seen in the area between West Iceland and East Greenland

and particularly in the Faroese survey area southeast of Iceland, where abundance was more than 26 times that seen in 2007.

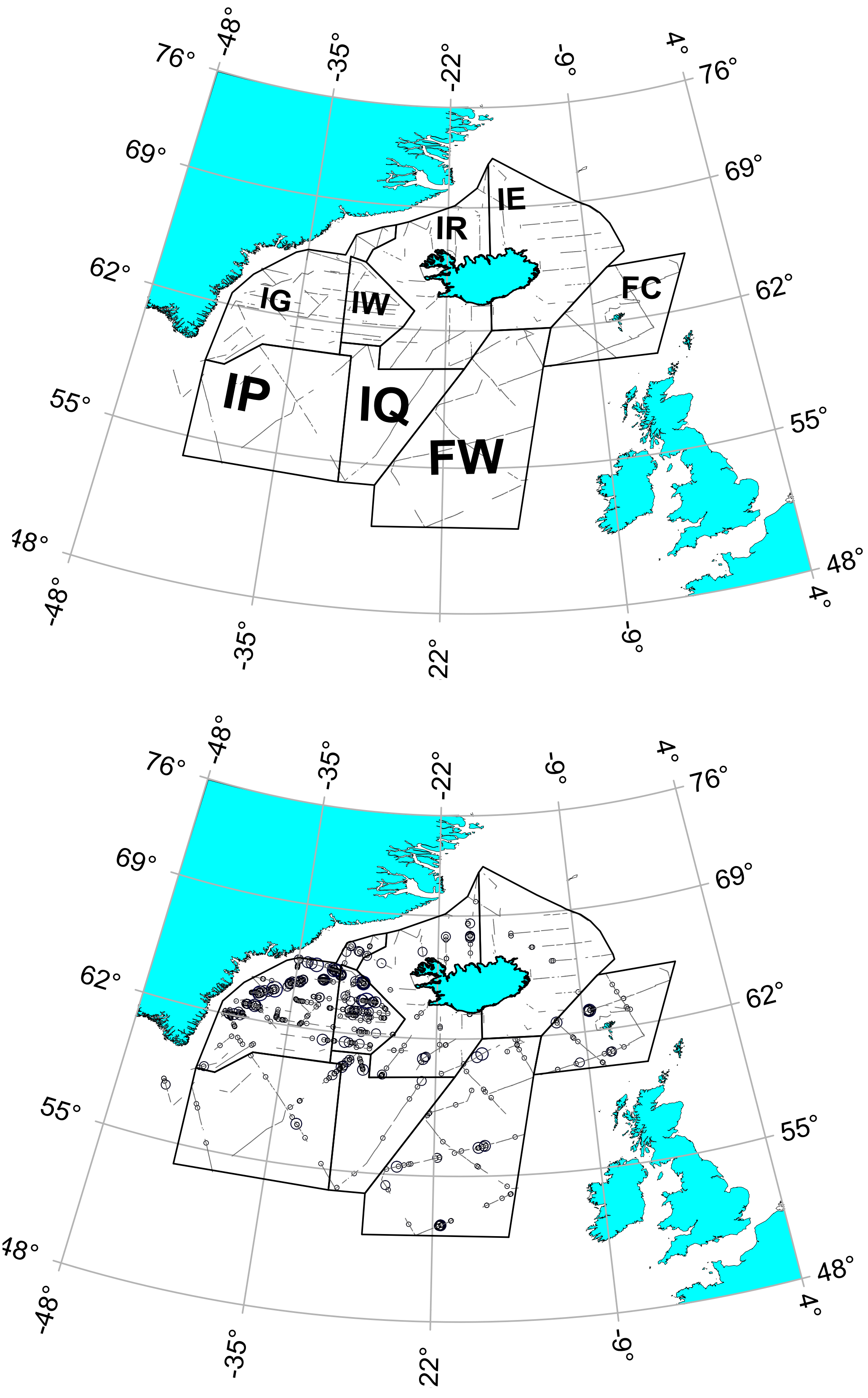

Fig.1. Stratification and survey effort (upper, BSS<=5) and sightings of fin whales (lower). Symbol size is proportional to group size in the range of 1 to 7.

Discussion

In discussion of the potential for bias in distance estimation it was noted that, unlike in previous surveys, no distance experiments were conducted by Iceland during the survey. The Faroe Islands conducted one experiment using sticks (rulers) to measure distance to targets during their survey but the results were not presented to the group. Gunnlaugsson pointed out that binocular reticles were used more frequently by both platforms than in previous surveys and that their use improves distance estimation. Also, the observers learn from using them, which improves their "naked-eye" distance estimates. Pike noted that it would be helpful in the future to have a more in-depth discussion on distance estimation and validation, and suggested the possibility of using drones to validate a sub-sample of distances.

The WG noted the higher abundance estimates from the NASS2015 than previous surveys, and that this could be due to stock growth, distributional shifts or some combination thereof. Vikingsson noted the long-term increase in numbers west of Iceland since 1987, and that the distribution in this area has expanded to include the central deep waters of Denmark Strait (Vikingsson et al. 2009). This appears to be related to an increase in ocean temperature and perhaps productivity in the area (Vikingsson et al. 2015).

The group noted that the survey was conducted over a longer period of time than previous surveys, and that the area west of Iceland was covered in two periods, from 10 June to 9 July and from 14 July to 10 August. It was suggested that it might not be appropriate to combine these two coverages if they produced very different estimates. Upon closer examination, it was determined that the sighting rates in the two periods were similar, so the group concluded that the combination was appropriate (Fig. 2, Table 1).

The WG **accepted** the MRDS estimates in SC/23/AE/04 that reject the compromised effort. The estimate including all fin whale sightings is the least biased, while the estimate incorporating only high and medium confidence sightings is more comparable to reported estimates for 2007. The uncorrected estimate using the same restrictions can be used for comparison to earlier estimates.

The WG noted that the distribution of fin whales in this area was similar to 2007 survey. However, the 2014 catches were from primarily south and east of Iceland, and whalers found very few whales west of Iceland.

Table 1. Fin whale sightings from strata IG and IW (see Fig 2) in the Icelandic/Faroese survey in in two time periods. Effort and sightings along "compromised" transects (see section 5.1) is excluded.

DATE1	DATE2	SPECIES	EFF	SIGHTINGS	BP_100NM
10-Jun	09-Jul	BP	1387	173	12.472963
10-Jul	10-Aug	BP	1392	212	15.229885

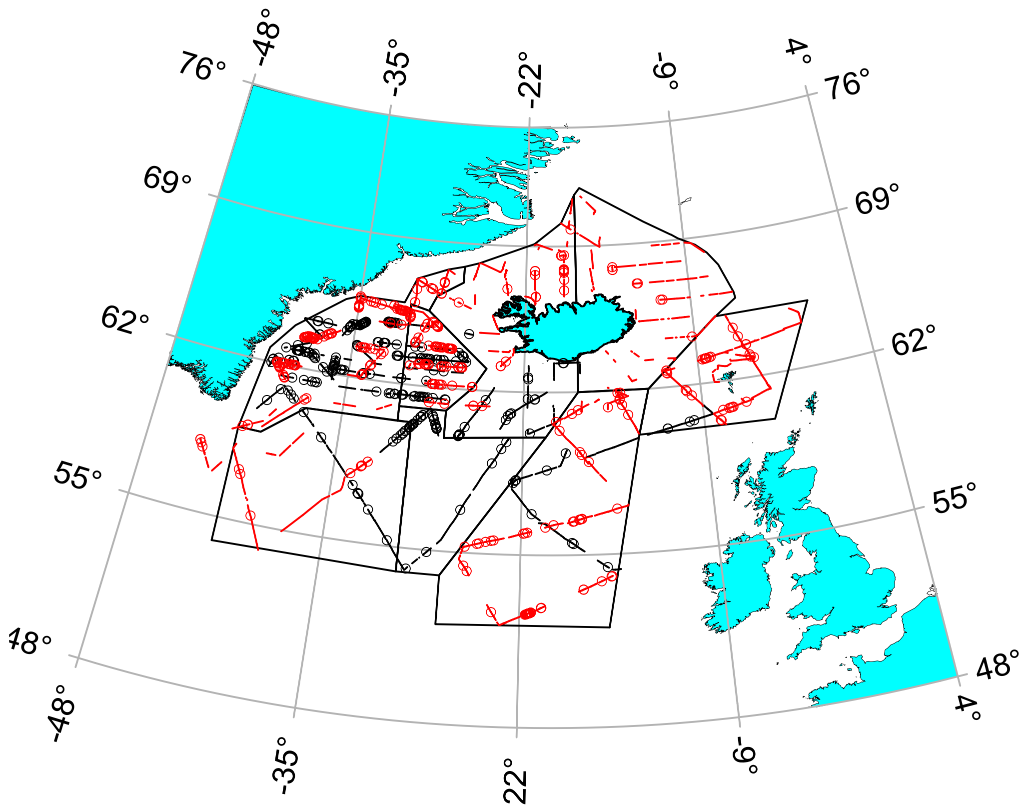

Fig. 2. Survey effort and sightings of fin whales from 10 June to 9 July (black) and from 10 July to 10 August (red).

Iceland updated the WG that they have had cetacean observers on capelin surveys (16 Sept-3 Oct 2015, 10 Sept-4 Oct 2016) with the NASS2015 platforms and methods. The sighting rates of fin whales were similar in these surveys in the EG area as during the midsummer NASS surveys (Fig. 3; also SC/22/21), while humpback whales are then heavily concentrated farther north on spots where capelin in detected. A point estimate of about 5,000 fin whales was obtained for the capelin area in 2015 (area within grey borders on Fig 3).

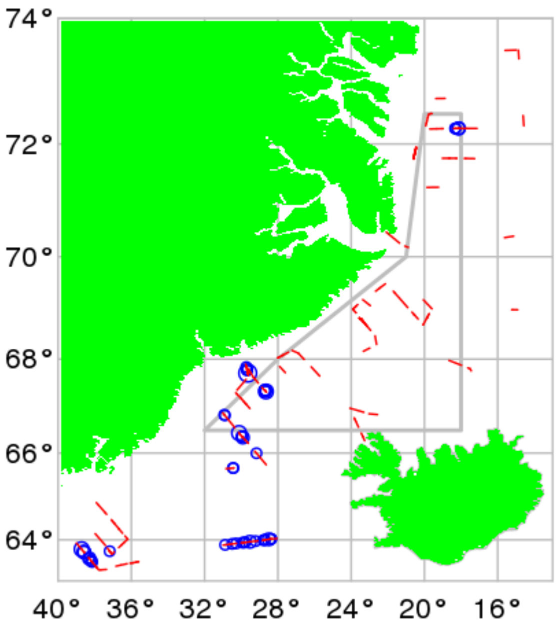

Fig. 3. Surveyed tracks and fin whale sightings (group size 1-5) during the Icelandic 2016 capelin survey (16 Sept.-3 Oct. 2015, 10 Sept.-4 Oct. 2016).

The WG **accepted** the abundance estimates from NASS2015 (Appendix 1).

5.2 Shipboard Norway

The Norwegian shipboard survey in 2015 covered the Norwegian Sea and an extension area around Jan Mayen (SC/23/AE/09 and SC/23/AE/O04). Fin whales were observed to be rather concentrated off northern Norway but were otherwise sparse in the survey area (Fig. 4). A few sightings (7 observations) of fin whales were made northeast of Jan Mayen. During the 2016 survey of the complete *CM* management area, 26 sightings were made from the primary platform. These were made in the southeastern area connected to the Denmark Strait and otherwise around Jan Mayen. No fin whale estimates based on these observations were presented to the meeting.

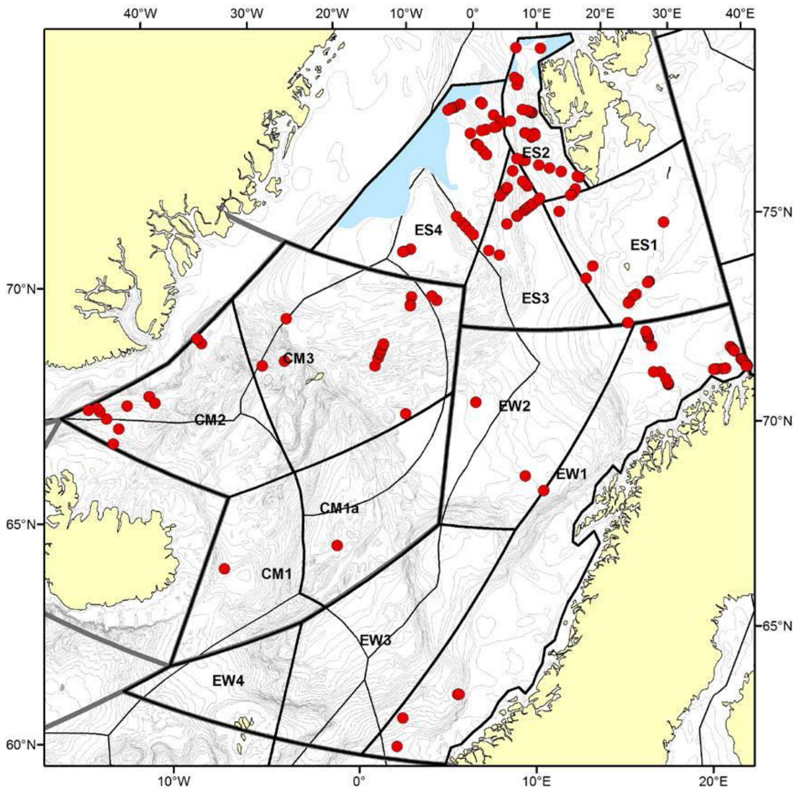

Fig. 4. The total survey area for the Norwegian surveys combined for 2014, 2015 and 2016: Primary fin whale sightings (red dots) made from platform A.

<u>Discussion</u>

Norway plans to generate abundance estimates for the large whales, but it is unclear at this time whether it will be possible to combine these estimates with those from the Icelandic surveys. The current mosaic survey cycle is 2014-2019, and estimates from the previous two mosaic survey cycle have not been produced. The WG encourages Norway to develop these estimates before the next meeting of the AEWG. This would likely increase the total estimate for the North Atlantic used by IUCN (ca 50,000 fin whales), which is primarily based on estimates around Iceland and Spain, and not including the whales seen around Northern Norway and Svalbard.

5.3 Aerial Greenland

An aerial line transect survey of whales in East and West Greenland was conducted in August-September 2015 (SC/23/AE/08). The survey covered the area between the coast of West Greenland and offshore (up to 100 km) to the shelf break. In East Greenland, the survey lines covered the area from the coast up to 50 km offshore crossing the shelf break. The search area covered was ~115,000 km2, 3,999 km on effort in Beaufort sea state <5, 3,499 km on effort in Beaufort sea state <3 (East Greenland) and ~221,000 km2, 9,003 km on effort in Beaufort sea state <5, 6,877 km on effort in Beaufort sea state <3 (West Greenland).

A common detection function was used for both the East and West Greenland surveys.

The estimates corrected for perception bias was 465 (95% CI: 233-929) in West Greenland and 1,932 (95% CI: 1,204-3,100) in East Greenland. These estimates are uncorrected for availability bias and both are therefore negatively biased. Heide-Jørgensen presented a possible means of correcting for availability bias. The observed surface time for one fin whale tracked in West Greenland was 18.13% and the average time-in-view of all fin whale sightings in East and West Greenland <700m from the trackline (n=136) was 10.3s with a bootstrapped cv of 0.10. Heide-Jørgensen and Simon (2007) observed that fin whales in West Greenland blew 50 times per hour (cv=0.07) when excluding observation periods <30min. This corresponds to an average duration of surfacing per hour of 13.1s (2,600*0.1813/50), assuming that fin whales blow every time they surface, and an average duration of dives of 58.9s (3,600-(1-0.18))/50). Using these values in model by Laake et al. (1997) increases the availability for fin whales to 31.26% (cv=0.10) and applying this to mark-recapture-distance sampling (MRDS) estimates gives fully corrected abundance estimates of 6,180 (cv= 0.26, 95%CI: 3,744-10,203) and 1,487 (cv=0.35, 95%CI: 745-2,970) fin whales in East and West Greenland, respectively.

Discussion

Fin whale abundance in West Greenland has apparently declined since 2007 from 4,400 to 465, a decrease of 89%. The proposed availability bias correction would increase both the 2007 and 2015 estimates, retaining the observed decline in abundance. Corrected estimates would however be useful for assessment purposes.

The WG noted that while the proposed method is acceptable, the dive data used for the correction is based on only one whale. To apply this method, dive data from 5-10 whales would be needed. The WG recognizes that this data is difficult to obtain, but encourages Greenland to continue efforts obtain more data to validate this approach.

The WG **recommended accepting** the MRDS abundance estimates (Appendix 1). However, when comparing to earlier surveys, the conventional distance sampling (CDS) estimates may be more appropriate.

The WG suggested cue counting for fin whales could provide fully corrected estimates without the need for additional data (i.e. only a cueing rate is required), but recognizes that it may be logistically difficult to implement during a multi-species survey.

5.4 Combined Estimates

The WG noted that the Greenlandic surveys were originally planned to occur at the same time as the Icelandic shipboard surveys, making them synoptic. However, the funding for the surveys came in very late, and by the time it was secured, the planes were not available before the 15th of August, which was after the Icelandic surveys had been completed. Despite this difference in timing, the WG concluded that the East Greenland estimates could be combined with the estimates from the Icelandic surveys. This is because the density of fin whales in this area appears to be stable between ca 1 June and 1 September, and possibly into October (see Fig. 2 and Fig. 3)

6. MINKE WHALES

6.1 Shipboard Iceland/Faroes

New abundance estimates of common minke whales from the Icelandic-Faroese shipboard part of NASS2015 were presented in SC/23/AE/05. The surveyed area and general methodology was as described above for fin whales (section 5.1.) including fully independent double platforms on each of the three vessels and the sharing of one of the vessels with fishery research. For the common minke whale analysis only data recorded in a BSS <4 were used. The designed strata were post-stratified so that block boundaries aligned with stock divisions recognized by the IWC, and also to correspond with realized effort.

Density and abundance were estimated using stratified line transect methods (Buckland *et al.* 2001) using the DISTANCE 6.2 (Thomas *et al.* 2010) software package.

Sightings on compromised transects (transits oriented parallel to coastlines) were included in the overall detection function but not in the estimation of encounter rate or group size within strata.

Density was highest in blocks FC and IC (Faroese and Icelandic coastal areas), and these two strata contributed more than half of the total uncorrected abundance estimate of 19,663 (cv 0.26, 95% CI 11,814 – 32,727). The total estimate corrected for perception bias was 36,185 (cv 0.31, 95% CI 19,942 to 65,658) for the survey area. The corrected estimate for Icelandic coastal waters (IC or CIC in RMP terms) was 12,710 (cv 0.52, 95% CI 4,498 to 35,912). These estimates are neither corrected for availability bias nor responsive movements. The first named is unlikely to be large for common minke whales, while the latter may be a source of considerable negative bias in the estimate.

<u>Discussion</u>
The WG noted that the effort north of Iceland, in the CM area, was very low and that the estimates from the Norwegian survey in this area should be preferred for use in assessments.

The WG discussed the setup on the Faroese surveys of having observers side-by-side and whether observers could cue each other. While there is visual isolation, the observers can hear each other, therefore there is some potential that observers could alert each other to presence of whales, which might increase the proportion of duplicate sightings. Mikkelsen felt that this did not occur under most conditions. Nevertheless, future surveys using this setup, which operationally functioned well, should take measures to limit this possibility.

The IO method used during NASS2015 produce more precise estimates compared the BT method which used in 2001 and 2007. This is likely due to the use of two fully staffed platforms using full searching effort, generating more sightings, and better use of sightings in estimating perception bias, which reduces variance. In addition, the IO method is logistically simpler in application.

The WG **accepted** these abundance estimates (Appendix 1): uncorrected for comparison to previous surveys, and corrected estimates for generating management advice.

6.2 Shipboard Norway

In 2014 a new survey cycle (2014-2019) was started. The first year 2014 was dedicated to the Svalbard area (management area ES), while the Norwegian Sea (EW) was the dedicated survey area in 2015. In addition, an extension survey was conducted in the Jan Mayen area (CM). CM received a complete coverage in 2016. The complete data set collected 2014-2016 so far during the present survey period has been used to calculate preliminary minke whale abundance estimates for the surveyed areas. Over the three years 2014-2016 a total primary effort of 18,718 km was conducted (Fig. 5). The total survey area was 2,085,102 km^2. A total of 510 sightings of groups (sum platform A and B) were made during primary search effort. They were distributed all over the survey areas although at varying densities. The total estimate for the areas surveyed in 2014 to 2016 is 81,527.

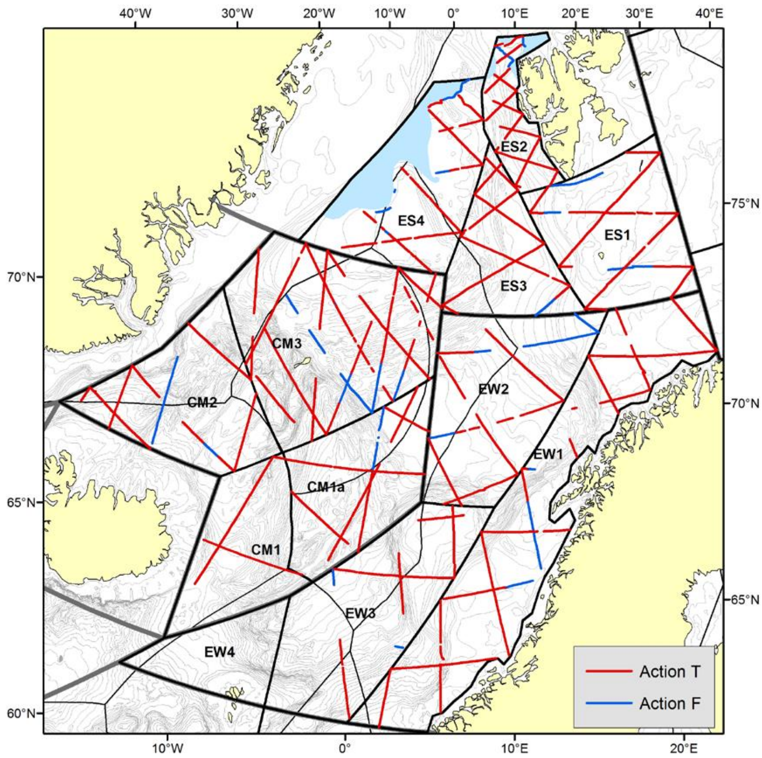

Fig. 5. The total survey area for the Norwegian surveys combined for 2014, 2015 and 2016. The Small Management Areas as decided at the Implementation Review in 2003 have been further divided into survey blocks carrying the SMA name and a number. Also shown are transect lines covered in primary search mode (realised survey effort - red lines. The blue lines are additional single platform effort). The stratum EW4 did not receive any coverage. The ice coverage in SMA ES is based on mid-July 2014 maps from the Norwegian Meteorological Institute.

While the survey cycle has not been completed, it is quite evident that considerable distributional changes are occurring in the Northeast Atlantic. In the previous cycle 2008-2013 there was an increase in minke whale abundance in the Svalbard area (ES). In 2014 the corresponding abundance was only 45% of that observed in 2008 and the lowest number since 1995. For the Norwegian Sea (EW) the estimate was similar (2015) or decreasing (2016 analysis) to the previous survey in 2011. And, for the Jan Mayen area there was an increase in numbers which may be 3-5 times larger than earlier estimates.

<u>Discussion</u>

Until 2016, the large decrease in minke whale abundance seen in Icelandic coastal waters since 2001 had not been matched by a concomitant increase in the abundance seen by Icelandic and Norwegian ship surveys since that time, leaving open the question of the fate of these "missing whales". One conjecture has been that the whales had moved farther north into the CM medium area. While estimates from 2009 did not show any increase in this area, the preliminary estimates from the most recent survey completed in 2016 suggest that abundance has indeed increased in this area. While this may indicate a shift in distribution from Icelandic coastal waters to CM, it leaves unanswered the question of where these whales were prior to 2016. In this respect, it was noted that large areas to the north and northwest of Iceland had little or no survey coverage during 2010-2015. It is apparent that minke whales show a degree of behavioural flexibility in their spatial and temporal migrations, as large variations in distribution have been seen throughout the NASS and Norwegian survey areas.

Vikingsson noted that there have been large ecosystem shifts in Iceland in recent years, with many fish species shifting northwards, including very important prey species for minke whales (Vikingsson et al 2015). Sandeels have been shown to be up to 80% of the diet of minke whales in some areas, and the sandeel population crashed around Iceland in about 2005. Capelin, another important diet item, also moved away from coastal Iceland towards Greenland.

The WG recommended satellite tagging, with priority on a smaller number of high-duration tags versus a larger number of lower duration tags. It was suggested that this may require the live-capture and handling of a small number of minke whales. Such attachments have resulted in tag lifespans of over 800 days on other species.

The large fluctuations in numbers seen in the Norwegian and Icelandic surveys for the *Small areas* suggest that these areas are too small to be considered as independent management areas.

6.3 Aerial Iceland

The Icelandic aerial survey carried out in July 2016 (SC/23/AE/07) is a continuation of a series of surveys, using nearly identical design and methodology, carried out in 1987, 1995, 2001, 2007 and 2009 **(**Pike *et al.* 2008, 2009, 2011). The survey was attempted in 2015 but insufficient effort was realized due to poor weather conditions (Pike 2015). The main target species of these surveys has been the common minke whale, however sightings of all species are registered. The cue counting procedure has been used for minke and other baleen whales, while for other species standard line transect methods are employed. In 2016 a Twin otter aircraft was used, for the first time allowing two full platforms each with 2 observers. As in 2015, a new electronic device called a Geometer was used to record sighting times and declination angles. Other data were recorded using time-stamped vocal recordings. In addition a video camera recorded a continuous record of the trackline. Only 53% of planned effort was completed due to poor weather conditions (Fig. 6). Duplicate sightings have been identified using an algorithm-based methodology developed by Southwell *et al.* (2002). A total of 647 sightings were made, including 66 of minke whales, 223 of white-beaked dolphins, 92 of harbour porpoises and 52 of pilot whales. Minke whale numbers in comparable areas were low compared to surveys carried out before and including 2001, and similar to ones done after that. Abundance estimates from this survey are feasible for minke whales, white beaked dolphins harbour porpoises and perhaps pilot and humpback whales. However the value of producing these estimates must be weighed against the relatively low coverage of the survey.

<u>Discussion</u>
Abundance estimates from this survey will be developed within the next several months. Overall, the 2016 survey had poor coverage, but adequate coverage in what were the most important blocks earlier surveys.

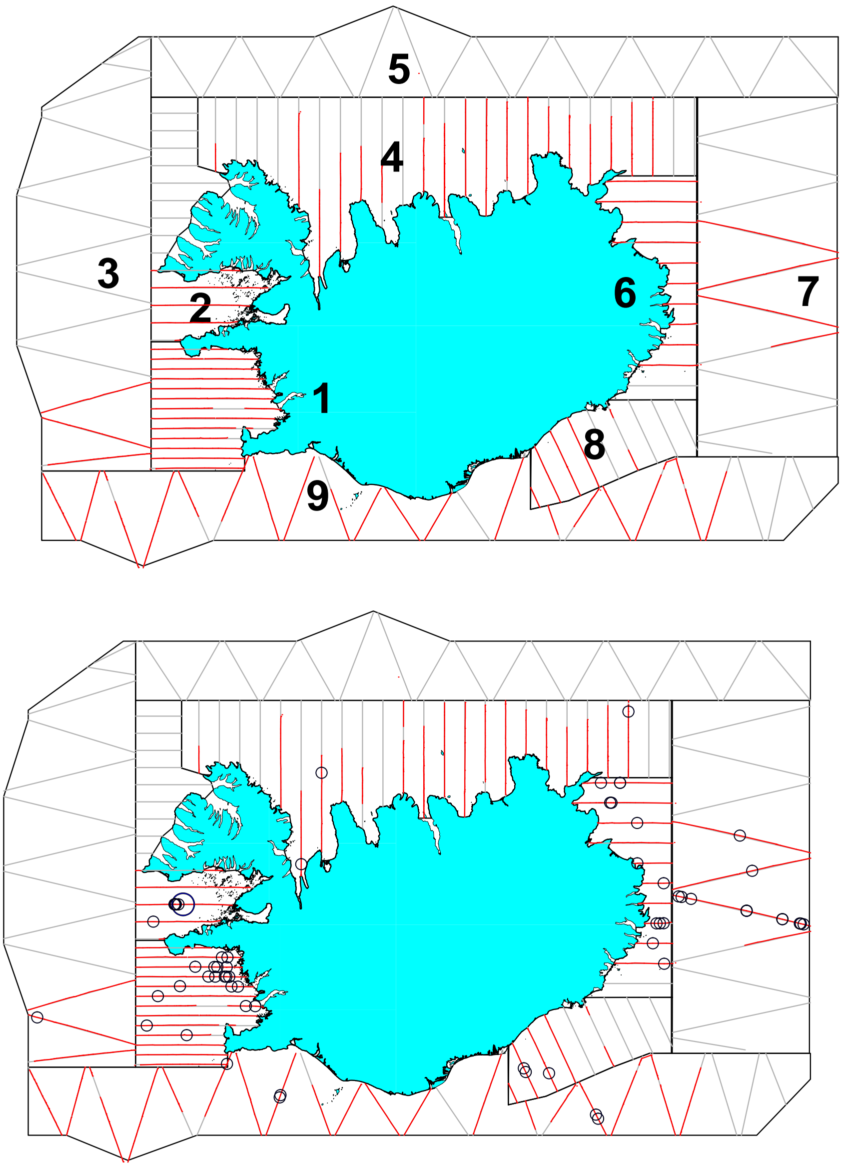

Fig. 6. Stratification and planned (black) and realized (red) effort (upper) and sightings of minke whales (lower) in the 2016 Icelandic aerial survey.

The WG suggested that Iceland consider attempting the coastal aerial survey more frequently for shorter periods of time (e.g., 10 days every year), possibly using the "mosaic" approach used in the Norwegian survey program, with the goal of completing the entire survey over 3-5 years. This approach has many practical advantages, including the maintenance of a trained cadre of observers, more efficient use of equipment, a reduced risk of a "failed" survey and more predictable budgeting. The main disadvantage would be a decrease in precision because of the added variance due to interannual variation, but it was noted that several years of data are available to address this. The Icelandic delegates agreed to consider this approach.

6.4 Aerial Greenland

An abundance estimate for minke whales was developed from data collected during the same aerial survey that was described above (Item 5.3).

Data on surface corrections for minke whales were collected from 5 whales instrumented with satellite-linked time-depth-recorders in West Greenland. The minke whale abundance estimate was corrected for perception bias, availability bias and time-in-view using MRDS analysis methods, producing a fully corrected abundance estimate of 4,204 whales (cv=0.47; 95% CI= 1,753-10,085) in West Greenland and 2,681 whales (cv= 0.45; 95% CI= 1,153-6,235) in East Greenland.

Discussion

The WG noted the remarkably low perception bias for all species in this survey. It was suggested that this was probably due to the use of highly experienced observers.

The WG discussed the correction factors for availability bias used for some species While the correction based on whales breaking the surface is simple in concept and application, the surfacing data, which is collected through satellite tag deployments, is vulnerable to bias due to 1) differences in placement of the satellite transmitter on the whale and 2) calibration drift in the depth transducer. As imprecision in this estimate will have a large effect on the abundance estimate, and the WG agreed that it is better to use the 0-2m depth for the availability correction factor, combined with the MRDS estimate.

The WG **endorsed** the MRDS estimate using the 0-2m correction for availability bias.

6.4.1 Trends in abundance

The time series of aerial surveys of large cetaceans off West Greenland conducted at regular intervals since 1984 was used to construct an index of the relative abundance of minke whales in the area (SC/23/AE/06). The effort was corrected for varying detection probabilities but no correction could be applied for the lack of coverage in South Greenland in 1984 and 1985 (south of 62°N). The resulting indices of relative minke whale abundance show large variation suggesting there is not a consistent fraction of minke whales from the North Atlantic that use the West Greenland banks as a summer feeding ground. The results suggest it is unlikely that pronounced site fidelity, coastal or offshore, occurs with West Greenland minke whales. It is more likely that some environmental factors influence the fraction of whales that move into West Greenland to feed in summer.

Discussion

The WG agreed that uncorrected line transect density provided a robust index of abundance, as biases due to perception and availability are unlikely to vary much between surveys. These results suggest that the surveys are capturing a variable component that is moving in and out of the area, as there is a great deal of variation between surveys, and no unidirectional trend.

6.5 Combined Estimates

The WG agreed that the estimates from the Norwegian and Icelandic shipboard surveys from 2015 can be combined. However, the estimate from the Norwegian survey in 2016 could not be combined with these because of the observed inter-annual variation in distribution. It will be possible to combine the Norwegian 2016 data with data from the aerial survey in Iceland 2016.

The WG discussed whether the Icelandic shipboard estimates could be combined with estimates from the Greenlandic aerial survey. Although there is no data on minke whale movements and distribution during this time, the likelihood of a positive bias due to directional movement of minke whales from the Icelandic survey area into East Greenland coastal waters in the short time between the surveys seems small. The WG therefore concluded that these estimates are additive.

7. HUMPBACK WHALES

7.1 Shipboard Iceland/Faroes

There are adequate numbers of humpback sightings concentrated to the northwest of Iceland to derive an abundance estimate from these surveys (Fig. 7). The WG recommended that such an estimate be presented at the next meeting.

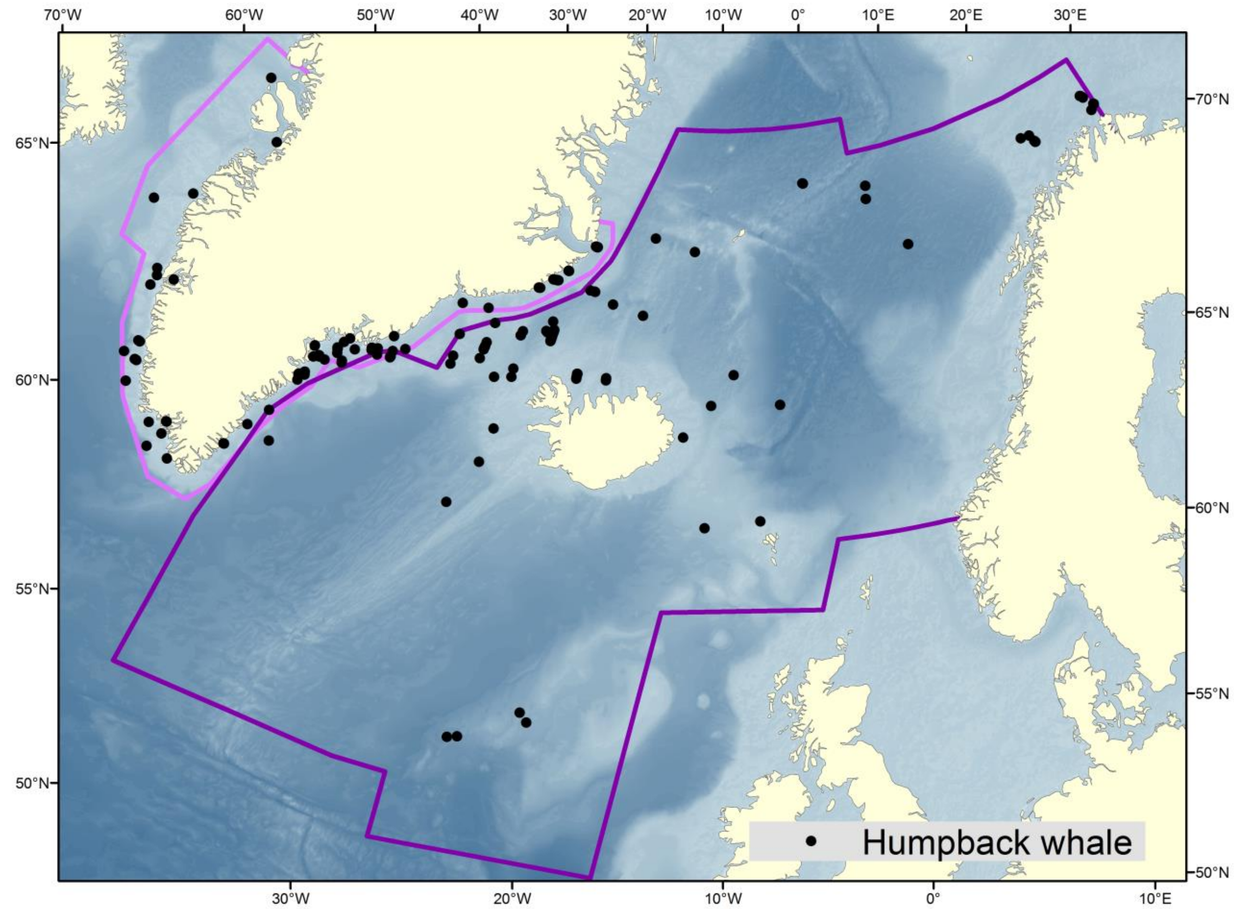

Fig. 7. Humpback whale sightings during NASS2015. This map does not include sightings during the 2015 Icelandic aerial survey.

7.2 Shipboard Norway

In the Norwegian 2015 survey only 14 primary sightings of humpback whales were made. One sighting was made northeast of Jan Mayen; the others were recorded in coastal areas off northern Norway. During the survey of CM in 2016, 12 primary sightings were made of humpbacks. Figure 8 shows the combined sightings from 2014-2016. They were thinly distributed in the northern areas of the Jan Mayen blocks. No estimate was presented to the meeting based on these sightings.

The WG **recommended** that Norway develop the large whale estimates before the next meeting.

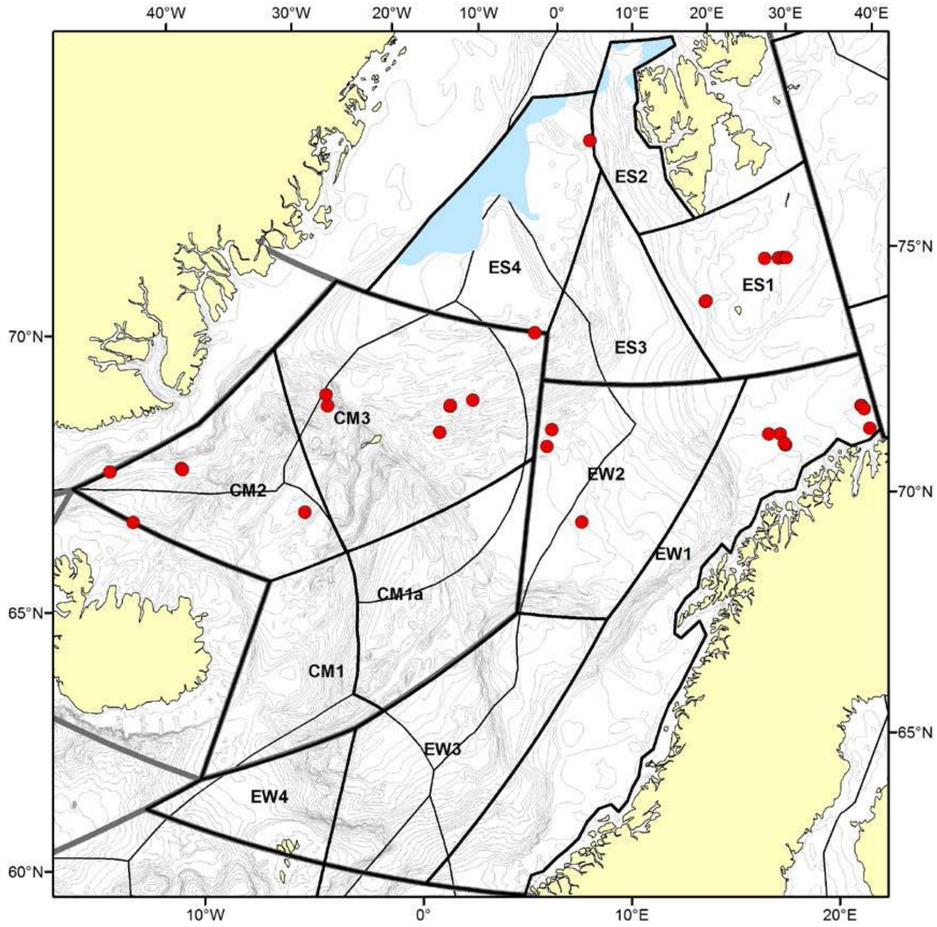

Fig. 8. The total survey area for the Norwegian surveys combined for 2014, 2015 and 2016: Primary humpback whale sightings (red dots) made from platform A.

7.3 Aerial Iceland

The 2015 survey was not successful due to poor weather. In 2016, there were 40 sightings, mainly off northern Iceland, but the survey was not able to cover the areas where most humpbacks whales would be expected (NW area). The utility of an estimate from this survey would therefore be limited.

7.4 Aerial Greenland

An abundance estimate for humpback whales in East and West Greenland were developed from data collected during the same aerial survey as described above (Fig. 9, Item 5.3, SC/23/AE/08). The humpback whale abundance estimate was corrected for perception bias, availability bias and time-in-view using MRDS analysis methods, producing a fully corrected abundance estimate of 1,321 whales (cv=0.44; 95% CI= 578-3,022) in West Greenland and 4,012 whales (cv= 0.35; 95% CI= 2,044-7,873) in East Greenland.

Stratum E1 (near Scoresby Sound) were discarded from the abundance estimation because of the low effort in this strata.

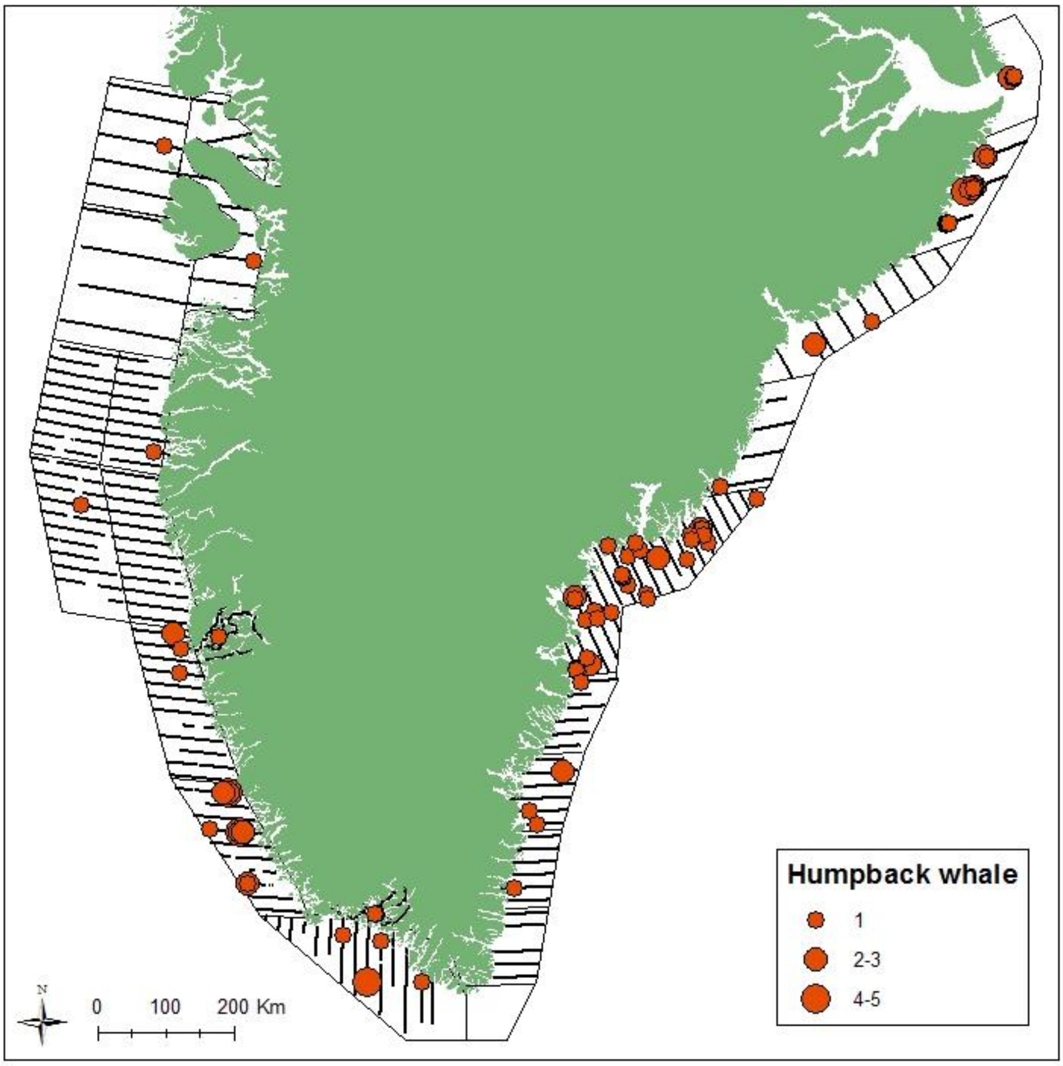

Fig. 9. Survey effort in sea states <5 and sightings with group sizes of humpback whales in East and West Greenland.

<u>Discussion</u>
The 2015 estimate for West Greenland is substantially lower than the previous survey in 2007 (50% decline). The WG did not identify any methodological problems with the survey; there was good coverage that was similar to that in 2007. There was slightly less effort in the northern strata, but this was not seen as problematic.

The WG **accepted** the MRDS estimates for both East and West Greenland.

7.5 Combined estimate

The WG recommended that the Icelandic estimate could be added to the EGL survey, for the same reasons as combining the fin and minke abundance estimates, i.e., there is evidence that the humpback whales remain in the area during the entire coverage period (Fig. 10).

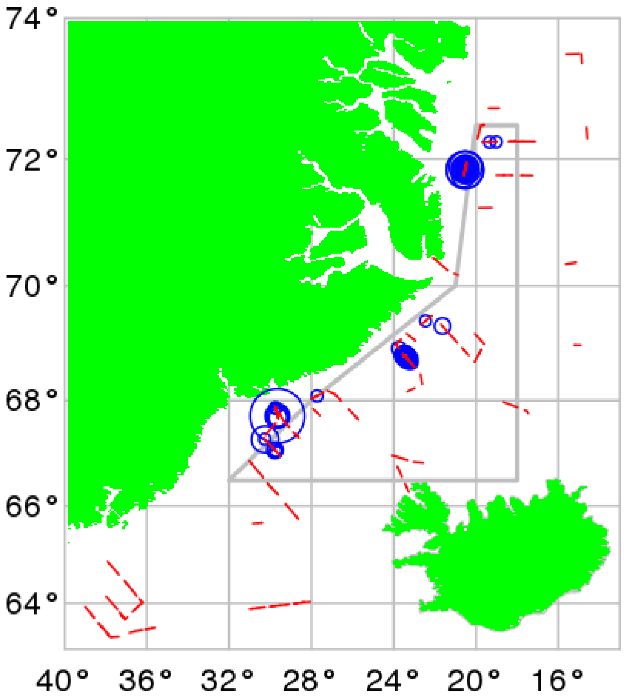

Fig. 10. Realized effort (red) and humpback whale sightings (blue circles) during the capelin survey 16 September to 4 October 2015 imposed on the NASS-15 vessel surveyed blocks (grey lines).

8. PILOT WHALES

8.1 Iceland/Faroes

No abundance estimate from the NASS 2015 survey was available to the WG; the data had not been fully explored for duplicate sightings in advance of the meeting. A trend analysis of pilot whales in the North Atlantic, that has integrated previous NASS and SCANS/CODA surveys, was presented to the SC in 2014. The plan is to integrate the NASS 2015, together with the SCANS 2016 data, in the trend analysis.

The sightings of pilot whales during NASS2015 can be seen in Fig. 11. Group size estimations of pilot whales in ship surveys have been an issue of discussion in previous abundance estimation WGs. During the preparations of NASS 2015, it was recommended that potential solutions for more accurate group size estimation be explored, (e.g. independent aerial surveys). A drone was used for filming groups to use as a comparable group size estimate. The drone was deployed successfully. The drone data have not been explored yet, as the video is not yet available.

The plan was also to tag some pilot whales with satellite transmitters during the survey, in order to determine the presence of pilot whales within the survey area during the survey. Although one attempt was made to approach and tag animals offshore, from a small boat, it was not possible to get close enough to the animals.

<u>Discussion</u>
The WG **recommended** that the analysis of the pilot whale data should be completed within the next few months.

The WG noted that there were adequate sightings in the Icelandic and Faroese surveys to derive an estimate, particularly in the northern areas.

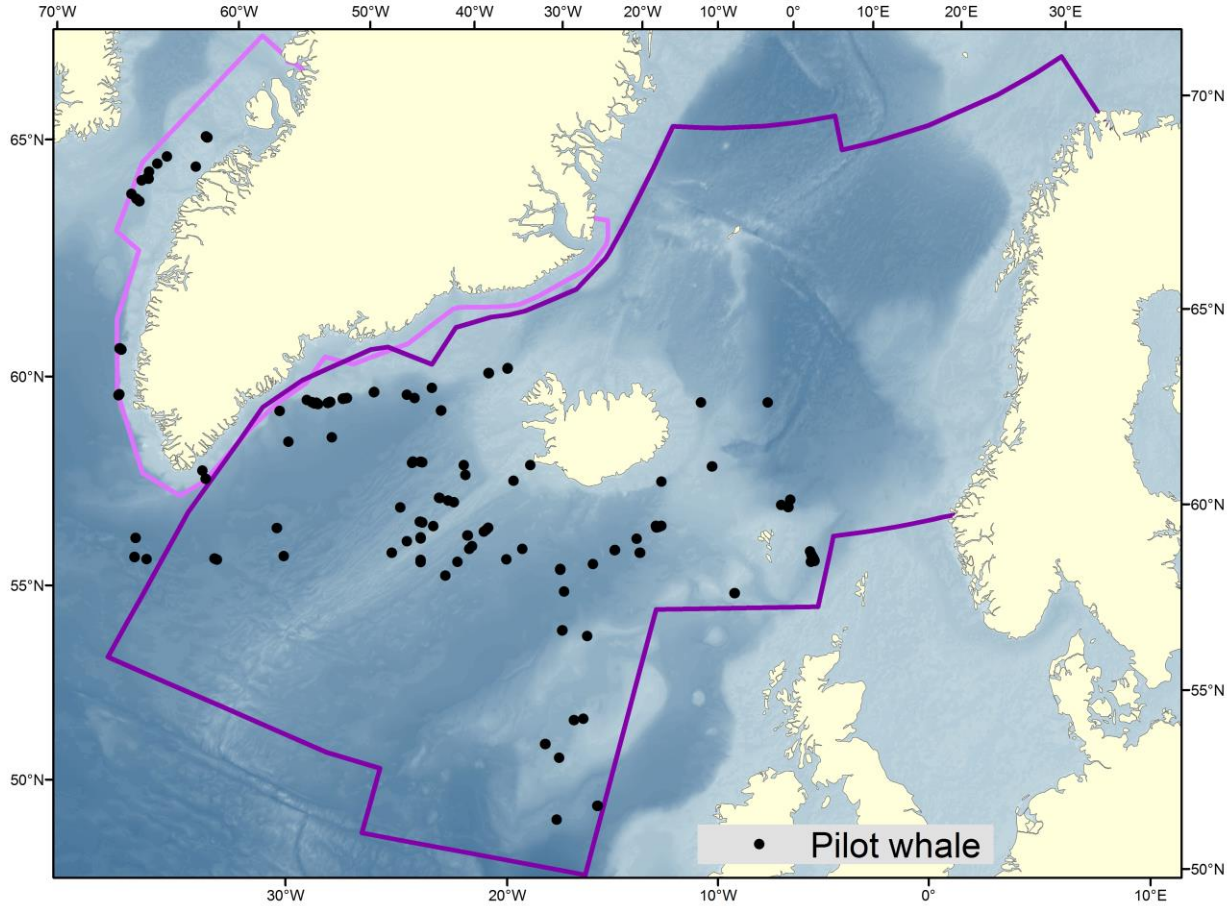

Fig. 11. Pilot whale sightings during NASS2015, not including the 2015 Icelandic aerial survey.

The WG discussed whether the group size estimation was necessary and whether there was any indication that the group sizes of offshore groups are different from the coastal areas. It has been previously suggested that aerial video of pilot whale groups could be useful in this context. The WG noted that the field experiments that were conducted were not successful in obtaining independent group size estimates for pilot whales. If the drone video becomes available, the WG encourages the Faroe Islands to analyse these data.

Mikkelsen noted that the plan is to combine the estimate from their survey with the results of the SCANS-III survey that was conducted in 2016. The WG will need to see the results of both of these surveys in order to determine whether this is possible.

8.2 Aerial Greenland

An abundance estimate for pilot whales was developed from the same survey as described above (Fig. 12, see Item 5.3). The pilot whale abundance estimate was corrected for perception bias and availability bias using MRDS analysis methods, producing a fully corrected abundance estimate of 11,993 whales (cv=0.52; 95% CI= 4,575-31,438) in West Greenland and 338 whales (cv= 1.01; 95% CI= 65-1,749) in East Greenland.

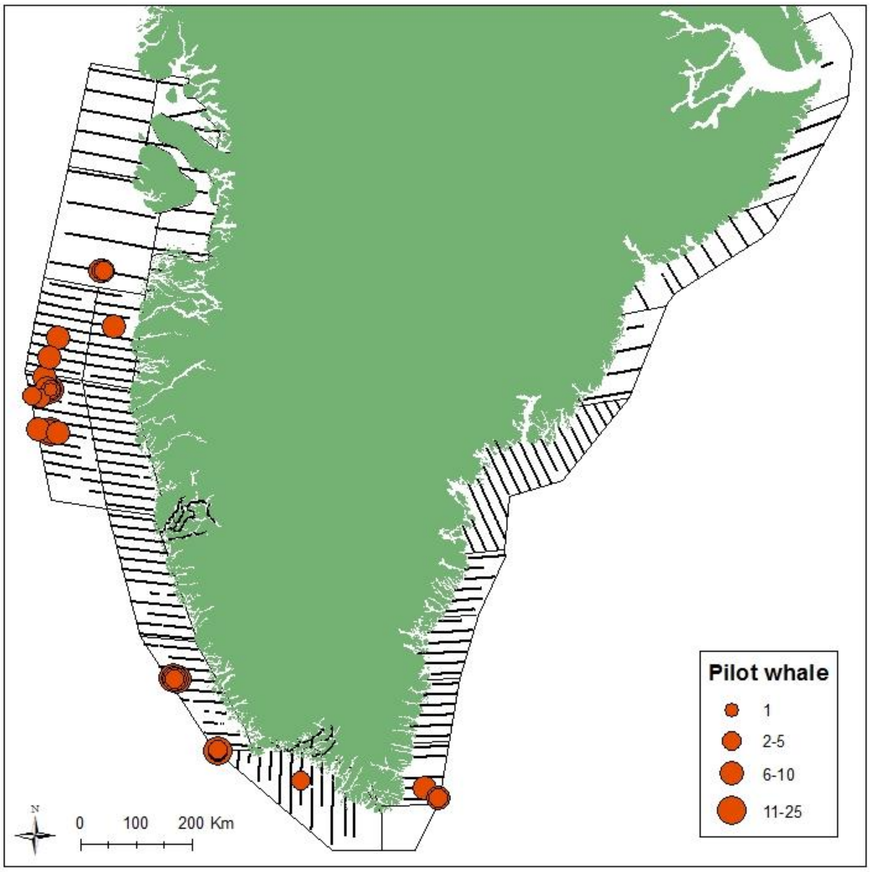

Fig. 12. Survey effort in sea states <5 and sightings with group sizes of pilot whales in East and West Greenland.

Discussion

The WG concluded that this survey was not designed to provide a complete coverage of the stock area in Baffin Bay and that the abundance estimates from West Greenland must therefore be considered a minimum estimate. The survey is only capturing a fraction of the population in Baffin Bay because there were sightings at the western edge of the strata, indicating that there are likely animals outside of the survey area. There are probably large fluctuations in abundance in West Greenland as reflected in recent surveys (e.g. 2007) and also in the catches.

The WG noted that the 0-7m depth interval used in deriving the availability correction factor was considered conservative and probably results in a negatively biased abundance estimate.

The WG **accepted** the estimate for West Greenland as a minimum given the caveats above regarding the distribution offshore with incomplete coverage of the stock, and endorsed the estimate for East Greenland.

8.3 Shipboard Norway

There were no sightings of pilot whales in 2015, and only a few sightings in 2016 in the southern part of the Jan Mayen (CM) area (see Fig. 11).

9. HARBOUR PORPOISES

9.1 Aerial Greenland

An abundance estimate was developed for harbour porpoises from data collected during the same aerial survey described above (Item 5.3; Fig. 13; SC/23/AE/08). Data on surface corrections for harbour porpoises were collected from 9 whales instrumented with satellite-linked time-depth-recorders in West Greenland. The harbour porpoise abundance estimate was corrected for perception bias using MRDS analysis methods and availability bias using data from satellite tagged animals, producing a fully corrected abundance estimate of 83,321 harbour porpoises (cv= 0.34; 95% CI=43,377-160,047) in West Greenland and 1,642 harbour porpoises (cv= 1.00; 95% CI= 318-8,464) in East Greenland.

Discussion

In 2015, 50% of satellite tagged harbour porpoises were outside of the West Greenland survey area during the survey period. This suggests that this estimate is an underestimate because the survey clearly missed animals from this stock that were outside the survey area at the time of the survey.

The WG **accepted** the abundance as a minimum estimate in West Greenland. This is an increase since 2007, while for all other species abundance estimates have declined.

The WG **accepted** the estimate for East Greenland.

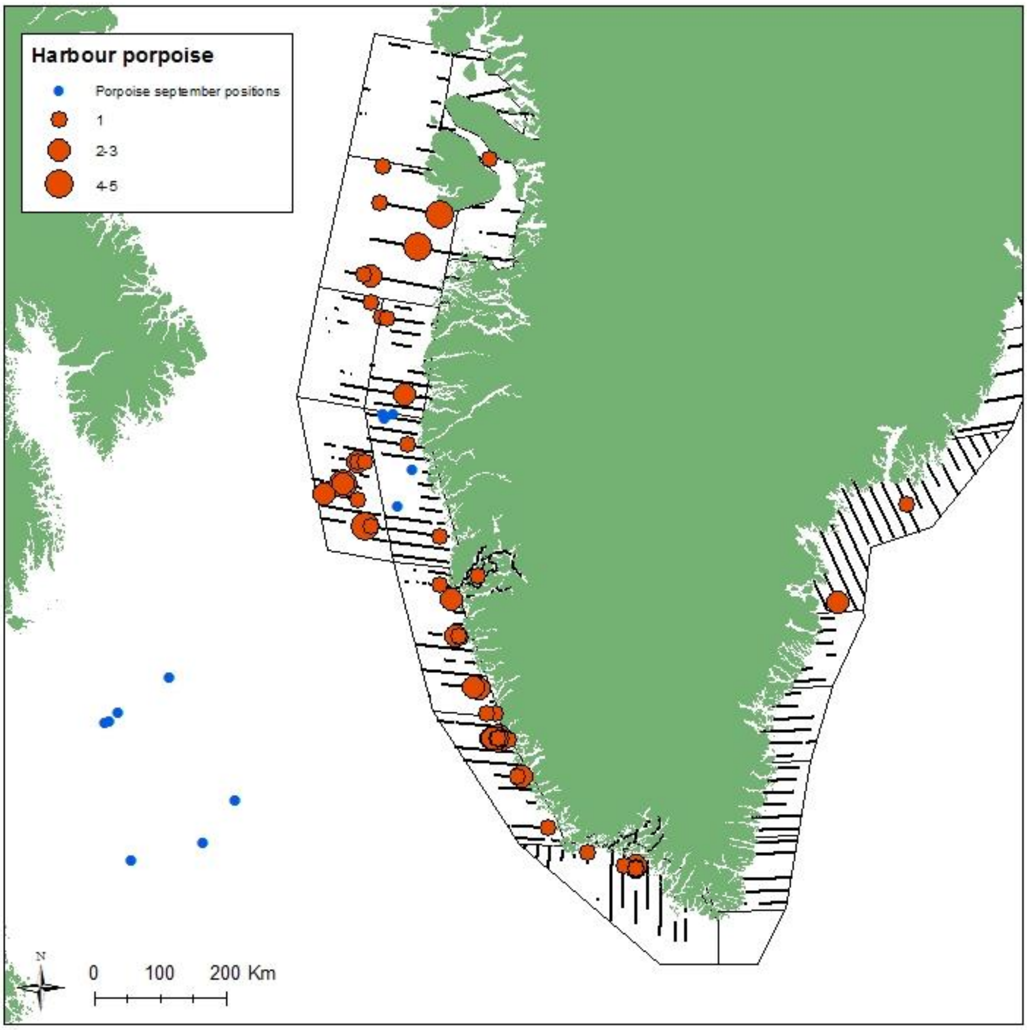

Fig. 13. Survey effort in sea states <3 and sightings with group sizes of harbour porpoises in East and West Greenland. Blue dots indicate satellite positions of harbour porpoises tagged inside the survey area and tracked in September 2015.

9.2 Aerial Iceland

There were 92 sightings of harbour porpoises during the 2016 survey (Fig. 14), and it should be possible to develop an abundance estimate. There is a previous estimate of harbour porpoises in Iceland from 2007 that the 2016 estimate could be compared to.

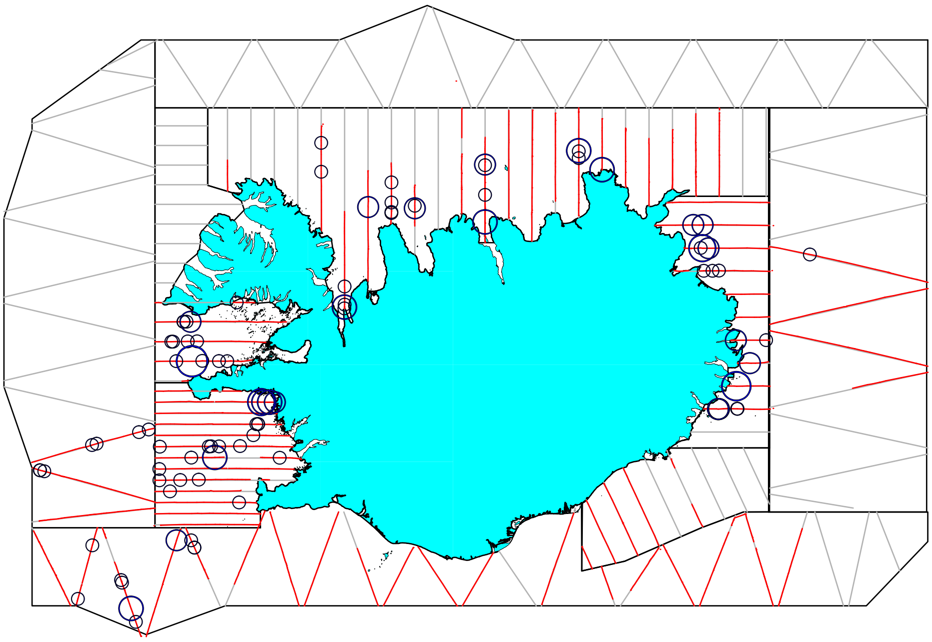

Fig. 14. Unique (non-duplicate) sightings of harbour porpoises (PP) in the Icelandic aerial survey of 2016. Symbol sizes are proportional to the group size limits given.

10. OTHER SPECIES

10.1 White-beaked dolphins

10.1.1 Aerial West Greenland

White-beaked dolphins were widespread in both East and Southwest Greenland (SC/23/AE/08; Fig. 15) but the number of sightings in West Greenland in 2015 was only half of the sightings in 2007.

The expected group size was 4.2 (cv=0.19) in West Greenland and 4.5 (0.19) in East Greenland. A half-normal key with sea state as a variable in the DS component was chosen for the MRDS model that provided at-surface abundance estimates of 2,747 white-beaked dolphins (95% CI: 1,257-6,002) in West Greenland and 2,140 (95% CI: 825-5,547) in East Greenland with a joint perception bias of 0.99 (cv=0.01, Table 5).

Hansen and Heide-Jørgensen (2013) used data from a single white-beaked dolphin from Iceland to develop an availability correction factor and applying this to the at-surface abundance gave a fully corrected estimate of 15,261 dolphins (cv=0.41; 95% CI= 7,048-33,046) in West Greenland and 11,889 dolphins (cv= 0.40; 95% CI= 4,710-30,008) in East Greenland.

Discussion

This estimate indicates a decline in West Greenland from the 2007 survey. There is no previous estimate for East Greenland for comparison.

The correction factor for availability is based on data from only one dolphin tagged off Iceland and should therefore be considered provisional. The WG noted that it is likely there are animals outside of the survey area because dolphins were seen on the ends of the transects, there for the survey is probably capturing only a portion of the West Greenland population. The decline observed since 2007 could possibly be more a function of a distributional shift.

The WG **accepted** the abundance estimates, corrected for perception bias, for East and West Greenland.

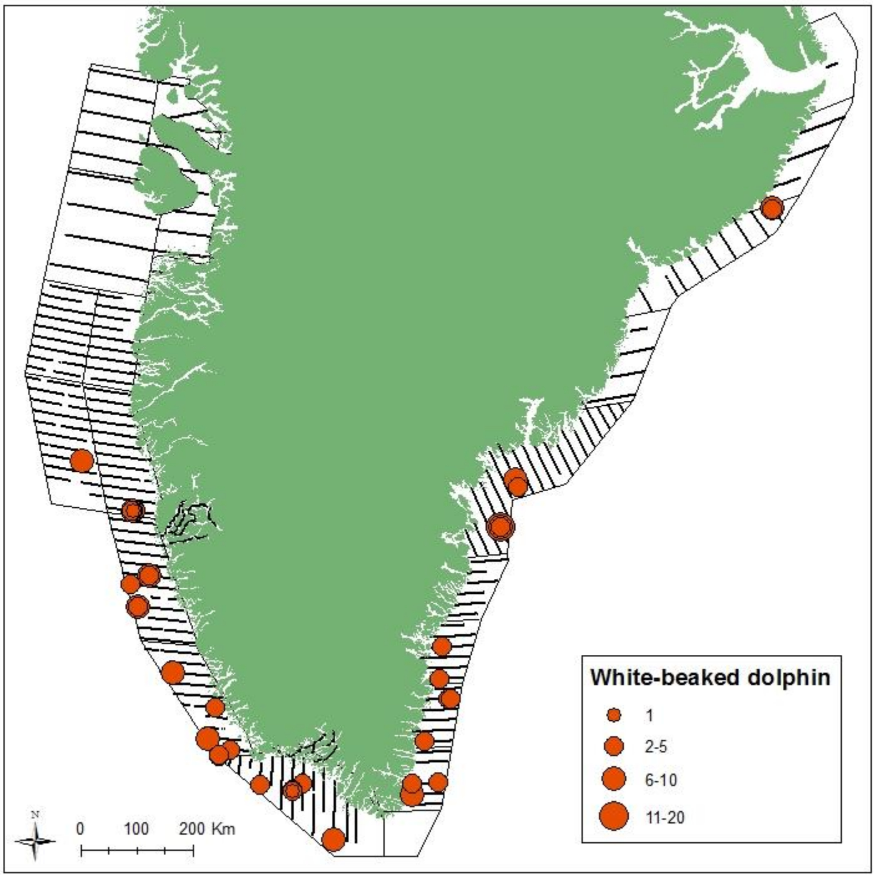

Fig. 15. Survey effort in sea states <5 and sightings with group sizes of white-beaked dolphins in East and West Greenland.

10.1.2 Aerial Iceland

White-beaked dolphins were the most commonly sighted species (Fig. 16), and therefore it is possible to develop an abundance estimate. The WG recommended that Iceland complete this analysis before the next meeting.

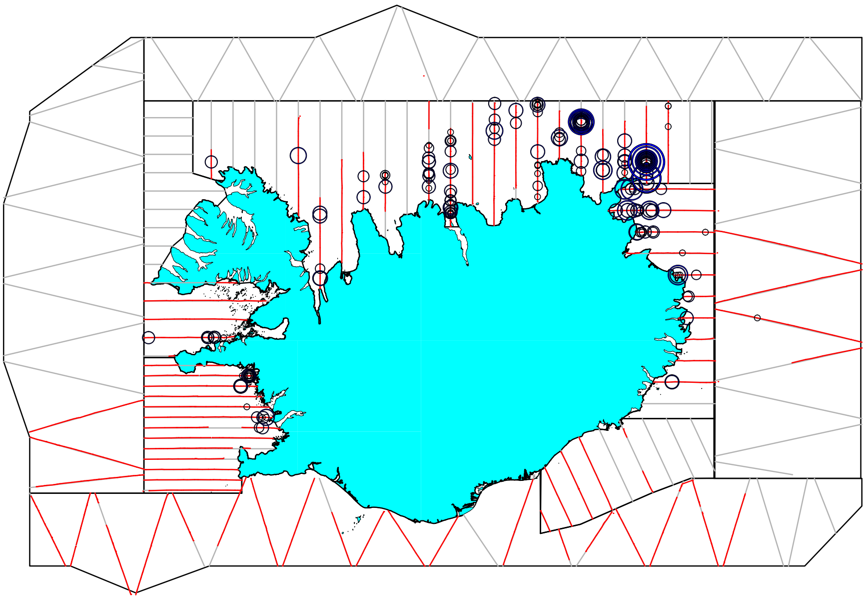

Fig. 16. Unique (non-duplicate) sightings of white-beaked dolphins (LA) in the Icelandic aerial survey of 2016. Symbol sizes are proportional to the group size limits given.

10.2 Other species

SC/23/AE/08 also contained information on sightings of additional species: sei whale, blue whale, sperm whale, and bottlenose whales seen during the aerial surveys in West and East Greenland (Fig. 17).

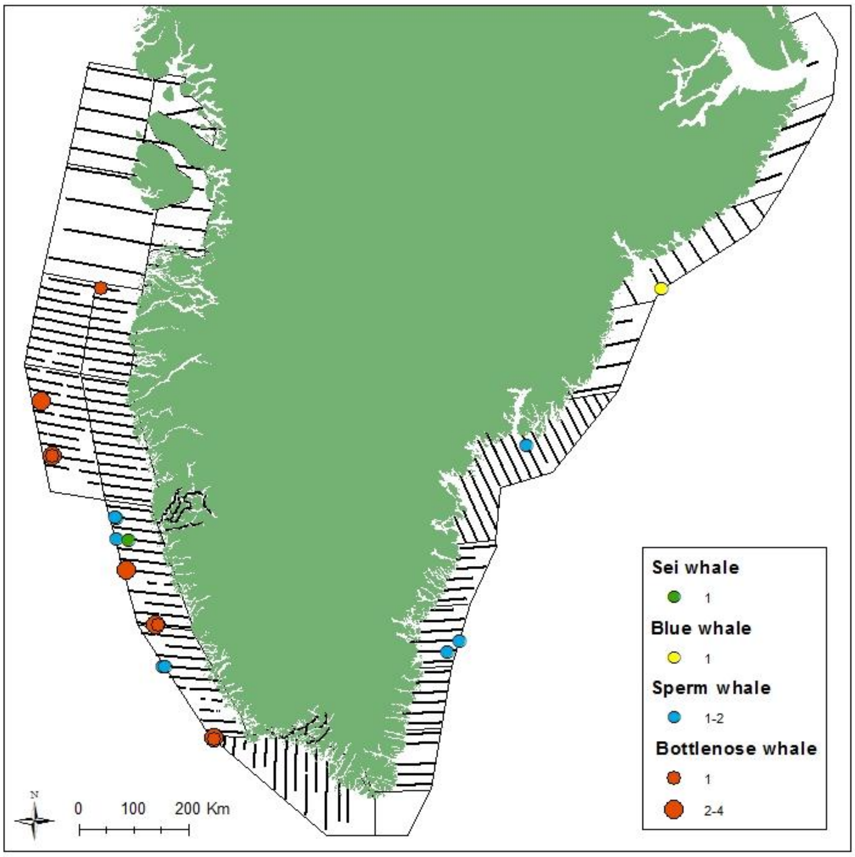

Fig. 17. Survey effort in sea states <5 and sightings with group sizes of sei, blue, sperm and bottlenose whales in East and West Greenland.

10.3 Killer whales

Sightings of killer whales during NASS2015 are shown in Fig. 18.

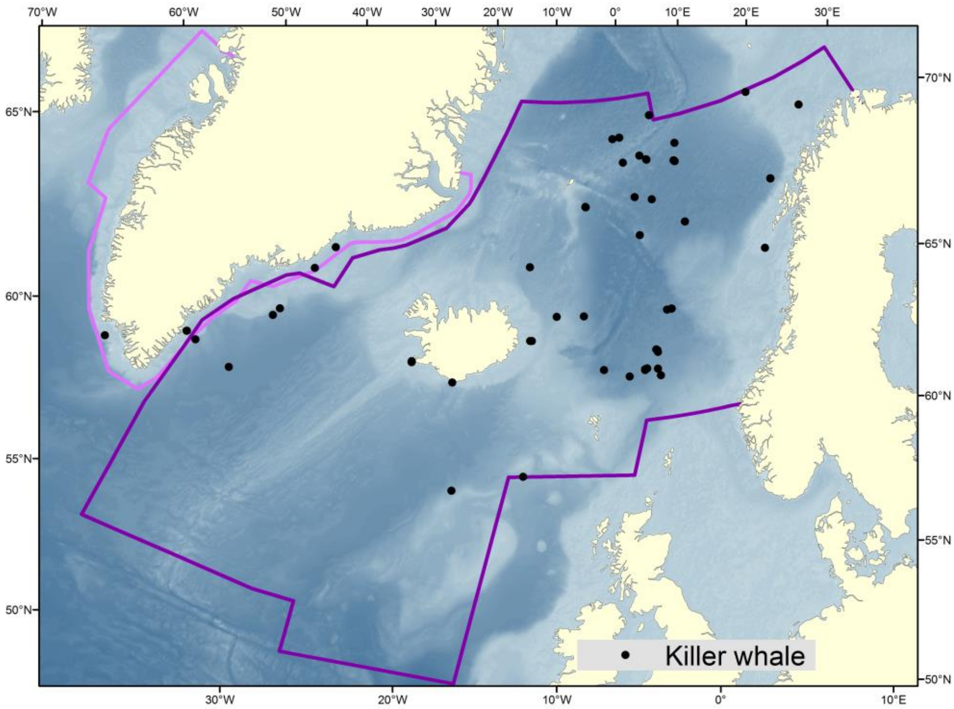

Fig. 18. Sightings of killer whales during NASS2015.

11. ADDITIONAL ANALYSES TO BE CARRIED OUT

Analyses that are still awaited were discussed under the individual species agenda items, and also summarized in Table 2.

Table 2. Analyses that are expected and/or possible to be developed.

Country/Survey	Species	Expected
Norway	Fin (previous and current cycle)	Spring 2017
	minke (current cycle)	Spring 2017
	humpback (previous and current cycle)	Spring 2017
Iceland aerial	minke	Spring 2017
	harbour porpoise	Spring 2017
	white-beaked dolphin	Spring 2017
Iceland/Faroes shipboard	pilot whale	Spring 2017
	humpback	Spring 2017

The WG **recommended** that abundance estimates should be developed for other species if the data permits.

The WG has **recommended** for certain species when abundance estimates can be combined, and this will be the responsibility of the appropriate assessment groups.

12. DUPLICATE IDENTIFICATION

Pike gave a presentation on the identification of duplicate sightings in aerial and ship surveys. Duplicate sightings are defined as those made by independent platforms of the same cue or group of animals. Duplicate identification is usually uncertain as there is no independent means of determining whether or not two sightings are in fact duplicates. Conceptually, if two sightings occur in the same place at the same time, they must be duplicates. However sighting location is measured with often considerable error, so duplicate determination must rely on the degree of similarity of sighting location, species identity, group size and other available covariates. In most reports of aerial surveys, little detail is given about the method used to identify duplicates, but most rely on some combination of similarity in beam time, declination angle and sometimes group size. Duplicate identification is straightforward when sightings are isolated in space and time, as is usually the case with minke whales, but much more difficult when species have an aggregated distribution, as seen with many dolphins, narwhal and pilot whales. Pike presented a method developed by Southwell *et al.* that uses differences in covariates such as sighting location, group size and species identification, and data-determined threshold levels for these differences, to derive a dissimilarity index for duplicate pairs, allowing the objective identification of duplicates from aerial surveys. This method was further developed by Pike and Doniol-Valcroze (2015) by comparing same-side between platform pairs (which contain duplicates) to opposite side pairs (which do not contain duplicates) using logistic regression, thereby deriving a similarity index that weights the importance of the available covariates in identifying duplicates. Pike concluded that the most important means of improving the accuracy and certainty of duplicate identification was to increase the precision of distance measurements and sighting times. Given that duplicate identification is probabilistic, uncertainty in duplicate identification should be incorporated in abundance estimates.

Øien described the methodology used to identify duplicate surfacings of minke whales used in the Norwegian survey program and documented by Bøthun and Skaug (2009). The procedure uses the tracks of minke whales documented by each platform to match surfacings by coincidence in space and time. The routine has been extensively tested using simulated and real survey data and found to correctly identify about 90% of true duplicate surfacings, with a very low rate of "false positive" identification. For other species, which are not tracked in the Norwegian surveys, duplicate identification is not algorithm-based and relies on coincidence in location variables such as sighting time and distance. Duplicate identification for large whales is therefore much more uncertain than that for minke whales.

In the Icelandic/Faroese surveys, duplicates are also identified by coincidence in space and time. While the routine is not algorithm-based, effort is made to be systematic in duplicate identification. Gunnlaugsson noted that field data collection methods would have to be improved to fulfil the data requirements of a fully algorithm based method.

In the Greenlandic aerial surveys, duplicates are identified by coincidence in space and time, with duplicate sightings having beam times of +- 3 seconds and perpendicular distances of +-200 m. In uncertain cases ancillary data such as group size is used. Duplicates are usually identified by the observers immediately after the flight, while memory is fresh.

<u>Discussion</u>
There was considerable discussion about the appropriate procedure to use in cases when two platforms disagreed about species identity in what was otherwise obviously a duplicate sighting, specifically in the common case where one platform identifies species A while the other cannot identify to species (U). Gunnlaugsson considered that AU duplicates should be omitted from the

analysis, because including them, for example by editing the species identity to AA, increases the number of AA duplicates and therefore lowers the abundance estimate for A. Gunnlaugsson provided a simple simulation that demonstrated that, if all the sighted A and U whales were in fact species A, omitting AU duplicates would produce an accurate estimate of the number of A, while editing AU duplicates to AA based on ancillary information would produce a negative bias by inflating p(0) for species A by increasing the number of duplicate sightings. Agreement was reached by correspondence after the meeting that, in cases where the species identity of otherwise obvious duplicates did not match, omitting these pairs from the abundance estimation was the correct procedure to produce an unbiased estimate of abundance. It was noted that this is primarily an issue for ship surveys, as inter-platform disagreement in species identity is rare in the Icelandic and Greenlandic aerial surveys.

The WG agreed that improving the accuracy and precision of distance measurements and the timing of sightings is the best way to reduce uncertainty in duplicate identification. In aerial surveys, use of the newly developed Geometer (see Item 6.3) provides a means of doing this. In ship surveys, the use of binocular reticles to measure distance when possible improves accuracy and also improves the accuracy of distance estimates without binoculars by observers. There should also be a greater emphasis of instrumentation to record cue times accurately.

The WG agreed that algorithm-based methods of duplicate identification should be preferred, as they make the procedure objective and replicable. However, it was recognized that, in some cases, field methodology will have to be improved, as noted above, to facilitate this. The Norwegian survey procedures provide one example of how this can be achieved, at least for minke whales.

An additional issue is data selection in duplicate pairs where distances, angles and other variables vary somewhat between platforms. Some analysts use the average between-platform values, while others choose the “best” estimates based on observer experience, the time the sighting was in view or other factors. The best procedure will depend on the specific conditions of the survey; for example, on some surveys one platform has very experienced observers while the other does not.

It was agreed that better documentation of the methods used to identify duplicates was required. This should include the choice of threshold covariate levels, selection algorithms and data choice for cases where there is difference in measurements (e.g. perpendicular distance) between platforms in duplicate pairs. Ideally, working papers should include a complete tabular presentation of all sightings, including covariates and species identity for all pairs identified as duplicates.

13. PUBLICATION OF SURVEY RESULTS

The AE WG again **recommended** (NAMMCO 2009, 2010, 2011, 2012) that results from NASS2015 and any unpublished results from T-NASS 2007 and other surveys be published in a new volume of the *NAMMCO Scientific Publications* (Table 3). Papers can be published as they are completed, i.e., it is not necessary to wait for all papers in the volume to be completed before publication begins online.

The WG suggested Daniel Pike and Rikke Hansen as possible scientific editors on the volume. As for the volume format, the WG suggested that authors should develop their papers either by species or survey however they wish. The volume could then contain an overview paper of each survey with distribution maps, and refer to specific surveys.

The WG also recommended that the Canadians be encouraged to publish their unpublished papers from the 2007 survey (and additional survey data if available).

Table 3. List of prospective scientific papers from NASS2015 and earlier surveys to be prepared for a coordinated publication in a single volume.

Paper Subject/ Working Title	**Authors (provisional)**	**Survey**
The North Atlantic Sightings Surveys: Counting whales in the North Atlantic.	Hansen, Pike et al.	All.
Abundance of whales in East and West Greenland in 2015	Hansen et al.	NASS2015
An index of the relative abundance of minke whales in West Greenland	Heide-Jørgensen and Hansen	NASS2015
Estimates of the relative abundance pilot whales (*Globicephala melas*) from North Atlantic Sightings Surveys, 1987 to 2015.	Pike, Mikkelsen, Desportes, Gunnlaugsson, Bloch.	NASS 1987-2015
Trends in the abundance of fin whales in the Central North Atlantic, 1987 – 2016.	Vikingsson, Pike, Gunnlaugsson et al.	TNASS 2007, NASS2015
Abundance of minke whales from recent NASS aerial and ship surveys	Pike, Gunnlaugsson, Vikingsson et al.	TNASS 2007, NASS2015 Aerial 2009, 2016.
Abundance of humpback whales from recent NASS aerial and ship surveys	Pike, Gunnlaugsson, Vikingsson et al.	TNASS 2007, NASS2015 Aerial 2009, 2016.
The Geometer: a device for measuring and recording times and angles in aerial surveys.	Thorgilsson, Pike, Gunnlaugsson, Hansen et al.	NASS 2015, Aerial 2016
Abundance of other species (blue, sei, northern bottlenose, killer, dolphins) from recent NASS aerial and ship surveys	Pike, Gunnlaugsson, Vikingsson et al.	TNASS 2007, NASS2015 Aerial 2009, 2016.
Large whales- Norwegian surveys (2 previous cycles)	Øien, et al.	2 previous mosaic cycles
Porpoises (Norway?)	???	SCANS-III + Norwegian surveys
Odontocetes	Øien	Nils surveys 2002-16(?)
Small toothed whales	Desportes?	T-NASS 2007
Recent abundance estimates of cetaceans off the NE USA.	Palka	SNESSA
Distribution and Abundance of Cetaceans off NE Canada in 2007.	Lawson?	Can T-NASS 2007
SC/16/AE/14 (find paper)		

14. FUTURE SURVEYS

A future NASS/T-NASS will likely occur in 5-7 years (ca 2021). The WG discussed whether there were any methodological/technical/logistical concerns with the surveys that the abundance estimates presented at this meeting were generated from, and therefore if there was a need for surveys before this time period. The WG saw no technical issues with the Icelandic shipboard and Greenlandic aerial surveys.

The WG **recommended** that Iceland consider more frequent coastal aerial surveying (see Item 6.3 for discussion).

Norway intends to continue their mosaic surveys where smaller parts of the larger survey area are covered each year to form a complete coverage of the northeast Atlantic during a six-year cycle.

In general, it is **recommended** that surveys are repeated more frequently in areas where declines have been observed (e.g., West Greenland).

15. OTHER ITEMS

15.1 Workshop at SMM 2017

The WG discussed the possibility of organizing a workshop at the next Society Marine Mammalogy conference (23-27 October 2017 in Halifax, Nova Scotia, Canada). This workshop would involve participants from NASS2015 (and other NAMMCO associated surveys), SCANS-III, Canadian, and USA surveys in the past few years to discuss cetacean distributions and abundance in the North Atlantic.

WG **recommended** proceeding with planning for this workshop.

16. NEXT MEETING

Several analyses are expected to be completed in the next year or so. The WG **recommended** tentatively planning a meeting of the AEWG in June 2017. The Secretariat will confirm in April that the analyses will be ready for a June meeting.

17. ADOPTION OF REPORT

The report was adopted provisionally on 18 October 2016, and in final form via correspondence on 28 October 16.

Pike thanked the group for their helpful comments, suggestions, and their hard work. He also thanked Prewitt for rapporteuring, and the participants for their contributions.

The participants thanked the Chair for his hard work and a well-run meeting.

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Pike, D.G, Gunnlaugsson, Th. and Víkingsson, G.A. 2008. T-NASS Icelandic aerial survey: Survey report and a preliminary abundance estimate for minke whales. SC/60/PFI 12 for the IWC Scientific Committee.

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Pike, D.G., Paxton, C.G.M., Gunnlaugsson, Th. and Víkingsson, G.A. 2009. Trends in the distribution and abundance of cetaceans from aerial surveys in Icelandic coastal waters, 1986-2001. *NAMMCO Sci. Publ.* 7:117-142.

Southwell, C., de la Mare, W., Underwood, M., Quartararo, F. and Cope, K. 2002. An automated system to log and process distance sight-resight aerial survey data. *Wildlife Soc. Bull*. 30: 394–404.

Thomas, L., S.T. Buckland, E.A. Rexstad, J. L. Laake, S. Strindberg, S. L. Hedley, J. R.B. Bishop, T. A. Marques, and K. P. Burnham. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. *Journal of Applied Ecology* 47: 5-14. DOI: 10.1111/j.1365-2664.2009.01737.

Table 1. Abundance estimates accepted by the Abundance Estimates Working Group (16-18 October 2016) for use in population assessments/generating management advice. Other estimates (e.g., uncorrected, etc.) might be more appropriate for used in comparison to previous surveys (see discussion under species agenda items).

Species	**Location/Survey**	**Abundance Estimate**
Fin whales	Iceland/Faroe Islands	35,605 (cv 0.18, 95% CI 24,615 to 51,505) p
	West Greenland	465 (95% CI: 233-929) p
	East Greenland	1,932 (95% CI: 1,204-3,100) p
Minke whales	Iceland/Faroes NASS2015 survey area	36,185 (cv 0.31, 95% CI 19,942 to 65,658) p
	IC/CIC area	12,710 (cv 0.52, 95% CI 4,498 to 35,912) p
	West Greenland	4,204 (cv=0.47; 95% CI= 1,753-10,085) p,a
	East Greenland	2,681 (cv= 0.45; 95% CI= 1,153-6,235) p,a
Humpback whales	West Greenland	1,321 (cv=0.44; 95% CI= 578-3,022) p,a
	East Greenland	4,012 (cv= 0.35; 95% CI= 2,044-7,873) p,a
Pilot whales	West Greenland	11,993 (cv=0.52; 95% CI= 4,575-31,438) p,a
	East Greenland	338 (cv= 1.01; 95% CI= 65-1,749) p,a
Harbour porpoises	West Greenland	83,321 (cv= 0.34; 95% CI=43,377 -160,047) p,a
	East Greenland	1,642 (cv= 1.00; 95% CI= 318-8,464) p,a
White-beaked dolphins	West Greenland	2,747 (95% CI: 1,257-6,002) p
	East Greenland	2,140 (95% CI: 825-5,547) p

p= corrected for perception bias
a= corrected for availability bias
u= uncorrected

Appendix 2.

WORKING GROUP ON ABUNDANCE ESTIMATES
Copenhagen, October 16-18, 2016

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WORKING GROUP ON ABUNDANCE ESTIMATE
Copenhagen, October 16-18, 2016

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1. **CHAIRMAN WELCOME AND OPENING REMARKS**
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   - 5.3 Aerial Greenland
   - 5.4 Combined Estimates
6. **MINKE WHALES**
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   - 6.2 Shipboard Greenland
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   - 6.4 Aerial Greenland
     - 6.4.1 Trends in Abundances
7. **HUMPBACK WHALES**
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8. **PILOT WHALES**
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9. **HARBOUR PORPOISES**
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10. **OTHER SPECIES**
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      - 10.1.1 Aerial West Greenland
      - 10.1.2 Aerial Iceland
    - 10.2 Killer whales, bottlenose whales
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12. **DUPLICATE IDENTIFICATION**
13. **PUBLICATION OF SURVEY RESULTS**
14. **FUTURE SURVEYS**
15. **OTHER ITEMS**
    - 15.1 Workshop at SMM 2017
16. **NEXT MEETING**
17. **ADOPTION OF REPORT**

WORKING GROUP ON ABUNDANCE ESTIMATE
Copenhagen, October 16-18, 2016

Document List

Working Documents

Doc. No.	Title	Agenda Item
SC/23/AE/01	Draft Agenda	2
SC/23/AE/02	Participant List	1
SC/23/AE/03	Document List	4
SC/23/AE/04	Pike et al. Estimates of the abundance of fin whales (*Balaenoptera physalus*) from the NASS Icelandic and Faroese ship surveys conducted in 2015.	5.1
SC/23/AE/05	Pike et al. Estimates of the abundance of common minke whales (*Balaenoptera acutorostrata*) from the NASS Icelandic and Faroese ship surveys conducted in 2015.	6.1
SC/23/AE/06	Heide-Jørgensen and Hansen. An index of the relative abundance of minke whales in West Greenland	6.4
SC/23/AE/07	Pike. Icelandic aerial survey 2016: Survey report	6.3, 7.1
SC/23/AE/08	Hansen et al. Abundance of whales in East and West Greenland in 2015.	
SC/23/AE/09	Øien. Updates 2014-2016: Preliminary abundance estimates	

Background Papers

SC/23/AE/O01	Pike and Doniol-Valcroze. Identification of duplicate sightings from the 2013 double-platform High Arctic Cetacean Survey	12
SC/23/AE/O02	Southwell et al. 2002. An Automated System to Log and Process Distance Sight-Resight Aerial Survey Data	12
SC/23/AE/O03	Icelandic aerial survey 2015: Survey report	6.3, 7.1
SC/23/AE/O04	Report of the Norwegian 2015 survey for minke whales in the Small Management Area EW–Norwegian Sea and NASS2015 extension survey in the Small Management Area CM – Jan Mayen area	
SC/23/AE/O05	Bøthun and Skaug. Description and performance of an automatic duplicate identification routine	
SC/23/AE/O06	Updates 2014-2016: Preliminary abundance estimates of common minke whales in Svalbard 2014, the Norwegian Sea and Jan Mayen 2015, and the Jan Mayen area 2016,	

	with distributional maps for minke, fin, humpback and sperm whales	
SC/23/AE/O07	Gunnlaugsson et al. Cruise Report of the Icelandic NASS 2015 Cetacean census vessel survey	